

APPENDIX B

Technical Specifications - Tender Packages 1, 2 and 3





WHYTES GULLY NEW LANDFILL CELL TENDER PACKAGE 1

Technical Specification - New Landfill Cell

Submitted to: Wollongong City Council

Report Number.

117625003_145_S_Rev1



CHNICAL SPECIFICATION

E.



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1.0 SECTION 1 – PRELIMINARIES

1.1 Introduction

The basic concept for the expansion of the Whytes Gully Landfill is that future waste will be placed within a lined and capped expansion area constructed over the existing landfill site, including:

- Overfilling of the existing Eastern and Western Gully Landfills (note: the term "piggyback liner" is used to refer to the proposed liner system to be constructed in overfill areas);
- Filling within existing natural areas on the Central Ridge and Western Ridge; and
- Filling within existing natural areas at the toe of the existing Eastern and Western Gully Landfills.

This Preliminary Technical Specification provides material and construction requirements for the first portion of construction for landfill expansion, referred to as Tender Package 1.

Background information on site conditions and the purpose of project can be found in the following reports, which also provide a detailed description of design intent.

- Design Report "Whytes Gully New Landfill Cell Report for Preliminary Design" prepared by Golder Associates, April 2012, ref. 117625003 - 058 - R - RevA.
- Detailed Design report "Detailed Design Report Tender Packages 1,2 and 3" prepared by Golder Associates, March2013, ref. 117625003 - 224 - R – Rev0. (report in preparation)

1.2 **Definitions**

The following parties are referred to in this Technical Specification.

Table 1: Parties relevant to the project

Superintendent	The party designated by the site owner to manage the Contractor in accordance with the construction contract. The Superintendent may delegate appropriate tasks to a Technical Superintendent.		
Contractor	The party awarded the contract to complete the works described in this Technical Specification.		
GITA	Geotechnical Inspection and Testing Authority: The party undertaking Level 1 inspection and testing of landfill earthworks in accordance with AS3798 -2007. The GITA shall be engaged by the Contractor, subject to Superintendent short list and approval, and shall be independent of the Contractor.		
Regulator	The NSW state agency responsible for oversight of landfill construction and environmental management. This is anticipated to be the NSW EPA.		

This Technical Specification includes 'Hold Points' and 'Inspection Points'. These are defined as follows:

- Hold Point An identified point in the landfill construction sequence where the Contractor must halt work and provide required information to the Superintendent. The Contractor must not resume work until the Hold Point is released, in writing, by the Superintendent.
- Inspection Point An identified point in the landfill construction sequence where the Contractor is required to provide written notification in advance of commencing work on identified items in order to allow the opportunity for the Superintendent to directly inspect the work; the notification must be provided when indicated and in no case less than 24 hours in advance of commencing the work.

The specific meaning of the term "Site" is defined in the contract documents.



1.3 Construction Materials

The table below presents the primary materials for cell construction. These materials are referred to in this Technical Specification by unit number. Additional construction materials are also named in this Technical Specification.

Table 2: Material List
SOILMATERIALS
Unit 1 – Topsoil
Unit 2 – General Fill
Unit 3 – Intermediate Cover Material
Unit 4 – Clay Rich Material
Unit 5 – Clay Material
Unit 6 – Base Material
Unit 7 – Drainage Aggregate
Unit 8 – Gas Drainage Gravel
Unit 9 – Protection Material
GEOSYNTHETIC MATERIALS
Unit 11 – Filter Geotextile
Unit 12 – Cushion Geotextile
Unit 13 – Geocomposite Drainage Net (Surface Water)
Unit 14 – Geocomposite Drainage Net
Unit 15 – LLDPE Geomembrane
Unit 16 – HDPE Geomembrane
Unit 17 – Geosynthetic Clay Liner (GCL)
Unit 18 – Geogrid
PIPE MATERIALS
Unit 21 – Gas Collection Pipe
Unit 22 – Groundwater Drainage Pipe
Unit 23 – Leachate Collection Pipe
Unit 24 – Leachate Sump Outlet Pipe
Unit 25 – Leachate Drainage Pipe
Unit 26 – Subsoil Drainage Pipe
Unit 27 – Leachate Sump Riser

Unit 28 – Leak Detection Pipe

SURFACE WATER DRAINAGE AND OTHER MATERIALS

Unit 31 – Bentonite

Unit 32 – Rip Rap Armourstone and Aggregate for Gabion Baskets and Wire Mattresses

Unit 33 - Granular Material for Concrete Pipe Installation

Unit 34 – Rock Filled Gabions and Mattresses

Unit 35 – Channel Lining

Unit 36 - Precast Reinforced Concrete Box Culverts (RCBC)

Unit 37 - Precast Reinforced Concrete Pipes (RCP)

Unit 38 – Drain Liner

1.4 Design Drawings

Detailed design drawings for Tender Package 1 are provided separately and referred to herein as the "Design drawings".

1.5 Site Preparation

Site preparation works shall be carried out by the Contractor in successive stages in accordance with the Contractor's approved Construction Program.

1.5.1 Removal of Vegetation

Existing vegetation shall be cut and disposed by the Contractor in all construction areas. .

1.5.2 Services

The Contractor is responsible for confirming service locations, and also locating any unknown services, and establishing whether services are active or inactive prior to initiating work in any area of the site.

Active services are currently present within the construction area and vicinity. Known active services include power, water, and communication lines to the existing staff amenities building (also potentially to the adjacent previous weighbridge building), power and communication lines along the Old Redalls Road alignment, and power and control lines to the existing leachate ponds.

These known active services will be decommissioned and/or de-energised by others prior to construction. The Contractor shall completely remove these services, including all service trench bedding materials.

In addition, 132 kVA overhead powerlines are present along the southern edge of the proposed landfill construction area. These power lines are owned by Endeavour Energy and are to remain in service at all times. The Contractor must use appropriate work methods in the vicinity of these lines.

Known inactive services at the site include the overhead power line along the Western Ridge, owned by BHP Billiton. This line will be removed by others prior to construction.

In the case that previously unknown services are encountered during the course of works, the Contractor shall immediately take appropriate safety precautions, and shall inform the Superintendent. The Contractor is responsible for protecting any active services identified by the Contractor at the time of construction until they are decommissioned and/or de-energised by others. Once decommissioned and/or de-energised, the Contractor shall completely remove services, including all service trench bedding materials.



The Contractor shall prepare and submit documentation of all his activities to confirm, locate and remove services.

1.5.3 Structures Demolition

Prior to the construction of the lining system in each area, existing structures shall be demolished and removed by the Contractor. Structures include the existing staff amenities building and previous weighbridge, disconnected power poles, as well as small concrete items in other areas (i.e., pads, slabs, channel lining, pits).

The Contractor shall provide a Work Method Statement presenting proposed methods for structure demolition, including identification of hazardous materials (eg asbestos), environmental management of demolition materials, and material disposal. Refer to *Technical Specification – 021 Demolition*, provided separately, for additional requirements. These activities shall not commence until the Hold Point is released.



2.0 SECTION 2 – MATERIALS

2.1 General Material Requirements

2.1.1 Contractor Supply and Protection of Materials

The Contractor shall be responsible for supply, delivery, storage, placement and installation of all materials required to carry out the works in this Technical Specification. However, the Superintendent may direct that some materials will be supplied by others. Once incorporated in the Works, the Contractor shall protect the materials throughout the duration of construction to ensure they do not degrade or become damaged so as to change the intended performance or function of the materials.

2.1.2 Material Approval

Source Approval

The Contractor shall demonstrate that all materials proposed by the Contractor for the works will meet the requirements of this Technical Specification. This constitutes a HOLD POINT for <u>each</u> of the materials identified in the Technical Specification and in the Design Drawings. No material shall be imported to the site, and no on-site materials shall be handled, placed or stockpiled, until the Hold Point for the material is released.

Materials that are considered by the Superintendent to have excessive settlement potential, or the potential to undergo or contribute to chemical reactions adverse to landfill performance, will not be approved.

The Contractor shall prepare a submittal for Superintendent review for each material to demonstrate that the proposed material will comply with all requirements of this Technical Specification. Hold Point release will be dependent on the submittal providing a satisfactory demonstration. Each submittal shall identify the material source, or sources, and include relevant test results that satisfy the testing requirements of this Technical Specification, description of material uniformity, and other information needed to confirm required properties, including waste classification for soil materials. For manufactured products, manufacturer's specifications and quality control information shall also be submitted.

Confirmation of Properties of Materials Delivered to Site

The Contractor is responsible for confirming that all materials delivered to site from approved sources meet the material property requirements of this Technical Specification. This includes complying with all sampling and testing requirements in this Technical Specification, as well as performing additional sampling and testing as needed to confirm as-delivered material properties.

Confirmation of material properties after placement and compaction is also required for some materials as indicated in this Technical Specification.

The Contractor is required to notify the Superintendent at least 24 hours in advance of taking samples for confirmation of as-delivered and as-placed material properties.

The Superintendent may, at his discretion, conduct Audit sampling and testing of any materials at source or at site. The Contractor must assist and facilitate the Superintendent in such activities. If Audit test results indicate that materials do not meet requirements then the Superintendent may direct that the materials be replaced at the Contractor's expense and that the Contractor pay the Audit sampling and testing costs.

2.1.3 VENM or ENM Requirement

All soil materials imported to the site and used to construct any portion of the landfill must meet the definition of virgin excavated natural material (VENM) or excavated natural material (ENM) under the Protection of the Environment Operations Act 1997 and the Protection of the Environment Operations Amendment 2008, unless otherwise permitted by this Technical Specification, consistent with the project approval conditions, and agreed with the Superintendent. If material other than VENM or ENM is proposed for import to the site, the Contractor shall be responsible for obtaining all relevant approvals, such as from the Regulator, prior to importing.



The Contractor shall commission a VENM/ENM assessment and waste classification for all imported soil material. The assessment and classification must be performed by a qualified person and be to the satisfaction of the Superintendent. The assessment and classification shall comprise a material source inspection, an assessment of historical land use at the source site, and chemical testing at a frequency of at least one sample per material source or at least one sample per 1,000 m³. The Superintendent may require more frequent sampling and testing at the Contractor's expense if the classification is considered incomplete or inadequate. Chemical testing shall comprise analysis for heavy metals, total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene, xylenes (BTEX), polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) and Organochlorine pesticides (OCPs). The provisions of current NSW EPAWaste Classification Guidelines shall apply.

The Contractor shall keep records of waste classification and quantity of all soil materials imported to site.

The Contractor may submit non-VENM or non-ENM soil materials from on site to be considered for use in landfill construction, provided that these materials meet Technical Specification requirements and are not designated for stockpiling for future use by the site owner. The Contractor submittal for on-site materials must address the requirements in Section 2.1.2, as for import materials.

2.1.4 Reporting

Reporting of all material test results shall be in accordance with the Contractor's Quality System, specific requirements in this Technical Specification, and other contract requirements. However, in all cases material test results shall be made available to the Superintendent no later than 1 week after each test is performed.

All material test results submitted to the Superintendent by the Contractor must be from a laboratory with NATA-accreditation for all tests performed. All survey results submitted to the Superintendent by the Contractor must be from a registered surveyor.

2.2 Material Properties

2.2.1 Unit 1 – Topsoil

Not used for Tender Package 1.

2.2.2 Unit 2 – General Fill

Unit 2 – General Fill shall comprise clay, silt, sand, gravel or any combination thereof or other approved materials. This material shall contain no organic matter. This material shall have a low erosion potential with an Emerson Class number greater than 4 (AS 1289.3.8.1), although the Superintendent may agree to reduce the Emerson Class number requirement where the fill will not be exposed to potential erosion. This material shall have a maximum particle size of 75 mm and a smooth gradation that results in minimal visible voids once compacted.

Source approval for Unit 2 will primarily require the Contractor to identify the source, describe the material, provide two representative Emerson Class test results and gradation test results (AS1289.3.6.1), and, for import material, provide an acceptable VENM/ENM classification.

Confirmation of the properties of as-delivered Unit 2 shall be by Contractor inspection and documentation of each incoming load, and by sampling and Emerson Class testing and gradation testing at a frequency of at least one testing event per 1,000 m³ of material placed, with a minimum of one testing event per source.

2.2.3 Unit 3 – Intermediate Cover Material

Unit 3 – Intermediate Cover Material will be sourced, handled and placed by the landfill operator. The Contractor will not be responsible for this material.

2.2.4 Unit 4 – Clay Rich Material

Unit 4 Clay Rich Material shall clayey soil, free of organic matter, capable of being compacted to a dense condition. The material shall have the following index properties:

Index properties:

- Plasticity Index > 15%;
- Liquid Limit > 25%.
- Emerson crumb classification > 4

The material shall have differing gradation requirements in different applications as indicated below.

A. Bearing Material in Cell Base: This application provides a surface for GCL placement

- Gradation:
 - Maximum particle size 13.2mm;
 - Passing 2.4 mm sieve > 90%;
 - Percentage fines (passing 0.075mm sieve)> 30%.

B. Bund – Main Body of Bund. This application is for bund material that is not in contact with GCL material

- Gradation:
 - Maximum particle size 53 mm;
 - Passing 19 mm sieve > 90%;
 - Percentage fines (passing 0.075mm sieve) > 30%.

C. Bund - Batters and top surface: This application provides a surface for GCL placement

Gradation: same as category A above.

Table 3: Material Testing Requirements for Unit 4 – Clay Rich Material

Property	Test method	Frequency		
		Source approval	As-delivered	
Atterberg Limits	AS1289.3.2.1	Two tests per source	One test per 2,000 m ³ material used on site, minimum 4 tests per source	
Gradation	AS1289.3.6.1	Two tests per source	One test per 2,000 m ³ material used on site, minimum 4 tests per source	
Emerson Class Number	AS1289.3.8.1	Two tests per source	One test per 2,000 m ³ material used on site, minimum 4 tests per source	

2.2.5 Unit 5 – Clay Material

Unit 5 Clay Material shall clayey soil, free of organic matter, capable of being compacted to a dense condition. The material shall have the following index properties:

- Gradation:
 - Maximum particle size 13.2 mm;
 - Percentage fines (passing 0.075mm sieve)> 50%.
- Index properties:
 - Plasticity Index >20%;
 - Liquid Limit >40%.

- Emerson crumb classification > 4.
- When remoulded to a Standard Maximum Dry Density (SMDD) of 95% in accordance with AS1289.5.1.1 at Standard Optimum Moisture Content (SOMC) have a co-efficient of permeability, measured in a triaxial cell at an effective confining pressure of 50 kPa in accordance with AS1289.6.7.3 ,of no greater than 1 x 10⁻⁹ m/s.

The following table shows the testing requirements for this material.

Broparty	Test method	Frequency		
Property		Source approval	As-delivered	
Atterberg Limits	AS1289.3.2.1	Two tests per source	One test per 200 m ³ material used on site, minimum 4 tests per source	
Gradation	AS1289.3.6.1	Two tests per source	One test per 200 m ³ material used on site, minimum 4 tests per source	
Emerson Class Number	AS1289.3.8.1	Two tests per source	One test per 200 m ³ material used on site, minimum 4 tests per source	
Permeability	AS1289.6.7.3	Two tests per source	One test per 200 m ³ material used on site, minimum 1 test per leachate sump, minimum 4 tests per source	

Table 4: Material Testing Requirements for Unit 5 - Clay Material

2.2.6 Unit 6 – Base Material

Unit 6 Base Material shall be well-graded sandy or gravelly materials, free of organic matter, carbonates and clay balls and capable of being compacted to a dense condition. The material shall have a USCS classification of GW, GW-GM, GM, GW-GC, GC, SW, SW-SM, SM, SW-SC, or SC.

The material shall have the following index properties:

- Gradation:
 - Max. particle size 40mm;
 - Percentage gravel (retained on 4.75 mm sieve) > 30%
 - Percentage Fines (passing 0.075 mm sieve) >5% and <20%</p>

The material shall have a minimum shear strength, at 25 kPa effective confining stress, equivalent to that of adrained friction angle of 35 degrees.

Source approval for Unit 6 will primarily require the Contractor to identify the source, describe the material, provide two representative gradation test results (AS1289.3.6.1) and two appropriate shear strength tests, and provide an acceptable VENM/ENM classification.

Confirmation of the properties of as-delivered Unit 6 shall be by Contractor inspection and documentation of each incoming load, and by sampling and gradation testing at a frequency of at least one testing event per 1,000 m³ of material placed, with a minimum of one testing event per source.

Coarse coal washery rejects will be considered for use as Unit 6 under the following conditions:

- the materials meet the above requirements, when sampled <u>after</u> placement and compaction;
- the material is demonstrated to the Superintendent's satisfaction to be from a source with no history of spontaneous combustion of stockpiled coal washery rejects; and
- the materials are supplied in full accordance with the requirements outlined by the NSW EPA under the Protection of the Environmental Operation (Waste) Regulation 2005 - General Exemption Under Part 6, Clause 51 and 51A; the Coal Washery Rejects General Exemption 2009.



If the Contractor proposes to use coarse coal washery rejects then full details of how the material requirements and conditions outlined above will be satisfied must be included in his source approval submission for the material.

2.2.7 Unit 7 – Drainage Aggregate

The Unit 7 – Drainage Aggregate shall consist of high durability, clean, hard, sound gravel or crushed rock of natural geologic origin, free of organic matter, lumps of clay or other deleterious material, carbonates, limestone or other calcareous material that would be subject to chemical attack. The material shall be washed to remove fines. Recycled materials or materials of ash/slag origin are not permitted.

The material shall have particle characteristics such that the placed drainage layer is stable under compaction using a smooth drum roller.

The material shall have the properties given below <u>following placement</u> and spreading to the required thickness:

- Gradation:
 - Max. particle size 40 mm;
 - Passing 19 mm sieve < 20%</p>
 - Passing 13.2 mm sieve < 10%</p>
 - Percentage Fines (passing 0.075 mm sieve) <2%</p>
- Aspect Ratio (in accordance with AS 1141.14):
 - Max. misshapen particles at 2:1 calliper ratio: 20%
 - Max. misshapen particles at 3:1 calliper ratio: 5%
- Permeability > 1×10^{-3} m/s
- Strength (in accordance with AS1141.22–2008):
 - Min.wet strength: 80 kN;
 - Max.wet/dry strength variation: 30%
- Calcium carbonate content (in accordance with Test Method: Rapid Titration specified in "Soil and Plant Analyses" by C.S. Piper):
 - Max.calcium carbonate content by volume: 15%
- Solubility in acid (in accordance with Test Method: AWWA B 100.96):
 - non-soluble in acid

The following material shall not be used as Unit 7 – Drainage Aggregate: volcanic breccia, mudstone, sandstone, shale, limestone, calcrete, and highly weathered or altered rocks.

The following table shows the testing requirements for this material.

Table 5: Material Testing Requirements for Unit 7 – Drainage Aggregate

	Test method	Frequency		
Property		Source approval	As-placed (following placement and spreading)	
Geologic Origin	NA	Certificate is required for each material source	Inspect and document each batch delivered to site to confirm composition and lack of organics, carbonates, and clay	
Gradation	AS1141.11 / AS1141.12	Two tests per source	One test per 500 m ³ material used on site, minimum 2 tests per source	



Aspect Ratio	AS 1141.14	Two tests per source	One test per 500 m ³ material used on site, minimum 2 tests per source
Permeability	AS1289.6.7.1	One test per source	not required
Strength	AS1141.22 - 2008	Two tests per source	One test per 500 m ³ material used on site, minimum 2 tests per source
Calcium carbonate content	Rapid Titration specified in "Soil and Plant Analyses" by C.S. Piper	One test per source	One test per 500 m ³ material used on site, minimum 2 tests per source
Solubility in acid	AWWA B 100.96	One test per source	One test per 500 m ³ material used on site, minimum 2 tests per source

2.2.8 Unit 8 – Gas Drainage Gravel

The Unit 8 – Gas Drainage Gravel shall consist of recycled concrete, natural gravel, crushed rock or combination thereof or other approved materials. This material shall be free of organic matter, carbonates and clay balls.

The material shall have the following properties

- Gradation:
 - Max. particle size 40mm;
 - Passing 19 mm sieve < 20%</p>
 - Passing 13.2 mm sieve < 10%</p>
 - Percentage Fines (passing 0.075 mm sieve) <3%</p>
- Permeability > 1×10^{-3} m/s
- Strength (in accordance with AS.2758.1 1998):
 - minimum wet strength: 40 kN;

The following material shall not be used as Unit 8 – Gas Drainage Gravel: shale and highly weathered or altered rocks.

The following table shows the testing requirements for this material.

Table 6: Material Testing Requirements for Unit 8 – Gas Drainage Gravel

	Test method	Frequency		
Property		Source approval	As-delivered	
Geologic Origin	NA	Certificate is required for each material source	Inspect and document each batch delivered to site to confirm composition and lack of organics, carbonates, and clay	
Strength	AS1141.22 - 2008	Two tests per source	One test per 500 m ³ material used on site, minimum 2 tests per source	
Gradation	AS1141.11 / AS1141.12	Two tests per source	One test per 500 m ³ material used on site, minimum 2 tests per source	
Permeability	AS1289.6.7.1	One test per source	not required	



2.2.9 Unit 9 – Protection Material

Unit 9 Protection Material shall comprise a material:

- capable of being spread smoothly in a 300mm thick layer without damaging underlying geocomposite drain;
- with compaction limited to tracking by the spreading plant;
- with sufficient strength and cohesion to maintain a stable long-term orientation on piggyback liner slopes, generally 2.5H:1V to 5H:1V; and
- with as-placed permeability within the identified range.

The material shall have the properties given below <u>following</u> placement and spreading to the required thickness:

- Gradation:
 - Max. particle size 19 mm;
 - Percentage Fines (passing 0.075 mm sieve) <3%</p>
- Permeability > 1 x 10^{-3} m/s
- Shear strength, measured at 25 kPa effective confining stress, equivalent to that of a drained friction angle of 35 degrees.

Source approval for Unit 9 will primarily require the Contractor to identify each source, describe the material, provide two representative gradation test results (AS1289.3.6.1), two permeability test results (AS. 1289.6.7.1), two appropriate shear strength tests, and an acceptable VENM/ENM classification.

Confirmation of the properties of as-delivered Unit 9 shall be by Contractor inspection and documentation of each incoming load, and by sampling and gradation and permeability testing at a frequency of at least one testing event per 1,000 m³ of material placed, with a minimum of two testing events per source. Note: This sampling and testing shall be on material recovered from the protection material layer after placement.

Coarse coal washery rejects will be considered for use as Unit 9 under the following conditions:

- the materials meet the above requirements;
- the material is demonstrated to the Superintendent's satisfaction to be from a source with no history of spontaneous combustion of stockpiled coal washery rejects; and
- the materials are supplied in full accordance with the requirements outlined by the NSW EPA under the Protection of the Environmental Operation (Waste) Regulation 2005 - General Exemption Under Part 6, Clause 51 and 51A; the Coal Washery Rejects General Exemption 2009.

If the Contractor proposes to use coarse coal washery rejects then full details of how the material requirements and conditions outlined above will be satisfied must be included in his source approval submission for the material.

2.2.10 Unit 10 – Not used

The Unit 10 designation has not been used.

2.2.11 Unit 11 – Filter Geotextile

Unit 11 – Filter Geotextile shall be woven or non-woven, polyester or polypropylene which has the following properties:

Equivalent Opening Size < 110 μm (Typical Value)

- CBR puncture strength >2100 N (Minimum Average Roll Value, MARV)
- Flow rate > 100 L/s/m² (cross-plane flow under 100mm head) (Typical Value)
- Mass per unit area>200 g/m² (MARV)

The following table shows the testing requirements for this material.

Table 7: Material Testing Requirements for Unit 11 - Filter Geotextile

Broparty	Tast method	Frequency		
Property	rest method	Source approval	As-delivered	
Mass	AS3706.1	Two tests per source	two tests per roll used on site	
Flow Rate (cross- plane flow under 100mm head)	AS3706.9	Two tests per source	One test per manufacturer batch	
Equivalent Opening Size	AS3706.7	Two tests per source	One test per manufacturer batch	
CBR Puncture Strength	AS3706.4	Two tests per source	Two tests per roll used on site	

2.2.12 Unit 12 – Cushion Geotextile

Unit 12 – Cushion Geotextile shall be a non-woven, needle-punched polyester or polypropylene material. The Cushion Geotextile shall be free of broken needles. The material shall be rejected if broken needles are present.

Requirements for the material will be provided at a later date and will include minimum required values for the following properties:

- Thickness
- Mass per unit area
- Trapezoidal tear strength
- CBR puncture strength

The following table shows the testing requirements for this material.

Table 8: Material Testing Requirements for Unit 12– Cushion Geotextile

Bronorty	Test method	Frequency		
Froperty	rest method	Source approval	As-delivered	
Thickness	AS3706.1	Two tests per source	One test per roll used on site	
Mass	AS3706.1	Two tests per source	One test per roll used on site	
Trapezoidal Tear	AS3706.3	Two tests per source	One test per 1,000 m ² material placed on site	
CBR Puncture Strength	AS3706.4	Two tests per source	One test per 1,000 m ² material placed on site	

Interface Shear Strength: The minimum interface shear strength requirements given in Section 2.2.19 apply to the performance of combinations of Unit 12, Unit 14, Unit 15, Unit 16 and Unit 17 materials comprising the



base and piggy back lining systems. The Contractor's attention is drawn to the requirement for each material to meet its individual requirements and also for the combined lining system materials to meet interface shear strength requirements.

2.2.13 Unit 13 – Geocomposite Drainage Net (Surface Water)

Not used for Tender Package 1.

2.2.14 Unit 14 – Geocomposite Drainage Net

Unit 14 – Geocomposite Drainage Net shall be a geocomposite material comprising a triplanar HDPE geonet core with non-woven, polyester, polypropylene, or polyethylene needle punched, resin or heat bonded geotextiles thermally bonded to both sides of the geonet core. The geocomposite drainage net material shall have the following properties:

- Thickness > 6.8 mm at 200 kPa normal stress (Minimum Average Roll Value, MARV)
- Mass > 1,000 g/m² (MARV)
- Hydraulic flow rate ≥ 0.4 x 10⁻³ m³/s per metre width at 20kPa normal stress with hydraulic gradient i = 0.1 (measured between rigid plates) (Typical value)
- Hydraulic flow rate ≥ 0.3 x 10⁻³ m³/s per metre width at 200 kPa normal stress with hydraulic gradient i = 0.1 (measured between rigid plates) (Typical value)
- Tensile strength >20 kN/m (MARV)
- Elongation at peak >38% (MARV)
- Ply adhesion (peel strength of geotextile from geonet) >180 g/cm (MARV); with no unbonded areas permitted
- Internal and Interface Shear Strength Requirements Refer to Section 2.2.19

Interface Shear Strength: The minimum interface shear strength requirements given in Section 2.2.19 apply to the performance of combinations of Unit 12, Unit 14, Unit 15, Unit 16 and Unit 17 materials comprising the base and piggy back lining systems. The Contractor's attention is drawn to the requirement for each material to meet its individual requirements and also for the combined lining system materials to meet interface shear strength requirements.

The geotextiles shall have the following properties:

- Mass > 115 g/m2 (MARV) or > 200 g/m2 (MARV) if field joints between Unit 14 sheets are made by hot-air seaming
- Equivalent Opening Size < 90 μm (Typical value)</p>

The Unit 14 Geocomposite Drainage Net must be demonstrated to remain stable under a sustained normal stress of 500 kPa.

The following table shows the testing requirements for this material.

		Frequency		
Property	Test method	Source approval	As-delivered	
Thickness	AS 3706.1 / ISO 9863 / ASTM D-5199-01 / EN 964-1	Two tests per source	One test per 2 rolls used on site	



		Frequency		
Property	Test method	Source approval	As-delivered	
Mass	AS3706.1 / ISO 9864 / ASTM D-5261-92 / EN 965	Two tests per source	One test per 2 rolls used on site	
Tensile strength	AS3706.2 / ISO 10319 / ASTM 4595-01	Two tests per source	One test per 3,000 m ² geocomposite material placed on site	
Elongation at peak	AS3706.2 / ISO 10319 / ASTM 4595-01	Two tests per source	One test per 3,000 m ² geocomposite material placed on site	
Hydraulic flow rate20 kPa stress200 kPa stress	AS 3706.10 / D-4716-01 / ISO-12958	Two tests per source for each stress level	One test per 10,000 m ² geocomposite material placed on site (200 kPa stress only)	
Hydraulic Flow Rate Reduction Factor for Creep (500 kPa normal stress)	extended AS 3706.10 / D- 4716-01 / ISO-12958	One test per source	Not required	
Ply Adhesion	Adhesion ASTM D7005		One test per 1,500 m ² geocomposite material placed on site Inspect and document each roll used onsite to confirm requirement for no unbonded areas	
Geotextiles				
- Mass per unit area	AS3706.1 / ISO 9864 / ASTM D-5261-92	Two tests per side per source	One test per side per 1,500 m ² geocomposite material placed	
- Opening size	AS 3706.7 / D-4751-95 / ISO 12956	Two tests per side per source	One test per side per 25,000 m ² geocomposite material placed (1 test per side minimum)	

2.2.15 Unit 15 – LLDPE Geomembrane

Unit 15 –Linear Low Density Polyethylene (LLDPE) Geomembrane with a nominal thickness of 1.5 mm for the piggy back liner system shall have the following properties:

- Thickness >1.45mm (minimum average roll value, MARV)
- LLDPE product density < 0.939 g/cm^3 (MARV)
- Base resin: density >0.915 g/cm³ and <0.926 g/cm³; melt flow index <1.0 g/10min
- Product textured on both sides with asperity height > 0.25mm (MARV)
- Tensile strength at break >16 kN/m (MARV)
- Elongation at break > 250% (MARV)
- Modulus at 2% strain <630 kN/m (max)
- Tear resistance >150N (MARV)
- Puncture resistance >300 N (MARV)
- Axi-symmetric break resistance strain > 30% (min)

- Oxidative Induction Time (OIT):
 - > 100 minutes at standard pressure (MARV); and
 - > 400 minutes at high pressure (MARV)
- Oven aging at 85°C for 90 days:
 - OIT retained > 35% at standard pressure (MARV); and
 - OIT retained > 60% at high pressure (MARV)
- Interface Shear Strength Requirements Refer to Section 2.2.19.

Interface Shear Strength: The minimum interface shear strength requirements given in Section 2.2.19 apply to the performance of combinations of Unit 12, Unit 14, Unit 15, Unit 16 and Unit 17 materials comprising the base and piggy back lining systems. The Contractor's attention is drawn to the requirement for each material to meet its individual requirements and also for the combined lining system materials to meet interface shear strength requirements.

The following table shows the testing requirements for this material.

Table 10: Material Testing		Frequency	
Requirements for Unit 15 - Textured LLDPE GeomembraneProperty	Test Method	Source approval	As-delivered
Thickness	ASTM D 5994		One test per roll
Density	ASTM D1505		One test per manufacture batch
Melt Flow Index	ASTM D 1238		One test per manufacture batch
Asperity Height (both sides)	GM12		Second roll or each roll if not in production sequence (measure at three to five locations across roll width)
Tensile Properties (each direction) - Strength at break - Elongation at break	ASTM D6693	Two tests per manufacture source	One test for each property per roll
2% Modulus	ASTM D5323		One test per roll
Tear Resistance	ASTM D1004		One test per roll
Puncture Resistance	ASTM D4833		One test per roll
Axi-Symmetric Break Resistance Strain	ASTM D 5617		Not required
Oxidative Induction Time (OIT) Standard OIT	ASTM D 3895		One test for each property per resin type or per 25,000 m ² of geomembrane



Table 10: Material Testing	Test Method	Frequency		
Requirements for Unit 15 - Textured LLDPE GeomembraneProperty		Source approval	As-delivered	
High Pressure OIT	ASTM D 5885			
Oven Aging at 85°C for 90 days	ASTM D 5721			
Standard OIT	ASTM D 3895		One test per resin type, manufacture batch, or	
- High Pressure OIT	ASTM D 5885		per geomembrane type	

2.2.16 Unit 16 – HDPE Geomembrane

Unit 16 –High Density Polyethylene (HDPE) Geomembrane with nominal thickness of 2 mm shall have the following properties:

- Thickness > 1.9mm (minimum average roll value, MARV)
- density > 0.94 g/cm³ (MARV)
- Base resin: density >0.932 g/cm³; melt flow index <1.0 g/10min
- Product textured on both sides with asperity height > 0.25 mm (MARV)
- Tensile strength at yield > 29 kN/m (MARV)
- Elongation at yield > 12% (MARV)
- Tear resistance > 249 N (MARV)
- Puncture resistance > 534 N (MARV)
- Oxidative Induction Time (OIT):
 - > 100 minutes at standard pressure (MARV); and
 - > 400 minutes at high pressure (MARV)
- Oven aging at 85°C for 90 days:
 - OIT retained > 55% at standard pressure (MARV); and
 - OIT retained > 80% at high pressure (MARV)
- Stress Cracking Resistance (performed on smooth portion of sheet) > 300hr (Typical value)
- Interface Shear Strength Requirements Refer to Section 2.2.19.

The following table shows the testing requirements for this material.

Table 11: Material Testing Requirements for Unit 16–Textured HDPE Geomembrane

Property		Frequency	
	Test Method	Source approval	As-delivered
Thickness	ASTM D 5994	Two tooto por	One test per roll
Density	ASTM D 1505	manufacture	One test per manufacture batch
Melt Flow Index	ASTM D 1238	source	One test per



Property		Fre	Frequency	
	Test Method	Source approval	As-delivered	
			manufacture batch	
Asperity Height	GM12		Every second roll or each roll if not in production sequence (measure at three to five locations across roll width)	
Tensile Properties (each direction) - Strength at yield - Elongation at yield	ASTM D 6693		One test for each property per roll	
Tear Resistance	ASTM D 1004		One test per roll	
Puncture Resistance	ASTM 4833		One test per roll	
Oxidative Induction Time (OIT) - Standard OIT - High Pressure OIT	ASTM D 3895 ASTM D 5885		One test for each property per resin type or per 25,000 m ² of geomembrane	
Oven Aging at 85°C for 90 days - Standard OIT - High Pressure OIT	ASTM D 5721 ASTM D 3895 ASTM D 5885		One test per resin type, manufacture batch, or per geomembrane type	
Environmental Tensile Load Crack Resistance	ASTM D 5397		One test per resin type, manufacture batch, or per geomembrane type	

Interface Shear Strength: The minimum interface shear strength requirements given in Section 2.2.19 apply to the performance of combinations of Unit 12, Unit 14, Unit 15, Unit 16 and Unit 17 materials comprising the base and piggy back lining systems. The Contractor's attention is drawn to the requirement for each material to meet its individual requirements and also for the combined lining system materials to meet interface shear strength requirements.

2.2.17 Unit 17 – Geosynthetic Clay Liner (GCL)

Unit 17 – Geosynthetic Clay Liner shall be a reinforced multi-layered system comprising at least two layers of geotextile encapsulating a layer of dry, sodium bentonite. The outer geotextile on both sides shall be nonwoven. The GCL shall be reinforced by needle punching and be free of broken needles.

The bentonite layer in the GCL shall have the following characteristics:

- form: natural sodium bentonite or >80% sodium as activated bentonite
- carbonate content< 1 to 2% (by weight)
- montmorillonite content> 70% (by weight)
- particle size: if powdered >80% passing 0.075mm sieve; if granulated <1% passing 0.075mm
- cation exchange capacity> 70 meq/100g

The GCL material shall have the following properties:

- Total mass (dry) > 4000 g/m²;
- Bentonite clay:
 - Bentonite mass (dry) > 3700 g/m²;
 - Swell index > 24 ml/2g
- Fluid loss < 18 ml</p>
- Tensile strength > 4 kN/m
- Peel strength > 360 N/m
- Permeability: k < 5 x 10⁻¹¹ m/s tested at 100kPa effective confining stress
- Internal and Interface Shear Strength Requirements Refer to Section 2.2.19

Interface Shear Strength: The minimum interface shear strength requirements given in Section 2.2.19 apply to the performance of combinations of Unit 12, Unit 14, Unit 15, Unit 16 and Unit 17 materials comprising the base and piggy back lining systems. The Contractor's attention is drawn to the requirement for each material to meet its individual requirements and also for the combined lining system materials to meet interface shear strength requirements

Geotextiles component of the GCL shall have the following property:

- The outer geotextile on both sides is nonwoven
- Mass of nonwoven geotextile >200 g/m²
- Mass of woven geotextile (if any) >100 g/m².

The following table shows the testing requirements for this material.

Table 12: Material Testing Requirements for Unit 17 - GCL

		Frequency		
Property	Test Method	Source approval	As-delivered	
Bentonite Clay: - Swell Index - Fluid Loss	ASTM D5890 ASTM D5891		Manufacturer certification for each batch represented	
Total Mass (dry)	DIN 53854		One test per 2 rolls used on site	
Bentonite Mass (dry)	ASTM D 5393	Two tests per manufacture	One test per 2 rolls used on site	
Tensile Strength	ASTM D 4595	source	One test per 2 rolls used on site	
Peel Strength	ASTM D 6496		One test per 2 rolls used on site	
Permeability (using 100kPa effective confining stress):	ASTM D 5887		One test per 25,000 m ² of GCL installed at site, minimum 3 tests total	



2.2.18 Unit 18 – Geogrid

Unit 18 – Geogrid shall have a minimum long-term multiaxial tensile stiffness of 500 kN/m at a tensile strain of 5%. The multiaxial stiffness value is to reflect the average value when the stiffness is assessed in four principal directions in the plane of the material, being MD (machine direction), XMD (cross machine direction), and the two diagonal directions between the MD and XMD. Geogrid shall be a single layer of material. Multiple layers may be considered if Contractor proposes acceptable alternate installation measures to those in Sections 4.7 and 4.14.

The stiffness reduction factors for long-term loading shall be based on an appropriate test method, to be nominated by the geogrid manufacturer and accepted by the Superintendent, to account for a 100-year design life and the effects of construction damage, tensile creep, and environmental degradation in a buried environment with potential exposure to leachate.

Note: Tensile stiffness calculated as the tensile load estimated to induce 5% strain in the long-term divided by 0.05 (i.e. 5%).

The following table shows the testing requirements for this material.

Table 13: Material Testing Requirements for Unit 18 - Geogrid

Bronorty	Tost mathed	Frequency		
Froperty	Test method	Source approval	As-delivered	
Tensile strength at 5% elongation (measured in MD and XMD)	ISO 10319	Two tests per source	One test per 5,000 m ² geogrid material placed on site	
Tensile strength at 5% elongation (measured in 4 principal directions)	ISO 10319	Two tests per source	One test on geogrid material placed during Package 1A and one test on geogrid material placed during Package 1B.	
Evaluate stiffness reduction factors for long-term loading	refer above text	One test per source	not required if manufacturer provides acceptable data	

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2.2.19 Lining System Shear Strength Requirements

Source Approval: The Contractor must include direct shear test results (ASTM D5321) in the submittal for Unit 12, Unit 14, Unit 15, Unit 16, and Unit 17 source approval that demonstrates that the lining systems will achieve the required shear strengths for the test conditions defined in the table below.

No.	Lining System	Required Minimum Equivalent Shear Strength Parameters	Direct Shear Test Cross Section	Direct Shear Test Conditions	
A	Piggy Back Lining in Tender Package 1	Peak Strength: Φ'= 19º , c'= 0 kPa Residual Strength: Φ'= 14º , c'= 0 kPa	 lightly compacted sand to represent an initial lift of Unit 9 – Protection Material; specific geocomposite proposed by the Contractor as Unit 14 – Geocomposite Drainage Net; specific 1.5mm thick textured geomembrane proposed by the Contractor as Unit 15 –LLDPE Geomembrane; specific GCL proposed by the Contractor as Unit 17 – GCL; compacted clayey soil (95% standard compaction at +2% above optimum moisture) to represent the compacted Unit 4 – Clay Rich Material below the GCL. 	 Normal stress = 100, 300, and 500 kPa; Shear rate = 0.1 mm/min; Total shear displacement > 75mm Test specimen configuration: no pre-determined shear surface – test to allow shearing to occur in actual weakest interface or material; Hydration and Consolidation: Apply low normal stress (7-14 kPa) to the test specimen and, while maintaining the normal stress, soak in tap water for 48 hours to allow GCL and soils to hydrate. Load the specimen at a constant rate to the test normal stress and allow to consolidate for 48 hours. Shear the hydrated and consolidated specimen. Provide information on shear response and shear plane location. 	
В	Piggy Back Lining in Tender Package 1 – Upper Components at Low Confining Stress	Peak Strength: Φ'= 30° , c'= 0 kPa Residual Strength: Φ'= 25° , c'= 0 kPa	 lightly compacted sand to represent an initial lift of Unit 9 – Protection Material; specific geocomposite proposed by the Contractor as Unit 14 – Geocomposite Drainage Net; specific 1.5 mm thick textured geomembrane proposed by the Contractor as Unit 15 –LLDPE Geomembrane; rigid substrate. 	 Normal stress = 5, 10 kPa; Shear rate = 1 mm/min; Total shear displacement > 75mm; Test specimen configuration: no pre-determined shear surface – test to allow shearing to occur in actual weakest interface or material; Provide information on shear response and shear plane location. 	

Table 14: Lining System Shear Strength Requirements





No.	Lining System	Required Minimum Equivalent Shear Strength Parameters	Direct Shear Test Cross Section	Direct Shear Test Conditions
С	Cell Base Lining in Tender Package 1	same as test no. A	 specific gravel proposed by the Contractor as Unit 7 Drainage Aggregate; specific geotextile proposed by the Contractor as Unit 12 – Cushion Geotextile; or representative non-woven, needle-punched geotextile with mass per unit area >540 g/m²; specific 2.0 mm thick textured geomembrane proposed by the Contractor as Unit 16 –HDPE Geomembrane; specific GCL proposed by the Contractor as Unit 17 GCL; compacted clayey soil (95% standard compaction at +2% above optimum moisture) to represent the compacted Unit 4 – Clay Rich Material below the GCL. 	same as test no. A, except ■ Normal stress = 100, 200, and 300 kPa;

As Delivered: The Contractor must perform direct shear tests (ASTM D5321) on as-delivered geosynthetic and soil materials to demonstrate that the lining systems will achieve the required shear strengths for the test conditions defined in the table above.

- Piggy Back Lining: Sampling and testing for the as-delivered piggy back lining (type A and B tests) must be performed at two separate times during the construction of the piggy back lining for Package 1A and at three separate times during the construction of the piggy back lining for Package 1B
- Cell Base Lining: Sampling and testing for the as-delivered cell base lining (type C tests) must be performed at two separate times during the construction of the cell base lining for Package 1A. Note: There is no cell base lining construction for Package 1B.



2.2.20 Not Used

Not used.

2.2.21 Unit 21 – Gas Collection Pipe

Unit 21 – Gas Collection Pipe shall comprise 110 mm diameter rating PN 12.5, HDPE (PE 100 material class) pipe with SDR 13.6 or approved equivalent.

Where the pipes are required to be perforated, the pipes shall be drilled in accordance with the detail pattern shown on the design drawing. All drill cuttings, including loose attachments and burrs, shall be removed from the perforated pipes before installation.

The pipe shall have perforations of 15 mm diameter as shown on design drawing.

All connections and fittings for the pipes shall be manufactured from the same material and strength class as the pipe, and shall be solid wall units. All ends of the pipes shall be capped with HDPE caps.

Pipe joins shall be carried out using full face fusion bonding. No filter sock shall be used.

Material property certificates from the manufacturer shall be submitted for approval for each source of material prior to construction.

The Contractor shall provide the Superintendent with manufacturer's documentation certifying the properties of the material for each manufacture batch used on site.

2.2.22 Unit 22 – Groundwater Drainage Pipe

Unit 22 – Groundwater Drainage Pipe shall comprise 160mm diameter rating PN 16, HDPE (PE 100 material class) pipe with SDR 11 or approved equivalent.

The pipes shall be solid wall pipes.

All connections and fittings for the pipes shall be manufactured from the same material and strength class as the pipe, and shall be solid wall units. All ends of the pipes shall be capped with HDPE caps.

Pipe joins shall be carried out using full face fusion bonding

Material property certificates from the manufacturer shall be submitted for approval for each source of material prior to construction.

The Contractor shall provide the Superintendent with manufacturer's documentation certifying the properties of the material for each manufacture batch used on site.

2.2.23 Unit 23 – Leachate Collection Pipe

Unit 23 – Leachate Collection Pipe shall have the diameter indicated below.

- Type 1: 160 mm diameter
- Type 2: 315 mm diameter
- Type 3: 355 mm diameter

Types 1, 2 and 3 Unit 23 – Leachate Collection Pipe shall all comprise HDPE (PE 100 material class) pipe rating PN 12.5, with SDR 13.6 or approved equivalent.

Where the pipes are required to be perforated, the pipes shall be drilled in accordance with the detail pattern shown on the design drawing. All drill cuttings, including loose attachments and burrs, shall be removed from the perforated pipes before installation.

The pipe shall have perforations of 15 mm diameter as shown on design drawing.





All connections and fittings for the pipes shall be manufactured from the same material and strength class as the pipe, and shall be solid wall units. All angled connections and fittings shall have sweeping bends unless agreed otherwise by the Superintendent. All ends of the pipes shall be capped with HDPE caps.

Pipe joins shall be carried out using full face fusion bonding. No filter sock shall be used.

Material property certificates from the manufacturer shall be submitted for approval for each source of material prior to construction.

The Contractor shall provide the Superintendent with manufacturer's documentation certifying the properties of the material for each manufacture batch used on site.

2.2.24 Unit 24 – Leachate Sump Outlet Pipe

Unit 24 – Leachate Sump Outlet Pipe shall have the diameter indicated below.

- Type 1: 400 mm diameter
- Type 2: 355mm diameter

Types 1 and 2 Unit 24 – Leachate Sump Outlet Pipe shall both comprise HDPE (PE 100 material class) pipe rating PN 6.3, with SDR 26 or approved equivalent.

The pipes shall be solid wall pipes.

All connections and fittings for the pipes shall be manufactured from the same material and strength class as the pipe, except where indicated otherwise on the Design Drawings, and shall be solid wall units.

Pipe joins shall be carried out using full face fusion bonding.

Material property certificates from the manufacturer shall be submitted for approval for each source of material prior to construction.

The Contractor shall provide the Superintendent with manufacturer's documentation certifying the properties of the material for each manufacture batch used on site.

2.2.25 Unit 25 – Leachate Drainage Pipe

Unit 25– Leachate Drainage Pipe shall comprise 315 mm diameter rating PN 16, HDPE (PE 100 material class) pipe with an SDR 11 or approved equivalent.

The pipes shall be solid wall pipes.

All connections and fittings for the pipes shall be manufactured from the same material and strength class as the pipe, except where indicated otherwise on the Design Drawings, and shall be solid wall units.

Pipe joins shall be carried out using full face fusion bonding.

Material property certificates from the manufacturer shall be submitted for approval for each source of material prior to construction.

The Contractor shall provide the Superintendent with manufacturer's documentation certifying the properties of the material for each manufacture batch used on site.

2.2.26 Unit 26 – Subsoil Drainage Pipe

Not used for Tender Package 1..

2.2.27 Unit 27 – Leachate Sump Riser

Unit 27 – Leachate Sump Riser shall be 2500 mm ID (internal diameter) precast concrete pipe with step irons and frame/cover (Class M). The riser shall be manufactured in accordance with AS 4198:1994.





The riser pipe shall incorporate an integral base section to minimise base leakage risk. The riser pipe shall have additional features as indicated on the Design Drawings.

The Contractor shall provide the Superintendent with manufacturer's documentation certifying the properties of the material for each riser pipe component or section.

2.2.28 Unit 28 – Leak Detection Pipe

Unit 28 – Leak Detection Pipe shall comprise 125 mm diameter rating PN 16, HDPE (PE 100 material class) pipe with SDR 11 or approved equivalent.

Where the pipes are required to be perforated, the pipes shall be drilled in accordance with the detail pattern shown on the design drawing. All drill cuttings, including loose attachments and burrs, shall be removed from the perforated pipes before installation.

Note: Unit 28 pipe shall have perforations of 10 mm diameter. This value is less than the value of 15 mm shown on the design drawing and applies to Unit 28 only. All connections and fittings for the pipes shall be manufactured from the same material and strength class as the pipe, and shall be solid wall units.

Pipe joins shall be carried out using full face fusion bonding.

Material property certificates from the manufacturer shall be submitted for approval for each source of material prior to construction.

The Contractor shall provide the Superintendent with manufacturer's documentation certifying the properties of the material for each manufacture batch used on site.

2.2.29 Not Used

Not used.

2.2.30 Not Used

Not used.

2.2.31 Unit 31 – Bentonite

Unit 31 - Bentonite pellets shall be nominal 6 mm, compressed dry bentonite pellets of a type used for sealing boreholes and monitoring wells. The bentonite shall have a swell index of at least 15 mL / 2g.

Material property certificates from the manufacturer shall be submitted for approval for each source of material prior to construction.

The Contractor shall provide the Superintendent with manufacturer's documentation certifying the properties of the material for each manufacture batch used on site.

2.2.32 Unit 32 – Rip Rap Armourstone and Aggregate for Gabion Baskets and Wire Mattresses

Unit 32 - Rip Rap shall be used to protect the diversion drains and provide rock for the gabions and mattresses.

The following standards shall apply:

- AS 2758.6-2008 Aggregates and Rock for Engineering Purposes; Part 6: Guidelines for the Specification of Armourstone
- AS 2758.4-2000 Aggregates and Rock for Engineering Purposes; Part 4: Aggregate for Gabion Baskets and Wire Mattresses.

The rip rap, gabion and mattress aggregates shall meet the specification provided in Table 15: .



Property	d₅₀ =300 mm Rip Rap	d₅₀ =150 mm Rip Rap	d₅₀ =190 mm Gabion Rock	Test Method				
Layer Thickness	600 mm (2d ₅₀)	300 mm (2d ₅₀)	-	-				
Gradation								
Maximum d ₁₀₀ Particle Size	450 mm	230 mm	250 mm	-				
Nominal d ₈₅ Size	360 mm	180 mm	-					
Nominal d ₅₀ Size ¹	325 mm	150 mm	190 mm	-				
Nominal d ₁₅ Minimum Particle Size	180 mm	90 mm	120 mm	AS 1289				
Material Requirements								
Point Load Strength	> 2MPa	> 2MPa	> 2MPa	AS 4133				
Water absorption < 2.5%		< 2.5%	< 2.5%	AS 1141				
Sodium Sulfate Soundness	< 9% (weighted average loss)	< 9% (weighted average loss)	< 9% (weighted average loss)	AS 1141				

Table 15: Rip Rap Armourstone and Aggregate for Gabion Baskets and Wire Mattresses Properties

Note: $1.d_{50}$ size is the particle size of the riprap for which 50% by weight is finer

2.2.33 Unit 33 – Granular Material for Concrete Pipe Installation

Unit 33 – Material for Concrete Pipe Installation shall be used for the installation of reinforced concrete pipe culverts and related products.

The following standards and their related documents shall apply:

- New South Wales Roads & Maritime Services Model Drawing MD.R11.A01.B Installation of Buried Concrete Pipes Type HS3 Support
- AS/NZS 3725:2007 Design for Installation of Buried Concrete Pipes

2.2.34 Unit 34 – Rock Filled Gabions and Mattresses

Unit 34 – Rock Filled Gabions and Mattresses shall conform to the materials per the specification below and the Design Drawings.

The following specification and their related documents shall apply:

 New South Wales Roads & Maritime Services QA Specification R55 Rock Filled Gabions and Mattresses

2.2.35 Unit 35 – Channel Lining

Unit 35 – Channel Lining shall be Enkamat[®] TRM or approved equivalent.

The Enkamat[®] TRM shall consist of the Enkamat[®] A20/2.4 permanent erosion prevention system.

2.2.36 Unit 36 – Precast Reinforced Concrete Box Culverts (RCBC)

Not used for Tender Package 1.

2.2.37 Unit 37 – Precast Reinforced Concrete Pipes (RCP)

Unit 37 – Precast Reinforced Concrete Pipes (RCP) shall have the diameters indicated below.

- Type 1: 900 mm diameter
- Type 2: 750 mm diameter





Both Types 1 and 2 Unit 37 –Precast Reinforced Concrete Pipes (RCP) shall meet the following specifications:

- Class 3 precast steel reinforced concrete pipe
- New South Wales Roads & Maritime Services QA Specification R11Stormwater Drainage, Clause 2.2 and 2.3
- AS 1379 Specification and manufacture of concrete
- AS 3725 Design for installation of buried concrete pipes

2.2.38 Unit 38 – Drain Liner

Unit 38 – Drain Liner used for temporary bench drainage channels shall be CANAL^{3®}Geocomposite Liner or approved equivalent.

The CANAL^{3®}Geocomposite Liners hall consist of the CANAL^{3®}8208 Geocomposite Liner which comprises a 0.5mm PE liner combined with 260gsm non-woven protection geotextiles bonded to either side. The Seaming process shall be undertaken using hot-melt glued seams.







3.0 SECTION 3 – CONSTRUCTION MANAGEMENT

3.1 General Management

Construction shall be achieved in compliance with the Contractor's site management plans prepared in accordance with contract requirements.

3.1.1 Stockpile Management

The Contractor will manage stockpiles in accordance with the requirements of the Contractor's CEMP for the project. There must be no unacceptable impact to the site as a result of stockpiling.

As a minimum, the following requirements must be met by the Contractor:

- All stockpiles must be managed to minimise the generation of dust;
- All stormwater must be managed in the vicinity of the stockpiles to minimise the volume of water coming into contact with the stockpiles; and
- Runoff from all stockpiles, other than contaminated material or waste stockpiles, shall be managed in the same way as other stormwater on the site according to the Contractor's CEMP.

Upon completion of the use of an area for stockpiling, the Contractor shall:

- Remove all remaining stockpiled material for reuse or placement in accordance with this Technical Specification; and
- The reinstated stockpile area is to be assessed by the Contractor to the satisfaction of the Superintendent to ensure that no waste materials remain.

3.1.2 Water Management during Construction

3.1.2.1 Surface Water

The Contractor shall manage surface water within the construction site in accordance with the CEMP, and approved surface water management plan. The surface water drainage system on site includes clean and dirty (i.e., potentially sediment-laden) water drains. The surface water collected from the construction area shall be discharged to the dirty water drainage system of the site.

The Contractor shall divert surface run-on to the construction area, and must prevent uncontrolled discharge of water originating in the construction area to the site surface water drainage system.

The Contractor shall ensure that his operations do not result in chemical contamination of surface waters.

The Superintendent (site owner)will be responsible for management of the existing major surface water ponds at the Whytes Gully site, surface water treatment, and controlled discharges from the ponds.

3.1.2.2 Leachate

The Contractor will be responsible for maintaining delivery of leachate in the existing leachate collection system in the Eastern Gully Landfill to designated points during all stages of cell base and piggyback liner construction. The Contractor shall install temporary sumps, pumps and pumping lines as needed to meet these requirements. All temporary items must comply with the CEMP and be acceptable to the Superintendent. Requirements for connection of existing leachate collection pipes are given in Section 4.3.

The Superintendent (site owner) will be responsible for management of leachate at the designated delivery points and for management of the existing leachate ponds, leachate treatment, and leachate discharge to sewer.





3.1.2.3 Dewatering

The Contractor shall manage, at his cost, any waters arising from groundwater dewatering activities in accordance with the CEMP and Contract requirements. Management requirements are likely to depend on water quality and quantity. In regard to the potential to transfer water arising from groundwater dewatering activities into the existing site surface water management and/or leachate management systems, any such transfer would be at the discretion of the Superintendent (site owner) and would depend on water quality and quantity and the capacity of the systems at the time.

3.2 Construction Quality Management

The Construction Quality Management system for construction comprises Contractor requirements and Superintendent actions. Contractor requirements include preparing management plans, preparing work method statements, material testing, compaction testing (through GITA), surveying, notifying for Inspection Points, and preparing Hold Point documentation and works-as-executed (WAE) documentation. Superintendent actions include review and approval of Contractor submittals and documentation, inspecting construction works, conducting audit testing, attending Inspection Points, and releasing Hold Points. Superintendent actions are typically referred to as Construction Quality Assurance (CQA).

A description of the approach for quality management of material properties is provided in Section 2.1.2, including description of approval of material sources, confirmation of as-delivered material properties, and audit testing. Details of material requirements and testing requirements are given in Chapter 2 of this document. For example, as indicated in Section 2.1.4, all material test results submitted to the Superintendent by the Contractor must be from a laboratory with NATA-accreditation for all tests performed; and all survey results submitted to the Superintendent by the Contractor must be from a registered surveyor.

Quality management requirements to be implemented by the Contractor during construction activities are given in the following chapter of this document.




4.0 CONSTRUCTION ACTIVITIES

4.1 Subgrade Preparation

Subgrade preparation by the Contractor comprises vegetation removal (refer Section 1.5.1) followed by cutting and filling to establish the subgrade surface shown in the Design Drawings. For the subgrade surface in the current work (i.e. Tender Package 1) the maximum design cut depth below the existing surface is approximately 5 m, occurring in the cell base liner area. The maximum design cut depth below the existing surface in the piggy back area is approximately 1.5 m, occurring on the Eastern Gully landfill (refer Section 4.1.3.1). The maximum design fill thickness is approximately 3 m, occurring at an existing pond in the cell base liner area (refer Section 4.1.3.4).

The Contractor shall provide a Work Method Statement presenting proposed methods for subgrade preparation activities, including cutting, filling, proof rolling, and undercutting and replacement and all items described below. The Work Method Statement must address safety, including issues related to working on steeply sloping areas of the site. Submission of the work method statement constitutes a HOLD POINT. These activities shall not commence until the Hold Point is released.

4.1.1 Cutting

Cutting is required in some areas to establish the subgrade surface. Rock excavation may be required in local areas. The Design Report contains general information on subsurface conditions and references to documents with more detailed subsurface information.

Dewatering (groundwater) may be required in some areas to facilitate excavation. The Design Report contains general information on hydrogeological conditions and references to documents with more detailed information. Contractor requirements for managing waters arising from dewatering are provided in Section 3.1.2.3.

The base of all excavations shall be proof rolled to identify soft materials that would form an unsuitable surface for fill placement or landfill base/liner construction. Remove and replace any such materials with Unit 2 – General Fill as per Section 4.2. Proof rolling of the soil/fill surface in each local area and/or removal of any unsuitable materials constitutes an INSPECTION POINT. The Contractor is required to provide 24 hour notice before commencing or recommencing this activity.

Existing service trenches may be present (refer Section 1.5.2 and Section 4.3). Any trenches that are identified to extend below the base of the excavation shall be fully excavated and then backfilled with Unit 2 – General Fill as per Section 4.2. Trench excavation and backfilling constitutes an INSPECTION POINT. The Contractor is required to provide 24 hour notice before commencing or recommencing this activity.

Over-excavation: The Contractor shall not excavate deeper than the subgrade surface. Any excavation deeper than the subgrade surface, not including any additional depth required for removal of unsuitable materials or existing service trench backfill (refer preceding paragraphs), shall be deemed Contractor over-excavation. If over-excavation occurs, the Contractor shall perform, at his cost, all activities required to safely manage any excess dewatering and excess cut materials in accordance with the CEMP and Contract requirements. The Contractor shall also be responsible for all costs associated with reinstatement of over-excavated areas with Unit 2 – General Fill as per Section 4.2. The Contractor's attention is drawn in particular to potential consequences of over-excavation in previously landfilled areas.

All excavated materials from above the subgrade surface are to be stockpiled by the Contractor in designated areas, and in accordance with the CEMP and Contract requirements, for future use by the site owner. The Contractor shall not re-use the excavated materials.

4.1.2 Filling

Filling is required in some areas to establish the subgrade surface. In these areas, the ground surface present after vegetation removal (refer Section1.5.1) shall be proof rolled to identify soft materials that would form an unsuitable surface for fill placement or landfill base/liner construction. Remove and replace any such materials with Unit 2 – General Fill as per Section 4.2.





Proof rolling of the surface in each local area and/or removal of any unsuitable materials constitutes an INSPECTION POINT. The Contractor is required to provide 24 hour notice before commencing or recommencing this activity.

Existing service trenches may be present (refer Section 1.5.2 and Section 4.3). Any trenches that are identified within the fill area shall be fully excavated and then backfilled with Unit 2 – General Fill as per Section 4.2. Trench excavation and backfilling constitutes an INSPECTION POINT. The Contractor is required to provide 24 hour notice before commencing or recommencing this activity. After the proof rolling, removal/replacement, and trench backfilling activities described in the preceding paragraphs are complete, then Unit 2 – General Fill material shall be placed to achieve subgrade levels as per Section 4.2, except that the minimum degree of compaction shall be <u>98%</u> of SMDD rather than 95% of SMDD.

4.1.3 Subgrade in Specific Areas

Subgrade preparation in specific work areas has requirements in addition to those given above. These additional requirements are presented below.

4.1.3.1 Eastern Gully Landfill Batter- General

Subgrade preparation for the existing Eastern Gully Landfill batter (i.e., previously landfilled area) requires excavation of cover materials to a depth of up to 1.5 m on the existing terraced surface. The design intent is to excavate cover materials, for re-use onsite as landfill daily cover, while maintaining a minimum 300 mm cover thickness above landfill waste materials. The additional requirements listed below apply to this activity.

- Test Pitting: In terraced areas, the Contractor shall conduct test pitting to measure the depth to landfill waste materials at approximate 10 m centres along <u>all</u> terraces prior to excavation and shall systematically record the test pit findings. In non-terraced areas, the test pitting shall be on an approximate 10m grid. Test pitting constitutes an INSPECTION POINT and the Contractor is required to provide 24 hour notice before commencing or recommencing this activity.
- Assessment: The Contractor shall assess, for each local area, whether the design subgrade surface can be established without excavating within 300 mm of landfill waste materials and shall present his excavation assessment and test pit records to the Superintendent at least 24 hours prior to initiating excavation in the local area
- Local Revisions to Design Subgrade: The Contractor shall adopt any local revisions to the design subgrade surface that are required by the Superintendent after his review of the Contractor's excavation assessment.
- Excavation: The Contractor shall proceed to excavate to the design subgrade surface, including any local revisions as indicated above. If landfill waste materials, not including small amounts of waste within the cover material, are encountered despite the required steps given above, then the Contractor shall limit excavation depth to remain above the landfill waste materials and shall notify the Superintendent and take appropriate actions in accordance with the CEMP and Contract requirements.
- Over-excavation: The Contractor shall not excavate deeper than the design subgrade surface, as modified by any local revisions as indicated above. Consequences of over-excavation are discussed in Section 4.1.1.
- Surface Suitability: The suitability of the prepared subgrade surface for placement of the Base Layer for the piggy back liner is addressed in Section 4.7.
- No Re-use: All excavated materials from above the subgrade surface are to be stockpiled by the Contractor in designated areas, and in accordance with the CEMP and Contract requirements, for future use by the site owner. Stockpiles of excavated cover materials shall be separated from stockpiles of excavated soils from non-landfilled areas. The Contractor shall not re-use the excavated materials.





The Contractor's Work Method Statement for subgrade preparation (refer Section 4.1) must reflect the above requirements for the existing landfill batter.

4.1.3.2 Eastern Gully Landfill Batter– Fill Area near Batter Toe

In the lower southern area of the Eastern Gully Landfill batter, i.e. the area of cross-section "F" on Design Drawing D1011, subgrade preparation involves placement of up to 2 m of fill. The existing surface in this area of the batter is flat (near-horizontal) and fill placement will establish an approximate 10% subgrade batter slope.

Fill placement in this area will be with Unit 2 – General Fill and subject to the requirements given in Section 4.1.2, with the following alterations:

- Proof rolling and removal and replacement of unsuitable foundation materials can be modified from that used by the Contractor in other areas to reflect the design intent that saturated landfill waste materials may underlie the area and such materials will be left in place unless they exhibit extremely soft behaviour. Any removal and replacement of extremely soft materials shall be limited to an excavation depth of 300 mm unless agreed by the Superintendent. Proof rolling of the surface in each local area and/or removal of any unsuitable materials constitutes an INSPECTION POINT. The Contractor is required to provide 24 hour notice before commencing or recommencing this activity.
- The first lift (300 mm) of Unit 2 General Fill shall be placed and compacted to achieve maximum practicable density but will not be subject to a minimum density requirement. This is intended to reflect the potential difficulty of compaction above underlying landfill waste materials which are potentially saturated in this area.
- Subsequent lifts of Unit 2 General Fill shall be placed and compacted to achieve a minimum density of 95% of SMDD.

The Contractor's Work Method Statement for subgrade preparation (refer Section 4.1) must reflect the above requirements for this fill area.

4.1.3.3 Western Gully Landfill Batter

Subgrade preparation for the existing Western Gully Landfill batter(i.e., previously landfilled area) will be subject to the requirements given in Section 4.1.3.1 for the Eastern Gully Landfill batter. It is noted that the Western Gully batter is generally non-terraced.

4.1.3.4 Filling of Former Surface Water Pond

The former surface water pond at the base of the Eastern Gully requires filling of up to approximately 5 m thickness to establish design subgrade levels.

Fill placement in this area will be with Unit 2 – General Fill and subject to the requirements given in Section 4.1.2, with the following additions:

- Prior to proof-rolling, any sediments that have accumulated in the bottom of the pond and any adjacent low-lying areas shall be removed and managed in accordance with the CEMP and Contract requirements. Sediment removal constitutes an INSPECTION POINT. The Contractor is required to provide 24 hour notice before commencing or recommencing this activity.
- The need for proof-rolling after sediment removal will be determined by the Superintendent.

The Contractor's Work Method Statement for subgrade preparation (refer Section 4.1) must reflect the above requirements for this fill area.

4.1.4 Survey and Documentation

The Contractor shall survey final subgrade levels to provide works-as-executed (WAE) drawings and to demonstrate that the design levels have been achieved. The survey shall be conducted on an approximate 10m grid with additional survey points along the benches and at the leachate sumps. WAE drawings shall





include surveyed locations and dimensions of soft areas identified during proof rolling and of any backfilled service trenches. WAE drawings shall also include information required for subgrade leachate pipe construction and landfill gas venting system construction (refer Sections 4.3 and 4.4). The Contractor shall submit the WAE drawings, and an accompanying analysis demonstrating compliance with design levels.

The Contractor shall also submit the items listed below as part of his WAE documentation:

- GITA certification statements for all fill placement and compaction, reflecting the requirements for Unit 2 – General Fill in Section 4.2.
- WAE report including description of the completed work, summary of construction materials and time periods of construction, applicable Work Method Statements, RFI records (if any), Contractor quality system records, and Hold and Inspection point documentation.

Submission of these items constitutes a HOLD POINT. Construction of the Base Layer or placement of the Bearing Layer shall not commence in an area until the Hold Point has been released for that area.

4.2 General Fill

Placement of Unit 2 - General Fill is required as part of several cell construction activities.

General Fill shall be placed with maximum 300 mm thick layers and compacted with suitable compaction equipment to achieve a minimum of 95% of SMDD (in accordance with AS1289.5.1.1 and 5.4.1) or a minimum HILF density ratio of 95% Standard (in accordance with AS1289.5.7.1) at a moisture content within the range of -3% to +3% of the Standard Optimum Moisture Content (SOMC). A trench roller is required for any compaction within trenches.

The GITA shall provide "Level 1" supervision for material placement and moisture density testing. The frequency of field density and moisture testing during placement of all General Fill material shall as a minimum conform the following, whichever requires the most tests:

- 1 test per 500 m³ per material type; or
- 2 tests per batch of work.

If the required density and moisture is not achieved, the compacted material shall be reworked in-situ to meet the density and moisture content requirements. If the density and moisture content requirements again cannot be achieved after reworking, the failed layer shall be removed for moisture conditioning at the material borrow area or at an approved designated area, or be discarded.

Note that the required compaction standard for filling with Unit 2 – General Fill to establish subgrade design levels is 98% of SMDD, as indicated in Section 4.1.2.

4.3 Subgrade Leachate Piping

The subgrade leachate piping construction comprises the elements shown in Design Drawing D1046. These elements are to be installed below the new cell base lining system.

The Contractor shall provide a Work Method Statement presenting proposed methods for subgrade leachate piping construction activities, including details on pipe trench construction in subgrade fill versus cut areas, work staging, and all items described below. The Work Method Statement must address safety, including issues related to excavations and management of active leachate drainage. Submission of the work method statement constitutes a HOLD POINT. These activities shall not commence until the Hold Point is released.

Connection to Existing Leachate Drainage Pipes

The existing drainage pipes shown in Drawing D1046 are active with leachate/water flow. Required work items include:





- Locate the existing buried HDPE leachate pipe in the northern part of Package 1A and connect to new Unit 25 pipe. Remove the downslope portion of existing pipe within the cell base liner area and backfill the trench if below subgrade design levels.
- Locate and plug the existing buried HDPE pipe in the central part of Package 1A Remove the downslope portion of the pipe within the cell base liner area and backfill the trench.
- Connect the existing capped leachate drainage pipe stub to new Unit 25 pipe.
- Connect the existing groundwater drainage outlet pipe to new Unit 22 pipe.

Install New Pipes and Drainage Pit

The Contractor shall install new Unit 22, Unit 25 and Unit 28 pipes in trenches as indicated on Design Drawings 1045 an 1046. This includes providing a temporary cap and accessible connection point for future extension of Unit 25 pipe into the Package 2 construction.

The Contractor shall also connect new Unit 21 gas venting pipes at two locations as indicated on Design Drawing D1046.

Each connection of new and existing pipes constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

Leachate Management

During these activities, the Contractor must construct temporary leachate storage sumps, pumps and pumping lines (refer Section 3.1.2.2) as necessary to maintain leachate delivery from the existing pipes to a designated point. The Contractor shall not interrupt leachate delivery (i.e. cease leachate collection and allow leachate to accumulate in the existing landfill area) from any of the existing pipes for longer than the following time periods:

- no more than 3 continuous days;
- no more than 3 days out of any 10 day period; and
- other limitations imposed by the Superintendent based on site conditions and landfill site operations.

Survey and Documentation

Following placement and connection of pipes in each area, the Contractor shall survey all pipe alignments and inverts and submit works-as-executed (WAE) drawings demonstrating compliance with the design. Submission of this item constitutes a HOLD POINT. Construction of the bearing layer for the cell base lining system shall not commence in an area until the Hold Point has been released for that area.

The Contractor shall also submit the items listed below as part of his WAE documentation,

- GITA certification statements for all fill placement and compaction, reflecting the requirements for Unit 2 – General Fill in Section 4.2 and pipe Embedment Material as indicated on Design Drawing D1045.
- WAE report including description of the completed work, summary of construction materials and time periods of construction, applicable Work Method Statements, RFI records (if any), Contractor quality system records, and Hold and Inspection point documentation.

4.4 Landfill Gas Venting System

Landfill gas venting trenches, comprising gravel, perforated collection pipes, and solid header pipes shall be constructed under the piggy back liner system.



The landfill gas venting trenches shall be constructed by excavation into the prepared subgrade of the piggy back liner, as shown in the Design Drawings.

Trenches shall be nominally 200 mm deep and 300 mm wide. The excavated material shall be used appropriately during further works.

The following construction sequence is required (unless alternatives are agreed with the Superintendent):

- Excavate trench;
- Partially backfill the trench with Unit 8 Gas Drainage Gravel;
- Place Unit 21 Gas Collection Pipe, make pipe connections, and backfill balance of trench; and
- Place Unit 11 Filter Geotextile above the gravel and secure in place.

Placement of gas collection pipes constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

Installation of gas header pipe and connection the gas collection pipes constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

Following placement of gas collection and header pipes in each area, and before covering the pipes, the Contractor shall survey all pipe alignments and inverts. Within 3 days of completing gas venting system construction in any area, the Contractor shall submit works-as-executed (WAE) drawings demonstrating compliance with the design. Submission of this item constitutes a HOLD POINT. Construction of the base layer shall not commence in an area until the Hold Point has been released for that area.

The Contractor shall also submit the items listed below as part of his WAE documentation,

WAE report including description of the completed work, summary of construction materials and time periods of construction, applicable Work Method Statements, RFI records (if any), Contractor quality system records, and Hold and Inspection point documentation.

4.5 **Perimeter Bund**

The Contractor shall conduct a set-out survey of the alignment of the perimeter bund prior to construction and shall peg out the surveyed alignment. This constitutes a HOLD POINT. Construction of the bund shall not commence until the Hold Point has been released by the Superintendent.

The bund shall be constructed in accordance with the Design Drawings. The bund shall be constructed with Unit 4 – Clay Rich Material to form a 1-m high bund with a 4m crest width and 2H:1V side batters. As indicated in Section 2.2.4, the required gradation of the Unit 4 material in the perimeter bund differs between the main body of the bund (i.e., max. particle size 53 mm) and the inboard batter surface where the GCL will be placed (i.e., max. particle size 13.2 mm). The finished surface where the GCL will be placed shall be smooth and well-drained with no protruding coarse materials, and with additional surface requirements given in Section 4.10.3.

The Unit 4 material shall be placed and compacted in nominal 200mm thick lifts with suitable compaction equipment to achieve a minimum of 98% SMDD (in accordance with AS1289.5.1.1 and 5.4.1) or a minimum HILF density ratio of 98% Standard (in accordance with AS1289.5.7.1) at a moisture content within the range of -2% to +2% of the Standard Optimum Moisture Content (SOMC). Prior to the placement of each lift of the bund, the top of the previous lift shall be scarified and moisture conditioned if necessary to bond each lift together and prevent laminations at the lift interfaces.

Bund construction constitutes an INSPECTION POINT and the Contractor is required to provide 48 hours notice before commencing or recommencing this activity.

In addition, the GITA shall provide "Level 1" supervision for material placement and moisture density testing. If the GITA or Contractor detects material changes or variations then he shall undertake testing as necessary





to assess the acceptability of the material. The frequency of field density and moisture testing during placement of the material shall as a minimum conform the following, whichever requires the most tests:

- 1 test per 400 m³ per material type; or
- 3 tests per batch of work.

If the required density and moisture is not achieved, the compacted material shall be reworked in-situ to meet the density and moisture content requirements. If the density and moisture content requirements again cannot be achieved after reworking, the failed material shall be removed for moisture conditioning at the material borrow area or at an approved designated area, or be discarded.

Upon completion of the bund, the Contractor shall maintain the integrity of the bund by limiting the traffic movement over the clay surface and maintaining the surface of the clay in a moist condition until covered by the base liner GCL and geomembrane. Should the bund surface have dried excessively (e.g. desiccation cracking>20mm depth) or wetted up excessively, as determined by the Superintendent, the affected materials shall be excavated to expose material that has moisture content within the specified tolerance. The excavated materials shall be returned to a designated area for moisture conditioning or be discarded, and the excavated bund material replaced.

Trafficked areas of the bund shall to be ripped, moisture conditioned and re-compacted if, in the opinion of the Superintendent, the quality of these areas has deteriorated.

Following bund placement, the Contractor shall survey the finished surface level to provide works-asexecuted (WAE) drawings and to demonstrate that the design geometry has been achieved. The WAE drawings shall include geosynthetic anchor trench alignments within the bunds. The Contractor shall submit the WAE drawings, an accompanying analysis demonstrating compliance with design geometry. Submission of the WAE drawings and documentation constitutes a HOLD POINT. Placement of liner materials or cap components on the surface of the berm shall not commence in an area until the Hold Point has been released for that area, and all other contractual requirements have been fulfilled.

The Contractor shall also submit the items listed below as part of his WAE documentation,

- GITA certification statements for all fill placement and compaction, reflecting the above requirements for Unit 4 Clay Rich Material.
- WAE report including description of the completed work, summary of construction materials and time periods of construction, applicable Work Method Statements, RFI records (if any), Contractor quality system records, and Hold and Inspection point documentation.

4.6 Internal Bunds

Internal bunds between new landfill cells and sub-cells will be constructed to provide a physical barrier for each stage and sub-stage of liner construction and waste filling. The locations of internal bunds are shown on the Design Drawings.

The internal bunds shall be constructed in the same manner and with the same requirements given in Section 4.5 for the perimeter bund.

4.7 Base Layer

Base Layer construction includes placement of Unit 6 - Base Material and Unit 18 – Geogrid in the piggy back liner area, within the area bounded by the Perimeter and Internal Bunds. The Base Layer shall be constructed with Geogrid sandwiched within the Base Material to form a minimum 500 mm thick layer above the design subgrade surface.

The Contractor shall provide a Work Method Statement presenting proposed methods for base layer construction, including compaction and subgrade surface preparation, geogrid installation and joining, geogrid ballasting, and geogrid covering. The Work Method Statement must address the requirements





presented in this section. Submission of the Work Method Statement constitutes a HOLD POINT. Base layer construction shall not commence until the Hold Point is released.

Base Layer construction requirements are provided below.

- a) Subgrade Surface Preparation:
 - The subgrade surface in the Base Layer area will be established on the existing landfill batters as described in Sections 4.1.3.1 and 4.1.3.3. The Contractor shall proof roll the subgrade surface in all areas 3H:1V or flatter, and perform a walkover inspection of all areas steeper than 3H:1V, to identify any areas unsuitable for Base Layer placement. The proof rolling and inspection can be modified from that used by the Contractor in other areas to reflect the design intent that landfill waste materials are expected to be present at shallow depth below the subgrade surface and will be left in place unless they exhibit extremely soft behaviour.
 - Remove and replace any extremely soft materials with Unit 2 General Fill or Unit 6 Base Material, limiting excavation to 300 mm depth unless agreed by the Superintendent. Compaction requirements for Unit 2 – General Fill shall be as per Section 4.2 and compaction requirements for Unit 6 – Base Material shall be as set out below.
 - Proof rolling and/or walkover inspection of the subgrade surface in each local area and/or removal of any unsuitable materials constitutes an INSPECTION POINT. The Contractor is required to provide 24 hour notice before commencing or recommencing this activity
- b) Base Material (Unit 6):
 - Base Material shall be placed in two lifts and compacted with suitable compaction equipment to achieve a minimum of 98% SMDD (in accordance with AS1289.5.1.1 and 5.4.1) or a minimum HILF density ratio of 98% Standard (in accordance with AS1289.5.7.1)at a moisture content within the range of -3% to +3% of the Standard Optimum Moisture Content (SOMC). Each lift shall have a compacted thickness of approximately 250 mm.
 - The GITA shall provide "Level 1" supervision for material placement and moisture density testing. The frequency of field density and moisture testing during placement of Base Material shall as a minimum conform the following, whichever requires the most tests:
 - 1 test per 250 m³ per material type; or
 - 2 tests per batch of work.

If the required density and moisture is not achieved, the compacted material shall be reworked insitu to meet the density and moisture content requirements. If the density and moisture content requirements again cannot be achieved after reworking, the failed layer shall be removed for moisture conditioning prior to recompaction.

- Base Material lower lift: Placement and compaction of the lower lift of Base Material shall include surface preparation to present a surface suitable for Unit 18 – Geogrid installation.
- Base Material upper lift: Following the installation of Unit 18 Geogrid, the upper lift of Unit 6 Base Material shall be placed and spread on top of the geogrid using a method that will not disrupt geogrid alignment and overlaps and will cause minimal damage to the geogrid. Placement and spreading of Base Material on top of Geogrid constitutes an INSPECTION POINT and the Contractor is required to provide 24 hour notice before commencing or recommencing this activity. The Base Material shall be compacted using a method that will not damage the underlying geogrid.
- c) Geogrid (Unit 18): Geogrid shall be installed on the prepared surface of the lower lift of Base Material as outlined in Section 4.14. The prepared surface with geogrid installation in each area shall constitute





a HOLD POINT. The upper lift of Base Material shall not be placed in the area until the Hold Point has been released by the Superintendent

- d) Additional Items:
 - Piggy Back Liner Benches: The design of the piggy back liner system includes slope benches where the piggy back liner may be temporarily terminated to allow future upslope extension. It is noted that in these areas the Base Layer shall not extend across the bench width as per Design Drawing D1025.
 - Cross-slope Leachate Collection Pipes: The upper surface of the Base Layer shall be locally modified at the alignment of cross-slope leachate collection pipes (refer Design Drawings D1041 and D1042) to provide a narrow bench to facilitate pipe installation. Each narrow bench shall be 1.5 m wide (min.) with at least a 2% down-slope fall and 2% cross-slope fall as indicated in Design Drawing D1044.
 - Gas Well Protection Slabs: Gas wells may be present beneath the subgrade surface at locations within the piggy back liner area for Construction Package 1B as shown in Design Drawing D1072. At these locations a concrete slab shall be installed within the lower part of the Base Layer, as indicated in the detail on Design Drawing D1072.

Survey and documentation requirements for the Base Layer are provided below.

The Contractor shall survey the finished surface of the Base Layer to provide works-as-executed (WAE) drawings and to demonstrate, by comparison to the WAE drawings of the subgrade surface, that the design thickness for the Base Layer has been achieved. The survey shall be conducted on an approximate 10 m grid with additional survey points at benches and leachate pipe alignments. The Contractor shall submit the WAE drawings and an accompanying analysis demonstrating compliance with the design thickness.

The Contractor shall also submit the items listed below as part of his WAE documentation,

- GITA certification statements for all fill placement and compaction, reflecting the above requirements for Unit 6 – Base Material.
- WAE report including description of the completed work, summary of construction materials and time periods of construction, applicable Work Method Statements, RFI records (if any), Contractor quality system records, and Hold and Inspection point documentation.

Submission of these items constitutes a HOLD POINT. Placement of the Bearing Layer shall not commence in an area until the Hold Point has been released for that area.

4.8 Bearing Layer

The bearing layer shall be constructed within the piggy back liner and cell base liner footprint, in accordance with the design drawings.

The bearing layer shall be constructed with Unit 4 – Clay Rich Material with a design as-compacted thickness of 200 mm.

The material shall be placed in one layer and compacted with suitable compaction equipment to achieve a minimum of 98% SMDD (in accordance with AS1289.5.1.1 and 5.4.1) or a minimum HILF density ratio of 98% Standard (in accordance with AS1289.5.7.1) at a moisture content within the range of -2% to +2% of the Standard Optimum Moisture Content (SOMC).

The GITA shall provide "Level 1" supervision for material placement and moisture density testing. The frequency of field density and moisture testing during placement of the material shall as a minimum conform the following, whichever requires the most tests:





- 1 test per 1,000 m² per layer of material type; or
- **3** tests per batch of work.

If the required density and moisture is not achieved, the compacted material shall be reworked in-situ to meet the density and moisture content requirements. If the density and moisture content requirements again cannot be achieved after reworking, the failed material shall be removed for moisture conditioning at the material borrow area or at an approved designated area, or be discarded.

The Contractor shall maintain the bearing layer in moist condition until Unit 17 - GCL is installed. Should the bearing layer surface have dried excessively (e.g. desiccation cracking>20mm depth) or wetted up excessively, as determined by the Superintendent, the affected materials shall be excavated to expose material that has moisture content within the specified tolerance. The excavated materials shall be returned to a designated area for moisture conditioning or be discarded, and the excavated bearing layer material replaced. Note that the surface of the bearing layer is designed to shed leachate and its shape shall be maintained during formation in order to avoid temporary water ponding during construction. Consideration may be given to use of micro-mist sprayers to limit loss of moisture from the completed surface during hot weather.

Trafficked areas of the bearing layer surface are to be ripped, moisture conditioned and recompacted if, in the opinion of the Superintendent, the quality of these areas has deteriorated.

The finished surface shall be smooth and well-drained. Coarse materials shall not protrude from the surface of the bearing layer by more than 10 mm. No areas of ponding shall be accepted on the surface. Additional surface requirements are given in Section 4.10.3.

The Contractor shall survey the final levels to provide works-as-executed (WAE) drawings and to demonstrate that the design levels and layer thickness have been achieved. The survey shall be conducted on an approximate 10 m grid. The Contractor shall submit the WAE drawings and an accompanying analysis demonstrating compliance with design levels. Submission of the WAE drawings and accompanying analysis constitutes a HOLD POINT. Placement of GCL shall not commence in an area until the Hold Point has been released for that area, and all other contractual requirements have been fulfilled.

The Contractor shall also submit the items listed below as part of his WAE documentation,

- GITA certification statements for all fill placement and compaction, reflecting the above requirements for Unit 4 – Clay Rich Material.
- WAE report including description of the completed work, summary of construction materials and time periods of construction, applicable Work Method Statements, RFI records (if any), Contractor quality system records, and Hold and Inspection point documentation.

4.9 General Requirements for Geosynthetics

4.9.1 Documentation

Specialist Installation Sub-Contractor

The Works described in the following sections shall be undertaken by an experienced geosynthetic installation specialist contractor approved by the Superintendent. The Contractor shall require that skilled sub-contractor personnel will supply, test and install all geosynthetic materials. The Contractor is responsible for all aspects of the work.

Prior to the installation of geosynthetics, the Contractor shall submit the proposed qualified subcontractor(s) to the Superintendent for approval. This submission constitutes a HOLD POINT. No geosynthetic material installation shall begin until the HOLD POINT is released. Any change to the geosynthetic supply or installation shall be subject to written approval from the Superintendent.





Alternative construction methods to those detailed in the following sections will be considered, subject to the approval of the Superintendent, provided they satisfy the intent of this Specification.

Quality Assurance and Quality Control

The Contractor shall be responsible for all quality assurance and quality control of the manufacture, transportation, storage and installation of the geosynthetic. This shall include the obtaining of material property details and certificates from the resin supplier and the geosynthetic manufacturer, the preparation of a quality control procedures manual and the undertaking of all inspections, non-destructive and destructive testing and repairs etc. and other activities detailed in this Specification.

The Contractor is responsible for compliance with this Specification; however, the Superintendent shall monitor installation of the geosynthetics. The Contractor shall accommodate all quality assurance activities undertaken by the Superintendent.

The Superintendent shall undertake audits of the quality control and assurance procedures. Should any areas of the works show non-conformances with the approved quality control procedures manual, then the Contractor shall cease work until the non-conformance is resolved. Resolution will be by either presentation of the appropriate documentation or undertaking sampling and testing, or another activity approved by the Superintendent.

The Superintendent may also undertake audit testing at his sole discretion at any time during the works. This may include a detailed Liner Integrity Survey (resistivity method) for the geomembrane materials (refer Section 4.11.5). The Contractor shall accommodate all audit testing activities.

Quality Control Procedures Manual

The Contractor shall submit a quality control procedures manual to the Superintendent at least 10 days before the supply of any geosynthetic to the Site. The quality control procedures manual shall include the following items, as appropriate to each type of geosynthetic:

- The Contractor's organisational structure and personnel, and the qualifications and experience of the proposed installation personnel;
- Trial weld procedures;
- Measures to minimise wrinkles;
- Welding procedures, including equipment make and model;
- Weld repair procedures;
- Non-destructive testing procedures;
- Destructive testing procedures;
- Pro forma sheets for recording of installation and test results;
- Deployment equipment and procedures;
- Safety equipment;
- Supply transportation, storage and handling procedures;
- Vent flap details; and
- Any proposed changes with respect to this Specification.



The Superintendent will review this information to assess the suitability of the quality control procedures manual. Upon review of the quality control procedures manual, the Superintendent may request additional information specific to the project installation conditions.

The submission of the geosynthetic quality control procedures manual constitutes a HOLD POINT. No geosynthetic materials shall be imported to the Site until the HOLD POINT is released.

Data, Statements, Reports and Certificates

The Contractor shall submit the following information at least 7 days prior to the installation of any geosynthetic at the Site:

- The manufacturer's certifications, descriptive data, specification sheets;
- Manufacturer's test results for geosynthetic composition and properties;
- The origin (resin name and supplier's name, resin production plant), identification (brand name, number) and production date of the resin;
- A list of quantities and descriptions of materials other than the base polymer which comprise the geosynthetic;
- Copies of the quality control certificates issued by the resin supplier;
- A statement regarding recycled polymer content (if permitted by this Specification);
- A properties sheet including, at a minimum, all specified properties, measured using test methods indicated in these specifications, or equivalent;
- Reports of the tests, including sampling procedures, conducted by the manufacturer to confirm that the geosynthetic meets these Specifications. Tests shall be conducted at frequencies outlined in Chapter 2.0 of this Specification; and
- A quality control certification that property values given in the properties sheet are guaranteed by the geosynthetic manufacturer. The quality control certificate shall include roll numbers and identification, resin lot, batch numbers, sampling procedures and results of quality control tests.

The Superintendent will review this information to assess the suitability of the data, statements, reports and certificates. Upon review, the Superintendent may request additional information specific to the project conditions.

The submission of the data, statements, reports and certificates constitutes a HOLD POINT. Geosynthetic material installation shall not commence until the HOLD POINT is released.

4.9.2 Site Records and Drawings

The Contractor shall submit all quality forms, test results and other documentation indicated in the quality control procedures manual to demonstrate its compliance with the quality system for the project and to demonstrate compliance of the installed geosynthetics with this Specification.

Copies of these records and tests, as well as records of corrective action taken when results are unsatisfactory, shall be presented to the Superintendent in writing, within one working day following an inspection, test or action. To scale as-built drawings (i.e., WAE drawings) shall be provided of all panel layouts, anchor trenches, test positions and defects within 14 days of completing the liner.

The Contractor shall keep records sufficient to document in detail the progress and location of work undertaken.

The Contractor shall also submit the items listed below as part of his WAE documentation,





WAE report including description of the completed work, summary of construction materials and time periods of construction, applicable Work Method Statements, RFI records (if any), Contractor quality system records, and Hold and Inspection point documentation.

4.9.3 Traffic over Geosynthetics

Construction traffic over geosynthetics is restricted or not permitted, to prevent damage and ensure the material performs its intended function. The construction of the different units with the general traffic limitations is as follows:

- GCL: No vehicle access over deployed GCL, only careful foot traffic, subject to footwear requirements.
- Geomembrane: No vehicle access over deployed geomembrane, only careful foot traffic, subject to footwear requirements.
- Geocomposite: No vehicle access over deployed geocomposite, only careful foot traffic, subject to footwear requirements.
- Geogrid: No vehicle access over deployed geogrid, only foot traffic.
- Geotextile: No vehicle access over deployed geotextile, only foot traffic.

The Contractor shall comply with geosynthetic manufacturer recommendations, as well as the requirements within this Specification, regarding limitations for periods of exposure for deployed geosynthetics prior to covering.

4.9.4 Anchor Trenches

The anchor trench for the base liner shall be used to anchor the GCL, geomembrane, and cushion geotextile at top of the perimeter bund. The installation of these units may require that the previous geosynthetic layer(s) is temporarily anchored while the next geosynthetic is installed.

The excavation of the anchor trench shall be presented to the Superintendent for inspection and approval before backfilling commences. This constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

The anchor trench for the base liner shall be located on top of the perimeter bund in accordance with the Design Drawings a dimension of 500 mm x 500mm. The anchor trenches of the cap liner shall be located on top of cap, having a dimension of 500mm x 300mm, and at the mid-slope bench and top of perimeter bund as shown in Design Drawings, having a dimension of 500mm x 500mm.

The geosynthetic placed in the anchor trench shall extend down one side. The geosynthetics shall not extend up the outer edge of the trench. Loose soil and ponded water shall not be permitted in the anchor trench. Anchor trenches shall be constructed and maintained so as to provide for free drainage of surface water flow and prevent ponding in or adjacent to anchor trenches.

The geosynthetics shall be placed against the side of the trench and the trench backfilled with excavated material. The backfill shall be placed in layers appropriate for the proposed construction equipment. The compaction shall be carried out in the presence of the GITA. The compacted material shall achieve at least dense or stiff consistency, as assessed by the GITA in accordance with AS 1726. Care shall be taken to not damage the geosynthetics during compaction of the backfill of the anchor trench. The Contractor shall propose equipment and method to demonstrate a low risk of damage to the geosynthetics.

The backfill of the trench shall be carried out using hand held compaction equipment, to achieve the consistency specified above.





4.10 Installation of Unit 17 – Geosynthetic Clay Liner (GCL)

4.10.1 Delivery, Storage and Handling

Unit 17 - GCL delivered to site shall be wrapped with weather and moisture resistant wrapping. The Contractor shall be responsible for the unloading, protection from the weather and storage of the delivered GCL. Rolls with damaged wrapping shall be inspected by the Superintendent to assess the extent of hydration of the GCL. Unit 17 - GCL with moisture content above 30% by weight (ASTM D5993) may be rejected. GCL rolls with damaged wrapping and moisture content lower than 30% shall be re-wrapped and sealed. All rolls of material shall be clearly marked with the type of GCL, unroll direction and batch number of manufacture.

All rolls of Unit 17 - GCL shall be delivered with the GCL tightly wrapped around a centre core, with the hole in the core suitable for the proposed spreader bar to be used during deployment. All rolls shall be stored off the ground on hard, dry, free-draining surface, with suitable bearers at closely spaced centres, suitably protected from runoff and other damage. Stacked rolls of GCL shall be covered with tarpaulins to promote runoff. GCL rolls shall not be rolled across the ground.

4.10.2 Acceptance Criteria for GCL

Delivery to Site

The Contractor shall supply, unload, store and protect the rolls of GCL.

Inspection of GCL after Unrolling

The Superintendent shall inspect the GCL as it is rolled out on the slope.

Where a roll of GCL has been damaged and the damaged area extends more than 300 mm across the deployed width of GCL, the roll may be rejected due to its reduced tensile strength. The Superintendent shall determine if the strength of the roll is unacceptable, based on the nature and location of the damage.

4.10.3 General Surface Preparation

Unit 17 - GCL shall generally be placed on the prepared surface of the bearing layer, but in limited areas the GCL will be placed on internal bund slopes and prepared subgrade (refer Design Drawings).

Portions of the prepared surfaces that have deteriorated to an extent that has potentially compromised the quality of the layer, shall be reworked at the contractor's expense, and subjected to appropriate geotechnical testing in order to prove the required compaction.

The Contractor shall be responsible for preparing and maintaining the prepared surface to provide a firm, unyielding foundation for the Unit 17 - GCL with no sudden, sharp or abrupt changes or breaks in grade, no wheel ruts/footprints, no standing water, and no voids and crack, to the satisfaction of the Superintendent.

The Contractor shall remove from the liner subgrade surface all particles that protrude from the surface by more than 10 mm, and sharp or angular particles to the satisfaction of the Superintendent. Significant voids created by removal of particles shall be filled with moist Unit 4 – Clay Rich Material. No standing water shall be allowed to accumulate on the surface of the base liner prior to installation of the Unit 17 - GCL. No GCL shall be placed onto an area that has become softened by prolonged precipitation.

The prepared surface shall constitute a HOLD POINT. No GCL shall be placed until the Hold Point has been signed off by the Superintendent. Only the area to be covered in the same day shall be signed off.

4.10.4 Placement

Rolls of Unit 17 - GCL shall be moved or deployed with a suitable spreader bar that is stiff enough to limit deflection over the width of the roll to ensure smooth uniform deployment of the GCL layer. The orientation of the GCL, that is which side is installed facing downward, is to be confirmed by the Superintendent prior to any GCL installation.

Unit 17 - GCL shall only be installed in dry weather conditions.





The Contractor shall submit a panel layout and their proposed installation method to the Superintendent for the installation at least 10 days prior to the commencement of the GCL placement for approval by the Superintendent. A minimum side and end overlay of 300 mm is required between panels. The submission of panel layout drawings and proposed installation method constitutes a HOLD POINT. GCL installation shall not commence until the HOLD POINT is released.

If manufacturer recommendations differ from procedures in this Specification, these differences shall be brought to the attention of the Superintendent prior to placement of any GCL in the facility. The requirements of this Specification will apply, unless a variation is approved in writing in consultation with the Superintendent.

Exposed Unit 17 - GCL shall not be trafficked by vehicles. Unit 17 - GCL is to be covered with Unit 15 – LLDPE Geomembrane or Unit 16 – HDPE Geomembrane, which shall be deployed concurrently with the GCL (i.e. roll width after roll width) and on the same day as the GCL. This requirement is to minimise the potential for wetting of the GCL by rainfall or runoff. Further, the Contractor must stage liner installation such that the Unit 7 Drainage Aggregate layer or the Unit 9 Protection Material is in place over each area of the liner system within 48 hours of GCL placement. This requirement is to minimise the potential for GCL swelling due to lack of confining pressure.

All GCL overlaps shall incorporate a system for achieving overlap sealing (for example, some GCL products include pre-treated side overlap area which comprises bentonite powder encapsulated in the geotextile). Overlaps shall be placed in down slope direction (roof tile effect). If an alternative joining procedure is proposed, details are to be provided to the Superintendent for consideration at least 14 days prior to purchase of the materials.

The Superintendent shall inspect and approve all overlaps prior to covering the overlap.

If wrinkles greater than 50 mm high occur in Unit 17 - GCL or where wrinkles extend to the edge of the roll due to manufacturing tolerances, the wrinkle shall be cut at the crest of the wrinkle. A layer 10 mm thick of bentonite paste shall be spread over the top of one flap of the cut and the other flap pushed over the paste to form an overlap. A 20 mm thick layer of bentonite paste shall be placed over the top of the overlap extending 100 mm beyond the edges of the cut and overlap. The paste shall be covered with a patch of Unit 11 - Filter Geotextile, and squeezed into the paste.

The exposed edges of deployed GCL shall be protected from rainfall runoff to prevent erosion of bentonite. Special care shall be taken to prevent flow of runoff or seepage under and/or over the geomembrane to prevent erosion of the bentonite in the GCL.

4.10.5 Repairs

Rolls or panels of GCL that have been damaged shall be brought to the attention of the Superintendent, who shall judge if the panel or roll is to be removed from site, or may be repaired. If the Superintendent decides the damage is minor the hole may be patched. If a roll is deployed with manufacturing defects, the entire roll shall be removed from site.

All defects and repairs shall be recorded and locations measured as the panels are deployed, to facilitate the timely deployment of the overlying geomembrane.

A patch of GCL shall be placed over any hole with a minimum overlay over the adjoining area of 300 mm. The repairs shall be joined to the main GCL in accordance with the following requirements:

All overlaps shall be made using a 10 mm thick layer of hydrated sodium bentonite paste between the GCL and the patch GCL. The Contractor shall submit details of the proposed bentonite paste to the Superintendent for approval prior to commencement of the GCL installation.





4.11 Installation of Unit 15 and Unit 16 - Geomembrane 4.11.1 Transport, labelling, handling and storage

Transportation

The Contractor is responsible for transportation of the geomembrane to the Site.

Labelling

Each geomembrane roll shall be clearly labelled with the following information:

- Material of the geomembrane;
- Thickness of the material;
- Length and width of the roll;
- Manufacturer's Name;
- Direction to unroll the material;
- Product identification;
- Batch number; and
- Roll number.

Any roll delivered to the Site without labelling shall be rejected and removed from the site by the Contractor. Each package of welding rod or extrusion welding beads shall be clearly labelled and shall include the Manufacturers name, product identification name/number, resin lot or batch number and the package number.

The Contractor shall also cross-reference each batch number and roll number of geomembrane delivered to site to the resin used and date of manufacture of the geomembrane.

Handling and On-site Storage

The Contractor is responsible for handling, storage and care of the geomembrane before and after installation at the Site. The geomembrane rolls shall be protected from dirt, mud, dust, fire and damage before installation. Rolls shall be stacked to provide access for roll identification and testing as required. The integrity and legibility of roll labels must be maintained during storage.

Geomembrane materials shall be stored in accordance with the quality control procedures manual and the Manufacturer's recommendations. This may include covering of geomembrane rolls.

4.11.2 Surface Preparation

Unit 15 – LLDPE Geomembrane and Unit 16 – HDPE Geomembrane shall be placed on top of the GCL in the piggy back and cell base lining systems, respectively. The Contractor is responsible for meeting the 48-hour time window requirements for GCL, geomembrane, and cover placement given in Section 4.10.4, and for maintaining the surface of the GCL to provide a firm, unyielding foundation for the geomembrane with no sudden, sharp or abrupt changes or break in grade. No standing water or excessive moisture shall be allowed to accumulate on the GCL prior to geomembrane installation. No geomembrane shall be placed onto an area that has become deteriorated due to moisture changes.

4.11.3 Geomembrane Placement

During geomembrane installation the Superintendent will provide direct input and involvement as indicated in the following sections of this Specification. The Contractor is required to accommodate and allow for the Superintendent's identified role.





Layout Drawings

The Contractor shall submit geomembrane panel layout drawings at least 7 days before installation starts. The drawings shall indicate the panel configuration, the location of seams and the staging/direction of deployment. The layout drawings shall be suitable for use as construction drawings, to scale and include dimensions and details.

The submission of the panel layout drawings constitutes a HOLD POINT. Geomembrane installation shall not commence until the HOLD POINT is released.

Panel Identification

A field panel is the unit area of geomembrane to be welded in the field and shall be bounded by field welds or anchor trenches. Each field panel shall be numbered and the panel layout drawings shall show the panel numbers and the dimensions and area of each panel.

Field Panel Placement

Field panels are to be placed so that the boundaries do not intersect at one point and form a cross seam. A minimum 150 mm is required to offset the occurrence of a cross seam. The Contractor shall allow for the effects of changes in temperature with the resulting expansion and contraction of the panel, to prevent occurrence of a cross seam.

Installation Procedure

Field panels shall be installed using any one of the following procedures:

- field panels for one day's installation may be placed prior to field welding (to protect the subgrade from erosion by rain, or desiccation).
- field panels are placed one at a time and welded immediately (to minimise the number of unwelded field panels exposed to wind), or
- any combination of the above.

Weather Conditions

Geomembrane seaming and welding shall not be started if the ambient temperature is below 10°C or above 35°C, unless the Contractor demonstrates what special measures will be applied for welding outside this temperature range, and is authorised by the Superintendent. Both panels of geomembrane to be welded shall be allowed to equilibrate to the same temperature, before starting to weld.

Geomembrane jointing shall not be undertaken;

- in the presence of excessive moisture (i.e. rain, fog, dew);
- in an area of ponded water;
- or during periods of high wind or excessive dust.

If geomembrane placement and jointing is to be carried out at night, the entire area of deployment shall be illuminated. Installation should preferably be carried out during daylight hours. Installation work carried out at night shall be inspected and tested during daylight hours. All joints shall be tested during daylight hours.

Method of Placement

The Contractor shall ensure that:

- No more geomembrane is installed at any one time than can be reasonably welded in one day.
- Geomembrane rolls and/or factory panels shall be unrolled or unfolded in accordance with the instructions and the direction shown on the boxes or wrapping.





- No equipment used shall damage the geomembrane by handling, trafficking, leakage of hydrocarbons or other means.
- Personnel working on the geomembranes shall not smoke, use footwear, or engage in other activities that could damage the geomembrane. The Contractor shall protect the geomembrane from damage by equipment or personnel traffic associated with construction.
- Methods used to unroll panels shall not cause scratches or crimps in the geomembrane and shall not damage the underlying compacted clay liner and other layers.
- The prepared surface awaiting covering by geomembrane shall not be allowed to deteriorate and shall be maintained in a condition suitable for geomembrane placement.
- Methods used to place panels shall preclude folds, wrinkles that may become folds, bridging (trampolining) and differential wrinkles between adjacent panels.
- Temporary ballast (such as sand bags) shall be applied to prevent uplift during high wind conditions. Such loading shall be spread out and shall not damage the geomembrane. It is the contractor's responsibility to ensure the geosynthetic liners are sufficiently loaded. High wind conditions are common at the site, particularly on the existing landfill slopes where the piggy back ling will be installed.
- Vent flaps shall be sealed once the geomembrane has been covered with heavier materials and air trapped under the geomembranes during installation has been expelled.
- Joints shall be orientated so that overlaps are in the downslope direction (roof tile effect).
- All cutting of the geomembrane during installation shall be with a hooked blade to avoid damage.
- The Contractor shall implement procedures with its staff, to the satisfaction of the Superintendent to manage the risk of sharp particles being trapped in footwear or equipment that may or will move over the geomembrane.

Damage and Defects

Damage

The Superintendent shall inspect geomembrane panels for damage, after placement and prior to welding. The Contractor shall replace or repair a field panel or portion of a panel that is damaged (torn, twisted or crimped). Damaged panels or portions of damaged panels that have been rejected shall be removed from the work area. The Superintendent shall decide on the need to repair or replace damaged field panels.

Inspection of Geomembrane

The geomembrane shall be inspected by the Contractor during installation from the roll to identify unacceptable areas of material. Irregularities in the geomembrane material identified during inspection shall be repaired, or if excessive, the roll shall be rejected. The decision to either repair unacceptable areas or reject the roll shall be the Superintendent's. This decision shall generally be based on the following considerations.

Defects

The acceptance of the geomembrane shall be based on a maximum number of manufacturing defects. Manufacturing defects include "fisheyes", blemishes and shallow scratches.

A "fisheye" is a thinning of the geomembrane. The specified minimum thickness of the geomembrane also applies to "fisheyes". The size of the fisheye is of no consequence, as it is the thinning or absence of the geomembrane inside the fisheye, which is of concern.





Surface blemishes are considered to be areas where the resin has not been properly mixed or filler can be noted on the geomembrane. The colour and surface texture of the geomembrane shall be uniform and consistent. Where changes occur in the surface texture or colour the contractor shall request the Superintendent to inspect the area. If the area is rejected as unacceptable, then the section of the geomembrane roll shall be removed and replaced.

Straight-line scratches that penetrate the geomembrane (approximately 0.1 mm) shall be pointed out to the Superintendent. The extent and depth of the scratch shall be examined by the Superintendent to decide if a defect is to be removed. The roll length where such a defect occurs shall be cut out and removed from site. All defects shall be patched or capped and subject to quality control testing, reporting and documentation by the Contractor.

If a roll has been rolled out and no fisheyes are present, the geomembrane will be accepted. If the end of a roll has a number of defects, then the end of the roll shall be cut off and removed from site. The Superintendent shall make the final decision on site.

Maximum number of manufacture defects per 300 m^2 of roll length shall be one, with the total number of manufacture defects for the liner to be less than 10 per ha. If more than one manufacture defect occurs over a local area of the geomembrane within a circular area of 0.5 m radius, the area shall be considered 'one defect' and be capped. Replacement of defective geomembrane is at the Contractor's expense.

Manufacturer defects are considered separate to installation defects. Manufacturing defects and installation defects are the Contractor's responsibility. The Superintendent shall decide if the number of installation defects over a certain area is too high, and whether the area should be cut out or capped.

All defects shall be patched or capped and subject to quality control testing, reporting and documentation by the Contractor.

4.11.4 Field Welding

Requirements of Personnel

Personnel performing welding operations shall be qualified as indicated below.

- Personnel performing welding operations shall be qualified by experience or by successfully passing welding tests and at least one welder shall have welded a minimum of 100,000 m² of geomembrane using the same type of welding apparatus in use at the site.
- The weld foreman, most experienced welder, shall directly supervise less experienced welders, as required.
- No field welding shall take place unless the weld foreman is present.

Welding Equipment and Products

Approved Processes for Field Welding.

Only extrusion welding or fusion welding, using equipment approved by make and model, shall be used. Alternative processes may be proposed and submitted to the Superintendent 14 days before the start of geomembrane deployment, for consideration for approval.

Extrusion Process

The extrusion apparatus shall be equipped with gauges giving the temperature in the apparatus and at the nozzle. The Contractor shall provide documentation for the extrudate to the Superintendent and shall certify that the extrudate is the same material as the geomembrane sheet to be welded. The extruder shall be purged before beginning a weld and until all heat-degraded extrudate has been removed from the barrel. Whenever, the extruder is stopped, the barrel shall be purged of all heat degraded extrudate.



Fusion Process

The fusion-welding apparatus must be automated vehicular-mounted devices. The fusion-welding apparatus shall be equipped with gauges giving the applicable temperatures and pressures. The edge of the cross seams to be fusion welded shall be ground to a smooth incline (top and bottom) prior to welding. A temporary movable protective layer shall be used directly below each overlap of geomembrane that is to be welded to prevent build up of moisture between the sheets.

Generator

The electric generator shall be placed on a smooth base such that no damage occurs to the geomembrane. Similarly, a smooth insulating plate or fabric shall be placed beneath the hot welding apparatus after usage to protect the geomembrane. The geomembrane should not be damaged during welding and the geomembrane shall be especially protected from damage in trafficked areas.

Seam Layout

The Contractor shall provide the Superintendent with a seam layout drawing i.e. a drawing of the area to be lined showing all expected seams. No panels shall be welded in the field without the Superintendent's approval. In addition, no panels not specifically shown on the seam layout drawing shall be used without the Superintendent's prior approval.

No seams shall be located in areas of potential stress concentrations.

No cross-shaped seams shall be allowed unless approved by the Superintendent. All fusion joints between panels are to form T-joints, with panel layouts being staggered to achieve this.

All seams and joints shall be surveyed and numbered or named, which shall be cross-referenced to field notes and records of the contractor. Seam numbers shall be marked on the seam layout drawing, and altered as required on the as-built drawings (refer Section 4.9.2).

Welding Method

The welding method to be employed shall be the dual-track fusion welding process. Extrusion welding shall be used for repairs and patches. Single-track fusion welding methods or possible other welding methods shall only be used with prior written approval from the Superintendent.

The Contractor shall maintain at least one spare, operable welding unit of each type employed on the project site at all times.

Weld Preparation

General weld preparation procedures, temporary bonding procedures, general equipment settings, including acceptable extrudate or wedge temperatures, rate or advancement, etc., and welding procedures, shall be specified in the quality control procedures manual.

Prior to welding, the weld area shall be clean and free of moisture, dust, dirt, debris, markings and foreign material.

Where abrading is required, the process shall be completed according to the Manufacturer's instructions within one hour of the welding operation and in a way that does not damage the geomembrane. Abrasion of the geomembrane surface shall not extend outside the weld bead or weld surface area.

Seams shall be aligned to minimise the number of wrinkles.

Artificially induced cooling of the extrudate welds using water or other means is not permitted. Care shall be exercised to ensure that non-destructive testing of the extrudate and/or other activities does not cause artificial cooling of the weld.

The Contractor shall record the following information on the geomembrane surface adjacent to the weld:

Unique seam number.





- Welding device number and operating temperature.
- Welding technician's initials and
- Date and time.

This information must be recorded onto the Contractor's quality assurance documentation at the end of the day's welding activities.

Overlapping and Temporary Bonding

The panels of geomembrane shall be overlapped by a minimum of 75 mm for extrusion welding and 125 mm for fusion welding. The overlap shall be sufficient to allow peel tests to be performed on the weld, and to provide enough space to form a reliable air channel between dual fusion welds for testing.

The procedure used to temporarily bond adjacent panels together shall not damage the geomembrane; in particular, the temperature of the air at the nozzle of any spot welding apparatus shall be controlled such that the geomembrane is not damaged.

No solvent or adhesive shall be used unless the product is approved in writing by the Superintendent (samples shall be submitted for testing and evaluation).

General Welding Procedures

The general welding procedure used by the Contractor shall be as follows:

- For fusion welding, a movable protective layer of plastic shall be placed directly below each overlap of geomembrane that is to be welded. This is to prevent any moisture build-up between the sheets to be welded.
- Welding shall extend to the outside edge of panels to be placed in the anchor trench.
- Ends of dual fusion welds extending into anchor trenches and into joints or patches shall be welded closed.
- If required, a firm substrate shall be provided by using a flat board or similar hard surface directly under the seam overlap to achieve necessary support.
- Wrinkles at the seam overlaps shall be cut along the ridge of the wrinkle to achieve a flat overlap. The overlap shall be welded and any portion where the overlap is inadequate shall then be patched with an oval or round patch of the same geomembrane extending a minimum of 150 mm beyond the cut in all directions.
- All cuts and patches shall be formed with rounded edges and ends, to prevent stress concentrations in the geomembrane. All cuts shall be removed or be ended off with a round cut-out.

T-Joins

All T-joins shall be treated as a potential defect and be patched and subject to quality control procedures in accordance with this Specification.

4.11.5 Testing

Trial Welds

Each welding technician shall qualify to operate on a daily basis, by performing a trial weld prior to welding activities or at times designated by the Superintendent. These trial welds shall be performed using each type of welding device to be employed by the welding technician during that period. Additionally, a trial weld shall be made using each welding device on resumption of work after the lunch break or at an interval of no greater than five (5) hours, whichever is less. The Superintendent may also require that a trial weld be



performed using each device at the conclusion of welding activities. Welding devices that have not produced a passing trial weld will not be permitted to perform production welding.

Trial welds shall be made on "fragment" pieces of geomembrane liner to verify that welding conditions are adequate. The trial weld sample shall be at least 0.3 m wide and 3.0 m long for fusion welds or 1.0 m long for extrusion welds with 125 mm overlap, with the weld centred length-wise. All trial welds shall be performed under the same weather and subgrade conditions as production welding.

Three specimens each (25 mm) wide shall be cut by use of a die from the trial weld sample by the Contractor - one near each end and one near the mid-point. The two near end specimens shall be tested in peel and the mid-point sample tested in shear.

All trial weld specimens shall be tested in the field by the Contractor and in the presence of the Superintendent, using an electrically operated tensiometer where the force exerted is displayed. The Contractor shall supply evidence demonstrating that the tensiometer has been calibrated within the previous 12-month period.

The shear test specimen shall, at a minimum, meet a strength of ninety five percent (95%) of the tensile yield strength of the parent geomembrane material where it fails in the material (i.e. film tear bond). Both tracks of dual-track fusion welds shall be tested for peel adhesion. Peel strength of welds shall meet at least 65% of the tensile strength of the parent geomembrane material where it fails in the material.

All seams shall fail in the material, i.e. film tear bond. Trial seams shall meet the following minimum strength criteria:

Material (including weld type)	Peel	Shear
HDPE (fusion welds)	65%(1)	95%(1)
HDPE (extrusion weld)	60%(1)	95% (1)
LLDPE (fusion weld)	220 N/25 mm	265 N/25 mm
LLDPE (extrusion weld)	190 N/25 mm	265 N/25 mm

Note (1): Test results relative to the strength of the parent sheet strength

The tensile yield strength of the parent material will be determined before testing the trial welds by testing a 25 mm wide strip cut with a dye.

If any one of the three specimens fails, the entire trial weld is considered to have failed.

In the event that a trial weld fails, the entire trial weld procedure shall be repeated after the appropriate adjustments to the welding device and/or operator has been made. If a second trial weld fails, the welding device and/or the welding technician shall be rejected and shall not be used for welding until such time as the deficiencies are resolved, verification of the resolution is provided, and a successful trial weld performed.

Non-destructive Weld Continuity Testing

General

The Contractor shall non-destructively test all field and factory welds over their full length by the vacuum box method for testing continuity of extrusion welds, and air pressure test for double fusion welds only, or other approved method. The Contractor will be required to have back-up vacuum testing apparatus on the Site. A trial will be required in the presence of the Superintendent to demonstrate the effectiveness of the contractor's apparatus and method prior to field welding commencing. Vacuum testing and air pressure testing are described below. The purpose of the non-destructive test is to check the continuity of welds. It does not provide any information on weld strength. Continuity testing shall be done as the welding work progresses. Any welds that fail non-destructive testing shall be repaired in accordance with this Specification. Welds, which cannot be non-destructively tested because of seam geometry, shall be capped.





All test equipment shall be in calibration and conform to manufacturer's specifications. The Contractor shall submit current calibration certificates.

Vacuum Testing

The equipment shall comprise the following:

- A vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole or valve assembly, and a vacuum gauge showing the pressure in the box;
- A steel vacuum tank and pump assembly equipped with a pressure controller and connections;
- A rubber pressure/vacuum hose with fittings, pressure gauge linked to the window housing and connections;
- A soapy solution to be applied over seam area.

Each section of the weld to be tested shall be tested to a vacuum pressure of at least minus 35 kPa. Each section of seam shall be vacuum tested for a period of not less than 10 seconds by examining the geomembrane through the viewing window for the presence of soap bubbles. Adjoining area shall to be tested with a minimum 75 mm overlap between sections.

Air Pressure Testing

The following procedures are applicable only to those processes that produce a double weld with an enclosed air channel. All double welds with an enclosed air channel shall be air pressure tested.

The equipment shall be comprised of the following:

- An air pump (manual or motor driven) capable of generating and sustaining a pressure of 180 to 200 kPa.
- A rubber hose with fittings and connections.
- A sharp hollow needle or other approved pressure feed device.
- A calibrated pressure gauge capable of reading pressures up to 250 kPa, with a tolerance of less than 5 kPa.

The following procedures shall be used for air pressure testing the HDPE Geomembrane:

- Seal both ends of the weld to be tested:
- Insert needle with pressure gauge, or other approved pressure feed device within 300 mm of one of the sealed ends, into the air channel created by the fusion weld:
- Energise the air pump and pressurise the channel to 200 kPa for a 25 mm wide channel or 350 kPa for a 13 mm wide channel. Close the valve and sustain the pressure for a minimum of 5 minutes. A pressure drop of less than 10 kPa is allowable, but the air pressure is still required to stabilise for a minimum of 5 minutes. Should a different width air channel be formed the Superintendent shall adjust the required minimum air pressure in the channel to achieve a similar stress on the weld as for a 25 mm wide channel.
- If loss of pressure exceeds 10 kPa, or does not stabilise, the faulty area should be located and repaired in accordance with this section. If, in the judgement of the Superintendent, significant changes in geomembrane temperature occur during the test (e.g., due to cloud cover), the test shall be repeated after the geomembrane temperature has stabilised.





- Cut end of weld opposite to the pressure gauge and observe that the pressure drops. If the pressure does not drop, locate the obstruction(s) in the weld, repair, and retest the weld.
- Remove needle or other approved pressure feed device and repair all holes and damage made to the air channel by extrusion welding over the damage.

The following procedures shall be used for air pressure testing the LLDPE geomembrane:

- Seal both ends of the weld to be tested.
- Insert needle with pressure gauge, or other approved pressure feed device within 300 mm of one of the sealed ends, into the air channel created by the fusion weld.
- Energise the air pump and pressurise the channel to 150 kPa for a 25 mm wide channel, or 200 kPa for a 13 mm wide channel. Close the valve and sustain the pressure for a minimum of 5 minutes. A pressure drop of less than 15 kPa is allowable, but the air pressure is still required to stabilise for a minimum of 5 minutes. Should a different width air channel be formed the Superintendent shall adjust the required minimum air pressure in the channel to achieve a similar stress on the weld as for a 25mm wide channel.
- If loss of pressure exceeds 10 kPa, or does not stabilise, the faulty area should be located and repaired in accordance with this section. If, in the judgement of the Superintendent, significant changes in geomembrane temperature occur during the test (e.g., due to cloud cover), the test shall be repeated after the geomembrane temperature has stabilised.
- Cut end of weld opposite to the pressure gauge and observe that the pressure drops. If the
 pressure does not drop, locate the obstruction(s) in the weld, repair, and retest the weld.
- Remove needle or other approved pressure feed device and repair all holes and damage made to the air channel by extrusion welding over the damage.

Alternative testing procedures may be considered by the Superintendent based on submission of relevant information by the Contractor. If an alternative testing procedure is to be considered the Contractor shall submit information to the Superintendent at least 14 days before the procedure is to be used.

Destructive Weld Continuity Testing

The Contractor shall perform destructive weld tests at selected locations. The Superintendent shall choose the test locations. The Superintendent reserves the right to vary the testing frequency depending on results of samples tested. The purpose of these tests is to evaluate field weld strength. Weld strength testing shall be done as the welding work progresses, not at the completion of all field welding.

Location and Frequency

Destructive test samples shall be collected at an average frequency of one test location per 150 m of seam length or at intervals designated by the Superintendent.

Test locations shall be determined during welding, and may be prompted by suspicion of excess crystallinity, contamination, offset welds, or any other potential cause of imperfect welding.

Sampling Procedure

The Contractor shall cut samples at locations designated by the Superintendent as welding progresses to obtain laboratory test results before the geomembrane is covered by another material. Each sample shall be numbered and the sample number and location surveyed and identified for inclusion on the as-built liner drawing (refer Section 4.9.2).

All holes in the geomembrane resulting from destructive weld sampling shall be repaired and tested in accordance with the repair procedures in this Specification. Cuts to remove the samples shall be rounded to prevent stress concentrations in the geomembrane.





Size of Samples

The samples shall be a minimum 0.3 m wide by 0.4 m long with the weld centred length-wise. The sample length shall be increased to provide material for additional laboratory testing or archiving. Two specimens shall be cut from each end of the sample for preliminary field tests. The remaining sample shall be retained by the Contractor pending instructions from the Superintendent which samples are to be subjected to laboratory testing.

Each portion of the test sample shall be labelled with a unique number for the sample, and referenced to the joint number from where the sample was taken. The sample number shall be noted on the as-built drawings (refer Section 4.9.2). The Superintendent may direct the Contractor to reduce the length of the sample removed from the welds, if the Superintendent is satisfied that field testing indicates high quality welds. Laboratory tests may be ordered by the Superintendent on random samples to compare to field test results.

Preliminary Field Testing

Weld Destructive Tests

Two (2) specimens, one from each end of the weld destructive sample, shall be removed and tested for peel adhesion by the Contractor in accordance with Standard GM13 while in the field. The results of this testing shall be evaluated in accordance with the criteria detailed in this Specification.

If either of the two field specimens fails, the entire destructive test is considered to have failed and additional destructive test samples shall be taken in accordance with the procedures of this specification.

If the laboratory destructive testing is to be performed on-site, the requirement for preliminary field weld destructive testing may be waived by the Superintendent.

Weld-end Tests

The Contractor may, if agreed by the Superintendent, perform an additional preliminary destructive test. This test shall take the form of a single specimen obtained from one end of the completed fusion weld. This will be a quality control test and, as such, shall be addressed in the quality control procedures manual.

Upon completion of a fusion weld, a specimen shall be removed from one or both ends and tested by the Contractor for peel adhesion in accordance with the procedures detailed in this Specification. Both tracks of the dual-track fusion weld shall be tested and evaluated. The weld shall not fail in the weld area. If one or both of these specimens fail, a complete destructive test sample shall be taken as previously detailed in this Specification.

Laboratory Weld Sample Destructive Testing

The destructive weld testing will be performed by the Contractor in an on-site or off-site geosynthetic testing laboratory, to be approved by the Superintendent. Typically tests performed by the laboratory shall be completed and the results reported to the Superintendent within 24 hours of receipt.

The Contractor shall conduct laboratory destructive testing on at least 10% of the destructive weld samples of the project, or at least five samples, whichever results in the greater number of tests.

Tests shall be performed on 10 specimens obtained from each field sample. From each sample 5 specimens shall be tested in shear and 5 specimens shall be tested in peel. The shear and peel specimens shall be selected from the sample alternately, so that no two adjacent specimens are tested in the same mode.

Weld Evaluation Criteria

Each weld sample must satisfy both the shear and peel criteria. All testing and evaluation shall be carried out in accordance with ASTM D 4437.

For both peel and shear tests the specimen shall fail in the geomembrane sheet and not in the weld area. This is referred to as "film tear bond," (FTB). The specimen shall be defined as failing in the weld if any portion of the weld exhibits separation across more than 10% of the width. Each track of a dual-track fusion





weld shall be considered to be a separate weld for the purpose of calculating the percentage separation. If more than one specimen fails in shear, the entire weld destructive test sample shall be considered as failing.

Failed Destructive Sample Procedure

The Contractor shall reconstruct the deficient weld once the extent has been determined. All welds that are to be reconstructed shall be bound by passing destructive tests.

The Contractor shall trace deficient welds by grinding through the top sheet of the seam air channel, extrusion weld the channel, and pressure test sections of the seam between channel seal welds. Deficient extrusion welds shall be traced by taking field specimens from the weld at 3 m intervals until the Contractor has confidence that destructive samples which pass laboratory testing can be obtained. A full laboratory destructive sample will then be taken at that location and tested. If one or both of these samples fail the laboratory weld destructive test, then the procedure is repeated in that direction until passing laboratory results are obtained. For the purposes of tracing a weld, the weld is considered to be the path of the given fusion welding apparatus or extrusion welding device/technician combination and may, if necessary, extend beyond any given welding period. Tracing which requires obtaining more than 2 specimens in either direction from the location of the initial failed destructive weld sample shall be brought to the attention of the Superintendent. The Superintendent shall decide if the whole seam is to be rejected, or if the Contractor may continue identifying the segment of the defective seam.

At such time that the initial destructive sample failure rate of 10% or greater is reached, the Superintendent shall be notified so that a review of the Contractor's performance may be conducted.

Liner Integrity Surveys

The Superintendent may conduct liner integrity surveys, using the resistivity method, to identify defects in the installed geomembrane. The surveys would be conducted either on exposed geomembrane (if practicable) or at the surface of the 300 mm thick cover layer of Unit 7 -Drainage Aggregate or Unit 9 – Protection Material above the geomembrane.

Identified defects shall be repaired at the Contractor's expense in accordance with this Specification or the Superintendent's instruction.

4.11.6 Repairs

General

All weld and non-weld areas of the geomembrane shall be visually inspected by the Contractor for signs of damage, defective welds, blisters, punctures, undispersed raw materials, and any sign of contamination by foreign matter. Defective welds shall include completed welds that have been formed using equipment that is subsequently identified as being defective.

Any defective or flawed areas observed shall be marked, repaired, tested; or removed from the installation and disposed of. Unless otherwise approved by the Superintendent, all air channels produced by the dual track fusion welding process shall be sealed at both ends and at any location where the air channel is severed and made discontinuous. The appropriate parties shall agree upon the method of sealing. All repairs (patches, caps, etc.) may, at the discretion of the Superintendent, be destructively tested.

All defect locations shall be surveyed for inclusion on the as-built liner drawing (refer Section 4.9.2).

Patching

Patches shall be used to repair defects such as holes (including areas from which destructive test samples were obtained) and pinholes (exclusive of non-destructive testing air pressure needle holes) which penetrate the entire geomembrane thickness, tears and crazing. Small surface blemishes and localised flaws which do not penetrate the entire thickness of the geomembrane shall also be patched, or as instructed by the Superintendent.

Areas of crazing shall be cut longitudinally (along the length). The ends of all holes shall be rounded, to prevent further propagation, prior to patching. Patches may be used to cover areas of undispersed raw

material or contaminated by foreign substances (gasoline, oil, etc.), if approved by the Superintendent. Patches shall extend a minimum of 150 mm beyond the limits of the defect and all corners of patches shall be rounded. Patches shall follow the contour of the defect area and remain free of crimping or pinching. The geomembrane material used for patches must, at a minimum, meet the requirements of this Specification.

Patches and defect areas shall be free of dirt, moisture, debris and markings. Patches shall be temporarily bonded by heat welding. Chemical adhesives and tape are prohibited without prior approval of the Superintendent. The perimeter of the patch shall be abraded with a hand-held grinder to produce a bevelled edge. Patches shall be temporarily installed by heat welding along the entire perimeter of the patch and defect areas. The patch shall be installed flat along all edges with no wrinkles or folds. The patch weld area shall be abraded no more than 1 hour in advance of permanent welding. Heat welding and abrasion shall not cause excessive melting, wear or puncturing of the geomembrane material; such occurrences shall be considered defects and shall be repaired by patching.

Patching or repairs that require more than two passes of a welding procedure shall be considered as a defect, and be covered by a patch. Patches covering parts of other patches are not acceptable.

Capping

A cap is a patch of extended length and may be used to repair failed welds. Caps shall extend a minimum of 150 mm beyond the limits of the defective weld and all corners shall be rounded. Caps shall be installed as detailed in this Specification for patches.

A cap used to repair a failed weld or portion of weld shall be destructively tested if it exceeds 35 m in length or if the weld is of questionable quality. Caps over failed welds shall be carried out only with the approval of the Superintendent if no other method of repair is feasible. Where welds are being repaired by caps, the failed weld shall be cut out, and the cap shall be welded using fusion welding over most of the joint. The length of extrusion weld required to close-off the cap shall be kept to a minimum, and shall be closed-off after the fusion weld has been pressure tested.

Grinding and Welding

Grinding and extrusion welding shall be used to repair sections of defective extrusion weld less than 0.3 m in length. Areas requiring repair shall be abraded no more than 1 hour prior to the repair being made.

In consultation with the Superintendent, where the reason for a failed dual-track fusion weld has been determined with certainty, and is not related to faulty welding equipment, the failed part of the weld may be repaired (if less than 5 m long) by bevelling the edge (if required), abrading the sheet surface and applying an extrusion weld along the exposed edge (flap) of the seam. Failed welds repaired in this manner must conform to the requirements of this Specification. If the length of the failed portion of the fusion weld exceeds 5 m, or if the flap is not wide enough to allow destructive testing of the extrusion weld (without first testing through the fusion weld), then the weld must be reconstructed by capping.

Geomembrane Wrinkles and Bridging

Geomembrane wrinkle and bridge size and extent shall be minimised to the satisfaction of the Superintendent. Covering the geomembrane with the specified materials early in the morning when the temperature of the liner is low will reduce the extent and size of wrinkles. Wherever possible wrinkles shall be kept small and spread over the panel. In general, wrinkles which, when loaded, will result in a fold in the geomembrane are too large. Wrinkles or bridging larger than 300 mm high shall be cut and welded as a seam if the overlap is sufficient, in accordance with this Specification. Where the overlap is not sufficient, the wrinkle shall be cut and patched or capped as detailed in this Specification. Whenever it is not possible to manage wrinkles to less than specified, wrinkles shall be combined through accumulation so as to minimise the number of repairs being made.

Care shall be taken to minimise the occurrence of wrinkles over or across joins and welds to reduce stress concentrations near heat affected zones in the geomembrane.



4.12 Geotextiles

4.12.1 Description

Once delivered to the Site the Contractor shall recover samples from the rolls of geotextile, as indicated by the Superintendent. Samples from on site rolls shall be recovered and tested at a frequency as indicated in Chapter 2 of this Technical Specification, or as varied by the Superintendent. The Contractor shall compare test results to both the design specifications and to the list of typical values of the properties provided by the manufacturer.

4.12.2 Storage and Handling and Installation of Geotextiles

During shipment and storage, the geotextiles shall be protected from ultraviolet light exposure, precipitation or other inundation, spills of hydrocarbons, mud, dirt, dust, puncture, cutting or other damaging deleterious conditions.

The Contractor shall be responsible for the storage of the geotextile on the Site.

The geotextiles shall be secured and then rolled down the slope in such a manner as to continually keep the geosynthetic tension to preclude folds and wrinkles. All geotextiles shall be weighted with sandbags or the equivalent. Such sandbags shall be installed during placement and shall remain until replaced with cover material. Geotextiles shall be cut using an approved cutting method and approved equipment only.

Cushion Geotextile Installation

Where geomembranes are in place care shall be taken to protect this material from any damage that could be caused by the cutting of the geotextiles. During placement, care shall be taken not to entrap soil, stones, excessive dust, or moisture that could damage the geotextiles or the geomembrane, or hamper subsequent seaming or joining. The surface of the geomembrane shall be free of any larger than silt size particles, prior to placement of the geotextile. An examination of the geotextile over the entire surface, after installation, shall be conducted to ensure that no broken needles from the manufacturing process or other potentially harmful foreign objects are present. If broken needles are present then the geotextile shall be replaced. Any foreign objects encountered shall be removed, or the geotextile replaced if required by the Superintendent.

If white coloured geotextile is used, precautions shall be taken to avoid "snow-blindness" of personnel.

The geotextile shall be deployed by rolling out by hand, with no vehicular traffic permitted over the underlying geomembrane.

The panels of geotextile shall be overlapped by at least 200 mm, and the overlap shall be tacked together by heat bonding or stitching. Overlaps shall be placed in a down-slope direction (roof tile effect). Stitching shall be carried out using a hand held stitching machine with thread of similar material to the geotextile. The joint shall have a tensile strength of not less than 50 % of the strength of the geotextile being joined. Where stitching is to be carried out, the contractor shall implement a needle management system, to the satisfaction of the Superintendent, to ensure no parts of needles remain in the stitched geotextile joints or on Site.

The geotextile shall be held in place to prevent uplift by wind. Temporary anchorage may be required to prevent displacement of the free-end of the geotextile.

The installation of the geotextile shall be carried out under the supervision of the geomembrane contractor to ensure no damage occurs to the geomembrane.

Placement of Unit 12 – cushion geotextile constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

The Contractor shall submit documentation related to the delivered and installed rolls of cushion geotextile to demonstrate that only the approved batch of geotextile was installed in the Works.



4.12.3 Ballast System for Geotextile

The geotextile shall be held in place to prevent uplift by wind by a ballast system that shall remain in place until the overlying layer covers the geotextile.

Mounds of soil may be placed to satisfy the ballast requirement. Material used for soil mounds shall conform to the same requirements of the material to be permanently placed over the geotextile. Proposed ballast configuration and details shall be submitted to the Superintendent for consideration before implementation.

Ballast shall be gently lowered onto the geotextile, with a maximum drop height of 500 mm. Vehicle traffic is not permitted on the geosynthetics, so the ballast shall be placed as each roll of material is deployed.

4.13 Geocomposites

4.13.1 Description

Once delivered to the Site the Contractor shall recover samples from the rolls of geocomposite, as indicated by the Superintendent. Samples from on site rolls shall be recovered at a frequency of one sample per 4000 m^2 , or as varied by the Superintendent. The Contractor shall arrange for the testing of the samples in accordance with the testing requirements outlined in Section 2.2.14 of this Specification to compare to both the design specifications and to the list of typical values of the properties provided by the manufacturer.

4.13.2 Storage and Handling of Geocomposites

During shipment and storage, the geocomposites shall be protected from ultraviolet light exposure, precipitation or other inundation, spills of hydrocarbons, mud, dirt, dust, puncture, cutting or other damaging deleterious conditions. The Contractor shall be responsible for the storage of the geocomposite on the Site.

The geocomposites shall be handled in such a manner as to ensure it is not damaged in any way.

4.13.3 Installation of Geocomposites

The geocomposites shall be placed directly on top of the geomembrane. The surface of the geomembrane shall be free of any larger than silt size particles, prior to placement of the geocomposite.

Care should be taken during the placement to avoid damage to underlying geomembrane.

The geocomposites shall be secured and then rolled down the slope in such a manner as to continually keep the geosynthetic tension to preclude folds and wrinkles. All geocomposites shall be weighted with sandbags or the equivalent. Such sandbags shall be installed during placement and shall remain until replaced with cover material. Geocomposites shall be cut using an approved cutting method and approved equipment only. Where geomembranes are in place care shall be taken to protect this material from any damage that could be caused by the cutting of the geocomposites. During placement, care shall be taken not to entrap soil, stones, excessive dust, or moisture that could damage the geocomposites or the geomembrane, or hamper subsequent seaming or joining.

If there are any obstructions while deploying the geocomposite, the geocomposite shall be cut to fit around the obstruction. Care should be taken to make sure there is no gap between the obstruction and the geocomposite, to prevent any soil particles from migrating into the geonet core.

The geocomposite shall be deployed by rolling out by hand, with no vehicular traffic permitted over the underlying geomembrane.

The joining of geocomposites shall be in accordance with the manufacturer's specification. Adjacent edges of the geonet along the roll length of the geocomposites shall be overlapped a minimum of 50 mm and tied by plastic ties with a maximum of 1,500 mm intervals. Adjoining geocomposite rolls (end to end) along the roll width shall have the geonet overlapped a minimum of 300 mm across the roll width. Geonet shall be tied by plastic ties in 300 mm intervals across the roll width. The bottom layer of geotextile shall be overlapped. The upper layer of geotextile shall be seamed by stitching or hot-air thermal sealing. Stitching shall be carried out using a hand held stitching machine with thread of similar material to the geocomposite. The



contractor shall implement a needle management system, to the satisfaction of the Superintendent, to ensure no parts of needles remain in the stitched geocomposite joints or on Site.

The installation of the geocomposite shall be carried out under the supervision of the geomembrane contractor to ensure no damage occurs to the geomembrane.

The Contractor shall submit documentation related to the delivered and installed rolls of geocomposite to demonstrate that only approved geocomposite material was installed in the Works.

4.13.4 Ballast System for Geocomposite

The geocomposite shall be held in place to prevent uplift by wind by a ballast system, such as sand bags that shall remain in place until the overlying layer covers the geocomposite. Ballast shall be gently lowered onto the geocomposite, with a maximum drop height of 500 mm. Vehicle traffic is not permitted on the geosynthetics, so the ballast shall be placed as each roll of material is deployed.

4.14 Geogrid

4.14.1 Description

Once delivered to the Site the Contractor shall recover samples from the rolls of geogrid, as indicated by the Superintendent. Samples from on site rolls shall be recovered at a frequency of one sample per 5000 m^2 , or as varied by the Superintendent. The Contractor shall arrange for the testing of the samples in accordance with the testing requirements outlined in Section 2.2.18 of this Specification to compare to both the design specifications and to the list of typical values of the properties provided by the manufacturer.

4.14.2 Storage and Handling of Geogrid

During shipment and storage, the geogrid shall be protected from ultraviolet light exposure, precipitation or other inundation, spills of hydrocarbons, mud, dirt, dust, cutting or other damaging deleterious conditions. The Contractor shall be responsible for the storage of the geogrid on the Site.

The geogrid shall be handled in such a manner as to ensure it is not damaged in any way.

4.14.3 Installation of Geogrid

The geogrid shall be sandwiched in Unit 6 – Base Material (refer Section 4.7)

The geogrid shall be secured and then rolled down the slope in such a manner as to continually keep the geosynthetic tension to preclude folds and wrinkles. All geogrid shall be weighted with sandbags or the equivalent. Such sandbags shall be installed during placement and shall remain until replaced with cover material. Geogrid shall be cut using an approved cutting method and approved equipment only. No vehicular traffic permitted over the installed geogrid.

Adjacent edges of the geogrid along the roll length (side by side) shall be overlapped a minimum of 300mm and tied by plastic ties at maximum of 1,500 mm intervals. The Contractor is to note that although a smaller side by side overlap is used in many geogrid applications, a 300 mm side by side overlap is a specific requirement for the project. Adjoining geogrid rolls (end to end) along the roll width shall be overlapped similarly and tied at maximum 1,000 m intervals.

The Contractor shall submit documentation related to the delivered and installed rolls of geogrid to demonstrate that only approved materials are installed in the Works.

4.14.4 Ballast System for Geogrid

The geogrid shall be held in place to prevent uplift by wind by a ballast system, such as sand bags that shall remain in place until the overlying layer covers the geogrid. Ballast shall be gently lowered onto the geogrid, with a maximum drop height of 500 mm. Traffic is not permitted on the geogrid, so the ballast shall be placed as each roll of material is deployed.





4.15 Leachate Collection System for Cell Base Lining

The Contractor shall construct the leachate collection system and leachate sumps in accordance with the Design Drawings and as given below. As the leachate collection system will likely be constructed in sections, the Contractor shall appropriately cap all temporary leachate pipe terminations to allow future connection.

The leachate collection system for the cell base lining in the Cells 1 to 4 area includes the following materials (bottom to top):

- Unit 12 Cushion Geotextile;
- 300 mm thick layer of Unit 7 Drainage Aggregate;
- Unit 23 Leachate Collection Pipe; and
- Unit 11 Filter Geotextile.

4.15.1 Leachate Collection Pipe

Unit 23- Leachate Collection Pipe shall be placed by hand or machinery on top of Unit 12 – Cushion Geotextile. The pipes shall be installed with the perforations at 45 degrees off the vertical and horizontal axes of the pipe. Minor adjustments to the alignment of the pipes are permitted to facilitate the use of standard angled bends and junctions. The ends of all pipes shall be capped during construction activities to prevent ingress of foreign materials.

Initial placement of leachate collection pipes, or the subsequent connection of a new portion of the piping system to a previously placed portion, constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

Following placement of each portion of leachate collection piping, the Contractor shall survey all pipe alignments and inverts, including leachate outlet pipes (Section 4.15.3) and leachate clean out access pipes, and submit works-as-executed (WAE) drawings demonstrating compliance with the design within 7 days of completion of each portion of the system. It is noted the a Hold Point has not been established at this point because it would likely preclude the Contractor from covering all areas of the liner with Unit 7 – Drainage Aggregate quickly enough to comply with the 48-hour time window requirements for GCL, geomembrane, and cover placement given in Section 4.10.4.

The Contractor shall also submit the items listed below as part of his WAE documentation,

 WAE report including description of the completed work, summary of construction materials and time periods of construction, applicable Work Method Statements, RFI records (if any), Contractor quality system records, and Hold and Inspection point documentation.

4.15.2 Leachate Drainage Layer

The Contractor shall place the Unit 7 – Drainage Aggregate over Unit 12 - Cushion geotextile using appropriate methods and equipment to prevent damage to the geotextile cushion, underlying geomembrane, and leachate collection pipes.

The Contractor shall prepare a Work Method Statement for handling and placement of the Unit 7 material. The Work Method Statement shall consider installation of and protection of the geosynthetic materials as well as fines generation in the Unit 7 material. The Work method statement must address the requirements in the remainder of this section. This constitutes a HOLD POINT. No transport or placement of the Unit 7 material shall be carried out until the HOLD POINT has been released by the Superintendent

The Contractor shall be responsible for the selection, loading and transport of the aggregate from the source location, and placement of the aggregate.

The Contractor shall consider the following for handling and placement of the aggregate;





- protection of the integrity of the underlying materials including the cushion geotextile, HDPE geomembrane and GCL;
- considerations and limitations on access over areas underlain by geosynthetic materials;
- potential for breakdown of the aggregate during handling and placement and the generation of excess fine grained particles that may not comply with the specified gradation requirements;
- non-uniform particle size distribution during production, stockpiling, handling and placement. This
 includes accumulation of excess fine grained particles in localised locations that do not comply with the
 specified gradation requirements;
- Potential inclusion of non-conforming materials during the loading of the aggregate at the source or stockpile;
- Consideration of on-site screening prior to placement to manage the risk of non-conforming particle size distribution; and
- Carrying out corrective action for non-conformances in particle size distribution in the placed material. This includes consideration of the protection of the integrity of the cushion layer and HDPE geomembrane.

Drainage aggregate shall be placed on top of the cushioning layer overlying the HDPE geomembrane to form a continuous leachate drainage blanket across the floor of the base cell. The blanket is intended to promote drainage of leachate to the leachate collection pipes and sump.

The drainage aggregate shall also be placed around the leachate collection pipes as shown on the Design Drawings. The Contractor shall take care to ensure that the aggregate is worked around the leachate collection pipes to provide uniform support around the pipes. Placement of Unit 7 material around the leachate collection pipes constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

Placement of the leachate drainage aggregate shall not impact on the integrity of the underlying base cell liner system, the collection pipes, nor completed areas of the drainage aggregate layer.

The aggregate shall be placed in a manner so as to ensure uniform particle size distribution. Concentration of fine grained particles (<0.075 mm) and particles < 19 mm, to greater than the specified limits is not acceptable. Any material placed, that according to the Superintendent, does not meet the specification shall be removed and replaced with new or remixed material that meets the specification.

The aggregate shall be handled and spread in a manner so as to manage the risk of particle crushing or abrasion to a practical minimum. Spreading of the aggregate to the required 300 mm thick layer shall be carried out with low bearing pressure equipment. Unless otherwise agreed, the maximum permitted machinery weight for drainage layer placement shall be 13T and at no point shall tracked placement equipment operate on a working platform of less than 300 mm thickness of material above the cushion geotextile.

The leachate aggregate shall be placed to ensure the underlying geosynthetics are not damaged. The placement shall be carried out so that trapped air under the geomembrane is directed to vent flaps at the edge of the works and so that wrinkles in the geomembrane do not form creases or similar.

Vehicles are not permitted to traffic on the surface of the cushion geotextile or geomembrane. The aggregate shall be placed by trucking the material over previously placed aggregate and unloading on the previously placed material.



The aggregate shall be no less than 0.75 m thick where wheeled vehicles are to traverse the aggregate on. The method of working shall comprise end-tipping and spreading from previously placed material, or a method agreed with the Superintendent prior to work commencing.

Spreading of gravel shall be carried out to prevent stretching, tearing, distortion or other damage to the cushioning layer and geomembrane. Blades of construction equipment that are used to place and spread the aggregate shall not move within 200 mm of the surface of the geosynthetic layers. Where a dozer is used, the material shall be rolled off the end of the layer to prevent tensioning the geotextile that may occur if the aggregate is just pushed off the end of the layer.

The Contractor may elect to prepare a trial pad to allow the Superintendent to assess a potentially thinner layer thickness for where wheeled vehicles are to traverse the aggregate on the surface of the Cell, depending on the cushioning layer, construction equipment and grading of the leachate collection aggregate.

Gravel shall be carefully placed around the leachate collection pipes. The shaping of the gravel to the required thickness shall be controlled using a laser guide or similar system.

Locking of tracks of excavators or dozers shall be prohibited. Stopping shall be carried out slowly. Where sudden stoppage of a vehicle was required, the underlying geosynthetics shall be exposed to assess if damage has occurred.

The Superintendent shall be present on site to view the placement and spreading of the gravel. Where damage occurs to the underlying materials, the Superintendent shall direct the Contractor on the actions required for repair.

After drainage layer placement, Unit 11 – Filter Geotextile shall be placed and secured over the drainage layer. Filter geotextile shall be installed in the same manner as outlined in Sections 4.12 of this Specification. Placement of Unit 11 – Filter geotextile constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

Following drainage layer placement and filter geotextile placement, the Contractor shall survey the finished surface level to provide works-as-executed (WAE) drawings and to demonstrate that the drainage layer design thickness has been achieved and that the constructed sump geometry is in accordance with the design. The survey shall be conducted on an approximate 10m grid with detailed survey of the sump. The Contractor shall submit the WAE drawings and an accompanying analysis demonstrating compliance with design thickness and sump geometry. Submission of the WAE drawings and accompanying analysis constitutes a HOLD POINT. Placement of any material above the drainage layer shall not commence until the Hold Point has been released, and all other contractual requirements have been fulfilled.

The Contractor shall also submit the items listed below as part of his WAE documentation,

 WAE report including description of the completed work, summary of construction materials and time periods of construction, applicable Work Method Statements, RFI records (if any), Contractor quality system records, and Hold and Inspection point documentation.

4.15.3 Leachate Sump and Outlet Pipe

The leachate sump and outlet pipe shall be constructed in accordance with the Design Drawings.

The Contractor shall provide a Work Method Statement for the installation of the leachate sump to the Superintendent for approval. This constitutes a HOLD POINT. No construction of the sump shall be carried out until the HOLD POINT has been released by the Superintendent.

The work method statement must include, but not necessarily be limited to, the minimum requirements as given in the remainder of this section.





Base and Lining Construction

The base surface on which the sump liner will be constructed shall be prepared to form a firm foundation. The surface shall be trimmed of all softened, loose and foreign materials, and formed to a uniform graded surface. Any depressions shall be filled with compacted Unit 4 – Clay Rich Material or Unit 2 – General Fill. No contaminated material shall be used for surface preparation.

Prior to liner placement, the Contractor shall survey the finished base surface level. This information shall be included in the works-as-executed (WAE) drawings of the leachate drainage layer (refer Section 4.15.2) and to demonstrate that the design levels have been achieved.

The sump liner shall comprise the following components:

- A 500 mm thick of Unit 5 Clay Material which have minimum permeability of 10⁻⁹ m/sec;
- Double layer of Unit 17 GCL;
- Unit 16 HDPE Geomembrane; and
- Unit 12 Cushion Geotextile.

Installation of Clay Material

The Contractor shall proposed method of moisture conditioning, placement and compaction, and maintenance of the leachate sump compacted clay liner to comply but not limit to the following requirements.

- The compacted clay liner layer shall be constructed in at least 3 layers. The clay liner shall be placed in layers of a nominal thickness of 170 mm. The clay liner layer shall have a minimum total thickness of 500 mm.
- The clay liner layer shall be compacted with a vibrating padfoot type roller, to achieve a minimum Dry Density Ratio (DDR) of at least of 98% standard (in accordance with AS1289.5.1.1 and 5.4.1) or a minimum HILF density ratio of 98% standard (in accordance with AS1289.5.7.1) at a moisture content within the range of 0% to +3% (wet) of the Standard Optimum Moisture Content (SOMC). The field density tests during placement of the material shall be minimum a test on each side of the base on each layer of as directed by Superintendent.
- If the required density and moisture is not achieved, the compacted material shall be reworked in-situ to meet the density and moisture content requirements. If the density and moisture content requirements again cannot be achieved after reworking, the failed layer shall be removed for moisture conditioning at the clay borrow area or at an approved designated area, or be discarded.
- Prior to the placement of each lift of the clay liner layer, the top of the previous lift shall be thoroughly scarified and moisture conditioned if necessary to bond each layer together and prevent laminations at the layer interfaces. Any areas where laminations occur, either between or within layers, shall be reworked such that all laminations and defects in the integrity of the clay liner layer are removed.
- Upon completion of the clay liner layer, the Contractor shall maintain the integrity of the layer by limiting the traffic movement over the clay surface and maintaining the surface of the clay in a moist condition, wet of SOMC, until covered by the geomembrane.
- Should the surface of a previously placed and compacted layer have dried or wetted up excessively, as determined by the Superintendent, the affected materials shall be excavated to expose material that has a moisture content within the specified tolerance. The excavated materials shall be returned to a designated area for moisture conditioning or be discarded.
- Trafficked areas are to be ripped, moisture conditioned and recompacted if in the opinion of the Superintendent the quality of these areas has deteriorated. Furthermore, any cracked clay that has formed due to desiccation shall be removed.





The placement of the leachate sump clay liner layer constitutes an INSPECTION POINT and the Contractor is required to provide 48 hours notice before commencing or recommencing this activity.

Following clay liner layer placement, the Contractor shall survey the finished surface level to include in the works-as-executed (WAE) drawings of the leachate sump and to demonstrate that the clay liner layer design thickness has been achieved and that design surface grades for geosynthetic placement have been achieved. The Contractor shall submit the WAE drawings and an accompanying analysis demonstrating compliance with design thickness and surface grades. This submission constitutes a HOLD POINT and geosynthetics installation for the sump shall not proceed until the Hold Point is released.

Geosynthetics Installation

The Contractor shall provide a rounded edge of the clay liner at the toe and crest of the side slope. The rounded edge shall be constructed to support the geomembrane so as to prevent stressing or creasing of the geomembrane under loads. In general, rounding shall be prepared over a length of approximately 300 mm.

The leachate sump shall be lined with the following layers:

- Two layers of Unit 17 GCL overlying the prepared Unit 5 Clay Material;
- A layer of Unit 16 HDPE Geomembrane above the GCL; and
- A layer of Unit 12 Cushion Geotextile.

The installation of the geosynthetic layers shall be as per Sections 4.10 to 4.12 of this Specification. This installation work constitutes an INSPECTION POINT and the Contractor is required to provide 48 hours notice before commencing or recommencing this activity.

At the completion of geosynthetics installation for the sump, the Contractor shall submit a WAE report including description of the completed work, summary of construction materials and time periods of construction, applicable Work Method Statements, RFI records (if any), Contractor quality system records, and Hold and Inspection point documentation

4.15.4 Installation of Unit 24 – Leachate Sump Outlet Pipe and Sump Backfill

Unit 24 – Leachate Sump Outlet Pipe shall be connected to the leachate sump at the concrete outlet structure as shown in the Design Drawings. It is recommended that the concrete outlet structure to be constructed prior to the installation of the liner system so that it will be ready to be connected with the geomembrane in the lining system.

Installation of Unit 24 – Leachate Sump Outlet Pipe constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

The backfilling of the sump with Unit 7 – Drainage Aggregate shall be by an excavator. The material shall be placed in a manner to minimise any impact on the geosynthetic layers underlain. Any damages shall be to be repaired to the satisfaction of the Superintendent at the Contractor's cost.

Backfilling shall occur within 24 hours of placement of the first GCL layer in the sump base in order to minimise potential GCL hydration swelling.

4.15.5 Installation of Unit 27 – Leachate Sump Risers

Unit 27 – Leachate Sump Risers for Package 1 shall be constructed outside of the perimeter bund and connected to the leachate sump outlet pipe. The Leachate Sump Risers shall also be connected with the existing leachate collection pipes and groundwater pipe from the existing Western and Eastern Gully Landfills as shown in the Design Drawings.

Requirements for bedding, sealing, pipe entrances, pipe trenching are shown on the Design Drawings.

The Contractor shall prepare a Work Method Statement for Unit 27 – Leachate Sump Riser installation and construction. The Work Method Statement shall address drawing and specification requirements as well as





safety issues associated with excavation and sump construction. Submission of the Work Method Statement constitutes a HOLD POINT. Sump riser excavation and construction shall not commence until the Hold Point is released.

Installation of the Unit 27 – Leachate Sump Riser constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing this activity.

4.16 Leachate Collection System for Piggy Back Lining

The Contractor shall construct the leachate collection system for the piggy back lining areas in accordance with the Design Drawings and as given below. As the leachate collection system will likely be constructed in stages, the Contractor shall appropriately cap all temporary leachate pipe terminations to allow future connection.

The leachate collection system for the piggy back lining includes the following materials (bottom to top):

- Unit 14 Geocomposite Drainage Net ; and
- Unit 23 Leachate Collection Pipe covered with Unit 7 Drainage Aggregate and wrapped with Unit 11 – Filter Geotextile.

It is noted that this leachate collection system will also used in the cell base lining (Type 2) areas.

4.16.1 Leachate Drainage Layer

The Contractor shall place the Unit 14 – Geocomposite Drainage Net over the LLDPE geomembrane using appropriate methods and equipment to prevent damage to the underlying geomembrane and GCL, in accordance with Section 4.13 of this Specification.

Should any damage occur to the geomembrane or the GCL the Contractor shall make a full repair at his own cost to the satisfaction of the Superintendent.

The geocomposite drainage net layer is discontinuous at leachate collection pipe locations (eg. at crossslope leachate collection pipes), as shown on the Design Drawings, to encourage flow into the pipes. In addition, the upper geotextile layer of the geocomposite net underlying drainage aggregate shall be removed, as shown on the Design Drawings, to minimise potential for flow resistance to develop between the geocomposite and the drainage gravel.

Placement of Unit 14 – Geocomposite Drainage Net constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

4.16.2 Leachate Collection Pipe

Unit 23 - Leachate Collection Pipe shall be placed by hand or machinery on top of Unit 14 – Geocomposite Drainage Net. The pipes shall be installed with the perforations at 45 degrees off the vertical and horizontal axes of the pipe. Minor adjustments to the alignment of the pipes are permitted to facilitate the use of sweeping angled bends and junctions. The ends of all pipes shall be capped during construction activities to prevent ingress of foreign materials.

Initial placement of leachate collection pipes, or the subsequent connection of a new portion of the piping system to a previously placed portion, constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

Following placement of each portion of leachate collection piping, the Contractor shall survey all pipe alignments and inverts, and submit works-as-executed (WAE) drawings demonstrating compliance with the design within 7 days of completion of each portion of the system. It is noted the a Hold Point has not been established at this point because it would likely preclude the Contractor from covering all areas of the liner with Unit 9 – Protection Material quickly enough to comply with the 48-hour time window requirements for GCL, geomembrane, and cover placement given in Section 4.10.4.


Prior to the placement of surrounds (Unit 7 – Drainage Aggregate) around the leachate collection pipes, the upper geotextile layer of Unit 14 – Geocomposite Drainage Net shall be removed within the zone which will be overlaid with the drainage aggregate.

Unit 7 – Drainage Aggregate shall then be placed around the pipes. Care shall be taken to ensure the granular material extends all around the pipe to support the pipe. No vehicle traffic shall be permitted over the installed pipes unless the Contractor can demonstrate to the satisfaction of the Superintendent that sufficient cover material is in place to protect the pipe from traffic loads. Placement of Unit 7 – Drainage Aggregate around the leachate collection pipes constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

Unit 11 – Filter Geotextile shall surround the drainage aggregate placed around the perforated leachate collection pipes. Filter geotextile shall be installed in the same manner as outlined in Sections 4.12.2 and 4.12.3 of this Specification and shall be placed concurrently with Unit 7.

Placement of Unit 11 – Filter geotextile constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

The Contractor shall also submit the items listed below as part of his WAE documentation for this activity,

WAE report including description of the completed work, summary of construction materials and time periods of construction, applicable Work Method Statements, RFI records (if any), Contractor quality system records, and Hold and Inspection point documentation.

4.17 Unit 9 – Protection Material

The Contractor shall place the Unit 9 – Protection Material over Unit 14 - Geocomposite Drainage Net using appropriate methods and equipment to prevent damage to the geocomposite drain, underlying geomembrane, and leachate collection pipes.

The Contractor shall provide a Work Method Statement presenting the proposed method of placement of the Unit 9 – Protection Material. The work method statement must include, but not necessarily be limited to, the minimum requirements listed below.

- The minimum thickness of the layer shall be 300 mm as measured perpendicular to the surface of the underlying layer, with a minimum slope of 2.5:1. The entire thickness shall be placed as one lift.
- The maximum permitted machinery weight for protection layer placement shall be 13T. At no point shall the placement equipment operate on a working platform of less than 300 mm thickness of material above the geocomposite drain. A field trial is required to confirm that the planned plant for use in hauling and spreading the protection material can operate without damaging the geocomposite drain, underlying geomembrane, or leachate collection pipes and to establish minimum equipment setbacks from the leading edge of protection material placement.
- Compaction shall be only by trafficking with the spreading plant.

The Work Method Statement shall demonstrate to the satisfaction of the Superintendent that the proposed methods will be protective of the geocomposite drain, geomembrane, and leachate collection pipes. The work method shall include "Level 1" supervision and reporting by the GITA. Submission of the work method statement constitutes a HOLD POINT. Placement of the Unit 9 – Protection Material shall not commence until the Hold Point is released.

Notwithstanding the above should any damage occur to the geocomposite drain, the leachate collection pipes or the geomembrane the Contractor shall make a full repair at his own cost to the satisfaction of the Superintendent.

Following protection layer placement, the Contractor shall survey the finished surface level to provide worksas-executed (WAE) drawings and to demonstrate that the protection layer design thickness has been achieved. The survey shall be conducted on an approximate 10m grid. The Contractor shall submit the





WAE drawings and an accompanying analysis demonstrating compliance with design thickness. Submission of the WAE drawings and accompanying analysis constitutes a HOLD POINT. Placement of any material above the protection layer shall not commence until the Hold Point has been released, and all other contractual requirements have been fulfilled.

The Contractor shall also submit the items listed below as part of his WAE documentation,

- GITA certification statements for the activity
- WAE report including description of the completed work, summary of construction materials and time periods of construction, applicable Work Method Statements, RFI records (if any), Contractor quality system records, and Hold and Inspection point documentation.

4.18 Stormwater Drainage

4.18.1 Drainage Channels and Pipes

The construction of stormwater drainage structures must comply with RMS Specification R11 'Stormwater Drainage', Ed4/Rev 0, dated 26.09.12.

4.18.1.1 Foundation Preparation

Backfilling, where required, must be done in accordance with the R11 Clause 3.7.1

Foundation, support and backfill materials related to open drains and the stormwater pipe must be compacted in layers not exceeding 150 mm, unless otherwise directed by the Superintendent. The minimum characteristic values of relative compaction must comply with the R11 Clause 3.7.2 requirements (Table 16).

Location	Minimum Standard Compaction Ratio		
Foundations and trench based to a depth of 150 mm below the bottom of the plain concrete or of the bed zone,	95%		
Trimmed surface of excavated open drains to a depth of 150 mm, before lining or spreading topsoil for vegetation	90%		
All other fill material for drainage structures including fill in bed, haunch, side and overlay zones, material replacing inadequate foundation material, backfill material and earth material in diversion banks	95%		

Table 16: Minimum Standard Compaction Ratios

Foundation material for pipe culvert bed and haunch zones must also comply with the R11 Clause 2.7.1 and must have:

- 1) A particle size distribution , determined by Test Method RMS T201, within the limits set out in Table 6 in AS3725; and
- 2) A Plasticity Index, determined by Test Method RMS T109, of not more than 6.

At pipe connection(s), these materials must be controlled low strength flowable fill material complying with Appendix A in AS 3725.

Side and Overlay zones of the pipe must comply with the R11 Clause 2.7.2, and must have a maximum dimension of 50 mm, and Plasticity Index, as determined by Test Method RMST109, of between 2 and 12.





4.18.1.2 Set out

The stormwater pipe and drainage channels must be set out as detailed in the R11 Clause 3.1.2.

4.18.2 Construction Traffic

Where the contractor proposes to move heavy construction plant or vehicles over stormwater pipe, the contractor shall design and provide protective measures for each crossing in accordance with Specification RMS 2.

4.18.3 Channel Linings

Channel Lining systems comprising Unit 34, Unit 35 and Unit 38 shall be constructed in accordance with manufacturer's recommendations, the Design Drawings, and Chapter 2 of this Technical Specification.

4.18.4 Drop Structures

The construction of drop structures must comply with RMS Specification R55 'Rock Filled Gabions and Mattresses', Ed3/Rev 1, dated 16.09.09.

4.18.5 Construction Tolerances and Inspection

Maximum construction tolerances for stormwater drainage components are specified in Table R11.2 of the R11 specification and as presented in Figure 1:

Component	Attribute	Tolerance	
Concrete pipes, box culverts, headwalls and wingwalls,	Location (plan)	Within 200 mm of the plan position shown on the Drawings or specified at any point	
energy dissipators, inlet and outlet structures	Invert level	Within 20 mm of the design level at any point	
Gully pits and junction boxes	Location (plan)	Within 200 mm longitudinally and 20 mm laterally or the plan position, with reference to the control line for the road shown on the Drawings	
	Outlet invert level	Within 20 mm of the invert level shown on the Drawings	
Lintels, covers and gratings	Line	The tolerances specified for the adjoining material; e.g RMS R15 for kerbs and gutters, RMS R116 or RMS R119 for asphalt, RMS R83 and RMS R84 for concrete base.	
Precast concrete box culvert units	Step between units	On the internal faces of the walls and roof, no step between adjacent units must exceed 20 mm. Steps between 10 mm and 20 mm must be smoothed to a standard of durability equal to the rest of the culvert.	
Open drains	Location	The tolerances specified for the adjoining material, including RMS R44 for berm drains and batter drains	
	Level	Within 50 mm of the design level at any point provided that there is a continuous downgrade in the direction of flow not less than 0.5% at any point	
	Waterway area	Not less than 95% of the design cross sectional area at any point	
	Shape	Not more than a 50 mm departure from a 3 m straight edge placed on the bottom or a side of the open drain at any point	
Trenches for precast concrete and fibre-reinforced concrete	When measu angles to the	ared horizontally at any point within the trench at right line of the pipes:	
pipe drainage structures	Position of trench face:	Within 100 mm of the design location	
	Excavation width:	Not less than the specified width; Not more than the specified width plus 100 mm	

Figure 1: Maximum Construction Tolerances (Source: Table R11.2 of the RMS Specification R11)





Closed-circuit television (CCTV) inspection of all drainage structures must be carried out in accordance with the R11 Clause 4.2.

4.19 Other Requirements

4.19.1 Surveying

All references in this Specification to required survey or survey to be performed by the Contractor means survey performed and reported by a registered surveyor.

4.19.2 Tolerances

The Contractor shall construct the cell to the construction dimension tolerances and minimum layer thicknesses provided for specific items in individual sections of this Specification.

For other items, the Contractor shall construct the cell to the general construction dimension tolerances provided below.

Levels and grades for material surfaces:

- 1) Surfaces shall be within +/- 100 mm of design levels;
- 2) Grades shall be in the design direction at all locations; and
- 3) Thickness of material layers shall be equal or greater than the design thickness.

Pipes and open drains:

- 1) Invert levels shall be within +/- 50 mm of design levels; and
- 2) Grades shall be maintained in the design direction at all locations.

RH:PR/GRS/rh:pr

https://aupws.golder.com/117625003wollongongcitycouncilnewcellwhytesgully/project doc/320 90percent design/3209 technical specification/117625003_145_s_rev1_whytes gully new cells - tech spec tender package 1.docx



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WHYTES GULLY NEW LANDFILL CELL TENDER PACKAGE 2

Technical Specification - New Landfill Cell

Submitted to: Wollongong City Council

Report Number.

117625003_245_S_Rev0



CHNICAL SPECIFICATION

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1.0 SECTION 1 – PRELIMINARIES

1.1 Introduction

The basic concept for the expansion of the Whytes Gully Landfill is that future waste will be placed within a lined and capped expansion area constructed over the existing landfill site, including:

- Overfilling of the existing Eastern and Western Gully Landfills (note: the term "piggyback liner" is used to refer to the proposed liner system to be constructed in overfill areas);
- Filling within existing natural areas on the Central Ridge and Western Ridge; and
- Filling within existing natural areas at the toe of the existing Eastern and Western Gully Landfills.

This Technical Specification provides material and construction requirements for the second portion of construction for landfill expansion, referred to as Tender Package 2.

Background information on site conditions and the purpose of project can be found in the following reports, which also provide a detailed description of design intent.

- Design Report "Whytes Gully New Landfill Cell Report for Preliminary Design" prepared by Golder Associates, April 2012, ref. 117625003 - 058 - R - RevA.
- Detailed Design report "Detailed Design Report Tender Packages 1,2 and 3" prepared by Golder Associates, ref. 117625003 - 224 - R

1.2 **Definitions**

The following parties are referred to in this Technical Specification.

Table 1:	Parties	relevant t	o the	project
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Superintendent	The party designated by the site owner to manage the Contractor in accordance with the construction contract. The Superintendent may delegate appropriate tasks to a Technical Superintendent.	
Contractor	The party awarded the contract to complete the works described in this Technical Specification.	
GITA	Geotechnical Inspection and Testing Authority: The party undertaking Level 1 inspection and testing of landfill earthworks in accordance with AS3798 -2007. The GITA shall be engaged by the Contractor, subject to Superintendent short list and approval, and shall be independent of the Contractor.	
Regulator	The NSW state agency responsible for oversight of landfill construction and environmental management. This is anticipated to be the NSW EPA.	

This Technical Specification includes 'Hold Points' and 'Inspection Points'. These are defined as follows:

- Hold Point An identified point in the landfill construction sequence where the Contractor must halt work and provide required information to the Superintendent. The Contractor must not resume work until the Hold Point is released, in writing, by the Superintendent.
- Inspection Point An identified point in the landfill construction sequence where the Contractor is required to provide written notification in advance of commencing work on identified items in order to allow the opportunity for the Superintendent to directly inspect the work; the notification must be provided when indicated and in no case less than 24 hours in advance of commencing the work.

The specific meaning of the term "Site" is defined in the contract documents.



1.3 Construction Materials

The table below presents the primary materials for cell construction. These materials are referred to in this Technical Specification by unit number. Additional construction materials are also named in this Technical Specification.

Table 2: Material List
SOILMATERIALS
Unit 1 – Topsoil – Not Used
Unit 2 – General Fill
Unit 3 – Intermediate Cover Material – Not Used
Unit 4 – Clay Rich Material
Unit 5 – Clay Material
Unit 6 – Base Material
Unit 7 – Drainage Aggregate
Unit 8 – Gas Drainage Gravel
Unit 9 – Protection Material
GEOSYNTHETIC MATERIALS
Unit 11 – Filter Geotextile
Unit 12 – Cushion Geotextile
Unit 13 –Geocomposite Drainage Net (Surface Water) – Not Used
Unit 14 – Geocomposite Drainage Net
Unit 15 – LLDPE Geomembrane
Unit 16 – HDPE Geomembrane
Unit 17 – Geosynthetic Clay Liner (GCL)
Unit 18 – Geogrid
PIPE MATERIALS
Unit 21 – Gas Collection Pipe
Unit 22 – Groundwater Drainage Pipe – Not used
Unit 23 – Leachate Collection Pipe
Unit 24 – Leachate Sump Outlet Pipe
Unit 25 – Leachate Drainage Pipe
Unit 26 – Subsoil Drainage Pipe – Not Used
Unit 27 – Leachate Sump Riser

Unit 28 – Leak Detection Pipe

SURFACE WATER DRAINAGE AND OTHER MATERIALS

Unit 31 – Bentonite

Unit 32 - Rip Rap Armourstone and Aggregate for Gabion Baskets and Wire Mattresses

Unit 33 – Granular Material for Concrete Pipe Installation – Not Used

Unit 34 – Rock Filled Gabions and Mattresses

Unit 35 – Drain Liner – Not Used

Unit 36 – Precast Reinforced Concrete Box Culverts (RCBC) and Headwalls

Unit 37 - Precast Reinforced Concrete Pipes (RCP) - Not Used

Unit 38 – Channel Liner - Not Used

1.4 Design Drawings

Detailed design drawings for Tender Package 2 are provided separately and referred to herein as the "Design drawings".

1.5 Site Preparation

Site preparation works shall be carried out by the Contractor in successive stages in accordance with the Contractor's approved Construction Program.

1.5.1 Removal of Vegetation

Existing vegetation shall be cut and disposed by the Contractor in all construction areas.

1.5.2 Services

The Contractor is responsible for confirming service locations, and also locating any unknown services, and establishing whether services are active or inactive prior to initiating work in any area of the site.

Active services are currently present within the construction area and vicinity. Known active services include power and communication lines along the Old Reddalls Road alignment, and power and control lines to the existing leachate ponds.

These known active services will be decommissioned and/or de-energised by others prior to construction. The Contractor shall completely remove these services, including all service trench bedding materials.

In addition, 132 kVA overhead powerlines are present along the southern edge of the proposed landfill construction area. These power lines are owned by Endeavour Energy and are to remain in service at all times. The Contractor must use appropriate work methods in the vicinity of these lines.

In the case that previously unknown services are encountered during the course of works, the Contractor shall immediately take appropriate safety precautions, and shall inform the Superintendent. The Contractor is responsible for protecting any active services identified by the Contractor at the time of construction until they are decommissioned and/or de-energised by others. Once decommissioned and/or de-energised, the Contractor shall completely remove services, including all service trench bedding materials.

The Contractor shall prepare and submit documentation of all his activities to confirm, locate and remove services.

1.5.3 Structures Demolition

Prior to the construction of the lining system in each area, any existing structures shall be demolished and removed by the Contractor. Note: Some structures within the Tender Package 2 construction area are planned to be demolished as part of Tender Package 1 works.

The Contractor shall provide a Work Method Statement presenting proposed methods for structure demolition, including identification of hazardous materials (eg asbestos), environmental management of demolition materials, and material disposal. Refer to *Technical Specification – 021 Demolition*, provided separately, for additional requirements. These activities shall not commence until the Hold Point is released.



2.0 SECTION 2 – MATERIALS

2.1 General Material Requirements

2.1.1 Contractor Supply and Protection of Materials

The Contractor shall be responsible for supply, delivery, storage, placement and installation of all materials required to carry out the works in this Technical Specification. However, the Superintendent may direct that some materials will be supplied by others. Once incorporated in the Works, the Contractor shall protect the materials throughout the duration of construction to ensure they do not degrade or become damaged so as to change the intended performance or function of the materials.

2.1.2 Material Approval

Source Approval

The Contractor shall demonstrate that all materials proposed by the Contractor for the works will meet the requirements of this Technical Specification. This constitutes a HOLD POINT for <u>each</u> of the materials identified in the Technical Specification and in the Design Drawings. No material shall be imported to the site, and no on-site materials shall be handled, placed or stockpiled, until the Hold Point for the material is released.

Materials that are considered by the Superintendent to have excessive settlement potential, or the potential to undergo or contribute to chemical reactions adverse to landfill performance, will not be approved.

The Contractor shall prepare a submittal for Superintendent review for each material to demonstrate that the proposed material will comply with all requirements of this Technical Specification. Hold Point release will be dependent on the submittal providing a satisfactory demonstration. Each submittal shall identify the material source, or sources, and include relevant test results that satisfy the testing requirements of this Technical Specification, description of material uniformity, and other information needed to confirm required properties, including waste classification for soil materials. For manufactured products, manufacturer's specifications and quality control information shall also be submitted.

Confirmation of Properties of Materials Delivered to Site

The Contractor is responsible for confirming that all materials delivered to site from approved sources meet the material property requirements of this Technical Specification. This includes complying with all sampling and testing requirements in this Technical Specification, as well as performing additional sampling and testing as needed to confirm as-delivered material properties.

Confirmation of material properties after placement and compaction is also required for some materials as indicated in this Technical Specification.

The Contractor is required to notify the Superintendent at least 24 hours in advance of taking samples for confirmation of as-delivered and as-placed material properties.

The Superintendent may, at his discretion, conduct Audit sampling and testing of any materials at source or at site. The Contractor must assist and facilitate the Superintendent in such activities. If Audit test results indicate that materials do not meet requirements then the Superintendent may direct that the materials be replaced at the Contractor's expense and that the Contractor pay the Audit sampling and testing costs.

2.1.3 VENM or ENM Requirement

All soil materials imported to the site and used to construct any portion of the landfill must meet the definition of virgin excavated natural material (VENM) or excavated natural material (ENM) under the Protection of the Environment Operations Act 1997 and the Protection of the Environment Operations Amendment 2008, unless otherwise permitted by this Technical Specification, consistent with the project approval conditions, and agreed with the Superintendent. If material other than VENM or ENM is proposed for import to the site, the Contractor shall be responsible for obtaining all relevant approvals, such as from the Regulator, prior to importing.



The Contractor shall commission a VENM/ENM assessment and waste classification for all imported soil material. The assessment and classification must be performed by a qualified person and be to the satisfaction of the Superintendent. The assessment and classification shall comprise a material source inspection, an assessment of historical land use at the source site, and chemical testing at a frequency of at least one sample per material source or at least one sample per 1,000 m³. The Superintendent may require more frequent sampling and testing at the Contractor's expense if the classification is considered incomplete or inadequate.

For VENM assessment, chemical testing shall comprise analysis for heavy metals, total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene, xylenes (BTEX), polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) and Organochlorine pesticides (OCPs). The provisions of current NSW EPA Waste Classification Guidelines shall apply.

For ENM assessment, the requirements given by the NSW EPA under the Protection of the Environmental Operation (Waste) Regulation 2005 - General Exemption Under Part 6, Clause 51 and 51A; The excavated natural material exemption 2012; shall apply.

The Contractor shall keep records of waste classification and quantity of all soil materials imported to site.

The Contractor may submit non-VENM or non-ENM soil materials from on site to be considered for use in landfill construction, provided that these materials meet Technical Specification requirements and are not designated for stockpiling for future use by the site owner. The Contractor submittal for on-site materials must address the requirements in Section 2.1.2, as for import materials.

2.1.4 Reporting

Reporting of all material test results shall be in accordance with the Contractor's Quality System, specific requirements in this Technical Specification, and other contract requirements. However, in all cases material test results shall be made available to the Superintendent no later than 1 week after each test is performed.

All material test results submitted to the Superintendent by the Contractor must be from a laboratory with NATA-accreditation for all tests performed. All survey results submitted to the Superintendent by the Contractor must be from a registered surveyor.

2.2 Material Properties

2.2.1 Unit 1 – Topsoil – Not Used

Not used for Tender Package 2.

2.2.2 Unit 2 – General Fill

Unit 2 – General Fill shall comprise clay, silt, sand, gravel or any combination thereof or other approved materials. This material shall contain no organic matter. This material shall have a low erosion potential with an Emerson Class number greater than 4 (AS 1289.3.8.1), although the Superintendent may agree to reduce the Emerson Class number requirement where the fill will not be exposed to potential erosion. This material shall have a maximum particle size of 75 mm and a smooth gradation that results in minimal visible voids once compacted.

Source approval for Unit 2 will primarily require the Contractor to identify the source, describe the material, provide two representative Emerson Class test results and gradation test results (AS1289.3.6.1), and, for import material, provide an acceptable VENM/ENM classification.

Confirmation of the properties of as-delivered Unit 2 shall be by Contractor inspection and documentation of each incoming load, and by sampling and Emerson Class testing and gradation testing at a frequency of at least one testing event per 1,000 m³ of material placed, with a minimum of one testing event per source.

2.2.3 Unit 3 – Intermediate Cover Material – Not Used

Not used for Tender Package 2.



2.2.4 Unit 4 – Clay Rich Material

Unit 4 Clay Rich Material shall clayey soil, free of organic matter, capable of being compacted to a dense condition. The material shall have the following index properties:

- Index properties:
 - Plasticity Index > 15%;
 - Liquid Limit > 25%.
- Emerson crumb classification > 4

The material shall have differing gradation requirements in different applications as indicated below.

A. Bearing Layer in Cell Base and Piggy Back Areas: This application provides a surface for GCL placement

- Gradation:
 - Maximum particle size 13.2mm;
 - Passing 2.4 mm sieve > 90%;
 - Percentage fines (passing 0.075mm sieve)> 30%.

B. Bund – Main Body of Bund. This application is for bund material that is not in contact with GCL material

- Gradation:
 - Maximum particle size 53 mm;
 - Passing 19 mm sieve > 90%;
 - Percentage fines (passing 0.075mm sieve) > 30%.
- C. Bund Batters and top surface: This application provides a surface for GCL placement
 - Gradation: same as category A above.

Table 3: Material Testing Requirements for Unit 4 – Clay Rich Material

Property	Test method	Frequency		
		Source approval	As-delivered	
Atterberg Limits	AS1289.3.2.1	Two tests per source	One test per 2,000 m ³ material used on site, minimum 4 tests per source	
Gradation	AS1289.3.6.1	Two tests per source	One test per 2,000 m ³ material used on site, minimum 4 tests per source	
Emerson Class Number	AS1289.3.8.1	Two tests per source	One test per 2,000 m ³ material used on site, minimum 4 tests per source	



2.2.5 Unit 5 – Clay Material

Unit 5 – Clay Material shall clayey soil, free of organic matter, capable of being compacted to a dense condition. The material shall have the following index properties:

- Gradation:
 - Maximum particle size 13.2 mm;
 - Percentage fines (passing 0.075mm sieve) > 50%.
- Index properties:
 - Plasticity Index > 20%;
 - Liquid Limit > 40%.
- Emerson crumb classification > 4.
- When remoulded to a Standard Maximum Dry Density (SMDD) of 95% in accordance with AS1289.5.1.1 at Standard Optimum Moisture Content (SOMC) have a co-efficient of permeability, measured in a triaxial cell at an effective confining pressure of 50 kPa in accordance with AS1289.6.7.3 ,of no greater than 1 x 10⁻⁹ m/s.

The following table shows the testing requirements for this material.

Drowerty Tool worthout		Frequency		
Froperty	rest method	Source approval	As-delivered	
Atterberg Limits	AS1289.3.2.1	Two tests per source	One test per 200 m ³ material used on site, minimum 4 tests per source	
Gradation	AS1289.3.6.1	Two tests per source	One test per 200 m ³ material used on site, minimum 4 tests per source	
Emerson Class Number	AS1289.3.8.1	Two tests per source	One test per 200 m ³ material used on site, minimum 4 tests per source	
Permeability	AS1289.6.7.3	Two tests per source	One test per 200 m ³ material used on site, minimum 1 test per leachate sump, minimum 4 tests per source	

Table 4: Material Testing Requirements for Unit 5 - Clay Material

2.2.6 Unit 6 – Base Material

Unit 6 – Base Material shall be well-graded sandy or gravelly materials, free of organic matter, carbonates and clay balls and capable of being compacted to a dense condition. The material shall have a USCS classification of GW, GW-GM, GM, GW-GC, GC, SW, SW-SM, SM, SW-SC, or SC.

The material shall have the following index properties:

- Gradation:
 - Max. particle size 40mm;
 - Percentage gravel (retained on 4.75 mm sieve) > 30%
 - Percentage Fines (passing 0.075 mm sieve) >5% and <20%</p>

The material shall have a minimum shear strength, at 25 kPa effective confining stress, equivalent to that of a drained friction angle of 35 degrees.



Source approval for Unit 6 will primarily require the Contractor to identify the source, describe the material, provide two representative gradation test results (AS1289.3.6.1) and two appropriate shear strength tests, and provide an acceptable VENM/ENM classification.

Confirmation of the properties of as-delivered Unit 6 shall be by Contractor inspection and documentation of each incoming load, and by sampling and gradation testing at a frequency of at least one testing event per 1,000 m³ of material placed, with a minimum of one testing event per source.

Coarse coal washery rejects will be considered for use as Unit 6 under the following conditions:

- the materials meet the above requirements, when sampled <u>after</u> placement and compaction;
- the material is demonstrated to the Superintendent's satisfaction to be from a source with no history of spontaneous combustion of stockpiled coal washery rejects; and
- the materials are supplied in full accordance with the requirements outlined by the NSW EPA under the Protection of the Environmental Operation (Waste) Regulation 2005 - General Exemption Under Part 6, Clause 51 and 51A; the Coal Washery Rejects General Exemption 2009.

If the Contractor proposes to use coarse coal washery rejects then full details of how the material requirements and conditions outlined above will be satisfied must be included in his source approval submission for the material.

2.2.7 Unit 7 – Drainage Aggregate

Unit 7 – Drainage Aggregate shall consist of high durability, clean, hard, sound gravel or crushed rock of natural geologic origin, free of organic matter, lumps of clay or other deleterious material, carbonates, limestone or other calcareous material that would be subject to chemical attack. The material shall be washed to remove fines. Recycled materials or materials of ash/slag origin are not permitted.

The material shall have particle characteristics such that the placed drainage layer is stable under compaction using a smooth drum roller.

The material shall have the properties given below <u>following</u> placement and spreading to the required thickness:

- Gradation:
 - Max. particle size 40 mm;
 - Passing 19 mm sieve < 20%</p>
 - Passing 13.2 mm sieve < 10%</p>
 - Percentage Fines (passing 0.075 mm sieve) <2%</p>
- Aspect Ratio (in accordance with AS 1141.14):
 - Max. misshapen particles at 2:1 calliper ratio: 20%
 - Max. misshapen particles at 3:1 calliper ratio: 5%
- Permeability > 1×10^{-3} m/s
- Strength (in accordance with AS1141.22–2008):
 - Min.wet strength: 80 kN;
 - Max.wet/dry strength variation: 30%
- Calcium carbonate content (in accordance with Test Method: Rapid Titration specified in "Soil and Plant Analyses" by C.S. Piper):
 - Max. calcium carbonate content by volume: 15%
- Solubility in acid (in accordance with Test Method: AWWA B 100.96):



non-soluble in acid

The following material shall not be used as Unit 7 – Drainage Aggregate: volcanic breccia, mudstone, sandstone, shale, limestone, calcrete, and highly weathered or altered rocks.

The following table shows the testing requirements for this material.

	Test method	Frequency		
Property		Source approval	As-placed (following placement and spreading)	
Geologic Origin	NA	Certificate is required for each material source	Inspect and document each batch delivered to site to confirm composition and lack of organics, carbonates, and clay	
Gradation	AS1141.11 / AS1141.12	Two tests per source	One test per 500 m ³ material used on site, minimum 2 tests per source	
Aspect Ratio	AS 1141.14	Two tests per source	One test per 500 m ³ material used on site, minimum 2 tests per source	
Permeability	AS1289.6.7.1	One test per source	not required	
Strength	AS1141.22 - 2008	Two tests per source	One test per 500 m ³ material used on site, minimum 2 tests per source	
Calcium carbonate content	Rapid Titration specified in "Soil and Plant Analyses" by C.S. Piper	One test per source	One test per 500 m ³ material used on site, minimum 2 tests per source	
Solubility in acid	AWWA B 100.96	One test per source	One test per 500 m ³ material used on site, minimum 2 tests per source	

Table 5: Material Testing Requirements for Unit 7 – Drainage Aggregate

2.2.8 Unit 8 – Gas Drainage Gravel

Unit 8 – Gas Drainage Gravel shall consist of recycled concrete, natural gravel, crushed rock or combination thereof or other approved materials. This material shall be free of organic matter, carbonates and clay balls.

The material shall have the following properties

- Gradation:
 - Max. particle size 40mm;
 - Passing 19 mm sieve < 20%</p>
 - Passing 13.2 mm sieve < 10%</p>
 - Percentage Fines (passing 0.075 mm sieve) <3%</p>
- Permeability > 1 x 10⁻³ m/s
- Strength (in accordance with AS.2758.1 1998):
 - minimum wet strength: 40 kN;

The following material shall not be used as Unit 8 – Gas Drainage Gravel: shale and highly weathered or altered rocks.

The following table shows the testing requirements for this material.

_	Test method	Frequency			
Property		Source approval	As-delivered		
Geologic Origin	NA	Certificate is required for each material source	Inspect and document each batch delivered to site to confirm composition and lack of organics, carbonates, and clay		
Strength	AS1141.22 - 2008	Two tests per source	One test per 500 m ³ material used on site, minimum 2 tests per source		
Gradation	AS1141.11 / AS1141.12	Two tests per source	One test per 500 m ³ material used on site, minimum 2 tests per source		
Permeability	AS1289.6.7.1	One test per source	not required		

Table 6: Material Testing Requirements for Unit 8 – Gas Drainage Gravel

2.2.9 Unit 9 – Protection Material

Unit 9 – Protection Material shall comprise a material:

- capable of being spread smoothly in a 300mm thick layer without damaging underlying geocomposite drain and/or geomembrane;
- with compaction limited to tracking by the spreading plant;
- with sufficient strength and cohesion to maintain a stable long-term orientation on piggyback liner slopes, generally 2.5H:1V to 5H:1V; and
- with as-placed permeability within the identified range.

The material shall have the properties given below <u>following</u> placement and spreading to the required thickness:

- Gradation:
 - Max. particle size 19 mm;
 - Percentage Fines (passing 0.075 mm sieve) <3%</p>
- Permeability > 1 x 10^{-3} m/s
- Shear strength, measured at 25 kPa effective confining stress, equivalent to that of a drained friction angle of 35 degrees.

Source approval for Unit 9 will primarily require the Contractor to identify each source, describe the material, provide two representative gradation test results (AS1289.3.6.1), two permeability test results (AS. 1289.6.7.1), two appropriate shear strength tests, and an acceptable VENM/ENM classification.

Confirmation of the properties of as-delivered Unit 9 shall be by Contractor inspection and documentation of each incoming load, and by sampling and gradation and permeability testing at a frequency of at least one testing event per 1,000 m³ of material placed, with a minimum of two testing events per source. Note: This sampling and testing shall be on material recovered from the protection material layer after placement.

Coarse coal washery rejects will be considered for use as Unit 9 under the following conditions:

- the materials meet the above requirements;
- the material is demonstrated to the Superintendent's satisfaction to be from a source with no history of spontaneous combustion of stockpiled coal washery rejects; and



the materials are supplied in full accordance with the requirements outlined by the NSW EPA under the Protection of the Environmental Operation (Waste) Regulation 2005 - General Exemption Under Part 6, Clause 51 and 51A; the Coal Washery Rejects General Exemption 2009.

If the Contractor proposes to use coarse coal washery rejects then full details of how the material requirements and conditions outlined above will be satisfied must be included in his source approval submission for the material.

2.2.10 Unit 10 – Not used

The Unit 10 designation has not been used.

2.2.11 Unit 11 – Filter Geotextile

Unit 11 – Filter Geotextile shall be woven or non-woven, polyester or polypropylene which has the following properties:

- Equivalent Opening Size < 110 μm (Typical Value)
- CBR puncture strength > 2100 N (Minimum Average Roll Value, MARV)
- Flow rate > 100 L/s/m² (cross-plane flow under 100mm head) (Typical Value)
- Mass per unit area > 200 g/m² (MARV)

The following table shows the testing requirements for this material.

Table 7: Material Testing Requirements for Unit 11 – Filter Geotextile

Bronorty	Test method	Frequency			
Froperty	rest method	Source approval	As-delivered		
Mass	AS3706.1	Two tests per source	two tests per roll used on site		
Flow Rate (cross- plane flow under 100mm head)	AS3706.9	Two tests per source	One test per manufacturer batch		
Equivalent Opening Size	AS3706.7	Two tests per source	One test per manufacturer batch		
CBR Puncture Strength	AS3706.4	Two tests per source	Two tests per roll used on site		

2.2.12 Unit 12 – Cushion Geotextile

Unit 12 – Cushion Geotextile shall be a non-woven, needle-punched polyester or polypropylene material. The Cushion Geotextile shall be free of broken needles. The material shall be rejected if broken needles are present.

Requirements for the material will be provided at a later date and will include minimum required values for the following properties:

- Thickness
- Mass per unit area
- Trapezoidal tear strength
- CBR puncture strength

The following table shows the testing requirements for this material.

	<u> </u>			
Dreperty	Toot mothed	Frequency		
Property	Test method	Source approval	As-delivered	
Thickness	AS3706.1	Two tests per source	One test per roll used on site	
Mass	AS3706.1	Two tests per source	One test per roll used on site	
Trapezoidal Tear	AS3706.3	Two tests per source	One test per 1,000 m ² material placed on site	
CBR Puncture Strength	AS3706.4	Two tests per source	One test per 1,000 m ² material placed on site	

Table 8: Material Testing Requirements for Unit 12– Cushion Geotextile

Interface Shear Strength: The minimum interface shear strength requirements given in Section 2.2.18 apply to the performance of combinations of Unit 12, Unit 14, Unit 15, Unit 16 and Unit 17 materials comprising the base and piggy back lining systems. The Contractor's attention is drawn to the requirement for each material to meet its individual requirements and also for the combined lining system materials to meet interface shear strength requirements. Unit 13 –Geocomposite Drainage Net (Surface Water) – Not Used

2.2.13 Not used for Tender Package 2.Unit 14 – Geocomposite Drainage Net

Unit 14 – Geocomposite Drainage Net shall be a geocomposite material comprising a triplanar HDPE geonet core with non-woven, polyester, polypropylene, or polyethylene needle punched, resin or heat bonded geotextiles thermally bonded to both sides of the geonet core. The geocomposite drainage net material shall have the following properties:

- Thickness > 6.8 mm at 200 kPa normal stress (Minimum Average Roll Value, MARV)
- Mass > 1,000 g/m² (MARV)
- Hydraulic flow rate ≥ 0.4 x 10⁻³ m³/s per metre width at 20kPa normal stress with hydraulic gradient i = 0.1 (measured between rigid plates) (Typical value)
- Hydraulic flow rate ≥ 0.3 x 10⁻³ m³/s per metre width at 200 kPa normal stress with hydraulic gradient i = 0.1 (measured between rigid plates) (Typical value)
- Tensile strength > 20 kN/m (MARV)
- Elongation at peak > 38% (MARV)
- Ply adhesion (peel strength of geotextile from geonet) >180 g/cm (MARV); with no unbonded areas permitted
- Internal and Interface Shear Strength Requirements Refer to Section 2.2.18

Interface Shear Strength: The minimum interface shear strength requirements given in Section 2.2.18 apply to the performance of combinations of Unit 12, Unit 14, Unit 15, Unit 16 and Unit 17 materials comprising the base and piggy back lining systems. The Contractor's attention is drawn to the requirement for each material to meet its individual requirements and also for the combined lining system materials to meet interface shear strength requirements.

The geotextiles shall have the following properties:

- Mass > 115 g/m2 (MARV) or > 200 g/m2 (MARV) if field joints between Unit 14 sheets are made by hot-air seaming
- Equivalent Opening Size < 90 μm (Typical value)

The Unit 14 Geocomposite Drainage Net must be demonstrated to remain stable under a sustained normal stress of 500 kPa.



The following table shows the testing requirements for this material.

Table 9: Material Testing Requirements for Unit 14 – Geocomposite Drainage Net
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		Frequency		
Property	Test method	Source approval	As-delivered	
Thickness	AS 3706.1 / ISO 9863 / ASTM D-5199-01 / EN 964-1	Two tests per source	One test per 2 rolls used on site	
Mass	AS3706.1 / ISO 9864 / ASTM D-5261-92 / EN 965	Two tests per source	One test per 2 rolls used on site	
Tensile strength	AS3706.2 / ISO 10319 / ASTM 4595-01	Two tests per source	One test per 3,000 m ² geocomposite material placed on site	
Elongation at peak	AS3706.2 / ISO 10319 / ASTM 4595-01	Two tests per source	One test per 3,000 m ² geocomposite material placed on site	
Hydraulic flow rate20 kPa stress200 kPa stress	AS 3706.10 / D-4716-01 / ISO-12958	Two tests per source for each stress level	One test per 10,000 m ² geocomposite material placed on site (200 kPa stress only)	
Hydraulic Flow Rate Reduction Factor for Creep (500 kPa normal stress)	extended AS 3706.10 / D- 4716-01 / ISO-12958	One test per source	Not required	
Ply Adhesion	ASTM D7005	Two tests per source	One test per 1,500 m ² geocomposite material placed on site Inspect and document each roll used onsite to confirm requirement for no unbonded areas	
Geotextiles				
- Mass per unit area	AS3706.1 / ISO 9864 / ASTM D-5261-92	Two tests per side per source	One test per side per 1,500 m ² geocomposite material placed	
- Opening size	AS 3706.7 / D-4751-95 / ISO 12956	Two tests per side per source	One test per side per 25,000 m ² geocomposite material placed (1 test per side minimum)	

2.2.14 Unit 15 – LLDPE Geomembrane

Unit 15 –Linear Low Density Polyethylene (LLDPE) Geomembrane with a nominal thickness of 1.5 mm for the piggy back liner system shall have the following properties:

- Thickness >1.45mm (minimum average roll value, MARV)
- LLDPE product density < 0.939 g/cm³ (MARV)
- Base resin: density > 0.915 g/cm³ and < 0.926 g/cm³; melt flow index < 1.0 g/10min
- Product textured on both sides with asperity height > 0.25mm (MARV)
- Tensile strength at break > 16 kN/m (MARV)
- Elongation at break > 250% (MARV)
- Modulus at 2% strain < 630 kN/m (max)

- Tear resistance > 150N (MARV)
- Puncture resistance > 300 N (MARV)
- Axi-symmetric break resistance strain > 30% (min)
- Oxidative Induction Time (OIT):
 - > 100 minutes at standard pressure (MARV); and
 - > 400 minutes at high pressure (MARV)
- Oven aging at 85°C for 90 days:
 - OIT retained > 35% at standard pressure (MARV); and
 - OIT retained > 60% at high pressure (MARV)
- Interface Shear Strength Requirements Refer to Section 2.2.18.

Interface Shear Strength: The minimum interface shear strength requirements given in Section 2.2.18 apply to the performance of combinations of Unit 12, Unit 14, Unit 15, Unit 16 and Unit 17 materials comprising the base and piggy back lining systems. The Contractor's attention is drawn to the requirement for each material to meet its individual requirements and also for the combined lining system materials to meet interface shear strength requirements.

The following table shows the testing requirements for this material

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rable	10: Ma	terial	resting	Requiren	nents for	Unit 15	- rexturea	LLUPE	Geomembra	ane

		Frequency		
Geomembrane Property	Test Method	Source approval	As-delivered	
Thickness	ASTM D 5994		One test per roll	
Density	ASTM D1505		One test per manufacture batch	
Melt Flow Index	ASTM D 1238		One test per manufacture batch	
Asperity Height (both sides)	GM12	Two tests per manufacture	Second roll or each roll if not in production sequence (measure at three to five locations across roll width)	
Tensile Properties (each direction) - Strength at break - Elongation at break	ASTM D6693	source	One test for each property per roll	
2% Modulus	ASTM D5323		One test per roll	
Tear Resistance	ASTM D1004		One test per roll	
Puncture Resistance	ASTM D4833		One test per roll	
Axi-Symmetric Break Resistance Strain	ASTM D 5617		Not required	



	Test Method	Frequency		
Geomembrane Property		Source approval	As-delivered	
Oxidative Induction Time (OIT)			One test for each	
Standard OIT	ASTM D 3895		property per resin type or per 25,000 m^2 of	
High Pressure OIT	ASTM D 5885		geomembrane	
Oven Aging at 85°C for 90 days	ASTM D 5721			
Standard OIT	ASTM D 3895		manufacture batch, or per geomembrane type	
- High Pressure OIT	ASTM D 5885			

2.2.15 Unit 16 – HDPE Geomembrane

Unit 16 –High Density Polyethylene (HDPE) Geomembrane with nominal thickness of 2 mm shall have the following properties:

- Thickness > 1.9mm (minimum average roll value, MARV)
- density > 0.94 g/cm^3 (MARV)
- Base resin: density > 0.932 g/cm³; melt flow index < 1.0 g/10min
- Product textured on both sides with asperity height > 0.25 mm (MARV)
- Tensile strength at yield > 29 kN/m (MARV)
- Elongation at yield > 12% (MARV)
- Tear resistance > 249 N (MARV)
- Puncture resistance > 534 N (MARV)
- Oxidative Induction Time (OIT):
 - > 100 minutes at standard pressure (MARV); and
 - > 400 minutes at high pressure (MARV)
- Oven aging at 85°C for 90 days:
 - OIT retained > 55% at standard pressure (MARV); and
 - OIT retained > 80% at high pressure (MARV)
- Stress Cracking Resistance (performed on smooth portion of sheet) > 300hr (Typical value)
- Interface Shear Strength Requirements Refer to Section 2.2.18.

The following table shows the testing requirements for this material.

Table 11: Material Testing Requirements for Unit 16–Textured HDPE Geomembrane

Property		Frequency		
Topony	Test Method	Source approval	As-delivered	
Thickness	ASTM D 5994		One test per roll	
Density	ASTM D 1505		One test per manufacture batch	
Melt Flow Index	ASTM D 1238		One test per manufacture batch	
Asperity Height	GM12		Every second roll or each roll if not in production sequence (measure at three to five locations across roll width)	
Tensile Properties (each direction) - Strength at yield - Elongation at yield	ASTM D 6693	Two tests per	One test for each property per roll	
Tear Resistance	ASTM D 1004	manufacture	One test per roll	
Puncture Resistance	ASTM 4833	source	One test per roll	
Oxidative Induction Time (OIT) - Standard OIT - High Pressure OIT	ASTM D 3895 ASTM D 5885		One test for each property per resin type or per 25,000 m ² of geomembrane	
Oven Aging at 85°C for 90 days - Standard OIT - High Pressure OIT	ASTM D 5721 ASTM D 3895 ASTM D 5885		One test per resin type, manufacture batch, or per geomembrane type	
Environmental Tensile Load Crack Resistance	ASTM D 5397		One test per resin type, manufacture batch, or per geomembrane type	

Interface Shear Strength: The minimum interface shear strength requirements given in Section 2.2.18 apply to the performance of combinations of Unit 12, Unit 14, Unit 15, Unit 16 and Unit 17 materials comprising the base and piggy back lining systems. The Contractor's attention is drawn to the requirement for each material to meet its individual requirements and also for the combined lining system materials to meet interface shear strength requirements.

2.2.16 Unit 17 – Geosynthetic Clay Liner (GCL)

Unit 17 – Geosynthetic Clay Liner shall be a reinforced multi-layered system comprising at least two layers of geotextile encapsulating a layer of dry, sodium bentonite. The outer geotextile on both sides shall be nonwoven. The GCL shall be reinforced by needle punching and be free of broken needles.

The bentonite layer in the GCL shall have the following characteristics:

- form: natural sodium bentonite or >80% sodium as activated bentonite
- carbonate content < 1 to 2% (by weight)</p>

- montmorillonite content > 70% (by weight)
- particle size: if powdered >80% passing 0.075mm sieve; if granulated <1% passing 0.075mm
- cation exchange capacity > 70 meq/100g

The GCL material shall have the following properties:

- Total mass (dry) > 4000 g/m²;
- Bentonite clay:
 - Bentonite mass (dry) > 3700 g/m²;
 - Swell index > 24 ml/2g
- Fluid loss < 18 ml</p>
- Tensile strength > 4 kN/m
- Peel strength > 360 N/m
- Permeability: k < 5 x 10⁻¹¹ m/s tested at 100kPa effective confining stress
- Internal and Interface Shear Strength Requirements Refer to Section 2.2.18

Interface Shear Strength: The minimum interface shear strength requirements given in Section 2.2.18 apply to the performance of combinations of Unit 12, Unit 14, Unit 15, Unit 16 and Unit 17 materials comprising the base and piggy back lining systems. The Contractor's attention is drawn to the requirement for each material to meet its individual requirements and also for the combined lining system materials to meet interface shear strength requirements

Geotextiles component of the GCL shall have the following property:

- The outer geotextile on both sides is nonwoven
- Mass of nonwoven geotextile > 200 g/m²
- Mass of woven geotextile (if any) > 100 g/m².

The following table shows the testing requirements for this material.

Table 12: Material Testing Requirements for Unit 17 - GCL

		Frequency		
Property	Test Method	Source approval	As-delivered	
Bentonite Clay: - Swell Index - Fluid Loss	ASTM D5890 ASTM D5891	Two tests per manufacture source	Manufacturer certification for each batch represented	
Total Mass (dry)	DIN 53854		One test per 2 rolls used on site	
Bentonite Mass (dry)	ASTM D 5393		One test per 2 rolls used on site	
Tensile Strength	ASTM D 4595		One test per 2 rolls used on site	
Peel Strength	ASTM D 6496		One test per 2 rolls used on site	
Permeability (using 100kPa effective confining stress)	ASTM D 5887		One test per 25,000 m ² of GCL installed at site, minimum 3 tests total	



2.2.17 Unit 18 – Geogrid

Unit 18 – Geogrid shall have a minimum long-term multiaxial tensile stiffness of 500 kN/m at a tensile strain of 5%. The multiaxial stiffness value is to reflect the average value when the stiffness is assessed in four principal directions in the plane of the material, being MD (machine direction), XMD (cross machine direction), and the two diagonal directions between the MD and XMD. Geogrid shall be a single layer of material. Multiple layers may be considered if Contractor proposes acceptable alternate installation measures to those in Sections 4.7 and 4.14.

The stiffness reduction factors for long-term loading shall be based on an appropriate test method, to be nominated by the geogrid manufacturer and accepted by the Superintendent, to account for a 100-year design life and the effects of construction damage, tensile creep, and environmental degradation in a buried environment with potential exposure to leachate.

Note: Tensile stiffness calculated as the tensile load estimated to induce 5% strain in the long-term divided by 0.05 (i.e. 5%).

The following table shows the testing requirements for this material.

Table 13: Material Testing Requirements for Unit 18 - Geogrid

Bronorty	Test method	Frequency			
Froperty	Test method	Source approval	As-delivered		
Tensile strength at 5% elongation (measured in MD and XMD)	ISO 10319	Two tests per source	One test per 5,000 m ² geogrid material placed on site		
Tensile strength at 5% elongation (measured in 4 principal directions)	ISO 10319	Two tests per source	One test per 5,000 m ² geogrid material placed on site		
Evaluate stiffness reduction factors for long-term loading	refer above text	One test per source	not required if manufacturer provides acceptable data		

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2.2.18 Lining System Shear Strength Requirements

Source Approval: The Contractor must include direct shear test results (ASTM D5321) in the submittal for Unit 12, Unit 14, Unit 15, Unit 16, and Unit 17 source approval that demonstrates that the lining systems will achieve the required shear strengths for the test conditions defined in the table below.

No.	Lining System	Required Minimum Equivalent Shear Strength Parameters	Direct Shear Test Cross Section	Direct Shear Test Conditions	
A	Piggy Back Lining in Tender Package 2	Peak Strength: Φ'= 17º, c'= 0 kPa Residual Strength: Φ'= 7º, c'= 0 kPa	 lightly compacted sand to represent an initial lift of Unit 9 – Protection Material; specific geocomposite proposed by the Contractor as Unit 14 – Geocomposite Drainage Net; specific 1.5mm thick textured geomembrane proposed by the Contractor as Unit 15 –LLDPE Geomembrane; specific GCL proposed by the Contractor as Unit 17 – GCL; compacted clayey soil (95% standard compaction at +2% above optimum moisture) to represent the compacted Unit 4 – Clay Rich Material below the GCL. 	 Normal stress = 100, 300, and 500 kPa; Shear rate = 0.1 mm/min; Total shear displacement > 75mm Test specimen configuration: no pre-determined shear surface – test to allow shearing to occur in actual weakest interface or material; Hydration and Consolidation: Apply low normal stress (7-14 kPa) to the test specimen and, while maintaining the normal stress, soak in tap water for 48 hours to allow GCL and soils to hydrate. Load the specimen at a constant rate to the test normal stress over a period of 24 to 48 hours to allow consolidation. Shear the hydrated and consolidated specimen. Provide information on shear response and shear plane location. 	
В	Piggy Back Lining in Tender Package 2 – Upper Components at Low Confining Stress	Peak Strength: Φ'= 30° , c'= 0 kPa Residual Strength: Φ'= 25° , c'= 0 kPa	 lightly compacted sand to represent an initial lift of Unit 9 – Protection Material; specific geocomposite proposed by the Contractor as Unit 14 – Geocomposite Drainage Net; specific 1.5 mm thick textured geomembrane proposed by the Contractor as Unit 15 –LLDPE Geomembrane; rigid substrate. 	 Normal stress = 5, 10 kPa; Shear rate = 1 mm/min; Total shear displacement > 75mm; Test specimen configuration: no pre-determined shear surface – test to allow shearing to occur in actual weakest interface or material; Provide information on shear response and shear plane location. 	

Table 14: Lining System Shear Strength Requirements



No.	Lining System	Required Minimum Equivalent Shear Strength Parameters	Direct Shear Test Cross Section	Direct Shear Test Conditions
С	Cell Base Lining in Tender Package 2	Peak Strength: Φ'= 19º, c'= 0 kPa Residual Strength: Φ'= 14º, c'= 0 kPa	 specific gravel proposed by the Contractor as Unit 7 Drainage Aggregate; specific geotextile proposed by the Contractor as Unit 12 – Cushion Geotextile; or representative non-woven, needle-punched geotextile with mass per unit area >540 g/m²; specific 2.0 mm thick textured geomembrane proposed by the Contractor as Unit 16 –HDPE Geomembrane; specific GCL proposed by the Contractor as Unit 17 GCL; compacted clayey soil (95% standard compaction at +2% above optimum moisture) to represent the compacted Unit 4 – Clay Rich Material below the GCL. 	same as test no. A, except ■ Normal stress = 100, 200, and 300 kPa;

As Delivered: The Contractor must perform direct shear tests (ASTM D5321) on as-delivered geosynthetic and soil materials to demonstrate that the lining systems will achieve the required shear strengths for the test conditions defined in the table above.

- Piggy Back Lining: Sampling and testing for the as-delivered piggy back lining (both type A and B tests) must be performed once during the construction of the piggy back lining for Package 2.
- Cell Base Lining: Sampling and testing for the as-delivered cell base lining (type C tests) must be performed at two separate times during the construction of the cell base lining for Package 2.



2.2.19 Not Used

Not used.

2.2.20 Unit 21 – Gas Collection Pipe

Unit 21 – Gas Collection Pipe shall comprise 110 mm diameter rating PN 12.5, HDPE (PE 100 material class) pipe with SDR 13.6 or approved equivalent.

Where the pipes are required to be perforated, the pipes shall be drilled in accordance with the detail pattern shown on the design drawing. All drill cuttings, including loose attachments and burrs, shall be removed from the perforated pipes before installation.

The pipe shall have perforations of 15 mm diameter as shown on design drawing.

All connections and fittings for the pipes shall be manufactured from the same material and strength class as the pipe, and shall be solid wall units. All ends of the pipes shall be capped with HDPE caps.

Pipe joins shall be carried out using full face fusion bonding. No filter sock shall be used.

Material property certificates from the manufacturer shall be submitted for approval for each source of material prior to construction.

The Contractor shall provide the Superintendent with manufacturer's documentation certifying the properties of the material for each manufacture batch used on site.

2.2.21 Unit 22 – Groundwater Drainage Pipe – Not used

Not used for Tender Package 2.

2.2.22 Unit 23 – Leachate Collection Pipe

Unit 23 – Leachate Collection Pipe shall have the diameter indicated below.

- Type 1: 160 mm diameter
- Type 2: 315 mm diameter
- Type 3: 355 mm diameter

Types 1, 2 and 3 Unit 23 – Leachate Collection Pipe shall all comprise HDPE (PE 100 material class) pipe rating PN 12.5, with SDR 13.6 or approved equivalent.

Where the pipes are required to be perforated, the pipes shall be drilled in accordance with the detail pattern shown on the design drawing. All drill cuttings, including loose attachments and burrs, shall be removed from the perforated pipes before installation.

The pipe shall have perforations of 15 mm diameter as shown on design drawing.

All connections and fittings for the pipes shall be manufactured from the same material and strength class as the pipe, and shall be solid wall units. All angled connections and fittings shall have sweeping bends unless agreed otherwise by the Superintendent. All ends of the pipes shall be capped with HDPE caps.

Pipe joins shall be carried out using full face fusion bonding. No filter sock shall be used.

Material property certificates from the manufacturer shall be submitted for approval for each source of material prior to construction.

The Contractor shall provide the Superintendent with manufacturer's documentation certifying the properties of the material for each manufacture batch used on site.





2.2.23 Unit 24 – Leachate Sump Outlet Pipe

Unit 24 – Leachate Sump Outlet Pipe shall have the diameter indicated below.

- Type 1: 400 mm diameter
- Type 2: 355mm diameter

Types 1 and 2 Unit 24 – Leachate Sump Outlet Pipe shall both comprise HDPE (PE 100 material class) pipe rating PN 6.3, with SDR 26 or approved equivalent.

The pipes shall be solid wall pipes.

All connections and fittings for the pipes shall be manufactured from the same material and strength class as the pipe, except where indicated otherwise on the Design Drawings, and shall be solid wall units.

Pipe joins shall be carried out using full face fusion bonding.

Material property certificates from the manufacturer shall be submitted for approval for each source of material prior to construction.

The Contractor shall provide the Superintendent with manufacturer's documentation certifying the properties of the material for each manufacture batch used on site.

2.2.24 Unit 25 – Leachate Drainage Pipe

Unit 25– Leachate Drainage Pipe shall comprise 315 mm diameter rating PN 16, HDPE (PE 100 material class) pipe with an SDR 11 or approved equivalent.

The pipes shall be solid wall pipes.

All connections and fittings for the pipes shall be manufactured from the same material and strength class as the pipe, except where indicated otherwise on the Design Drawings, and shall be solid wall units.

Pipe joins shall be carried out using full face fusion bonding.

Material property certificates from the manufacturer shall be submitted for approval for each source of material prior to construction.

The Contractor shall provide the Superintendent with manufacturer's documentation certifying the properties of the material for each manufacture batch used on site.

2.2.25 Unit 26 – Subsoil Drainage Pipe – Not Used

Not used for Tender Package 2.

2.2.26 Unit 27 – Leachate Sump Riser

Unit 27 – Leachate Sump Riser shall be 2500 mm ID (internal diameter) precast concrete pipe with step irons and frame/cover (Class M). The riser shall be manufactured in accordance with AS 4198:1994.

The riser shall incorporate an integral base section to minimise base leakage risk. The riser shall have additional features as indicated on the Design Drawings.

The Contractor shall provide the Superintendent with manufacturer's documentation certifying the properties of the material for each riser component or section.

2.2.27 Unit 28 – Leak Detection Pipe

Unit 28 – Leak Detection Pipe shall comprise 125 mm diameter rating PN 16, HDPE (PE 100 material class) pipe with SDR 11 or approved equivalent.





Where the pipes are required to be perforated, the pipes shall be drilled in accordance with the detail pattern shown on the design drawing. All drill cuttings, including loose attachments and burrs, shall be removed from the perforated pipes before installation.

Note: Unit 28 pipe shall have perforations of 10 mm diameter. This value is less than the value of 15 mm shown on the design drawing and applies to Unit 28 only. All connections and fittings for the pipes shall be manufactured from the same material and strength class as the pipe, and shall be solid wall units.

Pipe joins shall be carried out using full face fusion bonding.

Material property certificates from the manufacturer shall be submitted for approval for each source of material prior to construction.

The Contractor shall provide the Superintendent with manufacturer's documentation certifying the properties of the material for each manufacture batch used on site.

2.2.28 Not Used

Not used.

2.2.29 Not Used

Not used.

2.2.30 Unit 31 – Bentonite

Unit 31 - Bentonite pellets shall be nominal 6 mm, compressed dry bentonite pellets of a type used for sealing boreholes and monitoring wells. The bentonite shall have a swell index of at least 15 mL / 2g.

Material property certificates from the manufacturer shall be submitted for approval for each source of material prior to construction.

The Contractor shall provide the Superintendent with manufacturer's documentation certifying the properties of the material for each manufacture batch used on site.

2.2.31 Unit 32 – Rip Rap Armourstone and Aggregate for Gabion Baskets and Wire Mattresses

Unit 32 - Rip Rap shall be used to protect the diversion drains and provide rock for the gabions and mattresses.

The following standards shall apply:

- AS 2758.6-2008 Aggregates and Rock for Engineering Purposes; Part 6: Guidelines for the Specification of Armourstone
- AS 2758.4-2000 Aggregates and Rock for Engineering Purposes; Part 4: Aggregate for Gabion Baskets and Wire Mattresses.

The rip rap, gabion and mattress aggregates shall meet the specification provided in Table 15: .



Property	d₅₀ =300 mm Rip Rap	d₅₀ =150 mm Rip Rap	d₅₀ =190 mm Gabion Rock	Test Method				
Layer Thickness	600 mm (2d ₅₀)	300 mm (2d ₅₀)	-	-				
Gradation								
Maximum d ₁₀₀ Particle Size	450 mm	230 mm	250 mm	-				
Nominal d ₈₅ Size	360 mm	180 mm	-					
Nominal d ₅₀ Size ¹	325 mm	150 mm	190 mm	-				
Nominal d ₁₅ Minimum Particle Size	180 mm	90 mm	120 mm	AS 1289				
Material Requirements								
Point Load Strength	> 2MPa	> 2MPa	> 2MPa	AS 4133				
Water absorption	< 2.5%	< 2.5%	< 2.5%	AS 1141				
Sodium Sulfate Soundness	< 9% (weighted average loss)	< 9% (weighted average loss)	< 9% (weighted average loss)	AS 1141				

Table 15: Rip Rap Armourstone and Aggregate for Gabion Baskets and Wire Mattresses Properties

TECHNICAL SPECIFICATION - NEW LANDFILL CELL

Note: $1.d_{50}$ size is the particle size of the riprap for which 50% by weight is finer

2.2.32 Unit 33 – Granular Material for Concrete Pipe Installation – Not Used

Not used for Tender Package 2.

2.2.33 Unit 34 – Rock Filled Gabions and Mattresses

Unit 34 – Rock Filled Gabions and Mattresses shall conform to the materials per the specification below and the Design Drawings.

The following specification and their related documents shall apply:

 New South Wales Roads & Maritime Services QA Specification R55 Rock Filled Gabions and Mattresses

2.2.34 Unit 35 – Drain Liner – Not Used

Not used for Tender Package 2.

2.2.35 Unit 36 – Precast Reinforced Concrete Box Culverts (RCBC) and Headwalls

Unit 36 – Precast Reinforced Concrete Box Culverts (RCBC) and Headwalls shall consist of Humes Class 2415 Large Box Culverts and corresponding steel reinforced box culvert headwall or approved equivalents. Unit 36 components shall conform to the materials per the specification below and the Design Drawings.

The following specification and their related documents shall apply:

AS 1597.2 Precast reinforced concrete box culverts - Large culverts

This includes the bed zone materials and side zone materials as defined in Table 6.1 and 6.2, respectively, in Section 6 of the standard.

Source approval for bed zone materials and side zone materials will primarily require the Contractor to identify the source, describe the material, provide two representative gradation test results (AS1289.C6.1), provide two representative plasticity index test results for the fraction passing 0.075 mm (AS1726), and, for import material, provide an acceptable VENM/ENM classification.




Confirmation of the properties of as-delivered bed zone materials and side zone materials shall be by Contractor inspection and documentation of each incoming load, and by sampling and gradation and plasticity index testing of the fraction passing 0.075 mm at a frequency of at least one testing event per 1,000 m³ of material placed, with a minimum of one testing event per source.

Note: Cement slurry fill with a compressive strength in the range 3 MPa to 5 MPa may be used as side zone material as an alternative to the above.

2.2.36 Unit 37 – Precast Reinforced Concrete Pipes (RCP) – Not Used

Not used for Tender Package 2.

2.2.37 Unit 38 – Channel Liner - Not Used

Not used for Tender Package 2.





3.0 SECTION 3 – CONSTRUCTION MANAGEMENT

3.1 General Management

Construction shall be achieved in compliance with the Contractor's site management plans prepared in accordance with contract requirements.

3.1.1 Stockpile Management

The Contractor will manage stockpiles in accordance with the requirements of the Contractor's CEMP for the project. There must be no unacceptable impact to the site as a result of stockpiling.

As a minimum, the following requirements must be met by the Contractor:

- All stockpiles must be managed to minimise the generation of dust;
- All stormwater must be managed in the vicinity of the stockpiles to minimise the volume of water coming into contact with the stockpiles; and
- Runoff from all stockpiles, other than contaminated material or waste stockpiles, shall be managed in the same way as other stormwater on the site according to the Contractor's CEMP.

Upon completion of the use of an area for stockpiling, the Contractor shall:

- Remove all remaining stockpiled material for reuse or placement in accordance with this Technical Specification; and
- The reinstated stockpile area is to be assessed by the Contractor to the satisfaction of the Superintendent to ensure that no waste materials remain.

3.1.2 Water Management during Construction

3.1.2.1 Surface Water

The Contractor shall manage surface water within the construction site in accordance with the CEMP, and approved surface water management plan. The surface water drainage system on site includes clean and dirty (i.e., potentially sediment-laden) water drains. The surface water collected from the construction area shall be discharged to the dirty water drainage system of the site.

The Contractor shall divert surface run-on to the construction area, and must prevent uncontrolled discharge of water originating in the construction area to the site surface water drainage system.

The Contractor shall ensure that his operations do not result in chemical contamination of surface waters.

The Superintendent (site owner) will be responsible for management of the existing major surface water ponds at the Whytes Gully site, surface water treatment, and controlled discharges from the ponds.

3.1.2.2 Leachate

The Contractor will be responsible for maintaining delivery of leachate in the existing leachate collection system in the Western Gully Landfill to designated points during all stages of cell base and piggyback liner construction. The Contractor shall install temporary sumps, pumps and pumping lines as needed to meet these requirements. All temporary items must comply with the CEMP and be acceptable to the Superintendent. Requirements for connection of existing leachate collection pipes are given in Section 4.3.

The Superintendent (site owner) will be responsible for management of leachate at the designated delivery points and for management of the existing leachate ponds, leachate treatment, and leachate discharge to sewer.





3.1.2.3 Dewatering

The Contractor shall manage, at his cost, any waters arising from groundwater dewatering activities in accordance with the CEMP and Contract requirements. Management requirements are likely to depend on water quality and quantity. In regard to the potential to transfer water arising from groundwater dewatering activities into the existing site surface water management and/or leachate management systems, any such transfer would be at the discretion of the Superintendent (site owner) and would depend on water quality and quantity and the capacity of the systems at the time.

3.2 Construction Quality Management

The Construction Quality Management system for construction comprises Contractor requirements and Superintendent actions. Contractor requirements include preparing management plans, preparing work method statements, material testing, compaction testing (through GITA), surveying, notifying for Inspection Points, and preparing Hold Point documentation and works-as-executed (WAE) documentation. Superintendent actions include review and approval of Contractor submittals and documentation, inspecting construction works, conducting audit testing, attending Inspection Points, and releasing Hold Points. Superintendent actions are typically referred to as Construction Quality Assurance (CQA).

A description of the approach for quality management of material properties is provided in Section 2.1.2, including description of approval of material sources, confirmation of as-delivered material properties, and audit testing. Details of material requirements and testing requirements are given in Chapter 2 of this document. For example, as indicated in Section 2.1.4, all material test results submitted to the Superintendent by the Contractor must be from a laboratory with NATA-accreditation for all tests performed; and all survey results submitted to the Superintendent by the Contractor must be from a registered surveyor.

Quality management requirements to be implemented by the Contractor during construction activities are given in the following chapter of this document.





4.0 CONSTRUCTION ACTIVITIES

4.1 Subgrade Preparation

Subgrade preparation by the Contractor comprises vegetation removal (refer Section 1.5.1) followed by cutting and filling to establish the subgrade surface shown in the Design Drawings. For the subgrade surface in the current work (i.e. Tender Package 2) the maximum design cut depth below the existing surface is approximately 3.0 m, occurring in the cell base liner area. The maximum design cut depth below the existing surface in the piggy back area is approximately 1.5 m, occurring on the Western Gully landfill (refer Section 4.1.3.1). The maximum design fill thickness is approximately 3.5 m, occurring at an existing pond in the cell base liner area (refer Section 4.1.3.2).

The Contractor shall provide a Work Method Statement presenting proposed methods for subgrade preparation activities, including cutting, filling, proof rolling, and undercutting and replacement and all items described below. The Work Method Statement must address safety, including issues related to working on steeply sloping areas of the site. Submission of the work method statement constitutes a HOLD POINT. These activities shall not commence until the Hold Point is released.

4.1.1 Cutting

Cutting is required in some areas to establish the subgrade surface. Rock excavation may be required in local areas. The Design Report contains general information on subsurface conditions and references to documents with more detailed subsurface information.

Dewatering (groundwater) may be required in some areas to facilitate excavation. The Design Report contains general information on hydrogeological conditions and references to documents with more detailed information. Contractor requirements for managing waters arising from dewatering are provided in Section 3.1.2.3.

The base of all excavations shall be proof rolled to identify soft materials that would form an unsuitable surface for fill placement or landfill base/liner construction. Remove and replace any such materials with Unit 2 – General Fill as per Section 4.2. Proof rolling of the soil/fill surface in each local area and/or removal of any unsuitable materials constitutes an INSPECTION POINT. The Contractor is required to provide 24 hour notice before commencing or recommencing this activity.

Existing service trenches may be present (refer Section 1.5.2 and Section 4.3). Any trenches that are identified to extend below the base of the excavation shall be fully excavated and then backfilled with Unit 2 – General Fill as per Section 4.2. Trench excavation and backfilling constitutes an INSPECTION POINT. The Contractor is required to provide 24 hour notice before commencing or recommencing this activity.

Over-excavation: The Contractor shall not excavate deeper than the subgrade surface. Any excavation deeper than the subgrade surface, not including any additional depth required for removal of unsuitable materials or existing service trench backfill (refer preceding paragraphs), shall be deemed Contractor over-excavation. If over-excavation occurs, the Contractor shall perform, at his cost, all activities required to safely manage any excess dewatering and excess cut materials in accordance with the CEMP and Contract requirements. The Contractor shall also be responsible for all costs associated with reinstatement of over-excavated areas with Unit 2 – General Fill as per Section 4.2. The Contractor's attention is drawn in particular to potential consequences of over-excavation in previously landfilled areas.

All excavated materials from above the subgrade surface are to be stockpiled by the Contractor in designated areas, and in accordance with the CEMP and Contract requirements, for future use by the site owner. The Contractor shall not re-use the excavated materials.

4.1.2 Filling

Filling is required in some areas to establish the subgrade surface. In these areas, the ground surface present after vegetation removal (refer Section1.5.1) shall be proof rolled to identify soft materials that would form an unsuitable surface for fill placement or landfill base/liner construction. Remove and replace any such materials with Unit 2 – General Fill as per Section 4.2.





Proof rolling of the surface in each local area and/or removal of any unsuitable materials constitutes an INSPECTION POINT. The Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

Existing service trenches may be present (refer Section 1.5.2 and Section 4.3). Any trenches that are identified within the fill area shall be fully excavated and then backfilled with Unit 2 – General Fill as per Section 4.2. Trench excavation and backfilling constitutes an INSPECTION POINT. The Contractor is required to provide 24 hours notice before commencing or recommencing this activity. After the proof rolling, removal/replacement, and trench backfilling activities described in the preceding paragraphs are complete, then Unit 2 – General Fill material shall be placed to achieve subgrade levels as per Section 4.2, except that the minimum degree of compaction shall be <u>98%</u> of SMDD rather than 95% of SMDD.

4.1.3 Subgrade in Specific Areas

Subgrade preparation in specific work areas has requirements in addition to those given above. These additional requirements are presented below.

4.1.3.1 Western Gully Landfill Batter - General

Subgrade preparation for the existing Western Gully Landfill batter (i.e., previously landfilled area) requires excavation of cover materials to a depth of up to 1.5 m on the existing surface.

If landfill waste materials, not including small amounts of waste within the cover material, are encountered then the Contractor shall limit excavation depth to remain above the landfill waste materials and shall notify the Superintendent and take appropriate actions in accordance with the CEMP and Contract requirements.

- Over-excavation: The Contractor shall not excavate deeper than the design subgrade surface. Consequences of over-excavation are discussed in Section 4.1.1.
- Surface Suitability: The suitability of the prepared subgrade surface for placement of the Base Layer for the piggy back liner is addressed in Section 4.7.
- No Re-use: All excavated materials from above the subgrade surface are to be stockpiled by the Contractor in designated areas, and in accordance with the CEMP and Contract requirements, for future use by the site owner. Stockpiles of excavated cover materials shall be separated from stockpiles of excavated soils from non-landfilled areas. The Contractor shall not re-use the excavated materials.

The Contractor's Work Method Statement for subgrade preparation (refer Section 4.1) must reflect the above requirements for the existing landfill batter.

4.1.3.2 Filling of Former Surface Water Ponds

The former surface water ponds at the south of the Western Gully require filling of up to approximately 3.5 m thickness to establish design subgrade levels.

Fill placement in this area will be with Unit 2 – General Fill and subject to the requirements given in Section 4.1.2, with the following additions:

- Prior to proof-rolling, any sediments that have accumulated in the bottom of the pond shall be removed and managed in accordance with the CEMP and Contract requirements. Sediment removal constitutes an INSPECTION POINT. The Contractor is required to provide 24 hour notice before commencing or recommencing this activity.
- The need for proof-rolling after sediment removal will be determined by the Superintendent.

The Contractor's Work Method Statement for subgrade preparation (refer Section 4.1) must reflect the above requirements for this fill area.





4.1.4 Survey and Documentation

The Contractor shall survey final subgrade levels to provide works-as-executed (WAE) drawings and to demonstrate that the design levels have been achieved. The survey shall be conducted on an approximate 10m grid with additional survey points along the benches and at the leachate sumps. WAE drawings shall include surveyed locations and dimensions of soft areas identified during proof rolling and of any backfilled service trenches. WAE drawings shall also include information required for subgrade leachate pipe construction and landfill gas venting system construction (refer Sections 4.3 and 4.4). The Contractor shall submit the WAE drawings, and an accompanying analysis demonstrating compliance with design levels.

The Contractor shall also submit the items listed below as part of his WAE documentation:

- GITA certification statements for all fill placement and compaction, reflecting the requirements for Unit 2 – General Fill in Section 4.2.
- WAE report including description of the completed work, summary of construction materials and time periods of construction, applicable Work Method Statements, RFI records (if any), Contractor quality system records, and Hold and Inspection point documentation.

Submission of these items constitutes a HOLD POINT. Construction of the Base Layer or placement of the Bearing Layer shall not commence in an area until the Hold Point has been released for that area.

4.2 General Fill

Placement of Unit 2 - General Fill is required as part of several cell construction activities.

General Fill shall be placed with maximum 300 mm thick layers and compacted with suitable compaction equipment to achieve a minimum of 95% of SMDD (in accordance with AS1289.5.1.1 and 5.4.1) or a minimum HILF density ratio of 95% Standard (in accordance with AS1289.5.7.1) at a moisture content within the range of -3% to +3% of the Standard Optimum Moisture Content (SOMC). A trench roller is required for any compaction within trenches.

The GITA shall provide "Level 1" supervision for material placement and moisture density testing. The frequency of field density and moisture testing during placement of all General Fill material shall as a minimum conform the following, whichever requires the most tests:

- 1 test per 500 m³ per material type; or
- 2 tests per batch of work.

If the required density and moisture is not achieved, the compacted material shall be reworked in-situ to meet the density and moisture content requirements. If the density and moisture content requirements again cannot be achieved after reworking, the failed layer shall be removed for moisture conditioning at the material borrow area or at an approved designated area, or be discarded.

Note that the required compaction standard for filling with Unit 2 – General Fill to establish subgrade design levels is 98% of SMDD, as indicated in Section 4.1.2.

4.3 Subgrade Leachate Piping

The subgrade leachate piping construction comprises the elements shown in Design Drawing D2046. These elements are to be installed below the new cell base lining system.

The Contractor shall provide a Work Method Statement presenting proposed methods for subgrade leachate piping construction activities, including details on pipe trench construction in subgrade fill versus cut areas, work staging, and all items described below. The Work Method Statement must address safety, including issues related to excavations and management of active leachate drainage. Submission of the work method statement constitutes a HOLD POINT. These activities shall not commence until the Hold Point is released.





Connection to Existing Leachate Drainage Pipes

The proposed drainage pipes from Western Gully Landfill shown in Drawing D2046 will be active with leachate/water flow. The Contractor shall connect the existing HDPE leachate pipes to new Unit 25 pipe. The contractor shall also remove the downslope portion of existing pipe within the cell base liner area and backfill the trench if below subgrade design levels (if any).

Install New Pipes and Drainage Pit

The Contractor shall install new Unit 25 and Unit 28 pipes in trenches as indicated on Design Drawings D2045 and D2046. This includes connecting to the existing Unit 25 and Unit 28 pipes in Package 1.

The Contractor shall also connect new Unit 21 gas venting pipe at the location as indicated on Design Drawing D2046.

Each connection of new and existing pipes constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

Leachate Management

During these activities, the Contractor must construct temporary leachate storage sumps, pumps and pumping lines (refer Section 3.1.2.2) as necessary to maintain leachate delivery from the existing pipes to a designated point. The Contractor shall not interrupt leachate delivery (i.e. cease leachate collection and allow leachate to accumulate in the existing landfill area) from any of the existing pipes for longer than the following time periods:

- no more than 3 continuous days;
- no more than 3 days out of any 10 day period; and
- other limitations imposed by the Superintendent based on site conditions and landfill site operations.

Survey and Documentation

Following placement and connection of pipes in each area, the Contractor shall survey all pipe alignments and inverts and submit works-as-executed (WAE) drawings demonstrating compliance with the design. Submission of this item constitutes a HOLD POINT. Construction of the bearing layer for the cell base lining system shall not commence in an area until the Hold Point has been released for that area.

The Contractor shall also submit the items listed below as part of his WAE documentation, GITA certification statements for all fill placement and compaction, reflecting the requirements for Unit 2 – General Fill in Section 4.2 and pipe Embedment Material as indicated on Design Drawing D2045.

WAE report including description of the completed work, summary of construction materials and time periods of construction, applicable Work Method Statements, RFI records (if any), Contractor quality system records, and Hold and Inspection point documentation.

4.4 Landfill Gas Venting System

Landfill gas venting trenches, comprising gravel, perforated collection pipes, and solid header pipes shall be constructed under the piggy back liner system.

The landfill gas venting trenches shall be constructed by excavation into the prepared subgrade of the piggy back liner, as shown in the Design Drawings.

Trenches shall be nominally 200 mm deep and 300 mm wide. The excavated material shall be used appropriately during further works.

The following construction sequence is required (unless alternatives are agreed with the Superintendent):



- Excavate trench;
- Partially backfill the trench with Unit 8 Gas Drainage Gravel;
- Place Unit 21 Gas Collection Pipe, make pipe connections, and backfill balance of trench; and
- Place Unit 11 Filter Geotextile above the gravel and secure in place.

Placement of gas collection pipes constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

Installation of gas header pipe and connection the gas collection pipes constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

Following placement of gas collection and header pipes in each area, and before covering the pipes, the Contractor shall survey all pipe alignments and inverts. Within 3 days of completing gas venting system construction in any area, the Contractor shall submit works-as-executed (WAE) drawings demonstrating compliance with the design. Submission of this item constitutes a HOLD POINT. Construction of the base layer shall not commence in an area until the Hold Point has been released for that area.

The Contractor shall also submit the items listed below as part of his WAE documentation,

 WAE report including description of the completed work, summary of construction materials and time periods of construction, applicable Work Method Statements, RFI records (if any), Contractor quality system records, and Hold and Inspection point documentation.

4.5 Perimeter Bund

The Contractor shall conduct a set-out survey of the alignment of the perimeter bund prior to construction and shall peg out the surveyed alignment. This constitutes a HOLD POINT. Construction of the bund shall not commence until the Hold Point has been released by the Superintendent.

The bund shall be constructed in accordance with the Design Drawings. The bund shall be constructed with Unit 4 – Clay Rich Material to form a 1-m high bund with a 4m crest width and 2H:1V side batters. As indicated in Section 2.2.4, the required gradation of the Unit 4 material in the perimeter bund differs between the main body of the bund (i.e., max. particle size 53 mm) and the inboard batter surface where the GCL will be placed (i.e., max. particle size 13.2 mm). The finished surface where the GCL will be placed shall be smooth and well-drained with no protruding coarse materials, and with additional surface requirements given in Section 4.10.3.

The Unit 4 material shall be placed and compacted in nominal 200mm thick lifts with suitable compaction equipment to achieve a minimum of 98% SMDD (in accordance with AS1289.5.1.1 and 5.4.1) or a minimum HILF density ratio of 98% Standard (in accordance with AS1289.5.7.1) at a moisture content within the range of -2% to +2% of the Standard Optimum Moisture Content (SOMC). Prior to the placement of each lift of the bund, the top of the previous lift shall be scarified and moisture conditioned if necessary to bond each lift together and prevent laminations at the lift interfaces.

Bund construction constitutes an INSPECTION POINT and the Contractor is required to provide 48 hours notice before commencing or recommencing this activity.

In addition, the GITA shall provide "Level 1" supervision for material placement and moisture density testing. If the GITA or Contractor detects material changes or variations then he shall undertake testing as necessary to assess the acceptability of the material. The frequency of field density and moisture testing during placement of the material shall as a minimum conform the following, whichever requires the most tests:

- 1 test per 400 m³ per material type; or
- 3 tests per batch of work.





If the required density and moisture is not achieved, the compacted material shall be reworked in-situ to meet the density and moisture content requirements. If the density and moisture content requirements again cannot be achieved after reworking, the failed material shall be removed for moisture conditioning at the material borrow area or at an approved designated area, or be discarded.

Upon completion of the bund, the Contractor shall maintain the integrity of the bund by limiting the traffic movement over the clay surface and maintaining the surface of the clay in a moist condition until covered by the base liner GCL and geomembrane. Should the bund surface have dried excessively (e.g. desiccation cracking>20mm depth) or wetted up excessively, as determined by the Superintendent, the affected materials shall be excavated to expose material that has moisture content within the specified tolerance. The excavated materials shall be returned to a designated area for moisture conditioning or be discarded, and the excavated bund material replaced.

Trafficked areas of the bund shall to be ripped, moisture conditioned and re-compacted if, in the opinion of the Superintendent, the quality of these areas has deteriorated.

Following bund placement, the Contractor shall survey the finished surface level to provide works-asexecuted (WAE) drawings and to demonstrate that the design geometry has been achieved. The WAE drawings shall include geosynthetic anchor trench alignments within the bunds. The Contractor shall submit the WAE drawings, an accompanying analysis demonstrating compliance with design geometry. Submission of the WAE drawings and documentation constitutes a HOLD POINT. Placement of liner materials on the surface of the berm shall not commence in an area until the Hold Point has been released for that area, and all other contractual requirements have been fulfilled.

The Contractor shall also submit the items listed below as part of his WAE documentation,

- GITA certification statements for all fill placement and compaction, reflecting the above requirements for Unit 4 – Clay Rich Material.
- WAE report including description of the completed work, summary of construction materials and time periods of construction, applicable Work Method Statements, RFI records (if any), Contractor quality system records, and Hold and Inspection point documentation.

4.6 Internal Bunds

Internal bunds between new landfill cells and sub-cells will be constructed to provide a physical barrier for each stage and sub-stage of liner construction and waste filling. The locations of internal bunds are shown on the Design Drawings.

The internal bunds shall be constructed in the same manner and with the same requirements given in Section 4.5 for the perimeter bund.

4.7 Base Layer

Base Layer construction includes placement of Unit 6 - Base Material and Unit 18 – Geogrid in the piggy back liner area, within the area bounded by the Perimeter and Internal Bunds. The Base Layer shall be constructed with Geogrid sandwiched within the Base Material to form a minimum 500 mm thick layer above the design subgrade surface.

The Contractor shall provide a Work Method Statement presenting proposed methods for base layer construction, including compaction and subgrade surface preparation, geogrid installation and joining, geogrid ballasting, and geogrid covering. The Work Method Statement must address the requirements presented in this section. Submission of the Work Method Statement constitutes a HOLD POINT. Base layer construction shall not commence until the Hold Point is released.

Base Layer construction requirements are provided below.



- a) Subgrade Surface Preparation:
 - The subgrade surface in the Base Layer area will be established on the existing landfill batters as described in Sections 4.1.3.1 and 1.1.1.1. The Contractor shall proof roll the subgrade surface in all areas 3H:1V or flatter, and perform a walkover inspection of all areas steeper than 3H:1V, to identify any areas unsuitable for Base Layer placement. The proof rolling and inspection can be modified from that used by the Contractor in other areas to reflect the design intent that landfill waste materials are expected to be present at shallow depth below the subgrade surface and will be left in place unless they exhibit extremely soft behaviour.
 - Remove and replace any extremely soft materials with Unit 2 General Fill or Unit 6 Base Material, limiting excavation to 300 mm depth unless agreed by the Superintendent. Compaction requirements for Unit 2 – General Fill shall be as per Section 4.2 and compaction requirements for Unit 6 – Base Material shall be as set out below.
 - Proof rolling and/or walkover inspection of the subgrade surface in each local area and/or removal of any unsuitable materials constitutes an INSPECTION POINT. The Contractor is required to provide 24 hours notice before commencing or recommencing this activity
- b) Base Material (Unit 6):
 - Base Material shall be placed in two lifts and compacted with suitable compaction equipment to achieve a minimum of 98% SMDD (in accordance with AS1289.5.1.1 and 5.4.1) or a minimum HILF density ratio of 98% Standard (in accordance with AS1289.5.7.1) at a moisture content within the range of -3% to +3% of the Standard Optimum Moisture Content (SOMC). Each lift shall have a compacted thickness of approximately 250 mm.
 - The GITA shall provide "Level 1" supervision for material placement and moisture density testing. The frequency of field density and moisture testing during placement of Base Material shall as a minimum conform the following, whichever requires the most tests:
 - 1 test per 250 m³ per material type; or
 - 2 tests per batch of work.

If the required density and moisture is not achieved, the compacted material shall be reworked insitu to meet the density and moisture content requirements. If the density and moisture content requirements again cannot be achieved after reworking, the failed layer shall be removed for moisture conditioning prior to recompaction.

- Base Material lower lift: Placement and compaction of the lower lift of Base Material shall include surface preparation to present a surface suitable for Unit 18 – Geogrid installation.
- Base Material upper lift: Following the installation of Unit 18 Geogrid, the upper lift of Unit 6 Base Material shall be placed and spread on top of the geogrid using a method that will not disrupt geogrid alignment and overlaps and will cause minimal damage to the geogrid. Placement and spreading of Base Material on top of Geogrid constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity. The Base Material shall be compacted using a method that will not damage the underlying geogrid.
- c) Geogrid (Unit 18): Geogrid shall be installed on the prepared surface of the lower lift of Base Material as outlined in Section 4.14. The prepared surface with geogrid installation in each area shall constitute a HOLD POINT. The upper lift of Base Material shall not be placed in the area until the Hold Point has been released by the Superintendent
- d) Additional Items:



Cross-slope Leachate Collection Pipes: The upper surface of the Base Layer shall be locally modified at the alignment of cross-slope leachate collection pipes (refer Design Drawing D2041) to provide a narrow bench to facilitate pipe installation. Each narrow bench shall be 1.5 m wide (min.) with at least a 2% down-slope fall and 2% cross-slope fall as indicated in Design Drawing D2044.

Survey and documentation requirements for the Base Layer are provided below.

The Contractor shall survey the finished surface of the Base Layer to provide works-as-executed (WAE) drawings and to demonstrate, by comparison to the WAE drawings of the subgrade surface, that the design thickness for the Base Layer has been achieved. The survey shall be conducted on an approximate 10 m grid with additional survey points at benches and leachate pipe alignments. The Contractor shall submit the WAE drawings and an accompanying analysis demonstrating compliance with the design thickness.

The Contractor shall also submit the items listed below as part of his WAE documentation,

- GITA certification statements for all fill placement and compaction, reflecting the above requirements for Unit 6 – Base Material.
- WAE report including description of the completed work, summary of construction materials and time periods of construction, applicable Work Method Statements, RFI records (if any), Contractor quality system records, and Hold and Inspection point documentation.

Submission of these items constitutes a HOLD POINT. Placement of the Bearing Layer shall not commence in an area until the Hold Point has been released for that area.

4.8 Bearing Layer

The bearing layer shall be constructed within the piggy back liner and cell base liner footprint, in accordance with the Design Drawings.

The bearing layer shall be constructed with Unit 4 – Clay Rich Material with a design as-compacted thickness of 200 mm.

The material shall be placed in one layer and compacted with suitable compaction equipment to achieve a minimum of 98% SMDD (in accordance with AS1289.5.1.1 and 5.4.1) or a minimum HILF density ratio of 98% Standard (in accordance with AS1289.5.7.1) at a moisture content within the range of -2% to +2% of the Standard Optimum Moisture Content (SOMC).

The GITA shall provide "Level 1" supervision for material placement and moisture density testing. The frequency of field density and moisture testing during placement of the material shall as a minimum conform the following, whichever requires the most tests:

- 1 test per 1,000 m² per layer of material type; or
- 3 tests per batch of work.

If the required density and moisture is not achieved, the compacted material shall be reworked in-situ to meet the density and moisture content requirements. If the density and moisture content requirements again cannot be achieved after reworking, the failed material shall be removed for moisture conditioning at the material borrow area or at an approved designated area, or be discarded.

The Contractor shall maintain the bearing layer in moist condition until Unit 17 - GCL is installed. Should the bearing layer surface have dried excessively (e.g. desiccation cracking>20mm depth) or wetted up excessively, as determined by the Superintendent, the affected materials shall be excavated to expose material that has moisture content within the specified tolerance. The excavated materials shall be returned to a designated area for moisture conditioning or be discarded, and the excavated bearing layer material replaced. Note that the surface of the bearing layer is designed to shed leachate and its shape shall be maintained during formation in order to avoid temporary water ponding during construction. Consideration





may be given to use of micro-mist sprayers to limit loss of moisture from the completed surface during hot weather.

Trafficked areas of the bearing layer surface are to be ripped, moisture conditioned and recompacted if, in the opinion of the Superintendent, the quality of these areas has deteriorated.

The finished surface shall be smooth and well-drained. Coarse materials shall not protrude from the surface of the bearing layer by more than 10 mm. No areas of ponding shall be accepted on the surface. Additional surface requirements are given in Section 4.10.3.

The Contractor shall survey the final levels to provide works-as-executed (WAE) drawings and to demonstrate that the design levels and layer thickness have been achieved. The survey shall be conducted on an approximate 10 m grid. The Contractor shall submit the WAE drawings and an accompanying analysis demonstrating compliance with design levels. Submission of the WAE drawings and accompanying analysis constitutes a HOLD POINT. Placement of GCL shall not commence in an area until the Hold Point has been released for that area, and all other contractual requirements have been fulfilled.

The Contractor shall also submit the items listed below as part of his WAE documentation,

- GITA certification statements for all fill placement and compaction, reflecting the above requirements for Unit 4 – Clay Rich Material.
- WAE report including description of the completed work, summary of construction materials and time periods of construction, applicable Work Method Statements, RFI records (if any), Contractor quality system records, and Hold and Inspection point documentation.

4.9 General Requirements for Geosynthetics

4.9.1 Documentation

Specialist Installation Sub-Contractor

The Works described in the following sections shall be undertaken by an experienced geosynthetic installation specialist contractor approved by the Superintendent. The Contractor shall require that skilled sub-contractor personnel will supply, test and install all geosynthetic materials. The Contractor is responsible for all aspects of the work.

Prior to the installation of geosynthetics, the Contractor shall submit the proposed qualified subcontractor(s) to the Superintendent for approval. This submission constitutes a HOLD POINT. No geosynthetic material installation shall begin until the HOLD POINT is released. Any change to the geosynthetic supply or installation shall be subject to written approval from the Superintendent.

Alternative construction methods to those detailed in the following sections will be considered, subject to the approval of the Superintendent, provided they satisfy the intent of this Specification.

Quality Assurance and Quality Control

The Contractor shall be responsible for all quality assurance and quality control of the manufacture, transportation, storage and installation of the geosynthetic. This shall include the obtaining of material property details and certificates from the resin supplier and the geosynthetic manufacturer, the preparation of a quality control procedures manual and the undertaking of all inspections, non-destructive and destructive testing and repairs etc. and other activities detailed in this Specification.

The Contractor is responsible for compliance with this Specification; however, the Superintendent shall monitor installation of the geosynthetics. The Contractor shall accommodate all quality assurance activities undertaken by the Superintendent.

The Superintendent shall undertake audits of the quality control and assurance procedures. Should any areas of the works show non-conformances with the approved quality control procedures manual, then the Contractor shall cease work until the non-conformance is resolved. Resolution will be by either presentation





of the appropriate documentation or undertaking sampling and testing, or another activity approved by the Superintendent.

The Superintendent may also undertake audit testing at his sole discretion at any time during the works. This may include a detailed Liner Integrity Survey (resistivity method) for the geomembrane materials (refer Section 4.11.5). The Contractor shall accommodate all audit testing activities.

Quality Control Procedures Manual

The Contractor shall submit a quality control procedures manual to the Superintendent at least 10 days before the supply of any geosynthetic to the Site. The quality control procedures manual shall include the following items, as appropriate to each type of geosynthetic:

- The Contractor's organisational structure and personnel, and the qualifications and experience of the proposed installation personnel;
- Trial weld procedures;
- Measures to minimise wrinkles;
- Welding procedures, including equipment make and model;
- Weld repair procedures;
- Non-destructive testing procedures;
- Destructive testing procedures;
- Pro forma sheets for recording of installation and test results;
- Deployment equipment and procedures;
- Safety equipment;
- Supply transportation, storage and handling procedures;
- Vent flap details; and
- Any proposed changes with respect to this Specification.

The Superintendent will review this information to assess the suitability of the quality control procedures manual. Upon review of the quality control procedures manual, the Superintendent may request additional information specific to the project installation conditions.

The submission of the geosynthetic quality control procedures manual constitutes a HOLD POINT. No geosynthetic materials shall be imported to the Site until the HOLD POINT is released.

Data, Statements, Reports and Certificates

The Contractor shall submit the following information at least 7 days prior to the installation of any geosynthetic at the Site:

- The manufacturer's certifications, descriptive data, specification sheets;
- Manufacturer's test results for geosynthetic composition and properties;
- The origin (resin name and supplier's name, resin production plant), identification (brand name, number) and production date of the resin;



- A list of quantities and descriptions of materials other than the base polymer which comprise the geosynthetic;
- Copies of the quality control certificates issued by the resin supplier;
- A statement regarding recycled polymer content (if permitted by this Specification);
- A properties sheet including, at a minimum, all specified properties, measured using test methods indicated in these specifications, or equivalent;
- Reports of the tests, including sampling procedures, conducted by the manufacturer to confirm that the geosynthetic meets these Specifications. Tests shall be conducted at frequencies outlined in Chapter 2.0 of this Specification; and
- A quality control certification that property values given in the properties sheet are guaranteed by the geosynthetic manufacturer. The quality control certificate shall include roll numbers and identification, resin lot, batch numbers, sampling procedures and results of quality control tests.

The Superintendent will review this information to assess the suitability of the data, statements, reports and certificates. Upon review, the Superintendent may request additional information specific to the project conditions.

The submission of the data, statements, reports and certificates constitutes a HOLD POINT. Geosynthetic material installation shall not commence until the HOLD POINT is released.

4.9.2 Site Records and Drawings

The Contractor shall submit all quality forms, test results and other documentation indicated in the quality control procedures manual to demonstrate its compliance with the quality system for the project and to demonstrate compliance of the installed geosynthetics with this Specification.

Copies of these records and tests, as well as records of corrective action taken when results are unsatisfactory, shall be presented to the Superintendent in writing, within one working day following an inspection, test or action. To scale as-built drawings (i.e., WAE drawings) shall be provided of all panel layouts, anchor trenches, test positions and defects within 14 days of completing the liner.

The Contractor shall keep records sufficient to document in detail the progress and location of work undertaken.

The Contractor shall also submit the items listed below as part of his WAE documentation,

 WAE report including description of the completed work, summary of construction materials and time periods of construction, applicable Work Method Statements, RFI records (if any), Contractor quality system records, and Hold and Inspection point documentation.

4.9.3 Traffic over Geosynthetics

Construction traffic over geosynthetics is restricted or not permitted, to prevent damage and ensure the material performs its intended function. The construction of the different units with the general traffic limitations is as follows:

- GCL: No vehicle access over deployed GCL, only careful foot traffic, subject to footwear requirements.
- Geomembrane: No vehicle access over deployed geomembrane, only careful foot traffic, subject to footwear requirements.
- Geocomposite: No vehicle access over deployed geocomposite, only careful foot traffic, subject to footwear requirements.



- Geogrid: No vehicle access over deployed geogrid, only foot traffic.
- Geotextile: No vehicle access over deployed geotextile, only foot traffic.

The Contractor shall comply with geosynthetic manufacturer recommendations, as well as the requirements within this Specification, regarding limitations for periods of exposure for deployed geosynthetics prior to covering.

4.9.4 Anchor Trenches

The anchor trench for the base liner shall be used to anchor the GCL, geomembrane, and cushion geotextile at top of the perimeter bund. The installation of these units may require that the previous geosynthetic layer(s) is temporarily anchored while the next geosynthetic is installed.

The excavation of the anchor trench shall be presented to the Superintendent for inspection and approval before backfilling commences. This constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

The anchor trench for the base liner shall be located on top of the bund in accordance with the Design Drawings a dimension of 500 mm x 500mm.

The geosynthetic placed in the anchor trench shall extend down one side. The geosynthetics shall not extend up the outer edge of the trench. Loose soil and ponded water shall not be permitted in the anchor trench. Anchor trenches shall be constructed and maintained so as to provide for free drainage of surface water flow and prevent ponding in or adjacent to anchor trenches.

The geosynthetics shall be placed against the side of the trench and the trench backfilled with excavated material. The backfill shall be placed in layers appropriate for the proposed construction equipment. The compaction shall be carried out in the presence of the GITA. The compacted material shall achieve at least dense or stiff consistency, as assessed by the GITA in accordance with AS 1726. Care shall be taken to not damage the geosynthetics during compaction of the backfill of the anchor trench. The Contractor shall propose equipment and method to demonstrate a low risk of damage to the geosynthetics.

The backfill of the trench shall be carried out using hand held compaction equipment, to achieve the consistency specified above.

4.10 Installation of Unit 17 – Geosynthetic Clay Liner (GCL)

4.10.1 Delivery, Storage and Handling

Unit 17 - GCL delivered to site shall be wrapped with weather and moisture resistant wrapping. The Contractor shall be responsible for the unloading, protection from the weather and storage of the delivered GCL. Rolls with damaged wrapping shall be inspected by the Superintendent to assess the extent of hydration of the GCL. Unit 17 - GCL with moisture content above 30% by weight (ASTM D5993) may be rejected. GCL rolls with damaged wrapping and moisture content lower than 30% shall be re-wrapped and sealed. All rolls of material shall be clearly marked with the type of GCL, unroll direction and batch number of manufacture.

All rolls of Unit 17 - GCL shall be delivered with the GCL tightly wrapped around a centre core, with the hole in the core suitable for the proposed spreader bar to be used during deployment. All rolls shall be stored off the ground on hard, dry, free-draining surface, with suitable bearers at closely spaced centres, suitably protected from runoff and other damage. Stacked rolls of GCL shall be covered with tarpaulins to promote runoff. GCL rolls shall not be rolled across the ground.

4.10.2 Acceptance Criteria for GCL

Delivery to Site

The Contractor shall supply, unload, store and protect the rolls of GCL.





Inspection of GCL after Unrolling

The Superintendent shall inspect the GCL as it is rolled out on the slope.

Where a roll of GCL has been damaged and the damaged area extends more than 300 mm across the deployed width of GCL, the roll may be rejected due to its reduced tensile strength. The Superintendent shall determine if the strength of the roll is unacceptable, based on the nature and location of the damage.

4.10.3 General Surface Preparation

Unit 17 - GCL shall generally be placed on the prepared surface of the bearing layer, but in limited areas the GCL will be placed on internal bund slopes and prepared subgrade (refer Design Drawings).

Portions of the prepared surfaces that have deteriorated to an extent that has potentially compromised the quality of the layer, shall be reworked at the contractor's expense, and subjected to appropriate geotechnical testing in order to prove the required compaction.

The Contractor shall be responsible for preparing and maintaining the prepared surface to provide a firm, unyielding foundation for the Unit 17 - GCL with no sudden, sharp or abrupt changes or breaks in grade, no wheel ruts/footprints, no standing water, and no voids and crack, to the satisfaction of the Superintendent.

The Contractor shall remove from the liner subgrade surface all particles that protrude from the surface by more than 10 mm, and sharp or angular particles to the satisfaction of the Superintendent. Significant voids created by removal of particles shall be filled with moist Unit 4 – Clay Rich Material. No standing water shall be allowed to accumulate on the surface of the base liner prior to installation of the Unit 17 - GCL. No GCL shall be placed onto an area that has become softened by prolonged precipitation.

The prepared surface shall constitute a HOLD POINT. No GCL shall be placed until the Hold Point has been signed off by the Superintendent. Only the area to be covered in the same day shall be signed off.

4.10.4 Placement

Rolls of Unit 17 - GCL shall be moved or deployed with a suitable spreader bar that is stiff enough to limit deflection over the width of the roll to ensure smooth uniform deployment of the GCL layer. The orientation of the GCL, that is which side is installed facing downward, is to be confirmed by the Superintendent prior to any GCL installation.

Unit 17 - GCL shall only be installed in dry weather conditions.

The Contractor shall submit a panel layout and their proposed installation method to the Superintendent for the installation at least 10 days prior to the commencement of the GCL placement for approval by the Superintendent. A minimum side and end overlay of 300 mm is required between panels. The submission of panel layout drawings and proposed installation method constitutes a HOLD POINT. GCL installation shall not commence until the HOLD POINT is released.

If manufacturer recommendations differ from procedures in this Specification, these differences shall be brought to the attention of the Superintendent prior to placement of any GCL in the facility. The requirements of this Specification will apply, unless a variation is approved in writing in consultation with the Superintendent.

Exposed Unit 17 - GCL shall not be trafficked by vehicles. Unit 17 - GCL is to be covered with Unit 15 – LLDPE Geomembrane or Unit 16 – HDPE Geomembrane, which shall be deployed concurrently with the GCL (i.e. roll width after roll width) and on the same day as the GCL. This requirement is to minimise the potential for wetting of the GCL by rainfall or runoff. Further, the Contractor must stage liner installation such that the Unit 7 Drainage Aggregate layer or the Unit 9 Protection Material is in place over each area of the liner system within 48 hours of GCL placement. This requirement is to minimise the potential for GCL swelling due to lack of confining pressure.

All GCL overlaps shall incorporate a system for achieving overlap sealing (for example, some GCL products include pre-treated side overlap area which comprises bentonite powder encapsulated in the geotextile). Overlaps shall be placed in down slope direction (roof tile effect). If an alternative joining procedure is





proposed, details are to be provided to the Superintendent for consideration at least 14 days prior to purchase of the materials.

The Superintendent shall inspect and approve all overlaps prior to covering the overlap.

If wrinkles greater than 50 mm high occur in Unit 17 - GCL or where wrinkles extend to the edge of the roll due to manufacturing tolerances, the wrinkle shall be cut at the crest of the wrinkle. A layer 10 mm thick of bentonite paste shall be spread over the top of one flap of the cut and the other flap pushed over the paste to form an overlap. A 20 mm thick layer of bentonite paste shall be placed over the top of the overlap extending 100 mm beyond the edges of the cut and overlap. The paste shall be covered with a patch of Unit 11 - Filter Geotextile, and squeezed into the paste.

The exposed edges of deployed GCL shall be protected from rainfall runoff to prevent erosion of bentonite. Special care shall be taken to prevent flow of runoff or seepage under and/or over the geomembrane to prevent erosion of the bentonite in the GCL.

4.10.5 Repairs

Rolls or panels of GCL that have been damaged shall be brought to the attention of the Superintendent, who shall judge if the panel or roll is to be removed from site, or may be repaired. If the Superintendent decides the damage is minor the hole may be patched. If a roll is deployed with manufacturing defects, the entire roll shall be removed from site.

All defects and repairs shall be recorded and locations measured as the panels are deployed, to facilitate the timely deployment of the overlying geomembrane.

A patch of GCL shall be placed over any hole with a minimum overlay over the adjoining area of 300 mm. The repairs shall be joined to the main GCL in accordance with the following requirements:

All overlaps shall be made using a 10 mm thick layer of hydrated sodium bentonite paste between the GCL and the patch GCL. The Contractor shall submit details of the proposed bentonite paste to the Superintendent for approval prior to commencement of the GCL installation.

4.11 Installation of Unit 15 and Unit 16 - Geomembrane

4.11.1 Transport, labelling, handling and storage

Transportation

The Contractor is responsible for transportation of the geomembrane to the Site.

Labelling

Each geomembrane roll shall be clearly labelled with the following information:

- Material of the geomembrane;
- Thickness of the material;
- Length and width of the roll;
- Manufacturer's Name;
- Direction to unroll the material;
- Product identification;
- Batch number; and
- Roll number.





Any roll delivered to the Site without labelling shall be rejected and removed from the site by the Contractor. Each package of welding rod or extrusion welding beads shall be clearly labelled and shall include the Manufacturers name, product identification name/number, resin lot or batch number and the package number.

The Contractor shall also cross-reference each batch number and roll number of geomembrane delivered to site to the resin used and date of manufacture of the geomembrane.

Handling and On-site Storage

The Contractor is responsible for handling, storage and care of the geomembrane before and after installation at the Site. The geomembrane rolls shall be protected from dirt, mud, dust, fire and damage before installation. Rolls shall be stacked to provide access for roll identification and testing as required. The integrity and legibility of roll labels must be maintained during storage.

Geomembrane materials shall be stored in accordance with the quality control procedures manual and the Manufacturer's recommendations. This may include covering of geomembrane rolls.

4.11.2 Surface Preparation

Unit 15 – LLDPE Geomembrane and Unit 16 – HDPE Geomembrane shall be placed on top of the GCL in the piggy back and cell base lining systems, respectively. The Contractor is responsible for meeting the 48-hour time window requirements for GCL, geomembrane, and cover placement given in Section 4.10.4, and for maintaining the surface of the GCL to provide a firm, unyielding foundation for the geomembrane with no sudden, sharp or abrupt changes or break in grade. No standing water or excessive moisture shall be allowed to accumulate on the GCL prior to geomembrane installation. No geomembrane shall be placed onto an area that has become deteriorated due to moisture changes.

4.11.3 Geomembrane Placement

During geomembrane installation the Superintendent will provide direct input and involvement as indicated in the following sections of this Specification. The Contractor is required to accommodate and allow for the Superintendent's identified role.

Layout Drawings

The Contractor shall submit geomembrane panel layout drawings at least 7 days before installation starts. The drawings shall indicate the panel configuration, the location of seams and the staging/direction of deployment. The layout drawings shall be suitable for use as construction drawings, to scale and include dimensions and details.

The submission of the panel layout drawings constitutes a HOLD POINT. Geomembrane installation shall not commence until the HOLD POINT is released.

Panel Identification

A field panel is the unit area of geomembrane to be welded in the field and shall be bounded by field welds or anchor trenches. Each field panel shall be numbered and the panel layout drawings shall show the panel numbers and the dimensions and area of each panel.

Field Panel Placement

Field panels are to be placed so that the boundaries do not intersect at one point and form a cross seam. A minimum 150 mm is required to offset the occurrence of a cross seam. The Contractor shall allow for the effects of changes in temperature with the resulting expansion and contraction of the panel, to prevent occurrence of a cross seam.

Installation Procedure

Field panels shall be installed using any one of the following procedures:

 field panels for one day's installation may be placed prior to field welding (to protect the subgrade from erosion by rain, or desiccation).





- field panels are placed one at a time and welded immediately (to minimise the number of unwelded field panels exposed to wind), or
- any combination of the above.

Weather Conditions

Geomembrane seaming and welding shall not be started if the ambient temperature is below 10°C or above 35°C, unless the Contractor demonstrates what special measures will be applied for welding outside this temperature range, and is authorised by the Superintendent. Both panels of geomembrane to be welded shall be allowed to equilibrate to the same temperature, before starting to weld.

Geomembrane jointing shall not be undertaken;

- in the presence of excessive moisture (i.e. rain, fog, dew);
- in an area of ponded water;
- or during periods of high wind or excessive dust.

If geomembrane placement and jointing is to be carried out at night, the entire area of deployment shall be illuminated. Installation should preferably be carried out during daylight hours. Installation work carried out at night shall be inspected and tested during daylight hours. All joints shall be tested during daylight hours.

Method of Placement

The Contractor shall ensure that:

- No more geomembrane is installed at any one time than can be reasonably welded in one day.
- Geomembrane rolls and/or factory panels shall be unrolled or unfolded in accordance with the instructions and the direction shown on the boxes or wrapping.
- No equipment used shall damage the geomembrane by handling, trafficking, leakage of hydrocarbons or other means.
- Personnel working on the geomembranes shall not smoke, use footwear, or engage in other activities that could damage the geomembrane. The Contractor shall protect the geomembrane from damage by equipment or personnel traffic associated with construction.
- Methods used to unroll panels shall not cause scratches or crimps in the geomembrane and shall not damage the underlying compacted clay liner and other layers.
- The prepared surface awaiting covering by geomembrane shall not be allowed to deteriorate and shall be maintained in a condition suitable for geomembrane placement.
- Methods used to place panels shall preclude folds, wrinkles that may become folds, bridging (trampolining) and differential wrinkles between adjacent panels.
- Temporary ballast (such as sand bags) shall be applied to prevent uplift during high wind conditions. Such loading shall be spread out and shall not damage the geomembrane. It is the contractor's responsibility to ensure the geosynthetic liners are sufficiently loaded. High wind conditions are common at the site, particularly on the existing landfill slopes where the piggy back lining will be installed.
- Vent flaps shall be sealed once the geomembrane has been covered with heavier materials and air trapped under the geomembranes during installation has been expelled.
- Joints shall be orientated so that overlaps are in the downslope direction (roof tile effect).





- All cutting of the geomembrane during installation shall be with a hooked blade to avoid damage.
- The Contractor shall implement procedures with its staff, to the satisfaction of the Superintendent to manage the risk of sharp particles being trapped in footwear or equipment that may or will move over the geomembrane.

Damage and Defects

Damage

The Superintendent shall inspect geomembrane panels for damage, after placement and prior to welding. The Contractor shall replace or repair a field panel or portion of a panel that is damaged (torn, twisted or crimped). Damaged panels or portions of damaged panels that have been rejected shall be removed from the work area. The Superintendent shall decide on the need to repair or replace damaged field panels.

Inspection of Geomembrane

The geomembrane shall be inspected by the Contractor during installation from the roll to identify unacceptable areas of material. Irregularities in the geomembrane material identified during inspection shall be repaired, or if excessive, the roll shall be rejected. The decision to either repair unacceptable areas or reject the roll shall be the Superintendent's. This decision shall generally be based on the following considerations.

Defects

The acceptance of the geomembrane shall be based on a maximum number of manufacturing defects. Manufacturing defects include "fisheyes", blemishes and shallow scratches.

A "fisheye" is a thinning of the geomembrane. The specified minimum thickness of the geomembrane also applies to "fisheyes". The size of the fisheye is of no consequence, as it is the thinning or absence of the geomembrane inside the fisheye, which is of concern.

Surface blemishes are considered to be areas where the resin has not been properly mixed or filler can be noted on the geomembrane. The colour and surface texture of the geomembrane shall be uniform and consistent. Where changes occur in the surface texture or colour the contractor shall request the Superintendent to inspect the area. If the area is rejected as unacceptable, then the section of the geomembrane roll shall be removed and replaced.

Straight-line scratches that penetrate the geomembrane (approximately 0.1 mm) shall be pointed out to the Superintendent. The extent and depth of the scratch shall be examined by the Superintendent to decide if a defect is to be removed. The roll length where such a defect occurs shall be cut out and removed from site. All defects shall be patched or capped and subject to quality control testing, reporting and documentation by the Contractor.

If a roll has been rolled out and no fisheyes are present, the geomembrane will be accepted. If the end of a roll has a number of defects, then the end of the roll shall be cut off and removed from site. The Superintendent shall make the final decision on site.

Maximum number of manufacture defects per 300 m^2 of roll length shall be one, with the total number of manufacture defects for the liner to be less than 10 per ha. If more than one manufacture defect occurs over a local area of the geomembrane within a circular area of 0.5 m radius, the area shall be considered 'one defect' and be capped. Replacement of defective geomembrane is at the Contractor's expense.

Manufacturer defects are considered separate to installation defects. Manufacturing defects and installation defects are the Contractor's responsibility. The Superintendent shall decide if the number of installation defects over a certain area is too high, and whether the area should be cut out or capped.

All defects shall be patched or capped and subject to quality control testing, reporting and documentation by the Contractor.



4.11.4 Field Welding

Requirements of Personnel

Personnel performing welding operations shall be qualified as indicated below.

- Personnel performing welding operations shall be qualified by experience or by successfully passing welding tests and at least one welder shall have welded a minimum of 100,000 m² of geomembrane using the same type of welding apparatus in use at the site.
- The weld foreman, most experienced welder, shall directly supervise less experienced welders, as required.
- No field welding shall take place unless the weld foreman is present.

Welding Equipment and Products

Approved Processes for Field Welding.

Only extrusion welding or fusion welding, using equipment approved by make and model, shall be used. Alternative processes may be proposed and submitted to the Superintendent 14 days before the start of geomembrane deployment, for consideration for approval.

Extrusion Process

The extrusion apparatus shall be equipped with gauges giving the temperature in the apparatus and at the nozzle. The Contractor shall provide documentation for the extrudate to the Superintendent and shall certify that the extrudate is the same material as the geomembrane sheet to be welded. The extruder shall be purged before beginning a weld and until all heat-degraded extrudate has been removed from the barrel. Whenever, the extruder is stopped, the barrel shall be purged of all heat degraded extrudate.

Fusion Process

The fusion-welding apparatus must be automated vehicular-mounted devices. The fusion-welding apparatus shall be equipped with gauges giving the applicable temperatures and pressures. The edge of the cross seams to be fusion welded shall be ground to a smooth incline (top and bottom) prior to welding. A temporary movable protective layer shall be used directly below each overlap of geomembrane that is to be welded to prevent build up of moisture between the sheets.

Generator

The electric generator shall be placed on a smooth base such that no damage occurs to the geomembrane. Similarly, a smooth insulating plate or fabric shall be placed beneath the hot welding apparatus after usage to protect the geomembrane. The geomembrane should not be damaged during welding and the geomembrane shall be especially protected from damage in trafficked areas.

Seam Layout

The Contractor shall provide the Superintendent with a seam layout drawing i.e. a drawing of the area to be lined showing all expected seams. No panels shall be welded in the field without the Superintendent's approval. In addition, no panels not specifically shown on the seam layout drawing shall be used without the Superintendent's prior approval.

No seams shall be located in areas of potential stress concentrations.

No cross-shaped seams shall be allowed unless approved by the Superintendent. All fusion joints between panels are to form T-joints, with panel layouts being staggered to achieve this.

All seams and joints shall be surveyed and numbered or named, which shall be cross-referenced to field notes and records of the contractor. Seam numbers shall be marked on the seam layout drawing, and altered as required on the as-built drawings (refer Section 4.9.2).





Welding Method

The welding method to be employed shall be the dual-track fusion welding process. Extrusion welding shall be used for repairs and patches. Single-track fusion welding methods or possible other welding methods shall only be used with prior written approval from the Superintendent.

The Contractor shall maintain at least one spare, operable welding unit of each type employed on the project site at all times.

Weld Preparation

General weld preparation procedures, temporary bonding procedures, general equipment settings, including acceptable extrudate or wedge temperatures, rate or advancement, etc., and welding procedures, shall be specified in the quality control procedures manual.

Prior to welding, the weld area shall be clean and free of moisture, dust, dirt, debris, markings and foreign material.

Where abrading is required, the process shall be completed according to the Manufacturer's instructions within one hour of the welding operation and in a way that does not damage the geomembrane. Abrasion of the geomembrane surface shall not extend outside the weld bead or weld surface area.

Seams shall be aligned to minimise the number of wrinkles.

Artificially induced cooling of the extrudate welds using water or other means is not permitted. Care shall be exercised to ensure that non-destructive testing of the extrudate and/or other activities does not cause artificial cooling of the weld.

The Contractor shall record the following information on the geomembrane surface adjacent to the weld:

- Unique seam number.
- Welding device number and operating temperature.
- Welding technician's initials and
- Date and time.

This information must be recorded onto the Contractor's quality assurance documentation at the end of the day's welding activities.

Overlapping and Temporary Bonding

The panels of geomembrane shall be overlapped by a minimum of 75 mm for extrusion welding and 125 mm for fusion welding. The overlap shall be sufficient to allow peel tests to be performed on the weld, and to provide enough space to form a reliable air channel between dual fusion welds for testing.

The procedure used to temporarily bond adjacent panels together shall not damage the geomembrane; in particular, the temperature of the air at the nozzle of any spot welding apparatus shall be controlled such that the geomembrane is not damaged.

No solvent or adhesive shall be used unless the product is approved in writing by the Superintendent (samples shall be submitted for testing and evaluation).

General Welding Procedures

The general welding procedure used by the Contractor shall be as follows:

For fusion welding, a movable protective layer of plastic shall be placed directly below each overlap of geomembrane that is to be welded. This is to prevent any moisture build-up between the sheets to be welded.



- Welding shall extend to the outside edge of panels to be placed in the anchor trench.
- Ends of dual fusion welds extending into anchor trenches and into joints or patches shall be welded closed.
- If required, a firm substrate shall be provided by using a flat board or similar hard surface directly under the seam overlap to achieve necessary support.
- Wrinkles at the seam overlaps shall be cut along the ridge of the wrinkle to achieve a flat overlap. The overlap shall be welded and any portion where the overlap is inadequate shall then be patched with an oval or round patch of the same geomembrane extending a minimum of 150 mm beyond the cut in all directions.
- All cuts and patches shall be formed with rounded edges and ends, to prevent stress concentrations in the geomembrane. All cuts shall be removed or be ended off with a round cut-out.

T-Joins

All T-joins shall be treated as a potential defect and be patched and subject to quality control procedures in accordance with this Specification.

4.11.5 Testing

Trial Welds

Each welding technician shall qualify to operate on a daily basis, by performing a trial weld prior to welding activities or at times designated by the Superintendent. These trial welds shall be performed using each type of welding device to be employed by the welding technician during that period. Additionally, a trial weld shall be made using each welding device on resumption of work after the lunch break or at an interval of no greater than five (5) hours, whichever is less. The Superintendent may also require that a trial weld be performed using each device at the conclusion of welding activities. Welding devices that have not produced a passing trial weld will not be performed to perform production welding.

Trial welds shall be made on "fragment" pieces of geomembrane liner to verify that welding conditions are adequate. The trial weld sample shall be at least 0.3 m wide and 3.0 m long for fusion welds or 1.0 m long for extrusion welds with 125 mm overlap, with the weld centred length-wise. All trial welds shall be performed under the same weather and subgrade conditions as production welding.

Three specimens each (25 mm) wide shall be cut by use of a die from the trial weld sample by the Contractor - one near each end and one near the mid-point. The two near end specimens shall be tested in peel and the mid-point sample tested in shear.

All trial weld specimens shall be tested in the field by the Contractor and in the presence of the Superintendent, using an electrically operated tensiometer where the force exerted is displayed. The Contractor shall supply evidence demonstrating that the tensiometer has been calibrated within the previous 12-month period.

The shear test specimen shall, at a minimum, meet a strength of ninety five percent (95%) of the tensile yield strength of the parent geomembrane material where it fails in the material (i.e. film tear bond). Both tracks of dual-track fusion welds shall be tested for peel adhesion. Peel strength of welds shall meet at least 65% of the tensile strength of the parent geomembrane material where it fails in the material.

All seams shall fail in the material, i.e. film tear bond. Trial seams shall meet the following minimum strength criteria:

Material (including weld type)	Peel	Shear
HDPE (fusion welds)	65% ⁽¹⁾	95%(1)
HDPE (extrusion weld)	_{60%} (1)	95% (1)



Material (including weld type)	Peel	Shear
LLDPE (fusion weld)	220 N/25 mm	265 N/25 mm
LLDPE (extrusion weld)	190 N/25 mm	265 N/25 mm

Note (1): Test results relative to the strength of the parent sheet strength

The tensile yield strength of the parent material will be determined before testing the trial welds by testing a 25 mm wide strip cut with a dye.

If any one of the three specimens fails, the entire trial weld is considered to have failed.

In the event that a trial weld fails, the entire trial weld procedure shall be repeated after the appropriate adjustments to the welding device and/or operator has been made. If a second trial weld fails, the welding device and/or the welding technician shall be rejected and shall not be used for welding until such time as the deficiencies are resolved, verification of the resolution is provided, and a successful trial weld performed.

Non-destructive Weld Continuity Testing

General

The Contractor shall non-destructively test all field and factory welds over their full length by the vacuum box method for testing continuity of extrusion welds, and air pressure test for double fusion welds only, or other approved method. The Contractor will be required to have back-up vacuum testing apparatus on the Site. A trial will be required in the presence of the Superintendent to demonstrate the effectiveness of the contractor's apparatus and method prior to field welding commencing. Vacuum testing and air pressure testing are described below. The purpose of the non-destructive test is to check the continuity of welds. It does not provide any information on weld strength. Continuity testing shall be done as the welding work progresses. Any welds that fail non-destructive testing shall be repaired in accordance with this Specification. Welds, which cannot be non-destructively tested because of seam geometry, shall be capped.

All test equipment shall be in calibration and conform to manufacturer's specifications. The Contractor shall submit current calibration certificates.

Vacuum Testing

The equipment shall comprise the following:

- A vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole or valve assembly, and a vacuum gauge showing the pressure in the box;
- A steel vacuum tank and pump assembly equipped with a pressure controller and connections;
- A rubber pressure/vacuum hose with fittings, pressure gauge linked to the window housing and connections;
- A soapy solution to be applied over seam area.

Each section of the weld to be tested shall be tested to a vacuum pressure of at least minus 35 kPa. Each section of seam shall be vacuum tested for a period of not less than 10 seconds by examining the geomembrane through the viewing window for the presence of soap bubbles. Adjoining area shall to be tested with a minimum 75 mm overlap between sections.

Air Pressure Testing

The following procedures are applicable only to those processes that produce a double weld with an enclosed air channel. All double welds with an enclosed air channel shall be air pressure tested.

The equipment shall be comprised of the following:





- An air pump (manual or motor driven) capable of generating and sustaining a pressure of 180 to 200 kPa.
- A rubber hose with fittings and connections.
- A sharp hollow needle or other approved pressure feed device.
- A calibrated pressure gauge capable of reading pressures up to 250 kPa, with a tolerance of less than 5 kPa.

The following procedures shall be used for air pressure testing the HDPE Geomembrane:

- Seal both ends of the weld to be tested:
- Insert needle with pressure gauge, or other approved pressure feed device within 300 mm of one of the sealed ends, into the air channel created by the fusion weld:
- Energise the air pump and pressurise the channel to 200 kPa for a 25 mm wide channel or 350 kPa for a 13 mm wide channel. Close the valve and sustain the pressure for a minimum of 5 minutes. A pressure drop of less than 10 kPa is allowable, but the air pressure is still required to stabilise for a minimum of 5 minutes. Should a different width air channel be formed the Superintendent shall adjust the required minimum air pressure in the channel to achieve a similar stress on the weld as for a 25 mm wide channel.
- If loss of pressure exceeds 10 kPa, or does not stabilise, the faulty area should be located and repaired in accordance with this section. If, in the judgement of the Superintendent, significant changes in geomembrane temperature occur during the test (e.g., due to cloud cover), the test shall be repeated after the geomembrane temperature has stabilised.
- Cut end of weld opposite to the pressure gauge and observe that the pressure drops. If the
 pressure does not drop, locate the obstruction(s) in the weld, repair, and retest the weld.
- Remove needle or other approved pressure feed device and repair all holes and damage made to the air channel by extrusion welding over the damage.

The following procedures shall be used for air pressure testing the LLDPE geomembrane:

- Seal both ends of the weld to be tested.
- Insert needle with pressure gauge, or other approved pressure feed device within 300 mm of one of the sealed ends, into the air channel created by the fusion weld.
- Energise the air pump and pressurise the channel to 150 kPa for a 25 mm wide channel, or 200 kPa for a 13 mm wide channel. Close the valve and sustain the pressure for a minimum of 5 minutes. A pressure drop of less than 15 kPa is allowable, but the air pressure is still required to stabilise for a minimum of 5 minutes. Should a different width air channel be formed the Superintendent shall adjust the required minimum air pressure in the channel to achieve a similar stress on the weld as for a 25mm wide channel.
- If loss of pressure exceeds 10 kPa, or does not stabilise, the faulty area should be located and repaired in accordance with this section. If, in the judgement of the Superintendent, significant changes in geomembrane temperature occur during the test (e.g., due to cloud cover), the test shall be repeated after the geomembrane temperature has stabilised.
- Cut end of weld opposite to the pressure gauge and observe that the pressure drops. If the
 pressure does not drop, locate the obstruction(s) in the weld, repair, and retest the weld.





 Remove needle or other approved pressure feed device and repair all holes and damage made to the air channel by extrusion welding over the damage.

Alternative testing procedures may be considered by the Superintendent based on submission of relevant information by the Contractor. If an alternative testing procedure is to be considered the Contractor shall submit information to the Superintendent at least 14 days before the procedure is to be used.

Destructive Weld Continuity Testing

The Contractor shall perform destructive weld tests at selected locations. The Superintendent shall choose the test locations. The Superintendent reserves the right to vary the testing frequency depending on results of samples tested. The purpose of these tests is to evaluate field weld strength. Weld strength testing shall be done as the welding work progresses, not at the completion of all field welding.

Location and Frequency

Destructive test samples shall be collected at an average frequency of one test location per 150 m of seam length or at intervals designated by the Superintendent.

Test locations shall be determined during welding, and may be prompted by suspicion of excess crystallinity, contamination, offset welds, or any other potential cause of imperfect welding.

Sampling Procedure

The Contractor shall cut samples at locations designated by the Superintendent as welding progresses to obtain laboratory test results before the geomembrane is covered by another material. Each sample shall be numbered and the sample number and location surveyed and identified for inclusion on the as-built liner drawing (refer Section 4.9.2).

All holes in the geomembrane resulting from destructive weld sampling shall be repaired and tested in accordance with the repair procedures in this Specification. Cuts to remove the samples shall be rounded to prevent stress concentrations in the geomembrane.

Size of Samples

The samples shall be a minimum 0.3 m wide by 0.4 m long with the weld centred length-wise. The sample length shall be increased to provide material for additional laboratory testing or archiving. Two specimens shall be cut from each end of the sample for preliminary field tests. The remaining sample shall be retained by the Contractor pending instructions from the Superintendent which samples are to be subjected to laboratory testing.

Each portion of the test sample shall be labelled with a unique number for the sample, and referenced to the joint number from where the sample was taken. The sample number shall be noted on the as-built drawings (refer Section 4.9.2). The Superintendent may direct the Contractor to reduce the length of the sample removed from the welds, if the Superintendent is satisfied that field testing indicates high quality welds. Laboratory tests may be ordered by the Superintendent on random samples to compare to field test results.

Preliminary Field Testing

Weld Destructive Tests

Two (2) specimens, one from each end of the weld destructive sample, shall be removed and tested for peel adhesion by the Contractor in accordance with Standard GM13 while in the field. The results of this testing shall be evaluated in accordance with the criteria detailed in this Specification.

If either of the two field specimens fails, the entire destructive test is considered to have failed and additional destructive test samples shall be taken in accordance with the procedures of this specification.

If the laboratory destructive testing is to be performed on-site, the requirement for preliminary field weld destructive testing may be waived by the Superintendent.





Weld-end Tests

The Contractor may, if agreed by the Superintendent, perform an additional preliminary destructive test. This test shall take the form of a single specimen obtained from one end of the completed fusion weld. This will be a quality control test and, as such, shall be addressed in the quality control procedures manual.

Upon completion of a fusion weld, a specimen shall be removed from one or both ends and tested by the Contractor for peel adhesion in accordance with the procedures detailed in this Specification. Both tracks of the dual-track fusion weld shall be tested and evaluated. The weld shall not fail in the weld area. If one or both of these specimens fail, a complete destructive test sample shall be taken as previously detailed in this Specification.

Laboratory Weld Sample Destructive Testing

The destructive weld testing will be performed by the Contractor in an on-site or off-site geosynthetic testing laboratory, to be approved by the Superintendent. Typically tests performed by the laboratory shall be completed and the results reported to the Superintendent within 24 hours of receipt.

The Contractor shall conduct laboratory destructive testing on at least 10% of the destructive weld samples of the project, or at least five samples, whichever results in the greater number of tests.

Tests shall be performed on 10 specimens obtained from each field sample. From each sample 5 specimens shall be tested in shear and 5 specimens shall be tested in peel. The shear and peel specimens shall be selected from the sample alternately, so that no two adjacent specimens are tested in the same mode.

Weld Evaluation Criteria

Each weld sample must satisfy both the shear and peel criteria. All testing and evaluation shall be carried out in accordance with ASTM D 4437.

For both peel and shear tests the specimen shall fail in the geomembrane sheet and not in the weld area. This is referred to as "film tear bond," (FTB). The specimen shall be defined as failing in the weld if any portion of the weld exhibits separation across more than 10% of the width. Each track of a dual-track fusion weld shall be considered to be a separate weld for the purpose of calculating the percentage separation. If more than one specimen fails in shear, the entire weld destructive test sample shall be considered as failing.

Failed Destructive Sample Procedure

The Contractor shall reconstruct the deficient weld once the extent has been determined. All welds that are to be reconstructed shall be bound by passing destructive tests.

The Contractor shall trace deficient welds by grinding through the top sheet of the seam air channel, extrusion weld the channel, and pressure test sections of the seam between channel seal welds. Deficient extrusion welds shall be traced by taking field specimens from the weld at 3 m intervals until the Contractor has confidence that destructive samples which pass laboratory testing can be obtained. A full laboratory destructive sample will then be taken at that location and tested. If one or both of these samples fail the laboratory weld destructive test, then the procedure is repeated in that direction until passing laboratory results are obtained. For the purposes of tracing a weld, the weld is considered to be the path of the given fusion welding apparatus or extrusion welding device/technician combination and may, if necessary, extend beyond any given welding period. Tracing which requires obtaining more than 2 specimens in either direction from the location of the initial failed destructive weld sample shall be brought to the attention of the Superintendent. The Superintendent shall decide if the whole seam is to be rejected, or if the Contractor may continue identifying the segment of the defective seam.

At such time that the initial destructive sample failure rate of 10% or greater is reached, the Superintendent shall be notified so that a review of the Contractor's performance may be conducted.

Liner Integrity Surveys

The Superintendent may conduct liner integrity surveys, using the resistivity method, to identify defects in the installed geomembrane. The surveys would be conducted either on exposed geomembrane (if practicable)





or at the surface of the 300 mm thick cover layer of Unit 7 -Drainage Aggregate or Unit 9 – Protection Material above the geomembrane.

Identified defects shall be repaired at the Contractor's expense in accordance with this Specification or the Superintendent's instruction.

4.11.6 Repairs

General

All weld and non-weld areas of the geomembrane shall be visually inspected by the Contractor for signs of damage, defective welds, blisters, punctures, undispersed raw materials, and any sign of contamination by foreign matter. Defective welds shall include completed welds that have been formed using equipment that is subsequently identified as being defective.

Any defective or flawed areas observed shall be marked, repaired, tested; or removed from the installation and disposed of. Unless otherwise approved by the Superintendent, all air channels produced by the dual track fusion welding process shall be sealed at both ends and at any location where the air channel is severed and made discontinuous. The appropriate parties shall agree upon the method of sealing. All repairs (patches, caps, etc.) may, at the discretion of the Superintendent, be destructively tested.

All defect locations shall be surveyed for inclusion on the as-built liner drawing (refer Section 4.9.2).

Patching

Patches shall be used to repair defects such as holes (including areas from which destructive test samples were obtained) and pinholes (exclusive of non-destructive testing air pressure needle holes) which penetrate the entire geomembrane thickness, tears and crazing. Small surface blemishes and localised flaws which do not penetrate the entire thickness of the geomembrane shall also be patched, or as instructed by the Superintendent.

Areas of crazing shall be cut longitudinally (along the length). The ends of all holes shall be rounded, to prevent further propagation, prior to patching. Patches may be used to cover areas of undispersed raw material or contaminated by foreign substances (gasoline, oil, etc.), if approved by the Superintendent. Patches shall extend a minimum of 150 mm beyond the limits of the defect and all corners of patches shall be rounded. Patches shall follow the contour of the defect area and remain free of crimping or pinching. The geomembrane material used for patches must, at a minimum, meet the requirements of this Specification.

Patches and defect areas shall be free of dirt, moisture, debris and markings. Patches shall be temporarily bonded by heat welding. Chemical adhesives and tape are prohibited without prior approval of the Superintendent. The perimeter of the patch shall be abraded with a hand-held grinder to produce a bevelled edge. Patches shall be temporarily installed by heat welding along the entire perimeter of the patch and defect areas. The patch shall be installed flat along all edges with no wrinkles or folds. The patch weld area shall be abraded no more than 1 hour in advance of permanent welding. Heat welding and abrasion shall not cause excessive melting, wear or puncturing of the geomembrane material; such occurrences shall be considered defects and shall be repaired by patching.

Patching or repairs that require more than two passes of a welding procedure shall be considered as a defect, and be covered by a patch. Patches covering parts of other patches are not acceptable.

Capping

A cap is a patch of extended length and may be used to repair failed welds. Caps shall extend a minimum of 150 mm beyond the limits of the defective weld and all corners shall be rounded. Caps shall be installed as detailed in this Specification for patches.

A cap used to repair a failed weld or portion of weld shall be destructively tested if it exceeds 35 m in length or if the weld is of questionable quality. Caps over failed welds shall be carried out only with the approval of the Superintendent if no other method of repair is feasible. Where welds are being repaired by caps, the failed weld shall be cut out, and the cap shall be welded using fusion welding over most of the joint. The





length of extrusion weld required to close-off the cap shall be kept to a minimum, and shall be closed-off after the fusion weld has been pressure tested.

Grinding and Welding

Grinding and extrusion welding shall be used to repair sections of defective extrusion weld less than 0.3 m in length. Areas requiring repair shall be abraded no more than 1 hour prior to the repair being made.

In consultation with the Superintendent, where the reason for a failed dual-track fusion weld has been determined with certainty, and is not related to faulty welding equipment, the failed part of the weld may be repaired (if less than 5 m long) by bevelling the edge (if required), abrading the sheet surface and applying an extrusion weld along the exposed edge (flap) of the seam. Failed welds repaired in this manner must conform to the requirements of this Specification. If the length of the failed portion of the fusion weld exceeds 5 m, or if the flap is not wide enough to allow destructive testing of the extrusion weld (without first testing through the fusion weld), then the weld must be reconstructed by capping.

Geomembrane Wrinkles and Bridging

Geomembrane wrinkle and bridge size and extent shall be minimised to the satisfaction of the Superintendent. Covering the geomembrane with the specified materials early in the morning when the temperature of the liner is low will reduce the extent and size of wrinkles. Wherever possible wrinkles shall be kept small and spread over the panel. In general, wrinkles which, when loaded, will result in a fold in the geomembrane are too large. Wrinkles or bridging larger than 300 mm high shall be cut and welded as a seam if the overlap is sufficient, in accordance with this Specification. Where the overlap is not sufficient, the wrinkle shall be cut and patched or capped as detailed in this Specification. Whenever it is not possible to manage wrinkles to less than specified, wrinkles shall be combined through accumulation so as to minimise the number of repairs being made.

Care shall be taken to minimise the occurrence of wrinkles over or across joins and welds to reduce stress concentrations near heat affected zones in the geomembrane.

4.12 Geotextiles

4.12.1 Description

Once delivered to the Site the Contractor shall recover samples from the rolls of geotextile, as indicated by the Superintendent. Samples from on site rolls shall be recovered and tested at a frequency as indicated in Chapter 2 of this Technical Specification, or as varied by the Superintendent. The Contractor shall compare test results to both the design specifications and to the list of typical values of the properties provided by the manufacturer.

4.12.2 Storage and Handling and Installation of Geotextiles

During shipment and storage, the geotextiles shall be protected from ultraviolet light exposure, precipitation or other inundation, spills of hydrocarbons, mud, dirt, dust, puncture, cutting or other damaging deleterious conditions.

The Contractor shall be responsible for the storage of the geotextile on the Site.

The geotextiles shall be secured and then rolled down the slope in such a manner as to continually keep the geosynthetic tension to preclude folds and wrinkles. All geotextiles shall be weighted with sandbags or the equivalent. Such sandbags shall be installed during placement and shall remain until replaced with cover material. Geotextiles shall be cut using an approved cutting method and approved equipment only.

Cushion Geotextile Installation

Where geomembranes are in place care shall be taken to protect this material from any damage that could be caused by the cutting of the geotextiles. During placement, care shall be taken not to entrap soil, stones, excessive dust, or moisture that could damage the geotextiles or the geomembrane, or hamper subsequent seaming or joining. The surface of the geomembrane shall be free of any larger than silt size particles, prior to placement of the geotextile. An examination of the geotextile over the entire surface, after installation,





shall be conducted to ensure that no broken needles from the manufacturing process or other potentially harmful foreign objects are present. If broken needles are present then the geotextile shall be replaced. Any foreign objects encountered shall be removed, or the geotextile replaced if required by the Superintendent.

If white coloured geotextile is used, precautions shall be taken to avoid "snow-blindness" of personnel.

The geotextile shall be deployed by rolling out by hand, with no vehicular traffic permitted over the underlying geomembrane.

The panels of geotextile shall be overlapped by at least 200 mm, and the overlap shall be tacked together by heat bonding or stitching. Overlaps shall be placed in a down-slope direction (roof tile effect). Stitching shall be carried out using a hand held stitching machine with thread of similar material to the geotextile. The joint shall have a tensile strength of not less than 50 % of the strength of the geotextile being joined. Where stitching is to be carried out, the contractor shall implement a needle management system, to the satisfaction of the Superintendent, to ensure no parts of needles remain in the stitched geotextile joints or on Site.

The geotextile shall be held in place to prevent uplift by wind. Temporary anchorage may be required to prevent displacement of the free-end of the geotextile.

The installation of the geotextile shall be carried out under the supervision of the geomembrane contractor to ensure no damage occurs to the geomembrane.

Placement of Unit 12 – cushion geotextile constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

The Contractor shall submit documentation related to the delivered and installed rolls of cushion geotextile to demonstrate that only the approved batch of geotextile was installed in the Works.

4.12.3 Ballast System for Geotextile

The geotextile shall be held in place to prevent uplift by wind by a ballast system that shall remain in place until the overlying layer covers the geotextile.

Mounds of soil may be placed to satisfy the ballast requirement. Material used for soil mounds shall conform to the same requirements of the material to be permanently placed over the geotextile. Proposed ballast configuration and details shall be submitted to the Superintendent for consideration before implementation.

Ballast shall be gently lowered onto the geotextile, with a maximum drop height of 500 mm. Vehicle traffic is not permitted on the geosynthetics, so the ballast shall be placed as each roll of material is deployed.

4.13 Geocomposites

4.13.1 Description

Once delivered to the Site the Contractor shall recover samples from the rolls of geocomposite, as indicated by the Superintendent. Samples from on site rolls shall be recovered at a frequency of one sample per 4000 m^2 , or as varied by the Superintendent. The Contractor shall arrange for the testing of the samples in accordance with the testing requirements outlined in Section 2.2.13 of this Specification to compare to both the design specifications and to the list of typical values of the properties provided by the manufacturer.

4.13.2 Storage and Handling of Geocomposites

During shipment and storage, the geocomposites shall be protected from ultraviolet light exposure, precipitation or other inundation, spills of hydrocarbons, mud, dirt, dust, puncture, cutting or other damaging deleterious conditions. The Contractor shall be responsible for the storage of the geocomposite on the Site.

The geocomposites shall be handled in such a manner as to ensure it is not damaged in any way.

4.13.3 Installation of Geocomposites

The geocomposites shall be placed directly on top of the geomembrane. The surface of the geomembrane shall be free of any larger than silt size particles, prior to placement of the geocomposite.





Care should be taken during the placement to avoid damage to underlying geomembrane.

The geocomposites shall be secured and then rolled down the slope in such a manner as to continually keep the geosynthetic tension to preclude folds and wrinkles. All geocomposites shall be weighted with sandbags or the equivalent. Such sandbags shall be installed during placement and shall remain until replaced with cover material. Geocomposites shall be cut using an approved cutting method and approved equipment only. Where geomembranes are in place care shall be taken to protect this material from any damage that could be caused by the cutting of the geocomposites. During placement, care shall be taken not to entrap soil, stones, excessive dust, or moisture that could damage the geocomposites or the geomembrane, or hamper subsequent seaming or joining.

If there are any obstructions while deploying the geocomposite, the geocomposite shall be cut to fit around the obstruction. Care should be taken to make sure there is no gap between the obstruction and the geocomposite, to prevent any soil particles from migrating into the geonet core.

The geocomposite shall be deployed by rolling out by hand, with no vehicular traffic permitted over the underlying geomembrane.

The joining of geocomposites shall be in accordance with the manufacturer's specification. Adjacent edges of the geonet along the roll length of the geocomposites shall be overlapped a minimum of 50 mm and tied by plastic ties with a maximum of 1,500 mm intervals. Adjoining geocomposite rolls (end to end) along the roll width shall have the geonet overlapped a minimum of 300 mm across the roll width. Geonet shall be tied by plastic ties in 300 mm intervals across the roll width. The bottom layer of geotextile shall be overlapped. The upper layer of geotextile shall be seamed by stitching or hot-air thermal sealing. Stitching shall be carried out using a hand held stitching machine with thread of similar material to the geocomposite. The contractor shall implement a needle management system, to the satisfaction of the Superintendent, to ensure no parts of needles remain in the stitched geocomposite joints or on Site.

The installation of the geocomposite shall be carried out under the supervision of the geomembrane contractor to ensure no damage occurs to the geomembrane.

The Contractor shall submit documentation related to the delivered and installed rolls of geocomposite to demonstrate that only approved geocomposite material was installed in the Works.

4.13.4 Ballast System for Geocomposite

The geocomposite shall be held in place to prevent uplift by wind by a ballast system, such as sand bags that shall remain in place until the overlying layer covers the geocomposite. Ballast shall be gently lowered onto the geocomposite, with a maximum drop height of 500 mm. Vehicle traffic is not permitted on the geosynthetics, so the ballast shall be placed as each roll of material is deployed.

4.14 Geogrid

4.14.1 Description

Once delivered to the Site the Contractor shall recover samples from the rolls of geogrid, as indicated by the Superintendent. Samples from on site rolls shall be recovered at a frequency of one sample per 5000 m^2 , or as varied by the Superintendent. The Contractor shall arrange for the testing of the samples in accordance with the testing requirements outlined in Section 2.2.17 of this Specification to compare to both the design specifications and to the list of typical values of the properties provided by the manufacturer.

4.14.2 Storage and Handling of Geogrid

During shipment and storage, the geogrid shall be protected from ultraviolet light exposure, precipitation or other inundation, spills of hydrocarbons, mud, dirt, dust, cutting or other damaging deleterious conditions. The Contractor shall be responsible for the storage of the geogrid on the Site.

The geogrid shall be handled in such a manner as to ensure it is not damaged in any way.





4.14.3 Installation of Geogrid

The geogrid shall be sandwiched in Unit 6 – Base Material (refer Section 4.7)

The geogrid shall be secured and then rolled down the slope in such a manner as to continually keep the geosynthetic tension to preclude folds and wrinkles. All geogrid shall be weighted with sandbags or the equivalent. Such sandbags shall be installed during placement and shall remain until replaced with cover material. Geogrid shall be cut using an approved cutting method and approved equipment only. No vehicular traffic permitted over the installed geogrid.

Adjacent edges of the geogrid along the roll length (side by side) shall be overlapped a minimum of 300mm and tied by plastic ties at maximum of 1,500 mm intervals. The Contractor is to note that although a smaller side by side overlap is used in many geogrid applications, a 300 mm side by side overlap is a specific requirement for the project. Adjoining geogrid rolls (end to end) along the roll width shall be overlapped similarly and tied at maximum 1,000 m intervals.

The Contractor shall submit documentation related to the delivered and installed rolls of geogrid to demonstrate that only approved materials are installed in the Works.

4.14.4 Ballast System for Geogrid

The geogrid shall be held in place to prevent uplift by wind by a ballast system, such as sand bags that shall remain in place until the overlying layer covers the geogrid. Ballast shall be gently lowered onto the geogrid, with a maximum drop height of 500 mm. Traffic is not permitted on the geogrid, so the ballast shall be placed as each roll of material is deployed.

4.15 Leachate Collection System for Cell Base Lining

The Contractor shall construct the leachate collection system and leachate sumps in accordance with the Design Drawings and as given below. As the leachate collection system will likely be constructed in sections, the Contractor shall appropriately cap all temporary leachate pipe terminations to allow future connection.

The leachate collection system for the cell base lining includes the following materials (bottom to top):

- Unit 12 Cushion Geotextile;
- 300 mm thick layer of Unit 7 Drainage Aggregate;
- Unit 23 Leachate Collection Pipe; and
- Unit 11 Filter Geotextile.

4.15.1 Leachate Collection Pipe

Unit 23- Leachate Collection Pipe shall be placed by hand or machinery on top of Unit 12 – Cushion Geotextile. The pipes shall be installed with the perforations at 45 degrees off the vertical and horizontal axes of the pipe. Minor adjustments to the alignment of the pipes are permitted to facilitate the use of standard angled bends and junctions. The ends of all pipes shall be capped during construction activities to prevent ingress of foreign materials.

Initial placement of leachate collection pipes, or the subsequent connection of a new portion of the piping system to a previously placed portion, constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

Following placement of each portion of leachate collection piping, the Contractor shall survey all pipe alignments and inverts, including leachate outlet pipes (Section 4.15.3) and leachate clean out access pipes, and submit works-as-executed (WAE) drawings demonstrating compliance with the design within 7 days of completion of each portion of the system. It is noted the a Hold Point has not been established at this point because it would likely preclude the Contractor from covering all areas of the liner with Unit 7 – Drainage



Aggregate quickly enough to comply with the 48-hour time window requirements for GCL, geomembrane, and cover placement given in Section 4.10.4.

The Contractor shall also submit the items listed below as part of his WAE documentation,

 WAE report including description of the completed work, summary of construction materials and time periods of construction, applicable Work Method Statements, RFI records (if any), Contractor quality system records, and Hold and Inspection point documentation.

4.15.2 Leachate Drainage Layer

The Contractor shall place the Unit 7 – Drainage Aggregate over Unit 12 - Cushion geotextile using appropriate methods and equipment to prevent damage to the geotextile cushion, underlying geomembrane, and leachate collection pipes.

The Contractor shall prepare a Work Method Statement for handling and placement of the Unit 7 material. The Work Method Statement shall consider installation of and protection of the geosynthetic materials as well as fines generation in the Unit 7 material. The Work method statement must address the requirements in the remainder of this section. This constitutes a HOLD POINT. No transport or placement of the Unit 7 material shall be carried out until the HOLD POINT has been released by the Superintendent

The Contractor shall be responsible for the selection, loading and transport of the aggregate from the source location, and placement of the aggregate.

The Contractor shall consider the following for handling and placement of the aggregate;

- protection of the integrity of the underlying materials including the cushion geotextile, HDPE geomembrane and GCL;
- considerations and limitations on access over areas underlain by geosynthetic materials;
- potential for breakdown of the aggregate during handling and placement and the generation of excess fine grained particles that may not comply with the specified gradation requirements;
- non-uniform particle size distribution during production, stockpiling, handling and placement. This
 includes accumulation of excess fine grained particles in localised locations that do not comply with the
 specified gradation requirements;
- Potential inclusion of non-conforming materials during the loading of the aggregate at the source or stockpile;
- Consideration of on-site screening prior to placement to manage the risk of non-conforming particle size distribution; and
- Carrying out corrective action for non-conformances in particle size distribution in the placed material. This includes consideration of the protection of the integrity of the cushion layer and HDPE geomembrane.

Drainage aggregate shall be placed on top of the cushioning layer overlying the HDPE geomembrane to form a continuous leachate drainage blanket across the floor of the base cell. The blanket is intended to promote drainage of leachate to the leachate collection pipes and sump.

The drainage aggregate shall also be placed around the leachate collection pipes as shown on the Design Drawings. The Contractor shall take care to ensure that the aggregate is worked around the leachate collection pipes to provide uniform support around the pipes. Placement of Unit 7 material around the leachate collection pipes constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.





Placement of the leachate drainage aggregate shall not impact on the integrity of the underlying base cell liner system, the collection pipes, nor completed areas of the drainage aggregate layer.

The aggregate shall be placed in a manner so as to ensure uniform particle size distribution. Concentration of fine grained particles (<0.075 mm) and particles < 19 mm, to greater than the specified limits is not acceptable. Any material placed, that according to the Superintendent, does not meet the specification shall be removed and replaced with new or remixed material that meets the specification.

The aggregate shall be handled and spread in a manner so as to manage the risk of particle crushing or abrasion to a practical minimum. Spreading of the aggregate to the required 300 mm thick layer shall be carried out with low bearing pressure equipment. Unless otherwise agreed, the maximum permitted machinery weight for drainage layer placement shall be 13T and at no point shall tracked placement equipment operate on a working platform of less than 300 mm thickness of material above the cushion geotextile.

The leachate aggregate shall be placed to ensure the underlying geosynthetics are not damaged. The placement shall be carried out so that trapped air under the geomembrane is directed to vent flaps at the edge of the works and so that wrinkles in the geomembrane do not form creases or similar.

Vehicles are not permitted to traffic on the surface of the cushion geotextile or geomembrane. The aggregate shall be placed by trucking the material over previously placed aggregate and unloading on the previously placed material.

The aggregate shall be no less than 0.75 m thick where wheeled vehicles are to traverse the aggregate on. The method of working shall comprise end-tipping and spreading from previously placed material, or a method agreed with the Superintendent prior to work commencing.

Spreading of gravel shall be carried out to prevent stretching, tearing, distortion or other damage to the cushioning layer and geomembrane. Blades of construction equipment that are used to place and spread the aggregate shall not move within 200 mm of the surface of the geosynthetic layers. Where a dozer is used, the material shall be rolled off the end of the layer to prevent tensioning the geotextile that may occur if the aggregate is just pushed off the end of the layer.

The Contractor may elect to prepare a trial pad to allow the Superintendent to assess a potentially thinner layer thickness for where wheeled vehicles are to traverse the aggregate on the surface of the Cell, depending on the cushioning layer, construction equipment and grading of the leachate collection aggregate.

Gravel shall be carefully placed around the leachate collection pipes. The shaping of the gravel to the required thickness shall be controlled using a laser guide or similar system.

Locking of tracks of excavators or dozers shall be prohibited. Stopping shall be carried out slowly. Where sudden stoppage of a vehicle was required, the underlying geosynthetics shall be exposed to assess if damage has occurred.

The Superintendent shall be present on site to view the placement and spreading of the gravel. Where damage occurs to the underlying materials, the Superintendent shall direct the Contractor on the actions required for repair.

After drainage layer placement, Unit 11 – Filter Geotextile shall be placed and secured over the drainage layer. Filter geotextile shall be installed in the same manner as outlined in Sections 4.12 of this Specification. Placement of Unit 11 – Filter geotextile constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

Following drainage layer placement and filter geotextile placement, the Contractor shall survey the finished surface level to provide works-as-executed (WAE) drawings and to demonstrate that the drainage layer





design thickness has been achieved and that the constructed sump geometry is in accordance with the design. The survey shall be conducted on an approximate 10m grid with detailed survey of the sump. The Contractor shall submit the WAE drawings and an accompanying analysis demonstrating compliance with design thickness and sump geometry. Submission of the WAE drawings and accompanying analysis constitutes a HOLD POINT. Placement of any material above the drainage layer shall not commence until the Hold Point has been released, and all other contractual requirements have been fulfilled.

The Contractor shall also submit the items listed below as part of his WAE documentation,

WAE report including description of the completed work, summary of construction materials and time periods of construction, applicable Work Method Statements, RFI records (if any), Contractor quality system records, and Hold and Inspection point documentation.

4.15.3 Leachate Sump and Outlet Pipe

The leachate sump and outlet pipe shall be constructed in accordance with the Design Drawings.

The Contractor shall provide a Work Method Statement for the installation of the leachate sump to the Superintendent for approval. This constitutes a HOLD POINT. No construction of the sump shall be carried out until the HOLD POINT has been released by the Superintendent.

The work method statement must include, but not necessarily be limited to, the minimum requirements as given in the remainder of this section.

Base and Lining Construction

The base surface on which the sump liner will be constructed shall be prepared to form a firm foundation. The surface shall be trimmed of all softened, loose and foreign materials, and formed to a uniform graded surface. Any depressions shall be filled with compacted Unit 4 – Clay Rich Material or Unit 2 – General Fill. No contaminated material shall be used for surface preparation.

Prior to liner placement, the Contractor shall survey the finished base surface level. This information shall be included in the works-as-executed (WAE) drawings of the leachate drainage layer (refer Section 4.15.2) and to demonstrate that the design levels have been achieved.

The sump liner shall comprise the following components:

- A 500 mm thick of Unit 5 Clay Material which have minimum permeability of 10⁻⁹ m/sec;
- Double layer of Unit 17 GCL;
- Unit 16 HDPE Geomembrane; and
- Unit 12 Cushion Geotextile.

Installation of Clay Material

The Contractor shall proposed method of moisture conditioning, placement and compaction, and maintenance of the leachate sump compacted clay liner to comply but not limit to the following requirements.

- The compacted clay liner layer shall be constructed in at least 3 layers. The clay liner shall be placed in layers of a nominal thickness of 170 mm. The clay liner layer shall have a minimum total thickness of 500 mm.
- The clay liner layer shall be compacted with a vibrating padfoot type roller, to achieve a minimum Dry Density Ratio (DDR) of at least of 98% standard (in accordance with AS1289.5.1.1 and 5.4.1) or a minimum HILF density ratio of 98% standard (in accordance with AS1289.5.7.1) at a moisture content within the range of 0% to +3% (wet) of the Standard Optimum Moisture Content (SOMC). The field density tests during placement of the material shall be minimum a test on each side of the base on each layer of as directed by Superintendent.





- If the required density and moisture is not achieved, the compacted material shall be reworked in-situ to meet the density and moisture content requirements. If the density and moisture content requirements again cannot be achieved after reworking, the failed layer shall be removed for moisture conditioning at the clay borrow area or at an approved designated area, or be discarded.
- Prior to the placement of each lift of the clay liner layer, the top of the previous lift shall be thoroughly scarified and moisture conditioned if necessary to bond each layer together and prevent laminations at the layer interfaces. Any areas where laminations occur, either between or within layers, shall be reworked such that all laminations and defects in the integrity of the clay liner layer are removed.
- Upon completion of the clay liner layer, the Contractor shall maintain the integrity of the layer by limiting the traffic movement over the clay surface and maintaining the surface of the clay in a moist condition, wet of SOMC, until covered by the geomembrane.
- Should the surface of a previously placed and compacted layer have dried or wetted up excessively, as determined by the Superintendent, the affected materials shall be excavated to expose material that has a moisture content within the specified tolerance. The excavated materials shall be returned to a designated area for moisture conditioning or be discarded.
- Trafficked areas are to be ripped, moisture conditioned and recompacted if in the opinion of the Superintendent the quality of these areas has deteriorated. Furthermore, any cracked clay that has formed due to desiccation shall be removed.

The placement of the leachate sump clay liner layer constitutes an INSPECTION POINT and the Contractor is required to provide 48 hours notice before commencing or recommencing this activity.

Following clay liner layer placement, the Contractor shall survey the finished surface level to include in the works-as-executed (WAE) drawings of the leachate sump and to demonstrate that the clay liner layer design thickness has been achieved and that design surface grades for geosynthetic placement have been achieved. The Contractor shall submit the WAE drawings and an accompanying analysis demonstrating compliance with design thickness and surface grades. This submission constitutes a HOLD POINT and geosynthetics installation for the sump shall not proceed until the Hold Point is released.

Geosynthetics Installation

The Contractor shall provide a rounded edge of the clay liner at the toe and crest of the side slope. The rounded edge shall be constructed to support the geomembrane so as to prevent stressing or creasing of the geomembrane under loads. In general, rounding shall be prepared over a length of approximately 300 mm.

The leachate sump shall be lined with the following layers:

- Two layers of Unit 17 GCL overlying the prepared Unit 5 Clay Material;
- A layer of Unit 16 HDPE Geomembrane above the GCL; and
- A layer of Unit 12 Cushion Geotextile.

The installation of the geosynthetic layers shall be as per Sections 4.10 to 4.12 of this Specification. This installation work constitutes an INSPECTION POINT and the Contractor is required to provide 48 hours notice before commencing or recommencing this activity.

At the completion of geosynthetics installation for the sump, the Contractor shall submit a WAE report including description of the completed work, summary of construction materials and time periods of construction, applicable Work Method Statements, RFI records (if any), Contractor quality system records, and Hold and Inspection point documentation




4.15.4 Installation of Unit 24 – Leachate Sump Outlet Pipes and Sump Backfill

Unit 24 – Leachate Sump Outlet Pipes in Package 2 include two sections, as follows:

- Connecting the leachate sump with Unit 27 Leachate Sump Riser; and
- Connecting Unit 27 of Package 2 to the existing Unit 27 of Package 1.

Unit 24 – Leachate Sump Outlet Pipe for the sump shall be connected to the leachate sump at the concrete outlet structure as shown in the Design Drawings. It is recommended that the concrete outlet structure to be constructed prior to the installation of the liner system so that it will be ready to be connected with the geomembrane in the lining system.

Installation of Unit 24 – Leachate Sump Outlet Pipe connecting two sump risers requires trenching greater than 3.0 m below the subgrade surface. However, the trench depth may be smaller if excavated from existing surface in most areas. The Contractor should plan this work in advance to avoid deep excavation if possible.

Installation of Unit 24 – Leachate Sump Outlet Pipe constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

The backfilling of the sump with Unit 7 – Drainage Aggregate shall be by an excavator. The material shall be placed in a manner to minimise any impact on the geosynthetic layers underlain. Any damages shall be to be repaired to the satisfaction of the Superintendent at the Contractor's cost.

Backfilling shall occur within 24 hours of placement of the first GCL layer in the sump base in order to minimise potential GCL hydration swelling.

4.15.5 Installation of Unit 27 – Leachate Sump Riser

Unit 27 – The Leachate Sump Riser for Package 2 shall be constructed outside of the perimeter bund and connected to the leachate sump outlet pipe. The Leachate Sump Riser shall also be connected with the existing riser of Package 1 by Unit 24 – Leachate Sump Outlet Pipe as shown in the Design Drawings (refer Section 4.15.4).

Requirements for bedding, sealing, pipe entrances, pipe trenching are shown on the Design Drawings.

The Contractor shall prepare a Work Method Statement for Unit 27 – Leachate Sump Riser installation and construction. The Work Method Statement shall address drawing and specification requirements as well as safety issues associated with excavation and sump construction. Submission of the Work Method Statement constitutes a HOLD POINT. Sump riser excavation and construction shall not commence until the Hold Point is released.

Installation of the Unit 27 – Leachate Sump Riser constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing this activity.

4.16 Leachate Collection System for Piggy Back Lining

The Contractor shall construct the leachate collection system for the piggy back lining areas in accordance with the Design Drawings and as given below. As the leachate collection system will likely be constructed in stages, the Contractor shall appropriately cap all temporary leachate pipe terminations to allow future connection.

The leachate collection system for the piggy back lining includes the following materials (bottom to top):

- Unit 14 Geocomposite Drainage Net ; and
- Unit 23 Leachate Collection Pipe covered with Unit 7 Drainage Aggregate and wrapped with Unit 11 – Filter Geotextile.





4.16.1 Leachate Drainage Layer

The Contractor shall place the Unit 14 – Geocomposite Drainage Net over the LLDPE geomembrane using appropriate methods and equipment to prevent damage to the underlying geomembrane and GCL, in accordance with Section 4.13 of this Specification.

Should any damage occur to the geomembrane or the GCL the Contractor shall make a full repair at his own cost to the satisfaction of the Superintendent.

The geocomposite drainage net layer is discontinuous at leachate collection pipe locations (eg. at crossslope leachate collection pipes), as shown on the Design Drawings, to encourage flow into the pipes. In addition, the upper geotextile layer of the geocomposite net underlying drainage aggregate shall be removed, as shown on the Design Drawings, to minimise potential for flow resistance to develop between the geocomposite and the drainage gravel.

Placement of Unit 14 – Geocomposite Drainage Net constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

4.16.2 Leachate Collection Pipe

Unit 23 - Leachate Collection Pipe shall be placed by hand or machinery on top of Unit 14 – Geocomposite Drainage Net. The pipes shall be installed with the perforations at 45 degrees off the vertical and horizontal axes of the pipe. Minor adjustments to the alignment of the pipes are permitted to facilitate the use of sweeping angled bends and junctions. The ends of all pipes shall be capped during construction activities to prevent ingress of foreign materials.

Initial placement of leachate collection pipes, or the subsequent connection of a new portion of the piping system to a previously placed portion, constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

Following placement of each portion of leachate collection piping, the Contractor shall survey all pipe alignments and inverts, and submit works-as-executed (WAE) drawings demonstrating compliance with the design within 7 days of completion of each portion of the system. It is noted the a Hold Point has not been established at this point because it would likely preclude the Contractor from covering all areas of the liner with Unit 9 – Protection Material quickly enough to comply with the 48-hour time window requirements for GCL, geomembrane, and cover placement given in Section 4.10.4.

Prior to the placement of surrounds (Unit 7 – Drainage Aggregate) around the leachate collection pipes, the upper geotextile layer of Unit 14 – Geocomposite Drainage Net shall be removed within the zone which will be overlaid with the drainage aggregate.

Unit 7 – Drainage Aggregate shall then be placed around the pipes. Care shall be taken to ensure the granular material extends all around the pipe to support the pipe. No vehicle traffic shall be permitted over the installed pipes unless the Contractor can demonstrate to the satisfaction of the Superintendent that sufficient cover material is in place to protect the pipe from traffic loads. Placement of Unit 7 – Drainage Aggregate around the leachate collection pipes constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

Unit 11 – Filter Geotextile shall surround the drainage aggregate placed around the perforated leachate collection pipes. Filter geotextile shall be installed in the same manner as outlined in Sections 4.12.2 and 4.12.3 of this Specification and shall be placed concurrently with Unit 7.

Placement of Unit 11 – Filter geotextile constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

The Contractor shall also submit the items listed below as part of his WAE documentation for this activity,

 WAE report including description of the completed work, summary of construction materials and time periods of construction, applicable Work Method Statements, RFI records (if any), Contractor quality system records, and Hold and Inspection point documentation.





4.17 Unit 9 – Protection Material

The Contractor shall place the Unit 9 – Protection Material over Unit 14 - Geocomposite Drainage Net using appropriate methods and equipment to prevent damage to the geocomposite drain, underlying geomembrane, and leachate collection pipes.

The Contractor shall provide a Work Method Statement presenting the proposed method of placement of the Unit 9 – Protection Material. The work method statement must include, but not necessarily be limited to, the minimum requirements listed below.

- The minimum thickness of the layer shall be 300 mm as measured perpendicular to the surface of the underlying layer, with a minimum slope of 2.5H:1V. The entire thickness shall be placed as one lift.
- The maximum permitted machinery weight for protection layer placement shall be 13T. At no point shall the placement equipment operate on a working platform of less than 300 mm thickness of material above the geocomposite drain. A field trial is required to confirm that the planned plant for use in hauling and spreading the protection material can operate without damaging the geocomposite drain, underlying geomembrane, or leachate collection pipes and to establish minimum equipment setbacks from the leading edge of protection material placement.
- Compaction shall be only by trafficking with the spreading plant.

The Work Method Statement shall demonstrate to the satisfaction of the Superintendent that the proposed methods will be protective of the geocomposite drain, geomembrane, and leachate collection pipes. The work method shall include "Level 1" supervision and reporting by the GITA. Submission of the work method statement constitutes a HOLD POINT. Placement of the Unit 9 – Protection Material shall not commence until the Hold Point is released.

Notwithstanding the above should any damage occur to the geocomposite drain, the leachate collection pipes or the geomembrane the Contractor shall make a full repair at his own cost to the satisfaction of the Superintendent.

Following protection layer placement, the Contractor shall survey the finished surface level to provide worksas-executed (WAE) drawings and to demonstrate that the protection layer design thickness has been achieved. The survey shall be conducted on an approximate 10m grid. The Contractor shall submit the WAE drawings and an accompanying analysis demonstrating compliance with design thickness. Submission of the WAE drawings and accompanying analysis constitutes a HOLD POINT. Placement of any material above the protection layer shall not commence until the Hold Point has been released, and all other contractual requirements have been fulfilled.

The Contractor shall also submit the items listed below as part of his WAE documentation,

- GITA certification statements for the activity
- WAE report including description of the completed work, summary of construction materials and time periods of construction, applicable Work Method Statements, RFI records (if any), Contractor quality system records, and Hold and Inspection point documentation.

4.18 Stormwater Drainage

4.18.1 Drainage Channels

The construction of stormwater drainage structures must comply with RMS Specification R11 'Stormwater Drainage', Ed4/Rev 0, dated 26.09.12 and in accordance with manufacturer's specifications.

4.18.1.1 Foundation Preparation

Backfilling, where required, must be undertaken in accordance with the R11 Clause 3.7.1





Foundation, support and backfill materials related to drainage channels must be compacted in layers not exceeding 150 mm, unless otherwise directed by the Superintendent. The minimum characteristic values of relative compaction must comply with the R11 Clause 3.7.2 requirements (Table 16).

Location	Minimum Standard Compaction Ratio
Foundations and trench based to a depth of 150 mm below the bottom of the plain concrete or of the bed zone,	95%
Trimmed surface of excavated open drains to a depth of 150 mm, before lining or spreading topsoil for vegetation	90%
All other fill material for drainage structures including fill in bed, haunch, side and overlay zones, material replacing inadequate foundation material, backfill material and earth material in diversion banks	95%

Table 16: Minimum Standard Compaction Ratios

4.18.1.2 Set out

The drainage channels must be set out as detailed in the R11 Clause 3.1.2.

4.18.1.3 Installation

The construction of the permanent Southern Perimeter Drain using Unit 36 box culvert must comply with Section 6 of AS1597.2, in particular:

- Excavation width should provide a minimum gap of 150 mm between the culvert walls and trench wall.
- The precast culvert units shall be supported by a 150 mm (min) layer of bed zone material compacted to a dry density ratio of 90% or a density index of 60%.
- Side zone material shall be placed up to the level of the top of the culvert, whilst maintaining a
 maximum difference of 600 mm between compacted material levels on each side of the culvert.
- Side zone material shall be compacted to a dry density ratio of 90% or a density index of 60% (unless cement slurry fill is used).

Weep holes are to be provided as indicated in the Drawings. The end joints between Unit 36 precast concrete culvert units shall be constructed as indicated below.

- Joints shall be butt joints, connected using appropriate sealant in accordance with the manufacturer's specifications,
- At joints with no design change in channel invert slope maximum gap of 15 mm on the channel base and walls, unless otherwise approved by the Superintendent.
- Joints at location of design change in channel invert slope all gaps shall be smaller than 150 mm; all gaps greater than the maximum width appropriate for using sealant (up to approximately 50 mm) shall be filled to the channel surface on the channel base and walls with sand/cement mortar; all gaps 50 to 150 shall be filled to the channel surface on the channel base and walls with concrete.





Non-woven geotextile shall be installed between the culvert units and the base zone material and the side zone material across all joints. The geotextile shall be held or glued in place to prevent slipping and shall extend a minimum of 250 mm on either side of the joint.

Units shall be handled in accordance with the manufacturer's specifications, in particular:

- Lifting holes or inserts provided in each unit must be used.
- Lateral sliding of the box culverts shall be avoided.
- If stored on site, box culverts shall be placed on timber bearers (placed directly beneath the legs) and on firm level ground.

4.18.2 Construction Traffic

Where the contractor proposes to move heavy construction plant or vehicles over drainage channels, the contractor shall design and provide protective measures for each crossing in accordance with Specification RMS 2.

4.18.3 Construction Tolerances and Inspection

Maximum construction tolerances for stormwater drainage components are specified in Table R11.2 of the R11 specification and as presented in Figure 1:

Component	Attribute	Tolerance
Concrete pipes, box culverts, headwalls and wingwalls,	Location (plan)	Within 200 mm of the plan position shown on the Drawings or specified at any point
energy dissipators, inlet and outlet structures	Invert level	Within 20 mm of the design level at any point
Gully pits and junction boxes	Location (plan)	Within 200 mm longitudinally and 20 mm laterally of the plan position, with reference to the control line for the road shown on the Drawings
	Outlet invert level	Within 20 mm of the invert level shown on the Drawings
Lintels, covers and gratings	Line	The tolerances specified for the adjoining material; e.g RMS R15 for kerbs and gutters, RMS R116 or RMS R119 for asphalt, RMS R83 and RMS R84 for concrete base.
Precast concrete box culvert units	Step between units	On the internal faces of the walls and roof, no step between adjacent units must exceed 20 mm. Steps between 10 mm and 20 mm must be smoothed to a standard of durability equal to the rest of the culvert.
Open drains	Location	The tolerances specified for the adjoining material, including RMS R44 for berm drains and batter drains
	Level	Within 50 mm of the design level at any point provided that there is a continuous downgrade in the direction of flow not less than 0.5% at any point
	Waterway area	Not less than 95% of the design cross sectional area at any point
	Shape	Not more than a 50 mm departure from a 3 m straight edge placed on the bottom or a side of the open drain at any point
Trenches for precast concrete and fibre-reinforced concrete	When measu angles to the	ared horizontally at any point within the trench at right line of the pipes:
pipe drainage structures	Position of trench face:	Within 100 mm of the design location
	Excavation width:	Not less than the specified width; Not more than the specified width plus 100 mm

Figure 1: Maximum Construction Tolerances (Source: Table R11.2 of the RMS Specification R11)





Closed-circuit television (CCTV) inspection of all drainage structures must be carried out in accordance with the R11 Clause 4.2.

4.19 Other Requirements

4.19.1 Surveying

All references in this Specification to required survey or survey to be performed by the Contractor means survey performed and reported by a registered surveyor.

4.19.2 Tolerances

The Contractor shall construct the cell to the construction dimension tolerances and minimum layer thicknesses provided for specific items in individual sections of this Specification.

For other items, the Contractor shall construct the cell to the general construction dimension tolerances provided below.

Levels and grades for material surfaces:

- 1) Surfaces shall be within +/- 100 mm of design levels;
- 2) Grades shall be in the design direction at all locations; and
- 3) Thickness of material layers shall be equal or greater than the design thickness.

Pipes and open drains:

- 1) Invert levels shall be within +/- 50 mm of design levels; and
- 2) Grades shall be maintained in the design direction at all locations.

RH:PR/GRS/rh:pr

https://aupws.golder.com/117625003wollongongcitycouncilnewcellwhytesgully/project doc/320 90percent design/3209 technical specification/tender package 2/117625003_245_s_rev0_whytes gully new cells - tech spec tender package 2.docx



April 2013

WHYTES GULLY NEW LANDFILL CELL TENDER PACKAGE 3

Technical Specification - New Landfill Cell

Submitted to: Wollongong City Council

Report Number.

117625003_246_S_Rev0







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1.0 SECTION 1 – PRELIMINARIES

1.1 Introduction

The basic concept for the expansion of the Whytes Gully Landfill is that future waste will be placed within a lined and capped expansion area constructed over the existing landfill site, including:

- Overfilling of the existing Eastern and Western Gully Landfills (note: the term "piggyback liner" is used to refer to the proposed liner system to be constructed in overfill areas);
- Filling within existing natural areas on the Central Ridge and Western Ridge; and
- Filling within existing natural areas at the toe of the existing Eastern and Western Gully Landfills.

This Technical Specification provides material and construction requirements for the third portion of construction for landfill expansion, referred to as Tender Package 3.

Background information on site conditions and the purpose of project can be found in the following reports, which also provide a detailed description of design intent.

- Design Report "Whytes Gully New Landfill Cell Report for Preliminary Design" prepared by Golder Associates, April 2012, ref. 117625003 - 058 - R - RevA.
- Detailed Design report "Detailed Design Report Tender Packages 1,2 and 3" prepared by Golder Associates, ref. 117625003 - 224 - R

1.2 **Definitions**

The following parties are referred to in this Technical Specification.

Table 1: Parties relevant to the p	project
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Table III alties feld	
Superintendent	The party designated by the site owner to manage the Contractor in accordance with the construction contract. The Superintendent may delegate appropriate tasks to a Technical Superintendent.
Contractor	The party awarded the contract to complete the works described in this Technical Specification.
GITA	Geotechnical Inspection and Testing Authority: The party undertaking Level 1 inspection and testing of landfill earthworks in accordance with AS3798 -2007. The GITA shall be engaged by the Contractor, subject to Superintendent short list and approval, and shall be independent of the Contractor.
Regulator	The NSW state agency responsible for oversight of landfill construction and environmental management. This is anticipated to be the NSW EPA.

This Technical Specification includes 'Hold Points' and 'Inspection Points'. These are defined as follows:

- Hold Point An identified point in the landfill construction sequence where the Contractor must halt work and provide required information to the Superintendent. The Contractor must not resume work until the Hold Point is released, in writing, by the Superintendent.
- Inspection Point An identified point in the landfill construction sequence where the Contractor is required to provide written notification in advance of commencing work on identified items in order to allow the opportunity for the Superintendent to directly inspect the work; the notification must be provided when indicated and in no case less than 24 hours in advance of commencing the work.

The specific meaning of the term "Site" is defined in the contract documents.



1.3 Construction Materials

The table below presents the primary materials for cell construction. These materials are referred to in this Technical Specification by unit number. Additional construction materials are also named in this Technical Specification.

Table 2: Material List
SOILMATERIALS
Unit 1 – Topsoil – Not Used
Unit 2 – General Fill
Unit 3 – Intermediate Cover Material – Not Used
Unit 4 – Clay Rich Material
Unit 5 – Clay Material
Unit 6 – Base Material – Not used
Unit 7 – Drainage Aggregate
Unit 8 – Gas Drainage Gravel – Not used
Unit 9 – Protection Material
GEOSYNTHETIC MATERIALS
Unit 11 – Filter Geotextile
Unit 12 – Cushion Geotextile
Unit 13 –Geocomposite Drainage Net (Surface Water) – Not Used
Unit 14 – Geocomposite Drainage Net
Unit 15 – LLDPE Geomembrane – Not used
Unit 16 – HDPE Geomembrane
Unit 17 – Geosynthetic Clay Liner (GCL)
Unit 18 – Geogrid – Not used
PIPE MATERIALS
Unit 21 – Gas Collection Pipe – Not used
Unit 22 – Groundwater Drainage Pipe – Not used
Unit 23 – Leachate Collection Pipe
Unit 24 – Leachate Sump Outlet Pipe
Unit 25 – Leachate Drainage Pipe – Not used
Unit 26 – Subsoil Drainage Pipe – Not Used
Unit 27 – Leachate Sump Riser



Unit 28 – Leak Detection Pipe – Not used

SURFACE WATER DRAINAGE AND OTHER MATERIALS

Unit 31 – Bentonite

Unit 32 - Rip Rap Armourstone and Aggregate for Gabion Baskets and Wire Mattresses

Unit 33 – Granular Material for Concrete Pipe Installation – Not Used

Unit 34 – Rock Filled Gabions and Mattresses

Unit 35 – Drain Liner – Not Used

Unit 36 – Precast Reinforced Concrete Box Culverts (RCBC) and Headwalls

Unit 37 - Precast Reinforced Concrete Pipes (RCP) - Not Used

Unit 38 – Channel Liner

1.4 Design Drawings

Detailed design drawings for Tender Package 3 are provided separately and referred to herein as the "Design Drawings".

1.5 Site Preparation

Site preparation works shall be carried out by the Contractor in successive stages in accordance with the Contractor's approved Construction Program.

1.5.1 Removal of Vegetation

Existing vegetation shall be cut and disposed by the Contractor in all construction areas.

1.5.2 Services

No active services are known to be present within the construction area.

The Contractor is responsible for locating any unknown services, and establishing whether services are active or inactive prior to initiating work in any area of the site. The Contractor shall completely remove these services, including all service trench bedding materials.

In addition, 132 kVA overhead powerlines are present along the southern edge of the proposed landfill construction area. These power lines are owned by Endeavour Energy and are to remain in service at all times. The Contractor must use appropriate work methods in the vicinity of these lines.

In the case that previously unknown services are encountered during the course of works, the Contractor shall immediately take appropriate safety precautions, and shall inform the Superintendent. The Contractor is responsible for protecting any active services identified by the Contractor at the time of construction until they are decommissioned and/or de-energised by others. Once decommissioned and/or de-energised, the Contractor shall completely remove services, including all service trench bedding materials.

The Contractor shall prepare and submit documentation of all his activities to confirm, locate and remove services.

1.5.3 Structures Demolition

No existing structures are currently present within the construction area.



2.0 SECTION 2 – MATERIALS

2.1 General Material Requirements

2.1.1 Contractor Supply and Protection of Materials

The Contractor shall be responsible for supply, delivery, storage, placement and installation of all materials required to carry out the works in this Technical Specification. However, the Superintendent may direct that some materials will be supplied by others. Once incorporated in the Works, the Contractor shall protect the materials throughout the duration of construction to ensure they do not degrade or become damaged so as to change the intended performance or function of the materials.

2.1.2 Material Approval

Source Approval

The Contractor shall demonstrate that all materials proposed by the Contractor for the works will meet the requirements of this Technical Specification. This constitutes a HOLD POINT for <u>each</u> of the materials identified in the Technical Specification and in the Design Drawings. No material shall be imported to the site, and no on-site materials shall be handled, placed or stockpiled, until the Hold Point for the material is released.

Materials that are considered by the Superintendent to have excessive settlement potential, or the potential to undergo or contribute to chemical reactions adverse to landfill performance, will not be approved.

The Contractor shall prepare a submittal for Superintendent review for each material to demonstrate that the proposed material will comply with all requirements of this Technical Specification. Hold Point release will be dependent on the submittal providing a satisfactory demonstration. Each submittal shall identify the material source, or sources, and include relevant test results that satisfy the testing requirements of this Technical Specification, description of material uniformity, and other information needed to confirm required properties, including waste classification for soil materials. For manufactured products, manufacturer's specifications and quality control information shall also be submitted.

Confirmation of Properties of Materials Delivered to Site

The Contractor is responsible for confirming that all materials delivered to site from approved sources meet the material property requirements of this Technical Specification. This includes complying with all sampling and testing requirements in this Technical Specification, as well as performing additional sampling and testing as needed to confirm as-delivered material properties.

Confirmation of material properties after placement and compaction is also required for some materials as indicated in this Technical Specification.

The Contractor is required to notify the Superintendent at least 24 hours in advance of taking samples for confirmation of as-delivered and as-placed material properties.

The Superintendent may, at his discretion, conduct Audit sampling and testing of any materials at source or at site. The Contractor must assist and facilitate the Superintendent in such activities. If Audit test results indicate that materials do not meet requirements then the Superintendent may direct that the materials be replaced at the Contractor's expense and that the Contractor pay the Audit sampling and testing costs.

2.1.3 VENM or ENM Requirement

All soil materials imported to the site and used to construct any portion of the landfill must meet the definition of virgin excavated natural material (VENM) or excavated natural material (ENM) under the Protection of the Environment Operations Act 1997 and the Protection of the Environment Operations Amendment 2008, unless otherwise permitted by this Technical Specification, consistent with the project approval conditions, and agreed with the Superintendent. If material other than VENM or ENM is proposed for import to the site, the Contractor shall be responsible for obtaining all relevant approvals, such as from the Regulator, prior to importing.



The Contractor shall commission a VENM/ENM assessment and waste classification for all imported soil material. The assessment and classification must be performed by a qualified person and be to the satisfaction of the Superintendent. The assessment and classification shall comprise a material source inspection, an assessment of historical land use at the source site, and chemical testing at a frequency of at least one sample per material source or at least one sample per 1,000 m³. The Superintendent may require more frequent sampling and testing at the Contractor's expense if the classification is considered incomplete or inadequate.

For VENM assessment, chemical testing shall comprise analysis for heavy metals, total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene, xylenes (BTEX), polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) and Organochlorine pesticides (OCPs). The provisions of current NSW EPA Waste Classification Guidelines shall apply.

For ENM assessment, the requirements given by the NSW EPA under the Protection of the Environmental Operation (Waste) Regulation 2005 - General Exemption Under Part 6, Clause 51 and 51A; The excavated natural material exemption 2012; shall apply.

The Contractor shall keep records of waste classification and quantity of all soil materials imported to site.

The Contractor may submit non-VENM or non-ENM soil materials from on site to be considered for use in landfill construction, provided that these materials meet Technical Specification requirements and are not designated for stockpiling for future use by the site owner. The Contractor submittal for on-site materials must address the requirements in Section 2.1.2, as for import materials.

2.1.4 Reporting

Reporting of all material test results shall be in accordance with the Contractor's Quality System, specific requirements in this Technical Specification, and other contract requirements. However, in all cases material test results shall be made available to the Superintendent no later than 1 week after each test is performed.

All material test results submitted to the Superintendent by the Contractor must be from a laboratory with NATA-accreditation for all tests performed. All survey results submitted to the Superintendent by the Contractor must be from a registered surveyor.

2.2 Material Properties

2.2.1 Unit 1 – Topsoil – Not Used

Not used for Tender Package 3.

2.2.2 Unit 2 – General Fill

Unit 2 – General Fill shall comprise clay, silt, sand, gravel or any combination thereof or other approved materials. This material shall contain no organic matter. This material shall have a low erosion potential with an Emerson Class number greater than 4 (AS 1289.3.8.1), although the Superintendent may agree to reduce the Emerson Class number requirement where the fill will not be exposed to potential erosion. This material shall have a maximum particle size of 75 mm and a smooth gradation that results in minimal visible voids once compacted.

Source approval for Unit 2 will primarily require the Contractor to identify the source, describe the material, provide two representative Emerson Class test results and gradation test results (AS1289.3.6.1), and, for import material, provide an acceptable VENM/ENM classification.

Confirmation of the properties of as-delivered Unit 2 shall be by Contractor inspection and documentation of each incoming load, and by sampling and Emerson Class testing and gradation testing at a frequency of at least one testing event per 1,000 m³ of material placed, with a minimum of one testing event per source.

2.2.3 Unit 3 – Intermediate Cover Material – Not Used

Not used for Tender Package 3.



2.2.4 Unit 4 – Clay Rich Material

Unit 4 Clay Rich Material shall clayey soil, free of organic matter, capable of being compacted to a dense condition. The material shall have the following index properties:

- Index properties:
 - Plasticity Index > 15%;
 - Liquid Limit > 25%.
- Emerson crumb classification > 4

The material shall have differing gradation requirements in different applications as indicated below.

A. Bearing Layer in Cell Base: This application provides a surface for GCL placement

- Gradation:
 - Maximum particle size 13.2mm;
 - Passing 2.4 mm sieve > 90%;
 - Percentage fines (passing 0.075mm sieve) > 30%.

B. Bund – Main Body of Bund. This application is for bund material that is not in contact with GCL material

- Gradation:
 - Maximum particle size 53 mm;
 - Passing 19 mm sieve > 90%;
 - Percentage fines (passing 0.075mm sieve) > 30%.
- C. Bund Batters and top surface: This application provides a surface for GCL placement
 - Gradation: same as category A above.

Table 3: Material Testing Requirements for Unit 4 – Clay Rich Material

Property	Test method	Frequency	
		Source approval	As-delivered
Atterberg Limits	AS1289.3.2.1	Two tests per source	One test per 2,000 m ³ material used on site, minimum 4 tests per source
Gradation	AS1289.3.6.1	Two tests per source	One test per 2,000 m ³ material used on site, minimum 4 tests per source
Emerson Class Number	AS1289.3.8.1	Two tests per source	One test per 2,000 m ³ material used on site, minimum 4 tests per source



2.2.5 Unit 5 – Clay Material

Unit 5 – Clay Material shall clayey soil, free of organic matter, capable of being compacted to a dense condition. The material shall have the following index properties:

- Gradation:
 - Maximum particle size 13.2 mm;
 - Percentage fines (passing 0.075mm sieve) > 50%.
- Index properties:
 - Plasticity Index > 20%;
 - Liquid Limit > 40%.
- Emerson crumb classification > 4.
- When remoulded to a Standard Maximum Dry Density (SMDD) of 95% in accordance with AS1289.5.1.1 at Standard Optimum Moisture Content (SOMC) have a co-efficient of permeability, measured in a triaxial cell at an effective confining pressure of 50 kPa in accordance with AS1289.6.7.3 ,of no greater than 1 x 10⁻⁹ m/s.

The following table shows the testing requirements for this material.

|--|

Bronorty	Test method	Frequency		
Froperty	rest method	Source approval	As-delivered	
Atterberg Limits	AS1289.3.2.1	Two tests per source	One test per 200 m ³ material used on site, minimum 4 tests per source	
Gradation	AS1289.3.6.1	Two tests per source	One test per 200 m ³ material used on site, minimum 4 tests per source	
Emerson Class Number	AS1289.3.8.1	Two tests per source	One test per 200 m ³ material used on site, minimum 4 tests per source	
Permeability	AS1289.6.7.3	Two tests per source	One test per 200 m ³ material used on site, minimum 1 test per leachate sump, minimum 4 tests per source	

2.2.6 Unit 6 – Base Material – Not used

Not used for Tender Package 3.

2.2.7 Unit 7 – Drainage Aggregate

Unit 7 – Drainage Aggregate shall consist of high durability, clean, hard, sound gravel or crushed rock of natural geologic origin, free of organic matter, lumps of clay or other deleterious material, carbonates, limestone or other calcareous material that would be subject to chemical attack. The material shall be washed to remove fines. Recycled materials or materials of ash/slag origin are not permitted.

The material shall have particle characteristics such that the placed drainage layer is stable under compaction using a smooth drum roller.

The material shall have the properties given below <u>following</u> placement and spreading to the required thickness:

- Gradation:
 - Max. particle size 40 mm;

- Passing 19 mm sieve < 20%</p>
- Passing 13.2 mm sieve < 10%</p>
- Percentage Fines (passing 0.075 mm sieve) < 2%</p>
- Aspect Ratio (in accordance with AS 1141.14):
 - Max. misshapen particles at 2:1 calliper ratio: 20%
 - Max. misshapen particles at 3:1 calliper ratio: 5%
- Permeability > 1×10^{-3} m/s
- Strength (in accordance with AS1141.22–2008):
 - Min.wet strength: 80 kN;
 - Max.wet/dry strength variation: 30%
- Calcium carbonate content (in accordance with Test Method: Rapid Titration specified in "Soil and Plant Analyses" by C.S. Piper):
 - Max.calcium carbonate content by volume: 15%
- Solubility in acid (in accordance with Test Method: AWWA B 100.96):
 - non-soluble in acid

The following material shall not be used as Unit 7 – Drainage Aggregate: volcanic breccia, mudstone, sandstone, shale, limestone, calcrete, and highly weathered or altered rocks.

The following table shows the testing requirements for this material.

Table 5: Material Testing Requirements for Unit 7 – Drainage Aggregate

		Frequency		
Property	Test method	Source approval	As-placed (following placement and spreading)	
Geologic Origin	NA	Certificate is required for each material source	Inspect and document each batch delivered to site to confirm composition and lack of organics, carbonates, and clay	
Gradation	AS1141.11 / AS1141.12	Two tests per source	One test per 500 m ³ material used on site, minimum 2 tests per source	
Aspect Ratio	AS 1141.14	Two tests per source	One test per 500 m ³ material used on site, minimum 2 tests per source	
Permeability	AS1289.6.7.1	One test per source	not required	
Strength	AS1141.22 - 2008	Two tests per source	One test per 500 m ³ material used on site, minimum 2 tests per source	
Calcium carbonate content	Rapid Titration specified in "Soil and Plant Analyses" by C.S. Piper	One test per source	One test per 500 m ³ material used on site, minimum 2 tests per source	
Solubility in acid	AWWA B 100.96	One test per source	One test per 500 m ³ material used on site, minimum 2 tests per source	

2.2.8 Unit 8 – Gas Drainage Gravel – Not used

Not used for Tender Package 3.



2.2.9 Unit 9 – Protection Material

Unit 9 Protection Material shall comprise a material:

- capable of being spread smoothly in a 300mm thick layer without damaging underlying geocomposite drain and/or geomembrane;
- with compaction limited to tracking by the spreading plant;
- with sufficient strength and cohesion to maintain a stable long-term orientation on piggyback liner slopes, generally 2.5H:1V to 5H:1V; and
- with as-placed permeability within the identified range.

The material shall have the properties given below <u>following</u> placement and spreading to the required thickness:

- Gradation:
 - Max. particle size 19 mm;
 - Percentage Fines (passing 0.075 mm sieve) < 3%</p>
- Permeability > 1 x 10^{-3} m/s
- Shear strength, measured at 25 kPa effective confining stress, equivalent to that of a drained friction angle of 35 degrees.

Source approval for Unit 9 will primarily require the Contractor to identify each source, describe the material, provide two representative gradation test results (AS1289.3.6.1), two permeability test results (AS. 1289.6.7.1), two appropriate shear strength tests, and an acceptable VENM/ENM classification.

Confirmation of the properties of as-delivered Unit 9 shall be by Contractor inspection and documentation of each incoming load, and by sampling and gradation and permeability testing at a frequency of at least one testing event per 1,000 m³ of material placed, with a minimum of two testing events per source. Note: This sampling and testing shall be on material recovered from the protection material layer after placement.

Coarse coal washery rejects will be considered for use as Unit 9 under the following conditions:

- the materials meet the above requirements;
- the material is demonstrated to the Superintendent's satisfaction to be from a source with no history of spontaneous combustion of stockpiled coal washery rejects; and
- the materials are supplied in full accordance with the requirements outlined by the NSW EPA under the Protection of the Environmental Operation (Waste) Regulation 2005 - General Exemption Under Part 6, Clause 51 and 51A; the Coal Washery Rejects General Exemption 2009.

If the Contractor proposes to use coarse coal washery rejects then full details of how the material requirements and conditions outlined above will be satisfied must be included in his source approval submission for the material.

2.2.10 Unit 10 – Not used

The Unit 10 designation has not been used.

2.2.11 Unit 11 – Filter Geotextile

Unit 11 – Filter Geotextile shall be woven or non-woven, polyester or polypropylene which has the following properties:

Equivalent Opening Size < 110 μm (Typical Value)</p>

- CBR puncture strength >2100 N (Minimum Average Roll Value, MARV)
- Flow rate > 100 L/s/m² (cross-plane flow under 100mm head) (Typical Value)
- Mass per unit area>200 g/m² (MARV)

The following table shows the testing requirements for this material.

Table 6: Material Testing Requirements for Unit 11 – Filter Geotextile

Broparty	Test method	Frequency		
Property		Source approval	As-delivered	
Mass	AS3706.1	Two tests per source	two tests per roll used on site	
Flow Rate (cross- plane flow under 100mm head)	AS3706.9	Two tests per source	One test per manufacturer batch	
Equivalent Opening Size	AS3706.7	Two tests per source	One test per manufacturer batch	
CBR Puncture Strength	AS3706.4	Two tests per source	Two tests per roll used on site	

2.2.12 Unit 12 – Cushion Geotextile

Unit 12 – Cushion Geotextile shall be a non-woven, needle-punched polyester or polypropylene material. The Cushion Geotextile shall be free of broken needles. The material shall be rejected if broken needles are present.

Requirements for the material will be provided at a later date and will include minimum required values for the following properties:

- Thickness
- Mass per unit area
- Trapezoidal tear strength
- CBR puncture strength

The following table shows the testing requirements for this material.

Table 7: Material Testing Requirements for Unit 12– Cushion Geotextile

Dronorty	Test method	Frequency		
Froperty		Source approval	As-delivered	
Thickness	AS3706.1	Two tests per source	One test per roll used on site	
Mass	AS3706.1	Two tests per source	One test per roll used on site	
Trapezoidal Tear	AS3706.3	Two tests per source	One test per 1,000 m ² material placed on site	
CBR Puncture Strength	AS3706.4	Two tests per source	One test per 1,000 m ² material placed on site	

Interface Shear Strength: The minimum interface shear strength requirements given in Section 2.2.19 apply to the performance of combinations of Unit 12Unit 16 and Unit 17 materials comprising the base lining system. The Contractor's attention is drawn to the requirement for each material to meet its individual

requirements and also for the combined lining system materials to meet interface shear strength requirements.

2.2.13 Unit 13 – Geocomposite Drainage Net (Surface Water) – Not Used

Not used for Tender Package 3.

2.2.14 Unit 14 – Geocomposite Drainage Net

Unit 14 – Geocomposite Drainage Net shall be a geocomposite material comprising a triplanar HDPE geonet core with non-woven, polyester, polypropylene, or polyethylene needle punched, resin or heat bonded geotextiles thermally bonded to both sides of the geonet core. The geocomposite drainage net material shall have the following properties:

- Thickness > 6.8 mm at 200 kPa normal stress (Minimum Average Roll Value, MARV)
- Mass > 1,000 g/m² (MARV)
- Hydraulic flow rate ≥ 0.4 x 10⁻³ m³/s per metre width at 20kPa normal stress with hydraulic gradient i = 0.1 (measured between rigid plates) (Typical value)
- Hydraulic flow rate ≥ 0.3 x 10⁻³ m³/s per metre width at 200 kPa normal stress with hydraulic gradient i = 0.1 (measured between rigid plates) (Typical value)
- Tensile strength >20 kN/m (MARV)
- Elongation at peak >38% (MARV)
- Ply adhesion (peel strength of geotextile from geonet) >180 g/cm (MARV); with no unbonded areas permitted
- Internal and Interface Shear Strength Requirements Refer to Section 2.2.19

Interface Shear Strength: The minimum interface shear strength requirements given in Section 2.2.19 apply to the performance of combinations of Unit 12, Unit 16 and Unit 17 materials comprising the base lining system. The Contractor's attention is drawn to the requirement for each material to meet its individual requirements and also for the combined lining system materials to meet interface shear strength requirements.

The geotextiles shall have the following properties:

- Mass > 115 g/m2 (MARV) or > 200 g/m2 (MARV) if field joints between Unit 14 sheets are made by hot-air seaming
- Equivalent Opening Size < 90 μm (Typical value)

The Unit 14 Geocomposite Drainage Net must be demonstrated to remain stable under a sustained normal stress of 500 kPa.



The following table shows the testing requirements for this material.

Table 8: Material Testir	g Requirements for	Unit 14 – Geocom	posite Drainage Net
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		Frequency		
Property	Test method	Source approval	As-delivered	
Thickness	AS 3706.1 / ISO 9863 / ASTM D-5199-01 / EN 964-1	Two tests per source	One test per 2 rolls used on site	
Mass	AS3706.1 / ISO 9864 / ASTM D-5261-92 / EN 965	Two tests per source	One test per 2 rolls used on site	
Tensile strength	AS3706.2 / ISO 10319 / ASTM 4595-01	Two tests per source	One test per 3,000 m ² geocomposite material placed on site	
Elongation at peak	AS3706.2 / ISO 10319 / ASTM 4595-01	Two tests per source	One test per 3,000 m ² geocomposite material placed on site	
Hydraulic flow rate20 kPa stress200 kPa stress	AS 3706.10 / D-4716-01 / ISO-12958	Two tests per source for each stress level	One test per 10,000 m ² geocomposite material placed on site (200 kPa stress only)	
Hydraulic Flow Rate Reduction Factor for Creep (500 kPa normal stress)	extended AS 3706.10 / D- 4716-01 / ISO-12958	One test per source	Not required	
Ply Adhesion	ASTM D7005	Two tests per source	One test per 1,500 m ² geocomposite material placed on site Inspect and document each roll used onsite to confirm requirement for no unbonded areas	
Geotextiles				
- Mass per unit area	AS3706.1 / ISO 9864 / ASTM D-5261-92	Two tests per side per source	One test per side per 1,500 m ² geocomposite material placed	
- Opening size	AS 3706.7 / D-4751-95 / ISO 12956	Two tests per side per source	One test per side per 25,000 m ² geocomposite material placed (1 test per side minimum)	

2.2.15 Unit 15 – LLDPE Geomembrane – Not used

Not used for Tender Package 3.

2.2.16 Unit 16 – HDPE Geomembrane

Unit 16 – High Density Polyethylene (HDPE) Geomembrane with nominal thickness of 2 mm shall have the following properties:

- Thickness > 1.9mm (minimum average roll value, MARV)
- density > 0.94 g/cm³ (MARV)
- Base resin: density >0.932 g/cm³; melt flow index <1.0 g/10min
- Product textured on both sides with asperity height > 0.25 mm (MARV)
- Tensile strength at yield > 29 kN/m (MARV)
- Elongation at yield > 12% (MARV)

- Tear resistance > 249 N (MARV)
- Puncture resistance > 534 N (MARV)
- Oxidative Induction Time (OIT):
 - > 100 minutes at standard pressure (MARV); and
 - > 400 minutes at high pressure (MARV)
- Oven aging at 85°C for 90 days:
 - OIT retained > 55% at standard pressure (MARV); and
 - OIT retained > 80% at high pressure (MARV)
- Stress Cracking Resistance (performed on smooth portion of sheet) > 300hr (Typical value)
- Interface Shear Strength Requirements Refer to Section 2.2.19.

The following table shows the testing requirements for this material.

Table 9: Material Testing Requirements for Unit 16–Textured HDPE Geomembrane

Property		Frequency		
	Test Method	Source approval	As-delivered	
Thickness	ASTM D 5994		One test per roll	
Density	ASTM D 1505		One test per manufacture batch	
Melt Flow Index	ASTM D 1238		One test per manufacture batch	
Asperity Height	GM12		Every second roll or each roll if not in production sequence (measure at three to five locations across roll width)	
Tensile Properties (each direction) - Strength at yield - Elongation at yield	ASTM D 6693	Two tests per	One test for each property per roll	
Tear Resistance	ASTM D 1004	manufacture source	One test per roll	
Puncture Resistance	ASTM 4833		One test per roll	
Oxidative Induction Time (OIT) - Standard OIT - High Pressure OIT	ASTM D 3895 ASTM D 5885		One test for each property per resin type or per 25,000 m ² of geomembrane	
Oven Aging at 85°C for 90 days - Standard OIT - High Pressure OIT	ASTM D 5721 ASTM D 3895 ASTM D 5885		One test per resin type, manufacture batch, or per geomembrane type	
Environmental Tensile Load Crack Resistance	ASTM D 5397		One test per resin type, manufacture batch, or per geomembrane type	



Interface Shear Strength: The minimum interface shear strength requirements given in Section 2.2.19 apply to the performance of combinations of Unit 12, Unit 16 and Unit 17 materials comprising the base lining system. The Contractor's attention is drawn to the requirement for each material to meet its individual requirements and also for the combined lining system materials to meet interface shear strength requirements.

2.2.17 Unit 17 – Geosynthetic Clay Liner (GCL)

Unit 17 – Geosynthetic Clay Liner shall be a reinforced multi-layered system comprising at least two layers of geotextile encapsulating a layer of dry, sodium bentonite. The outer geotextile on both sides shall be nonwoven. The GCL shall be reinforced by needle punching and be free of broken needles.

The bentonite layer in the GCL shall have the following characteristics:

- form: natural sodium bentonite or >80% sodium as activated bentonite
- carbonate content< 1 to 2% (by weight)</p>
- montmorillonite content> 70% (by weight)
- particle size: if powdered >80% passing 0.075mm sieve; if granulated <1% passing 0.075mm
- cation exchange capacity> 70 meq/100g

The GCL material shall have the following properties:

- Total mass (dry) > 4000 g/m²;
- Bentonite clay:
 - Bentonite mass (dry) > 3700 g/m²;
 - Swell index > 24 ml/2g
- Fluid loss < 18 ml</p>
- Tensile strength > 4 kN/m
- Peel strength > 360 N/m
- Permeability: k < 5 x 10⁻¹¹ m/s tested at 100kPa effective confining stress
- Internal and Interface Shear Strength Requirements Refer to Section 2.2.19

Interface Shear Strength: The minimum interface shear strength requirements given in Section 2.2.19 apply to the performance of combinations of Unit 12, Unit 16 and Unit 17 materials comprising the base lining system. The Contractor's attention is drawn to the requirement for each material to meet its individual requirements and also for the combined lining system materials to meet interface shear strength requirements

Geotextiles component of the GCL shall have the following property:

- The outer geotextile on both sides is nonwoven
- Mass of nonwoven geotextile > 200 g/m²
- Mass of woven geotextile (if any) > 100 g/m².



The following table shows the testing requirements for this material.

Table 10: Material Testing Requirements for Unit 17 - GCL

		Frequency		
Property	Test Method	Source approval	As-delivered	
Bentonite Clay: - Swell Index - Fluid Loss	ASTM D5890 ASTM D5891		Manufacturer certification for each batch represented	
Total Mass (dry)	DIN 53854		One test per 2 rolls used on site	
Bentonite Mass (dry)	ASTM D 5393	Two tests per manufacture	One test per 2 rolls used on site	
Tensile Strength	ASTM D 4595	source	One test per 2 rolls used on site	
Peel Strength	ASTM D 6496		One test per 2 rolls used on site	
Permeability (using 100kPa effective confining stress):	ASTM D 5887		One test per 25,000 m ² of GCL installed at site, minimum 3 tests total	

2.2.18 Unit 18 - Geogrid - Not used

Not used for Tender Package 3.

100 F	
	1
	100 C
7.4	

2.2.19 Lining System Shear Strength Requirements

Source Approval: The Contractor must include direct shear test results (ASTM D5321) in the submittal for Unit 12, Unit 16, and Unit 17 source approval that demonstrates that the lining systems will achieve the required shear strengths for the test conditions defined in the table below.

No.	Lining System	Required Minimum Equivalent Shear Strength Parameters	Direct Shear Test Cross Section	Direct Shear Test Conditions
A	Cell Base Lining in Tender Package 3	Peak Strength: Φ'= 17° , c'= 0 kPa Residual Strength: Φ'= 11° , c'= 0 kPa	 specific gravel proposed by the Contractor as Unit 7 Drainage Aggregate; specific geotextile proposed by the Contractor as Unit 12 – Cushion Geotextile; or representative nonwoven, needle-punched geotextile with mass per unit area >540 g/m²; specific 2.0 mm thick textured geomembrane proposed by the Contractor as Unit 16 –HDPE Geomembrane; specific GCL proposed by the Contractor as Unit 17 GCL; compacted clayey soil (95% standard compaction at +2% above optimum moisture) to represent the compacted Unit 4 – Clay Rich Material below the GCL. 	 Normal stress = 100, 200, and 300 kPa; Shear rate = 0.1 mm/min; Total shear displacement > 75mm Test specimen configuration: no pre-determined shear surface – test to allow shearing to occur in actual weakest interface or material; Hydration and Consolidation: Apply low normal stress (7-14 kPa) to the test specimen and, while maintaining the normal stress, soak in tap water for 48 hours to allow GCL and soils to hydrate. Load the specimen at a constant rate to the test normal stress over a period of 24 to 48 hours to allow consolidation. Shear the hydrated and consolidated specimen. Provide information on shear response and shear plane location.

Table 11: Lining System Shear Strength Requirements

As Delivered: The Contractor must perform direct shear tests (ASTM D5321) on as-delivered geosynthetic and soil materials to demonstrate that the lining systems will achieve the required shear strengths for the test conditions defined in the table above.

Sampling and testing for the as-delivered cell base lining (type A tests) must be performed at two separate times during the construction of the cell base lining for Package 3. Note: There is no piggy back lining construction for Package 3.





2.2.20 Not Used

Not used.

2.2.21 Unit 21 – Gas Collection Pipe – Not used

Not used for Tender Package 3.

2.2.22 Unit 22 – Groundwater Drainage Pipe – Not used

Not used for Tender Package 3.

2.2.23 Unit 23 – Leachate Collection Pipe

Unit 23 – Leachate Collection Pipe shall have the diameter indicated below.

- Type 1: 160 mm diameter (not used for Tender Package 3)
- Type 2: 315 mm diameter (not used for Tender Package 3)
- Type 3: 355 mm diameter

Types 1, 2 and 3 Unit 23 – Leachate Collection Pipe shall all comprise HDPE (PE 100 material class) pipe rating PN 12.5, with SDR 13.6 or approved equivalent.

Where the pipes are required to be perforated, the pipes shall be drilled in accordance with the detail pattern shown on the design drawing. All drill cuttings, including loose attachments and burrs, shall be removed from the perforated pipes before installation.

The pipe shall have perforations of 15 mm diameter as shown on design drawing.

All connections and fittings for the pipes shall be manufactured from the same material and strength class as the pipe, and shall be solid wall units. All angled connections and fittings shall have sweeping bends unless agreed otherwise by the Superintendent. All ends of the pipes shall be capped with HDPE caps.

Pipe joins shall be carried out using full face fusion bonding. No filter sock shall be used.

Material property certificates from the manufacturer shall be submitted for approval for each source of material prior to construction.

The Contractor shall provide the Superintendent with manufacturer's documentation certifying the properties of the material for each manufacture batch used on site.

2.2.24 Unit 24 – Leachate Sump Outlet Pipe

Unit 24 – Leachate Sump Outlet Pipe shall have the diameter indicated below.

- Type 1: 400 mm diameter
- Type 2: 355mm diameter

Types 1 and 2 Unit 24 – Leachate Sump Outlet Pipe shall both comprise HDPE (PE 100 material class) pipe rating PN 6.3, with SDR 26 or approved equivalent.

The pipes shall be solid wall pipes.

All connections and fittings for the pipes shall be manufactured from the same material and strength class as the pipe, except where indicated otherwise on the Design Drawings, and shall be solid wall units.

Pipe joins shall be carried out using full face fusion bonding.

Material property certificates from the manufacturer shall be submitted for approval for each source of material prior to construction.





The Contractor shall provide the Superintendent with manufacturer's documentation certifying the properties of the material for each manufacture batch used on site.

2.2.25 Unit 25 – Leachate Drainage Pipe – Not used

Not used for Tender Package 3.

2.2.26 Unit 26 – Subsoil Drainage Pipe – Not Used

Not used for Tender Package 3.

2.2.27 Unit 27 – Leachate Sump Riser

Unit 27 – Leachate Sump Riser shall be 2500 mm ID (internal diameter) precast concrete pipe with step irons and frame/cover (Class M). The riser shall be manufactured in accordance with AS 4198:1994.

The riser shall incorporate an integral base section to minimise base leakage risk. The riser shall have additional features as indicated on the Design Drawings.

The Contractor shall provide the Superintendent with manufacturer's documentation certifying the properties of the material for each riser component or section.

2.2.28 Unit 28 – Leak Detection Pipe – Not used

Not used for Tender Package 3.

2.2.29 Not Used

Not used.

2.2.30 Not Used

Not used.

2.2.31 Unit 31 – Bentonite

Unit 31 - Bentonite pellets shall be nominal 6 mm, compressed dry bentonite pellets of a type used for sealing boreholes and monitoring wells. The bentonite shall have a swell index of at least 15 mL / 2g.

Material property certificates from the manufacturer shall be submitted for approval for each source of material prior to construction.

The Contractor shall provide the Superintendent with manufacturer's documentation certifying the properties of the material for each manufacture batch used on site.

2.2.32 Unit 32 – Rip Rap Armourstone and Aggregate for Gabion Baskets and Wire Mattresses

Unit 32 - Rip Rap shall be used to protect the diversion drains and provide rock for the gabions and mattresses.

The following standards shall apply:

- AS 2758.6-2008 Aggregates and Rock for Engineering Purposes; Part 6: Guidelines for the Specification of Armourstone
- AS 2758.4-2000 Aggregates and Rock for Engineering Purposes; Part 4: Aggregate for Gabion Baskets and Wire Mattresses.



Property	d₅₀ =300 mm Rip Rap	d₅₀ =150 mm Rip Rap	d₅₀ =190 mm Gabion Rock	Test Method
Layer Thickness	600 mm (2d ₅₀)	300 mm (2d ₅₀)	-	-
		Gradation		
Maximum d ₁₀₀ Particle Size	450 mm	230 mm	250 mm	-
Nominal d ₈₅ Size	360 mm	180 mm	-	
Nominal d ₅₀ Size ¹	325 mm	150 mm	190 mm	-
Nominal d ₁₅ Minimum Particle Size	180 mm	90 mm	120 mm	AS 1289
	Mate	erial Requirements		
Point Load Strength	> 2MPa	> 2MPa	> 2MPa	AS 4133
Water absorption	< 2.5%	< 2.5%	< 2.5%	AS 1141
Sodium Sulfate Soundness	< 9% (weighted average loss)	< 9% (weighted average loss)	< 9% (weighted average loss)	AS 1141

The rip rap, gabion and mattress aggregates shall meet the specification provided in Table 12: .

Table 12: Rip Rap Armourstone and Aggregate for Gabion Baskets and Wire Mattresses Properties

Note: $1.d_{50}$ size is the particle size of the riprap for which 50% by weight is finer

2.2.33 Unit 33 – Granular Material for Concrete Pipe Installation – Not Used

Not used for Tender Package 3.

2.2.34 Unit 34 – Rock Filled Gabions and Mattresses

Unit 34 – Rock Filled Gabions and Mattresses shall conform to the materials per the specification below and the Design Drawings.

The following specification and their related documents shall apply:

 New South Wales Roads & Maritime Services QA Specification R55 Rock Filled Gabions and Mattresses

2.2.35 Unit 35 – Drain Liner – Not Used

Not used for Tender Package 3.

2.2.36 Unit 36 – Precast Reinforced Concrete Box Culverts (RCBC) and Headwalls

Unit 36 – Precast Reinforced Concrete Box Culverts (RCBC) and Headwalls shall consist of Humes Class 2415 Large Box Culverts and corresponding steel reinforced box culvert headwall or approved equivalents. Unit 36 components shall conform to the materials per the specification below and the Design Drawings.

The following specification and their related documents shall apply:

AS 1597.2 Precast reinforced concrete box culverts - Large culverts

This includes the bed zone materials and side zone materials as defined in Table 6.1 and 6.2, respectively, in Section 6 of the standard.

Source approval for bed zone materials and side zone materials will primarily require the Contractor to identify the source, describe the material, provide two representative gradation test results (AS1289.C6.1), provide two representative plasticity index test results for the fraction passing 0.075 mm (AS1726), and, for import material, provide an acceptable VENM/ENM classification.





Confirmation of the properties of as-delivered bed zone materials and side zone materials shall be by Contractor inspection and documentation of each incoming load, and by sampling and gradation and plasticity index testing of the fraction passing 0.075 mm at a frequency of at least one testing event per 1,000 m³ of material placed, with a minimum of one testing event per source.

Note: Cement slurry fill with a compressive strength in the range 3 MPa to 5 MPa may be used as side zone material as an alternative to the above.

2.2.37 Unit 37 – Precast Reinforced Concrete Pipes (RCP) – Not Used

Not used for Tender Package 3.

2.2.38 Unit 38 – Channel Liner

Unit 38 – Channel Liner used for temporary bench drainage channels shall be CANAL3®Geocomposite Liner or approved equivalent.

CANAL3®Geocomposite Liner comprises a 0.5mm polyethylene (PE) liner combined with 260gsm nonwoven protection geotextiles bonded to either side. The Seaming process shall be undertaken using hotmelt glued seams.





3.0 SECTION 3 – CONSTRUCTION MANAGEMENT

3.1 General Management

Construction shall be achieved in compliance with the Contractor's site management plans prepared in accordance with contract requirements.

3.1.1 Stockpile Management

The Contractor will manage stockpiles in accordance with the requirements of the Contractor's CEMP for the project. There must be no unacceptable impact to the site as a result of stockpiling.

As a minimum, the following requirements must be met by the Contractor:

- All stockpiles must be managed to minimise the generation of dust;
- All stormwater must be managed in the vicinity of the stockpiles to minimise the volume of water coming into contact with the stockpiles; and
- Runoff from all stockpiles, other than contaminated material or waste stockpiles, shall be managed in the same way as other stormwater on the site according to the Contractor's CEMP.

Upon completion of the use of an area for stockpiling, the Contractor shall:

- Remove all remaining stockpiled material for reuse or placement in accordance with this Technical Specification; and
- The reinstated stockpile area is to be assessed by the Contractor to the satisfaction of the Superintendent to ensure that no waste materials remain.

3.1.2 Water Management during Construction

3.1.2.1 Surface Water

The Contractor shall manage surface water within the construction site in accordance with the CEMP, and approved surface water management plan. The surface water drainage system on site includes clean and dirty (i.e., potentially sediment-laden) water drains. The surface water collected from the construction area shall be discharged to the dirty water drainage system of the site.

The Contractor shall divert surface run-on to the construction area, and must prevent uncontrolled discharge of water originating in the construction area to the site surface water drainage system.

The Contractor shall ensure that his operations do not result in chemical contamination of surface waters.

The Superintendent (site owner) will be responsible for management of the existing major surface water ponds at the Whytes Gully site, surface water treatment, and controlled discharges from the ponds.

3.1.2.2 Dewatering

The Contractor shall manage, at his cost, any waters arising from groundwater dewatering activities in accordance with the CEMP and Contract requirements. Management requirements are likely to depend on water quality and quantity. In regard to the potential to transfer water arising from groundwater dewatering activities into the existing site surface water management and/or leachate management systems, any such transfer would be at the discretion of the Superintendent (site owner) and would depend on water quality and quantity and the capacity of the systems at the time.

3.2 Construction Quality Management

The Construction Quality Management system for construction comprises Contractor requirements and Superintendent actions. Contractor requirements include preparing management plans, preparing work method statements, material testing, compaction testing (through GITA), surveying, notifying for Inspection Points, and preparing Hold Point documentation and works-as-executed (WAE) documentation.





Superintendent actions include review and approval of Contractor submittals and documentation, inspecting construction works, conducting audit testing, attending Inspection Points, and releasing Hold Points. Superintendent actions are typically referred to as Construction Quality Assurance (CQA).

A description of the approach for quality management of material properties is provided in Section 2.1.2, including description of approval of material sources, confirmation of as-delivered material properties, and audit testing. Details of material requirements and testing requirements are given in Chapter 2 of this document. For example, as indicated in Section 2.1.4, all material test results submitted to the Superintendent by the Contractor must be from a laboratory with NATA-accreditation for all tests performed; and all survey results submitted to the Superintendent by the Contractor must be from a registered surveyor.

Quality management requirements to be implemented by the Contractor during construction activities are given in the following chapter of this document.





4.0 CONSTRUCTION ACTIVITIES

4.1 Subgrade Preparation

Subgrade preparation by the Contractor comprises vegetation removal (refer Section 1.5.1) followed by cutting and filling to establish the subgrade surface shown in the Design Drawings. For the subgrade surface in the current work (i.e. Tender Package 3) the maximum design cut depth below the existing surface is approximately 1.5 m. The maximum design fill thickness is approximately 4.0 m, occurring at an existing pond (refer Section 4.1.3).

The Contractor shall provide a Work Method Statement presenting proposed methods for subgrade preparation activities, including cutting, filling, proof rolling, and undercutting and replacement and all items described below. The Work Method Statement must address safety, including issues related to working on steeply sloping areas of the site. Submission of the work method statement constitutes a HOLD POINT. These activities shall not commence until the Hold Point is released.

4.1.1 Cutting

Cutting is required in some areas to establish the subgrade surface. Rock excavation may be required in local areas. The Design Report contains general information on subsurface conditions and references to documents with more detailed subsurface information.

Dewatering (groundwater) may be required in some areas to facilitate excavation. The Design Report contains general information on hydrogeological conditions and references to documents with more detailed information. Contractor requirements for managing waters arising from dewatering are provided in Section 3.1.2.2.

The base of all excavations shall be proof rolled to identify soft materials that would form an unsuitable surface for fill placement or landfill base/liner construction. Remove and replace any such materials with Unit 2 – General Fill as per Section 4.2. Proof rolling of the soil/fill surface in each local area and/or removal of any unsuitable materials constitutes an INSPECTION POINT. The Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

Existing service trenches may be present (refer Section 1.5.2 and Section 1.1). Any trenches that are identified to extend below the base of the excavation shall be fully excavated and then backfilled with Unit 2 – General Fill as per Section 4.2. Trench excavation and backfilling constitutes an INSPECTION POINT. The Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

Over-excavation: The Contractor shall not excavate deeper than the subgrade surface. Any excavation deeper than the subgrade surface, not including any additional depth required for removal of unsuitable materials or existing service trench backfill (refer preceding paragraphs), shall be deemed Contractor over-excavation. If over-excavation occurs, the Contractor shall perform, at his cost, all activities required to safely manage any excess dewatering and excess cut materials in accordance with the CEMP and Contract requirements. The Contractor shall also be responsible for all costs associated with reinstatement of over-excavated areas with Unit 2 – General Fill as per Section 4.2. The Contractor's attention is drawn in particular to potential consequences of over-excavation in previously landfilled areas.

All excavated materials from above the subgrade surface are to be stockpiled by the Contractor in designated areas, and in accordance with the CEMP and Contract requirements, for future use by the site owner. The Contractor shall not re-use the excavated materials.

4.1.2 Filling

Filling is required in some areas to establish the subgrade surface. In these areas, the ground surface present after vegetation removal (refer Section1.5.1) shall be proof rolled to identify soft materials that would form an unsuitable surface for fill placement or landfill base/liner construction. Remove and replace any such materials with Unit 2 – General Fill as per Section 4.2.



Proof rolling of the surface in each local area and/or removal of any unsuitable materials constitutes an INSPECTION POINT. The Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

Existing service trenches may be present (refer Section 1.5.2 and Section 1.1). Any trenches that are identified within the fill area shall be fully excavated and then backfilled with Unit 2 – General Fill as per Section 4.2. Trench excavation and backfilling constitutes an INSPECTION POINT. The Contractor is required to provide 24 hours notice before commencing or recommencing this activity. After the proof rolling, removal/replacement, and trench backfilling activities described in the preceding paragraphs are complete, then Unit 2 – General Fill material shall be placed to achieve subgrade levels as per Section 4.2, except that the minimum degree of compaction shall be <u>98%</u> of SMDD rather than 95% of SMDD.

4.1.3 Filling of Former Surface Water Ponds

The former surface water ponds at the south of the Western Gully requires filling of up to approximately 4.0 m thickness to establish design subgrade levels.

Fill placement in this area will be with Unit 2 – General Fill and subject to the requirements given in Section 4.1.2, with the following additions:

- Prior to proof-rolling, any sediments that have accumulated in the bottom of the pond shall be removed and managed in accordance with the CEMP and Contract requirements. Sediment removal constitutes an INSPECTION POINT. The Contractor is required to provide 24 hour notice before commencing or recommencing this activity.
- The need for proof-rolling after sediment removal will be determined by the Superintendent.

The Contractor's Work Method Statement for subgrade preparation (refer Section 4.1) must reflect the above requirements for this fill area.

4.1.4 Survey and Documentation

The Contractor shall survey final subgrade levels to provide works-as-executed (WAE) drawings and to demonstrate that the design levels have been achieved. The survey shall be conducted on an approximate 10m grid with additional survey points along the benches and at the leachate sumps. WAE drawings shall include surveyed locations and dimensions of soft areas identified during proof rolling and of any backfilled service trenches. WAE drawings shall also include information required for subgrade leachate pipe construction and landfill gas venting system construction (refer Sections 1.1 and 1.1). The Contractor shall submit the WAE drawings, and an accompanying analysis demonstrating compliance with design levels.

The Contractor shall also submit the items listed below as part of his WAE documentation:

- GITA certification statements for all fill placement and compaction, reflecting the requirements for Unit 2 – General Fill in Section 4.2.
- WAE report including description of the completed work, summary of construction materials and time periods of construction, applicable Work Method Statements, RFI records (if any), Contractor quality system records, and Hold and Inspection point documentation.

Submission of these items constitutes a HOLD POINT. Construction of the Base Layer or placement of the Bearing Layer shall not commence in an area until the Hold Point has been released for that area.

4.2 General Fill

Placement of Unit 2 - General Fill is required as part of several cell construction activities.

General Fill shall be placed with maximum 300 mm thick layers and compacted with suitable compaction equipment to achieve a minimum of 95% of SMDD (in accordance with AS1289.5.1.1 and 5.4.1) or a minimum HILF density ratio of 95% Standard (in accordance with AS1289.5.7.1) at a moisture content within


the range of -3% to +3% of the Standard Optimum Moisture Content (SOMC). A trench roller is required for any compaction within trenches.

The GITA shall provide "Level 1" supervision for material placement and moisture density testing. The frequency of field density and moisture testing during placement of all General Fill material shall as a minimum conform the following, whichever requires the most tests:

- 1 test per 500 m³ per material type; or
- 2 tests per batch of work.

If the required density and moisture is not achieved, the compacted material shall be reworked in-situ to meet the density and moisture content requirements. If the density and moisture content requirements again cannot be achieved after reworking, the failed layer shall be removed for moisture conditioning at the material borrow area or at an approved designated area, or be discarded.

Note that the required compaction standard for filling with Unit 2 – General Fill to establish subgrade design levels is 98% of SMDD, as indicated in Section 4.1.2.

4.3 Perimeter Bund

The Contractor shall conduct a set-out survey of the alignment of the perimeter bund prior to construction and shall peg out the surveyed alignment. This constitutes a HOLD POINT. Construction of the bund shall not commence until the Hold Point has been released by the Superintendent.

The bund shall be constructed in accordance with the Design Drawings. The bund shall be constructed with Unit 4 – Clay Rich Material to form a 1-m high bund with a 4m crest width and 2H:1V side batters. As indicated in Section 2.2.4, the required gradation of the Unit 4 material in the perimeter bund differs between the main body of the bund (i.e., max. particle size 53 mm) and the inboard batter surface where the GCL will be placed (i.e., max. particle size 13.2 mm). The finished surface where the GCL will be placed shall be smooth and well-drained with no protruding coarse materials, and with additional surface requirements given in Section 4.7.3.

The Unit 4 material shall be placed and compacted in nominal 200mm thick lifts with suitable compaction equipment to achieve a minimum of 98% SMDD (in accordance with AS1289.5.1.1 and 5.4.1) or a minimum HILF density ratio of 98% Standard (in accordance with AS1289.5.7.1) at a moisture content within the range of -2% to +2% of the Standard Optimum Moisture Content (SOMC). Prior to the placement of each lift of the bund, the top of the previous lift shall be scarified and moisture conditioned if necessary to bond each lift together and prevent laminations at the lift interfaces.

Bund construction constitutes an INSPECTION POINT and the Contractor is required to provide 48 hours notice before commencing or recommencing this activity.

In addition, the GITA shall provide "Level 1" supervision for material placement and moisture density testing. If the GITA or Contractor detects material changes or variations then he shall undertake testing as necessary to assess the acceptability of the material. The frequency of field density and moisture testing during placement of the material shall as a minimum conform the following, whichever requires the most tests:

- 1 test per 400 m³ per material type; or
- 3 tests per batch of work.

If the required density and moisture is not achieved, the compacted material shall be reworked in-situ to meet the density and moisture content requirements. If the density and moisture content requirements again cannot be achieved after reworking, the failed material shall be removed for moisture conditioning at the material borrow area or at an approved designated area, or be discarded.

Upon completion of the bund, the Contractor shall maintain the integrity of the bund by limiting the traffic movement over the clay surface and maintaining the surface of the clay in a moist condition until covered by





the base liner GCL and geomembrane. Should the bund surface have dried excessively (e.g. desiccation cracking>20mm depth) or wetted up excessively, as determined by the Superintendent, the affected materials shall be excavated to expose material that has moisture content within the specified tolerance. The excavated materials shall be returned to a designated area for moisture conditioning or be discarded, and the excavated bund material replaced.

Trafficked areas of the bund shall to be ripped, moisture conditioned and re-compacted if, in the opinion of the Superintendent, the quality of these areas has deteriorated.

Following bund placement, the Contractor shall survey the finished surface level to provide works-asexecuted (WAE) drawings and to demonstrate that the design geometry has been achieved. The WAE drawings shall include geosynthetic anchor trench alignments within the bunds. The Contractor shall submit the WAE drawings, an accompanying analysis demonstrating compliance with design geometry. Submission of the WAE drawings and documentation constitutes a HOLD POINT. Placement of liner materials on the surface of the berm shall not commence in an area until the Hold Point has been released for that area, and all other contractual requirements have been fulfilled.

The Contractor shall also submit the items listed below as part of his WAE documentation,

- GITA certification statements for all fill placement and compaction, reflecting the above requirements for Unit 4 Clay Rich Material.
- WAE report including description of the completed work, summary of construction materials and time periods of construction, applicable Work Method Statements, RFI records (if any), Contractor quality system records, and Hold and Inspection point documentation.

4.4 Internal Bunds

Internal bunds between new landfill cells and sub-cells will be constructed to provide a physical barrier for each stage and sub-stage of liner construction and waste filling. The locations of internal bunds are shown on the Design Drawings.

The internal bunds shall be constructed in the same manner and with the same requirements given in Section 4.3 for the perimeter bund.

4.5 Bearing Layer

The bearing layer shall be constructed within the cell base liner footprint, in accordance with the Design Drawings.

The bearing layer shall be constructed with Unit 4 – Clay Rich Material with a design as-compacted thickness of 200 mm.

The material shall be placed in one layer and compacted with suitable compaction equipment to achieve a minimum of 98% SMDD (in accordance with AS1289.5.1.1 and 5.4.1) or a minimum HILF density ratio of 98% Standard (in accordance with AS1289.5.7.1) at a moisture content within the range of -2% to +2% of the Standard Optimum Moisture Content (SOMC).

The GITA shall provide "Level 1" supervision for material placement and moisture density testing. The frequency of field density and moisture testing during placement of the material shall as a minimum conform the following, whichever requires the most tests:

- 1 test per 1,000 m² per layer of material type; or
- 3 tests per batch of work.

If the required density and moisture is not achieved, the compacted material shall be reworked in-situ to meet the density and moisture content requirements. If the density and moisture content requirements again cannot be achieved after reworking, the failed material shall be removed for moisture conditioning at the material borrow area or at an approved designated area, or be discarded.



The Contractor shall maintain the bearing layer in moist condition until Unit 17 - GCL is installed. Should the bearing layer surface have dried excessively (e.g. desiccation cracking>20mm depth) or wetted up excessively, as determined by the Superintendent, the affected materials shall be excavated to expose material that has moisture content within the specified tolerance. The excavated materials shall be returned to a designated area for moisture conditioning or be discarded, and the excavated bearing layer material replaced. Note that the surface of the bearing layer is designed to shed leachate and its shape shall be maintained during formation in order to avoid temporary water ponding during construction. Consideration may be given to use of micro-mist sprayers to limit loss of moisture from the completed surface during hot weather.

Trafficked areas of the bearing layer surface are to be ripped, moisture conditioned and recompacted if, in the opinion of the Superintendent, the quality of these areas has deteriorated.

The finished surface shall be smooth and well-drained. Coarse materials shall not protrude from the surface of the bearing layer by more than 10 mm. No areas of ponding shall be accepted on the surface. Additional surface requirements are given in Section 4.7.3.

The Contractor shall survey the final levels to provide works-as-executed (WAE) drawings and to demonstrate that the design levels and layer thickness have been achieved. The survey shall be conducted on an approximate 10 m grid. The Contractor shall submit the WAE drawings and an accompanying analysis demonstrating compliance with design levels. Submission of the WAE drawings and accompanying analysis constitutes a HOLD POINT. Placement of GCL shall not commence in an area until the Hold Point has been released for that area, and all other contractual requirements have been fulfilled.

The Contractor shall also submit the items listed below as part of his WAE documentation,

- GITA certification statements for all fill placement and compaction, reflecting the above requirements for Unit 4 – Clay Rich Material.
- WAE report including description of the completed work, summary of construction materials and time periods of construction, applicable Work Method Statements, RFI records (if any), Contractor quality system records, and Hold and Inspection point documentation.

4.6 General Requirements for Geosynthetics

4.6.1 Documentation

Specialist Installation Sub-Contractor

The Works described in the following sections shall be undertaken by an experienced geosynthetic installation specialist contractor approved by the Superintendent. The Contractor shall require that skilled sub-contractor personnel will supply, test and install all geosynthetic materials. The Contractor is responsible for all aspects of the work.

Prior to the installation of geosynthetics, the Contractor shall submit the proposed qualified subcontractor(s) to the Superintendent for approval. This submission constitutes a HOLD POINT. No geosynthetic material installation shall begin until the HOLD POINT is released. Any change to the geosynthetic supply or installation shall be subject to written approval from the Superintendent.

Alternative construction methods to those detailed in the following sections will be considered, subject to the approval of the Superintendent, provided they satisfy the intent of this Specification.

Quality Assurance and Quality Control

The Contractor shall be responsible for all quality assurance and quality control of the manufacture, transportation, storage and installation of the geosynthetic. This shall include the obtaining of material property details and certificates from the resin supplier and the geosynthetic manufacturer, the preparation of a quality control procedures manual and the undertaking of all inspections, non-destructive and destructive testing and repairs etc. and other activities detailed in this Specification.



The Contractor is responsible for compliance with this Specification; however, the Superintendent shall monitor installation of the geosynthetics. The Contractor shall accommodate all quality assurance activities undertaken by the Superintendent.

The Superintendent shall undertake audits of the quality control and assurance procedures. Should any areas of the works show non-conformances with the approved quality control procedures manual, then the Contractor shall cease work until the non-conformance is resolved. Resolution will be by either presentation of the appropriate documentation or undertaking sampling and testing, or another activity approved by the Superintendent.

The Superintendent may also undertake audit testing at his sole discretion at any time during the works. This may include a detailed Liner Integrity Survey (resistivity method) for the geomembrane materials (refer Section 4.8.5). The Contractor shall accommodate all audit testing activities.

Quality Control Procedures Manual

The Contractor shall submit a quality control procedures manual to the Superintendent at least 10 days before the supply of any geosynthetic to the Site. The quality control procedures manual shall include the following items, as appropriate to each type of geosynthetic:

- The Contractor's organisational structure and personnel, and the qualifications and experience of the proposed installation personnel;
- Trial weld procedures;
- Measures to minimise wrinkles;
- Welding procedures, including equipment make and model;
- Weld repair procedures;
- Non-destructive testing procedures;
- Destructive testing procedures;
- Pro forma sheets for recording of installation and test results;
- Deployment equipment and procedures;
- Safety equipment;
- Supply transportation, storage and handling procedures;
- Vent flap details; and
- Any proposed changes with respect to this Specification.

The Superintendent will review this information to assess the suitability of the quality control procedures manual. Upon review of the quality control procedures manual, the Superintendent may request additional information specific to the project installation conditions.

The submission of the geosynthetic quality control procedures manual constitutes a HOLD POINT. No geosynthetic materials shall be imported to the Site until the HOLD POINT is released.

Data, Statements, Reports and Certificates

The Contractor shall submit the following information at least 7 days prior to the installation of any geosynthetic at the Site:

The manufacturer's certifications, descriptive data, specification sheets;





- Manufacturer's test results for geosynthetic composition and properties;
- The origin (resin name and supplier's name, resin production plant), identification (brand name, number) and production date of the resin;
- A list of quantities and descriptions of materials other than the base polymer which comprise the geosynthetic;
- Copies of the quality control certificates issued by the resin supplier;
- A statement regarding recycled polymer content (if permitted by this Specification);
- A properties sheet including, at a minimum, all specified properties, measured using test methods indicated in these specifications, or equivalent;
- Reports of the tests, including sampling procedures, conducted by the manufacturer to confirm that the geosynthetic meets these Specifications. Tests shall be conducted at frequencies outlined in Chapter 2.0 of this Specification; and
- A quality control certification that property values given in the properties sheet are guaranteed by the geosynthetic manufacturer. The quality control certificate shall include roll numbers and identification, resin lot, batch numbers, sampling procedures and results of quality control tests.

The Superintendent will review this information to assess the suitability of the data, statements, reports and certificates. Upon review, the Superintendent may request additional information specific to the project conditions.

The submission of the data, statements, reports and certificates constitutes a HOLD POINT. Geosynthetic material installation shall not commence until the HOLD POINT is released.

4.6.2 Site Records and Drawings

The Contractor shall submit all quality forms, test results and other documentation indicated in the quality control procedures manual to demonstrate its compliance with the quality system for the project and to demonstrate compliance of the installed geosynthetics with this Specification.

Copies of these records and tests, as well as records of corrective action taken when results are unsatisfactory, shall be presented to the Superintendent in writing, within one working day following an inspection, test or action. To scale as-built drawings (i.e., WAE drawings) shall be provided of all panel layouts, anchor trenches, test positions and defects within 14 days of completing the liner.

The Contractor shall keep records sufficient to document in detail the progress and location of work undertaken.

The Contractor shall also submit the items listed below as part of his WAE documentation,

WAE report including description of the completed work, summary of construction materials and time periods of construction, applicable Work Method Statements, RFI records (if any), Contractor quality system records, and Hold and Inspection point documentation.

4.6.3 Traffic over Geosynthetics

Construction traffic over geosynthetics is restricted or not permitted, to prevent damage and ensure the material performs its intended function. The construction of the different units with the general traffic limitations is as follows:

 GCL: No vehicle access over deployed GCL, only careful foot traffic, subject to footwear requirements.





- Geomembrane: No vehicle access over deployed geomembrane, only careful foot traffic, subject to footwear requirements.
- Geocomposite: No vehicle access over deployed geocomposite, only careful foot traffic, subject to footwear requirements.
- Geotextile: No vehicle access over deployed geotextile, only foot traffic.

The Contractor shall comply with geosynthetic manufacturer recommendations, as well as the requirements within this Specification, regarding limitations for periods of exposure for deployed geosynthetics prior to covering.

4.6.4 Anchor Trenches

The anchor trench for the base liner shall be used to anchor the GCL, geomembrane, and cushion geotextile at top of the perimeter bund. The installation of these units may require that the previous geosynthetic layer(s) is temporarily anchored while the next geosynthetic is installed.

The excavation of the anchor trench shall be presented to the Superintendent for inspection and approval before backfilling commences. This constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

The anchor trench for the base liner shall be located on top of the bund in accordance with the Design Drawings a dimension of 500 mm x 500mm.

The geosynthetic placed in the anchor trench shall extend down one side. The geosynthetics shall not extend up the outer edge of the trench. Loose soil and ponded water shall not be permitted in the anchor trench. Anchor trenches shall be constructed and maintained so as to provide for free drainage of surface water flow and prevent ponding in or adjacent to anchor trenches.

The geosynthetics shall be placed against the side of the trench and the trench backfilled with excavated material. The backfill shall be placed in layers appropriate for the proposed construction equipment. The compaction shall be carried out in the presence of the GITA. The compacted material shall achieve at least dense or stiff consistency, as assessed by the GITA in accordance with AS 1726. Care shall be taken to not damage the geosynthetics during compaction of the backfill of the anchor trench. The Contractor shall propose equipment and method to demonstrate a low risk of damage to the geosynthetics.

The backfill of the trench shall be carried out using hand held compaction equipment, to achieve the consistency specified above.

4.7 Installation of Unit 17 – Geosynthetic Clay Liner (GCL)

4.7.1 Delivery, Storage and Handling

Unit 17 - GCL delivered to site shall be wrapped with weather and moisture resistant wrapping. The Contractor shall be responsible for the unloading, protection from the weather and storage of the delivered GCL. Rolls with damaged wrapping shall be inspected by the Superintendent to assess the extent of hydration of the GCL. Unit 17 - GCL with moisture content above 30% by weight (ASTM D5993) may be rejected. GCL rolls with damaged wrapping and moisture content lower than 30% shall be re-wrapped and sealed. All rolls of material shall be clearly marked with the type of GCL, unroll direction and batch number of manufacture.

All rolls of Unit 17 - GCL shall be delivered with the GCL tightly wrapped around a centre core, with the hole in the core suitable for the proposed spreader bar to be used during deployment. All rolls shall be stored off the ground on hard, dry, free-draining surface, with suitable bearers at closely spaced centres, suitably protected from runoff and other damage. Stacked rolls of GCL shall be covered with tarpaulins to promote runoff. GCL rolls shall not be rolled across the ground.





4.7.2 Acceptance Criteria for GCL

Delivery to Site

The Contractor shall supply, unload, store and protect the rolls of GCL.

Inspection of GCL after Unrolling

The Superintendent shall inspect the GCL as it is rolled out on the slope.

Where a roll of GCL has been damaged and the damaged area extends more than 300 mm across the deployed width of GCL, the roll may be rejected due to its reduced tensile strength. The Superintendent shall determine if the strength of the roll is unacceptable, based on the nature and location of the damage.

4.7.3 General Surface Preparation

Unit 17 - GCL shall generally be placed on the prepared surface of the bearing layer, but in limited areas the GCL will be placed on internal bund slopes and prepared subgrade (refer Design Drawings).

Portions of the prepared surfaces that have deteriorated to an extent that has potentially compromised the quality of the layer, shall be reworked at the contractor's expense, and subjected to appropriate geotechnical testing in order to prove the required compaction.

The Contractor shall be responsible for preparing and maintaining the prepared surface to provide a firm, unyielding foundation for the Unit 17 - GCL with no sudden, sharp or abrupt changes or breaks in grade, no wheel ruts/footprints, no standing water, and no voids and crack, to the satisfaction of the Superintendent.

The Contractor shall remove from the liner subgrade surface all particles that protrude from the surface by more than 10 mm, and sharp or angular particles to the satisfaction of the Superintendent. Significant voids created by removal of particles shall be filled with moist Unit 4 – Clay Rich Material. No standing water shall be allowed to accumulate on the surface of the base liner prior to installation of the Unit 17 - GCL. No GCL shall be placed onto an area that has become softened by prolonged precipitation.

The prepared surface shall constitute a HOLD POINT. No GCL shall be placed until the Hold Point has been signed off by the Superintendent. Only the area to be covered in the same day shall be signed off.

4.7.4 Placement

Rolls of Unit 17 - GCL shall be moved or deployed with a suitable spreader bar that is stiff enough to limit deflection over the width of the roll to ensure smooth uniform deployment of the GCL layer. The orientation of the GCL, that is which side is installed facing downward, is to be confirmed by the Superintendent prior to any GCL installation.

Unit 17 - GCL shall only be installed in dry weather conditions.

The Contractor shall submit a panel layout and their proposed installation method to the Superintendent for the installation at least 10 days prior to the commencement of the GCL placement for approval by the Superintendent. A minimum side and end overlay of 300 mm is required between panels. The submission of panel layout drawings and proposed installation method constitutes a HOLD POINT. GCL installation shall not commence until the HOLD POINT is released.

If manufacturer recommendations differ from procedures in this Specification, these differences shall be brought to the attention of the Superintendent prior to placement of any GCL in the facility. The requirements of this Specification will apply, unless a variation is approved in writing in consultation with the Superintendent.

Exposed Unit 17 - GCL shall not be trafficked by vehicles. Unit 17 - GCL is to be covered with Unit 16 – HDPE Geomembrane, which shall be deployed concurrently with the GCL (i.e. roll width after roll width) and on the same day as the GCL. This requirement is to minimise the potential for wetting of the GCL by rainfall or runoff. Further, the Contractor must stage liner installation such that the Unit 7 Drainage Aggregate layer or the Unit 9 Protection Material is in place over each area of the liner system within 48 hours of GCL placement. This requirement is to minimise the potential for GCL swelling due to lack of confining pressure.





All GCL overlaps shall incorporate a system for achieving overlap sealing (for example, some GCL products include pre-treated side overlap area which comprises bentonite powder encapsulated in the geotextile). Overlaps shall be placed in down slope direction (roof tile effect). If an alternative joining procedure is proposed, details are to be provided to the Superintendent for consideration at least 14 days prior to purchase of the materials.

The Superintendent shall inspect and approve all overlaps prior to covering the overlap.

If wrinkles greater than 50 mm high occur in Unit 17 - GCL or where wrinkles extend to the edge of the roll due to manufacturing tolerances, the wrinkle shall be cut at the crest of the wrinkle. A layer 10 mm thick of bentonite paste shall be spread over the top of one flap of the cut and the other flap pushed over the paste to form an overlap. A 20 mm thick layer of bentonite paste shall be placed over the top of the overlap extending 100 mm beyond the edges of the cut and overlap. The paste shall be covered with a patch of Unit 11 - Filter Geotextile, and squeezed into the paste.

The exposed edges of deployed GCL shall be protected from rainfall runoff to prevent erosion of bentonite. Special care shall be taken to prevent flow of runoff or seepage under and/or over the geomembrane to prevent erosion of the bentonite in the GCL.

4.7.5 Repairs

Rolls or panels of GCL that have been damaged shall be brought to the attention of the Superintendent, who shall judge if the panel or roll is to be removed from site, or may be repaired. If the Superintendent decides the damage is minor the hole may be patched. If a roll is deployed with manufacturing defects, the entire roll shall be removed from site.

All defects and repairs shall be recorded and locations measured as the panels are deployed, to facilitate the timely deployment of the overlying geomembrane.

A patch of GCL shall be placed over any hole with a minimum overlay over the adjoining area of 300 mm. The repairs shall be joined to the main GCL in accordance with the following requirements:

All overlaps shall be made using a 10 mm thick layer of hydrated sodium bentonite paste between the GCL and the patch GCL. The Contractor shall submit details of the proposed bentonite paste to the Superintendent for approval prior to commencement of the GCL installation.

4.8 Installation of Unit 16 - Geomembrane

4.8.1 Transport, labelling, handling and storage

Transportation

The Contractor is responsible for transportation of the geomembrane to the Site.

Labelling

Each geomembrane roll shall be clearly labelled with the following information:

- Material of the geomembrane;
- Thickness of the material;
- Length and width of the roll;
- Manufacturer's Name;
- Direction to unroll the material;
- Product identification;
- Batch number; and



Roll number.

Any roll delivered to the Site without labelling shall be rejected and removed from the site by the Contractor. Each package of welding rod or extrusion welding beads shall be clearly labelled and shall include the Manufacturers name, product identification name/number, resin lot or batch number and the package number.

The Contractor shall also cross-reference each batch number and roll number of geomembrane delivered to site to the resin used and date of manufacture of the geomembrane.

Handling and On-site Storage

The Contractor is responsible for handling, storage and care of the geomembrane before and after installation at the Site. The geomembrane rolls shall be protected from dirt, mud, dust, fire and damage before installation. Rolls shall be stacked to provide access for roll identification and testing as required. The integrity and legibility of roll labels must be maintained during storage.

Geomembrane materials shall be stored in accordance with the quality control procedures manual and the Manufacturer's recommendations. This may include covering of geomembrane rolls.

4.8.2 Surface Preparation

Unit 16 – HDPE Geomembrane shall be placed on top of the GCL in the cell base lining system. The Contractor is responsible for meeting the 48-hour time window requirements for GCL, geomembrane, and cover placement given in Section 4.7.4, and for maintaining the surface of the GCL to provide a firm, unyielding foundation for the geomembrane with no sudden, sharp or abrupt changes or break in grade. No standing water or excessive moisture shall be allowed to accumulate on the GCL prior to geomembrane installation. No geomembrane shall be placed onto an area that has become deteriorated due to moisture changes.

4.8.3 Geomembrane Placement

During geomembrane installation the Superintendent will provide direct input and involvement as indicated in the following sections of this Specification. The Contractor is required to accommodate and allow for the Superintendent's identified role.

Layout Drawings

The Contractor shall submit geomembrane panel layout drawings at least 7 days before installation starts. The drawings shall indicate the panel configuration, the location of seams and the staging/direction of deployment. The layout drawings shall be suitable for use as construction drawings, to scale and include dimensions and details.

The submission of the panel layout drawings constitutes a HOLD POINT. Geomembrane installation shall not commence until the HOLD POINT is released.

Panel Identification

A field panel is the unit area of geomembrane to be welded in the field and shall be bounded by field welds or anchor trenches. Each field panel shall be numbered and the panel layout drawings shall show the panel numbers and the dimensions and area of each panel.

Field Panel Placement

Field panels are to be placed so that the boundaries do not intersect at one point and form a cross seam. A minimum 150 mm is required to offset the occurrence of a cross seam. The Contractor shall allow for the effects of changes in temperature with the resulting expansion and contraction of the panel, to prevent occurrence of a cross seam.

Installation Procedure

Field panels shall be installed using any one of the following procedures:





- field panels for one day's installation may be placed prior to field welding (to protect the subgrade from erosion by rain, or desiccation).
- field panels are placed one at a time and welded immediately (to minimise the number of unwelded field panels exposed to wind), or
- any combination of the above.

Weather Conditions

Geomembrane seaming and welding shall not be started if the ambient temperature is below 10°C or above 35°C, unless the Contractor demonstrates what special measures will be applied for welding outside this temperature range, and is authorised by the Superintendent. Both panels of geomembrane to be welded shall be allowed to equilibrate to the same temperature, before starting to weld.

Geomembrane jointing shall not be undertaken;

- in the presence of excessive moisture (i.e. rain, fog, dew);
- in an area of ponded water;
- or during periods of high wind or excessive dust.

If geomembrane placement and jointing is to be carried out at night, the entire area of deployment shall be illuminated. Installation should preferably be carried out during daylight hours. Installation work carried out at night shall be inspected and tested during daylight hours. All joints shall be tested during daylight hours.

Method of Placement

The Contractor shall ensure that:

- No more geomembrane is installed at any one time than can be reasonably welded in one day.
- Geomembrane rolls and/or factory panels shall be unrolled or unfolded in accordance with the instructions and the direction shown on the boxes or wrapping.
- No equipment used shall damage the geomembrane by handling, trafficking, leakage of hydrocarbons or other means.
- Personnel working on the geomembranes shall not smoke, use footwear, or engage in other activities that could damage the geomembrane. The Contractor shall protect the geomembrane from damage by equipment or personnel traffic associated with construction.
- Methods used to unroll panels shall not cause scratches or crimps in the geomembrane and shall not damage the underlying compacted clay liner and other layers.
- The prepared surface awaiting covering by geomembrane shall not be allowed to deteriorate and shall be maintained in a condition suitable for geomembrane placement.
- Methods used to place panels shall preclude folds, wrinkles that may become folds, bridging (trampolining) and differential wrinkles between adjacent panels.
- Temporary ballast (such as sand bags) shall be applied to prevent uplift during high wind conditions. Such loading shall be spread out and shall not damage the geomembrane. It is the contractor's responsibility to ensure the geosynthetic liners are sufficiently loaded. High wind conditions are common at the site.
- Vent flaps shall be sealed once the geomembrane has been covered with heavier materials and air trapped under the geomembranes during installation has been expelled.





- Joints shall be orientated so that overlaps are in the downslope direction (roof tile effect).
- All cutting of the geomembrane during installation shall be with a hooked blade to avoid damage.
- The Contractor shall implement procedures with its staff, to the satisfaction of the Superintendent to manage the risk of sharp particles being trapped in footwear or equipment that may or will move over the geomembrane.

Damage and Defects

Damage

The Superintendent shall inspect geomembrane panels for damage, after placement and prior to welding. The Contractor shall replace or repair a field panel or portion of a panel that is damaged (torn, twisted or crimped). Damaged panels or portions of damaged panels that have been rejected shall be removed from the work area. The Superintendent shall decide on the need to repair or replace damaged field panels.

Inspection of Geomembrane

The geomembrane shall be inspected by the Contractor during installation from the roll to identify unacceptable areas of material. Irregularities in the geomembrane material identified during inspection shall be repaired, or if excessive, the roll shall be rejected. The decision to either repair unacceptable areas or reject the roll shall be the Superintendent's. This decision shall generally be based on the following considerations.

Defects

The acceptance of the geomembrane shall be based on a maximum number of manufacturing defects. Manufacturing defects include "fisheyes", blemishes and shallow scratches.

A "fisheye" is a thinning of the geomembrane. The specified minimum thickness of the geomembrane also applies to "fisheyes". The size of the fisheye is of no consequence, as it is the thinning or absence of the geomembrane inside the fisheye, which is of concern.

Surface blemishes are considered to be areas where the resin has not been properly mixed or filler can be noted on the geomembrane. The colour and surface texture of the geomembrane shall be uniform and consistent. Where changes occur in the surface texture or colour the contractor shall request the Superintendent to inspect the area. If the area is rejected as unacceptable, then the section of the geomembrane roll shall be removed and replaced.

Straight-line scratches that penetrate the geomembrane (approximately 0.1 mm) shall be pointed out to the Superintendent. The extent and depth of the scratch shall be examined by the Superintendent to decide if a defect is to be removed. The roll length where such a defect occurs shall be cut out and removed from site. All defects shall be patched or capped and subject to quality control testing, reporting and documentation by the Contractor.

If a roll has been rolled out and no fisheyes are present, the geomembrane will be accepted. If the end of a roll has a number of defects, then the end of the roll shall be cut off and removed from site. The Superintendent shall make the final decision on site.

Maximum number of manufacture defects per 300 m^2 of roll length shall be one, with the total number of manufacture defects for the liner to be less than 10 per ha. If more than one manufacture defect occurs over a local area of the geomembrane within a circular area of 0.5 m radius, the area shall be considered 'one defect' and be capped. Replacement of defective geomembrane is at the Contractor's expense.

Manufacturer defects are considered separate to installation defects. Manufacturing defects and installation defects are the Contractor's responsibility. The Superintendent shall decide if the number of installation defects over a certain area is too high, and whether the area should be cut out or capped.

All defects shall be patched or capped and subject to quality control testing, reporting and documentation by the Contractor.



4.8.4 Field Welding

Requirements of Personnel

Personnel performing welding operations shall be qualified as indicated below.

- Personnel performing welding operations shall be qualified by experience or by successfully passing welding tests and at least one welder shall have welded a minimum of 100,000 m² of geomembrane using the same type of welding apparatus in use at the site.
- The weld foreman, most experienced welder, shall directly supervise less experienced welders, as required.
- No field welding shall take place unless the weld foreman is present.

Welding Equipment and Products

Approved Processes for Field Welding.

Only extrusion welding or fusion welding, using equipment approved by make and model, shall be used. Alternative processes may be proposed and submitted to the Superintendent 14 days before the start of geomembrane deployment, for consideration for approval.

Extrusion Process

The extrusion apparatus shall be equipped with gauges giving the temperature in the apparatus and at the nozzle. The Contractor shall provide documentation for the extrudate to the Superintendent and shall certify that the extrudate is the same material as the geomembrane sheet to be welded. The extruder shall be purged before beginning a weld and until all heat-degraded extrudate has been removed from the barrel. Whenever, the extruder is stopped, the barrel shall be purged of all heat degraded extrudate.

Fusion Process

The fusion-welding apparatus must be automated vehicular-mounted devices. The fusion-welding apparatus shall be equipped with gauges giving the applicable temperatures and pressures. The edge of the cross seams to be fusion welded shall be ground to a smooth incline (top and bottom) prior to welding. A temporary movable protective layer shall be used directly below each overlap of geomembrane that is to be welded to prevent build up of moisture between the sheets.

Generator

The electric generator shall be placed on a smooth base such that no damage occurs to the geomembrane. Similarly, a smooth insulating plate or fabric shall be placed beneath the hot welding apparatus after usage to protect the geomembrane. The geomembrane should not be damaged during welding and the geomembrane shall be especially protected from damage in trafficked areas.

Seam Layout

The Contractor shall provide the Superintendent with a seam layout drawing i.e. a drawing of the area to be lined showing all expected seams. No panels shall be welded in the field without the Superintendent's approval. In addition, no panels not specifically shown on the seam layout drawing shall be used without the Superintendent's prior approval.

No seams shall be located in areas of potential stress concentrations.

No cross-shaped seams shall be allowed unless approved by the Superintendent. All fusion joints between panels are to form T-joints, with panel layouts being staggered to achieve this.

All seams and joints shall be surveyed and numbered or named, which shall be cross-referenced to field notes and records of the contractor. Seam numbers shall be marked on the seam layout drawing, and altered as required on the as-built drawings (refer Section 4.6.2).





Welding Method

The welding method to be employed shall be the dual-track fusion welding process. Extrusion welding shall be used for repairs and patches. Single-track fusion welding methods or possible other welding methods shall only be used with prior written approval from the Superintendent.

The Contractor shall maintain at least one spare, operable welding unit of each type employed on the project site at all times.

Weld Preparation

General weld preparation procedures, temporary bonding procedures, general equipment settings, including acceptable extrudate or wedge temperatures, rate or advancement, etc., and welding procedures, shall be specified in the quality control procedures manual.

Prior to welding, the weld area shall be clean and free of moisture, dust, dirt, debris, markings and foreign material.

Where abrading is required, the process shall be completed according to the Manufacturer's instructions within one hour of the welding operation and in a way that does not damage the geomembrane. Abrasion of the geomembrane surface shall not extend outside the weld bead or weld surface area.

Seams shall be aligned to minimise the number of wrinkles.

Artificially induced cooling of the extrudate welds using water or other means is not permitted. Care shall be exercised to ensure that non-destructive testing of the extrudate and/or other activities does not cause artificial cooling of the weld.

The Contractor shall record the following information on the geomembrane surface adjacent to the weld:

- Unique seam number.
- Welding device number and operating temperature.
- Welding technician's initials and
- Date and time.

This information must be recorded onto the Contractor's quality assurance documentation at the end of the day's welding activities.

Overlapping and Temporary Bonding

The panels of geomembrane shall be overlapped by a minimum of 75 mm for extrusion welding and 125 mm for fusion welding. The overlap shall be sufficient to allow peel tests to be performed on the weld, and to provide enough space to form a reliable air channel between dual fusion welds for testing.

The procedure used to temporarily bond adjacent panels together shall not damage the geomembrane; in particular, the temperature of the air at the nozzle of any spot welding apparatus shall be controlled such that the geomembrane is not damaged.

No solvent or adhesive shall be used unless the product is approved in writing by the Superintendent (samples shall be submitted for testing and evaluation).

General Welding Procedures

The general welding procedure used by the Contractor shall be as follows:

For fusion welding, a movable protective layer of plastic shall be placed directly below each overlap of geomembrane that is to be welded. This is to prevent any moisture build-up between the sheets to be welded.



- Welding shall extend to the outside edge of panels to be placed in the anchor trench.
- Ends of dual fusion welds extending into anchor trenches and into joints or patches shall be welded closed.
- If required, a firm substrate shall be provided by using a flat board or similar hard surface directly under the seam overlap to achieve necessary support.
- Wrinkles at the seam overlaps shall be cut along the ridge of the wrinkle to achieve a flat overlap. The overlap shall be welded and any portion where the overlap is inadequate shall then be patched with an oval or round patch of the same geomembrane extending a minimum of 150 mm beyond the cut in all directions.
- All cuts and patches shall be formed with rounded edges and ends, to prevent stress concentrations in the geomembrane. All cuts shall be removed or be ended off with a round cut-out.

T-Joins

All T-joins shall be treated as a potential defect and be patched and subject to quality control procedures in accordance with this Specification.

4.8.5 Testing

Trial Welds

Each welding technician shall qualify to operate on a daily basis, by performing a trial weld prior to welding activities or at times designated by the Superintendent. These trial welds shall be performed using each type of welding device to be employed by the welding technician during that period. Additionally, a trial weld shall be made using each welding device on resumption of work after the lunch break or at an interval of no greater than five (5) hours, whichever is less. The Superintendent may also require that a trial weld be performed using each device at the conclusion of welding activities. Welding devices that have not produced a passing trial weld will not be performed to perform production welding.

Trial welds shall be made on "fragment" pieces of geomembrane liner to verify that welding conditions are adequate. The trial weld sample shall be at least 0.3 m wide and 3.0 m long for fusion welds or 1.0 m long for extrusion welds with 125 mm overlap, with the weld centred length-wise. All trial welds shall be performed under the same weather and subgrade conditions as production welding.

Three specimens each (25 mm) wide shall be cut by use of a die from the trial weld sample by the Contractor - one near each end and one near the mid-point. The two near end specimens shall be tested in peel and the mid-point sample tested in shear.

All trial weld specimens shall be tested in the field by the Contractor and in the presence of the Superintendent, using an electrically operated tensiometer where the force exerted is displayed. The Contractor shall supply evidence demonstrating that the tensiometer has been calibrated within the previous 12-month period.

The shear test specimen shall, at a minimum, meet a strength of ninety five percent (95%) of the tensile yield strength of the parent geomembrane material where it fails in the material (i.e. film tear bond). Both tracks of dual-track fusion welds shall be tested for peel adhesion. Peel strength of welds shall meet at least 65% of the tensile strength of the parent geomembrane material where it fails in the material.





All seams shall fail in the material, i.e. film tear bond. Trial seams shall meet the following minimum strength criteria:

Material (including weld type)	Peel	Shear
HDPE (fusion welds)	65%(1)	95%(1)
HDPE (extrusion weld)	60%(1)	95% (1)
	60%(1)	95% (1)

Note (1): Test results relative to the strength of the parent sheet strength

The tensile yield strength of the parent material will be determined before testing the trial welds by testing a 25 mm wide strip cut with a dye.

If any one of the three specimens fails, the entire trial weld is considered to have failed.

In the event that a trial weld fails, the entire trial weld procedure shall be repeated after the appropriate adjustments to the welding device and/or operator has been made. If a second trial weld fails, the welding device and/or the welding technician shall be rejected and shall not be used for welding until such time as the deficiencies are resolved, verification of the resolution is provided, and a successful trial weld performed.

Non-destructive Weld Continuity Testing

General

The Contractor shall non-destructively test all field and factory welds over their full length by the vacuum box method for testing continuity of extrusion welds, and air pressure test for double fusion welds only, or other approved method. The Contractor will be required to have back-up vacuum testing apparatus on the Site. A trial will be required in the presence of the Superintendent to demonstrate the effectiveness of the contractor's apparatus and method prior to field welding commencing. Vacuum testing and air pressure testing are described below. The purpose of the non-destructive test is to check the continuity of welds. It does not provide any information on weld strength. Continuity testing shall be done as the welding work progresses. Any welds that fail non-destructive testing shall be repaired in accordance with this Specification. Welds, which cannot be non-destructively tested because of seam geometry, shall be capped.

All test equipment shall be in calibration and conform to manufacturer's specifications. The Contractor shall submit current calibration certificates.

Vacuum Testing

The equipment shall comprise the following:

- A vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole or valve assembly, and a vacuum gauge showing the pressure in the box;
- A steel vacuum tank and pump assembly equipped with a pressure controller and connections;
- A rubber pressure/vacuum hose with fittings, pressure gauge linked to the window housing and connections;
- A soapy solution to be applied over seam area.

Each section of the weld to be tested shall be tested to a vacuum pressure of at least minus 35 kPa. Each section of seam shall be vacuum tested for a period of not less than 10 seconds by examining the geomembrane through the viewing window for the presence of soap bubbles. Adjoining area shall to be tested with a minimum 75 mm overlap between sections.

Air Pressure Testing

The following procedures are applicable only to those processes that produce a double weld with an enclosed air channel. All double welds with an enclosed air channel shall be air pressure tested.





The equipment shall be comprised of the following:

- An air pump (manual or motor driven) capable of generating and sustaining a pressure of 180 to 200 kPa.
- A rubber hose with fittings and connections.
- A sharp hollow needle or other approved pressure feed device.
- A calibrated pressure gauge capable of reading pressures up to 250 kPa, with a tolerance of less than 5 kPa.

The following procedures shall be used for air pressure testing the HDPE Geomembrane:

- Seal both ends of the weld to be tested:
- Insert needle with pressure gauge, or other approved pressure feed device within 300 mm of one of the sealed ends, into the air channel created by the fusion weld:
- Energise the air pump and pressurise the channel to 200 kPa for a 25 mm wide channel or 350 kPa for a 13 mm wide channel. Close the valve and sustain the pressure for a minimum of 5 minutes. A pressure drop of less than 10 kPa is allowable, but the air pressure is still required to stabilise for a minimum of 5 minutes. Should a different width air channel be formed the Superintendent shall adjust the required minimum air pressure in the channel to achieve a similar stress on the weld as for a 25 mm wide channel.
- If loss of pressure exceeds 10 kPa, or does not stabilise, the faulty area should be located and repaired in accordance with this section. If, in the judgement of the Superintendent, significant changes in geomembrane temperature occur during the test (e.g., due to cloud cover), the test shall be repeated after the geomembrane temperature has stabilised.
- Cut end of weld opposite to the pressure gauge and observe that the pressure drops. If the pressure does not drop, locate the obstruction(s) in the weld, repair, and retest the weld.
- Remove needle or other approved pressure feed device and repair all holes and damage made to the air channel by extrusion welding over the damage.

Alternative testing procedures may be considered by the Superintendent based on submission of relevant information by the Contractor. If an alternative testing procedure is to be considered the Contractor shall submit information to the Superintendent at least 14 days before the procedure is to be used.

Destructive Weld Continuity Testing

The Contractor shall perform destructive weld tests at selected locations. The Superintendent shall choose the test locations. The Superintendent reserves the right to vary the testing frequency depending on results of samples tested. The purpose of these tests is to evaluate field weld strength. Weld strength testing shall be done as the welding work progresses, not at the completion of all field welding.

Location and Frequency

Destructive test samples shall be collected at an average frequency of one test location per 150 m of seam length or at intervals designated by the Superintendent.

Test locations shall be determined during welding, and may be prompted by suspicion of excess crystallinity, contamination, offset welds, or any other potential cause of imperfect welding.

Sampling Procedure

The Contractor shall cut samples at locations designated by the Superintendent as welding progresses to obtain laboratory test results before the geomembrane is covered by another material. Each sample shall be





numbered and the sample number and location surveyed and identified for inclusion on the as-built liner drawing (refer Section 4.6.2).

All holes in the geomembrane resulting from destructive weld sampling shall be repaired and tested in accordance with the repair procedures in this Specification. Cuts to remove the samples shall be rounded to prevent stress concentrations in the geomembrane.

Size of Samples

The samples shall be a minimum 0.3 m wide by 0.4 m long with the weld centred length-wise. The sample length shall be increased to provide material for additional laboratory testing or archiving. Two specimens shall be cut from each end of the sample for preliminary field tests. The remaining sample shall be retained by the Contractor pending instructions from the Superintendent which samples are to be subjected to laboratory testing.

Each portion of the test sample shall be labelled with a unique number for the sample, and referenced to the joint number from where the sample was taken. The sample number shall be noted on the as-built drawings (refer Section 4.6.2). The Superintendent may direct the Contractor to reduce the length of the sample removed from the welds, if the Superintendent is satisfied that field testing indicates high quality welds. Laboratory tests may be ordered by the Superintendent on random samples to compare to field test results.

Preliminary Field Testing

Weld Destructive Tests

Two (2) specimens, one from each end of the weld destructive sample, shall be removed and tested for peel adhesion by the Contractor in accordance with Standard GM13 while in the field. The results of this testing shall be evaluated in accordance with the criteria detailed in this Specification.

If either of the two field specimens fails, the entire destructive test is considered to have failed and additional destructive test samples shall be taken in accordance with the procedures of this specification.

If the laboratory destructive testing is to be performed on-site, the requirement for preliminary field weld destructive testing may be waived by the Superintendent.

Weld-end Tests

The Contractor may, if agreed by the Superintendent, perform an additional preliminary destructive test. This test shall take the form of a single specimen obtained from one end of the completed fusion weld. This will be a quality control test and, as such, shall be addressed in the quality control procedures manual.

Upon completion of a fusion weld, a specimen shall be removed from one or both ends and tested by the Contractor for peel adhesion in accordance with the procedures detailed in this Specification. Both tracks of the dual-track fusion weld shall be tested and evaluated. The weld shall not fail in the weld area. If one or both of these specimens fail, a complete destructive test sample shall be taken as previously detailed in this Specification.

Laboratory Weld Sample Destructive Testing

The destructive weld testing will be performed by the Contractor in an on-site or off-site geosynthetic testing laboratory, to be approved by the Superintendent. Typically tests performed by the laboratory shall be completed and the results reported to the Superintendent within 24 hours of receipt.

The Contractor shall conduct laboratory destructive testing on at least 10% of the destructive weld samples of the project, or at least five samples, whichever results in the greater number of tests.

Tests shall be performed on 10 specimens obtained from each field sample. From each sample 5 specimens shall be tested in shear and 5 specimens shall be tested in peel. The shear and peel specimens shall be selected from the sample alternately, so that no two adjacent specimens are tested in the same mode.





Weld Evaluation Criteria

Each weld sample must satisfy both the shear and peel criteria. All testing and evaluation shall be carried out in accordance with ASTM D 4437.

For both peel and shear tests the specimen shall fail in the geomembrane sheet and not in the weld area. This is referred to as "film tear bond," (FTB). The specimen shall be defined as failing in the weld if any portion of the weld exhibits separation across more than 10% of the width. Each track of a dual-track fusion weld shall be considered to be a separate weld for the purpose of calculating the percentage separation. If more than one specimen fails in shear, the entire weld destructive test sample shall be considered as failing.

Failed Destructive Sample Procedure

The Contractor shall reconstruct the deficient weld once the extent has been determined. All welds that are to be reconstructed shall be bound by passing destructive tests.

The Contractor shall trace deficient welds by grinding through the top sheet of the seam air channel, extrusion weld the channel, and pressure test sections of the seam between channel seal welds. Deficient extrusion welds shall be traced by taking field specimens from the weld at 3 m intervals until the Contractor has confidence that destructive samples which pass laboratory testing can be obtained. A full laboratory destructive sample will then be taken at that location and tested. If one or both of these samples fail the laboratory weld destructive test, then the procedure is repeated in that direction until passing laboratory results are obtained. For the purposes of tracing a weld, the weld is considered to be the path of the given fusion welding apparatus or extrusion welding device/technician combination and may, if necessary, extend beyond any given welding period. Tracing which requires obtaining more than 2 specimens in either direction from the location of the initial failed destructive weld sample shall be brought to the attention of the Superintendent. The Superintendent shall decide if the whole seam is to be rejected, or if the Contractor may continue identifying the segment of the defective seam.

At such time that the initial destructive sample failure rate of 10% or greater is reached, the Superintendent shall be notified so that a review of the Contractor's performance may be conducted.

Liner Integrity Surveys

The Superintendent may conduct liner integrity surveys, using the resistivity method, to identify defects in the installed geomembrane. The surveys would be conducted either on exposed geomembrane (if practicable) or at the surface of the 300 mm thick cover layer of Unit 7 -Drainage Aggregate or Unit 9 – Protection Material above the geomembrane.

Identified defects shall be repaired at the Contractor's expense in accordance with this Specification or the Superintendent's instruction.

4.8.6 Repairs

General

All weld and non-weld areas of the geomembrane shall be visually inspected by the Contractor for signs of damage, defective welds, blisters, punctures, undispersed raw materials, and any sign of contamination by foreign matter. Defective welds shall include completed welds that have been formed using equipment that is subsequently identified as being defective.

Any defective or flawed areas observed shall be marked, repaired, tested; or removed from the installation and disposed of. Unless otherwise approved by the Superintendent, all air channels produced by the dual track fusion welding process shall be sealed at both ends and at any location where the air channel is severed and made discontinuous. The appropriate parties shall agree upon the method of sealing. All repairs (patches, caps, etc.) may, at the discretion of the Superintendent, be destructively tested.

All defect locations shall be surveyed for inclusion on the as-built liner drawing (refer Section 4.6.2).





Patching

Patches shall be used to repair defects such as holes (including areas from which destructive test samples were obtained) and pinholes (exclusive of non-destructive testing air pressure needle holes) which penetrate the entire geomembrane thickness, tears and crazing. Small surface blemishes and localised flaws which do not penetrate the entire thickness of the geomembrane shall also be patched, or as instructed by the Superintendent.

Areas of crazing shall be cut longitudinally (along the length). The ends of all holes shall be rounded, to prevent further propagation, prior to patching. Patches may be used to cover areas of undispersed raw material or contaminated by foreign substances (gasoline, oil, etc.), if approved by the Superintendent. Patches shall extend a minimum of 150 mm beyond the limits of the defect and all corners of patches shall be rounded. Patches shall follow the contour of the defect area and remain free of crimping or pinching. The geomembrane material used for patches must, at a minimum, meet the requirements of this Specification.

Patches and defect areas shall be free of dirt, moisture, debris and markings. Patches shall be temporarily bonded by heat welding. Chemical adhesives and tape are prohibited without prior approval of the Superintendent. The perimeter of the patch shall be abraded with a hand-held grinder to produce a bevelled edge. Patches shall be temporarily installed by heat welding along the entire perimeter of the patch and defect areas. The patch shall be installed flat along all edges with no wrinkles or folds. The patch weld area shall be abraded no more than 1 hour in advance of permanent welding. Heat welding and abrasion shall not cause excessive melting, wear or puncturing of the geomembrane material; such occurrences shall be considered defects and shall be repaired by patching.

Patching or repairs that require more than two passes of a welding procedure shall be considered as a defect, and be covered by a patch. Patches covering parts of other patches are not acceptable.

Capping

A cap is a patch of extended length and may be used to repair failed welds. Caps shall extend a minimum of 150 mm beyond the limits of the defective weld and all corners shall be rounded. Caps shall be installed as detailed in this Specification for patches.

A cap used to repair a failed weld or portion of weld shall be destructively tested if it exceeds 35 m in length or if the weld is of questionable quality. Caps over failed welds shall be carried out only with the approval of the Superintendent if no other method of repair is feasible. Where welds are being repaired by caps, the failed weld shall be cut out, and the cap shall be welded using fusion welding over most of the joint. The length of extrusion weld required to close-off the cap shall be kept to a minimum, and shall be closed-off after the fusion weld has been pressure tested.

Grinding and Welding

Grinding and extrusion welding shall be used to repair sections of defective extrusion weld less than 0.3 m in length. Areas requiring repair shall be abraded no more than 1 hour prior to the repair being made.

In consultation with the Superintendent, where the reason for a failed dual-track fusion weld has been determined with certainty, and is not related to faulty welding equipment, the failed part of the weld may be repaired (if less than 5 m long) by bevelling the edge (if required), abrading the sheet surface and applying an extrusion weld along the exposed edge (flap) of the seam. Failed welds repaired in this manner must conform to the requirements of this Specification. If the length of the failed portion of the fusion weld exceeds 5 m, or if the flap is not wide enough to allow destructive testing of the extrusion weld (without first testing through the fusion weld), then the weld must be reconstructed by capping.

Geomembrane Wrinkles and Bridging

Geomembrane wrinkle and bridge size and extent shall be minimised to the satisfaction of the Superintendent. Covering the geomembrane with the specified materials early in the morning when the temperature of the liner is low will reduce the extent and size of wrinkles. Wherever possible wrinkles shall be kept small and spread over the panel. In general, wrinkles which, when loaded, will result in a fold in the





geomembrane are too large. Wrinkles or bridging larger than 300 mm high shall be cut and welded as a seam if the overlap is sufficient, in accordance with this Specification. Where the overlap is not sufficient, the wrinkle shall be cut and patched or capped as detailed in this Specification. Whenever it is not possible to manage wrinkles to less than specified, wrinkles shall be combined through accumulation so as to minimise the number of repairs being made.

Care shall be taken to minimise the occurrence of wrinkles over or across joins and welds to reduce stress concentrations near heat affected zones in the geomembrane.

4.9 Geotextiles

4.9.1 Description

Once delivered to the Site the Contractor shall recover samples from the rolls of geotextile, as indicated by the Superintendent. Samples from on site rolls shall be recovered and tested at a frequency as indicated in Chapter 2 of this Technical Specification, or as varied by the Superintendent. The Contractor shall compare test results to both the design specifications and to the list of typical values of the properties provided by the manufacturer.

4.9.2 Storage and Handling and Installation of Geotextiles

During shipment and storage, the geotextiles shall be protected from ultraviolet light exposure, precipitation or other inundation, spills of hydrocarbons, mud, dirt, dust, puncture, cutting or other damaging deleterious conditions.

The Contractor shall be responsible for the storage of the geotextile on the Site.

The geotextiles shall be secured and then rolled down the slope in such a manner as to continually keep the geosynthetic tension to preclude folds and wrinkles. All geotextiles shall be weighted with sandbags or the equivalent. Such sandbags shall be installed during placement and shall remain until replaced with cover material. Geotextiles shall be cut using an approved cutting method and approved equipment only.

Cushion Geotextile Installation

Where geomembranes are in place care shall be taken to protect this material from any damage that could be caused by the cutting of the geotextiles. During placement, care shall be taken not to entrap soil, stones, excessive dust, or moisture that could damage the geotextiles or the geomembrane, or hamper subsequent seaming or joining. The surface of the geomembrane shall be free of any larger than silt size particles, prior to placement of the geotextile. An examination of the geotextile over the entire surface, after installation, shall be conducted to ensure that no broken needles from the manufacturing process or other potentially harmful foreign objects are present. If broken needles are present then the geotextile shall be replaced. Any foreign objects encountered shall be removed, or the geotextile replaced if required by the Superintendent.

If white coloured geotextile is used, precautions shall be taken to avoid "snow-blindness" of personnel.

The geotextile shall be deployed by rolling out by hand, with no vehicular traffic permitted over the underlying geomembrane.

The panels of geotextile shall be overlapped by at least 200 mm, and the overlap shall be tacked together by heat bonding or stitching. Overlaps shall be placed in a down-slope direction (roof tile effect). Stitching shall be carried out using a hand held stitching machine with thread of similar material to the geotextile. The joint shall have a tensile strength of not less than 50 % of the strength of the geotextile being joined. Where stitching is to be carried out, the contractor shall implement a needle management system, to the satisfaction of the Superintendent, to ensure no parts of needles remain in the stitched geotextile joints or on Site.

The geotextile shall be held in place to prevent uplift by wind. Temporary anchorage may be required to prevent displacement of the free-end of the geotextile.

The installation of the geotextile shall be carried out under the supervision of the geomembrane contractor to ensure no damage occurs to the geomembrane.





Placement of Unit 12 – cushion geotextile constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

The Contractor shall submit documentation related to the delivered and installed rolls of cushion geotextile to demonstrate that only the approved batch of geotextile was installed in the Works.

4.9.3 Ballast System for Geotextile

The geotextile shall be held in place to prevent uplift by wind by a ballast system that shall remain in place until the overlying layer covers the geotextile.

Mounds of soil may be placed to satisfy the ballast requirement. Material used for soil mounds shall conform to the same requirements of the material to be permanently placed over the geotextile. Proposed ballast configuration and details shall be submitted to the Superintendent for consideration before implementation.

Ballast shall be gently lowered onto the geotextile, with a maximum drop height of 500 mm. Vehicle traffic is not permitted on the geosynthetics, so the ballast shall be placed as each roll of material is deployed.

4.10 Geocomposites

4.10.1 Description

Once delivered to the Site the Contractor shall recover samples from the rolls of geocomposite, as indicated by the Superintendent. Samples from on site rolls shall be recovered at a frequency of one sample per 4000 m^2 , or as varied by the Superintendent. The Contractor shall arrange for the testing of the samples in accordance with the testing requirements outlined in Section 2.2.14 of this Specification to compare to both the design specifications and to the list of typical values of the properties provided by the manufacturer.

4.10.2 Storage and Handling of Geocomposites

During shipment and storage, the geocomposites shall be protected from ultraviolet light exposure, precipitation or other inundation, spills of hydrocarbons, mud, dirt, dust, puncture, cutting or other damaging deleterious conditions. The Contractor shall be responsible for the storage of the geocomposite on the Site.

The geocomposites shall be handled in such a manner as to ensure it is not damaged in any way.

4.10.3 Installation of Geocomposites

The geocomposites shall be placed directly on top of the geomembrane. The surface of the geomembrane shall be free of any larger than silt size particles, prior to placement of the geocomposite.

Care should be taken during the placement to avoid damage to underlying geomembrane.

The geocomposites shall be secured and then rolled down the slope in such a manner as to continually keep the geosynthetic tension to preclude folds and wrinkles. All geocomposites shall be weighted with sandbags or the equivalent. Such sandbags shall be installed during placement and shall remain until replaced with cover material. Geocomposites shall be cut using an approved cutting method and approved equipment only. Where geomembranes are in place care shall be taken to protect this material from any damage that could be caused by the cutting of the geocomposites. During placement, care shall be taken not to entrap soil, stones, excessive dust, or moisture that could damage the geocomposites or the geomembrane, or hamper subsequent seaming or joining.

If there are any obstructions while deploying the geocomposite, the geocomposite shall be cut to fit around the obstruction. Care should be taken to make sure there is no gap between the obstruction and the geocomposite, to prevent any soil particles from migrating into the geonet core.

The geocomposite shall be deployed by rolling out by hand, with no vehicular traffic permitted over the underlying geomembrane.

The joining of geocomposites shall be in accordance with the manufacturer's specification. Adjacent edges of the geonet along the roll length of the geocomposites shall be overlapped a minimum of 50 mm and tied by plastic ties with a maximum of 1,500 mm intervals. Adjoining geocomposite rolls (end to end) along the





roll width shall have the geonet overlapped a minimum of 300 mm across the roll width. Geonet shall be tied by plastic ties in 300 mm intervals across the roll width. The bottom layer of geotextile shall be overlapped. The upper layer of geotextile shall be seamed by stitching or hot-air thermal sealing. Stitching shall be carried out using a hand held stitching machine with thread of similar material to the geocomposite. The contractor shall implement a needle management system, to the satisfaction of the Superintendent, to ensure no parts of needles remain in the stitched geocomposite joints or on Site.

The installation of the geocomposite shall be carried out under the supervision of the geomembrane contractor to ensure no damage occurs to the geomembrane.

The Contractor shall submit documentation related to the delivered and installed rolls of geocomposite to demonstrate that only approved geocomposite material was installed in the Works.

4.10.4 Ballast System for Geocomposite

The geocomposite shall be held in place to prevent uplift by wind by a ballast system, such as sand bags that shall remain in place until the overlying layer covers the geocomposite. Ballast shall be gently lowered onto the geocomposite, with a maximum drop height of 500 mm. Vehicle traffic is not permitted on the geosynthetics, so the ballast shall be placed as each roll of material is deployed.

4.11 Leachate Collection System for Cell Base Lining

The Contractor shall construct the leachate collection system and leachate sumps in accordance with the Design Drawings and as given below. As the leachate collection system will likely be constructed in sections, the Contractor shall appropriately cap all temporary leachate pipe terminations to allow future connection.

The leachate collection system for the cell base lining includes the following materials (bottom to top):

- Unit 12 Cushion Geotextile;
- 300 mm thick layer of Unit 7 Drainage Aggregate;
- Unit 23 Leachate Collection Pipe; and
- Unit 11 Filter Geotextile.

4.11.1 Leachate Collection Pipe

Unit 23 - Leachate Collection Pipe shall be placed by hand or machinery on top of Unit 12 – Cushion Geotextile. The pipes shall be installed with the perforations at 45 degrees off the vertical and horizontal axes of the pipe. Minor adjustments to the alignment of the pipes are permitted to facilitate the use of standard angled bends and junctions. The ends of all pipes shall be capped during construction activities to prevent ingress of foreign materials.

Initial placement of leachate collection pipes, or the subsequent connection of a new portion of the piping system to a previously placed portion, constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

Following placement of each portion of leachate collection piping, the Contractor shall survey all pipe alignments and inverts, including leachate outlet pipes (Section 4.11.3) and leachate clean out access pipes, and submit works-as-executed (WAE) drawings demonstrating compliance with the design within 7 days of completion of each portion of the system. It is noted the a Hold Point has not been established at this point because it would likely preclude the Contractor from covering all areas of the liner with Unit 7 – Drainage Aggregate quickly enough to comply with the 48-hour time window requirements for GCL, geomembrane, and cover placement given in Section 4.7.4.



The Contractor shall also submit the items listed below as part of his WAE documentation:

 WAE report including description of the completed work, summary of construction materials and time periods of construction, applicable Work Method Statements, RFI records (if any), Contractor quality system records, and Hold and Inspection point documentation.

4.11.2 Leachate Drainage Layer

The Contractor shall place the Unit 7 – Drainage Aggregate over Unit 12 - Cushion geotextile using appropriate methods and equipment to prevent damage to the geotextile cushion, underlying geomembrane, and leachate collection pipes.

The Contractor shall prepare a Work Method Statement for handling and placement of the Unit 7 material. The Work Method Statement shall consider installation of and protection of the geosynthetic materials as well as fines generation in the Unit 7 material. The Work method statement must address the requirements in the remainder of this section. This constitutes a HOLD POINT. No transport or placement of the Unit 7 material shall be carried out until the HOLD POINT has been released by the Superintendent

The Contractor shall be responsible for the selection, loading and transport of the aggregate from the source location, and placement of the aggregate.

The Contractor shall consider the following for handling and placement of the aggregate;

- protection of the integrity of the underlying materials including the cushion geotextile, HDPE geomembrane and GCL;
- considerations and limitations on access over areas underlain by geosynthetic materials;
- potential for breakdown of the aggregate during handling and placement and the generation of excess fine grained particles that may not comply with the specified gradation requirements;
- non-uniform particle size distribution during production, stockpiling, handling and placement. This
 includes accumulation of excess fine grained particles in localised locations that do not comply with the
 specified gradation requirements;
- Potential inclusion of non-conforming materials during the loading of the aggregate at the source or stockpile;
- Consideration of on-site screening prior to placement to manage the risk of non-conforming particle size distribution; and
- Carrying out corrective action for non-conformances in particle size distribution in the placed material. This includes consideration of the protection of the integrity of the cushion layer and HDPE geomembrane.

Drainage aggregate shall be placed on top of the cushioning layer overlying the HDPE geomembrane to form a continuous leachate drainage blanket across the floor of the base cell. The blanket is intended to promote drainage of leachate to the leachate collection pipes and sump.

The drainage aggregate shall also be placed around the leachate collection pipes as shown on the Design Drawings. The Contractor shall take care to ensure that the aggregate is worked around the leachate collection pipes to provide uniform support around the pipes. Placement of Unit 7 material around the leachate collection pipes constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

Placement of the leachate drainage aggregate shall not impact on the integrity of the underlying base cell liner system, the collection pipes, nor completed areas of the drainage aggregate layer.





The aggregate shall be placed in a manner so as to ensure uniform particle size distribution. Concentration of fine grained particles (<0.075 mm) and particles < 19 mm, to greater than the specified limits is not acceptable. Any material placed, that according to the Superintendent, does not meet the specification shall be removed and replaced with new or remixed material that meets the specification.

The aggregate shall be handled and spread in a manner so as to manage the risk of particle crushing or abrasion to a practical minimum. Spreading of the aggregate to the required 300 mm thick layer shall be carried out with low bearing pressure equipment. Unless otherwise agreed, the maximum permitted machinery weight for drainage layer placement shall be 13T and at no point shall tracked placement equipment operate on a working platform of less than 300 mm thickness of material above the cushion geotextile.

The leachate aggregate shall be placed to ensure the underlying geosynthetics are not damaged. The placement shall be carried out so that trapped air under the geomembrane is directed to vent flaps at the edge of the works and so that wrinkles in the geomembrane do not form creases or similar.

Vehicles are not permitted to traffic on the surface of the cushion geotextile or geomembrane. The aggregate shall be placed by trucking the material over previously placed aggregate and unloading on the previously placed material.

The aggregate shall be no less than 0.75 m thick where wheeled vehicles are to traverse the aggregate on. The method of working shall comprise end-tipping and spreading from previously placed material, or a method agreed with the Superintendent prior to work commencing.

Spreading of gravel shall be carried out to prevent stretching, tearing, distortion or other damage to the cushioning layer and geomembrane. Blades of construction equipment that are used to place and spread the aggregate shall not move within 200 mm of the surface of the geosynthetic layers. Where a dozer is used, the material shall be rolled off the end of the layer to prevent tensioning the geotextile that may occur if the aggregate is just pushed off the end of the layer.

The Contractor may elect to prepare a trial pad to allow the Superintendent to assess a potentially thinner layer thickness for where wheeled vehicles are to traverse the aggregate on the surface of the Cell, depending on the cushioning layer, construction equipment and grading of the leachate collection aggregate.

Gravel shall be carefully placed around the leachate collection pipes. The shaping of the gravel to the required thickness shall be controlled using a laser guide or similar system.

Locking of tracks of excavators or dozers shall be prohibited. Stopping shall be carried out slowly. Where sudden stoppage of a vehicle was required, the underlying geosynthetics shall be exposed to assess if damage has occurred.

The Superintendent shall be present on site to view the placement and spreading of the gravel. Where damage occurs to the underlying materials, the Superintendent shall direct the Contractor on the actions required for repair.

After drainage layer placement, Unit 11 – Filter Geotextile shall be placed and secured over the drainage layer. Filter geotextile shall be installed in the same manner as outlined in Sections 4.9 of this Specification. Placement of Unit 11 – Filter geotextile constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

Following drainage layer placement and filter geotextile placement, the Contractor shall survey the finished surface level to provide works-as-executed (WAE) drawings and to demonstrate that the drainage layer design thickness has been achieved and that the constructed sump geometry is in accordance with the design. The survey shall be conducted on an approximate 10m grid with detailed survey of the sump. The Contractor shall submit the WAE drawings and an accompanying analysis demonstrating compliance with





design thickness and sump geometry. Submission of the WAE drawings and accompanying analysis constitutes a HOLD POINT. Placement of any material above the drainage layer shall not commence until the Hold Point has been released, and all other contractual requirements have been fulfilled.

The Contractor shall also submit the items listed below as part of his WAE documentation,

 WAE report including description of the completed work, summary of construction materials and time periods of construction, applicable Work Method Statements, RFI records (if any), Contractor quality system records, and Hold and Inspection point documentation.

4.11.3 Leachate Sump and Outlet Pipe

The leachate sump and outlet pipe shall be constructed in accordance with the Design Drawings.

The Contractor shall provide a Work Method Statement for the installation of the leachate sump to the Superintendent for approval. This constitutes a HOLD POINT. No construction of the sump shall be carried out until the HOLD POINT has been released by the Superintendent.

The work method statement must include, but not necessarily be limited to, the minimum requirements as given in the remainder of this section.

Base and Lining Construction

The base surface on which the sump liner will be constructed shall be prepared to form a firm foundation. The surface shall be trimmed of all softened, loose and foreign materials, and formed to a uniform graded surface. Any depressions shall be filled with compacted Unit 4 -Clay Rich Material or Unit 2 -General Fill. No contaminated material shall be used for surface preparation.

Prior to liner placement, the Contractor shall survey the finished base surface level. This information shall be included in the works-as-executed (WAE) drawings of the leachate drainage layer (refer Section 4.11.2) and to demonstrate that the design levels have been achieved.

The sump liner shall comprise the following components:

- A 500 mm thick of Unit 5 Clay Material which have minimum permeability of 10⁻⁹ m/sec;
- Double layer of Unit 17 GCL;
- Unit 16 HDPE Geomembrane; and
- Unit 12 Cushion Geotextile.

Installation of Clay Material

The Contractor shall proposed method of moisture conditioning, placement and compaction, and maintenance of the leachate sump compacted clay liner to comply but not limit to the following requirements.

- The compacted clay liner layer shall be constructed in at least 3 layers. The clay liner shall be placed in layers of a nominal thickness of 170 mm. The clay liner layer shall have a minimum total thickness of 500 mm.
- The clay liner layer shall be compacted with a vibrating padfoot type roller, to achieve a minimum Dry Density Ratio (DDR) of at least of 98% standard (in accordance with AS1289.5.1.1 and 5.4.1) or a minimum HILF density ratio of 98% standard (in accordance with AS1289.5.7.1) at a moisture content within the range of 0% to +3% (wet) of the Standard Optimum Moisture Content (SOMC). The field density tests during placement of the material shall be minimum a test on each side of the base on each layer of as directed by Superintendent.
- If the required density and moisture is not achieved, the compacted material shall be reworked in-situ to meet the density and moisture content requirements. If the density and moisture content



requirements again cannot be achieved after reworking, the failed layer shall be removed for moisture conditioning at the clay borrow area or at an approved designated area, or be discarded.

- Prior to the placement of each lift of the clay liner layer, the top of the previous lift shall be thoroughly scarified and moisture conditioned if necessary to bond each layer together and prevent laminations at the layer interfaces. Any areas where laminations occur, either between or within layers, shall be reworked such that all laminations and defects in the integrity of the clay liner layer are removed.
- Upon completion of the clay liner layer, the Contractor shall maintain the integrity of the layer by limiting the traffic movement over the clay surface and maintaining the surface of the clay in a moist condition, wet of SOMC, until covered by the geomembrane.
- Should the surface of a previously placed and compacted layer have dried or wetted up excessively, as determined by the Superintendent, the affected materials shall be excavated to expose material that has a moisture content within the specified tolerance. The excavated materials shall be returned to a designated area for moisture conditioning or be discarded.
- Trafficked areas are to be ripped, moisture conditioned and recompacted if in the opinion of the Superintendent the quality of these areas has deteriorated. Furthermore, any cracked clay that has formed due to desiccation shall be removed.

The placement of the leachate sump clay liner layer constitutes an INSPECTION POINT and the Contractor is required to provide 48 hours notice before commencing or recommencing this activity.

Following clay liner layer placement, the Contractor shall survey the finished surface level to include in the works-as-executed (WAE) drawings of the leachate sump and to demonstrate that the clay liner layer design thickness has been achieved and that design surface grades for geosynthetic placement have been achieved. The Contractor shall submit the WAE drawings and an accompanying analysis demonstrating compliance with design thickness and surface grades. This submission constitutes a HOLD POINT and geosynthetics installation for the sump shall not proceed until the Hold Point is released.

Geosynthetics Installation

The Contractor shall provide a rounded edge of the clay liner at the toe and crest of the side slope. The rounded edge shall be constructed to support the geomembrane so as to prevent stressing or creasing of the geomembrane under loads. In general, rounding shall be prepared over a length of approximately 300 mm.

The leachate sump shall be lined with the following layers:

- Two layers of Unit 17 GCL overlying the prepared Unit 5 Clay Material;
- A layer of Unit 16 HDPE Geomembrane above the GCL; and
- A layer of Unit 12 Cushion Geotextile.

The installation of the geosynthetic layers shall be as per Sections 4.7 to 4.9 of this Specification. This installation work constitutes an INSPECTION POINT and the Contractor is required to provide 48 hours notice before commencing or recommencing this activity.

At the completion of geosynthetics installation for the sump, the Contractor shall submit a WAE report including description of the completed work, summary of construction materials and time periods of construction, applicable Work Method Statements, RFI records (if any), Contractor quality system records, and Hold and Inspection point documentation

4.11.4 Installation of Unit 24 – Leachate Sump Outlet Pipes and Sump Backfill

Unit 24 – Leachate Sump Outlet Pipes in Package 3 include two sections, as follows:

Connecting the leachate sump with Unit 27 – Leachate Sump Riser; and





Connecting Unit 27 of Package 3 to the existing Unit 27 of Package 2.

Unit 24 – Leachate Sump Outlet Pipe for the sump shall be connected to the leachate sump at the concrete outlet structure as shown in the Design Drawings. It is recommended that the concrete outlet structure to be constructed prior to the installation of the liner system so that it will be ready to be connected with the geomembrane in the lining system.

Installation of Unit 24 – Leachate Sump Outlet Pipe connecting two sump risers requires trenching greater than 2.5 m below the subgrade surface near the Package 2 riser. The Contractor should stage the subgrade preparation to avoid deep trench excavation if possible.

Installation of Unit 24 – Leachate Sump Outlet Pipes constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

The backfilling of the sump with Unit 7 – Drainage Aggregate shall be by an excavator. The material shall be placed in a manner to minimise any impact on the geosynthetic layers underlain. Any damages shall be to be repaired to the satisfaction of the Superintendent at the Contractor's cost.

Backfilling shall occur within 24 hours of placement of the first GCL layer in the sump base in order to minimise potential GCL hydration swelling.

4.11.5 Installation of Unit 27 – Leachate Sump Riser

Unit 27 – The Leachate Sump Riser for Package 3 shall be constructed outside of the perimeter bund and connected to the leachate sump outlet pipe. The Leachate Sump Riser shall also be connected with the existing riser of Package 2 as shown in the Design Drawings (refer Section 4.11.4).

Requirements for bedding, sealing, pipe entrances, pipe trenching are shown on the Design Drawings.

The Contractor shall prepare a Work Method Statement for Unit 27 – Leachate Sump Riser installation and construction. The Work Method Statement shall address drawing and specification requirements as well as safety issues associated with excavation and sump construction. Submission of the Work Method Statement constitutes a HOLD POINT. Sump riser excavation and construction shall not commence until the Hold Point is released.

Installation of the Unit 27 – Leachate Sump Riser constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing this activity.

4.12 Unit 9 – Protection Material

The Contractor shall place the Unit 9 – Protection Material over Unit 14 - Geocomposite Drainage Net using appropriate methods and equipment to prevent damage to the geocomposite drain, underlying geomembrane, and leachate collection pipes.

The Contractor shall provide a Work Method Statement presenting the proposed method of placement of the Unit 9 – Protection Material. The work method statement must include, but not necessarily be limited to, the minimum requirements listed below.

- The minimum thickness of the layer shall be 300 mm as measured perpendicular to the surface of the underlying layer, with a minimum slope of 2.5H:1V. The entire thickness shall be placed as one lift.
- The maximum permitted machinery weight for protection layer placement shall be 13T. At no point shall the placement equipment operate on a working platform of less than 300 mm thickness of material above the geocomposite drain. A field trial is required to confirm that the planned plant for use in hauling and spreading the protection material can operate without damaging the geocomposite drain, underlying geomembrane, or leachate collection pipes and to establish minimum equipment setbacks from the leading edge of protection material placement.
- Compaction shall be only by trafficking with the spreading plant.





The Work Method Statement shall demonstrate to the satisfaction of the Superintendent that the proposed methods will be protective of the geocomposite drain, geomembrane, and leachate collection pipes. The work method shall include "Level 1" supervision and reporting by the GITA. Submission of the work method statement constitutes a HOLD POINT. Placement of the Unit 9 – Protection Material shall not commence until the Hold Point is released.

Notwithstanding the above should any damage occur to the geocomposite drain, the leachate collection pipes or the geomembrane the Contractor shall make a full repair at his own cost to the satisfaction of the Superintendent.

Following protection layer placement, the Contractor shall survey the finished surface level to provide worksas-executed (WAE) drawings and to demonstrate that the protection layer design thickness has been achieved. The survey shall be conducted on an approximate 10m grid. The Contractor shall submit the WAE drawings and an accompanying analysis demonstrating compliance with design thickness. Submission of the WAE drawings and accompanying analysis constitutes a HOLD POINT. Placement of any material above the protection layer shall not commence until the Hold Point has been released, and all other contractual requirements have been fulfilled.

The Contractor shall also submit the items listed below as part of his WAE documentation,

- GITA certification statements for the activity
- WAE report including description of the completed work, summary of construction materials and time periods of construction, applicable Work Method Statements, RFI records (if any), Contractor quality system records, and Hold and Inspection point documentation.

4.13 Stormwater Drainage

4.13.1 Drainage Channels

The construction of stormwater drainage structures must comply with RMS Specification R11 'Stormwater Drainage', Ed4/Rev 0, dated 26.09.12 and in accordance with manufacturer's specifications.

4.13.1.1 Foundation Preparation

Backfilling, where required, must be undertaken in accordance with the R11 Clause 3.7.1

Foundation, support and backfill materials related to drainage channels must be compacted in layers not exceeding 150 mm, unless otherwise directed by the Superintendent. The minimum characteristic values of relative compaction must comply with the R11 Clause 3.7.2 requirements (Table 13).

Table 13: Minimum Standard Compaction Ratios

Location	Minimum Standard Compaction Ratio
Foundations and trench based to a depth of 150 mm below the bottom of the plain concrete or of the bed zone,	95%
Trimmed surface of excavated open drains to a depth of 150 mm, before lining or spreading topsoil for vegetation	90%
All other fill material for drainage structures including fill in bed, haunch, side and overlay zones, material replacing inadequate foundation material, backfill material and earth material in diversion banks	95%





4.13.1.2 Set out

The drainage channels must be set out as detailed in the R11 Clause 3.1.2.

4.13.1.3 Installation

The construction of the permanent Southern Perimeter Drain using Unit 36 box culvert must comply with Section 6 of AS1597.2, in particular:

- Excavation width should provide a minimum gap of 150 mm between the culvert walls and trench wall.
- The precast culvert units shall be supported by a 150 mm (min) layer of bed zone material compacted to a dry density ratio of 90% or a density index of 60%.
- Side zone material shall be placed up to the level of the top of the culvert, whilst maintaining a
 maximum difference of 600 mm between compacted material levels on each side of the culvert.
- Side zone material shall be compacted to a dry density ratio of 90% or a density index of 60% (unless cement slurry fill is used).

Weep holes are to be provided as indicated in the Drawings. The end joints between Unit 36 precast concrete culvert units shall be constructed as indicated below.

- Joints shall be butt joints, connected using appropriate sealant in accordance with the manufacturer's specifications,
- At joints with no design change in channel invert slope maximum gap of 15 mm on the channel base and walls, unless otherwise approved by the Superintendent.
- Joints at location of design change in channel invert slope all gaps shall be smaller than 150 mm; all gaps greater than the maximum width appropriate for using sealant (up to approximately 50 mm) shall be filled to the channel surface on the channel base and walls with sand/cement mortar; all gaps 50 to 150 shall be filled to the channel surface on the channel base and walls with concrete.
- Non-woven geotextile shall be installed between the culvert units and the base zone material and the side zone material across all joints. The geotextile shall be held or glued in place to prevent slipping and shall extend a minimum of 250 mm on either side of the joint.

Units shall be handled in accordance with the manufacturer's specifications, in particular:

- Lifting holes or inserts provided in each unit must be used.
- Lateral sliding of the box culverts shall be avoided.
- If stored on site, box culverts shall be placed on timber bearers (placed directly beneath the legs) and on firm level ground.

4.13.2 Construction Traffic

Where the contractor proposes to move heavy construction plant or vehicles over drainage channels, the contractor shall design and provide protective measures for each crossing in accordance with Specification RMS 2.

4.13.3 Construction Tolerances and Inspection

Maximum construction tolerances for stormwater drainage components are specified in Table R11.2 of the R11 specification and as presented in Figure 1:



TECHNICAL SPECIFICATION - NEW LANDFILL CELL

Component	Attribute	Tolerance		
Concrete pipes, box culverts, headwalls and wingwalls,	Location (plan)	Within 200 mm of the plan position shown on the Drawings or specified at any point		
energy dissipators, inlet and outlet structures	Invert level	Within 20 mm of the design level at any point		
Gully pits and junction boxes	Location (plan)	Within 200 mm longitudinally and 20 mm laterally of the plan position, with reference to the control line for the road shown on the Drawings		
	Outlet invert level	Within 20 mm of the invert level shown on the Drawings		
Lintels, covers and gratings	Line	The tolerances specified for the adjoining material; e.g RMS R15 for kerbs and gutters, RMS R116 or RMS R119 for asphalt, RMS R83 and RMS R84 for concrete base.		
Precast concrete box culvert units	Step between units	On the internal faces of the walls and roof, no step between adjacent units must exceed 20 mm. Steps between 10 mm and 20 mm must be smoothed to a standard of durability equal to the rest of the culver		
Open drains	Location	The tolerances specified for the adjoining material, including RMS R44 for berm drains and batter drains		
	Level	Within 50 mm of the design level at any point provided that there is a continuous downgrade in the direction of flow not less than 0.5% at any point		
	Waterway area	Not less than 95% of the design cross sectional area at any point		
	Shape	Not more than a 50 mm departure from a 3 m straight edge placed on the bottom or a side of the open drain at any point		
Trenches for precast concrete and fibre-reinforced concrete	When measured horizontally at any point within the trench at right angles to the line of the pipes:			
pipe drainage structures	Position of trench face:	Within 100 mm of the design location		
	Excavation width:	Not less than the specified width; Not more than the specified width plus 100 mm		

Figure 1: Maximum Construction Tolerances (Source: Table R11.2 of the RMS Specification R11)

Closed-circuit television (CCTV) inspection of all drainage structures must be carried out in accordance with the R11 Clause 4.2.

4.14 Other Requirements

4.14.1 Surveying

All references in this Specification to required survey or survey to be performed by the Contractor means survey performed and reported by a registered surveyor.

4.14.2 Tolerances

The Contractor shall construct the cell to the construction dimension tolerances and minimum layer thicknesses provided for specific items in individual sections of this Specification.

For other items, the Contractor shall construct the cell to the general construction dimension tolerances provided below.

Levels and grades for material surfaces:

- 1) Surfaces shall be within +/- 100 mm of design levels;
- 2) Grades shall be in the design direction at all locations; and
- 3) Thickness of material layers shall be equal or greater than the design thickness.



Pipes and open drains:

- 1) Invert levels shall be within +/- 50 mm of design levels; and
- 2) Grades shall be maintained in the design direction at all locations.

RH:PR/GRS/rh:pr

https://aupws.golder.com/117625003wollongongcitycouncilnewcellwhytesgully/project doc/320 90percent design/3209 technical specification/tender package 3/117625003_246_s_rev0_whytes gully new cells - tech spec tender package 3.docx





APPENDIX C

Addendum to April 2012 Interpretative Geotechnical Investigation Report for 50% Design





DATE May 2013

REFERENCE No. 117625003-214-M-Rev0

TO Michael Herraman Wollongong City Council

СС

FROMParnel Richards, Gary Schmertmann, Craig CurnowEMAILgschmertmann@golder.com.auSLOPE STABILITY ASSESSMENT FOR DETAILED DESIGN OF TENDER PACKAGES 1, 2 AND 3 –WHYTES GULLY NEW LANDFILL CELL

1.0 INTRODUCTION

1.1 **Project Description**

The Whytes Gully Resource Recovery Park (WGRRP) is owned and operated by Wollongong City Council (Council) under Environment Protection Licence 5862. Existing landfill airspace at the WGRRP is projected to expire in late 2013. As part of a coordinated delivery of resource recovery and waste services in the Wollongong Local Government Area (LGA), Council are proposing to increase landfill capacity at the site by constructing a new landfill cell within the existing WGRRP, to the south of the existing landfill footprint and piggy-backing waste over the existing western and eastern gully landfills. This is referred to as the 'New Landfill Cell' and is estimated to provide more than 5 million cubic metres of additional airspace, projected to extend the life of the landfill by up to 50 years.

1.2 Previous Investigations

A number of investigations have been carried out across the site prior to this current phase of work, including a geotechnical investigation undertaken at the WGRRP in July and August 2011 by Golder Associates Pty Ltd (Golder) on behalf of the Council. The objectives of this geotechnical investigation were to inform design development of the proposed new landfill cell. The geotechnical investigation was targeted to provide subsurface information for the foundation conditions for the proposed new landfill cell footprint.

Information from these previous investigations has been reviewed during the preparation of this study and is included in the *Geotechnical Investigation Report* (Golder, 2012b).

The slope stability of the proposed final landform for the New Landfill Cell project has been previously assessed in the *Interpretative Geotechnical Investigation Report for 50% Design* (Golder, 2012c).

1.3 Scope of Report

The interpretation and analysis detailed in this report has been prepared for the detailed design of Tender Packages 1, 2 and 3 of the Whytes Gully New Landfill Cell. These tender packages represent the initial portions of landfill base construction for the project. Further to slope stability assessment previously reported for the final landform in the *Interpretative Geotechnical Investigation Report for 50% Design* (Golder, 2012c), this report provides additional interpretation and recommendations on:

- Geotechnical cross-sections for Tender Packages 1, 2 and 3;
- Revision of interpreted geotechnical characterisation and design input;
- Interim slope stability analyses for Tender Packages 1, 2 and 3; and
- Piggy back liner construction stability analyses.



A.B.N. 64 006 107 857

2.0 GEOTECHNICAL CHARACTERISATION & DESIGN INPUT

2.1 Interim Slope Stability

The geotechnical characterisation and design input presented in the *Interpretative Geotechnical Investigation Report for 50% Design* (Golder, 2012c) has been adopted for the assessment of the interim slope stability for Tender Packages 1, 2 and 3, with the following revisions/clarifications:

2.1.1 Geological Model

For modelling purposes, Unit 42a - Alluvial soils and Unit 42b - Colluvial soils have been represented as a single unit with revised parameters (refer Table 1). Based on the *Geotechnical Investigation Report* (Golder, 2012b), the alluvium/colluvium is assumed to extend below the new cell floor area from the western extent of the existing Western Gully landfill to the toe of the existing Eastern Gully landfill with a maximum depth of 16 mBGL along the Western Gully drainage line. The assumed geology is shown as Unit 42a – Alluvium in Figures B1 to B42 (Appendix B).

2.1.2 Hydrogeological Conditions

Groundwater levels below Tender Packages 1, 2 and 3 (within the new cell floor area) are based on the levels presented in the *Hydrogeological Investigation Report* (Golder, 2012a) but amended to be at least 2 m below the proposed subgrade as a result of subsequent water level monitoring conducted by Golder on behalf of the Council up to 30 October 2012.

As no additional leachate level data is available, leachate levels have been assumed to be 5 m above the base of the existing old waste in the Eastern and Western Gully Landfills as per the *Interpretative Geotechnical Investigation Report for 50% Design* (Golder, 2012c).

2.1.3 Geotechnical Design Parameters

The geotechnical design parameters adopted in the interim slope stability analyses that vary from those previously adopted in the *Interpretative Geotechnical Investigation Report for 50% Design* (Golder, 2012c) are summarised in Table 1.

Geotechnical Unit / Interface	Bulk Unit Weight (γ)	Drained Friction Angle (Φ')	Drained Cohesion (c')	Undrained Shear Strength (s _u)	
	(kN/m³)	(°)	(kPa)	(kPa)	
Unit 41a - New Landfill ¹	11	33 (min. shear strength = 24 kPa) ²	0	N/A	
Unit 42a - Alluvium ³	17	25	2	40 + 0.22σ _v p (if z ≤ 4m), OR 18z – 32 + 0.22σ _v p (max 100) (if z > 4 m) ⁴	
Unit 42b - Colluvium ³	.,	25			
Interface 1 - Critical Interface within Proposed Piggy Back Liner ⁵	10	Peak (slopes) = 17 Peak (flat) = 17 Peak (Eastern Gully) = 19 Residual (slopes) = 7 Residual (flat) = 11 Residual (Eastern Gully) = 14 ⁶	0	NI/A	
Interface 2 - Critical Interface within Proposed Cell Liner ⁵	19			11/2	

Table 1: Revised	Geotechnical Design	n Parameters for	r Interim Slope	Stability /	Assessment
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Notes:

¹ Unit 41a – New Landfill refers to compacted landfill that will be placed as part of the proposed new cell (above Interface 1 & 2).

² Waste properties sourced from Kavazanjian et al (1995).

³ Represented as Unit 42a – Alluvium in Figures B1 to B42 (Appendix B).

⁴ Adopted undrained shear strength profile is dependent on depth below top of the alluvium/colluvium layer (z), depth, overburden stress due to new landfill (σ_v) and strength gain due to consolidation (p), as defined in Section 2.1.4.

⁵ The shear strength of each liner system has been characterised by the minimum shear strength of each component or interface in each system, as described further in Section 4.1.1. The shear strength parameters assigned to each component and interface is included in Appendix B1 of the *Interpretative Geotechnical Investigation Report for 50% Design* (Golder, 2012c).

⁶ As per zones in Figures A1 to A3 (Appendix A).



2.1.4 Undrained Shear Strength of Alluvium/Colluvium

The revised undrained shear strength of existing alluvium/colluvium has been estimated based on available geotechnical data. In particular, we have considered the boreholes and SPT test results for BH1, BH11, BH16, BH22 and GABH06D that were carried out around the toe of the proposed Tender Packages 1, 2 and 3 (previously reported in the *Geotechnical Investigation Report* (Golder, 2012b)).

Figure 1 presents a summary of SPT N variation versus depth at the boreholes considered.



Figure 1: SPT N variation with depths and design profile considered to estimate undrained shear strength for alluvium/colluvium material (Source: *Geotechnical Investigation Report* (Golder, 2012b)).

The selected design SPT N profile, as shown in Figure 1, is utilised to estimate the undrained shear strength of existing alluvial/colluvial clay, S_u , adopting the following correlation:

$S_u(kPa) = k.N$

Where k is a site-dependent factor conservatively assumed 5 in this assessment based on our experience and published values for similar materials (Bowles, 1997). Thus, the following S_u profile is adopted for alluvium/colluvium in our stability assessments:



 $S_{u} = \begin{cases} 40 + 0.22\sigma_{v}p & Z \le 4m \\ 18Z - 32 + 0.22\sigma_{v}p \pmod{2} & Z > 4m \end{cases} \text{ (kPa)}$

Where: z = depth below top of the alluvium/colluvium layer (m)

 σ_v = overburden stress due to new landfill (kPa)

p = percentage strength gain due to consolidation; conservatively assumed to be 50% for the alluvium/colluvium below the waste placed during one Tender Package and 75% at the end of the placement of waste during subsequent Tender Packages to simulate the shear strength of the alluvium immediately after waste placement in each respective Tender Package; this approach reflects that waste placement within each Tender Package area is expected to occur for at least two years before advancing to the next Tender Package area.

2.2 Piggy Back Liner Construction Stability

The stability of the multi-layer piggy back liner system during construction (prior to the placement of waste) depends on the shear strength of cover materials and the interfaces between materials, and on subsurface drainage components for infiltrating water.

For the piggy back liner system, the critical (or weakest) surface was considered to be above the geomembrane, specifically at the interface between the geocomposite drainage net and the underlying textured LLDPE geomembrane (refer Section 3.2.1). For this type of critical interface, stability analyses are performed for both peak and residual (large-displacement) shear strength conditions.

The shear strength parameters adopted for the potential critical interfaces are included in Table 2.

Critical Interface	Equivalent Shear Strength Parameters	Comment	
Geocomposite-	Peak: $\delta_p = 30^\circ$, c = 0 kPa	Typical values at <u>very low confining stresses</u> based	
Geomembrane	Residual: $\delta_r = 25^\circ$, c = 0 kPa	on project experience and Koerner & Narejo (2005)	

Table 2: Geotechnical Desi	on Parameters for Piggy	Back Liner Construction	Stability Assessment
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Notes: δ_p denotes peak friction angle δ_r denotes residual friction angle c denotes effective cohesion


3.0 METHODOLOGY

3.1 Interim Slope Stability

3.1.1 Analytical Method

Stability of the proposed interim landforms have been assessed using the limit-equilibrium program *SLOPE/W*¹ for Spencer circular and non-circular failure mechanisms for both static and earthquake stability. Stability analysis checks are conducted at the serviceability limit state. Consequently overall Factors of Safety (FoS) are applied in the interim stability analysis, as follows:

- Target FoS of 1.5 or greater to provide acceptable long term stability under static loading, where the landfill liner is at peak strength; this has been applied for interim conditions that may be present for one year or more.
- Target FoS of 1.3 or greater to provide acceptable stability under static loading, where the alluvium/colluvium is at undrained strength; this reflects a short-term condition (i.e., 'end of waste placement')
- Target FoS of 1.2 or greater to provide acceptable long term stability under static loading where the landfill liner is at residual strength (such as post earthquake conditions). Considered a conservative test of stability, as residual strengths are unlikely to develop simultaneously across the whole area of the liner;
- Target FoS of 1.1 or greater to provide acceptable stability under earthquake loading, where the landfill liner is at peak strength; and
- Target FoS of 1.0 or greater to provide acceptable stability under earthquake loading, where the landfill liner is at residual strength.

These target FoS values are the same used for the Golder (2012c) assessment.

Long term (effective) material parameters were generally used as these govern design, but a check of the undrained condition under earthquake loading was also carried out, using the undrained shear strength parameters (where applicable, such as for cohesive materials) as described in Section 2.1.3.

Additional notes regarding the slope stability analysis methods are:

- Analysis has been performed for the selected cross-section geometries, thus providing a twodimensional (2-D) representation of the actual (3-D) conditions. Although this is consistent with standard geotechnical practice, it is known that 2-D analysis of valley landfills, such as the eastern gully landfill, when performed for critical cross sections, is generally a conservative approach because it does not account for beneficial 3-D geometry effects. Slope stability analyses that fully account for 3-D effects can be performed but are significantly more costly and complex than 2-D analyses.
- The critical surface search algorithms in Slope/W can converge on insignificant shallow veneer failures. To prevent this, a minimum slip surface depth within the waste mass was selected as required for the condition analysed.
- Where required for ease of slope stability modelling, the base liner layers are collectively represented by the properties of the "weakest material or interface in liner system" as indicated in Appendix B1 of the *Interpretative Geotechnical Investigation Report for 50% Design* (Golder, 2012c)).
- Results are based on the optimised Spencer limit equilibrium search methods as implemented in Slope/W.



¹ SLOPE/W, "Slope Stability Analysis", GeoStudio 2007, Geo-Slope International, 2007

3.1.2 Seismicity

To simulate potential seismic forces, a pseudo-static slope stability approach has been adopted wherein potential seismic effects are modelled as additional (destabilising) horizontal forces. Although this approach simplifies complex, dynamic seismic loading as static forces, it is commonly applied for slope stability analysis of landfill embankments, with more complex analysis generally justified only in cases where the simplified analysis indicates stability concerns.

As per Table 3.2 in AS1170.4 (2007), a peak horizontal acceleration of 0.09g (the peak horizontal acceleration for Wollongong) has been identified; and subsequently modified to 50% (i.e. 0.045g) in the horizontal direction for application to landfill embankment analysis. This represents an earthquake event with an approximate 475-year recurrence interval, a recurrence interval generally considered very conservative for landfill slope stability analysis.

As indicated in Table I2 in AS4678 (2002), a site amplification factor of 1.0 (for less than 30 m of medium dense coarse sands and gravels, firm to stiff clays or controlled fill under the landfill mass) has been applied to the horizontal acceleration of 0.045g. A horizontal acceleration coefficient of 0.045g has therefore been adopted for the pseudo-static slope stability analysis. This is the same value used for the Golder (2012c) assessment.

3.1.3 Slope Geometry

Slope stability analyses were carried out on six cross-sections that were considered to present the highest relative risk of instability for interim landfill slopes for Tender Packages 1, 2 and 3 based on geometry and subsurface conditions. The location of these sections is shown in Appendix A, Figures A1 to A3 and the sections are provided in Appendix A, Figures A4 to A9. The sections are described as follows:

Tender Package	Section	Description	Location Plan
	Section J-J'	This section extends north-east to south-west along the proposed 3.5H:1V leading face of Tender Package 1	
1	Section K-K'	This section extends north-east to south-west along the proposed 3.5H:1V leading face of Tender Package 1 (south of Section J-J')	Figure A1
	Section L-L'	This section extends north-east to south-west along the proposed 3.5H:1V leading face of Tender Package 1 (south of Section K-K' and oriented normal to the lower new waste slope)	
	Section M-M'	This section extends north-east to south-west along the proposed 3.5H:1V leading face of Tender Package 2	
2	Section N-N'	This section extends north-east to south-west along the proposed 3.5H:1V leading face of Tender Package 2 (south of Section N-N')	Figure A2
3	Section P-P'	This section extends north-east to south-west along the proposed 3.5H:1V leading face of Tender Package 3	Figure A3

Table 3: Descriptions of cross-sections analysed in the interim slope stability assessment

It is noted that the analyses were conducted in stages, with initial results leading to changes in landfill liner subgrade levels, tender package boundary lines, and maximum interim waste placement slopes. These changes were adopted in the final cross sections analysed and reported herein.

3.2 Piggy Back Liner Construction Stability

3.2.1 Analytical Method

The potential failure mechanism considered is downslope sliding along a surface within the piggy back lining system during the construction of the cell, at a time after the placement of the protection material over the liner but before overlying landfill waste placement. Based on the range of slope angles included in the



Eastern Gully subgrade design for Tender Package 1, two analysis cases have been selected as described below in Table 4. Based on engineering judgment and project experience, these two cases are considered the most critical potential failure mechanisms during the construction of the piggy back liner.

Table 4: Summary of Analysis Meth	ods for Piggy Back Line	r Construction Stability
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Case	Geometry	Analysis Method	Target FoS
A	Steepest subgrade design slope, 2H:1V. This case occurs in limited areas with a maximum horiz. slope length of 10 m. In these areas the protection material above the piggy back liner will be placed at a flatter slope angle than the 2H:1V slope of the liner – a protection material slope of 2.5H:1V has been adopted - at min. 300 mm thickness.	Stability assessment under gravity loading (static conditions) using a two part wedge limit equilibrium method for both peak and residual (large- displacement) liner shear strength conditions. This method assumes the protection soil is fully drained, i.e. no pore pressure build-up in the local area from infiltrating rainwater.	 Target FoS of 1.3 to provide acceptable stability under static loading for <u>peak</u> liner strength; and Target FoS of 1.1 to provide acceptable stability under static loading for <u>residual</u> liner strength (note: development of residual conditions over widespread areas of the liner considered unlikely).
В	Prevailing subgrade design slopes ranging from 3H:1V to 4H:1V with maximum horiz. slope lengths of 30 to 80 m. In these areas the protection material above the piggy back liner will be placed at the same slope angle as the liner and at min. 300 mm thickness.	Stability assessment under gravity loading with water pressures in accordance with the limit equilibrium method outlined by Koerner & Soong (1998) for both peak and residual liner shear strength conditions. This method applies for a finite length slope with uniformly thick cover soil where a saturated zone of uniform thickness develops within the cover soil. A saturated thickness of 50% of the protection material thickness has been adopted (i.e., 150mm).	 Target FoS of 1.1 to provide acceptable stability for the water pressure case for <u>peak</u> liner strength (note: adopted value of saturated zone thickness considered a rare condition based on infiltration drainage design); and Target FoS of 1.0 to provide acceptable stability for the water pressure case for <u>residual</u> liner strength.

It should be noted that the following cases have not been analysed:

- The effect of potential seismic forces on the stability of the piggy back liner prior to the placement of waste has not been analysed as waste placement is expected to commence immediately following the construction of the liner.
- There is potential for the underside of the piggy back liner to be subjected to destabilising gas pressures from within the existing landfill. Given that a landfill gas venting system below the piggy back liner is included in the design, these potential effects are assumed to be negligible.



4.0 RESULTS AND DISCUSSION

4.1 Interim Slope Stability

A summary of interim slope stability analysis results is provided in Table 5 below, which indicate that all sections analysed meet the target factors of safety. A full list of analysis results and the output figures referenced below are included in Appendix B.

Table 5: Summar	y of Interim	Slope Stability	y Analysis	Results

Failure Mechanism	Conditions	Target FoS	Calculated FoS	Output Figures
	Long-term	1.5	1.83 – 2.38	B1, B8, B15, B22, B29, B36
Circular through alluvium	Short-term	1.3	1.40 – 2.09	B2, B9, B16, B23, B30, B37
	Earthquake	1.0	1.18 – 1.77	B3, B10, B17, B24, B31, B38
Non-circular (sliding) along	Long-term	1.5	1.52 – 1.85	B4, B11, B18, B25, B32, B39
cell liners at peak strength	Earthquake	1.1	1.29 – 1.55	B5, B12, B19, B26, B33, B40
Non-circular (sliding) along	Long-term	1.2	1.22 – 1.47	B6, B13, B20, B27, B34, B41
cell liners at residual strength	Earthquake	1.0	1.03 - 1.21	B7, B14, B21, B28, B35, B42

Based on the analysis results, the target slope stability factors of safety are achieved for interim slopes for Tender Packages 1, 2 and 3.

For all of the six cross-sections analysed, the critical failure mode for the stability of the interim Tender Package 1, 2 and 3 landforms is non-circular (sliding) failure along the proposed piggy back and new cell liners. This is the case for both long-term static conditions and under earthquake loading. Consequently, the stability is dependent on the shear strength of the critical interface or component within the proposed liner systems and the slope of the leading face of Tender Packages 1, 2 and 3. These issues are discussed further below.

4.1.1 Liner Shear Strength Requirements

The minimum liner shear strengths previously indicated in the *Interpretative Geotechnical Investigation Report for 50% Design* (Golder, 2012c) were designed to buttress the middle and upper slopes of the final landform. As a result of the current detailed assessment of the stability of the Tender Package 1, 2 and 3 interim slopes, the minimum liner shear strengths and zones have been revised. The revisions are applicable for interim waste slopes of 3.5H:1V (refer Section 4.1.2 below).

The revised minimum liner shear strengths and zones required to support the designs for interim slope stability and the final landform are presented in Table 1 and summarised in Table 6.

It should be noted that the following shear strength requirements and zones supersede the values previously presented in the *Interpretative Geotechnical Investigation Report for 50% Design* (Golder, 2012c).



 Table 6: Revised Shear Strength Requirements for Piggy Back Liner and New Cell Liner for Tender

 Packages 1, 2 and 3

	м	inimum Shear Stre	ngth within Liner Sys	tem
	P	eak	Resid	ual
Zone ¹	Drained Friction Angle (Φ') (°)	Drained Cohesion (c') (kPa)	Drained Friction Angle (Φ') (°)	Drained Cohesion (c') (kPa)
Slopes of old and new landfill	17	0	7	0
Flat areas of new cell floor	17	0	11	0
Eastern Gully (lower portion only)	19	0	14	0

1. Refer to Appendix A, Figure A1 to A3. These requirements are applicable for a leading (i.e., west-facing) waste slope of 3.5H:1V or flatter within Tender Packages 1, 2 and 3.

These liner shear strength requirements have been adopted within the Technical Specifications for Tender Packages 1, 2 and 3 prepared by Golder. It is noted that the Technical Specification has conservatively adopted the 'Eastern Gully (lower portion only)' shear strength requirement for the entire new cell floor area for Tender Package 1.

It should be noted that laboratory testing (interface shear and internal shear strength testing of each liner component) will be required to confirm the above shear strength parameters are satisfied as part of the selection process of the liner components.

4.1.2 Interim Waste Slope Requirements

As well as the liner shear strength, this assessment demonstrates that the stability of the interim waste slopes anticipated to be developed during landfilling within Tender Packages 1, 2 and 3 (refer Figures A1 to A3) is dependent on the slope of the leading face of the waste. Specifically, the assessment demonstrates that an interim waste slope inclination of 3.5H:1V or flatter is required for the leading (i.e., west and southwest facing) slope that will be formed during waste placement within the Tender Packages 1, 2 and 3 areas. Supplementary analyses indicated that target FoS values are not met, and there is potential for slope instability, if the leading (i.e., west and southwest facing) slopes are constructed at 3V:1H rather than at the required inclination of 3.5H:1V or flatter.

The following actions are recommended for Tender Packages 1, 2 and 3:

- The requirement for the leading (i.e. west and southwest facing) waste slope to be constructed at an inclination of 3.5H:1V or flatter, as described above, should be incorporated into the Safety in Design Risk Register. It is noted that the interim waste slopes that face west-northwest and do not toe out in the base liner area may be constructed at a steeper inclination of 3H:1V or flatter.
- The requirement in the previous bullet item should also be incorporated into the landfill Operations Plan. Please provide a copy to Golder for our review. Final copy to be kept on site during landfill waste placement operations.
- The leading waste slope should be constructed in an upslope direction (building from the toe up) to ensure the 3.5H:1V requirement is met during the construction of the cell.

4.2 Piggy Back Liner Construction Stability

The calculated Factors of Safety (FoS) against instability for each case considered are summarised in Table 7 below. These results indicate that the piggy back liner system meets the target Factors of Safety for the range of variables considered. The complete set of calculated results is included in Appendix C.



Case	Liner Shear Strength	Target FoS	Calculated FoS
٨	Peak	1.3	1.47
A	Residual	1.1	1.18
Р	Peak	1.1	1.33 – 1.75
D	Residual	1.0	1.09 – 1.42

Table 7: Summary of Piggy Back Liner Construction Stability Analysis Results

Provided that the relevant design elements described below are implemented in the detailed design for the piggy back liner, we expect there to be a low risk of instability along the piggy back liner during construction and prior to waste placement.

- The liner shear strength requirements provide in Table 2 of this memo should be implemented. Note: These requirements have been adopted within the Technical Specifications for Tender Packages 1, 2 and 3 prepared by Golder and laboratory testing (interface shear and internal shear strength testing of each liner component) is required to confirm these requirements are satisfied as part of the selection process of the liner components.
- The protection material layer must be placed at a slope of 2.5H:1V or flatter in the steep (2H:1V) subgrade areas in order to maintain acceptable FOS levels.
- The piggy back drainage design must limit saturated zone thickness within the protection material layer to less than 150 mm during rare rainfall events in order to maintain acceptable FOS levels. Please refer to Golder memorandum 117625003_227_M_Rev0 for relevant design information.
- Potential gas pressure below the geomembrane must be efficiently removed via a landfill gas collection/venting system installed below the piggy back liner. It is noted that such a system will also be effective in draining any perched leachate in the existing waste from below the piggy back liner.



5.0 REFERENCES

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6.0 CLOSURE

Your attention is drawn to the document "Limitations", which is attached in Appendix D. The statements presented in this document are intended to advise you of what your realistic expectations of this report should be. The document is not intended to reduce the level of responsibility accepted by Golder Associates, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing.

Please do not hesitate to contact the undersigned should you have any queries.

P. Richardy

Parnel Richards Civil/Environmental Engineer

PR/CSC:GRS/pr

Gary Schmertmann Principal Geotechnical Engineer

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Appendices

- Appendix A Interim Slope Cross Sections
- Appendix B Interim Slope Stability Analysis Results
- Appendix C Piggy Back Liner Construction Stability Analysis Results
- Appendix D Limitations



APPENDIX A Interim Slope Cross Sections





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DESIGN SURFACE																						26.67	29.52	32.38	35.24	38.09	40.94 42 80	46.65	49.51	52.17	53.82	55.52	57.21 50.08	60.94	62.55	64.09	65.65	67.22	67.70	68.21							
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EASTERN GULLY																											27.49	27.64	27.58	27.43	27.34	27.15	26.99 26.99	28.13	29.68	31.08	32.11	33.62	35.30	36.96	38.02	40.08	42.80	43.00 48.20	51.71	55.04	
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	<u>90.00</u>	100.00	110.00	120.00	130.00	140.00	160.00	170.00	180.00	190.00	200.00	210.00	220.00	230.00	240.00	250.00	260.00	270.00	200.00	300.00	310.00	320.00	330.00	340.00	360.00	370.00	380.00	390.00	400.00	410.00	420.00	430.00	440.00	450.00	470.00	480.00	490.00	



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NATURAL SURFACE	20.22 20.58	20.94 21.40	21.76	22.29	22.31 22.31 21.87	21.09	22.U/ 23.23	24.17 21.55	20.40	24.19 24.53	24.44 24.45	24.70	25.13 25.54	26.18 26.79	27.59 30.56	32.04	34.65 37.34	40.10 41.45	44.54 47.18	49.14	54.29	57.08 59.62	62.52	65.62	67.44 69.29	72.16	77.73	81.84 84.29	86.77 80.75	89.25 90.63	92.33 04.51	94.51 94.08	91.70 80.10	86.99	85.02 87.14	90 72	90.70	
DESIGN SURFACE													26.67	29.52 32.38	35.24 38.09	40.94	43.80 46.65	49.51 52.17	53.82 55.52	57.21 57.21	60.94 60.94	62.55 64.09	65.65 67.72	67.70	68.21													
SUBGRADE	21.90 22.17	22.55 22.79	23.00	23.28	23.60	23.92	24 1U 24 30	24.48 24.62	24.78	24.95 25.14	25.34 25.55	25.76	25.97 26.19	26.41 26.70	27.30 30.54	31.62	33.76 36.14	38.42 40.90	43.44 45.73	48.98 50.35	52.87	55.92 58.70	60.67 60.67	64.98	67 13 68 81	71.50 74 34	77.55	80.94 84.23	86.77 80.75	89.25 90.63	92.33 04.51	94.01 94.08	91.70 80.10	86.99	85.02 87.14	<u> 98.78</u>		
EASTERN GULLY																27.49	27.44 27.64	27.58 27.43	27.34 27.15	26.99 26.99 26.99	28.13	29.68 31.08	32.11	35.30	36.96 38.02	40.08 42 86	45.86	48.20 51.71	55.04	58.90 61.77	64.43 67.48	o/ 48 70.49	73.63 76.75	61.01				
CHAINAGE	0.00 10.00	20 00 30 00	40.00	60.00	80.00 90.00	100.00	110.00 120.00	130 00 140 00	150.00	160.00 170.00	180.00 190.00	200.00	210.00 220.00	230.00 240.00	250.00 260.00	270.00	280.00 290.00	300.00 310.00	320 00 330 00	350.00 350.00	360.00	370 00 380 00	390.00	400.00 410.00	420.00 430.00	440.00	460.00	470.00 480.00	490.00	510.00	520.00 530.00	540.00	550 00 560 00	570.00	580.00 590.00	600 00	602.28	
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NEW	LAND	FILL (1	TENDE	r Pa(CKAGE	2)-							()LD LA	NDFII														
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91 27.70	75 29.88	60 34 4	66 37.42	07 40.9	29 42.52	59 44 50	.05 49.7	62 55.4	20 61.23	83 65.48	.61 69.68	58 73.50	21 77.8	.91 82.66	86.62	89.3	92.01	94.98	94.26	92.36	89.27	86.26	81.48	82.50	87.4	93.15	98.4	105.6	
26.85 44	29.36 51	34.28 58	37.21 64	40.27 67	41.75 70	43.68 72	49.56 74	54.91 76	60.22 79	64.84 78	68.20 78	73.31 79	77.80 81	82.66 83	86.62	89.35	92.07	94.98	94.26	92.39	89.22	86.26	81.48	82.53	87.45	93.15	98.41	05.67	
				7	7	7	47 11	46.36	47.04 (45.83 (44.60 (42.55	40.87	40.51	38.82	38.86	42.27	46.48	52.26	58.44	65.21 8	70.45 8						-	
420.00	440.00	460.00	480.00	500.00	520.00	540.00	560.00	580.00	600.009	620.00	640.00	660.00	680.00	700.00	720.00	740.00	760.00	780.00	800.00	820.00	840.00	860.00	880.00	00.006	920.00	940.00	960.00	977 45	
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DATUM -20.00 (m))	АНП																																					
	20.33	20.76	19.62	19.51	20.15	21.37	21.10	21.00	21.14	22.49	22.97	22.89	23.73	24.21	24.71	24.71	24.24	22.43	22.43	25.97	26.82	27.70	29.88	34.45	37.42	40.94	42.52	44.56	49.74	55.47	61.23	65.48	69.68	73.53	77.81	82.66	86.62	89.35
DESIGN SURFACE																				31.31	38.07	44.91	51.75	58.60	64.66	67.07	70.29	72.59	74.05	76.62	79.20	78.83	78.61	79.58	81.21	83.91		
SUBGRADE	20.33	20.76	21.17	21.06	21.04	21.29	21.62	21.95	22.37	22.84	23.49	23.90	24.18	24.48	24.81	25.16	25.46	25.73	25.98	26.24	26.54	26.85	29.36	34.28	37.21	40.27	41.75	43.68	49.56	54.91	60.22	64.84	68.20	73.31	77.80	82.66	86.62	89.35
EASTERN GULLY																													47.11	46.36	47.04	45.83	44.60	42.55	40.87	40.51	38.82	38.86
CHAINAGE	0.00	20.00	40.00	60.00	80.00	100.00	120.00	140.00	160.00	180.00	200.00	220.00	240.00	260.00	280.00	300.00	320.00	340.00	360.00	380.00	400.00	420.00	440.00	460.00	480.00	500.00	520.00	540.00	560.00	580.00	600.00	620.00	640.00	660.00	680.00	700.00	720.00	740.00
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DATUM -20.00 (m)AI	17.15 च	17.59	17.35	16.48	15.72	15.72	7/·GI	17.76 18.61	18.61	18.61	18.77	19.23	20.06	21.23	21.85	21.01	21.00	22.69	23.87	25.30	25.84	30.62	35.40	39.16	43.94	49.62	53.73	59.47	62.69	6/.15 71.48	75.71	82.30	87.02	91.76	96.58	101.41	104.27	98.52	92.79	88.03	82.53	83.02	90.77	98.32	104.01		
DESIGN SURFACE																		24.82	31.48	38.16	44.82	4/ 64 50.91	53.96	57.11	60.29	63.74	67.40	71.14	75.03	/9.04 83.05	87.07	91.20	95.07	93.49													
SUBGRADE	17.15	17.59	17.35	16.48	15.72	15.72	7/.Cl	17.76 18.61	18.61	18.61 19.43	21.05	21.45	22.29	22.84	23.30	23./3 24.18	24.59	24.94	25.33	25.74	26.15	26.97	34.31	38.34	43.00	50.12	53.10	58.09	62.30	65 84 70 14	75.11	81.90	87.02	91.76	96.58	101.41	104.27	98.52	92.79	88.03	82.53	83.02	77.09 77.02	98.32	104.01		
EASTERN GULLY																							30.62	31.49	31.52	31.72	32.19	29.35	29.13	29.28 29.89	31.61	35.98	40.17	44.60	50.04	55.28	60.43	64.82	69.14								
CHAINAGE	00.0	20.00	40.00	60.00	80.00	100.00	120.00	140.00	160.00	180.00 200.00	220.00	240.00	260.00	280.00	300.00	320.00 340.00	360.00	380.00	400.00	420.00	440.00	480.00	500.00	520.00	540.00	560.00	580.00	600.00	620.00	640.00 660.00	680.00	700.00	720.00	740.00	760.00	780.00	800.00	820.00	840.00	860.00	880.00	00.006	920.00	940.00	960.00	;	
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bruary 2013 Time:3:53:24 PM By	: Cam	obell. He	en Patr	n: J:\civ	/\2011\11	7625003	3 Woll	lonaona (Council	New La	ndfill Ce	ell Whyte	s Gully\	Technic	al Doc\C	ADD\FIG	URES ·	File Na	me:117	7625003-2	214-M-F0	08-REV0	GOL	ww LDER AS	w.golder.e SOCIATE	com ES PTY. LTI	D.	SCALE		1:3,00	. 00		S	A3	E PRO	^{JECT №}	2500	3	^{DOC №}	4	М	FIGURE	008		N	IGURE	A8



								LEA AS A SLO	DING FAC A RESULI PE HAS E	NEW LANDFILL (TENDER PACKAGE 3) T OF SLOPE STABILITY ASSESSMENT, BEEN REVISED TO 3.5H:1V 3.5H 1V 3.5H															
													3.5H	1						•					
DATUM -20.00 (m	i)AHD																								
NATURAL SURFACE	17.00	18.33	19.80	19.02	19.23	19.35	19.33	20.12	20.74	23.17	23.16	23 <u>.</u> 93	25.18	24.71	24.71	24.71	24.01	27.03	27.92	32.14	36.11	38.07	41.01	43.74	
DESIGN SURFACE												24.55	31 <u>.</u> 44	38.31	45.17	49.86	52.63	50.85	50.88	50.91	50.89	50.79	51.67	52.89	
SUBGRADE	17.00	18.33	19.80	21.00	21.00	21.00	21.37	21.99	22.77	23.39	24.01	24.36	24.78	25.24	25.64	25,98	26.28	26.59	26.94	31.89	35.90	38.07	40.76	43.83	
EASTERN GULLY																									
CHAINAGE	0.00	20.00	40.00	60.00	80.00	100.00	120.00	140.00	160.00	180.00	200 <u>.</u> 00	220.00	240.00	260.00	280.00	300,00	320.00	340.00	360.00	380.00	400 <u>.</u> 00	420.00	440.00	460.00	



_	WOLLONGONG	CITY COUNC	IL
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Golder	EJJ	22.02.2013	
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GOLD Plot Date: 28 February 2013 Time:3:59:49 PM By: Campbell, Helen Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\FIGURES - File Name:117625003-214-M-F009-REV0.dwg Xref: GAP_LOGO-A3.dwg:

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Ι										
	48.00	51.75	55.29	57.85	64.57	65.61	68.59	70.21	71.00	
	54.09	56.63	57.27	57.91						
	47.75	51.59	54.99	57.90	62.48	65.52	65.59	65.90	66.00	
	480.00	500.00	520.00	540.00	560.00	580.00	600.00	620 <u>.</u> 00	636.18	
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ZΕ 3	PROJECT	× 76250	03	[∞] №	ос туре М	FIGURE NO FOOS		FI	GURE	E A9



Interim Slope Stability Analysis Results





Client: Wollongong City Council Project No: 117625003

Project: Whytes Gully New Landfill Cell

Reference: 117625003_214_R_Rev0-Slope Stability Assessment for Detailed Design

	Analysed Cross-Section	Analysis	Target FoS	Calculated FoS	Checked By	Figure Number	Comments
		CR through Alluvium DR*	1.5	1.83	SZ	B1	Circular failure through proposed liner & alluvium at toe
		CR through Alluvium UD*	1.3	1.64	SZ	B2	Circular failure through proposed liner & alluvium at toe
		CR through Alluvium UD & EQ*	1.0	1.39	SZ	B3	Circular failure through proposed liner & alluvium at toe
	Section J-J'	NC along Proposed Liner DR (P)	1.5	1.64	SZ	B4	Block failure at toe along proposed liner
		NC along Proposed Liner EQ (P)	1.1	1.36	SZ	B5	Block failure at toe along proposed liner
		NC along Proposed Liner DR (R) [^]	1.2	1.31	SZ	B6	Block failure at toe along proposed liner
		NC along Proposed Liner EQ (R)	1.0	1.07	SZ	B7	Block failure at toe along proposed liner
		CR through Alluvium DR*	1.5	2.15	SZ	B8	Circular failure through proposed liner & alluvium at toe
e 1		CR through Alluvium UD*	1.3	2.14	SZ	B9	Circular failure through proposed liner & alluvium at toe
ckag		CR through Alluvium UD & EQ*	1.0	1.83	SZ	B10	Circular failure through proposed liner & alluvium at toe
- Pac	Section K-K'	NC along Proposed Liner DR (P)	1.5	1.56	SZ	B11	Block failure along proposed liner extending to toe
ıəpı		NC along Proposed Liner EQ (P)	1.1	1.31	SZ	B12	Block failure along proposed liner extending to toe
Ter		NC along Proposed Liner DR (R) [^]	1.2	1.23	SZ	B13	Block failure along proposed liner
		NC along Proposed Liner EQ (R)	1.0	1.03	SZ	B14	Block failure along proposed liner
		CR through Alluvium DR*	1.5	2.27	SZ	B15	Circular failure through proposed liner & alluvium at toe
		CR through Alluvium UD*	1.3	2.09	SZ	B16	Circular failure through proposed liner & alluvium at toe
		CR through Alluvium UD & EQ*	1.0	1.78	SZ	B17	Circular failure through proposed liner & alluvium at toe
	Section L-L'	NC along Proposed Liner DR (P)	1.5	1.52	SZ	B18	Block failure along proposed liner extending to toe
		NC along Proposed Liner EQ (P)	1.1	1.29	SZ	B19	Block failure along proposed liner extending to toe
		NC along Proposed Liner DR (R) [^]	1.2	1.22	SZ	B20	Block failure along proposed liner extending to toe
		NC along Proposed Liner EQ (R)	1.0	1.03	SZ	B21	Block failure along proposed liner extending to toe
		CR through Alluvium DR	1.5	1.98	SZ	B22	Circular failure through proposed liner & alluvium at toe
		CR through Alluvium UD	1.3	1.40	SZ	B23	Circular failure through proposed liner & alluvium at toe
		CR through Alluvium UD & EQ	1.0	1.18	SZ	B24	Circular failure through proposed liner & alluvium at toe
	Section M-M'	NC along Proposed Liner DR (P)	1.5	1.58	SZ	B25	Block failure along proposed liner at toe
~		NC along Proposed Liner EQ (P)	1.1	1.33	SZ	B26	Block failure along proposed liner at toe
age		NC along Proposed Liner DR (R) [^]	1.2	1.36	SZ	B27	Block failure along proposed liner at toe
acka		NC along Proposed Liner EQ (R)	1.0	1.13	SZ	B28	Block failure along proposed liner at toe
er P		CR through Alluvium DR	1.5	2.09	SZ	B29	Circular failure through proposed liner & alluvium at toe
end		CR through Alluvium UD	1.3	1.76	SZ	B30	Circular failure through proposed liner & alluvium at toe
F		CR through Alluvium UD & EQ	1.0	1.47	SZ	B31	Circular failure through proposed liner & alluvium at toe
	Section N-N'	NC along Proposed Liner DR (P)	1.5	1.77	SZ	B32	Block failure along proposed liner at toe
		NC along Proposed Liner EQ (P)	1.1	1.48	SZ	B33	Block failure along proposed liner at toe
		NC along Proposed Liner DR (R) ^A	1.2	1.37	SZ	B34	Block failure along proposed liner at toe
		NC along Proposed Liner EQ (R)	1.0	1.14	SZ	B35	Block failure along proposed liner at toe
		CR through Alluvium DR*	1.5	2.38	SZ	B36	Circular failure through proposed liner & alluvium at toe
e 3		CR through Alluvium UD	1.3	1.90	SZ	B37	Circular failure through proposed liner & alluvium at toe
kag		CR through Alluvium UD & EQ	1.0	1.57	SZ	B38	Circular failure through proposed liner & alluvium at toe
Pac	Section P-P'	NC along Proposed Liner DR (P)	1.5	1.85	SZ	B39	Block failure along proposed liner at toe
der		NC along Proposed Liner EQ (P)	1.1	1.55	SZ	B40	Block failure along proposed liner at toe
Ten		NC along Proposed Liner DR (R)^	1.2	1.47	SZ	B41	Block failure along proposed liner at toe
		NC along Proposed Liner EQ (R)	1.0	1.21	SZ	B42	Block failure along proposed liner at toe

Notes:

CR: Circular

NC: Non-Circular DR: Drained (Long-term)

UD: Undrained EQ: Earthquake

P: Peak interface shear strength (liner)

R: Residual interface shear strength (liner) ^ Factor of Safety of 1.2 adopted for long-term (drained) scenarios where failure occurs along the proposed liner at residual shear strength conditions. Note that

A Factor of Safety of 1.2 adopted for long-term (drained) scenarios where failure occurs along the proposed liner at residual shear strength conditions. Note that
residual conditions are unlikely to develop across all areas of the liner simultaneously.
 Earthquake loading assumes a horizontal acceleration of 0.045g (refer Section 3.1.2 of report).
 Alluvium refers to the combined "Alluvium/Colluvium" unit.
 For Undrained Alluvium cases, the percentage strength and ue to consolidation has conservatively been assumed to be 50% for the alluvium/colluvium below the
waste placed during one Tender Package and 75% at the end of the placement of waste during subsequent Tender Packages to simulate the shear strength of the
alluvium immediately after the construction of each respective Tender Package.
 For ease of modelling, all liner layers are characterised by the shear strength properties of the critical interface.
 A 5 m limit of slip surface depth was added to the landfill mass to prevent SlopeW converging on shallow veneer failures as required.
 Results based on optimised Spencer limit equilibrium analyses, unless optimised slip appeared kinematically inadmissable (*).

Whytes Gully SlopeW - Section J-J' Name: CR through Alluvium DR

Model: Bilinear Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Model: Mohr-Coulomb Model: Bedrock (Impenetrable)



	CLIENT	Wollon	gong C	ity Council
Golder	DRAWN	PR	DATE:	28/02/
Associates	CHECKED	SZ	DATE:	18/03/
	SCALE:	As sh	own	

Whytes Gully SlopeW - Section J-J' Name: CR through Alluvium UD (immediately after construction)

Name: Unit 41a - New Landfill Model: Bilinear Unit Weight: 11 kN/m³ Cohesion: 24 kPa Phi 1: 0.1 ° Phi 2: 33 ° Bilinear Norma Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Name: Interface 3 - Eastern Gully Base Liner System (Steep) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 3 Name: Unit 42a - Alluvium - 1u - 50% strength gain Model: Undrained (Phi=0) Unit Weight: 17 kN/m³ Cohesion: 47 kPa Name: Interface 1 - Proposed Piggy Back Liner System (Peak) (19 deg) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 k Name: Unit 42a - Alluvium - 2u - undisturbed Model: Undrained (Phi=0) Unit Weight: 17 kN/m³ Cohesion: 40 kPa Name: Unit 42a - Alluvium - 2 - undisturbed Model: S=f(depth) Unit Weight: 17 kN/m³ C-Top of Layer: 40 kPa C-Rate of Change: 14



	SCALE:	As sh	nown	
Associates	CHECKED	SZ	DATE:	18/03/13
Golder	DRAWN	PR	DATE:	28/02/13
	CLIENT	Wollor	ngong Ci	ty Council

al: 37 kPa	
30 °	
kPa Phi: 19°	
18 kPa/m Limiting C: 100 kPa	
700	
Whytes Gully New Landfill Cel Stability Assessment for Detaile	I - Slope
TITLE: Section J-J'	a Boolgii
Circular through Alluvium - Short-te	erm
PROJECT №. 117625003 FIGURE №. B2	Δ3

Whytes Gully SlopeW - Section J-J' Name: CR through Alluvium UD & EQ (immediately after construction)

Name: Unit 41a - New Landfill Model: Bilinear Unit Weight: 11 kN/m³ Cohesion: 24 kPa Phi 1: 0.1 ° Phi 2: 33 ° Bilinear Normal: 37 kPa Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Name: Interface 3 - Eastern Gully Base Liner System (Steep) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Unit 42a - Alluvium - 1u - 50% strength gain Model: Undrained (Phi=0) Unit Weight: 17 kN/m³ Cohesion: 47 kPa Name: Interface 1 - Proposed Piggy Back Liner System (Peak) (19 deg) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 19 ° Name: Unit 42a - Alluvium - 2u - undisturbed Model: Undrained (Phi=0) Unit Weight: 17 kN/m³ Cohesion: 40 kPa Name: Unit 42a - Alluvium - 2u - undisturbed Model: S=f(depth) Unit Weight: 17 kN/m³ C-Top of Layer: 40 kPa C-Rate of Change: 18 kPa/m Limiting C: 100 kPa



	CLIENT	Wollongong City Council				
Golder	DRAWN	PR	DATE:	28/02/13		
Associates	CHECKED	SZ	DATE:	18/03/13		
	SCALE:	As sh	nown			

PROJECT	Whytes Gully Stability Asses	New Land	fill Cel Detaile	l - Slope ed Design				
TITLE:		Section J-	J'					
Circular through Alluvium - Earthquake								
PROJECT No.	117625003	FIGURE No.	B3	A3				

Whytes Gully SlopeW - Section J-J' Name: NC along Proposed Liner (P)

Model: Bilinear Unit Weight: 11 kN/m³ Cohesion: 24 kPa Phi 1: 0.1 ° Phi 2: 33 ° Bilinear Normal: 37 kPa Name: Unit 41a - New Landfill Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Unit 42a - Alluvium Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 ° Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Name: Interface 3 - Eastern Gully Base Liner System (Steep) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Interface 1 - Proposed Piggy Back Liner System (Peak) (19 deg) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 19 °



	CLIENT	Wollon	gong C	ity Council	PROJECT	Whytes Gully Stability Asses	/ New Lan ssment fo	dfill Cel r Detaile	l - Slope ed Design
Golder	DRAWN	PR	DATE:	28/02/13	TITLE:		Section J	l-J'	
Associates	CHECKED	SZ	DATE:	18/03/13	Non-circ	ular along Propo	osed Liner	(Peak) -	Long-term
	SCALE:	As sh	own		PROJECT No.	117625003	FIGURE No.	B4	A3

Whytes Gully SlopeW - Section J-J' Name: NC along Proposed Liner_EQ (P)

Name: Unit 41a - New Landfill Model: Bilinear Unit Weight: 11 kN/m³ Cohesion: 24 kPa Phi 1: 0.1 ° Phi 2: 33 ° Bilinear Normal: 37 kPa Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Name: Unit 42a - Alluvium Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 ° Model: Bedrock (Impenetrable) Name: Unit 45 - Fresh Sandstone Name: Interface 3 - Eastern Gully Base Liner System (Steep) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Interface 1 - Proposed Piggy Back Liner System (Peak) (19 deg) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 19 °







Whytes Gully New Landfill Cell - Slope Stability Assessment for Detailed Design								
	Section J-J'							
n-circular along Proposed Liner (Peak) - Earthquake								
^{T No.} 117625003	FIGURE No. B5	A3						

Name: NC along Proposed Liner (R)

Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Unit Weight: 17 kN/m3 Cohesion: 2 kPa Phi: 25 ° Model: Mohr-Coulomb Model: Bedrock (Impenetrable)



Whytes Gully SlopeW - Section J-J' Name: NC along Proposed Liner_EQ (R)

Name: Unit 41a - New Landfill Model: Bilinear Unit Weight: 11 kN/m³ Cohesion: 24 kPa Phi 1: 0.1 ° Phi 2: 33 ° Bilinear Normal: 37 kPa Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Unit 42a - Alluvium Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 ° Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Name: Interface 3 - Eastern Gully Base Liner System (Steep) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Interface 1 - Proposed Piggy Back Liner System (Residual 14 deg) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi



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Associates	CHECKED	SZ	DATE:	18/03/13	Nor		
	SCALE:	As sł	nown		PROJE		



Whytes Gully SlopeW - Section K-K' Name: CR through Alluvium DR

Name: Unit 41a - New Landfill Model: Bilinear Unit Weight: 11 kN/m³ Cohesion: 24 kPa Phi 1: 0.1 ° Phi 2: 33 ° Bilinear Normal: 37 kl Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Unit 42a - Alluvium Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 ° Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Name: Interface 1 - Proposed Piggy Back Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Name: Interface 3 - Eastern Gully Base Liner System (Steep) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Unit 41d - Existing Compacted Clay Bund Model: Mohr-Coulomb Unit Weight: 18 kN/m³ Cohesion: 2 kPa Phi: 30 °



	CLIENT Wollongong City Council					
Golder	DRAWN	PR	DATE:	28/02/13	TITLE:	
Associates	CHECKED	SZ	DATE:	18/03/13		
	SCALE:	As sł	nown		PROJEC	



Whytes Gully SlopeW - Section K-K'

Name: CR through Alluvium UD (immediately after construction)

Name: Unit 41a - New Landfill Model: Bilinear Unit Weight: 11 kN/m³ Cohesion: 24 kPa Phi 1: 0.1 ° Phi 2: 33 ° Bilinear Normal: 37 kPa Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Name: Interface 1 - Proposed Piggy Back Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Name: Interface 3 - Eastern Gully Base Liner System (Steep) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Unit 42a - Alluvium - 1u - 50% strength gain Model: Undrained (Phi=0) Unit Weight: 17 kN/m³ Cohesion: 46 kPa Name: Unit 42a - Alluvium - 2u - undisturbed Model: Undrained (Phi=0) Unit Weight: 17 kN/m³ Cohesion: 40 kPa Name: Unit 42a - Alluvium - 2 - undisturbed Model: S=f(depth) Unit Weight: 17 kN/m³ C-Top of Layer: 40 kPa C-Rate of Change: 18 kPa/m Limiting C: 100 kPa Name: Unit 41d - Existing Compacted Clay Bund (UD) Model: Undrained (Phi=0) Unit Weight: 18 kN/m³ Cohesion: 75 kPa



	CLIENT	Wollongong City Council			PROJECT	Whytes Gully New Landfill Cell - Slope Stability Assessment for Detailed Design			
Golder	DRAWN	PR	DATE:	28/02/13	2/13			K-K'	
Associates	CHECKED	SZ	DATE:	18/03/13		Circular throug	h Alluvium	- Short-tei	m
	SCALE:	As sh	own		PROJECT No.	117625003	FIGURE No.	B9	A3



Whytes Gully SlopeW - Section K-K'

Name: CR through Alluvium UD & EQ (immediately after construction)

Name: Unit 41a - New Landfill Model: Bilinear Unit Weight: 11 kN/m³ Cohesion: 24 kPa Phi 1: 0.1 ° Phi 2: 33 ° Bilinear Normal: 37 kPa Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Name: Interface 1 - Proposed Piggy Back Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Name: Interface 3 - Eastern Gully Base Liner System (Steep) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Unit 42a - Alluvium - 1u - 50% strength gain Model: Undrained (Phi=0) Unit Weight: 17 kN/m³ Cohesion: 46 kPa Name: Unit 42a - Alluvium - 2u - undisturbed Model: Undrained (Phi=0) Unit Weight: 17 kN/m³ Cohesion: 40 kPa Name: Unit 42a - Alluvium - 2 - undisturbed Model: S=f(depth) Unit Weight: 17 kN/m³ C-Top of Layer: 40 kPa C-Rate of Change: 18 kPa/m Limiting C: 100 kPa Name: Unit 41d - Existing Compacted Clay Bund (UD) Model: Undrained (Phi=0) Unit Weight: 18 kN/m³ Cohesion: 75 kPa



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		CLIENT	Wollongong City Council				Whytes Gully New Landfill Cell - Slope Stability Assessment for Detailed Design				
	Golder	DRAWN	PR	DATE:	28/02/13	TITLE:	Section K-K'				
	Associates	CHECKED	SZ	DATE:	18/03/13		Circular through	n Alluvium ·	Earthqua	ke	
		SCALE:	As sh	own		PROJECT No.	117625003	FIGURE No.	B10	A3	



Whytes Gully SlopeW - Section K-K' Name: NC along Proposed Liner (P) (toe)

Name: Unit 41a - New Landfill Model: Bilinear Unit Weight: 11 kN/m³ Cohesion: 24 kPa Phi 1: 0.1 ° Phi 2: 33 ° Bilinear Normal: 37 kPa Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Unit 42a - Alluvium Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 ° Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Name: Interface 3 - Eastern Gully Base Liner System (Steep) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Interface 1 - Proposed Piggy Back Liner System (Peak) (19 deg) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Interface 2 - Proposed Cell Liner System (Peak) (19 deg) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 19 ° Name: Unit 41d - Existing Compacted Clay Bund Model: Mohr-Coulomb Unit Weight: 18 kN/m³ Cohesion: 2 kPa Phi: 30 °



		CLIENT	Wollongong City Council					
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	Associates	CHECKED	SZ	DATE:	18/03/13	No		
		SCALE:	As sh	lown		PROJEC		
4								



Whytes Gully SlopeW - Section K-K' Name: NC along Proposed Liner_EQ (P) (toe)

Name: Unit 41a - New Landfill Model: Bilinear Unit Weight: 11 kN/m³ Cohesion: 24 kPa Phi 1: 0.1 ° Phi 2: 33 ° Bilinear Normal: 37 kPa Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Unit 42a - Alluvium Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 ° Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Name: Interface 3 - Eastern Gully Base Liner System (Steep) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Interface 1 - Proposed Piggy Back Liner System (Peak) (19 deg) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 19 ° Name: Interface 2 - Proposed Cell Liner System (Peak) (19 deg) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 19 ° Name: Unit 41d - Existing Compacted Clay Bund (UD) Model: Undrained (Phi=0) Unit Weight: 18 kN/m³ Cohesion: 75 kPa



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Whytes Gully SlopeW - Section K-K' Name: NC along Proposed Liner (R)

Name: Unit 41a - New Landfill Unit Weight: 11 kN/m³ Cohesion: 24 kPa Phi 1: 0.1 ^o Phi 2: 33 ^o Model: Bilinear Model: Mohr-Coulomb Name: Unit 41b - Old Landfill Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Unit 42a - Alluvium Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 ° Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Name: Interface 3 - Eastern Gully Base Liner System (Steep) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Interface 2 - Proposed Cell Liner System (Residual 14 deg) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Name: Interface 1 - Proposed Piggy Back Liner System (Residual 14 deg) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 14 ° Name: Interface 1 - Proposed Piggy Back Liner System (Residual - Eastern Gully) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Name: Unit 41d - Existing Compacted Clay Bund Model: Mohr-Coulomb Unit Weight: 18 kN/m³ Cohesion: 2 kPa Phi: 30 °



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Golder	DRAWN	PR	DATE:	28/02/13	TITLE:
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	SCALE:	As sł	nown		PROJE



Whytes Gully SlopeW - Section K-K' Name: NC along Proposed Liner_EQ (R)

Name: Unit 41a - New Landfill Model: Bilinear Unit Weight: 11 kN/m³ Cohesion: 24 kPa Phi 1: 0.1 ° Phi 2: 33 ° Cohesion: 0 kPa Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Phi: 30 ° Unit Weight: 17 kN/m³ Cohesion: 2 kPa Name: Unit 42a - Alluvium Model: Mohr-Coulomb Phi: 25 ° Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Name: Interface 3 - Eastern Gully Base Liner System (Steep) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Interface 2 - Proposed Cell Liner System (Residual 14 deg) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Name: Interface 1 - Proposed Piggy Back Liner System (Residual 14 deg) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Name: Interface 1 - Proposed Piggy Back Liner System (Residual - Eastern Gully) Model: Mohr-Coulomb Name: Unit 41d - Existing Compacted Clay Bund (UD) Model: Undrained (Phi=0) Unit Weight: 18 kN/m³ Cohesion: 75 kPa



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Golder	DRAWN	PR	DATE:	28/02/13	TITLE:
Associates	CHECKED	SZ	DATE:	18/03/13	Non
	SCALE:	As sł	nown		PROJEC



Name: CR through Alluvium DR

Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Model: Bedrock (Impenetrable)



	Wollongong City Council				PROJEC
Golder	DRAWN	PR	DATE:	28/02/13	TITLE:
Associates	CHECKED	SZ	DATE:	18/03/13	
	SCALE: As shown				PROJEC

Whytes Gully SlopeW - Section L-L' Name: CR through Alluvium UD (immediately after construction)

Name: Unit 41a - New Landfill Model: Bilinear Unit Weight: 11 kN/m³ Cohesion: 24 kPa Phi 1: 0.1 ° Phi 2: 33 ° Bilinear Normal: 37 kPa Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Name: Interface 3 - Eastern Gully Base Liner System (Steep) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Interface 4 - Eastern Gully Base Liner System (Shallow) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Unit 42a - Alluvium - 1u - 50% strength gain Model: Undrained (Phi=0) Unit Weight: 17 kN/m³ Cohesion: 45 kPa Name: Unit 42a - Alluvium - 2u - undisturbed Model: Undrained (Phi=0) Unit Weight: 17 kN/m³ Cohesion: 40 kPa Name: Unit 42a - Alluvium - 2 - undisturbed Model: S=f(depth) Unit Weight: 17 kN/m³ C-Top of Layer: 40 kPa C-Rate of Change: 18 kPa/m Limiting C: 100 kPa Name: Unit 41d - Existing Compacted Clay Bund (UD) Model: Undrained (Phi=0) Unit Weight: 18 kN/m³ Cohesion: 75 kPa



https://aupws.golder.com/117625003wollongongCityCouncilnewCellwhytesGully/Project Doc/320 90percent design/3206 Stability/Report/Appendix B - Interim Slope Stability Results/[Appendix B - Slope W Summary Figures.xlsx]B1

Whytes Gully New Landfill Cell - Slope **Stability Assessment for Detailed Design** Section L-L' Circular through Alluvium - Short-term 117625003 B16 A3

As shown
Whytes Gully SlopeW - Section L-L'

Name: CR through Alluvium UD & EQ (immediately after construction)

Name: Unit 41a - New Landfill Model: Bilinear Unit Weight: 11 kN/m³ Cohesion: 24 kPa Phi 1: 0.1 ° Phi 2: 33 ° Bilinear Normal: 37 kPa Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Name: Interface 3 - Eastern Gully Base Liner System (Steep) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Interface 4 - Eastern Gully Base Liner System (Shallow) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 18 ° Name: Unit 42a - Alluvium - 1u - 50% strength gain Model: Undrained (Phi=0) Unit Weight: 17 kN/m³ Cohesion: 45 kPa Name: Unit 42a - Alluvium - 2u - undisturbed Model: Undrained (Phi=0) Unit Weight: 17 kN/m³ Cohesion: 40 kPa Name: Unit 42a - Alluvium - 2 - undisturbed Model: S=f(depth) Unit Weight: 17 kN/m³ C-Top of Layer: 40 kPa C-Rate of Change: 18 kPa/m Limiting C: 100 kPa Name: Unit 41d - Existing Compacted Clay Bund (UD) Model: Undrained (Phi=0) Unit Weight: 18 kN/m³ Cohesion: 75 kPa



	CLIENT	Wollongong City Council				PROJECT Whytes Gully New Landfill Cell - Slope Stability Assessment for Detailed Design				
Golder	DRAWN	PR	DATE:	28/02/13	13 Section L-L'					
Associates	CHECKED	SZ	DATE:	18/03/13		Circular through	n Alluvium -	Earthqua	ke	
	SCALE:	As sh	iown		PROJECT No.	117625003	FIGURE No.	B17	A3	

Name: NC along Proposed Liner (P) (toe)

Model: Bilinear Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 ° Model: Mohr-Coulomb Model: Bedrock (Impenetrable) Unit Weight: 19 kN/m³



Name: Unit 41a - New Landfill Model: Bilinear Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 ° Model: Mohr-Coulomb Model: Bedrock (Impenetrable)



Whytes Gully SlopeW - Section L-L' Name: NC along Proposed Liner (R) (toe)

Name: Unit 41a - New Landfill Unit Weight: 11 kN/m³ Bilinear Normal: 37 kPa Model: Bilinear Cohesion: 24 kPa Phi 1: 0.1 ° Phi 2: 33 ° Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 ° Name: Unit 42a - Alluvium Model: Mohr-Coulomb Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Name: Interface 2 - Proposed Cell Liner System (Residual - Slopes) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 7 ° Name: Interface 3 - Eastern Gully Base Liner System (Steep) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Interface 4 - Eastern Gully Base Liner System (Shallow) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 18 ° Name: Interface 1 - Proposed Piggy Back Liner System (Residual - Eastern Gully) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Name: Interface 2 - Proposed Cell Liner System (Residual - Eastern Gully) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 14 ° Name: Unit 41d - Existing Compacted Clay Bund Model: Mohr-Coulomb Unit Weight: 18 kN/m³ Cohesion: 2 kPa Phi: 30 °



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	Golder	DRAWN	PR	DATE:	28/02/13	S TITLE: Section L-L'					
	Associates	CHECKED	SZ	DATE:	18/03/13	Non-circ	ular along Propo	sed Liner (Residual)	- Long-term	
		SCALE:	As sh	own		PROJECT No.	117625003	FIGURE No.	B20	A3	

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Cohesion: 0 kPa Phi: 14 °
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Whytes Gully SlopeW - Section L-L' Name: NC along Proposed Liner_EQ (R) (toe)

Name: Unit 41a - New Landfill Model: Bilinear Unit Weight: 11 kN/m³ Cohesion: 24 kPa Phi 1: 0.1 ° Phi 2: 33 ° Name: Unit 41b - Old Landfill Unit Weight: 11 kN/m³ Cohesion: 0 kPa Model: Mohr-Coulomb Phi: 30 ° Name: Unit 42a - Alluvium Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 ° Model: Mohr-Coulomb Model: Bedrock (Impenetrable) Name: Unit 45 - Fresh Sandstone Name: Interface 2 - Proposed Cell Liner System (Residual - Slopes) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Name: Interface 3 - Eastern Gully Base Liner System (Steep) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Name: Interface 4 - Eastern Gully Base Liner System (Shallow) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Name: Interface 1 - Proposed Piggy Back Liner System (Residual - Eastern Gully) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Name: Interface 2 - Proposed Cell Liner System (Residual - Eastern Gully) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Name: Unit 41d - Existing Compacted Clay Bund (UD) Model: Undrained (Phi=0) Unit Weight: 18 kN/m³ Cohesion: 75 kPa



	Wollongong City Council				PROJECT Whytes Gully New Landfill Cell - Slope Stability Assessment for Detailed Design				
Golder	DRAWN	PR	DATE:	28/02/13	TITLE:		Section	L-L'	
Associates	CHECKED	SZ	DATE:	18/03/13	Non-circu	lar along Propos	sed Liner (Residual) -	Earthquake
	SCALE:	As sh	own		PROJECT No.	117625003	FIGURE No.	B21	A3

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Bilinear Normal: 37 kPa
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Phi: 7 °
Phi: 30 °
Phi: 18 °
Cohesion: 0 kPa
                   Phi: 14 °
           Phi: 14 °
```



Whytes Gully SlopeW - Section M-M' Name: CR through Alluvium_UD (Immediately after Construction)

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Name: Unit 41a - New Landfill Model: Bilinear Unit Weight: 11 kN/m³ Cohesion: 24 kPa Phi 1: 0.1 ° Phi 2: 33 ° Bilinear Normal: 37 kPa Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Name: Interface 3 - Eastern Gully Base Liner System (Steep) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Interface 3 - Eastern Gully Base Liner System (Peak) (19 deg) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Interface 2 - Proposed Cell Liner System (Peak) (19 deg) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 19 ° Name: Interface 2 - Proposed Cell Liner System (Peak) (19 deg) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 19 ° Name: Unit 42a-3u-Alluvium (UD) - undisturbed Model: Undrained (Phi=0) Unit Weight: 17 kN/m³ Cohesion: 40 kPa Name: Unit 42a-3u-Alluvium (UD) - undisturbed Model: S=f(depth) Unit Weight: 17 kN/m³ Cohesion: 76 kPa Name: Unit 42a-1u-Alluvium (UD)-75% strength gain Model: Undrained (Phi=0) Unit Weight: 17 kN/m³ Cohesion: 76 kPa Name: Unit 42a-1-Alluvium (UD) - 50% Strength Gain Model: Undrained (Phi=0) Unit Weight: 17 kN/m³ Cohesion: 52 kPa Name: Unit 42a-2-Alluvium (UD) - 50% Strength Gain Model: S=f(depth) Unit Weight: 17 kN/m³ C-Top of Layer: 52 kPa C-Rate of Change: 18 kPa/m Limiting C: 100 kPa Name: Unit 42a-2-Alluvium (UD) - 50% Strength Gain Model: S=f(depth) Unit Weight: 17 kN/m³ C-Top of Layer: 76 kPa C-Rate of Change: 18 kPa/m Limiting C: 100 kPa Name: Unit 42a-2-Alluvium (UD) - 50% Strength Gain Model: S=f(depth) Unit Weight: 17 kN/m³ C-Top of Layer: 76 kPa C-Rate of Change: 18 kPa/m Limiting C: 100 kPa



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Whytes Gully SlopeW - Section M-M' Name: CR through Alluvium_UD & EQ (Immediately after Construction)

Name: Unit 41a - New Landfill Model: Bilinear Unit Weight: 11 kN/m³ Cohesion: 24 kPa Phi 1: 0.1 ° Phi 2: 33 ° Bilinear Normal: 37 kPa Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Name: Interface 3 - Eastern Gully Base Liner System (Steep) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Interface 1 - Proposed Piggy Back Liner System (Peak) (19 deg) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Interface 2 - Proposed Cell Liner System (Peak) (19 deg) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 19 ° Name: Interface 2 - Proposed Cell Liner System (Peak) (19 deg) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 19 ° Name: Unit 42a-3u-Alluvium (UD) - undisturbed Model: Undrained (Phi=0) Unit Weight: 17 kN/m³ Cohesion: 40 kPa Name: Unit 42a-3u-Alluvium (UD) - undisturbed Model: S=f(depth) Unit Weight: 17 kN/m³ Cohesion: 76 kPa Name: Unit 42a-1u-Alluvium (UD)-50% Strength Gain Model: Undrained (Phi=0) Unit Weight: 17 kN/m³ Cohesion: 76 kPa Name: Unit 42a-1-Alluvium (UD)-50% Strength Gain Model: Undrained (Phi=0) Unit Weight: 17 kN/m³ C-Top of Layer: 52 kPa C-Rate of Change: 18 kPa/m Limiting C: 100 kPa Name: Unit 42a-2-Alluvium (UD)-50% Strength Gain Model: S=f(depth) Unit Weight: 17 kN/m³ C-Top of Layer: 76 kPa C-Rate of Change: 18 kPa/m Limiting C: 100 kPa Name: Unit 42a-2-Alluvium (UD)-50% Strength Gain Model: S=f(depth) Unit Weight: 17 kN/m³ C-Top of Layer: 76 kPa C-Rate of Change: 18 kPa/m Limiting C: 100 kPa



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Whytes Gully SlopeW - Section N-N' Name: CR through Alluvium_DR

Unit Weight: 11 kN/m³ Cohesion: 24 kPa Phi 1: 0.1 ° Phi 2: 33 ° Bilinear Normal: 37 kPa Name: Unit 41a - New Landfill Model: Bilinear Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Unit Weight: 17 kN/m³ Cohesion: 2 kPa Name: Unit 42a - Alluvium Model: Mohr-Coulomb Phi: 25 ° Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 °

Name: Interface 3 - Eastern Gully Base Liner System (Steep) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Interface 4 - Eastern Gully Base Liner System (Shallow) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 18 ° Name: Interface 1 - Proposed Piggy Back Liner System (Peak) (19 deg) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Name: Interface 2 - Proposed Cell Liner System (Peak) (19 deg) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 19 °



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Name: Unit 41b - Old Landfill Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Model: Mohr-Coulomb Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Name: Interface 3 - Eastern Gully Base Liner System (Steep) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Interface 4 - Eastern Gully Base Liner System (Shallow) Model: Mohr-Coulomb Name: Interface 1 - Proposed Piggy Back Liner System (Peak) (19 deg) Model: Mohr-Coulomb Name: Unit 42a-3u-Alluvium (UD)- undisturbed Model: Undrained (Phi=0) Unit Weight: 17 kN/m³ Cohesion: 40 kPa Name: Unit 42a-3-Alluvium (UD)- undisturbed Name: Unit 42a-2u-Alluvium (UD)- 50% strength gain Model: Undrained (Phi=0) Unit Weight: 17 kN/m³ Cohesion: 53 kPa Name: Unit 42a-2-Alluvium (UD)- 50% strength gain Model: S=f(depth) Model: Undrained (Phi=0) Unit Weight: 17 kN/m³ Cohesion: 69 kPa



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Whytes Gully SlopeW - Section N-N' Name: CR through Alluvium_UD & EQ (Immediately after Construction)

Name: Unit 41a - New Landfill Model: Bilinear Unit Weight: 11 kN/m³ Cohesion: 24 kPa Phi 1: 0.1 ° Phi 2: 33 ° Bilinear Normal: 37 kPa Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Name: Interface 3 - Eastern Gully Base Liner System (Steep) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Interface 4 - Eastern Gully Base Liner System (Shallow) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 18 ° Name: Interface 1 - Proposed Piggy Back Liner System (Peak) (19 deg) Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 19 ° Model: Mohr-Coulomb Name: Interface 2 - Proposed Cell Liner System (Peak) (19 deg) Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 19 ° Model: Mohr-Coulomb Name: Unit 42a-3u-Alluvium (UD)- undisturbed Model: Undrained (Phi=0) Unit Weight: 17 kN/m³ Cohesion: 40 kPa Name: Unit 42a-3-Alluvium (UD)- undisturbed Model: S=f(depth) Unit Weight: 17 kN/m³ C-Top of Layer: 40 kPa C-Rate of Change: 18 kPa/m Limiting C: 100 kPa Name: Unit 42a-2u-Alluvium (UD)- 50% strength gain Model: Undrained (Phi=0) Unit Weight: 17 kN/m³ Cohesion: 53 kPa Name: Unit 42a-2-Alluvium (UD)- 50% strength gain Model: S=f(depth) Unit Weight: 17 kN/m³ C-Top of Layer: 53 kPa C-Rate of Change: 18 kPa/m Limiting C: 100 kPa Name: Unit 42a-1u-Alluvium (UD)- 75% strength gain Model: Undrained (Phi=0) Unit Weight: 17 kN/m³ Cohesion: 69 kPa



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Whytes Gully SlopeW - Section N-N' Name: NC along Proposed Liner (P) Bilinear Normal: 37 kPa Name: Unit 41a - New Landfill Model: Bilinear Unit Weight: 11 kN/m³ Cohesion: 24 kPa Phi 1: 0.1 ° Phi 2: 33 ° Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Unit 42a - Alluvium Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 ° Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Name: Interface 3 - Eastern Gully Base Liner System (Steep) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Interface 4 - Eastern Gully Base Liner System (Shallow) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 18 ° Name: Interface 1 - Proposed Piggy Back Liner System (Peak) (19 deg) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 19 ° Name: Interface 2 - Proposed Cell Liner System (Peak) (19 deg) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 19 ° 150 FOS: 1.77 1.77 Horz Seismic Load: 0 Elevation (mAHD) Unit 41a - New Landfill Unit 42a - Alluvium (Upper Zone 1) 100 Interface 2 - Proposed Cell Liner Unit 42a - Alluvium (Upper Zone 2) 50 Unit 42a - Alluvium (Upper Zone 3) 0 Unit 42a - Alluvium (Lower Zone 3) Interface 4 - Existing Eastern Gully Base Liner (Shallow) Unit 45 - Fresh Sandstone Unit 42a - Alluvium (Lower Zone 2) -50

Section N.gsz

0

50

100

150

200

250

300

350

400

Distance (m)

500

550

450

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	SCALE:	As sl	nown		PROJEC

600

650

700



Whytes Gully SlopeW - Section N-N' Name: NC along Proposed Liner_EQ (P)

Bilinear Normal: 37 kPa Name: Unit 41a - New Landfill Model: Bilinear Unit Weight: 11 kN/m³ Cohesion: 24 kPa Phi 1: 0.1 ° Phi 2: 33 ° Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Unit 42a - Alluvium Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 ° Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Name: Interface 3 - Eastern Gully Base Liner System (Steep) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 °

Name: Interface 4 - Eastern Gully Base Liner System (Steep) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 18 ° Name: Interface 1 - Proposed Piggy Back Liner System (Peak) (19 deg) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 19 ° Name: Interface 2 - Proposed Cell Liner System (Peak) (19 deg) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 19 °



	CLIENT	Wollo	ngong Ci	ty Council	PROJEC	
Golder	DRAWN	PR	DATE:	28/02/13	TITLE:	
Associates	CHECKED	SZ	DATE:	18/03/13	No	
	SCALE:	As shown				

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<u>_</u>	CLIENT	Wollo	ngong Ci	ty Council	PROJEC
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Associates	CHECKED	SZ	DATE:	18/03/13	Nor
	SCALE:	As sl	hown		PROJEC

Whytes Gully SlopeW - Section N-N' Name: NC along Proposed Liner_EQ (R)

Name: Unit 41a - New Landfill Model: Bilinear Unit Weight: 11 kN/m³ Cohesion: 24 kPa Phi 1: 0.1 ° Phi 2: 33 ° Bilinear Normal: 37 kPa Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Unit 42a - Alluvium Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 ° Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Name: Interface 3 - Eastern Gully Base Liner System (Steep) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 °

Name: Interface 4 - Eastern Gully Base Liner System (Shallow) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 18 ° Name: Interface 2 - Proposed Cell Liner System (Residual 11 deg) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 11 ° Name: Interface 2 - Proposed Cell Liner System (Residual 14 deg) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 14 ° Name: Interface 1 - Proposed Piggy Back Liner System (Residual 14 deg) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 14 °



	CLIENT	Wollo	ngong Ci	ty Council	PROJE
Golder	DRAWN	PR	DATE:	28/02/13	TITLE:
Associates	CHECKED	SZ	DATE:	18/03/13	Non
	SCALE:	As sl	hown		PROJE

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Whytes Gully SlopeW - Section P-P'

Name: CR through Alluvium_UD (Immediately after Construction)

Name: Unit 41a - New Landfill Model: Bilinear Unit Weight: 11 kN/m³ Cohesion: 24 kPa Phi 1: 0.1 ° Phi 2: 33 ° Bilinear Normal: 37 Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Name: Interface 1 - Proposed Piggy Back Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 Name: Interface 1 - Proposed Piggy Back Liner System (Peak) (19 deg) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 Name: Unit 42a-3u-Alluvium (UD)- undisturbed Model: Undrained (Phi=0) Unit Weight: 17 kN/m³ Cohesion: 40 kPa Name: Unit 42a-3-Alluvium (UD)- undisturbed Model: S=f(depth) Unit Weight: 17 kN/m³ Cohesion: 58 kPa Name: Unit 42a-2u-Alluvium (UD)- 50% strength gain Model: Undrained (Phi=0) Unit Weight: 17 kN/m³ Cohesion: 58 kPa Name: Unit 42a-1u-Alluvium (UD)- 75% strength gain Model: Undrained (Phi=0) Unit Weight: 17 kN/m³ Cohesion: 84 kPa Name: Unit 42a-1-Alluvium (UD)- 75% strength gain Model: S=f(depth) Unit Weight: 17 kN/m³ C-Top of Layer: 84 kPa C-Rate of Change



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	<u> </u>	CLIENT	Wollon	gong C	ity Council	PROJECT	Whytes Gul Stability Ass	lly New La essment f	ndfill Cell or Detaile	- Slope d Design
	Golder	DRAWN	PR	DATE:	28/02/13	TITLE:		Section	P-P'	
	Associates	CHECKED	SZ	DATE:	18/03/13		Circular through	n Alluvium ·	- Short-ter	m
		SCALE:	As sh	own		PROJECT No.	117625003	FIGURE No.	B37	A3

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7 kPa	
7° Phi: 19°	
kPa/m Limit	ing C: 100 kPa
ige: 18 kPa/m	Limiting C: 100 kPa
ige: 18 kPa/m	Limiting C: 100 kPa

Whytes Gully SlopeW - Section P-P'

Name: CR through Alluvium_UD & EQ (Immediately after Construction)

Name: Unit 41a - New Landfill Model: Bilinear Unit Weight: 11 kN/m³ Cohesion: 24 kPa Phi 1: 0.1 ° Phi 2: 33 ° Bilinear Normal: 37 kPa Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Name: Interface 1 - Proposed Piggy Back Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Name: Interface 1 - Proposed Piggy Back Liner System (Peak) (19 deg) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 19 ° Name: Unit 42a-3u-Alluvium (UD)- undisturbed Model: Undrained (Phi=0) Unit Weight: 17 kN/m³ Cohesion: 40 kPa Name: Unit 42a-3-Alluvium (UD)- undisturbed Model: S=f(depth) Unit Weight: 17 kN/m³ C-Top of Layer: 40 kPa C-Rate of Change: 18 kPa/m Limiting C: 100 kPa Name: Unit 42a-2u-Alluvium (UD)- 50% strength gain Model: Undrained (Phi=0) Unit Weight: 17 kN/m³ Cohesion: 58 kPa Name: Unit 42a-2-Alluvium (UD)- 50% strength gain Model: S=f(depth) Unit Weight: 17 kN/m³ C-Top of Layer: 58 kPa C-Rate of Change: 18 kPa/m Limiting C: 100 kPa Name: Unit 42a-1u-Alluvium (UD)- 75% strength gain Model: Undrained (Phi=0) Unit Weight: 17 kN/m³ Cohesion: 84 kPa Name: Unit 42a-1-Alluvium (UD)- 75% strength gain Model: S=f(depth) Unit Weight: 17 kN/m³ C-Top of Layer: 84 kPa C-Rate of Change: 18 kPa/m Limiting C: 100 kPa



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		CLIENT	Wollon	gong C	ity Council	PROJECT	Whytes Gul Stability Ass	lly New La	ndfill Cell or Detaile	- Slope d Design
	Golder	DRAWN	PR	DATE:	28/02/13	TITLE:		Section	P-P'	
	Associates	CHECKED	SZ	DATE:	18/03/13		Circular through	Alluvium -	Earthqua	ke
		SCALE:	As sh	own		PROJECT No.	117625003	FIGURE No.	B38	A3

Whytes Gully SlopeW - Section P-P' Name: NC along Proposed Liner (P)

Name: Unit 41a - New Landfill Model: Bilinear Unit Weight: 11 kN/m³ Cohesion: 24 kPa Phi 1: 0.1 ° Phi 2: 33 ° Name: Unit 42a - Alluvium Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 ° Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable)



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	SCALE:	As sł	nown		PROJE



Whytes Gully SlopeW - Section P-P' Name: NC along Proposed Liner (R)

Name: Unit 41a - New Landfill Model: Bilinear Unit Weight: 11 kN/m³ Cohesion: 24 kPa Phi 1: 0.1 ° Name: Unit 42a - Alluvium Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 ° Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Name: Interface 2 - Proposed Cell Liner System (Residual - Slopes) Model: Mohr-Coulomb Name: Interface 1 - Proposed Piggy Back Liner System (Residual - Slopes) Model: Mohr-Coulomb Name: Interface 2 - Proposed Cell Liner System (Residual 11 deg) Model: Mohr-Coulomb Model: Mohr-Coulomb





Whytes Gully SlopeW - Section P-P' Name: NC along Proposed Liner EQ (R)

Unit Weight: 11 kN/m³ Phi 2: 33 ° Name: Unit 41a - New Landfill Model: Bilinear Cohesion: 24 kPa Phi 1: 0.1 ° Name: Unit 42a - Alluvium Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 ° Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable)

Model: Mohr-Coulomb Model: Mohr-Coulomb Name: Interface 1 - Proposed Piggy Back Liner System (Residual 14 deg) Model: Mohr-Coulomb



ps://aupws.golder.com/117625003wollongongCi	tvCouncilnewCellwhytesGully/Project Doc/320 90per	cent design/3206 Stability/Report/Appendix B - Inte	terim Slope Stability Results/[Appendix B -	Slope W Summary Figures.xlsx1B1



Piggy Back Liner Construction Stability Analysis Results



Case A (tapered protection material along steeper slope near benches) Geometry & Force Diagram



Case A (tapered protection material along steeper slope near benches) Static Case (Gravity Loading) - Peak Interface Shear Strength

Key: Yellow = Input Blue = Output

Image: A constraint of a cons
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $
$ \begin{array}{ c c c c c c } & \beta & Subgrade slope angle on upper wedge & tan^{1}(V:H) & 26.6 & \circ & 2H:1V subgrade slope \\ \hline & X_{U} & Horizontal length of upper wedge & - & 10.0 & m & Maximum length of 2H:1V s \\ \hline & X_{U} & Horizontal length of subgrade slope in upper & X_{U} / cos\beta & 11.2 & m & 10.0 \\ \hline & a_{U} & Length of cover soil slope in upper & X_{U} / cos\beta & 10.8 & m & 10.0 \\ \hline & & X_{L} & Horizontal length of lower wedge & x_{U} / (tan - tan q) / (tan - tan q)] & 15.0 & m & Function of a, θ, β and x_{U} & 10.0 \\ \hline & & X_{L} & Horizontal length of lower wedge & x_{L} / cos q & 15.8 & m & 10.0 \\ \hline & & A_{L} & Length of subgrade slope in lower & x_{L} / cos q & 16.1 & m & 10.0 \\ \hline & & Maximum height of cover soil slope in lower & x_{L} / cos q & 16.1 & m & 10.0 \\ \hline & & Maximum height of cover soil at at base & x_{U} (tan - tan q) & 1.0 & m & 10.0 \\ \hline & & Maximum height of protection material & - & 18 & kN/m^3 & Typical value \\ \hline & & \Phi & Friction angle of protection material & - & 35 & \circ & Typical value for drainage m \\ \hline & Material Properties & \delta & Critical interface friction angle & Min (interface and material shear strength) & 30 & \circ & Peak shear strength \\ \hline \end{array}$
$ \begin{array}{ c c c c c c c } \hline K_{U} & Horizontal length of upper wedge & - & 10.0 & m & Maximum length of 2H:1V since subgrade \\ \hline K_{U} & Length of subgrade slope in upper & K_{U} / cos \beta & 11.2 & m & 10.8 & m & 10$
$ \begin{array}{ c c c c c c c c } \hline & a_{u} & Length of subgrade slope in upper & x_{u} / cos\beta & 11.2 & m \\ \hline & a_{u} & Length of cover soil slope in upper & x_{u} / cos\beta & 10.8 & m \\ \hline & b_{u} & Length of cover soil slope in upper & x_{u} / cos\alpha & 10.8 & m \\ \hline & x_{L} & Horizontal length of lower wedge & x_{u} ((tan\beta - tanq) / (tanq - tanθ)) & 15.0 & m & Function of α, θ, β and x_{u} \\ \hline & a_{L} & Length of subgrade slope in lower & x_{L} / cos\theta & 15.8 & m \\ \hline & b_{L} & Length of cover soil slope in lower & x_{L} / cos\theta & 16.1 & m \\ \hline & h & Maximum height of cover soil at at base & x_{u} (tan\beta - tanq) & 1.0 & m \\ \hline & h & Maximum height of protection material & - & 18 & kN/m^3 & Typical value \\ \hline & \phi & Friction angle of protection material & - & 35 & ° & Typical value for drainage m \\ \hline & Material Properties & \delta & Critical interface friction angle & Min (interface and material shear strength) & 30 & ° & Peak shear strength \\ \hline \end{array}$
$ \begin{array}{ c c c c c c } \hline \begin{tabular}{ c c c c } \hline \begin{tabular}{ c c c c c c } \hline \begin{tabular}{ c c c c c c } \hline \begin{tabular}{ c c c c c c } \hline \begin{tabular}{ c c c c c c } \hline \begin{tabular}{ c c c c c c c } \hline \begin{tabular}{ c c c c c c c } \hline \begin{tabular}{ c c c c c c c } \hline \begin{tabular}{ c c c c c c c } \hline \begin{tabular}{ c c c c c c c } \hline \begin{tabular}{ c c c c c c c c c c c c c c c c c c c$
$ \begin{array}{ c c c c c c c c } \hline & & & & & & & & & & & & & & & & & & $
$ \begin{array}{ c c c c c c } \hline & a_L & Length of subgrade slope in lower & x_L/\cos\theta & 15.8 & m \\ \hline & wedge & x_L/\cos\theta & 16.1 & m \\ \hline & b_L & Length of cover soil slope in lower & x_L/\cos\alpha & 16.1 & m \\ \hline & h & Maximum height of cover soil at at base & x_U (tan\beta - tana) & 1.0 & m \\ \hline & & f' upper wedge & x_U (tan\beta - tana) & 1.0 & m \\ \hline & & & & & & & & & & \\ \hline & & & & & &$
$\frac{b_{L}}{b_{L}} = \frac{b_{L}}{wedge} = \frac{b_{L}}{wedge} = \frac{b_{L}}{wedge} = \frac{b_{L}}{wedge} = \frac{b_{L}}{wedge} = \frac{b_{L}}{wedge} = \frac{b_{L}}{cos\alpha} = \frac{b_{L}}{cos\alpha}$
h Maximum height of cover soil at at base of upper wedge x _U (tanβ - tanα) 1.0 m γ Unit weight of protection material - 18 kN/m³ Typical value Φ Friction angle of protection material Properties - 35 ° Typical value for drainage material shear strength)
γ Unit weight of protection material - 18 kN/m³ Typical value Φ Friction angle of protection material - 35 ° Typical value for drainage material Material Properties δ Critical interface friction angle Min (interface and material shear strength) 30 ° Peak shear strength
Φ Friction angle of protection material - 35 ° Typical value for drainage material Material Properties δ Critical interface friction angle Min (interface and material shear strength) 30 ° Peak shear strength
Material Properties δ Critical interface friction angle Min (interface and material shear strength) 30 ° Peak shear strength
c _a Adhesion along active failure plane - 0 kPa Conservatively assumed ner
c Cohesion of cover soil - 0 kPa Conservatively assumed ner
W_A Total weight of active wedge $[\gamma a_U b_U \sin(\beta - \alpha)]/2$ 90.7 kN/m
Active Forces N _A Effective force normal to failure plane of
E _A Interwedge force acting on active wedge kN/m Function of E _A and FS
W_P Total weight of passive wedge $[\gamma a_L b_L \sin(\alpha - \theta)]/2$ 135.8 kN/m
Passive Forces N _P Effective force normal to failure plane of
E _P Interwedge force acting on passive wedge kN/m Function of E _P and FS
Setting $E_{A} = E_{P}$ and rearranging into the form $a(FS)^{2} + b(FS) + c = 0$, the quadratic can be solved for FS as follows:
a ₁ - W _A sinβ (cosΦ cosθ + sinΦ 38.9 kN/m
a ₂ - Ψ _P sinθ (cosΦ cosβ + sinΦ 42.4 kN/m
a - a ₁ + a ₂ 81.3 kN/m
b ₁ - ^W _A tanδ sinβ (cosΦ sinθ - sinΦ -6.7 kN/m
b_2 - $W_A tanδ cosβ (cosΦ cosθ + 44.9 kN/m)$ sinΦ sinθ)
Solving for b_3 - $W_P \tan \delta \sin \theta (\cos \Phi \sin \beta - \sin \Phi -3.6 kN/m)$
FS b_4 - $W_{\rho} \tan \delta \cos \theta (\cos \Phi \cos \beta + 73.6 kN/m)$
b - b ₁ - b ₂ + b ₃ - b ₄ -128.8 kN/m
c ₁ - Ψ _A tan ² δ cosβ (cosΦ sinθ7.7 kN/m sinΦ cosθ)
c ₂ - W _P tan ² δ cosθ (cosΦ sinβ6.3 kN/m
c
FS Factor of safety [-b + √(b ² - 4ac)] / 2a 1.466 -

Target FS	1.3
Calculated FS	1.47
Result	ABOVE TARGET

Case A (tapered protection material along steeper slope near benches) Static Case (Gravity Loading) - Residual Interface Shear Strength

Key: Yellow = Input

•	Tellow – Input	
	Blue = Output	

	Symbol	Description	Equation	Value	Units	Comment
	α	Slope angle of cover soil	tan ⁻¹ (V:H)	21.8	٥	2.5H:1V cover soil slope (Note: $\theta < \alpha < \beta$)
	θ	Subgrade slope angle on lower wedge	tan ⁻¹ (V:H)	18.4	۰	3H:1V subgrade slope
	β	Subgrade slope angle on upper wedge	tan ⁻¹ (V:H)	26.6	0	2H:1V subgrade slope
	x _U	Horizontal length of upper wedge	-	10.0	m	Maximum length of 2H:1V section of subgrade
	a∪	Length of subgrade slope in upper wedge	x _U / cosβ	11.2	m	
Geometry	b _U	Length of cover soil slope in upper wedge	x _U / cosα	10.8	m	
	x _L	Horizontal length of lower wedge	x _U {(tanβ - tanα) / (tanα - tanθ)]	15.0	m	Function of α,θ,β and x_U
	aL	Length of subgrade slope in lower wedge	x _L / cosθ	15.8	m	
	bL	Length of cover soil slope in lower wedge	x _L / cosα	16.1	m	
	h	Maximum height of cover soil at at base of upper wedge	x _U (tanβ - tanα)	1.0	m	
	Y	Unit weight of protection material	-	18	kN/m ³	Typical value
	Φ	Friction angle of protection material	-	35	0	Typical value for drainage material
Material Properties	δ	Critical interface friction angle	Min (interface and material shear strength)	25	0	Residual shear strength
	Ca	Adhesion along active failure plane	-	0	kPa	Conservatively assumed negligible
	с	Cohesion of cover soil	-	0	kPa	Conservatively assumed negligible
	W _A	Total weight of active wedge	[γ a _U b _U sin(β - α)] / 2	90.7	kN/m	
Active Forces	N _A	Effective force normal to failure plane of active wedge	-	-	kN/m	Function of E _A and FS
	E _A	Interwedge force acting on active wedge from passive wedge	-	-	kN/m	Function of E _A and FS
	W _P	Total weight of passive wedge	$[\gamma a_L b_L \sin(\alpha - \theta)] / 2$	135.8	kN/m	
Passive Forces	N _P	Effective force normal to failure plane of passive wedge	-	-	kN/m	Function of E_P and FS
	E _P	Interwedge force acting on passive wedge from active wedge	-	-	kN/m	Function of E_P and FS
Setting E _A =	E _P and rearranging into	the form $a(FS)^2 + b(FS) + c = 0$, the quad	ratic can be solved for FS as follo	ws:		
	a ₁	-	$W_A \sin\beta (\cos\Phi \cos\theta + \sin\Phi \sin\theta)$	38.9	kN/m	
	a ₂	-	$W_P \sin\theta (\cos\Phi \cos\beta + \sin\Phi \sin\beta)$	42.4	kN/m	
	а	-	a ₁ + a ₂	81.3	kN/m	
	b ₁	-	W _A tanδ sinβ (cosΦ sinθ - sinΦ cosθ)	-5.4	kN/m	
	b ₂	-	W_A tanδ cosβ (cosΦ cosθ + sinΦ sinθ)	36.2	kN/m	
Solving for	b ₃	-	W _P tanδ sinθ (cosΦ sinβ - sinΦ cosβ)	-2.9	kN/m	
FS	b ₄	-	$W_P \tan \delta \cos \theta (\cos \Phi \cos \beta + \sin \Phi \sin \beta)$	59.5	kN/m	
	b	-	b ₁ - b ₂ + b ₃ - b ₄	-104.0	kN/m	
	C ₁	-	$W_A \tan^2 \delta \cos\beta$ ($\cos \Phi \sin \theta - \sin \Phi \cos \theta$)	-5.0	kN/m	
	C ₂	-	$W_P \tan^2 \delta \cos\theta (\cos \Phi \sin \beta - \sin \Phi \cos \beta)$	-4.1	kN/m	
	с	-	- c ₁ - c ₂	9.1	kN/m	
	FS	Factor of safety	[-b + √(b ² - 4ac)] / 2a	1.184	-	

Calculated FS	1.18
D	

Case B (along shallower subgrade slope between benches) Water Pressure Case (buildup parallel to slope) - Peak Interface Shear Strength (3H:1V subgrade slope)



	Symbol	Description	Equation	Value	Units	Comment
	β	Soil slope angle beneath geomembrane	tan ⁻¹ (V:H)	18.4	٥	3H:1V subgrade slope
	×	Horizontal length of critical slope	-	30.0	m	Longest 3H:1V slope
	У	Vertical height of critical slope	x tanβ	10.0	m	
Geometry	L	Length of critical slope measured along the geomembrane	x / cosβ	31.6	m	
	h	Thickness of cover soil	-	0.3	m	Drainage layer thickness assumed negligible
	h _w	Height of free water surface (perpendicular to slope)	-	0.15	m	
	γ	Unit weight of protection material	-	18	kN/m ³	Typical value
	Ysat	Saturated unit weight of protection material	-	21	kN/m ³	
Material	Yt	Total (moist) unit weight of protection material	-	18	kN/m ³	
Properties	Yw	Unit weight of water	-	9.8	kN/m ³	
	Φ	Friction angle of protection material	-	35	٥	Typical value for drainage material
	δ	Critical interface friction angle	Min (interface and material shear strength)	30	0	
	W _A	Total weight of active wedge	$ \begin{array}{l} \left[\left[\gamma_t (h - h_w) (2y cos\beta - (h + h_w)) \right] / \\ sin2\beta \right\} + \left[\gamma_{sat} (h_w) (2y cos\beta - h_w) \right] / \\ sin2\beta \end{array} $	182.1	kN/m	
	Un	Resultant of the pore pressures acting perpendicular to the slope	$[\gamma_w h_w cos\beta(2ycos\beta) - h_w] \ / \ sin2\beta$	43.8	kN/m	
Active Forces	U _h	Resultant of the pore pressures acting on the interwedge surfaces	$\gamma_w h_w^2/2$	0.1	kN/m	
	N _A	Effective force normal to failure plane of active wedge	$W_A \cos\beta + U_h \sin\beta - U_n$	129.1	kN/m	
	E _A	Interwedge force acting on active wedge from passive wedge	W _A sinβ - U _h cosβ - [(N _A tanδ) / FS]	-	kN/m	Function of FS
	W _P	Total weight of passive wedge	$[\gamma_t \ (h^2 - {h_w}^2) + \gamma_{sat} \ ({h_w}^2)] \ / \ sin 2\beta$	2.8	kN/m	
Passive Forces	U,	Resultant of the vertical pore pressures acting on the passive wedge	U _h / tanβ	0.3	kN/m	
	E _P	Interwedge force acting on passive wedge from active wedge	[U _h (FS) - (W _P - U _ν) tanΦ] / [sinβ tanΦ - cosβ (FS)]	-	kN/m	Function of FS
Setting $E_A =$	E_P and rearranging into	the form $a(FS)^2 + b(FS) + c = 0$, the quarter of the second se	dratic can be solved for FS as follow	vs:		
	а	-	$W_A \sin\beta\cos\beta - U_h \cos^2\beta + U_h$	54.6	kN/m	
	b ₁	-	$W_A \sin^2\beta \tan\Phi$	12.7	kN/m	
	b ₂	-	$U_h \sin\beta \cos\beta \tan\Phi$	0.0	kN/m	
	b ₃	-	N _A cosβ tanδ	70.7	kN/m	
FS	b ₄	-	(W _P - U _v) tanΦ	1.7	kN/m	
	b	-	- b ₁ + b ₂ - b ₃ - b ₄	-85.2	kN/m	
	с	-	$N_A sin\beta$ tan δ tan Φ	16.5	kN/m	
	FS	Factor of safety	[-b + √(b ² - 4ac)] / 2a	1.334	-	

Target FS	1.1
Calculated FS	1.33
Result	ABOVE TARGET

Case B (along shallower subgrade slope between benches) Water Pressure Case (buildup parallel to slope) - Peak Interface Shear Strength (3.5H:1V subgrade slope)



	Symbol	Description	Equation	Value	Units	Comment
	β	Soil slope angle beneath geomembrane	tan ⁻¹ (V:H)	15.9	٥	3.5H:1V subgrade slope
	x	Horizontal length of critical slope	-	60.0	m	Longest 3.5H:1V slope
	У	Vertical height of critical slope	x tanβ	17.1	m	
Geometry	L	Length of critical slope measured along the geomembrane	x / cosβ	62.4	m	
	h	Thickness of cover soil	-	0.3	m	Drainage layer thickness assumed negligible
	h _w	Height of free water surface (perpendicular to slope)	-	0.15	m	
	Y	Unit weight of protection material	-	18	kN/m ³	Typical value
	Y _{sat}	Saturated unit weight of protection material	-	21	kN/m ³	
Material	Yt	Total (moist) unit weight of protection material	-	18	kN/m ³	
Properties	Υw	Unit weight of water	-	9.8	kN/m ³	
	Φ	Friction angle of protection material	-	35	٥	Typical value for drainage material
	δ	Critical interface friction angle	Min (interface and material shear strength)	30	۰	
	W _A	Total weight of active wedge	$ \begin{array}{l} \left[\left[\gamma_t (h - h_w) (2y cos\beta - (h + h_w)) \right] / \\ sin2\beta \right\} + \left[\gamma_{sat} (h_w) (2y cos\beta - h_w) \right] / \\ sin2\beta \end{array} $	361.8	kN/m	
	Un	Resultant of the pore pressures acting perpendicular to the slope	$[\gamma_w h_w cos\beta(2ycos\beta) - h_w] \ / \ sin2\beta$	87.8	kN/m	
Active Forces	U _h	Resultant of the pore pressures acting on the interwedge surfaces	$\gamma_w h_w^2/2$	0.1	kN/m	
	N _A	Effective force normal to failure plane of active wedge	$W_A \cos\beta + U_h \sin\beta - U_n$	260.2	kN/m	
	E _A	Interwedge force acting on active wedge from passive wedge	W _A sinβ - U _h cosβ - [(N _A tanδ) / FS]	-	kN/m	Function of FS
	W _P	Total weight of passive wedge	$[\gamma_t \ (h^2 - {h_w}^2) + \gamma_{sat} \ ({h_w}^2)] \ / \ sin 2\beta$	3.2	kN/m	
Passive Forces	U,	Resultant of the vertical pore pressures acting on the passive wedge	U _h / tanβ	0.4	kN/m	
	E _P	Interwedge force acting on passive wedge from active wedge	$\label{eq:constraint} \begin{array}{l} \left[U_{h}\left(FS\right) \text{-}\left(W_{P} \text{-} U_{v}\right) \tan\Phi \right] / \left[sin\beta \right. \\ \left. tan\Phi \text{-}cos\beta \left(FS\right) \right] \end{array}$	-	kN/m	Function of FS
Setting E _A =	E _P and rearranging into	the form $a(FS)^2 + b(FS) + c = 0$, the qua	dratic can be solved for FS as follow	vs:		
	а	-	$W_A \sin\beta\cos\beta - U_h \cos^2\!\beta + U_h$	95.3	kN/m	
	b ₁	-	$W_A sin^2\beta tan\Phi$	19.0	kN/m	
	b ₂	-	U _h sinβ cosβ tanΦ	0.0	kN/m	
	b ₃	-	N _A cosβ tanδ	144.5	kN/m	
Solving for FS	b ₄	-	(W _P - U _v) tanΦ	2.0	kN/m	
	b	-	- b ₁ + b ₂ - b ₃ - b ₄	-165.4	kN/m	
	с	-	N _A sinβ tanδ tanΦ	28.8	kN/m	
	FS	Factor of safety	[-b + √(b ² - 4ac)] / 2a	1.539	-	

Target FS	1.1
Calculated FS	1.54
Result	ABOVE TARGET

Case B (along shallower subgrade slope between benches) Water Pressure Case (buildup parallel to slope) - Peak Interface Shear Strength (4H:1V subgrade slope)



	Symbol	Description	Equation	Value	Units	Comment
	β	Soil slope angle beneath geomembrane	tan ⁻¹ (V:H)	14.0	٥	4H:1V subgrade slope
	х	Horizontal length of critical slope	-	80.0	m	Longest 4H:1V slope
	У	Vertical height of critical slope	x tanβ	19.9	m	
Geometry	L	Length of critical slope measured along the geomembrane	x / cosβ	82.4	m	
	h	Thickness of cover soil	-	0.3	m	Drainage layer thickness assumed negligible
	h _w	Height of free water surface (perpendicular to slope)	-	0.15	m	
	γ	Unit weight of protection material	-	18	kN/m ³	Typical value
	Ysat	Saturated unit weight of protection material	-	21	kN/m ³	
Material	Yt	Total (moist) unit weight of protection material	-	18	kN/m ³	
Properties	Yw	Unit weight of water	-	9.8	kN/m ³	
	Φ	Friction angle of protection material	-	35	٥	Typical value for drainage material
	δ	Critical interface friction angle	Min (interface and material shear strength)	30	0	
	W _A	Total weight of active wedge	$ \begin{array}{l} \left[\left[\gamma_t \left(h - h_w \right) (2ycos\beta - \left(h + h_w \right) \right) \right] / \\ sin2\beta \} + \left[\gamma_{sat} \left(h_w \right) (2ycos\beta - h_w) \right] / \\ sin2\beta \end{array} $	478.7	kN/m	
	Un	Resultant of the pore pressures acting perpendicular to the slope	$[\gamma_w h_w cos\beta(2ycos\beta) - h_w] / sin2\beta$	117.1	kN/m	
Active Forces	U _h	Resultant of the pore pressures acting on the interwedge surfaces	$\gamma_w h_w^2/2$	0.1	kN/m	
	N _A	Effective force normal to failure plane of active wedge	$W_A \cos\beta + U_h \sin\beta - U_n$	347.4	kN/m	
	E _A	Interwedge force acting on active wedge from passive wedge	W _A sinβ - U _h cosβ - [(N _A tanδ) / FS]	-	kN/m	Function of FS
	W _P	Total weight of passive wedge	$[\gamma_t \ (h^2 - {h_w}^2) + \gamma_{sat} \ ({h_w}^2)] \ / \ sin 2\beta$	3.6	kN/m	
Passive Forces	U _v	Resultant of the vertical pore pressures acting on the passive wedge	U _h / tanβ	0.4	kN/m	
	E _P	Interwedge force acting on passive wedge from active wedge	[U _h (FS) - (W _P - U _v) tanΦ] / [sinβ tanΦ - cosβ (FS)]	-	kN/m	Function of FS
Setting E _A =	E_{P} and rearranging into	the form $a(FS)^2 + b(FS) + c = 0$, the quarter of the term of the second seco	dratic can be solved for FS as follow	vs:		
	а	-	$W_A \sin\beta\cos\beta - U_h \cos^2\beta + U_h$	112.4	kN/m	
	b ₁	-	$W_A \sin^2\beta \tan\Phi$	19.6	kN/m	
	b ₂	-	U _h sinβ cosβ tanΦ	0.0	kN/m	
	b ₃	-	N _A cosβ tanδ	194.6	kN/m	
Solving for FS	b ₄	-	(W _P - U _v) tanΦ	2.2	kN/m	
	b	-	- b ₁ + b ₂ - b ₃ - b ₄	-216.4	kN/m	
	С	-	N _A sinβ tanδ tanΦ	34.0	kN/m	
	FS	Factor of safety	[-b + √(b ² - 4ac)] / 2a	1.753	-	

Target FS	1.1
Calculated FS	1.75
Result	ABOVE TARGET

Case B (along shallower subgrade slope between benches) Water Pressure Case (buildup parallel to slope) - Residual Interface Shear Strength (3H:1V subgrade slope)

Key: Yellow = Input Blue = Output

β <b< th=""><th></th><th>Symbol</th><th>Description</th><th>Equation</th><th>Value</th><th>Units</th><th>Comment</th></b<>		Symbol	Description	Equation	Value	Units	Comment
x detected length of critical length x		β	Soil slope angle beneath geomembrane	tan ⁻¹ (V:H)	18.4	٥	3H:1V subgrade slope
general General Comparisony v 		x	Horizontal length of critical slope	-	30.0	m	Longest 3H:1V slope
Geompting L Length of critical aloge measured along properties Main Thickness of cover soil 0.03 0.01 m Drainage layer thickness assumed negligibit Main Height of protestion 10.01 0.01 m Drainage layer thickness assumed negligibit Main Height of protection 10.01 0.01 Min Trainage layer thickness assumed negligibit Main Saturated unit weight of protection 10.01 Min Min Trainage layer thickness assumed negligibit Via Saturated unit weight of protection 10.01 Min Min Trainage layer thickness assumed negligibit Via Total (meight of protection material 10.01 Min Min Trainage layer thickness assumed negligibit Via Total (meight of protection material Min (interface and material and materia		У	Vertical height of critical slope	x tanβ	10.0	m	
Image: head of the sector solution of the sector sol	Geometry	L	Length of critical slope measured along the geomembrane	x / cosβ	31.6	m	
Image: biologyImage:		h	Thickness of cover soil	-	0.3	m	Drainage layer thickness assumed negligible
Image: space s		h _w	Height of free water surface (perpendicular to slope)	-	0.15	m	
Number PropertiesSaturate unit weight of protection material		Y	Unit weight of protection material	-	18	kN/m ³	Typical value
Material PropertiesTotal (moist) unit weight of protection material.18 kNm^3 Water9.8.0 kNm^3 Q_{μ} Unit weight of vater9.8.0 kNm^3 Q_{μ} Friction angle of protection material9.8.0 kNm^3 Q_{μ} Critical interface friction angle $Min (interface and material shearstrength)2.5.5\circV_{\mu}Critical interface friction angleMin (interface and material shearstrength)2.5.5\circV_{\mu}Critical interface friction angleMin (interface and material shearstrength)1882.1kNmV_{\mu}Resultant of the pore pressures actionproperdicular to the slopeon the intervedge surfacesof active wedgeV_{\mu}^2/20.0.1kNmV_{\mu}Resultant of the pore pressures actionon the intervedge surfacesof active wedgeV_{\mu}^2/20.1kNmV_{\mu}Resultant of the pore pressures actionon the intervedge surfacesof active wedgeV_{\mu}^2/20.1kNmV_{\mu}Resultant of the pore pressures actionof active wedgeV_{\mu}^2/20.1kNmV_{\mu}Interwedge fore acting on activewedge from passive wedgeV_{\mu}^2/20.1kNmV_{\mu}Resultant of the vertical pore pressurewedge from active wedgeV_{\mu}(r^2 \cdot h_{\mu}^2) + V_{uet}(h_{\mu}^2)/20.3kNmV_{\mu}Resultant of the vertical pore pressurewedge from active wedgeV_{\mu}(r^2 \cdot h_{\mu}^2) + V_{uet}(h_{\mu}^2)/20.3kNm$		Y _{sat}	Saturated unit weight of protection material	-	21	kN/m ³	
	Motorial	Yt	Total (moist) unit weight of protection material	-	18	kN/m ³	
	Properties	Yw	Unit weight of water	-	9.8	kN/m ³	
$ \frac{\delta}{\delta} Critical interface friction angle Min (interface and material shear strength) = 25 o e e e e e e e e e e e e e e e e e e $		Φ	Friction angle of protection material	-	35	٥	Typical value for drainage material
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$		δ	Critical interface friction angle	Min (interface and material shear strength)	25	٥	
Active Forces U_n Resultant of the pore pressures acting on the intervedge surfaces $(V_{\mu}h_{\nu}cos\beta(2ycos\beta) \cdot h_{\nu}l / sin2\beta)$ 43.8kN/m U_n Resultant of the pore pressures acting on the intervedge surfaces $V_{\mu}h_{\nu}^2/2$ 0.1kN/m N_A Effective force normal to failure plane of active wedge $W_A \cos\beta + U_h \sin\beta - U_n$ 129.1kN/m E_A Interwedge force acting on active wedge form passive wedge $W_A \sin\beta - U_h \cos\beta - ([N_A \tan\beta) / FS]$ kN/m Function of FS $Passive$ W_P Total weight of passive wedge $W_A \sin\beta - V_{hu}^2 > Y_{hut} (h_{u}^2) / sin2\beta$ 2.8kN/m $Passive$ U_v Resultant of the verical pore pressures acting on the passive wedge $U_h / \tan\beta$ 0.3 kN/m $Passive$ U_v Resultant of the verical pore pressures 		W _A	Total weight of active wedge	$ \begin{array}{l} \left[\left[\gamma_t \left(h - h_w \right) (2y cos\beta - \left(h + h_w \right) \right) \right] / \\ sin2\beta \} + \left[\gamma_{sat} \left(h_w \right) (2y cos\beta - h_w) \right] / \\ sin2\beta \end{array} $	182.1	kN/m	
		Un	Resultant of the pore pressures acting perpendicular to the slope	$[\gamma_w h_w cos \beta(2y cos \beta) - h_w] / sin 2\beta$	43.8	kN/m	
$\begin{tabular}{ c c c c } \hline N_A & $$$$ Effective force normal to failure plane V_A cos$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$	Active Forces	U _h	Resultant of the pore pressures acting on the interwedge surfaces	$\gamma_w h_w^2/2$	0.1	kN/m	
$\begin{tabular}{ c c c c c } \hline E_A & Interwedge force acting on active wedge & W_A sin \beta - U_h cos \beta - [(N_A tan \delta) / FS] & . & kN/m & Function of FS \\ \hline Passive Forces & W_P & Total weight of passive wedge & [y_t (h^2 - h_w^2) + y_{satt} (h_w^2)] / sin 2\beta & 2.8 & kN/m \\ \hline U_v & Resultant of the vertical pore pressures & U_h / tan \beta & 0.3 & kN/m \\ \hline U_v & Resultant of the varical pore pressures & U_h / tan \beta & 0.3 & kN/m \\ \hline E_P & Interwedge force acting on passive & [U_b (FS) - (W_P - U_b) tan 0] / [sin \beta & - & kN/m & Function of FS \\ \hline Setting E_A = E_P and rearranging into the form a(FS)^2 + b(FS) + c = 0, the quattic can be solved for FS as follows: \\ \hline \\ \hline Solving for FS & b_1 & - & W_A sin \beta cos \beta - U_h cos^2 \beta + U_h & 54.6 & kN/m \\ \hline b_1 & - & W_A sin^2 \beta tan \Phi & 12.7 & kN/m \\ \hline \\ b_2 & - & U_h sin \beta cos \beta tan \Phi & 0.0 & kN/m \\ \hline \\ \hline \\ b_3 & - & N_A cos \beta tan \delta & 57.1 & kN/m \\ \hline \\ \hline \\ b_4 & - & (W_P - U_b) tan \Phi & 1.7 & kN/m \\ \hline \\ \hline \\ b_6 & - & - & b_1 + b_2 \cdot b_3 \cdot b_4 & -71.6 & kN/m \\ \hline \\ \hline \\ \hline \\ FS & Factor of safety & [-b + \sqrt{(b^2 - 4ac)]/2a} & 1.097 & - \\ \hline \end{array}$		N _A	Effective force normal to failure plane of active wedge	$W_A \cos\beta + U_h \sin\beta - U_n$	129.1	kN/m	
$ \begin{array}{ c c c c c } \hline W_P & Total weight of passive wedge & [V_1 (h^2 - h_w^2) + V_{satl} (h_w^2)] / sin2\beta & 2.8 & kN/m \\ \hline W_P & Resultant of the vertical pore pressures acting on the passive wedge & U_h / tan\beta & 0.3 & kN/m \\ \hline U_v & Resultant of the vertical pore pressures & U_h / tan\beta & 0.3 & kN/m \\ \hline E_P & Interwedge force acting on passive & [U_h (FS) - (W_P - U_v) tan0] / [sin\beta tan0 - cos\beta (FS)] & - & kN/m & Function of FS \\ \hline Setting E_A = E_P and rearranging into the form a(FS)^2 + b(FS) + c = 0, the quattriatic can be solved for FS as follows: \\ \hline Setting E_A = E_P and rearranging into the form a(FS)^2 + b(FS) + c = 0, the quattriatic can be solved for FS as follows: \\ \hline Setting E_A = E_P and rearranging into the form a(FS)^2 + b(FS) + c = 0, the quattriatic can be solved for FS as follows: \\ \hline Setting E_A = E_P and rearranging into the form a(FS)^2 + b(FS) + c = 0, the quattriatic can be solved for FS as follows: \\ \hline Setting E_A = E_P and rearranging into the form a(FS)^2 + b(FS) + c = 0, the quattriatic can be solved for FS as follows: \\ \hline Setting E_A = E_P and rearranging into the form a(FS)^2 + b(FS) + c = 0, the quattriatic can be solved for FS as follows: \\ \hline Setting E_A = E_P and rearranging into the form a(FS)^2 + b(FS) + c = 0, the quattriatic can be solved for FS as follows: \\ \hline Setting E_A = E_P and rearranging into the form a(FS)^2 + b(FS) + c = 0, the quattriatic can be solved for FS as follows: \\ \hline Setting E_A = E_P and rearranging into the form a(FS)^2 + b(FS) + c = 0, the quattriatic can be solved for FS as follows: \\ \hline Setting E_A = E_P and rearranging into the form a(FS)^2 + b(FS) + c = 0, the quattriatic can be solved for FS as follows: \\ \hline Setting E_A = E_P and rearranging into the form a(FS)^2 + b(FS) + c = 0, the gas follows: \\ \hline Setting E_A = E_P and F and F$		E _A	Interwedge force acting on active wedge from passive wedge	W _A sinβ - U _h cosβ - [(N _A tanδ) / FS]	-	kN/m	Function of FS
$ \begin{array}{ c c c c c } \hline Passive \\ Forces \hline U_{\nu} & Resultant of the vertical pore pressures \\ acting on the passive wedge & U_h / tan\beta & 0.3 & kN/m \\ \hline E_p & Interwedge force acting on passive \\ wedge from active wedge & [U_h (FS) - (W_p - U_v) tan0] / [sin\beta \\ tan 0 - cos\beta (FS)] & - & kN/m \\ \hline Function of FS \\ \hline Setting E_A = E_p and rearranging into the form a(FS)2 + b(FS) + c = 0, the quadratic can be solved for FS as follows: \\ \hline \\ Setting E_A = E_p and rearranging into the form a(FS)2 + b(FS) + c = 0, the quadratic can be solved for FS as follows: \\ \hline \\ \hline \\ Setting E_A = E_p and rearranging into the form a(FS)2 + 0 (FS) + c = 0, the quadratic can be solved for FS as follows: \\ \hline \\ \hline \\ Setting E_A = E_p and rearranging into the form a(FS)2 + 0 (FS) + c = 0, the quadratic can be solved for FS as follows: \\ \hline \\ \hline \\ Setting E_A = E_p and rearranging into the form a(FS)2 + 0 (FS) + c = 0, the quadratic can be solved for FS as follows: \\ \hline \\ \hline \\ \\ \hline \\ Solving for FS & \hline \\ \hline \\ \hline \\ \hline \\ \hline \\ \\ \hline \\ \\ \hline \\ \\ \hline \\ \hline \\ \hline \\ \hline \\ \hline \\ \\ \hline \hline \\ \hline \\ \hline \\ \hline \hline \\ \hline \hline \\ \hline \hline \\ \hline \\ \hline \\ \hline \\ \hline \\ \hline \\ \hline \hline \\ \hline \\ \hline \\ \hline \\ \hline \hline \\ \hline \\ \hline \\ \hline \\ \hline \\ \hline \hline \\ \hline \\ \hline \\ \hline \hline \hline \hline \\ \hline \hline \hline \hline \\ \hline \hline$		W _P	Total weight of passive wedge	$[\gamma_t \ (h^2 - {h_w}^2) + \gamma_{sat} \ ({h_w}^2)] \ / \ sin 2\beta$	2.8	kN/m	
$\begin{tabular}{ c c c c } \hline E_p & $\frac{1}{wedge from active wedge}$ & $\frac{U_h(FS) - (W_p - U_v) \tan \Phi}{\tan \Phi - \cos\beta (FS)]}$ & I & $kN'm$ & $\frac{Function of FS}{Function of FS}$ \\ \hline $Setting E_A = E_p and rearranging into the form $a(FS)^2 + b(FS) + $c = 0$, the quadratic can be solved for FS as follow: $$$ $$ $$ $$ $$ $$ $$ $$ $$ $$ $$ $$ $$	Passive Forces	Uv	Resultant of the vertical pore pressures acting on the passive wedge	U _h / tanβ	0.3	kN/m	
		E _P	Interwedge force acting on passive wedge from active wedge	[U _h (FS) - (W _P - U _v) tanΦ] / [sinβ tanΦ - cosβ (FS)]	-	kN/m	Function of FS
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	Setting E _A =	E _P and rearranging into	the form $a(FS)^2 + b(FS) + c = 0$, the quarter of the term of the second seco	dratic can be solved for FS as follow	vs:		
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$		а	-	$W_A \sin\beta\cos\beta - U_h \cos^2\beta + U_h$	54.6	kN/m	
$ \begin{array}{ c c c c c c } \hline b_2 & - & U_h \sin\beta\cos\beta \tan\Phi & 0.0 & kN/m \\ \hline b_3 & - & N_A \cos\beta \tan\delta & 57.1 & kN/m \\ \hline b_4 & - & (W_P - U_v) \tan\Phi & 1.7 & kN/m \\ \hline b_4 & - & -b_1 + b_2 - b_3 - b_4 & -71.6 & kN/m \\ \hline c & - & N_A \sin\beta\tan\delta \tan\Phi & 13.3 & kN/m \\ \hline FS & Factor of safety & [-b + \sqrt{b^2 - 4ac}]/2a & 1.087 & - \\ \hline \end{array} $		b ₁	-	$W_A sin^2\beta tan\Phi$	12.7	kN/m	
$ \begin{array}{ c c c c c c } \hline b_3 & - & & & & & & & & & & & & & & & & & $		b ₂	-	U _h sinβ cosβ tanΦ	0.0	kN/m	
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $		b ₃	-	N _A cosβ tanδ	57.1	kN/m	
b - $-b_1 + b_2 \cdot b_3 \cdot b_4$ -71.6 kN/m c - N _A sing tanō tanΦ 13.3 kN/m FS Factor of safety $[-b + \sqrt{(b^2 - 4ac)}]/2a$ 1.087 -	Solving for FS	b ₄	-	(W _P - U _v) tanΦ	1.7	kN/m	
c - N _A sinβ tanδ tanΦ 13.3 kN/m FS Factor of safety $[-b + \sqrt{b^2 - 4ac}]/2a$ 1.087 -		b	-	- b ₁ + b ₂ - b ₃ - b ₄	-71.6	kN/m	
FS Factor of safety $[-b + \sqrt{(b^2 - 4ac)}] / 2a$ 1.087 -		С	-	N _A sinβ tanδ tanΦ	13.3	kN/m	
		FS	Factor of safety	[-b + √(b ² - 4ac)] / 2a	1.087	-	

Target FS	1.0
Calculated FS	1.09
Result	ABOVE TARGET

Case B (along shallower subgrade slope between benches) Water Pressure Case (buildup parallel to slope) - Residual Interface Shear Strength (3.5H:1V subgrade slope)

Key: Yellow = Input Blue = Output

	Symbol	Description	Equation	Value	Units	Comment
	β	Soil slope angle beneath geomembrane	tan ⁻¹ (V:H)	15.9	٥	3.5H:1V subgrade slope
	×	Horizontal length of critical slope	-	60.0	m	Longest 3.5H:1V slope
	У	Vertical height of critical slope	x tanβ	17.1	m	
Geometry	L	Length of critical slope measured along the geomembrane	x / cosβ	62.4	m	
	h	Thickness of cover soil	-	0.3	m	Drainage layer thickness assumed negligible
	h _w	Height of free water surface (perpendicular to slope)	-	0.15	m	
	Y	Unit weight of protection material	-	18	kN/m ³	Typical value
	Y _{sat}	Saturated unit weight of protection material	-	21	kN/m ³	
Material	Yt	Total (moist) unit weight of protection material	-	18	kN/m ³	
Properties	Yw	Unit weight of water	-	9.8	kN/m ³	
	Φ	Friction angle of protection material	-	35	٥	Typical value for drainage material
	δ	Critical interface friction angle	Min (interface and material shear strength)	25	0	
	W _A	Total weight of active wedge	$ \begin{array}{l} \left\{ \left[\gamma_t (h - h_w) (2y cos\beta - (h + h_w)) \right] / \\ sin2\beta \right\} + \left[\gamma_{sat} (h_w) (2y cos\beta - h_w) \right] / \\ sin2\beta \end{array} $	361.8	kN/m	
	Un	Resultant of the pore pressures acting perpendicular to the slope	$[\gamma_w h_w cos\beta(2ycos\beta) - h_w] / sin2\beta$	87.8	kN/m	
Active Forces	U _h	Resultant of the pore pressures acting on the interwedge surfaces	$\gamma_w h_w^2/2$	0.1	kN/m	
	N _A	Effective force normal to failure plane of active wedge	$W_A \cos\beta + U_h \sin\beta - U_n$	260.2	kN/m	
	E _A	Interwedge force acting on active wedge from passive wedge	W _A sinβ - U _h cosβ - [(N _A tanδ) / FS]	-	kN/m	Function of FS
	W _P	Total weight of passive wedge	$[\gamma_t \ (h^2 - {h_w}^2) + \gamma_{sat} \ ({h_w}^2)] \ / \ sin 2\beta$	3.2	kN/m	
Passive Forces	U _v	Resultant of the vertical pore pressures acting on the passive wedge	U _h / tanβ	0.4	kN/m	
	Ep	Interwedge force acting on passive wedge from active wedge	[U _h (FS) - (W _P - U _v) tanΦ] / [sinβ tanΦ - cosβ (FS)]	-	kN/m	Function of FS
Setting E _A =	E_P and rearranging into	the form $a(FS)^2 + b(FS) + c = 0$, the qua	dratic can be solved for FS as follow	vs:		
	а	-	$W_A \sin\beta\cos\beta - U_h \cos^2\beta + U_h$	95.3	kN/m	
	b ₁	-	$W_A sin^2\beta tan\Phi$	19.0	kN/m	
	b ₂	-	U _h sinβ cosβ tanΦ	0.0	kN/m	
	b ₃	-	N _A cosβ tanδ	116.7	kN/m	
Solving for FS	b ₄	-	(W _P - U _v) tanΦ	2.0	kN/m	
	b	-	- b ₁ + b ₂ - b ₃ - b ₄	-137.6	kN/m	
	с	-	N _A sinβ tanδ tanΦ	23.3	kN/m	
	FS	Factor of safety	$[-b + \sqrt{(b^2 - 4ac)}] / 2a$	1.248	-	

Target FS	1.0
Calculated FS	1.25
Result	ABOVE TARGET

Case B (along shallower subgrade slope between benches) Water Pressure Case (buildup parallel to slope) - Residual Interface Shear Strength (4H:1V subgrade slope)

Key: Yellow = Input Blue = Output

	Symbol	Description	Equation	Value	Units	Comment
	β	Soil slope angle beneath geomembrane	tan ⁻¹ (V:H)	14.0	0	4H:1V subgrade slope
	x	Horizontal length of critical slope	-	80.0	m	Longest 4H:1V slope
	У	Vertical height of critical slope	x tanβ	19.9	m	
Geometry	L	Length of critical slope measured along the geomembrane	x / cosβ	82.4	m	
	h	Thickness of cover soil	-	0.3	m	Drainage layer thickness assumed negligible
	h _w	Height of free water surface (perpendicular to slope)	-	0.15	m	
	γ	Unit weight of protection material	-	18	kN/m ³	Typical value
	Ysat	Saturated unit weight of protection material	-	21	kN/m ³	
Material	Yt	Total (moist) unit weight of protection material	-	18	kN/m ³	
Properties	Yw	Unit weight of water	-	9.8	kN/m ³	
	Φ	Friction angle of protection material	-	35	٥	Typical value for drainage material
	δ	Critical interface friction angle	Min (interface and material shear strength)	25	0	
	W _A	Total weight of active wedge	$ \begin{array}{l} \left[\left[\gamma_t (h - h_w) (2y cos\beta - (h + h_w)) \right] / \\ sin2\beta \right\} + \left[\gamma_{sat} (h_w) (2y cos\beta - h_w) \right] / \\ sin2\beta \end{array} $	478.7	kN/m	
	Un	Resultant of the pore pressures acting perpendicular to the slope	$[\gamma_w h_w cos\beta(2ycos\beta) - h_w] / sin2\beta$	117.1	kN/m	
Active Forces	U _h	Resultant of the pore pressures acting on the interwedge surfaces	$\gamma_w h_w^2/2$	0.1	kN/m	
	N _A	Effective force normal to failure plane of active wedge	$W_A \cos\beta + U_h \sin\beta - U_n$	347.4	kN/m	
	E _A	Interwedge force acting on active wedge from passive wedge	W _A sinβ - U _h cosβ - [(N _A tanδ) / FS]	-	kN/m	Function of FS
	W _P	Total weight of passive wedge	$[\gamma_t \ (h^2 - {h_w}^2) + \gamma_{sat} \ ({h_w}^2)] \ / \ sin 2\beta$	3.6	kN/m	
Passive Forces	U _v	Resultant of the vertical pore pressures acting on the passive wedge	U _h / tanβ	0.4	kN/m	
	E _P	Interwedge force acting on passive wedge from active wedge	[U _h (FS) - (W _P - U _ν) tanΦ] / [sinβ tanΦ - cosβ (FS)]	-	kN/m	Function of FS
Setting E _A =	E_{P} and rearranging into	the form $a(FS)^2 + b(FS) + c = 0$, the qua	dratic can be solved for FS as follow	vs:		
	а	-	$W_A \sin\beta\cos\beta - U_h \cos^2\beta + U_h$	112.4	kN/m	
	b ₁	-	$W_A \sin^2\beta \tan\Phi$	19.6	kN/m	
	b ₂	-	U _h sinβ cosβ tanΦ	0.0	kN/m	
Oshiki (b ₃	-	N _A cosβ tanδ	157.2	kN/m	
Solving for FS	b ₄	-	(W _P - U _v) tanΦ	2.2	kN/m	
	b	-	- b ₁ + b ₂ - b ₃ - b ₄	-179.0	kN/m	
	с	-	N _A sinβ tanδ tanΦ	27.4	kN/m	
	FS	Factor of safety	$[-b + \sqrt{(b^2 - 4ac)}] / 2a$	1.421	-	

Target FS	1.0
Calculated FS	1.42
Result	ABOVE TARGET






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PROJECT No. 117625003_248_M_Rev0

DATE 27 May 2013

- TO Michael Herraman Wollongong City Council
- CC Kelly Dohle

FROM Parnel Richards, Gary Schmertmann

EMAIL GSchmertmann@golder.com.au

WHYTES GULLY NEW LANDFILL CELL - SETTLEMENT LOAD TEST - ANALYSIS REPORT

Introduction

As outlined in Variation Number 11 (ref: 117625003_L_105_Rev0, dated 16 November 2011), this Analysis Report presents the outcome of our assessment on the compressibility characteristics of existing Municipal Soil Waste (MSW) at Whytes Gully Landfill site, owned by Wollongong City Council (Council). This assessment was undertaken through back-analysis calculations using results of the settlement load trial and accompanying settlement monitoring to refine the compressibility characteristics of the existing MSW in the Western and Eastern Gullies. This will enable future quantification of the most likely ongoing landfill settlements and assessment of the impact on the proposed piggy-back liner system.

The following documents are relevant to this report:

- Whytes Gully Resource Recovery Park, Interpretive Geotechnical Investigation Report for 50% Design (Golder ref. 117625003_059_R_Rev1, dated April 2012) provides a full discussion of the geotechnical setting of the site, together with recommended design parameters for settlement assessment.
- Whytes Gully Landfill New Cell Design, Settlement Load Test Completion Report (Golder ref. 117625003_191_R_Rev0, dated August 2012) includes details of the site conditions, construction of the two load test pads (by Council), the installation of 19 settlement survey monuments (by Council), loading magnitude and dimensions of the load test pads, and measured deformations through to June 2012.
- Whytes Gully New Landfill Cell Settlement Back-analysis Results for Western Gully Load Test (Golder ref. 117625003_253_Rev0, dated 27 May 2013) provides a detailed assessment of the settlement back-analysis results for the Western Gully.
- Whytes Gully Resource Recovery Park (WGRRP) New Landfill Cell Settlement Back-analysis Results (Eastern Gully) (Golder ref. 117625003_254_M_Rev0, dated 27 May 2013) provides a detailed assessment of the settlement back-analysis results for the Eastern Gully.

This Analysis Report provides a summary of the above two settlement back-analysis technical memoranda which are provided as attachments.

Methodology

Following the review of existing information, the following methodology was adopted in the assessment of the compressibility characteristics of the existing MSW in the Western and Eastern Gullies. For all cases, the initial compressibility parameters adopted for the settlement models were based on the Interpretive Geotechnical Report for Preliminary Design (Golder, April 2012).



Western Gully

Simplified 3D settlement models were created using 'Settle3D' software to back-analyse the observed response under trial pad loading using settlement information from two trial pads that were constructed on the Western Gully in February and March 2012. The key assumptions relating to the 'Settle3D' model are summarised below:

- The main stages of the assumed landfill settlement model are as follows:
 - 1) Initial compression occurs directly when an external load is applied to a landfill;
 - 2) Primary compression and compaction due to the dissipation of pore water and gas from the void space would be a function of applied stresses, stress history and compressibility of waste material;
 - 3) Secondary compression due to creep of refuse skeleton and biological decay is considered to increase with logarithm of time (assumed to commence after primary consolidation is practically finished - not more than a month based on the Western Gully settlement data) for the 'Settle3D' analyses.
- The applied settlement pad loading was simplified as 52 kPa over a 25 m x 25 m area for the upper pad and 75 kPa applied over a 17 m x 17 m area for the lower pad. This is equivalent to up to 7 m of additional filling (about 15-20 % of that proposed for the full landfill expansion project).
- The settlement pad loading sequence was simplified as follows:
 - 1) February 2012: Trial Commenced
 - 2) February 2012: Settlement Load Trial Loading applied in four equal lifts over a time period of 10 days for the lower pad and 20 days for the upper pad
 - 3) November 2012: Last available monitoring reading
- Stress history was also considered using two alternate methods:
 - 1) Assuming that the landfill material is normally consolidated (modelled by setting the Over Consolidation Ratio (OCR) to unity throughout the waste body).
 - 2) Assuming 25 kPa pre-consolidation pressure (P_c) at the base of the trial pads.

The models were then calibrated by adjusting the waste compressibility parameters to replicate measured data, for both the cases with no stress history and those assuming P_{c} .

Further to 'Settle3D' model analyses, we also carried out settlement back-calculations using an in-house spreadsheet, which assumes 1D settlement conditions, stress distribution similar to Settle 3D (isotropic elastic semi-infinite solid using Boussinesq equation), but allowing different time references for long-term compression of the existing waste materials by assuming that the start of secondary compression of each existing landfill layer occurs at the time each layer was placed. This method is similar to Incremental Settlement Prediction Model (ISPM) which was introduced by Gourc et al. (1999) and developed by others.

Eastern Gully

The settlement model for the Eastern Gully was established using the in-house spreadsheet described above for different settlement survey monuments installed across the Eastern Gully and calibrated by adjusting compressibility parameters to replicate on-going settlement monitoring data up to November 2012. The analyses focused on long-term landfill settlements associated with creep and decomposition, using a secondary compression settlement model.



Assessment Outcomes

Western Gully

Both Settle3D and the Spreadsheet calculation results indicate that the existing waste materials in the Western Gully are low compressibility with a modified primary compression index of $C_R \le 0.13$ and modified secondary compression index of $C_{\alpha\epsilon} \le 0.05$. These back-analysed compressibility parameters for the Western Gully landfill waste materials are similar to or smaller than those reported in the literature for "very low to low" waste compressibility¹ (i.e., Gourc and Olivier, 2005). The results indicate that the waste materials at the upper test pad are more compressible than those at the lower pad, possibly due to the younger age of the waste at the upper pad.

Eastern Gully

The results indicate that the modified secondary compression index, $C_{\alpha\epsilon}$, of existing waste at the Eastern Gully could vary between 0.045 and 0.085, with a mean value of 0.06. This is consistent with the range of $C_{\alpha\epsilon} = 0.02$ to > 0.14 reported in the literature for MSW (e.g. Gourc & Olivier, 2005 and Hossain et. al., 2003).

Recommendations and Conclusions

One dimensional settlement calculations for the existing waste at the Western Gully should generally adopt the following design parameters:

- Modified Primary Compression Index, C_R = 0.12
- Modified Secondary Compression Index, $C_{\alpha\epsilon} = 0.04$

One dimensional settlement calculations for the existing waste at the Eastern Gully should adopt the following design parameters:

Modified Secondary Compression Index, $C_{\alpha\epsilon} = 0.07$

The following issues should also be considered in future settlement calculations:

- Due to inherent variability of landfill waste, settlement predictions should generally be assessed for a range of potential compressibility values.
- Potential for additional settlement due to variations in leachate level.

Closure

If you have any questions regarding this memorandum, please contact the undersigned.

P. Richard

Parnel Richards Civil/Environmental Engineer

PR/GRS/pr

Gary Schmertmann Principal Geotechnical Engineer

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Attachments

Attachment 1: Whytes Gully New Landfill Cell - Settlement Back-analysis Results for Western Gully Load Test (Golder ref. 117625003_253_Rev0, 27 May 2013).

Attachment 2: Whytes Gully Resource Recovery Park (WGRRP) New Landfill Cell - Settlement Backanalysis Results (Eastern Gully) (Golder ref. 117625003_254_M_Rev0, 27 May 2013).

References

- Gourc, J. P., Olivier, F. Calibration of the Incremental Settlement Prediction Model (ISPM) from field monitoring campaigns, *International Workshop "Hydro-Physico-Mechanics of Landfills*, Grenoble University, 21-22 March 2005.
- Gourc, J.P., Thomas, S. and Vuillemin , M. (1999) Proposal of a waste settlement survey methodology. *Proc. Geo-Env Conference*, Lisbon, Vol. I, pp. 195-200.
- Hossain, M, S., Gabr, M.A., and Barlaz, M.A. 'Relationship of compressibility parameters to municipal solid waste decomposition.' Journal of Geotechnical and Geoenvironmental Engineering, 2003, 129 (12), 1151-1158.



ATTACHMENT 1

Settlement Backanalysis Results for Western Gully Load Test





DATE 27 May 2013

- TO Michael Herraman Wollongong City Council
- CC Jacinta McMahon

FROM Jessica Dalton, Gary Schmertmann

EMAIL jdalton@golder.com.au

PROJECT No. 117625003_253_TM_Rev0

WHYTES GULLY NEW LANDFILL CELL – SETTLEMENT BACK-ANALYSIS RESULTS FOR WESTERN GULLY

Note on Document Number: This technical memorandum was originally prepared under document sequence number 205 and this number was used when preparing figures and tables. Although the document number was subsequently revised to number 253, the number 205 has been retained on some figures and tables.

Introduction

This report provides the results of a settlement load trial and accompanying settlement monitoring carried out to support the design of the piggyback liner at Whytes Gully Landfill, NSW. Back analysis calculations have been completed using settlement information from two trial pads that were constructed at the site in February and March 2012 and on-going settlement data up to November 2012.

The trial was carried out to obtain site specific data on the deformation performance of the existing waste in the Western Gully. Two trial loading pads were created and positioned as follows:

- "Lower pad", approximately 20 m x 20 m (base area) positioned between approximately RL +44 m AHD and RL +49 m AHD on the lower portion of the Western Gully, to target older sections of the existing waste; and
- "Upper pad", approximately 30 m x 30 m (base area) positioned between approximately RL +70 m AHD and RL +76 m AHD on the upper portion of the Western Gully, to target newer sections of the existing waste.

To quantify the on-going landfill settlements and assess the impact on the proposed liner system, the historical performance of the existing landfill and the trial pad settlements has been back-analysed to refine landfill compressibility characteristics. The following methodology has been used:

- Review existing information and create simplified 3D settlement models using 'Settle3D' software to back-analyse the observed response under trial pad loading;
- Calibrate the models by adjusting compressibility parameters to replicate measured data; and
- Once calibrated against measured data, it is proposed that these will be used for additional design analyses to complete detailed design of the project, this work will be completed and reported separately to this memo.

Further to 'Settle3D' model analyses, we have also carried out settlement back-calculation using an in-house spread sheet (Spreadsheet), which assumes a one-dimensional (1D) settlement condition, stress distribution as in an isotropic elastic semi-infinite solid using the Boussinesq equation (similar to Settle 3D) but allows



different time references for long-term compression of the existing waste materials as discussed later in this memo.

Background Information

Full discussion of the geotechnical setting of the site, together with preliminary design parameters for settlement assessment is included in the Interpretive Geotechnical Report for preliminary design Ref. 117625003_059_R_Rev1, dated April 2012.

Details of the settlement load trial, including the loading magnitude and dimensions of the load test pads are given in Golder report ref. 117625003_191_R_Rev0, dated August 2012. The location of the trial pads is shown on Figure 1.

The contents of the landfill site are not reliably known. In general, landfill waste is likely to be highly heterogeneous. The degree of compaction (if any) during filling is also not known.

A review of background information relevant to landfill design and construction¹ and reference to in-house landfill specialists, indicates that the long term settlement behaviour of landfills is mainly due to the decomposition of organic material within fill. This is best represented in a geotechnical model by secondary compression, or creep. It is also found that under self-weight or imposed loading, landfill undergoes primary compression (related to crushing and movement of landfill contents²) relatively rapidly, usually within about a month. Long term movements are due mainly to decomposition of organic materials within the fill, movement of finer materials to fill voids created by the decomposition process, and creep of the refuse skeleton (Sowers 1973).

The decomposition of organic materials can be impacted by the leachate levels within the landfill. Organic material above the leachate table will generally decompose faster than material below the leachate table.

Settle3D Model

A Settle3D model was created to back analyse observed settlements and calibrate the waste compressibility parameters used for fill materials. Key assumptions and constraints relating to this model are summarised below:

Assumed Loading

The applied loading from the pads has been simplified for the Settle3D model to the following:

- Lower pad 75 kPa applied over a 17 m x 17 m area
- Upper pad 52 kPa applied over a 25 m x 25 m area

Loading Sequence

The loading sequence assumed is as follows:

- Feb 2012: Trial Commenced
- Feb 2012: Settlement Load Trial Loading applied in four equal lifts over a time period of 10 days for the lower pad and 20 days for the upper pad
- November 2012: Last available monitoring reading

² Leonard, M.L. & Floom, K.J. Estimating Method and Use of Landfill Settlement, in Environmental Geotechnics, Proceedings of sessions of Geo-Denver 2000, Denver, Colorado, August 5-8, 2000, 165 pp.



¹ Qian X., Koerner R.M & Gray D.H., 2002, Geotechnical Aspects of Landfill Design and Construction, Prentice Hall, 1st Edition

Stratigraphy

A simplified stratigraphy was assumed at each of the pad locations, based on contour drawings showing the base of the landfill (see preliminary design drawings), intermediate filling levels from the Interpretative Geotechnical Report and the survey completed as part of the construction of the pads. A simplified diagram showing the major stratigraphy assumed for each pad is shown in Figure 2:



Figure 2: Stratigraphy Assumptions for Lower and Upper Pads

We note that Settle 3D models stratigraphic layers as laterally uniform and continuous. This means that it does not take into account variation in fill thickness in three dimensions associated with the former creek valleys that lie below the landfill (Refer to Figures 3 to 5 for sections showing the thickness of waste at the two pad locations).

This could lead to Settle 3D models (or 1D analysis approaches) tending to over predict settlements associated with the trial. Generally, settlements deep in the landfill will tend to have less impact on the overall settlement as these will be older and will have been consolidated under a greater loading. We consider Settle 3D an appropriate method for this back analysis, taking advantages and constraints of the modelling process into account.

A less simplified stratigraphy was adopted for the 1D Spreadsheet calculations, representing different filling periods for the Western Gully landfill as follows:

- Stage 1: landfilled between 1984 and 1986 to maximum RL 44 mAHD,
- Stage 2: landfilled between 1986 and 1991 to maximum RL 70 mAHD,
- Stage 3: landfilled between 1991 and 1996 to final landform,
- Stage 4: not applicable to Western Gully landfill,
- Stage 5: not applicable to Western Gully landfill,
- Stage 6: not applicable to Western Gully landfill.

Stress History

Stress history assumptions can have a major impact on calculation of primary compression settlement. For this back analysis, two different approaches have been used to consider the stress history effect.

The first back analysis approach assumed that the landfill material is normally consolidated. To model this, the Over Consolidation Ratio (OCR) has been set to unity throughout the waste body. This assumption has the effect of causing calculated primary compression to reflect the full stress increase imposed by the trial pads.

The second approach involved applying an assumed 25 kPa pre-consolidation pressure (Pc) at the base of the trial pads. The Pc in the Settle 3D models has been assumed to increase with depth using the assumed



unit weight of the landfill. Hence the fill is slightly over consolidated throughout (OCR is slightly greater than 1). This assumption has the effect of causing calculated compression due to loading to reflect less than the full load imposed by the trial pads, with the remainder of the load causing calculated re-compression only. The re-compression coefficient has been assumed to be 10% of the primary compression coefficient.

This assumption can be considered to represent the effect of compaction stresses imposed during placement of each landfill lift. Alternatively, this assumption may be considered to reflect a physical aging phenomenon, sometimes referred to as pseudo over-consolidation, resulting from material creep under sustained loading.

Material Parameters

The Settle 3D model initially used preliminary compressibility parameters as discussed in the Interpretive Geotechnical Report (059 Rev 1) and these were modified to attempt to match the observed behaviour. We note that 1 m of Residual soil / Extremely Weathered rock was included at the base of all Settle 3D models. This material does not impact the results of the back analysis significantly (less than 1 mm settlement predicted), so has not been discussed in detail in this memo.

Secondary Compression

The reference time for secondary compression is not standard in the literature. In this assessment, 'Settle3D' analyses assume that the secondary compression commences after primary consolidation is practically finished (not more than a month based on the Western Gully settlement data). The Spreadsheet calculations, however, assume that secondary compression of each existing landfill layer commenced at the time each layer was placed - this method is similar to the Incremental Settlement Prediction Model (ISPM) which was introduced by Gourc et al. (1999) and developed by others.

Monitoring Data

Two sources of monitoring data are available for the Western Gully. The first is monitoring data recorded during the settlement load trial. The second source is settlement data recorded using monuments installed over the entire landfill area, outside of the load trial areas, which have been monitored for the past nine months to assess ongoing settlements in areas not influenced by the load trial.

In general, very little ongoing settlement has been recorded at the settlement monuments over a period of eight months before the trial and during the time the trial was carried out. Comparison of predicted and measured creep (secondary compression) has been completed and is discussed later in this memo.

The Eastern Gully landfill area, by contrast, still appears to be undergoing recordable creep settlements. This area was landfilled much more recently than the Western Gully.

Full results of the monument monitoring from both Eastern and Western Gullies are included as Figures 15 and 16. These results highlight the fact that the age of waste is an important factor to consider when attempting to back analyse or predict on-going settlement performance. This memo is focussed on the trials completed in the Western Gully area, settlement parameters and predictions for the Eastern Gully will be reported in a separate document.



Table 1: Settle3D Geotechnical Parameters – Back Analysis

Figure Number Description on Figure	Geotechnical Unit	Over Consolidation Ratio OCR	Pre-consolidation Pressure Pc (kPa)	Initial Void Ratio e₀	Permeability K (m/yr)	Compression Index, C_c / Modified Compression Index, $C_R=C_c$ / (1 + e_0)	Recompression Index C _r / C _r / (1 + e₀)	Creep Coefficient C_{α}
Original Design Paran	neters (After 059 Rev 1)				-			-
Figures 6, 8, 10 and 12 Original Parameters	41a – New Landfill (older and younger than 1991)	1	N/A	2	10	0.6 / 0.2	0.06 / 0.02	0.06
Figures 6, 8, 10 and 12 Original Parameters	41a – New Landfill (older and younger than 1991)	1	N/A	2	10	0.6 / 0.2	0.06 / 0.02	0.06
No Stress History Incl	uded – Lower Pad							
Figures 6 and 7 Lower Estimate	41a – New Landfill (older than 1991)	1	N/A	2	6	0.055 / 0.018	N/A ¹	0.008
Figures 6 and 7 Upper Estimate	41a – New Landfill (older than 1991)	1	N/A	2	10	0.075 / 0.025	N/A ¹	0.008
No Stress History Incl	uded – Upper Pad							
Figures 8 and 9 Lower Estimate	41a – New Landfill (older and younger than 1991)	1	N/A	2	6	0.03 / 0.01	N/A ¹	0.006
Figures 8 and 9 Upper Estimate	41a – New Landfill (older and younger than 1991)	1	N/A	2	10	0.07 / 0.023	N/A ¹	0.006
Stress History Include	ed – Lower Pad							
Figures 10 and 11 Lower Estimate	41a – New Landfill (older than 1991)	N/A	25 to 190 ²	2	6	0.13 / 0.043	0.013 / 0.004	0.006
Figures 10 and 11 Upper Estimate	41a – New Landfill (older than 1991)	N/A	25 to 190 ²	2	10	0.16 / 0.053	0.016 / 0.005	0.008
Stress History Include	ed – Upper Pad							
Figures 12 and 13 Lower Estimate	41a – New Landfill (younger than 1991)	N/A	25 to 135 ²	2	4	0.13 / 0.043	0.013 / 0.004	0.006
Figures 12 and 13 Upper Estimate	41a – New Landfill (younger than 1991)	N/A	25 to 135 ²	2	4	0.2 / 0.066	0.02 / 0.007	0.008
Figures 12 and 13 Lower Estimate	41a – New Landfill (older than 1991)	N/A	135 to 355 ²	2	6	0.13 / 0.043	0.013 / 0.004	0.006
Figures 12 and 13 Upper Estimate	41a – New Landfill (older than 1991)	N/A	135 to 355 ²	2	10	0.16 / 0.053	0.016 / 0.005	0.008

Note: 1. For the Settle 3D Model with no stress history included no parameter was required for recompression index, due to the load staging in the model.

2. Pre-consolidation pressure set to be overburden pressure + 25 kPa depending on depth within fill body.



Results of Settle3D analysis

Back Analysis of Trial Pads

The results of the Settle 3D analysis are attached to this memo as Figures 6 to 13. During the analysis process it was apparent that the additional loading applied from the trial pads did not generate the amount of settlement anticipated for virgin compression of typical municipal solid waste materials, in the case where materials are assumed to be normally consolidated.

This is illustrated in Figures 6 and 8 of this memo:

- For the lower pad the maximum predicted settlement during the test period using the preliminary design parameters is approximately 1200 mm, compared to measured settlements in the range 140 mm to 175 mm, i.e. measured settlements are approximately 12 % to 15 % of those predicted using the preliminary design parameters.
- For the upper pad the maximum predicted settlement during the test period using the preliminary design parameters is approximately 1450 mm, compared to measured settlements in the range 125 mm to 183 mm, i.e. measured settlements are approximately 9 % to 13 % of those predicted using the preliminary design parameters.

A major factor in these high predicted settlements is that creep is assumed to commence at the start of the load trial, whereas if it were assumed to commence at initial filling of the landfill in 1984, predicted creep settlements would be significantly smaller.

The effect of assumed stress history on the settlement calculations was investigated (refer Figures 10 and 12). Specifically, when pre-consolidation pressures are included in the modelling, predicted settlements reduce by approximately 50% as the settlement is assumed to be in re-compression, rather than primary compression, for the increment of imposed loading that is less than Pc. This is indicated by comparison of Figure 10 to Figure 6 and comparison of Figure 12 to Figure 8.

Based on these initial analyses, the compressibility parameters were adjusted to achieve a "best match" prediction, for both the cases with no stress history (Figures 7 and 9) and those assuming Pc (Figures 11 and 13). The parameters achieving a best match to the data are summarised in Table 1. It is noted that due primarily to the assumption of the time for start of secondary compression, the best match values of the secondary compression parameter (i.e., creep coefficient) are considered to have limited significance for use in prediction of future settlements at the site.

The load trial achieved an imposed loading of between 52 and 75 kPa. This is equivalent to up to 7 m of additional landfilling (roughly 15 to 25% of that proposed to take the landfill to final levels in most areas. The results from the trials suggest that using virgin compression parameters may overestimate settlements. Because the proposed final loading is relatively large, and because results from the load trials suggest that using primary compression parameters without a preconsolidation pressure may overestimate settlements, we consider that a method which takes into account the stress history of the waste would be generally appropriate for use in assessing potential settlement of the waste in the Western Gully.

Ultimately the loading to be applied for the landfill expansion project will be large scale and as such one dimensional loading conditions will prevail. The proposed stress history approach is that once the imposed loading is greater than 25 kPa (2 to 3 m of new landfill placement) then primary compression will be assumed to be occurring until filling is complete.

Settlement Monuments for Western Gully

Results of survey of the existing monuments on the landfill during the period of the trial (Figure 15) do not show a reliable consistent settlement trend for back-analysis. Further, measured settlement values are small (less than 20mm). In general, long-term settlements in the southern section of the landfill are anticipated to be negligible for the existing waste which is over 20 years old.



Results of Spreadsheet Calculations

Observed settlements at the centre of each loading pad (P2 for the Upper Pad and P4 for the Lower Pad) have been back-analysed using our in-house Spreadsheet. The central points were considered because vertical movements at these locations are less likely to be affected by potential slump of the pad side slopes and are likely to reflect pad settlement behaviour. As previously indicated, the Spreadsheet calculations considered the filling period history of the landfill by adopting different reference times for the commencement of secondary compression in each layer.

Typical back-calculation results are summarised in Table 2 (upper pad) and Table 3 (lower pad).

An overall summary of the Spreadsheet back-calculations for "best match" compressibility parameters is given below. These parameters were obtained by considering a range of values for assumed stress history (0 kPa < Pc < 25 kPa) and primary compression coefficient (3 m²/day < c_v < 5 m²/day).

- Lower Pad:
 - Modified Compression Index [$C_R = C_{cc} = C_c / (1+e_0)$]: value ranged from 0.04 to 0.08
 - Creep Coefficient $[C_{\alpha\epsilon} = C_{\alpha} / (1+e_0)]$: value ranged from 0.01 to 0.03
- Upper Pad:
 - Modified Compression Index [$C_R = C_{c\epsilon} = C_c / (1+e_0)$]: value ranged from 0.04 to 0.13
 - Creep Coefficient $[C_{\alpha\epsilon} = C_{\alpha} / (1+e_0)]$: value ranged from 0.01 to 0.05

Recommendations and Conclusions

This memorandum contains a back analysis of data from two settlement load trials at the Western Gully landfill. It contains discussion of the methods used to predict settlements using Settle 3D and an in-house 1D settlement spreadsheet, along with the assumptions used. Both Settle3D and the Spreadsheet calculation results indicate that the existing waste materials in the Western Gully are low compressibility with a modified primary compression index of $C_R \le 0.13$ and modified secondary compression index of $C_{\alpha\varepsilon} \le 0.05$. These back-analysed compressibility parameters for the Western Gully landfill waste materials are similar to or smaller than those reported in the literature for "very low to low" waste compressibility³ (i.e., Gourc and Olivier, 2005). The results indicate that the waste materials at the upper test pad are more compressible than those at the lower pad, possibly due to the younger age of the waste at the upper pad.

Considering our results, literature values, and the inherent variability of landfill waste materials, we recommend that the following compressibility parameters should generally be adopted for assessment of future waste settlement at the Western Gully:

- Modified Compression Index [$C_R = C_{c\epsilon} = C_c / (1+e_0)$]: value of 0.12
- Creep Coefficient $[C_{\alpha\epsilon} = C_{\alpha} / (1+e_0)]$: value of 0.04

These recommended values correspond to: (a) for modified compression index, the lower end of the reported range for "very low to low" compressibility by Gourc and Olivier (2005); (b) for creep coefficient, the middle of the same reported range.

Additional discussion is as follows:

- Due to inherent variability of landfill waste, settlement predictions should generally be assessed for a range of potential compressibility values.
- Parameters for the Eastern Gully landfill area should be considered in light of the contents of this memo, this will be reported separately.



³ Municipal Solid Waste

This assessment does not take account of potential effects due to variations in leachate level. Final landfill design should consider whether additional settlement could be triggered by this mechanism.

If you have any questions regarding this memorandum, please contact the undersigned.

Jessica Dalton Geotechnical Engineer

JKD/JDM:PRED:GRS/jkd

Gary Schmertmann Associate

Attachments:

Figure 1: Plan of Test Pad Location and Sections (1 No Page)
Figures 3 to 5: Long Section and Cross Sections through Trial Pads (3 No Pages)
Figures 6 to 13: Settle 3D Results for Back Analysis of Trial Pads (8 No Pages)
Figure 14: Not Used
Figures 15 and 16: Settlement Monument Monitoring Results for Western and Eastern Gullies (2 No Pages)
Tables 2 and 3: Spreadsheet Back-calculations (2 No Pages)

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References:

- Gourc, J. P., Olivier, F. Calibration of the Incremental Settlement Prediction Model (ISPM) from field monitoring campaigns, *International Workshop "Hydro-Physico-Mechanics of Landfills*, Grenoble University, 21-22 March 2005.
- Gourc, J.P., Thomas, S. and Vuillemin , M. (1999) Proposal of a waste settlement survey methodology. *Proc. Geo-Env Conference*, Lisbon, Vol. I, pp. 195-200.
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- Sowers G.F. (1973) Settlement of waste disposal fills. *Proc. Eighth International Conference on Soil Mechanics and Foundation Engineering*, Moscow, pp. 207-210.





NOT TO SCALE.

117625003-205

FIGURE 1

16/11/12



LONG SECTION A - A'

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16/11/12



scele = 1 in 1900 J L h

16/11/12





Seell = 1 in 500 v l L

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50.00	66.11	69.95	
60.00	68.18	69.82	
63.58		70.02	

c′

16/11/12





















117625003_205

Figure 16

16/11/2012



117625003 Whytes Gully New Landfill Cell EXISTING WASTE SETTLEMENT CALCULATION

EXISTING WASTE SETTLEMENT CA	LCULATIO	ON										_										— •		•			
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					Material	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6																
				1	Naste Type	MSW	MSW	MSW	MSW	MSW	MSW	from ava	ailable site	information													
				Unit Wei	aht (kN/m3)	11	11	11	11	11	11	assume	d based o	n waste tvpe													
				C-ce (m	od primary)	0.12	0.12	0.12	0.12	0.12	0.12	range fro	om Gourc	& Olivier (20	005) is 0 12 t	0 >0 24											
			C	c alph (mod	secondary)	0.04	0.12	0.04	0.04	0.04	0.04	range fr	om Gourc	& Olivier (20	005) is 0.02 t	0 >0 14											
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				CV (II	12/uay)	3.0	3.0	3.0	3.0	3.0	3.0	1															
2.1 SHORT-TERM "PRIMARY CONSOLIDAT	ION''								W "SECOND	ARY CONSOL																	
								LONG-TEIM	W OLOOND	AIT CONCOL	DATION																
Section 12.4.2 Settlement of existing solid v	vaste: Eq 12	2.9, Ref Xue	ede, Koernei	and Gray P.4	<u>51</u>			Section 12.4	4.2 Settleme	nt of existing	solid waste:	Eg 12.11,	Ref Xuede,	Koerner and	Gray P.451												
	6	τ. +	$\Delta \sigma$	C						1	t _{final}	C															
$s = H \times C_{cs} \times$	log –	- 0 -		C_{ce} -	Modified prima	ry compressi	on index	<i>s</i> =	$= H \times C$	$\alpha \epsilon \times \log -$		$C_{\alpha\epsilon}$	 Modified s 	econdary com	pression index												
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Assumptions									Assumption	is						20.00									P2		
	use Sigma	a-0 = current	t vertical stre	s at layer mid	point				1) Croop	-	mmorcoc					40.00	р -							+	ŀ		
	use delta-	sigma = vert	tical stress in	crease from ne	w waste placer	nent			2) Variation	n of modified a	econdary com	nression i	ndev with w	nid ratio is igno	red	60.00	o ₩		+ $+$ $+$ $+$						Model		
PAD Surcharge (kPa)=	52								z) variatio	n or mourneu s	econuary con	ipression ii	idex with v	olu l'atio is igrio	ieu.	Ē											
Preload surcharge (kPa) =	25															÷ 80.00											
																5 100.00	o ∐\\										
0.1 Chart Tarm "Driman " Cattlemant	of Lines															E .	1 M										
2.1 Short-Term "Primary" Settlement	of Liner															₩ ^{120.00}) 										
			Dalla Olivera and			- (1)		detion An el cie en e								a 140.00	o ———	\sim									
Point	P2	1	Mid point	ulations based on	Boussinesq equalic	in (Newinark, 195	5), pg.255 Found	Jation Analysis and	u Designi, Bowle	5 2005)	1																
	RL (mAHD)) Thickness	z (m)	L	В	M	N	V=M2+N2+1	V1=(MN)2	Delta Sigma	-					160.00	J										
Top of Stage 6		0									1					180.00	o ————							-			
Top of Stage 5		0					1		1		1																
Top of Stage 4	73.4	0.4	0.	2 12.5	12.5	62.5	62.5	7813.5	15258789	51.99984025						200.00	1	E1	101	• • •	151	201	251		201		
Top of Stage 3	73	3	1.	9 12.5	12.5	6.57894737	6.57894737	87.565097	1873.379	51.86697322							1	51	10	I	101	201	201		501		
Top of Stage 2	70	25	15.	9 12.5	12.5	0.78616352	0.78616352	2 2.23610617	0.3819896	29.8867651	-									Tim	e (Day)						
Top of Stage 1 Bettom of Wests	45	0	28.	4 12.5	12.5	0.44014085	0.44014085	1.38744793	0.037529	14.51808219	-																
Total thickness of existing waste (40 m)	28.4									1																
Thickness Western Gully Elling Stage	0.00	t (dav)		0 10	20	30	40	50	60	70	80	q	11	130	150	170 190	210	230	250	270	290	310	330	350	370	390	410
Sigma-0 (kN/m2)	NA	T	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA NA	A NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Delta-sigma (kN/m2)	0.00	U.	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA NA	A NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calc settlement of layer (m)	0.00	Δs (m)		0 0	0	0	C	0 0	0	0 0	0	()	0 0	0 0	0 (0 0	C) () 0	0	0 0	0	0	0	0	(
Thickness Western Gully Filling Stage5	0.00	t (day)		0 10	20	30	40	50	60	70	80	90) 11	0 130	150	170 190	210	230	250	270	290	310	330	350	370	390	410
Sigma-0 (kN/m2)	NA	Т	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA N/	A NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Delta-sigma (kN/m2)	0.00	U	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA NA	A NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calc settlement of layer (m)	0.00	Δs (m)		0 0	0	0	0	0	0	0	0	(1	0 100	0	170 (0		0 0	0	0 0	0	0	0	0	
Finickness Western Gully Filling Stage4	0.40	t (day)		0 10	20	30	40	50	60	70	80	90	ע 11 נו	130	150	1/0 190	210	230	250	2/0	290	310	330	350	3/0	390	410
Delta-sigma (kN/m2)	52.00			0 0 9212507	0.931250679	0 93125009	0.93125069	1 0 93125069	0 0212507	1 0 931250679	0.93125069	0 02120	0 021250	1 0 93125069	0.93126	0.93126 0.0212	0 0 0 0 1 0 0	0 02120	0 02120	0.02126	0 02120	0.02126	0.03100	0.02126	0 03120	0.03100	0 0310
Calc settlement of laver (m)	0.02	Δs (m)		0 0.0196149	0.019614899	0.0196149	0.0196149	0.0196149	0.0196149	0.019614899	0.0196149	0.019615	5 0.019614	0.0196149	0.019615 0	019615 0.01961	0.019615	0.019615	0.019615	0.019615	0.019615	0.019615	0.019615	0.019615	0.019615	0.019615	0.01961
Thickness Western Gully Filling Stage3	3.00	t (dav)		0 10	20	30	40	50	60	70	80	90) 11	0 130	150	170 190	210	230	250	270	290	310	330	350	370	390	410
Sigma-0 (kN/m2)	20.90	T	1	0 1	1	1	1	1	1	1	1	1	il	1 1	1	1	1	1	1	1	1	1	1	1	1	1	
Delta-sigma (kN/m2)	51.87	U		0 0.9312597	0.931259678	0.93125968	0.93125968	0.93125968	0.9312597	0.931259678	0.93125968	0.93126	6 0.931259	7 0.93125968	0.93126	0.93126 0.9312	0.93126	0.93126	0.93126	0.93126	0.93126	0.93126	0.93126	0.93126	0.93126	0.93126	0.9312
Calc settlement of layer (m)	0.08	Δs (m)		0 0.0843438	0.084343775	0.08434378	0.08434378	0.08434378	0.0843438	0.084343775	0.08434378	0.084344	1 0.084343	8 0.08434378	0.084344 0	0.084344 0.084344	0.084344	0.084344	0.084344	0.084344	0.084344	0.084344	0.084344	0.084344	0.084344	0.084344	0.084344
Thickness Western Gully Filling Stage2	25.00	t (day)		0 10	20	30	40	50	60	70	80	90) 11	0 130	150	170 190	210	230	250	270	290	310	330	350	370	390	410
Sigma-0 (kN/m2)	174.90	Т		0 0.048	0.096	0.144	0.192	0.24	0.288	0.336	0.384	0.432	2 0.52	8 0.624	0.72	0.816 0.91	2 1	1	1	1	1	1	1	1	1	1	
Delta-sigma (kN/m2)	29.89	U		0 0.2472155	0.349615498	0.42818979	0.49443098	0.551656	0.6017318	8 0.646214683	0.6857292	0.72083	0.77970	9 0.82616983	0.862832 0	.891761 0.9145	0.93126	0.93126	0.93126	0.93126	0.93126	0.93126	0.93126	0.93126	0.93126	0.93126	0.9312
Calc settlement of layer (m)	0.05	Δs (m)		0.0120825	0.017087167	0.02092742	0.0241649	0.02696173	0.0294091	0.031583206	0.03351445	0.03523	0.038107	6 0.04037837	0.04217 0	.043584 0.044	0.048874	0.048874	0.048874	0.048874	0.048874	0.048874	0.048874	0.048874	0.048874	0.048874	0.048874
I nickness Western Gully Filling Stage1	0.00	t (day)	NA	U 10	20	30	40	50	60 NA	70	80	90	J 11	130	150	1/0 190	210	230	250	J 270	290	310	330	350	370	390	410
Sigma-u (KN/m2) Delta-sigma (kN/m2)	14.52		NA	NA		NA	NA	NA	NA	NA	NA	NA	NA	NA NA			NA	NA	NA	NA	NA NA	NA	NA	NA	NA	NA	NA
Calc settlement of laver (m)	0.00	Δs (m)	14/5	0 0	0	0	лил. Г		0		0	- C	1					л. С			0		0	0	0	0	100
Total "Primary" settlement (mm)	152.83	()	0.00	116.04	121.05	124.89	128.12	130.92	133.37	135.54	137.47	139.19	142.07	144.34	146.13	147.54 148.66	152.83	152.83	152.83	152.83	152.83	152.83	152.83	152.83	152.83	152.83	152.83

2.2 Long-Term "Secondary" Settlement of Liner Note: for the purpose of this secondary settlement calculation, all piggy back liner and overlying new waste is assumed to be placed at the same time. This is chosen to corrspond of the start

Point		P2	P2	P2	P2	P2	P2	P2	P2	P2	P2	P2	P2	P2	P2	P2	P2	P2	P2	P2	P2	P2	P2	P2	P2	P2
Total Thickness		28.40	28.40	28.40	28.40	28.40	28.40	28.40	28.40	28.40	28.40	28.40	28.40	28.40	28.40	28.40	28.40	28.40	28.40	28.40	28.40	28.40	28.40	28.40	28.40	28.40
Old Waste																										
Thickness Western Gully Filling Stage6		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T-initial (yr)		6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
T-final (yr)		6.00	6.03	6.05	6.08	6.11	6.14	6.16	6.19	6.22	6.25	6.30	6.36	6.41	6.47	6.52	6.58	6.63	6.68	6.74	6.79	6.85	6.90	6.96	7.01	7.07
Calc settlement of layer (m)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thickness Western Gully Filling Stage5		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T-initial (yr)		11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00
T-final (yr)		11.00	11.03	11.05	11.08	11.11	11.14	11.16	11.19	11.22	11.25	11.30	11.36	11.41	11.47	11.52	11.58	11.63	11.68	11.74	11.79	11.85	11.90	11.96	12.01	12.07
Calc settlement of layer (m)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thickness Western Gully Filling Stage4		0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
T-initial (yr)		16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00
T-final (yr)		16.00	16.03	16.05	16.08	16.11	16.14	16.16	16.19	16.22	16.25	16.30	16.36	16.41	16.47	16.52	16.58	16.63	16.68	16.74	16.79	16.85	16.90	16.96	17.01	17.07
Calc settlement of layer (m)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thickness Western Gully Filling Stage3		3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
T-initial (yr)		21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00
T-final (yr)		21.00	21.03	21.05	21.08	21.11	21.14	21.16	21.19	21.22	21.25	21.30	21.36	21.41	21.47	21.52	21.58	21.63	21.68	21.74	21.79	21.85	21.90	21.96	22.01	22.07
Calc settlement of layer (m)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thickness Western Gully Filling Stage2		25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
T-initial (yr)		26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00
T-final (yr)		26.00	26.03	26.05	26.08	26.11	26.14	26.16	26.19	26.22	26.25	26.30	26.36	26.41	26.47	26.52	26.58	26.63	26.68	26.74	26.79	26.85	26.90	26.96	27.01	27.07
Calc settlement of layer (m)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02
Thickness Western Gully Filling Stage1		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T-initial (yr)		28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00
T-final (yr)		28.00	28.03	28.05	28.08	28.11	28.14	28.16	28.19	28.22	28.25	28.30	28.36	28.41	28.47	28.52	28.58	28.63	28.68	28.74	28.79	28.85	28.90	28.96	29.01	29.07
Calc settlement of layer (m)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total "Secondary" settlement(mm)		0.00	0.54	1.07	1.61	2.15	2.68	3.21	3.75	4.28	4.81	5.88	6.94	8.00	9.05	10.11	11.16	12.21	13.26	14.30	15.34	16.39	17.42	18.46	19.49	20.53
Monitoring Time (days)		0	10	20	30	40	50	60	70	80	90	110	130	150	170	190	210	230	250	270	290	310	330	350	370	390
Sum of calculated "Primary" and "Secondary" settl	lement (mm)	0.00	116.58	122.12	126.50	130.27	133.60	136.58	139.29	141.75	144.00	147.94	151.28	154.13	156.60	158.77	163.99	165.04	166.09	167.13	168.18	169.22	170.26	171.29	172.33	173.36

P2 28.40 28.40 7.12 0.00 10.00 11.00 12.12 0.00 12.12 12.00 12.12 12.00 12.00 12.12 12.00 12.00 12.12 12.00 12.12 12.00 12.12 12.00 12.00 12.12 12.00 12.	
28.40 28.40 0.00 6.00 7.12 0.00 0.00 11.00 12.12 0.00 0.40 17.12 0.00 24.00 25.00 25.00 25.00 25.00 27.12 0.02 0.00 27.12 0.02 0.00 27.12 0.02 0.00 27.12 0.00 0.00 27.12 0.00 27.12 0.00 0.00 27.12 0.00 0.00 27.12 0.00 0.00 27.12 0.00 0.00 27.12 0.00 0.00 27.12 0.00 0.00 27.12 0.00 0.00 27.12 0.00 0.00 0.00 27.12 0.00 0.00 0.00 0.00 27.12 0.00 0.00 0.00 0.00 27.12 0.00	P2
28.40 0.00 6.00 7.12 0.00 11.00 12.12 0.00 12.12 0.00 17.12 0.00 12.12 0.00 17.12 0.00 22.12 0.00 22.12 0.00 22.12 0.00 25.00 26.00 27.12 0.00 25.00 26.00 27.12 0.00 25.00 25.00 25.00 26.00 27.12 0.00 27.12 0.00 25.00 25.00 26.00 27.12 0.02 0.00 27.12 0.02 0.02 0.02 0.02 0.02 0.02 0.00 27.12 0.02 0.02 0.02 0.02 0.00 27.12 0.02 0.02 0.00 27.12 0.02 0.02 0.02 0.02 0.02 0.02 0.00 27.12 0.02 0.02 0.00 27.12 0.02 0.02 0.02 0.02 0.02 0.00 27.12 0.02 0.00 27.12 0.02 0.02 0.00 27.12 0.02 0.00 27.12 0.02 0.00 27.12 0.02 0.00 27.12 0.02 0.00 27.12 0.02 0.00 27.12 0.02 0.00 27.12 0.02 0.00 27.12 0.02 0.00 27.12 0.02 0.00 27.12 0.02 0.00 27.12 0.02 0.00 27.12 0.02 0.00 27.12 0.02 0.00 0.00 27.12 0.00 0	
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0.00 6.00 7.12 0.00 11.00 12.12 0.00 0.40 17.12 0.00 21.00 22.12 0.00 25.00 25.00 25.00 27.12 0.02 0.00 27.12 0.02 0.00 27.12 0.02 0.00 27.12 0.02 0.00 27.12 0.02 0.00 27.12 0.00 27.12 0.00 27.12 0.00 27.12 0.00 27.12 0.00 27.12 0.00 0.00 27.12 0.00 21.00 21.00 25.00 27.12 0.02 0.00 27.12 0.00 27.12 0.00 27.12 0.00 27.12 0.00 27.12 0.00 27.12 0.00 27.12 0.00 27.12 0.00 27.12 0.00 27.12 0.00 27.12 0.00 28.00 28.00 28.00 28.00 28.00 28.00 29.12 0.00 29.12 0.00 29.12 0.00 20.00 28.00 28.00 21.56 410 21.56 21.56 20.56 20.5567 20.556 20.5567 20.5567 20.5567 20.5567 20.556	
6.00 7.12 0.00 11.00 12.12 0.00 12.12 0.00 17.12 0.00 22.12 0.00 22.12 0.00 22.12 0.00 22.12 0.00 22.12 0.00 22.12 0.00 22.12 0.00 22.12 0.00 22.12 0.00 23.10 24.10 25.00 25.	0.00
7.12 0.00 0.00 11.00 12.12 0.00 0.40 17.12 0.00 21.00 22.12 0.00 22.12 0.00 22.12 0.00 22.00 26.00 27.12 0.00 25.00 26.00 27.12 0.00 29.12 0.00 29.12 0.00	6.00
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22.12 0.00 25.00 26.00 27.12 0.02 0.00 29.12 0.00 29.12 0.00 21.56 410	21.00
0.00 25.00 26.00 27.12 0.02 0.00 29.12 0.00 21.56 410	22.12
25.00 26.00 27.12 0.02 0.00 28.00 29.12 0.00 21.56 410	0.00
26.00 27.12 0.02 0.00 28.00 29.12 0.00 21.56 410	25.00
27.12 0.02 0.00 28.00 29.12 0.00 21.56 410	26.00
0.02 0.00 28.00 29.12 0.00 21.56 410	27.12
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21.56 410	29.12
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117625003 Whytes Gully New Landfill Cell EXISTING WASTE SETTLEMENT CALCULATION

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 | Stage 5 | Stage 6
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102 to ∿0 |
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| 2.1 SHORT-TERM "PRIMARY CONSOLIDA | FION'' | | | | |
 | | LONG-TER | M "SECOND
 | ARY CONSOL | IDATION"
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| Section 12.4.2 Settlement of existing solid | waste: Eg 1 | 2.9, Ref Xu | ede, Koerner | and Gray P.4 | <u>451</u> |
 | | Section 12.4 | 4.2 Settleme
 | nt of existing | solid waste:
 | Eg 12.11, F | Ref Xuede, | Koerner and Gray P.4 | <u>51</u> |
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 | on index | s = | $= H \times C$
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 | $C_{\alpha\varepsilon}$ | Modified se | econdary compression | ndex |
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siama = ver | tical stress inc | s at layer mid
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ew waste nia | cement
 | | | 1) Creep st
 | tarts as filling o | ommences.
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| PAD Surcharge (kPa)= | 75 | | 1001 311033 110 | Cuse II UIII II | ow waste pla | Coment
 | | | 2) Variatio
 | n of modified s | econdary con
 | npression in | idex with vo | d ratio is ignored. | | Ē ⁶⁰
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| Preload surcharge (kPa) = | 25 |] | | | |
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| Point | P4 | 1 | Mid point | | |
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 | | | | | 160
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 | | | | |
 |
| oint | P4
RL (mAHD | Thickness | Mid point
z (m) | L | В | M
 | N | V=M2+N2+1 | 1 V1=(MN)2
 | Delta Sigma | -
 | | | | | 160
 | | | * |
 | | | | |
 |
| Point | P4
RL (mAHD | Thickness
0 | Mid point
z (m) | | B | M
 | N | V=M2+N2+1 | I V1=(MN)2
 | Delta Sigma | -
 | | | | | 160 ·
180 ·
 | | | |
 | | | | |
 |
| Point
Top of Stage 6
Top of Stage 5
Top of Stage 4 | P4
RL (mAHD | Thickness
0
0
0 | Mid point
z (m) | | B | M
 | N | V=M2+N2+1 | V1=(MN)2
 | Delta Sigma | -
 | | | | | 160 -
180 -
200 -
 | | | |
 | | | | |
 |
| Point
Top of Stage 6
Top of Stage 5
Top of Stage 4
Top of Stage 3 | P4
RL (mAHD | Thickness
0
0
0
0 | Mid point
z (m) | | B
 | M

 | N | V=M2+N2+1 | V1=(MN)2
 | Delta Sigma | -
 | | | | | 160 -
180 -
200 -
 | | 51 | 101 | 15
 | 51 | 201 | 251 | 30 |
 |
| Point
Fop of Stage 6
Fop of Stage 5
Fop of Stage 4
Fop of Stage 2
Fop of Stage 2 | P4
RL (mAHD
46.5 | Thickness
0
0
0
2.5 | Mid point
z (m) | L
 | B
 | M

 | N
N
3
6.8 | V=M2+N2+1 | V1=(MN)2
 | Delta Sigma |
 | | | | | 160 -
180 -
200 -
 | | 51 | 101 | 15
Tin
 | i1 | 201 | 251 | 30 |
 |
| Point
Fop of Stage 6
Fop of Stage 5
Fop of Stage 4
Fop of Stage 2
Fop of Stage 2
Fop of Stage 1
Extern of Monthe | P4
RL (mAHD
46.5
44 | Thickness
0
0
0
2.5
12.36 | Mid point
Z (m)
1.25
8.68 | L
8.5
8.5 | B | M
M

 | N
N
3
6.8
0.97926267 | V=M2+N2+1
93.48
2.91791076 | V1=(MN)2
2138.1376
0.9195954
 | Delta Sigma
Delta Sigma
74.82591924
51.79027721 |
 | | | | | 160 -
180 -
200 -
 | | 51 | 101 | 15
Tin
 | 51
ne (Day) | 201 | 251 | 30 |
 |
| ont
op of Stage 6
op of Stage 5
op of Stage 4
op of Stage 3
op of Stage 2
op of Stage 1
otom of Waste
Total thickness of existing waste | P4
RL (mAHD
46.5
44
31.64
(m) | Thickness
0
0
2.5
12.36 | Mid point
Z (m)
1.25
8.68 | L
 | B
 | M
M
5 6.8
.5 0.97926267
 | N
N
3 6.8
0.97926267 | V=M2+N2+1
93.48
2.91791076 | V1=(MN)2
 | Delta Sigma
 |
 | | | | | 160 -
180 -
200 -
 | | 51 | 101 | 15
Tin
 | 51
ne (Day) | 201 | 251 | 30 |
 |
| Point
Fop of Stage 6
Fop of Stage 5
Fop of Stage 4
Fop of Stage 3
Fop of Stage 2
Fop of Stage 1
Soltom of Waste
Total thickness of existing waste
Total thickness of existing waste | P4
RL (mAHD
46.5
44
31.64
(m)
0.00 | Thickness
0
0
0
2.5
12.36
14.86
t (day) | Mid point
z (m)
1.25
8.68 | L
8.5
8.5 | B
B
1
1
8
8
8 | M
5 6.8
5 0.97926267
 | N
N
3 6.8
7 0.97926267 | V=M2+N2+1
93.48
2.91791076 | 2138.1376
0.9195954
 | Delta Sigma |
 | 90 | 110 | 130 | 50 17 | 160 -
180 -
200 -
0 19
 | 210 | 51 | 101 | 15
Tin
 | 51
ne (Day) | 201 | 251 | 30 | 370
 |
| Point
Fop of Stage 6
Fop of Stage 5
Fop of Stage 4
Fop of Stage 3
Fop of Stage 2
Fop of Stage 1
Soltom of Waste
Total thickness of existing waste
Fhickness Western Gully Filling Stage6
Sigma-0 (kV/m2) | P4
RL (mAHD
46.5
44
31.64
(m)
0.00
NA | Thickness
0
0
0
2.5
12.36
14.86
t (day)
T | Mid point
z (m)
1.25
8.68
0
NA | L
8.5
8.5
10
NA | B
B
8
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8
8
8 | M
5 6.8
5 0.97926267
20 30
 | N
N
3 6.8
7 0.97926267
0 40 | V=M2+N2+1
93.48
2.91791076
50 | 2138.1376
0.9195954
 | Delta Sigma | 0 80
NA
 | 90
NA | 110
NA | 130
NA NA | 50 17
NA | 160 -
180 -
200 -
0 <u>19</u>
NA
 | 210
NA | 51
230
NA | 101
0 250
NA | 15
Tin
270
NA
 | 51
ne (Day)
0 290
NA | 201
201
NA | 251
251
0 330
NA | 30 ⁻ | 370
NA
 |
| Point
Fop of Stage 6
Fop of Stage 5
Fop of Stage 4
Fop of Stage 2
Fop of Stage 2
For of Stage 1
Sottom of Waste
Total thickness of existing waste
Thickness Western Gully Filling Stage6
Sigma-0 (kN/m2)
Delta-sigma (kN/m2) | P4
RL (mAHD
46.5
44
31.64
(m)
0.00
NA
0.00 | Thickness
0
0
0
2.5
12.36
14.86
t (day)
T | 0 Mid point
z (m)
1.25
8.68
0
NA
NA | L
8.5
8.5
NA
NA | B
B
B
B
B
B
B
B
B
B
B
B
B
B
B
B
B
B
B | M
M

 | N
0.97926267
0.97926267
40
NA
NA | V=M2+N2+1
93.48
2.91791076
50
NA
NA | V1=(MN)2
2138.1376
0.9195954
0.9195954
0.9195954
 | Delta Sigma
74.82591924
51.79027721
70
NA
NA | 0 80
NA
NA
 | 90
NA
NA | 110
NA
NA | 130
NA NA
NA NA | 50 17
NA
NA | 160 -
180 -
200 -
NA
NA
NA
 |) 210
NA
NA | 51
NA
NA | 101
101
NA
NA | 15
Tin
270
NA
NA
 | 51
ne (Day)
) 290
NA
NA | 201
201
NA
NA | 251
0 330
NA
NA | 30
30
NA
NA | 370
NA
NA
 |
| Point Top of Stage 6 Top of Stage 5 Top of Stage 4 Top of Stage 2 Top of Stage 1 Bottom of Waste Total thickness of existing waste Thickness Western Gully Filling Stage6 Sigma (kN/m2) Patta-sigma (kN/m2) Patte-settlement of layer (m) | P4
RL (mAHD
46.5
44
31.64
(m)
0.00
NA
0.00
0.00
0.00 | Thickness
0
0
0
2.5
12.36
14.86
t (day)
T
U
Δs (m)
0
14.86 | 0 mid point
z (m)
1.25
8.68
0
NA
NA | L
8.5
8.5
NA
NA
0 | B
B
B
B
B
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B
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B
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B
B
B
B
B | M
M
5.5 6.8
0.97926267
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0.97777777
0.9777777777777777777777777777777777777 | V=M2+N2+1
93.48
2.91791076
50
NA
NA | V1=(MN)2
V1=(MN)2
2138.1376
0.9195954
0.9195954
0.9195954
0.9195954
 | Delta Sigma
74.82591924
51.79027721
0 70
NA
NA | NA 80
 | 90
NA
NA
0 | 110
NA
NA
0 | 130
NA NA
NA NA
0 | 50 17
NA
NA
0 | 160 -
180 -
200 -
NA
NA
0
 | 0 210
NA
NA
0 00 | 51
51
NA
NA
C | 101
101
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NA
0 | 15
Tin
0 270
NA
NA
 | 51
ne (Day)
NA
NA
0 000 | 201
201
NA
NA
0
0
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0
0
0
0
0
0
0
0
0
0 | 251
251
NA
NA
0
0
0 | 30
30
NA
NA
0 | 370
NA
NA
0
 |
| Point Top of Stage 6 Top of Stage 5 Top of Stage 4 Top of Stage 2 Top of Stage 2 Top of Stage 2 Top of Stage 1 Bottom of Waste Total thickness of existing waste Total thickness vestern Gully Filling Stage6 Sigma-0 (kN/m2) Delta-sigma (kN/m2) Cals settlement of layer (m) Thickness Western Gully Filling Stage5 Sigma-0 (kM/m2) | P4
RL (mAHD
46.5
44
31.64
(m)
0.00
NA
0.00
0.00
0.00
NA | Thickness 0 0 0 0 12.36 14.86 t (day) T U Δs (m) t (day) | Mid point
2 (m)
1.25
8.68
0
NA
NA
0
NA | L
8.5
8.5
NA
NA
0
10
NA | B
B
B
B
B
B
B
B
B
B
B
B
B
B
B
B
B
B
B | M
M
5.5 6.8
5 0.97926267
20 30
NA
NA
0 0 0
20 30
NA
 | N
N
N
N
NA
NA
NA
NA
NA
NA | V=M2+N2+1
93.48
2.91791076
50
NA
NA
0
50 | V1=(MN)2
2138.1376
0.9195954
0 60
NA
NA
NA
 | Delta Sigma | 0 80
NA
NA
0 0
NA
 | 90
NA
NA
0
90 | 110
NA
NA
0
110 | 130
NA NA
NA NA
0
130
NA NA | 50 17
NA
NA
0
50 17 | 160 -
180 -
200 -
NA
NA
0 19
NA
0 19
NA
 |) 210
NA
NA
0 0
210 | 51
51
NA
NA
C
230 | 101
101
0 250
NA
NA
0 (0)
250
NA | 15
Tin
0 270
NA
NA
0 0
270
NA
 | 51
ne (Day)
D 290
NA
NA
D (0)
290
NA | 201
201
NA
NA
0
0
310
NA | 251
251
NA
NA
0 0
330
NA | 300
300
NA
NA
0
350
NA | 370
NA
NA
0
370
 |
| Point Top of Stage 6 Top of Stage 5 Top of Stage 5 Top of Stage 4 Top of Stage 2 Top of Stage 1 Sottom of Waste Total thickness of existing waste Thickness Western Gully Filling Stage6 Sigma-0 (kV/m2) 2alc settlement of layer (m) Thickness Western Gully Filling Stage5 Sigma-0 (kV/m2) 2blta-sigma (kV/m2) | P4
RL (mAHD
46.5
44
31.64
(m)
0.00
NA
0.00
0.00
NA
0.00
NA
0.00 | Thickness 0 0 0 0 2.5 12.36 14.86 t (day) T U Δs (m) t (day) T U | Mid point
2 (m)
1.25
8.68
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8.5
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5.5 6.8
5.0 97926267
20 30
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20 30
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 | N N 3 6.8 7 0.97926267 0 40 NA NA NA 0 0 40 NA NA NA NA NA NA NA NA NA NA | V=M2+N2+1
93.48
2.91791076
NA
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NA |
V1=(MN)2
2138.1376
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51.79027721
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180 -
200 -
NA
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0 19
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NA | 210
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NA
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230
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ne (Day)
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| Point Top of Stage 6 Top of Stage 5 Top of Stage 4 Top of Stage 2 Top of Stage 2 Top of Stage 2 Top of Stage 1 Bottom of Waste Total thickness of existing waste Thickness Western Gully Filling Stage6 Sigma-0 (kN/m2) Calc settlement of layer (m) Thickness Western Gully Filling Stage5 Sigma-0 (kN/m2) Delta-sigma (kN/m2) Calc settlement of layer (m) | P4
RL (mAHD
46.5
44
31.64
(m)
0.00
NA
0.00
0.00
NA
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0.00 | Thickness 0 0 0 0 0 2.5 12.36 14.86 t (day) T U Δs (m) U Δs (m) | Mid point
z (m)
1.25
8.68
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B
B | M
M
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 | N
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0. | V=M2+N2+1
93.48
2.91791076
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V1=(MN)2
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| Point Top of Stage 6 Top of Stage 5 Top of Stage 4 Top of Stage 2 Top of Stage 2 Top of Stage 1 Bottom of Waste Total thickness of existing waste Total thickness of existing waste Oelta-sigma (kV/m2) Calc settlement of layer (m) Thickness Western Gully Filling Stage5 Sigma-0 (kV/m2) Calc settlement of layer (m) Thickness Western Gully Filling Stage4 | P4
RL (mAHD
46.5
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31.64
(m)
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2 (m)
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V1=(MN)2
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0.91950000000000000000000000000000000000
 | Delta Sigma
Delta Sigma
74.82591924
51.79027721
51.79027721
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0 0 0
70
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NA
0 0 70
NA | 0 80
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110 | 130
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130 | 50 17
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| Point Top of Stage 6 Top of Stage 5 Top of Stage 5 Top of Stage 2 Top of Stage 2 Top of Stage 2 Total thickness of existing waste Total thickness vestern Gully Filling Stage6 Sigma-0 (kN/m2) Delta-sigma (kN/m2) Cale settlement of layer (m) Thickness Western Gully Filling Stage5 Sigma-0 (kN/m2) Cale settlement of layer (m) Thickness Vestern Gully Filling Stage4 Sigma-0 (kN/m2) Cale settlement of layer (m) Thickness Vestern Gully Filling Stage4 Sigma-0 (kN/m2) | P4
RL (mAHD
46.5
44
31.64
(m)
0.00
NA
0.00
0.00
NA
0.00
NA
0.00
NA | Thickness 0 0 0 0 0 12.36 14.86 t (day) T U Δs (m) t (day) T U Δs (m) | Mid point
z (m)
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8.68
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NA
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NA
NA | L 8.5
8.5
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NA | M
M
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0.979777 | V=M2+N2+1
93.48
2.91791076
500
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NA | V1=(MN)2
V1=(MN)2
2138.1376
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2.2 Long-Term "Secondary" Settlement of Liner Note: for the purpose of this secondary settlement calculation, all piggy back liner and overlying new waste is assumed to be placed at the same time. This is chosen to corrspond of the start

Point			P4	P4	P4	P4	P4	P4	P4	P4	P4	P4	P4	P4	P4	P4	P4	P4	P4	P4	P4	P4	P4	P4	P4	P4	P4	P4
Total Thickness			14.86	14.86	14.86	14.86	14.86	14.86	14.86	14.86	14.86	14.86	14.86	14.86	14.86	14.86	14.86	14.86	14.86	14.86	14.86	14.86	14.86	14.86	14.86	14.86	14.86	14.86
Old Waste																										[
Thickness Western Gully Filling Stage6			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T-initial (yr)			6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
T-final (yr)			6.00	6.03	6.05	6.08	6.11	6.14	6.16	6.19	6.22	6.25	6.30	6.36	6.41	6.47	6.52	6.58	6.63	6.68	6.74	6.79	6.85	6.90	6.96	7.01	7.07	7.12
Calc settlement of layer (m)			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thickness Western Gully Filling Stage5			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T-initial (yr)			11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00
T-final (yr)			11.00	11.03	11.05	11.08	11.11	11.14	11.16	11.19	11.22	11.25	11.30	11.36	11.41	11.47	11.52	11.58	11.63	11.68	11.74	11.79	11.85	11.90	11.96	12.01	12.07	12.12
Calc settlement of layer (m)			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thickness Western Gully Filling Stage4			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T-initial (yr)			16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00
T-final (yr)			16.00	16.03	16.05	16.08	16.11	16.14	16.16	16.19	16.22	16.25	16.30	16.36	16.41	16.47	16.52	16.58	16.63	16.68	16.74	16.79	16.85	16.90	16.96	17.01	17.07	17.12
Calc settlement of layer (m)			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thickness Western Gully Filling Stage3			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T-initial (yr)			21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00
T-final (yr)			21.00	21.03	21.05	21.08	21.11	21.14	21.16	21.19	21.22	21.25	21.30	21.36	21.41	21.47	21.52	21.58	21.63	21.68	21.74	21.79	21.85	21.90	21.96	22.01	22.07	22.12
Calc settlement of layer (m)			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thickness Western Gully Filling Stage2			2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
T-initial (yr)			26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00
T-final (yr)			26.00	26.03	26.05	26.08	26.11	26.14	26.16	26.19	26.22	26.25	26.30	26.36	26.41	26.47	26.52	26.58	26.63	26.68	26.74	26.79	26.85	26.90	26.96	27.01	27.07	27.12
Calc settlement of layer (m)			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thickness Western Gully Filling Stage1			12.36	12.36	12.36	12.36	12.36	12.36	12.36	12.36	12.36	12.36	12.36	12.36	12.36	12.36	12.36	12.36	12.36	12.36	12.36	12.36	12.36	12.36	12.36	12.36	12.36	12.36
T-initial (yr)			28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00
T-final (yr)			28.00	28.03	28.05	28.08	28.11	28.14	28.16	28.19	28.22	28.25	28.30	28.36	28.41	28.47	28.52	28.58	28.63	28.68	28.74	28.79	28.85	28.90	28.96	29.01	29.07	29.12
Calc settlement of layer (m)			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total "Secondary" settlement(mm)			0.00	0.13	0.26	0.38	0.51	0.64	0.77	0.89	1.02	1.15	1.40	1.65	1.90	2.16	2.41	2.66	2.91	3.16	3.41	3.66	3.91	4.15	4.40	4.65	4.90	5.14
Monitoring Time (days)			0	10	20	30	40	50	60	70	80	90	110	130	150	170	190	210	230	250	270	290	310	330	350	370	390	410
Sum of calculated "Primary" and "Secondar	y" settleme	ent (mm)	0.00	108.71	120.34	129.30	136.66	142.88	148.19	152.73	156.62	159.94	165.22	169.12	172.01	179.18	179.43	179.68	179.93	180.18	180.43	180.68	180.92	181.17	181.42	181.67	181.91	182.16

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ATTACHMENT 2

Settlement Backanalysis Results (Eastern Gully)





PROJECT No. 117625003_254_M_Rev0

DATE 27 May 2013

TO Michael Herraman Wollongong City Council

CC Jacinta McMahon

FROM Saman Zargarbashi, Gary Schmertmann

EMAIL GSchmertmann@golder.com.au

WHYTES GULLY RESOURCE RECOVERY PARK (WGRRP) NEW LANDFILL CELL – SETTLEMENT BACK-ANALYSIS RESULTS (EASTERN GULLY)

Introduction

This technical memorandum presents the outcome of our assessment on the compressibility of existing Municipal Soil Waste (MSW) in the Eastern Gully of WGRRP (Figure 1). This assessment was undertaken through back-analysis calculations using available settlement information.

Assessment Methodology and Assumptions

Back-analysis calculations have been undertaken on surface settlement monuments for the Eastern Gully to refine the landfill compressibility characteristics. This assessment has been carried out to enable quantification of the most likely on-going landfill settlements and assessment of the impact on the proposed piggy-back liner system.

The following methodology has been adopted:

- Review existing information and create the landfill geotechnical model,
- Establish settlement model for different monuments and calibrate the model by adjusting compressibility parameters to replicate measured data, and
- Once calibrated against measured data, it is proposed that these parameters will be used for additional design analyses to complete detailed design of the project, this work will be completed and reported separately to this memo.

The analyses assume the followings:

- The analyses are focused on long-term landfill settlements associated with creep and decomposition, using a secondary compression settlement model,
- Long-term settlement mechanisms commence at the start of the filling period for each landfilling stage,
- The modified secondary compression index is constant over time,
- Settlement observed at monuments SM1 to SM6 reflect ongoing long-term settlements, and
- Settlements observed at monuments SM18 and SM19 are likely to be affected by recent filling at the northern section of the landfill and are not considered in this assessment.

We have undertaken sensitivity analyses to assess effect of waste thickness on the back-calculated compression indexes for the monuments located at the upper side slopes of the valley. This was carried out



to allow for possible errors in the estimation of the original ground surface level before landfilling. We have also assessed the effect of time reference on the back-calculated secondary compression indexes, which was carried out by setting the time for the start of secondary compression to reflect the start and also the end of each landfilling stage.

Landfill Model

The age of waste is an important factor to consider when attempting to back analyse or predict on-going long-term settlement performance. The landfill formation history has been assumed based on the available historical survey plans as detailed in the Golder Report 'Interpretative Geotechnical Investigation Report for 50% Design', No 117625003_059_R-Rev 1, dated April 2012. Figures 2 and 3 (reproduced Figure C.9 of the 2012 report) show the extent of fill layers formed across the Eastern Gully in different time periods. Table 1 also summaries the thickness of MSW at different stages below the settlement monuments

	Reduced Al	Levels (m HD)		Fill Thicl	kness (m))
Monument No.	Bottom of Waste	Existing Surface (Feb 2012)	1993- 2001	2001- 2004	2004- 2009	2009- 2012
SM1	30.9	73.4	0	19.1	23.0	0
SM2	45.1	72.6	0	4.9	22.6	0
SM3	32.0	61.3	0	18.0	11.3	0
SM4	31.3	59.5	0	18.7	9.5	0
SM5	27.0	52.2	0	23.0	2.2	0
SM6	31.8	52.2	0	18.2	2.2	0
SM18	45.4	84.8	0	4.6	30.0	4.8
SM19	59.5	82.7	0	0	20.5	2.7

Table 1: Fill thickness at Settlement Monuments (Eastern Gully)

Monitoring Data

The Eastern Gully area is currently being filled at its northern section, and is undergoing recordable creep settlements due to its relatively young age. Results of the monument monitoring from Eastern Gully are shown in Figure 4 for a monitoring period between 8 February and 14 November 2012. These results have been compiled by Golder based on survey data provided by Wollongong City Council. The installation of the settlement monuments was reported by Golder in August 2012 ('Settlement Load Test-Completion Report', Ref 117625003_191_R_Rev0).

We note that horizontal displacements of the top of the monuments measured in the nine months after installation were less than 30 mm in both cross-slope (East-West) and upslope-downslope (North-South) directions, therefore the observed vertical movements at monuments are considered to reflect vertical settlements.

Assessment Outcome

Selected analysis results are presented as Tables 2 to 7, attached. The results indicate that the modified

secondary compression index, $c_{\alpha\varepsilon} = \frac{c_{\alpha}}{1 + e_o}$, of the existing MSW could vary between 0.045 to 0.085, with a

mean value of 0.06 (c_a and e_o are secondary compression index and initial void ratio, respectively). This is



consistent with the range of $c_{\alpha\varepsilon} = 0.02$ to >0.14 reported in the literature for MSW (e.g. Gourc & Olivier¹ [2005] and Hossain et. al². [2003]). The analysis results suggest a slight trend in that areas with thicker waste, and/or more recently placed waste, may have a higher secondary compression index.

Our analyses also indicate that up to ± 4 m variation in the waste thickness placed between 2001 and 2004 could change $c_{\alpha\varepsilon}$ about ± 10 ~25% for SM2 and SM6, which are located on the valley side slopes (see Figure 3). This degree of sensitivity is considered acceptable.

Therefore, further to the recommendations provided in the Golder memo No. 117625003_253_M_Rev0, we recommend a value of $c_{\alpha\varepsilon}$ =0.07 is adopted for the existing waste in the Eastern Gully landfill in the detail design settlement analyses. The value of 0.07 is slightly more conservative than the mean value back-calculated value of 0.06.

If you have any questions regarding this memorandum, please contact the undersigned.

Saman Jorgarbeshi

Saman Zargarbashi Senior Geotechnical Engineer

SZ/JDM:GRS/sz

Attachments:

Gary Schmertmann Principal Geotechnical Engineer

Figure 1: WGRRP –Eastern Gully Plan and Settlement Monuments(1 No Page). Figures 2 to 3: Long Section and Cross Sections through the Eastern Gully (2 No Pages). Figures 4: Results of Settlement Monuments for Eastern Gully (1 No Page). Table 2 to 7: Back-analysis calculations summary at each settlement monument (6 No Pages).

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² Hossain, M, S., Gabr, M.A., and Barlaz, M.A. 'Relationship of compressibility parameters to municipal solid waste decomposition.' Journal of Geotechnical and Geoenvironmental Engineering, 2003, 129 (12), 1151-1158.



¹ Gourc, J. P., Olivier, F. 'Calibration of the Incremental Settlement Prediction Model (ISPM) from field monitoring campaigns', International Workshop "Hydro-Physico-Mechanics of Landfills, Grenoble University, 21-22 March 2005.



Figure 1.

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DATUM 0.00	29.11	27.91	28.68	29.02	29.42	29.73	30.71	10.05	18.07	41.94	44.65	48.58	52.17	54.89	60.04	62.29	64.20	65.18	66.73	68.88	70.92	72.52	76.40	78.66	81.08	82.84	84.45	86.60	87.88	87.80	86.01	83.73	83.16	79.36	75.69	74.92	74.88	75.84	77.40	78.62	78.70	78.86	79.12	81.79	83.38	00.00	93.73	95.76	98.64	103.20	106.36	112.85	12:00	
SIGN SURFACE		30.84	36.62	39.51	42.40	45.29	48.18	1010	56.85	59.74	62.63	65.52	68.44	74.44	77.45	80,45	83.46	86.46	89.46	52.43	95.39	99.45	103.47	100.96	99.63	98.40	97.37	96.09	96.56	96.03	35.45	94.06 04.61	93.09	92.56	91.83	68.29	86.29	84.40	82.78	81.32	78.47	76.99	-										t	
D. SURFACE 4					27.26	25.22	25.91	PERCZ	25.08	26.38	26.98	27.09	27.68	28.42	29,39	29.00	28.42	28.45	28.85	29,30	29.90	30.72	31.75	34.81	36.31	37.67	38.99	40.00	40.96	42.02	43.45	46.47	47.94	49,58	51.98	56.25	58.85	61.57	63.68	66.95	69.12	70.89	73.76										Ī	
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Section A-A

Figure 2.

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29/11/2012



Section B_B

Figure 3

					Se	ttlement (m	m)				
Monument No	8-Feb-12	14-Feb-12	13-Mar-12	12-Apr-12	9-May-12	14-Jun-12	12-Jul-12	8-Aug-12	10-Sep-12	5-Oct-12	14-Nov-12
SM1		3.000	3	36	31.000	58	74.000	92.000	108.000	121.000	137
SM2		1.000	0	26	16	35	37.000	51.000	59.000	70.000	69
SM3		3.000	2	15	13	18	23.000	41.000	49.000	49.000	56
SM4		2.000	4	19	14	19	22.000	41.000	43.000	55.000	68
SM5		3.000	0	12	11	11	15.000	30.000	33.000	37.000	46
SM6		3.000	0	5	-1	7	5.000	9.000	16.000	21.000	30
SM18		-55.000	0	48	41	131	142.000	205.000	255	0	0
SM19		3.000	59	127	120	215	260.000	304.000	0	0	0







Waste Materials		Old W	/aste	Basis of adopted value
Material	Stage 1	Stage 2	Stage 3	
	2001-2004	2004-2009	2009-2012	
waste type	MSW	MSW	MSW	from available site information
Unit Weight (kN/m3)	11	11	11	assumed based on waste type
C-ce (mod primary)	0.2	0.2	0.2	range from Gourc & Olivier (2005) is 0.12 to >0.24
C-c alph (mod secondary)	0.085	0.085	0.085	range from Gourc & Olivier (2005) is 0.02 to >0.14
Average age till 8/02/2012	10.2	7.7	2.2	from available site information

Section 12.4.2 Settlement of existing solid waste: Eq 12.11, Ref Xuede, Koerner and Gray P.451

$$s = H \times C_{\alpha\varepsilon} \times \log \frac{t_{final}}{t_{initial}}$$

 $C_{lphaarepsilon}$ - Modified secondary compression index

Assumptions

t-initial= average age in Feb 2012 at the start of settlement monitoring.
Creep starts as filling commences.

Point	SM1										
Thickness of Existing Landfill Waste Filli	ng Stages (m)										
Stage 1 (2001-2004)	19.135										[
Stage 2 (2004-2009)	23.426										1
Stage 3 (2009-2012)	0										1
Stage 4	0										1
Total thickness of existing waste	42 561										f

Point	SM1	SM1	SM1	SM1	SM1	SM1	SM1	SM1	SM1	SM1	SM1	SM1														
Total Thickness	42.56	42.56	42.56	42.56	42.56	42.56	42.56	42.56	42.56	42.56	42.56	42.56	42.56	42.56	42.56	42.56	42.56	42.56	42.56	42.56	42.56	42.56	42.56	42.56	42.56	42.56
Old Waste																										
Thickness Western Gully Filling Stage3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T-initial (yr)	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17
T-final (yr)	2.19	2.25	2.28	2.30	2.33	2.36	2.39	2.41	2.44	2.47	2.52	2.58	2.63	2.69	2.74	2.80	2.85	2.91	2.96	3.02	3.07	3.13	3.18	3.24	3.29	3.34
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thickness Western Gully FIlling Stage2	23.43	23.43	23.43	23.43	23.43	23.43	23.43	23.43	23.43	23.43	23.43	23.43	23.43	23.43	23.43	23.43	23.43	23.43	23.43	23.43	23.43	23.43	23.43	23.43	23.43	23.43
T-initial (yr)	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67
T-final (yr)	7.69	7.75	7.78	7.80	7.83	7.86	7.89	7.91	7.94	7.97	8.02	8.08	8.13	8.19	8.24	8.30	8.35	8.41	8.46	8.52	8.57	8.63	8.68	8.74	8.79	8.84
Calc settlement of layer (m)	0.00	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.05	0.05	0.06	0.06	0.07	0.07	0.08	0.09	0.09	0.10	0.10	0.11	0.11	0.12	0.12
Thickness Western Gully Filling Stage1	19.14	19.14	19.14	19.14	19.14	19.14	19.14	19.14	19.14	19.14	19.14	19.14	19.14	19.14	19.14	19.14	19.14	19.14	19.14	19.14	19.14	19.14	19.14	19.14	19.14	19.14
T-initial (yr)	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17
T-final (yr)	10.19	10.25	10.28	10.30	10.33	10.36	10.39	10.41	10.44	10.47	10.52	10.58	10.63	10.69	10.74	10.80	10.85	10.91	10.96	11.02	11.07	11.13	11.18	11.24	11.29	11.34
Calc settlement of layer (m)	0.00	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.04	0.04	0.04	0.05	0.05	0.05	0.06	0.06	0.06	0.07	0.07	0.07	0.08
Total "Secondary" settlement(mm)	4.99	14.91	19.85	24.77	29.68	34.57	39.44	44.30	49.15	53.98	63.59	73.15	82.64	92.08	101.46	110.78	120.05	129.27	138.42	147.53	156.58	165.58	174.53	183.42	192.26	201.06
Monitoring Time (days)	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260	280	300	320	340	360	380	400	420



TABLE 2.



Waste Materials		Old V	Vaste	Basis of adopted value
Material	Stage 1	Stage 2	Stage 3	
	2001-2004	2004-2009	2009-2012	
waste type	MSW	MSW	MSW	from available site information
Unit Weight (kN/m3)	11	11	11	assumed based on waste type
C-ce (mod primary)	0.2	0.2	0.2	range from Gourc & Olivier (2005) is 0.12 to >0.24
C-c alph (mod secondary)	0.07	0.07	0.07	range from Gourc & Olivier (2005) is 0.02 to >0.14
Average age till 8/02/2012	10.2	7.7	2.2	from available site information

Section 12.4.2 Settlement of existing solid waste: Eq 12.11, Ref Xuede, Koerner and Gray P.451

$$s = H \times C_{\alpha\varepsilon} \times \log \frac{t_{final}}{t_{initial}}$$

 $C_{lphaarepsilon}$ - Modified secondary compression index

Assumptions

t-initial= average age in Feb 2012 at the start of settlement monitoring.
Creep starts as filling commences.

Point	SM2													
Thickness of Existing Landfill Waste Fillin	g Stages (m)												
Stage 1 (2001-2004)	4.881													
Stage 2 (2004-2009)	22.579													1
Stage 3 (2009-2012)	0													1
Stage 4														
Total thickness of existing waste	27.46													

Point	SM2	SM2	SM2																							
Total Thickness	27.46	27.46	27.46	27.46	27.46	27.46	27.46	27.46	27.46	27.46	27.46	27.46	27.46	27.46	27.46	27.46	27.46	27.46	27.46	27.46	27.46	27.46	27.46	27.46	27.46	27.46
Old Waste																										
Thickness Western Gully FIlling Stage3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T-initial (yr)	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17
T-final (yr)	2.19	2.25	2.28	2.30	2.33	2.36	2.39	2.41	2.44	2.47	2.52	2.58	2.63	2.69	2.74	2.80	2.85	2.91	2.96	3.02	3.07	3.13	3.18	3.24	3.29	3.34
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thickness Western Gully FIlling Stage2	22.58	22.58	22.58	22.58	22.58	22.58	22.58	22.58	22.58	22.58	22.58	22.58	22.58	22.58	22.58	22.58	22.58	22.58	22.58	22.58	22.58	22.58	22.58	22.58	22.58	22.58
T-initial (yr)	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67
T-final (yr)	7.69	7.75	7.78	7.80	7.83	7.86	7.89	7.91	7.94	7.97	8.02	8.08	8.13	8.19	8.24	8.30	8.35	8.41	8.46	8.52	8.57	8.63	8.68	8.74	8.79	8.84
Calc settlement of layer (m)	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.04	0.04	0.05	0.05	0.05	0.06	0.06	0.07	0.07	0.08	0.08	0.09	0.09	0.09	0.10
Thickness Western Gully FIlling Stage1	4.88	4.88	4.88	4.88	4.88	4.88	4.88	4.88	4.88	4.88	4.88	4.88	4.88	4.88	4.88	4.88	4.88	4.88	4.88	4.88	4.88	4.88	4.88	4.88	4.88	4.88
T-initial (yr)	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17
T-final (yr)	10.19	10.25	10.28	10.30	10.33	10.36	10.39	10.41	10.44	10.47	10.52	10.58	10.63	10.69	10.74	10.80	10.85	10.91	10.96	11.02	11.07	11.13	11.18	11.24	11.29	11.34
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02
Total "Secondary" settlement(mm)	2.85	8.51	11.33	14.14	16.94	19.73	22.51	25.28	28.05	30.80	36.28	41.72	47.13	52.50	57.84	63.14	68.41	73.65	78.85	84.02	89.16	94.27	99.34	104.39	109.40	114.39
Monitoring Time (days)	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260	280	300	320	340	360	380	400	420



TABLE 3.



Waste Materials		Old V	/aste	Basis of adopted value
Material	Stage 1	Stage 2	Stage 3	
	2001-2004	2004-2009	2009-2012	
waste type	MSW	MSW	MSW	from available site information
Unit Weight (kN/m3)	11	11	11	assumed based on waste type
C-ce (mod primary)	0.2	0.2	0.2	range from Gourc & Olivier (2005) is 0.12 to >0.24
C-c alph (mod secondary)	0.06	0.06	0.06	range from Gourc & Olivier (2005) is 0.02 to >0.14
Average age till 8/02/2012	10.2	7.7	2.2	from available site information

Section 12.4.2 Settlement of existing solid waste: Eq 12.11, Ref Xuede, Koerner and Gray P.451

$$s = H \times C_{\alpha\varepsilon} \times \log \frac{t_{final}}{t_{initial}}$$

 $C_{lphaarepsilon}$ - Modified secondary compression index

Assumptions

t-initial= average age in Feb 2012 at the start of settlement monitoring.
Creep starts as filling commences.

Point	SM3												
Thickness of Existing Landfill Waste Fill	ing Stages (m)												
Stage 1 (2001-2004)	17.979												
Stage 2 (2004-2009)	11.325												
Stage 3 (2009-2012)	0												
Stage 4													
Total thickness of existing waste	29 304											1	

Point	SM3																									
Total Thicknoss	20.30	20.20	20.30	20.30	20.30	20.30	20.20	20.30	20.30	29.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.20	20.30	20.30	20.30	20.30
Old Waste	29.50	29.30	23.30	29.30	29.30	23.30	23.30	29.30	23.30	23.30	23.30	23.30	29.30	23.30	23.30	23.30	29.30	23.30	23.30	29.00	23.30	29.30	29.00	29.30	23.30	29.30
Thickness Western Gully Filling Stage3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T-initial (yr)	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17
T-final (yr)	2.19	2.25	2.28	2.30	2.33	2.36	2.39	2.41	2.44	2.47	2.52	2.58	2.63	2.69	2.74	2.80	2.85	2.91	2.96	3.02	3.07	3.13	3.18	3.24	3.29	3.34
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thickness Western Gully Filling Stage2	11.33	11.33	11.33	11.33	11.33	11.33	11.33	11.33	11.33	11.33	11.33	11.33	11.33	11.33	11.33	11.33	11.33	11.33	11.33	11.33	11.33	11.33	11.33	11.33	11.33	11.33
T-initial (yr)	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67
T-final (yr)	7.69	7.75	7.78	7.80	7.83	7.86	7.89	7.91	7.94	7.97	8.02	8.08	8.13	8.19	8.24	8.30	8.35	8.41	8.46	8.52	8.57	8.63	8.68	8.74	8.79	8.84
Calc settlement of layer (m)	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04
Thickness Western Gully Filling Stage1	17.98	17.98	17.98	17.98	17.98	17.98	17.98	17.98	17.98	17.98	17.98	17.98	17.98	17.98	17.98	17.98	17.98	17.98	17.98	17.98	17.98	17.98	17.98	17.98	17.98	17.98
T-initial (yr)	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17
T-final (yr)	10.19	10.25	10.28	10.30	10.33	10.36	10.39	10.41	10.44	10.47	10.52	10.58	10.63	10.69	10.74	10.80	10.85	10.91	10.96	11.02	11.07	11.13	11.18	11.24	11.29	11.34
Calc settlement of layer (m)	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05
Total "Secondary" settlement(mm)	2.31	6.92	9.21	11.50	13.77	16.05	18.31	20.57	22.82	25.06	29.53	33.97	38.39	42.78	47.14	51.48	55.80	60.09	64.35	68.59	72.81	77.00	81.17	85.32	89.45	93.55
Monitoring Time (days)	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260	280	300	320	340	360	380	400	420



TABLE 4.



Waste Materials		Old V	/aste	Basis of adopted value
Material	Stage 1	Stage 2	Stage 3	
	2001-2004	2004-2009	2009-2012	
waste type	MSW	MSW	MSW	from available site information
Unit Weight (kN/m3)	11	11	11	assumed based on waste type
C-ce (mod primary)	0.2	0.2	0.2	range from Gourc & Olivier (2005) is 0.12 to >0.24
C-c alph (mod secondary)	0.06	0.06	0.06	range from Gourc & Olivier (2005) is 0.02 to >0.14
Average age till 8/02/2012	10.2	7.7	2.2	from available site information

Section 12.4.2 Settlement of existing solid waste: Eq 12.11, Ref Xuede, Koerner and Gray P.451

$$s = H \times C_{\alpha\varepsilon} \times \log \frac{t_{final}}{t_{initial}}$$

 $C_{lpha arepsilon}$ - Modified secondary compression index

Assumptions

t-initial= average age in Feb 2012 at the start of settlement monitoring.
Creep starts as filling commences.

Point	SM4												
Thickness of Existing Landfill Waste Fillin	ig Stages (m)												
Stage 1 (2001-2004)	18.687												
Stage 2 (2004-2009)	9.528												
Stage 3 (2009-2012)	0												
Stage 4													
Total thickness of existing waste	28 215											1	1

Point	SM4																									
Total Thickness	28.22	28.22	28.22	28.22	28.22	28.22	28.22	28.22	28.22	28.22	28.22	28.22	28.22	28.22	28.22	28.22	28.22	28.22	28.22	28.22	28.22	28.22	28.22	28.22	28.22	28.22
Old Waste																										
Thickness Western Gully FIlling Stage3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T-initial (yr)	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17
T-final (yr)	2.19	2.25	2.28	2.30	2.33	2.36	2.39	2.41	2.44	2.47	2.52	2.58	2.63	2.69	2.74	2.80	2.85	2.91	2.96	3.02	3.07	3.13	3.18	3.24	3.29	3.34
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thickness Western Gully FIlling Stage2	9.53	9.53	9.53	9.53	9.53	9.53	9.53	9.53	9.53	9.53	9.53	9.53	9.53	9.53	9.53	9.53	9.53	9.53	9.53	9.53	9.53	9.53	9.53	9.53	9.53	9.53
T-initial (yr)	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67
T-final (yr)	7.69	7.75	7.78	7.80	7.83	7.86	7.89	7.91	7.94	7.97	8.02	8.08	8.13	8.19	8.24	8.30	8.35	8.41	8.46	8.52	8.57	8.63	8.68	8.74	8.79	8.84
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.04
Thickness Western Gully Filling Stage1	18.69	18.69	18.69	18.69	18.69	18.69	18.69	18.69	18.69	18.69	18.69	18.69	18.69	18.69	18.69	18.69	18.69	18.69	18.69	18.69	18.69	18.69	18.69	18.69	18.69	18.69
T-initial (yr)	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17
T-final (yr)	10.19	10.25	10.28	10.30	10.33	10.36	10.39	10.41	10.44	10.47	10.52	10.58	10.63	10.69	10.74	10.80	10.85	10.91	10.96	11.02	11.07	11.13	11.18	11.24	11.29	11.34
Calc settlement of layer (m)	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05
Total "Secondary" settlement(mm)	2.20	6.57	8.74	10.91	13.08	15.23	17.38	19.53	21.67	23.80	28.04	32.26	36.45	40.62	44.77	48.89	52.99	57.07	61.12	65.15	69.16	73.15	77.11	81.06	84.98	88.88
Monitoring Time (days)	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260	280	300	320	340	360	380	400	420



TABLE 5.



Waste Materials		Old V	/aste	Basis of adopted value
Material	Stage 1	Stage 2	Stage 3	
	2001-2004	2004-2009	2009-2012	
waste type	MSW	MSW	MSW	from available site information
Unit Weight (kN/m3)	11	11	11	assumed based on waste type
C-ce (mod primary)	0.2	0.2	0.2	range from Gourc & Olivier (2005) is 0.12 to >0.24
C-c alph (mod secondary)	0.055	0.055	0.055	range from Gourc & Olivier (2005) is 0.02 to >0.14
Average age till 8/02/2012	10.2	7.7	2.2	from available site information

Section 12.4.2 Settlement of existing solid waste: Eq 12.11, Ref Xuede, Koerner and Gray P.451

$$s = H \times C_{\alpha\varepsilon} \times \log \frac{t_{final}}{t_{initial}}$$

 $C_{lpha arepsilon}$ - Modified secondary compression index

Assumptions

t-initial= average age in Feb 2012 at the start of settlement monitoring.
Creep starts as filling commences.

Point	SM5												
Thickness of Existing Landfill Waste Filling	Stages (m)												
Stage 1 (2001-2004)	22.98												1
Stage 2 (2004-2009)	2.159												1
Stage 3 (2009-2012)	0												1
Stage 4													1
Total thickness of existing waste	25,139												í The second sec

Point	SM5																									
Total Thickness	25.14	25.14	25.14	25.14	25.14	25.14	25.14	25.14	25.14	25.14	25.14	25.14	25.14	25.14	25.14	25.14	25.14	25.14	25.14	25.14	25.14	25.14	25.14	25.14	25.14	25.14
Old Waste																										
Thickness Western Gully Filling Stage3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T-initial (yr)	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17
T-final (yr)	2.19	2.25	2.28	2.30	2.33	2.36	2.39	2.41	2.44	2.47	2.52	2.58	2.63	2.69	2.74	2.80	2.85	2.91	2.96	3.02	3.07	3.13	3.18	3.24	3.29	3.34
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thickness Western Gully FIlling Stage2	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16
T-initial (yr)	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67
T-final (yr)	7.69	7.75	7.78	7.80	7.83	7.86	7.89	7.91	7.94	7.97	8.02	8.08	8.13	8.19	8.24	8.30	8.35	8.41	8.46	8.52	8.57	8.63	8.68	8.74	8.79	8.84
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Thickness Western Gully Filling Stage1	22.98	22.98	22.98	22.98	22.98	22.98	22.98	22.98	22.98	22.98	22.98	22.98	22.98	22.98	22.98	22.98	22.98	22.98	22.98	22.98	22.98	22.98	22.98	22.98	22.98	22.98
T-initial (yr)	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17
T-final (yr)	10.19	10.25	10.28	10.30	10.33	10.36	10.39	10.41	10.44	10.47	10.52	10.58	10.63	10.69	10.74	10.80	10.85	10.91	10.96	11.02	11.07	11.13	11.18	11.24	11.29	11.34
Calc settlement of layer (m)	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.06	0.06
Total "Secondary" settlement(mm)	1.66	4.97	6.62	8.26	9.90	11.53	13.16	14.79	16.41	18.02	21.24	24.44	27.63	30.80	33.95	37.08	40.20	43.30	46.39	49.46	52.51	55.55	58.57	61.58	64.58	67.55
Monitoring Time (days)	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260	280	300	320	340	360	380	400	420



TABLE 6.



Waste Materials		Old V	/aste	Basis of adopted value
Material	Stage 1	Stage 2	Stage 3	
	2001-2004	2004-2009	2009-2012	
waste type	MSW	MSW	MSW	from available site information
Unit Weight (kN/m3)	11	11	11	assumed based on waste type
C-ce (mod primary)	0.2	0.2	0.2	range from Gourc & Olivier (2005) is 0.12 to >0.24
C-c alph (mod secondary)	0.045	0.045	0.045	range from Gourc & Olivier (2005) is 0.02 to >0.14
Average age till 8/02/2012	10.2	7.7	2.2	from available site information

Section 12.4.2 Settlement of existing solid waste: Eq 12.11, Ref Xuede, Koerner and Gray P.451

$$s = H \times C_{\alpha \varepsilon} \times \log \frac{t_{final}}{t_{initial}}$$

 $C_{lphaarepsilon}$ - Modified secondary compression index

Assumptions

t-initial= average age in Feb 2012 at the start of settlement monitoring.
Creep starts as filling commences.

Point	SM6												
Thickness of Existing Landfill Waste Filling	Stages (m)												
Stage 1 (2001-2004)	18.168											,	1
Stage 2 (2004-2009)	2.25											, ,	1
Stage 3 (2009-2012)	0											, !	i i
Stage 4													1
Total thickness of existing waste	20.418												

Point	SM6																									
Total Thickness	20.42	20.42	20.42	20.42	20.42	20.42	20.42	20.42	20.42	20.42	20.42	20.42	20.42	20.42	20.42	20.42	20.42	20.42	20.42	20.42	20.42	20.42	20.42	20.42	20.42	20.42
Old Waste	20.42	20.42	20.42	20.42	20.42	20.42	20.42	20.42	20.42	20.42	20.42	20.42	20.42	20.42	20.42	20.42	20.42	20.42	20.42	20.42	20.42	20.42	20.42	20.42	20.42	20.42
Thickness Western Gully Filling Stage3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T-initial (yr)	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17
T-final (yr)	2.19	2.25	2.28	2.30	2.33	2.36	2.39	2.41	2.44	2.47	2.52	2.58	2.63	2.69	2.74	2.80	2.85	2.91	2.96	3.02	3.07	3.13	3.18	3.24	3.29	3.34
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thickness Western Gully FIlling Stage2	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25
T-initial (yr)	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67
T-final (yr)	7.69	7.75	7.78	7.80	7.83	7.86	7.89	7.91	7.94	7.97	8.02	8.08	8.13	8.19	8.24	8.30	8.35	8.41	8.46	8.52	8.57	8.63	8.68	8.74	8.79	8.84
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
Thickness Western Gully FIlling Stage1	18.17	18.17	18.17	18.17	18.17	18.17	18.17	18.17	18.17	18.17	18.17	18.17	18.17	18.17	18.17	18.17	18.17	18.17	18.17	18.17	18.17	18.17	18.17	18.17	18.17	18.17
T-initial (yr)	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17
T-final (yr)	10.19	10.25	10.28	10.30	10.33	10.36	10.39	10.41	10.44	10.47	10.52	10.58	10.63	10.69	10.74	10.80	10.85	10.91	10.96	11.02	11.07	11.13	11.18	11.24	11.29	11.34
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04
Total "Secondary" settlement(mm)	1.11	3.33	4.43	5.53	6.63	7.72	8.81	9.90	10.99	12.07	14.22	16.37	18.50	20.62	22.73	24.83	26.91	28.99	31.05	33.11	35.15	37.18	39.21	41.22	43.22	45.21
Monitoring Time (days)	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260	280	300	320	340	360	380	400	420





WHYTES GULLY NEW LANDFILL CELL Report for Preliminary Design

Submitted to: Wollongong City Council

REPORT

Distribution: Wollongong City Council Golder Associates

Report Number.

117625003_058_R_Rev0

Golder



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FIGURES WITHIN REPORT

Figure A – Lining System Details

Figure B – Final Capping System Details

APPENDICES

APPENDIX A Preliminary Design Drawings

APPENDIX B Preliminary Technical Specification

APPENDIX C

Interpretative Geotechnical Investigation Report for 50% Design

APPENDIX D International Peer Review





1.0 INTRODUCTION

1.1 Report Context

This design report has been prepared on behalf of Wollongong City Council and presents a preliminary design (at 50% design status) for the proposed New Landfill Cell expansion project at the Whytes Gully Resource Recovery Park (RRP) near Kembla Grange, NSW. This design report forms part of the Environmental Assessment (EA) documentation for the proposed project.

This design report makes extensive reference to other relevant documents as listed in Table 1 below.

Document	Description	Location			
Preliminary Design Document	Preliminary Design Documents				
Preliminary Design Drawings	engineering drawings (preliminary) with landfill construction details; refer Section 1.2 below	Appendix A			
Preliminary Technical Specification	technical specifications for landfill construction materials and construction works (preliminary); includes construction quality management requirements	Appendix B			
Information Documents - app	ended to this report				
Interpretative Geotechnical Investigation Report for 50% Design	interpretative report with geotechnical parameters for landfill design; includes slope stability and settlement analysis for the proposed project	Appendix C			
International Peer Review	international peer review letter for the preliminary design	Appendix D			
Information Documents - app	ended to Environmental Assessment (EA) d	locument			
Environmental Site Assessment Reports relevant to the preliminary design	site assessments relevant to landfill design and operations with information on flora and fauna, site contamination, noise, and air quality	EA document- Appendices: - F: flora and fauna - G: site contamination - D: noise generation - H: air quality			
Hydrogeological Site Investigation Report	report on results of the hydrogeological investigation at the site	EA document - Appendix G			
Geotechnical Site Investigation Report	report on results of the geotechnical investigation at the site	EA document - Appendix G			
Leachate Generation and Water Balance Modelling	report on estimated leachate generation rates and storage requirements	EA document - Appendix G			
Surface Water Assessment Report	report on site surface water conditions and storage and management requirements	EA document - Appendix G			
Landscape Strategy	plan and approach to revegetation of the final landform	EA document - Appendix N			
LEMP– Draft Landfill Environmental Management Plan	draft documentation of environmental objectives and management strategies for landfill site operations; includes planned landfill staging; includes post-closure monitoring and maintenance protocols	EA document - Appendix P			

Table 1: Documents Relevant to Proposed New Landfill Cell Design





1.2 Preliminary Design Drawings

The preliminary design drawings in Appendix A comprise 23 sheets which are referred to frequently in this report. For ease of reference, the drawing list is presented in the table below.

Drawing No.	Revision No.	Drawing Title	
Existing Infor	rmation		
D001	В	Site Locality and Drawing List	
D002	В	Site Plan	
D003	В	Existing Contours and Easements	
D004	В	Approximate Bottom of Existing Waste Plan	
Final Landform			
D011	В	Waste Cutback Plan and Sections	
D012	В	Staging and Subgrade Preparation Plan	
D013	В	Subgrade Preparation Sections	
D014	В	Final Cap Profile	
D015	В	Final Landform Indicative Sections – Sheet 1	
D016	В	Final Landform Indicative Sections – Sheet 2	
D017	В	Indicative Sections Along Landform Edge – Sheet 1	
D018	В	Indicative Sections Along Landform Edge – Sheet 2	
D019	В	Indicative Sections Along Landform Edge – Sheet 3	
Cell Base			
D021	В	New Cell Cross Sections	
D022	В	Cell Base Liner Details	
Piggy Back			
D031	В	Piggy Back Liner Details	
Leachate Col	lection		
D041	В	Leachate Collection System Plan	
D042	В	Leachate Collection System Details – Sheet 1	
D043	В	Leachate Collection System Details – Sheet 2	
Surface Water Management			
D051	В	Surface Water Management System Concept Plan	
D052	В	Bench and Drop Structure Details	
Final Capping			
D061	В	Capping Details	
Landfill Gas Management			
D071	В	Piggy Back Gas Venting System Plan	

Table 2: List of Preliminary Design Drawings



1.3 Report Organisation

The remainder of this report is organised as follows:

- site conditions that are relevant to the design are presented in Chapter 2;
- the design approach is presented in Chapter 3;
- design features are described in Chapter 4;
- key issues for construction and for operation and maintenance are outlined in Chapters 5 and 6;
- technical references are given in Chapter 7; and
- limitations of this report are described in Chapter 8.

Supporting information is provided in the appendices of this report, including a letter resulting from an international peer review of this report (Appendix D).

2.0 SITE CONDITIONS

2.1 General

Whytes Gully RRP is located approximately 10 km to the south west of the Wollongong CBD and is approximately 65 ha in size. Whytes Gully RRP is generally bounded by Reddalls Road to the south and west, rural residential lands to the north, north-east and north-west, and a water treatment plant to the south east. Dapto Creek is also located to the immediate west of the site. The site vicinity is indicated in Drawing D001.

The wider area around Whytes Gully RRP includes the Illawarra escarpment to the north and west, and an industrial area to the south and south west of the site. The residential suburb of Farmborough Heights is located to the north east over a ridgeline, with the closest residents of this suburb approximately 360 m from Whytes Gully RRP. Two individual residences are within 120 m of the site boundary - one to the north of the Eastern Gully landfill and the other to the west of the Western Gully landfill - as visible in the aerial photograph presented in Drawing D002.

The site information provided in this chapter is relevant to preliminary landfill design. Detailed site information is provided in the documents identified in Table 1.

2.2 Topography and Hydrology

The west-northwest and eastern extents of the landfill area are bounded by ridgelines, referred to as the western ridge and eastern ridge. A central north-south trending ridgeline, referred to as the central ridge, separates the two existing landfill areas, the Western Gully landfill and Eastern Gully landfill (refer Section 2.6). The site rises from RL 15 m at the south west to RL 100 m at the north east. Refer to Drawing D003.

The current surface of the Western Gully landfill is generally sloped at approximately 5H:1V, with indistinct benches at 5 m to 10 m vertical intervals. The landfill surface above RL 80 m has gentler slopes, generally flatter than 10%.

The current surface of the Eastern Gully landfill has an upper platform portion where active landfilling is taking place, as well as a southwest-facing batter portion. The batter portion has an average slope of approximately 4H:1V and is terraced with benches at 2m to 3m vertical intervals, bench widths at 3m to 5m, and slope inclinations of 2H:1V to 3H:1V between benches.

The general surface water drainage direction on the site is from the north east towards the south west. The catchment area of the site is approximately 65 ha and extends from a ridge to the north of the site to Reddalls Road to the south. Run-on to the site is minimal due to the site being bounded by ridgelines.

Surface water runoff from covered areas of the Western and Eastern Gully landfills is captured by swales on the landfill surface. The swales divert the runoff towards drains around the perimeter of the landfills and to a central drain between the Eastern and Western Gully landfills. Runoff from the natural slope above the northern edge of the Eastern Gully landfill is also directed to the central drain.

Surface water runoff reports to the surface water ponds at the southwest corner of the site before discharge to Dapto Creek. Additional information on hydrology and surface water management is provided in Section 2.5.4 and in the Surface Water Assessment Report in Appendix G of the EA document.

2.3 Subsurface Conditions

2.3.1 Geology and Seismicity

Based on the 1:100,000 geological map 'Wollongong-Port Hacking', the site is on the boundary of two major geological formations. The southern part of the site is underlain by alluvial sands, silts and clays associated with nearby Dapto Creek, with sandstone of the Budgong Sandstone formation underlying these alluvial soils. The central part of the site is underlain by red, brown and grey lithic sandstone that forms part of the Budgong Sandstone formation. The northern portion of the site is underlain by interbedded lithic sandstone, coal, carbonaceous claystone, siltstone and claystone of the Pheasants Nest Formation. It appears that the Pheasants Nest formation is mainly encountered on the ridgelines.





The EIS (1982) for the Western Gully landfill indicates that prior to land-filling, volcanic sandstone covered most of the site with a transition to andesitic sandstone with coal seams, carbonaceous shale and mudstone in the higher section (above approximately RL 100 m) and a zone of alluvium, gravels and sands in the lower sections (below approximately RL 30 m). Bedrock is reported at the surface in the upper sections of the site.

The EIS (1992) for the Eastern Gully landfill notes that a relatively thick layer of colluvium was found along the base of the Eastern Gully. Soils are discussed further in Section 2.3.2.

The potential seismicity for the site has been assessed using Australian Standard AS1170.4-2007, specifically Structural design action Part 4: Earthquake actions in Australia. The Peak Ground Acceleration (PGA), probability factor, and hazard factor are obtained from AS1170.4 2007 Section 3, as follows:

- The design earthquake adopted for the site is equivalent to an event with an annual probability of occurrence of 1 in 500; and the Probability Factor (*kp*) associated with a 1/500 annual probability event is 1.0. Refer to Table 3.1 AS1170.4 2007 for values; and
- The earthquake hazard factor (z) is equivalent to an acceleration coefficient with an annual probability of exceedence in 1/500, and in the Wollongong vicinity is equal to 0.09. Refer to Table 3.2 AS1170.4 2007 for values.

The proposed design PGA for the Whytes Gully RRP site is therefore 0.09 g (α).

2.3.2 Stratigraphy

As indicated in Appendix C, the inferred subsurface stratigraphy generally consists of soil fill materials, landfill waste, colluvial / alluvial soils, residual soils and sandstone and siltstone rock.

The thickness of the soil and fill units varies throughout the site. The depth to sandstone and siltstone rock in the existing natural slope areas is relatively small, typically 3m or less.

Relevant information on soil and fill materials is given in the table below, with additional detail provided in Appendix C.

Material	Description	
Fill - general	Fill was encountered in zones of the proposed Cell 1 to 4 area at the southern edge of the proposed landfill (refer Drawing D004). This area is also referred to as the new cell floor area. This fill had variable thickness and comprised clayey soils with sands. Observation indicates that thickness may be up to 5m in the vicinity of the existing landfill access road and recycling area.	
Fill – existing landfill cap	Fill in the existing landfill cap comprises mixed soils (clays/sands) with pockets of gravels, slag and coal-wash. Thickness generally ranges from 0.5m to 2.0m.	
Existing Landfill Waste	Landfill Waste is present beneath the existing landfill cap material in both the Eastern and Western Gully landfills. Maximum thickness is approximately 50 m in the Eastern Gully Landfill and 35 m in the Western Gully Landfill. Refer to Section 2.6 for additional information.	
Colluvial and Alluvial soils	These soils comprise mostly silty clay and clay with zones of sands and gravels and traces of cobbles. Soils within 2 m to 3 m of the surface are soft to firm in parts and strength improves with depth. Clear distinction between the Colluvial soils on the lower slopes and the Alluvial soils at the base of the slopes is not generally possible. The maximum combined thickness of colluvial/alluvial soils within the proposed landfill footprint is approximately 16 m. Additional discussion is provided below.	
Residual soil	Residual soil is mostly clay with varying quantities of gravel, silt and sand. The clay is medium plasticity and generally stiff to very stiff with zones of medium dense to dense sand. The maximum thickness of this material in natural areas of the site is approximately 2m. Additional discussion is provided below.	

Table 3: General Description of Soil and Fill Materials





Discussion of colluvial soils

The "Geology and Natural Slope Stability Zones in the City of Greater Wollongong, Figure 19, Sheets 1 and 2" (Rec. Geol. Surv. NSW, 14(2): Bowman, 1972) characterise the upper natural slopes at the site as "moderately unstable, generally topographically high-relief land underlain by potentially unstable material requiring thorough investigation before development" and the site area at the toe of the natural slopes as "stable land with no landslip problems." This 1972 categorisation for the upper natural slopes is likely due to the observed presence of colluvium. Further, historical photographs taken from ground-level in the Eastern Gully at a time before landfill development, which have been provided to Golder by Council, show surface topography and conditions that are generally consistent with the presence of colluvial soils and potentially perched groundwater levels within the gully slopes.

We understand that colluvial and residual soil were excavated from the sloping portions of the Eastern and Western Gully landfill areas during preparation works prior to landfill development. This is based on discussion and photographs from with Mr. L. Monaghan of Council, who was involved in this operation. It appears that the slopes are likely to have been almost completely stripped to rockhead. However, it appears that colluvium and residual soils were only partially removed at the base of the natural slopes.

2.3.3 Groundwater

As indicated in the Site Hydrogeological Investigation Report (Appendix G of EA document), groundwater occurrence at the Whytes Gully RRP is generally associated with two shallow systems: groundwater present in the upper weathered and fractured profile of the local bedrock geology, and groundwater present in the colluvium/alluvium deposits that infill the two gullies at the site at the toe of the sloping topography. Water levels measured in wells installed within the shallow weathered bedrock in the sloping northern portion of the site generally range from 5 to 10 metres below ground level (mbgl), whereas water levels in wells installed in both the shallow bedrock and unconsolidated material in the flatter southern portion of the site are shallower, generally on the order of 1 to 3 mbgl.

Anecdotal information suggests that isolated springs were present in the mid and upper slopes of the two gullies prior to landfilling of these areas. The specific locations and characteristics of such springs are unknown.

2.4 Climate

Climate data for the Whytes Gully RRP site is presented in reports within Appendix G of the EA document, and also in the Draft LEMP (Appendix P of the EA document). Major climate factors are summarised below.

- Rainfall
 - annual rainfall: mean approximately 1.3 m; 90th percentile approximately 1.8 m.
 - The rainfall distribution throughout the year is higher for summer, with winter and spring months experiencing drier weather.
- Temperature
 - Average maximum air temperature (°C) is in the mid-to-high twenties in summer months and in the mid-to-high teens in winter months.
 - Freezing air temperatures are rare.
- Wind Wind direction at the site is seasonal and is characterised by strong westerly winds during the winter months. North easterly winds dominate during the remainder of the year.

With regard to design and construction of the New Landfill Cell project, key climate considerations are that the site experiences relatively high rainfall, and can be hot and windy at times.





2.5 Site Infrastructure

2.5.1 Landfill Roads

The existing landfill access road is shown in Drawings D002 and D003. It is a two-lane, paved road extending approximately 1.7 km from the existing weighbridge at approximate elevation RL 20 m to the northern edge of the Eastern Gully Landfill at approximate elevation RL 75 m. The road traverses existing Western Gully waste for a distance of approximately 250 m at approximate elevation RL 65 m.

Access tracks suitable for 4WD vehicles extend: (a) from the landfill toe up the central ridge to the landfill access road; and (b) up the eastern ridge. These tracks are visible in Drawing in D002.

2.5.2 Easements

Easements within the New Landfill Cell project footprint are shown on Drawing D003. These are summarised below.

- An easement for the 132 kV overhead power transmission line which runs east to west across the site, situated south of the Eastern Gully landfill and north of Reddalls Road.
- A private power line easement is present in the northern part of the site and crosses the Western Gully landfill. It is understood this line is de energised and due for decommissioning.

In addition, although not in easements, overhead power lines and telephone lines run along Old Reddalls Road and water pipes service the staff amenities building.

2.5.3 Leachate Management

Leachate is collected from the Eastern Gully Landfill and Western Gully Landfill as described in Section 2.6 below and is piped to the Primary Leachate Pond. In the Primary Leachate Pond, the leachate is mixed and aerated and transferred to either the Leachate Treatment Plant or, depending on plant capacity, to the Secondary Leachate Pond for storage.

The Primary and Secondary leachate ponds are lined with 1.5 mm HDPE geomembrane liner and have a capacity to store 18,000 cu.m leachate with a 300 mm freeboard. Both ponds contain surface aerators located on pontoons. The primary leachate pond also contains an axial mixer. The design of the ponds is detailed in design drawings prepared by Forbes Rigby (2003).

The Leachate Treatment Plant is a biological treatment process using sequencing batch reactor (SBR) technology, with the capacity to treat up to 250 kL per day. The design of the leachate treatment plant is detailed in work as executed drawings prepared by URS Australia (URS, 2006). Treated leachate is discharged to sewer under a Trade Waste Agreement with Sydney Water.

Irrigation of leachate over landfill areas has historically been undertaken at the site but has not been practiced in recent years.

Additional information is provided in the Leachate Generation and Water Balance Modelling Report in Appendix G of the EA document.

2.5.4 Surface Water Management

As indicated in Section 2.2, surface water runoff from covered areas of the Western and Eastern Gully landfills is captured by swales on the landfill surface. The swales divert the runoff towards drains around the perimeter of the landfill and to a central drain between the Eastern and Western Gully landfills. Runoff from the natural slope above the northern edge of the Eastern Gully landfill is also directed to the central drain.

The perimeter drain around the Eastern Gully Landfill is grass lined. The perimeter drain around the Western Gully Landfill is mostly grass lined. The central drain is lined with a reno mattress.

Ponds originally constructed for the Western Gully landfill are located at the toe of the landfill (Drawing D002). The ponds comprise two surface water ponds with a capacity of 3,000 cu.m and 4,200 cu.m,



respectively and a former leachate pond with a capacity of 8,000 cu.m. These three ponds are currently used for temporary surface water storage. A fourth surface water pond, located at the toe of the Eastern Gully Landfill, collects surface water but also drainage from the groundwater underdrain system in the Eastern Gully Landfill (refer Section 2.6.2). These ponds are within the proposed footprint of the New Landfill Cell Project and will be decommissioned during construction of its first stage.

All surface water flows are eventually directed to the surface water pond system located on the south western portion of the site. The system is located in the south west corner of the site and comprises three reed beds (Reed Beds 1 through to 3) and an upper and lower surface water polishing pond. The total capacity of the surface water ponds system is 40,000 cu.m. Discharge from the ponds is to Dapto Creek.

Additional information is provided in the Surface Water Assessment Report in Appendix G of the EA document.

2.5.5 Other

An amenities building for site staff is located near the toe of the Eastern Gully landfill as indicated in Drawing D002. A car park is located outside this building. The building and its foundations will be demolished and its services decommissioned during construction of the first stage of the New Landfill Cell Project.

The previous site weighbridge is located on the landfill access road near the amenities building. The weighbridge and its foundations will be demolished during construction of the first stage of the New Landfill Cell Project.

2.6 Existing Landfill

The existing landfill comprises two filling areas located in the Western and Eastern Gullies. Filling of the Western Gully Landfill commenced in 1984 and finished in 1993, when filling of the Eastern Gully Landfill commenced. Filling of the Eastern Gully is projected to finish at the end of 2013. The development and existing engineering features of the two landfill areas are summarised in the following subsections.

2.6.1 Western Gully

Lining - The Western Gully Landfill is unlined.

Leachate Collection –Collection of leachate was initially via a central 100 mm diameter perforated pipe located at the base of the landfill. From discussions with Council staff we understand that this pipe did not have filter protection and became non-functional very early in the landfilling process. These discussions also indicate that an alternate leachate collection system was constructed with the following features:

- a. leachate collection horizons were established successively at approximate 5m vertical intervals within the landfill mass; the first (lowest) horizon was at approximately RL 40 m and the last (highest) horizon was at approximately RL 60 m;
- b. each horizon comprised a network of finger drains constructed of windrows of railway ballast-size gravel with no filter protection;
- c. prior to constructing the finger drains at each horizon, the working landfill surface was prepared by placement and smooth rolling of a layer of silty coal washery rejects to create a fall toward a low point on the landfill batter (i.e., the southern batter);
- d. at the low point on each horizon, flows in the finger drains enter a shallow 300 mm concrete or HDPE pipe and are conveyed to the base of the landfill batter; a pipe pit was installed at each horizon; and
- e. at the toe of the landfill batter the shallow 300 mm pipe extends through the landfill bund wall to the current main leachate collection pit near the landfill access road; this pipe is indicated as an "existing leachate pipe" on Drawing D041. The shallow 300mm pipe will be replaced and upgraded prior to construction of the first stage of the New Landfill Cell project (refer Section 3.3.4); and the main leachate collection pit will be removed and the existing leachate flow directed into the new leachate collection system (refer 4.3.4).

The effectiveness of the alternate leachate collection system is uncertain. Measurements of current water levels in abandoned gas wells and observation of high surface moisture conditions and occasional surface





seepage on portions of the landfill batter suggest that accumulated leachate may be present within the Western Gully waste mass below RL 40m and possibly in local perched layers at higher elevations. This condition is discussed further in Section 3.3.4.

Volume - The Western Gully Landfill received approximately 980,000 cubic meters (cu.m.) of waste during its 9.5 year life from 1984 to 1993 (Forbes Rigby, 2001).

Filling - Landfilling commenced following the construction of a large soil bund wall at the toe of the landfill with a height of 5 m and a crest elevation of RL 35 m. The bund wall extends from one side of the Western Gully to the other. After site preparation, waste was subsequently placed in the gully behind the bund wall. Once waste was placed to the height of the bund wall, a second, smaller, bund wall was placed to an elevation of approximately RL 37.5 m. Waste was then placed to the crest level of the second bund wall. This filling technique of bund construction followed by waste filling was continued throughout the life of the landfill with each bund wall being approximately 2.5 m high. The maximum waste thickness is approximately 30 m.

Footprint – The approximate footprint of landfilling (i.e., extent of waste placement) is indicated in Drawing D003. The footprint area of the Western Gully Landfill is approximately 10 ha.

Bund wall and cover material was won from site preparation works prior to filling of each lift. The external bund wall surfaces were subsequently vegetated following completion of each lift.

Capping – the Western Gully Landfill is covered with a varying depth of cover materials comprising generally low to medium plasticity sandy clay ranging in thickness from 0.3 m to 2.5 m (Appendix C).

Landfill Gas Collection – Approximately 40 vertical landfill gas extraction wells were previously installed and operated in all areas of the Western Gully Landfill. These gas wells were abandoned in approximately 2005. Some or all of these wells may be exposed, renovated, and reactivated to restore active gas extraction prior to the start of construction for the New Landfill Cell project.

2.6.2 Eastern Gully

Leachate Barrier - The Eastern Gully landfill was constructed as a lined landfill, with the barrier component of the lining system comprising a high density polyethylene (HDPE) geomembrane liner (2 mm thickness). The HDPE geomembrane liner has a textured surface in sloped areas to enhance landfill stability. It is noted that the geomembrane liner was installed directly on top of a blanket underdrain, described below.

The Eastern Gully leachate barrier can be classified as a 'single geomembrane liner'. We note that if the geomembrane liner had been installed on top of low-permeability soil layer, then the leachate barrier would be classified as a 'single composite liner' and would be expected to have significantly higher resistance to leachate leakage.

Groundwater Underdrain - The HDPE geomembrane liner is underlain by a groundwater drainage layer comprising an approximate 500 mm thick fine gravel layer that is intended to collect any groundwater seepage from natural materials below the liner. This layer incorporates an HDPE collection pipe that drains by gravity to the surface water pond at the toe of the Eastern Gully landfill, as indicated in Section 2.5.4 above. This pipe is identified as the "existing groundwater pipe" on Drawing D041. We understand that, for reasons outlined in Section 2.6.3 below, when high water levels develop in the surface water pond, the pond is pumped out to the leachate ponds rather than released into the surface water management system.

Leachate Collection - The HDPE geomembrane liner is overlain by a blanket leachate drainage layer comprising an approximate 300 mm thick clean sand layer. This layer incorporates two 300 mm diameter HDPE leachate collection pipes that drain by gravity to the toe of the landfill – one pipe drains Eastern Gully Stage 1 and the other pipe drains Eastern Gully Stage 2 (refer below for stage description). Each of these two pipes is identified as an "existing leachate pipe" on Drawing D041. These pipes currently pass through the HDPE geomembrane liner and are then connected to external pipes that drain to the current main leachate collection pit near the landfill access road at the toe of the Western Gully Landfill. These external pipes and the main leachate collection pit will be removed and the existing leachate flow directed into the new leachate collection system (refer Section 3.3.4 and Section 4.3.4).





Base lining and Filling – Base lining and landfilling has been undertaken in four stages. Stage 1 commenced in 1993 and was located in the upper portion of the Eastern Gully. Stage 2, located on the lower section of the Eastern Gully commenced in 2001. Stages 1 and 2 together received approximately 1,250,000 cu.m. of waste to the year 2004. Stage 3 is located over the Stage 1 and Stage 2 filling area and had an estimated 610,000 cu.m. capacity over a five year period (2004 to 2009). Stage 4, located in the upper portion of the gully over Stage 3 and Stage 1 is currently underway and has an estimated 750,000 cu.m. capacity over a four year period (2009 to 2013) with completion of filling expected in 2013. The maximum waste thickness at the completion of planned filling is anticipated to be approximately 50 m.

Footprint – The approximate footprint of landfilling (i.e., extent of waste placement) is indicated in Drawing D003. The footprint area of the Eastern Gully Landfill is approximately 10 ha.

Capping - Capping materials encountered had a variable composition of materials throughout the existing cap. The measured thickness of the capping ranges from 0.1 m (GAHA04) to 0.6 m (GAHA01) across the Eastern Gully landfill (Appendix C).

Landfill Gas Collection – Approximately 30 vertical landfill gas extraction wells were previously installed and operated in the Eastern Gully Landfill, primarily in the Stage 3 portion. These gas wells were abandoned in approximately 2005.

Rainforest Area – An area between the current northern limit of the Eastern Gully Landfill and the property boundary has been identified as an Endangered Ecological Community (EEC) - "Illawarra Subtropical Rainforest." This is discussed further in Chapter 13 of the EA document.

2.6.3 Discussion of Existing Eastern Gully Landfill Liner

The collection pipe for the groundwater underdrain in the Eastern Gully Landfill was described in the preceding section. Recent sampling and testing of outflow from the groundwater pipe, as well as previous observations by landfill staff, suggests that water collected in the groundwater underdrain is likely impacted by leachate. The source of leachate is not known and it could hypothetically arise from: (i) leachate seepage travelling from the unlined base of the Western Gully Landfill through natural materials and into the underdrain; or from (ii) leakage of leachate collected at the base of the Eastern Gully Landfill through flaws in the overlying HDPE geomembrane liner into the underdrain.

Due to the likely presence of leachate, the groundwater collection pipe will connected into the new leachate collection system during construction of the first stage of the New Landfill Cell project (refer Section 3.3.4 and Section 4.3.4).

Further, because identification of the leachate source and location of entry into the underdrain is not practicable at this time, we have adopted for the preliminary design a classification of "uncertain" for the current performance of the existing Eastern Gully leachate barrier. The performance and environmental risks associated with the existing Eastern Gully leachate barrier may be considered further at the time that the project is advanced to detailed design.

2.6.4 Settlement Potential

Compared to most natural foundation materials, landfill waste has a high potential to exhibit large short-term and long-term settlements, as well as lateral deformations, due to its high compressibility and decomposition potential. Settlement potential of waste depends on a number of material characteristics including age since placement, composition, organic content, total thickness, degree of initial compaction, and moisture content.

Waste settlement is typically considered over both 'short term' and 'long term' time frames. Short-term refers to settlement occurring in response to loading and generally within a few months of load application. Attributed mechanisms for short-term waste settlement are physical, primarily particle breakage and/or rearrangement into a denser structure. Long-term refers to settlement that generally occurs over a period of decades, at a diminishing rate, and is not directly associated with any load application. Attributed mechanisms for long-term waste settlement are chemical/biological rather than physical, being primarily decomposition of organic materials resulting in conversion of solid mass to landfill gas.





Evaluation of the potential effects of waste settlement on the proposed engineering features of the New Landfill Cell Project, particularly landfill lining and capping systems, is a key component of the design process. Such evaluation should include if practicable a site-specific assessment of waste compressibility through measurement and analysis of ongoing surface settlements and/or through surface loading trials conducted in previously landfilled areas. Measurements and loading trials are underway at the site at the time of preparation of this preliminary design report, and results will be incorporated at the time of detailed design. For this preliminary design, evaluations have been performed using typical published values for waste settlement potential. To put the issue in context, preliminary values calculated for long-term settlement of the existing waste materials range up to a maximum of approximately 5 m (refer Appendix C), confirming that waste settlement is a significant issue for the project.





3.0 DESIGN APPROACH

3.1 **Project Capacity Requirements**

3.1.1 Waste Type and Landfilling Rate

Current estimates indicate that the currently approved plans will provide landfilling capacity until late 2013. This existing capacity is available in the upper elevation of the Eastern Gully landfill. The New Landfill Cell project is required to provide ongoing landfill capacity, after the existing capacity is exhausted, for placement of up to 180,000 tonnes of Council municipal solid waste and cover soils per year. This tonnage rate is assumed to correspond to a volumetric rate of 140,000 cubic metres per year (i.e. average landfill density of 1.3 t/cu.m.).

Please refer to the Chapter 8 of the EA for further information on waste types and anticipated quantities.

3.1.2 Landfill Capacity and Staging

The term "airspace" refers to the available volume for landfill material placement between an upper and a lower surface, with the upper surface typically corresponding to the design levels for the top of a planned landfill. The New Landfill Cell project is required to develop additional landfill airspace that is sufficient to provide for 40 years or more of landfill operations at the rate indicated above (i.e. airspace consumption rate of 140,000 m³/yr). The project is required to be developed in a number of workable stages with each stage providing at least two years of landfill airspace.

Please refer to the Chapter 4 of the EA for additional discussion of the required additional landfill capacity.

3.1.3 Geometric Constraints

Key geometric constraints for the landform to be created for the New Landfill Cell project are given below.

- The landform will be completely within the current property boundaries, with sufficient setback for a full perimeter access track and drainage channels, as well as for a 5 m wide area for potential nature strip planting on the western ridge boundary.
- The landform will remain between the natural eastern and western ridge lines.
- The maximum landform elevation is to be generally consistent with the current design which has a maximum elevation of RL 105 m as indicated in Drawing D003.
- The southern extent of the landform will not impinge on the easement for the 132 kV overhead power transmission line (Section 2.5.2), except for the portion of the existing Eastern Gully Landfill that currently extends approximately 5 m into the easement (Drawing D003).
- The northern extent of the landform at the eastern gully will not impinge on the "Illawarra Subtropical Rainforest" flora in this vicinity (refer Section 2.6.2), except for a small area near the central ridge where the detailed flora assessment, presented in Appendix F of the EA document, has concluded that disturbance will not result in a significant impact.

3.1.4 Piggy Back Filling

In order to satisfy the landfill capacity requirement and geometric constraints identified above, the preliminary design includes placement of a substantial thickness of new waste over the existing waste in the Eastern Gully and Western Gully Landfill areas. This is referred to as piggy back filling, and is depicted in the cross sections on Drawings D015 and D016. The maximum piggy back fill thickness is approximately 40 m above the Western Gully Landfill and 30 m above the Eastern Gully Landfill.

Piggy back filling of existing landfill areas may require specific engineering measures for environmental protection. In particular, lining systems are sometimes constructed at the interface between the existing waste and the overlying new waste. Such lining systems are commonly referred to as "piggy back" systems. The use of piggy back lining for the New Landfill Cell project is described in Section 3.3.2 below.





3.2 Environmental Requirements

3.2.1 Overall Environmental Assessment

Potential environmental impacts arising from construction and operation of the New Landfill Cell Project are comprehensively assessed in the EA document. The assessments have considered the features of the preliminary design (e.g. overall geometry, progressive stages of construction and landfilling, construction requirements, engineering features) and have identified environmental mitigation measures, where required, for the most critical stages of construction and operation. The assessments have also considered the features of the features of the Eastern Waste Cutback (refer Section 4.2.3). It is noted that initial results from some of the assessments resulted in design changes which were then reflected in the final assessment results.

The environmental assessments have included the following:

- air quality, including potential odour and dust generation;
- noise;
- flora and fauna;
- heritage;
- traffic;
- visual amenity; and
- soil and water.

Additional information is provided in the relevant sections and appendices of the EA document.

3.2.2 Regulatory Design Requirements

NSW Guidelines

The preliminary design for the New Landfill Cell is generally consistent with the NSW EPA *Environmental Guidelines: Solid Waste Landfills 1996* (Landfill Guidelines). These are the most current NSW guidelines considered applicable to the project.

An assessment of the preliminary design with respect to the Landfill Guidelines benchmark techniques is provided within the Cover Statement of the Draft LEMP document. We consider that all benchmark techniques are met or exceeded, or suitable alternatives proposed. It is noted that the Landfill Guidelines do not contain specific requirements for piggy back filling and/or piggy back liners.

Surface water management elements of the preliminary design have been developed in relation to the NSW Department of Environment & Climate Change guidelines *Managing Urban Stormwater, Soils and Construction – Volume 2B Waste Landfills 2008* (Landfills Blue Book).

Best Practice Design

The preliminary design for the New Landfill Cell project incorporates measures to reflect "best practice landfill design and operation", as suggested by Clause 123 of the NSW *State Environmental Planning Policy (Infrastructure) 2007.* For design aspects where Golder considers that the 1996 Landfill Guidelines do not reflect current best practice, the Victoria EPA document *Best Practice Environmental Management: Siting, Design, Operation and Rehabilitation of Landfills 2010* (herein referred to as the BPEM) has been used as a guiding document for best practice. The BPEM is believed to be the most recent Australian regulatory guideline that adopts current generally accepted international best practices.

BPEM guidelines have been adopted for most aspects of the liner system and leachate collection system design, and for other landfill design elements where indicated in this Design Report. It is noted, however, that the BPEM does not contain specific guidelines for piggy back filling and/or piggy back liners and Golder



has therefore adopted a design approach that extends the BPEM liner design guidance and is consistent with our project experience.

3.3 Key Design Issues

3.3.1 General

In addition to satisfying the landfill capacity requirements, site geometric constraints, and regulatory requirements identified in the preceding sections, the preliminary design addresses key design issues as described below.

3.3.2 Need for Piggy Back Lining System

Landfilling of new waste for the New Landfill Cell project will occur in both: (i) areas underlain by existing waste, i.e. piggy back filling areas as indicated in Section 3.1.4; and (ii) areas of natural ground. Different base lining systems will be required to suit these different underlying conditions. The use of piggy back lining in the areas underlain by existing waste is described in this section. The base lining system proposed for areas of natural ground is not discussed in this section as it is not considered a key design issue for the site, but is discussed in Section 4.3.4.

Construction of a piggy back lining system in both the Eastern Gully and Western Gully piggy back fill areas is considered prudent for the project based on the existing landfill conditions (Refer Sections 2.6.1 to 2.6.3) and the environmental factors outlined below.

Leachate Control

Leachate generated within new waste placed above the existing landfill areas is generally expected to migrate vertically downward by gravity. In the case that no piggy back lining is constructed then leachate from new waste would eventually report to the base of the existing landfill with the following potential consequences:

- Western Gully Landfill leachate reporting to the base of the existing landfill could potentially cause an impact to groundwater due to the lack of a base lining system in the Western Gully Landfill.
- Eastern Gully Landfill leachate reporting to the base of the existing landfill could potentially cause an impact to groundwater due to the uncertain current performance of the existing Eastern Gully leachate barrier (Section 2.6.3). Further, even without the performance uncertainty, the existing Eastern Gully leachate barrier is classified as a 'single geomembrane liner' and does not meet the current best practice design standards of "single composite liner" (Section 4.3.1).

In the case that a piggy back lining is constructed then leachate from new waste in both the Eastern Gully and Western Gully piggy back fill areas could be collected in a new leachate collection system installed on top of the piggy back lining. The new leachate collection system would be designed to function independently of the existing leachate collection systems. If the piggy back lining and leachate collection systems are designed to comply with best practice standards (i.e.,BPEM) then the risk of groundwater impact from new waste would be considered acceptable.

Implications for Landfill Gas Control

Landfill gas generated from new waste could be drawn upward with active gas extraction systems and its fate would not depend on the presence or absence of a piggy back lining. However, collection and/or migration of landfill gas generated in existing waste would be affected by the presence of a piggy back lining as indicated below.

- Movement of gas currently being generated in the existing waste is not controlled and migration pathways are uncertain. It is likely that installation of a piggy back liner would affect migration with a bias toward increased lateral migration.
- Although there are currently no gas extraction wells in existing waste at the site, we understand that there are plans to initiate active gas extraction from existing waste in both the Eastern Gully and



Western Gully Landfills, via vertical wells, prior to the start of construction for the New Landfill Cell project. A piggy back lining system would interrupt such vertical wells. In addition, it will not be possible to install vertical gas wells into existing waste in areas of piggy back lining after the piggyback lining is in place because such wells would penetrate and locally disrupt the piggy back lining.

In order to address these issues, design of the piggy back lining will include both: (i) gas collection vents beneath the piggy back lining to reduce the risk of increased lateral gas migration; and (ii) features to allow ongoing collection of gas from any vertical extraction wells that may be installed prior to piggy back lining construction. Refer to Section 3.3.3 for additional discussion.

3.3.3 Piggy Back Lining Design Considerations

Certain design issues may be of key importance for a piggy back lining system, although they are often insignificant for typical base liners established on natural ground. Key issues relevant to the proposed piggy back lining for piggy back fill areas are presented below. Piggy Back Lining design features are discussed further in Section 4.3.3.

3.3.3.1 Potential for Deformation of Piggy Back Lining System

Compared to most natural foundation materials, landfill waste has a high potential to exhibit large short-term and long-term settlements due to its high compressibility and decomposition potential (refer Section 2.6.4). Such settlements can result in distortion of the original geometry of the lining system, through differential movements, and overall changes in lining system slopes, through total settlement. Waste can also exhibit large lateral deformations that depend on the geometry of the existing and new waste masses, and that can have similar effects on lining systems.

Settlement and lateral deformation potential of waste depends on a number of material characteristics including age since placement, composition, organic content, total thickness, degree of initial compaction, and moisture content.

Design for piggy back liners must address the potential effects of long term foundation settlement and lateral deformations, considering the waste material characteristics (as above) and geometry. For detailed design, this should ideally include a site-specific assessment of waste compressibility through analysis of historical settlements in previously filled areas and/or through surface loading trials conducted in previously filled areas. Settlement measurements and loading trials are underway at the site at the time of preparation of this preliminary design report, and results will be considered at the time of detailed design.

3.3.3.2 Effect of Deformation on Lining System Integrity

Behaviour and Analysis

Any differential movements imposed on the piggy back lining system will distort its original geometry and thereby induce strains in the lining system materials. This will include tensile strain, compressive strain, and shear strain. The lining system will come to equilibrium with the imposed deformations, including locally redistributing strains depending on the stiffness properties of the lining system materials and the interfaces between layers. Strain redistribution can also be affected by local variations in lining system geometry or waste thickness and by the presence of vertical gas wells or other gas collection infrastructure below the lining system.

In general, if equilibrium strains are within the allowable range for the materials comprising the barrier layers (i.e., very low-permeability layers) within the lining system, then shear or tensile failure of materials will be prevented and lining system integrity maintained.

Design of the piggy back lining should therefore consider the range of conditions across the piggy back fill area and should ideally include the following design/analysis items:

- a) identification of characteristics and geometry of existing waste, existing capping soil materials that will form the lining subgrade, and new waste;
- b) selection of lining system materials and thicknesses;





- c) estimation of imposed differential movements due to waste deformation;
- d) calculation of corresponding equilibrium strains including local strain redistribution; and
- e) assessment against allowable strains of lining system materials.

We note that items c) and d) will require a displacement-based analysis such as finite element or finite difference analysis.

Design Considerations

Piggy back lining system design often includes selection of materials for barrier layers that have relatively high allowable tensile strains. For example, linear low-density polyethylene (LLDPE) geomembranes and geosynthetic clay liners (GCLs) are often selected. Compacted clay layers are not generally selected because their allowable tensile strains under some confining stress states can be significantly lower than other available materials.

Design features that may reduce the strain levels that develop in piggy back lining system materials include: (i) a lining subgrade layer constructed of engineered fill; (ii) incorporation of high tensile stiffness geosynthetic materials (i.e. geogrid) into the lining subgrade; and (iii) provision of preferential slip layers. A preferential slip layer is a very low stiffness and/or shear strength interface between adjacent lining system materials such that deformation-induced shear strains cannot transfer across the interface and induce significant tensile strains within barrier layer materials. In effect, shear strains can be localised along the preferential slip layer to shield the barrier layers.

However, due to the hillside configuration of the existing waste surface in much of the piggy back fill area with slopes of 4H:1V to 5H:1V (refer Section 2.6), slope stability requirements dictate that preferential slip layers are not advisable for the project. Therefore, design features (i) and (ii) indicated above have been considered in detail for the New Landfill Cell project. Slope Stability is discussed further in Section 3.3.6.

3.3.3.3 Landfill Gas Collection

Continuing operation of any vertical gas extraction wells that are installed in the existing waste prior to the start of construction for the New Landfill Cell project may be a factor that will affect the piggy back liner design. In general, the need to maintain gas extraction would depend on the quantum of future gas generation expected at the time of piggy back lining construction. As indicated in Section 3.3.2, the piggy back lining system design will include features to allow ongoing collection of gas from vertical wells in underlying waste.

Such design features would need to address the potential large magnitude of settlement and lateral deformation that will likely occur in the piggy back lining system after construction and overlying waste placement (refer Section 3.3.3.1). In addition, the top of any vertical gas well pipe will not settle as much as the piggyback lining system (i.e. pile effect), resulting in locally large differential settlements. Differential lateral deformation is not considered to be as significant an issue as differential settlement because of the relatively small lateral stiffness of the gas well pipe.

General options for these design features are described below.

Well Cut Off: (i) Cut off vertical well below piggyback lining elevation; (ii) construct a lateral extraction flowline, below the piggyback lining, to the edge of the piggy back fill area; and (iii) install a high flexibility connection between the top of the cut off well and the lateral flowline. Major technical issues to be addressed with this approach include identifying a safe depth below the piggy back lining for the vertical well cut off and designing a sufficiently flexible connection, with both these issues are dependent on the potential magnitude of differential settlement. Other issues for this option include potential challenges in achieving extraction over the long flowline distance that would be needed to reach the northern edge of the landform (i.e., up to 300 m) and managing gas condensate within such a long flowline. An advantage of this option is that the piggy back lining at the gas well location would be continuous at the time of installation.



Piggy Back Penetration: This option would comprise an engineered penetration of the piggy back lining system to provide for vertical extension of the gas well through overlying new waste and to accommodate differential settlement between the gas well and the piggy back lining. Major technical issues to be addressed with this approach include maintaining drainage in the piggy back leachate collection system at the penetration and minimising the potential for vertical leachate migration through the penetration, with both these issues dependent on the potential magnitude of differential settlement. An advantage of this option is that reliable gas extraction is more likely to be maintained because the typical vertical well configuration is preserved.

The preliminary design does not identify a preferred design option. It is appropriate to address this issue at the time of detailed design when additional information is available regarding the actual or likely locations of gas wells in the existing waste and the results of the settlement loading trial and detailed surface settlement measurements that are currently being undertaken at the site.

3.3.3.4 Effect of Deformation on Leachate Collection System

Any differential movements imposed on the piggy back lining system will alter the drainage grades within the leachate collection system and also induce strains in the leachate collection system materials.

With respect to drainage grades, the piggy back lining would generally be constructed on the relatively steep existing landfill slopes of 4H:1V to 5H:1V. In this circumstance, downslope leachate drainage is anticipated to be maintained in the long-term. It is considered highly unlikely that waste deformation could alter the lining system geometry to a degree that overall down slope leachate drainage was disrupted on the slopes. This has been assessed for the preliminary design. A relatively flatter area of piggy back lining will need to be constructed on the northern portion of the Western Gully Landfill, and for this area a minimum grade will be established during detailed design to address long-term (i.e., post-settlement) requirements for positive leachate drainage.

With respect to material strains, there are a number of candidate materials for the piggy back leachate collection layer, in particular drainage aggregate/sand with filter geotextile and geocomposite drain. A geocomposite drain comprises a polymer geonet drainage core sandwiched between filter geotextiles. Both candidate materials have relatively high allowable tensile strains, but differ in other characteristics. In particular, they may differ significantly in thickness and internal and interface shear strength. The preliminary design has considered these factors.

3.3.3.5 Short-Term Lining System Stability

The risk for the piggy back lining to become unstable, or to locally uplift, due to pressure from landfill gas or leachate generated in the waste beneath the lining will be assessed as part of the design. This risk may be present due the nature of the barrier layer materials in the lining system to restrict gas and liquid flow. This is considered a short-term issue because the risk is generally significant only immediately after lining construction before substantial confining stresses have developed from material placement above the piggy back lining.

The gas pressure risk can be managed as part of detailed design through selection of lining system materials with appropriate material and interface properties and with gas depressurisation measures. As indicated in Section 3.3.2, the piggy back lining system design will include the following gas management measures which will provide the required depressurisation: (i) gas collection vents beneath the piggy back lining; and (ii) features to allow ongoing collection of gas from any vertical extraction wells that may be installed prior to piggy back lining construction.

Leachate seepage on the existing landfill slopes, for example from perched leachate within the existing waste, may also present a short- term risk for destabilising uplift pressure on the piggy back lining system in local areas. This would be managed by temporary shallow subsurface drainage of any observed local saturated/seepage zones, to be determined at the time of piggy back liner construction. On the Western Gully slope, where surface seepage is more likely, another management option is installation of local shallow subsurface drainage with connection to the shallow leachate collection system that is proposed to be replaced as indicated in Section 3.3.4.





3.3.4 Leachate Management

Key design issues for leachate management for the New Landfill Cell project are discussed below.

Gravity Drainage

Given the hillside nature of the site, the design can incorporate leachate collection system drainage grades such that leachate from all new waste areas will be collected and removed from the landfill via gravity flow. No internal pumping wells with leachate risers through the waste mass are needed. This approach will generally provide a passive, high-reliability, drainage system with minimal long-tem maintenance and power requirements.

Existing Leachate Drainage - Eastern Gully Landfill

The existing leachate collection system and groundwater underdrain for the Eastern Gully Landfill were described in Section 2.6.2 and Section 2.6.3.

The design will provide for ongoing collection of leachate from the two existing leachate collection pipes by directly connecting these pipes into the new leachate collection system. It is noted that connection of the existing leachate collection pipe from Eastern Gully Stage 2 will first require locating the point where the pipe penetrates the existing HDPE geomembrane liner and then excavating soil materials to expose the pipe just outside the penetration point. The design will also provide for ongoing collection of water, which is likely impacted by leachate, from the existing groundwater underdrain collection pipe by directly connecting this pipe into the new leachate collection system (refer Section 4.3.4).

Existing Leachate Drainage - Western Gully Landfill

The existing leachate collection system for the Western Gully Landfill was described in Section 2.6.1 to have uncertain effectiveness such that accumulated leachate may be present within the Western Gully waste mass below RL 40m and possibly in local perched layers at higher elevations.

The preliminary design has been prepared assuming that the measures outlined below will be implemented prior to the start of construction of the New Landfill Cell project. These proposed measures would be intended to reduce environmental risks associated with potential for leachate migration into groundwater and surface water.

- The first proposed measure is construction of a drainage collection trench to the base of the existing waste along the alignment of the uphill side of the existing soil bund wall at the landfill toe (approximate trench length 100 to 150m). The outlet from the drainage trench would be a pipe installed to extend from the base of the trench, through the existing soil bund wall, to a point at the downhill toe of the berm (approximate pipe length 40 m). This proposed pipe is identified as the "proposed leachate pipe for existing Western Gully Landfill" on Drawing D041.
- The second proposed measure is replacement of the existing 300 mm shallow leachate drainage pipe and pits on the landfill slope that are described in Section 2.6.1. The current effectiveness of this pipe is uncertain. Further, the concrete elements of the pipe and pits will pose a protrusion and/or puncture risk to the piggy back lining system and are generally strain intolerant and likely to function less effectively after piggy back filling of the area due to differential settlements and stress increases that will develop.

The existing pipe is proposed to be replaced with a flexible pipe (HDPE), without pits, in order to minimise protrusion and/or puncture risks for the piggy back lining system and to provide a system with high strain-tolerance so that leachate collection and drainage can be maintained after piggy back filling. Construction would also include enhancement with new shallow finger collection drains to areas of known high surface moisture and/or surface seepage. A supplemental benefit of this measure is to reduce the likely occurrence of saturated surface conditions that could lead to difficulties in preparing the subgrade for piggyback lining construction.





The preliminary design provides for ongoing collection of leachate from the proposed drainage trench outlet pipe and replacement shallow leachate drainage pipe by directly connecting these two pipes into the new leachate collection system (refer Section 4.3.4).

The need for the proposed measures outlined above may be further assessed during detailed design if additional information on existing leachate levels and waste thickness within the lower portion of the Western Gully Landfill is obtained.

Leachate Management System Capacity

The capacity of the existing leachate management system has been assessed as part of the preliminary design. Recommendations for the New Landfill Cell project have been developed, including site operational measures to reduce leachate generation rates and modifications to the existing leachate storage and treatment system. This information is presented in the Leachate Generation and Water Balance Modelling Report in Appendix G of the EA document.

3.3.5 Groundwater Separation

A key issue for the design of the New Landfill Cell project is achieving an acceptable vertical separation between the bottom of new landfill waste and the top of the groundwater table in all areas. Although various approaches can be adopted with respect to minimising risk of groundwater contamination from landfill leachate, and construction of landfill liners below the groundwater table is suitable in some circumstances, it is generally accepted that greater separation distances result in reduced risk.

Measured groundwater levels at the site that have been used to develop the preliminary design are discussed in Section 2.3.3. It is noted that construction of the New Landfill Cell project is generally anticipated to result in falling groundwater levels beneath the liner.

Based on BPEM guidance (Table 5.1 in BPEM), the preliminary design has been developed to maintain a 2 m vertical separation distance between waste and the groundwater table. The separation distance primarily impacts design of the new cell areas as indicated below.

- In the lower lying areas of new base liner for the project, specifically the southern portion of Cells 1 to 4 shown in Drawing D012, measured groundwater levels may as high as 1 m below ground level. Therefore, in these areas the design requires placement of imported fill VENM (virgin excavated natural material) to raise liner subgrade levels such that the elevation of the base of waste in the lowest areas, at the leachate sumps, will maintain the target separation distance and such that suitable grades are achieved for leachate drainage.
- In the areas of the existing Central Ridge and Western Ridge, being Cells 2A, 2B, and 4A shown in Drawing D012, measured groundwater levels generally range from 5 m to 10 m below ground level. Therefore, in these areas the preliminary design limits the depth of excavation to establish liner subgrade levels to 5 m. This is considered appropriate to maintain the target separation distance in almost all areas and will be subject to modification as needed during detailed design. It is noted that the excavation depth limit of 5 m also results in a limit to the quantity of natural material that will be excavated for potential use in landfill construction and operational.

3.3.6 Slope Stability

Slope stability is a key design issue for several elements of the New Landfill Cell project. The hillside nature of the site and the presence of colluvial and alluvial soils in some areas accentuate the need to consider this issue. Further, the site is in an identified seismic zone and therefore slope stability under earthquake loading conditions will be assessed.

Slope stability requirements are expected to significantly influence the landfill elements given below.

 Final landform batter angle: maximum slope angle permissible for global stability of the final landform and for stability of the final capping system





- Interim landform batter angle: maximum slope angle permissible for stability of temporary landfill slopes at various stages of landfill development
- Lining Systems: shear strength requirements for materials, and interfaces between materials, within both the piggy back lining system and the cell base lining system
- Final Capping System: shear strength requirements for materials, and interfaces between materials, within the capping system; and also the water drainage capacity of these materials

Target slope stability factors of safety for the analyses are as given in the table below. The selected target factors of safety for slope stability are consistent with those commonly accepted by the geotechnical profession to provide an acceptably low risk of slope instability.

Landfill Element	Loading: Static or Earthquake	Material Shear Strengths: Peak or Residual	Target Minimum Factor of Safety
Global stability of final landform slopes	static	peak	1.5
	static	residual	1.2
	earthquake	peak	1.1
	earthquake	residual	1.0
Global stability of interim landform slopes	static	peak	1.3

Table 4: Target Slope Stability Factors of Safety for Preliminary Design

The target values in the table above for final landform slopes will also apply for veneer slope stability analysis of the final capping system that will be prepared during final design (refer Section 4.4.2).

Slope stability analysis results are discussed subsequently in Section 4.8. Analysis details are provided in Appendix C.

3.3.7 Surface Water Drainage

Given the hillside nature of the site and the relatively high rainfall environment, a key issue for the design of the New Landfill Cell project is achieving a passive and high-reliability surface water drainage system that will minimise the potential for interaction between surface water and landfill waste. Required features for such a system are to include:

- unrestricted storm water flow paths without water storage or detention, except within the existing surface water ponds system;
- all flow by gravity with no pumping required;
- open channel stormwater flow with no piped flow, except at road culverts;
- no run-on to landfilled areas; and
- permanent drainage channels located outside the landfill footprint.

In the context of achieving these required features, a very significant issue for the project design is management of surface water at the northern boundary of the Eastern Gully Landfill area. Further, minimal disturbance of the identified EEC rainforest in this area is also a design requirement (refer Section 3.1.3). Landform design options relating to this issue are discussed in the Chapter 5 of the EA document with the selected option requiring major works, i.e., implementation of the Eastern Waste Cutback (refer Section 4.2.3) as part of the project.





3.3.8 Excavated Materials

Soil and highly weathered rock materials will be generated from excavations to prepare the site for landfill construction. These materials will be generally suitable for landfill operational use, primarily as daily cover material. This is a significant issue due to the high cost of importing, and particularly paying the NSW landfill levy, for the large quantity of daily cover material needed for landfill operation.

In existing natural slope areas, excavation for landfill construction will generally be limited by the relatively thin soil thickness, typically 3 m or less (refer Section 2.3.2), and the relatively high groundwater table as noted in Section 3.3.5.

Existing fill and excess landfill cover soils which are present in some developed areas, and which have lost VENM status due to landfilling operations, are likely suitable for excavation and re-use as daily cover.

Excavated materials are also discussed in Section 4.3.5.

3.3.9 Landfill Staging

Given the hillside nature of the site and associated surface water management issues (refer Section 3.3.7), and the proposed size and longevity of the New Landfill Cell project, landfill staging is a key design issue.

The general activities identified below will occur progressively at the site during the lifetime of the project. It is noted that construction works activities will be episodic, likely executed through a series of individual construction contracts, while landfilling will be continuous.

- Landfill base construction comprising construction of lining system, perimeter bunds and surface water channels, intercell bunds, and leachate collection system.
- Landfilling normal landfill operation and environmental management, including landfill gas extraction and temporary capping.
- Final Capping construction comprising capping construction and revegetation of capped areas.

In addition, the Eastern Waste Cutback works will occur as a major works activity early in the project.

The New Landfill Cell project is to be developed in a series of stages that accommodate the activities listed above and allow for the following site controls to be continuously implemented;

- maintaining controlled surface water drainage from the landfill footprint and upslope areas;
- minimising leachate generation;
- maintaining effective leachate management; and
- maintaining acceptable site stability, particularly for interim waste batters.

Another requirement is that suitable access roads are needed at all times for landfilling, and also needed simultaneously for all episodes of construction works. For example, the current landfill access road (refer Drawing D003) passes though the area where landfill base construction will occur in first stage of the New Landfill Cell Project, i.e. Cell 1. Therefore, a replacement landfill access must be constructed in another area prior to liner base construction.

Due to the relatively large elevation difference between the lower areas of the site, at approximate RL 20 m, and the higher areas, at approximate RL 100 m, maintaining acceptable grades on access roads is a significant issue. Loaded waste transport trucks and some construction plant cannot transit excessively steep grades.

The preliminary staging plan developed in consideration of the issues and requirements given above, and the need for feasible site operations, is discussed further in Section 4.2.5.





4.0 **DESIGN FEATURES**

4.1 Environment Protection Measures

An overview of the principal environmental protection measures incorporated into the New Landfill Cell design is provided in the table below. These measures are described subsequent sections.

System	Protection Measure	Function
Cell Base Liner	Barrier	Limit infiltration of leachate through the cell base
	Leachate collection system	Remove leachate from above the base liner and thereby limit the potential for contaminant migration through the base liner
Piggy Back Liner	Gas collection system	Remove landfill gas from beneath the piggyback liner to prevent pressure build up and discourage lateral migration
	Barrier	Limit infiltration of leachate from new waste into existing waste
	leachate collection system	Remove leachate from above the piggyback liner and thereby limit the potential for contaminant migration through to existing waste
Cell Capping	gas collection system	Remove landfill gas from beneath the cap
	barrier	Limit infiltration of water and oxygen into the landfill and contain waste
	subsurface drainage system	Drain infiltrating rainwater from above the barrier liner
	topsoil (vegetation growth medium)	Support vegetation growth to limit erosion from the cap and to provide visual amenity; provide sufficient thickness to reduce potential for human contact with cell materials
Surface Water	cap drainage	Collect and convey runoff from rainfall on the landfill
	perimeter drain	Collect and control runoff from cap drainage and run-on from upslope areas

Table 5: Principal Environmental Protection Measures incorporated into New Landfill Cell Design

A construction quality management system will be in place for landfill construction because the performance of these environmental protection measures, particularly the cell liner, piggy back liner and cap barrier, is known to be highly dependent on the quality of their construction (refer Section 5.1).

These measures are designed to be operated and maintained to provide long-term performance (refer Section 6.0).

4.2 Landform

4.2.1 **Overall Characteristics**

The proposed final project landform is shown in Drawing D014, which includes final cap contour levels and landform extent, or footprint. Overall characteristics of the landform are summarised in the table below. Slope stability is discussed in Section 4.8.




Characteristic	Description
Footprint	The landform footprint is roughly rectangular and measures approximately 850 m (E-W) by 550 m (N-S), extending between the crests of the natural eastern and western ridge lines at the site. The footprint includes pulling back from the current extent of waste by up to 35m in the area of the proposed Eastern Waste Cutback (Drawing D011). The total landform footprint area is approximately 35 ha.
Elevation	The peak of the landform is at elevation RL 111 m. From the high point, slopes extend to the north to meet the natural ground surface at RL 75m to RL 95m. The lowest point of the landform is at RL 19 m along the southern edge, with a 500 m length of the southern edge at RL 25m or less.
Piggy Back Filling	Approximately half of the landform footprint is piggy back fill area where new waste will be placed over the existing Eastern Gully and Western Gully Landfills. The piggy back fill area is approximately 17 ha and is indicated by the region labelled 'piggy back area" on Drawing D012. Piggy back filling is indicated in the cross sections in Drawings D015 and D016 where new waste overlies existing waste and piggy back liner is present.
	For the Eastern Gully Landfill, the maximum existing waste thickness is approximately 50 m and the maximum new waste thickness is approximately 30 m. The maximum new waste thickness occurs on the eastern edge of the Eastern Gully, with the maximum new waste thickness along the gully centreline limited to approximately 15 m.
	For the Western Gully Landfill, the maximum existing waste thickness is approximately 30 m and the maximum new waste thickness is approximately 40 m.
Batter Slopes	The principal landform batter is south and southwest-facing with a maximum height of greater than 80 m and a 4.5H:1V average inclination. North and east-facing batters have an average inclination of 4H:1V and a maximum height of 30 m.
	Landform batters will include near-horizontal slope benches at 10 m vertical intervals, resulting in slope inclinations between benches 4H:1V on the principal batter (refer Drawing D014, section G) and as steep as 3.5H:1V on the north and east-facing batters. The purpose of the slope benches is to reduce runoff velocity and erosion potential for the final capping system, to increase overall landform slope stability, and to provide access on the slope for capping system and gas extraction system inspection and maintenance.
	A small area near the peak of the landform has relatively flat design grades (5%).
Access and Perimeter Features	The landform design allows for access around the entire site perimeter and to the landform summit for groundwater monitoring, site inspection and maintenance, and bushfire protection, with road details to be developed during final design. The design also includes surface water drains along the entire perimeter, with combined drains/access tracks in some areas. In addition, the design setback distance of 20 m along the western ridge property boundary also provides space for a nature strip if required. Typical edge details for the landform are given on Drawings D017 to D019.
	The distance between from the design limit of landfill waste placement to the closest adjacent residence buildings is approximately 70 m for the residence near the western ridge and 160 m for the residence to the north of the Eastern Gully Landfill area. It is noted the design limit of landfill waste placement is approximately 10 m inside the edge of the landform footprint.

Table 6: Characteristics of Final Landform for New Landfill Cell Project





4.2.2 Airspace

The design provides a total new landfill volume of approximately 6 million cu.m., measured between the liner subgrade surface (Drawing D012) and the final cap profile (Drawing D014). This corresponds to approximately 40 years of landfill life based on an airspace consumption rate of 140,000 cu.m. per annum (refer Section 3.1.1), therefore satisfying the project lifespan requirement identified in Section 3.1.2.

4.2.3 Eastern Waste Cutback

In order to achieve gravity drainage of surface water around the perimeter of the final landform, the design includes that the existing eastern batter of the Eastern Gully Landfill will be excavated (cutback) and the waste material relocated to Stage 1 of the project. These works are shown in Drawing D011 with key design elements described below.

- 300,000 cu.m. (approximate) of existing waste material would be excavated and relocated.
- The total footprint area of the cutback is approximately 40,000 sq.m. A minority of this area will have its entire thickness of existing waste excavated, identified by the shaded area labelled with Note 2 on Drawing D012, while the majority of this area will have partial waste excavation.
- The cutback will establish a drainage channel alignment on natural ground extending from the northern edge of the landform at elevation RL 75 m to a location at elevation RL 73 m on the eastern ridge. The drainage channel length will be approximately 400m with an average design slope of 0.5%, which is a small slope but considered acceptable.
- Edge details for the cutback area are shown in Drawing D019.

Cutback works should begin as soon as sufficient lined areas in Stage 1 are available to accommodate the relocated waste, simultaneously with normal waste placement operations. When the cutback is complete and surface water drainage can be directed along the eastern edge of the landform, then any temporary diversion channels on the existing Western Gully Landfill surface can be decommisioned (e.g. the diversion channel shown in Section F on Drawings D013).

4.2.4 Power Transmission Easement

Along the southern edge of the landform, the design provides for a 5 m separation distance between the 132 kV power transmission easement and the landform. This is depicted on Drawing D018 (Section F) where the final cap profile is shown terminating 5 m outside the easement, with the perimeter access road and the outer perimeter drain within the easement. In preliminary discussions, the easement owner has indicated the proposed design is acceptable. This will required confirmation from the easement owner at the time of detailed design.

The portion of the existing Eastern Gully Landfill liner that currently extends approximately 5 m into the easement (Drawing D003) will be considered further at the time of. Given that this occurs in a relatively steeply sloping area of the eastern ridge, and is more than 100 m from the nearest transmission tower, it is considered likely that this will not affect easement access and will not require modification. This will required confirmation from the easement owner at the time of detailed design.

4.2.5 Staging

Overview

The design provides for the New Landfill Cell project to be constructed in five major stages as indicated in Drawing D012 - Stage 1, Stage 2A, Stage 2B, Stage 3 and Stage 4. The staging generally advances from east to west, with a combination of new base liner cell and piggyback liner cell construction and waste placement and piggy back filling. As filling in each stage is completed, capping can occur, resulting in progressive rehabilitation proceeding from east to west throughout the life of the project. A summary of the each stage is provided in the table below.

Stage	Base Liner Cells	Piggy Back Liner Cells	Total Stage Area (m²)	Available Stage Airspace ¹ (cu.m.)	Approximate Life of Stage ² (Years)	Proposed Construction Start
1	1	1	82,000	912,000	4.4 ³	2013
2A	2A	2A	22,500	343,000	2.4	2017
2B	2, 2B	2B	81,200	2,134,000	15.2	2019
3	3	3	67,200	1,589,000	11.3	2035
4	4, 4A	NA	69,000	1,007,000	7.2	2046
TOTAL			321,900	5,985,000	40.5	

Table 7: Stage Volumes and Timelines for the New Landfill Cell Project

Notes: 1. Available airspace within each stage assumes interim landfill batters sloped at 3H:1V (refer below)

2. Based on average airspace consumption rate of 140,000 cu.m. per annum.

3. Stage 1 includes placement of 300,000 cu.m. of waste relocated from Eastern Waste Cutback.

The Overall staging sequence is summarised as follows:

Stage 1 covers the Eastern Gully landfill, a section of the Western Gully landfill and a non-landfilled area at the foot of the Eastern Gully landfill that is occupied by roads, buildings, and stormwater infrastructure.

In order to divert stormwater from the northern side of the Eastern Gully landfill to the southern side, approximately 300,000 cu.m. of waste will be removed from the eastern portion of the Eastern Gully landfill (i.e. Eastern Waste Cutback). This waste will be placed into the Stage 1 area..

- Stage 2 covers part of the Western Gully landfill, a non-landfilled area at the toe of the Western Gully landfill that is occupied by roads and stormwater infrastructure and also the non-landfilled central ridge.
- Stage 3 covers part of the Western Gully landfill and a non-landfilled area at the toe of the Western Gully that is occupied by roads, the green waste process area and stockpiling areas.
- Stage 4 covers an area to the west of the Western Gully landfill that has previously not been landfilled as well as a non-landfilled area at the toe of the Western Gully landfill that is currently occupied by roads and the Primary and Secondary Leachate Ponds.

Interim Landfill Batters

As the project advances from east to west, the leading edge will generally comprise west-facing landfill batters. These leading-edge batters are temporary and each will be subsequently covered by landfilling during the subsequent stage. The design has adopted a slope inclination of 3H:1V for all temporary landfill batters, which is steeper than the average final landform batters of 4.5H:1V, based on the need to maximise available airspace within each stage and maintain acceptable levels of slope stability. With respect to slope stability, it is noted that the west-facing temporary landfill batters have a generally favourable alignment in that hillside slopes are predominately south-facing.

Slope stability is discussed further in Section 4.8

Staging Feasibility - Access and Surface Water Management

As indicated in Section 3.3.9, the hillside nature of the site must be fully considered in establishing a feasible landfill staging plan. This is because site topography can create constraints to effective storm water drainage and to providing access roads with acceptable grades for both project construction (episodic) and for landfilling operations (continuous).

To confirm the feasibility of the design staging plan, a series of staging drawings have been developed that depict the site at eleven stages of project development, that is with approximately two sub stages for each of





the five major stages. These staging drawings are presented in the Landfill Master Plan which is part of the Draft LEMP (Appendix P of the EA document). These staging drawings include the elements listed below.

- Temporary landfill batters
- Temporary access roads
- Permanent access roads
- Landfilling areas
- Liner construction areas
- Final capping areas

Storm water runoff drainage paths for each stage are also presented in Drawing D051 and discussed in Section 4.5.

4.3 Base of New Landfill

4.3.1 Lining System Configuration

The Victoria BPEM indicates that the leachate barrier at the base of a municipal waste landfill should comprise a single composite liner (Table 6.1 in BPEM). The term "single composite liner" refers to a two-component liner where the upper layer is a welded geomembrane placed in intimate contact with a lower layer of low-permeability clay. The performance of composite lining systems in minimising leachate escape from landfills is known to be significantly better than that of single-component lining systems (e.g., Rowe, 2005). This is particularly true of composite liners using a geosynthetic clay liner (GCL) as the lower component.

Use of a single composite liner exceeds the standard indicated by the NSW Landfill guidelines but is considered consistent with modern international practice for landfill design. Therefore, the base liner design for this project has adopted the more stringent approach from BPEM to provide a single composite liner in all new lining areas (both cell base liner and piggy back liner). The design also provides a continuous blanket leachate collection layer directly above the liner, consistent with both the NSW Landfill Guidelines and the BPEM.

Selection of lining system and leachate collection system materials for the design has also considered the following requirements:

- materials must be durable and resistant to degradation from potential long-term exposure to cell leachate in the temperature and pressure range expected at the cell base;
- materials must maintain acceptable performance when subjected to anticipated deformations, particularly within the piggy back lining system (refer Section 3.3.3); and
- Internal shear strengths and interface shear strengths must be consistent with project requirements to maintain acceptable levels of slope stability.

4.3.2 Design Elements

The primary components for the design and construction of landfill base areas are summarised in the following table. Lining system profiles are indicated in Figure A below (refer Drawings D022 and D031). Additional detail is provided in subsequent sections 4.3.3 to 4.3.5.





NEW LANDFILL CELL - PRELIMINARY DESIGN

Figure A – Lining System Details



PIGGY BACK LINER



CELL BASE LINER FOR CELLS 1 TO 4



CELL BASE LINER FOR CELLS 2A, 2B & 4A





Table 8: Summary of Landfill Base Components

Component	Base Lining System for Southern Extension	Base Lining System for Ridge Areas	Piggy Back Lining System for Piggy Back Fill Areas
[listed from bottom to top]	[Cells 1, 2, 3 & 4]	[Cells 2A, 2B & 4A]	[PB Cells 1, 2A, 2B, & 3]
Subgrade Preparation	 a. Cut/fill natural and fill materials in higher areas to create smooth liner grades. b. Fill in lower areas to achieve target groundwater separation distance, including at sumps. c. Proof roll and replace or recompact identified soft zones. 	 a. Cut natural material to achieve liner grades. b. Maximum 5 m cut depth to maintain target groundwater separation. c. Proof roll and replace identified soft zones. 	 a. Minor cut/fill existing cover soil in W. Gully area to create smooth liner grades. b. Cut existing cover soil and terrace bunds in E. Gully area to create smooth liner grades. c. Proof roll and replace or recompact identified soft zones.
Base Elevation	 a. Establish suitable grades for leachate drainage; allow for foundation soil settlement. b. Establish suitable grades such that sumps will gravity drain to an external drain line with acceptable invert depth 	a. Grades for leachate drainage will be readily achieved due to the sloping nature of the area.	a. Liner elevation generally corresponds to existing landfill surface.b. Grades for leachate drainage will be readily achieved due to the sloping nature of the area.
Landfill Gas Collection (beneath lining system)	None. Landfill gas collection not needed. No existing waste in this area.	None. Landfill gas collection not needed. No existing waste in this area.	a. Features to allow continuing collection of gas from vertical wells in existing waste (refer Section 3.3.3.3).b. Gravel trenches (periodic) with venting pipes.
Foundation Layer	None. Not needed.	None. Not needed.	Compacted base material (500 mm) with geogrid reinforcement
Liner Bearing Layer	Compacted clay soil (200 mm)	Compacted clay soil (200 mm)	Compacted clay soil (200 mm)
Lining System	Single composite liner: textured HDPE geomembrane overlying GCL	Single composite liner: textured HDPE geomembrane overlying GCL	Single composite liner: textured LLDPE geomembrane overlying GCL
Leachate Collection	Drainage aggregate (300 mm) with periodic collection pipes	Geocomposite drainage layer with periodic collection pipes	Geocomposite drainage layer with periodic collection pipes
Lining System Cover	None. Not needed.	Protection material (300 mm)	Protection material (300 mm)

4.3.3 Piggy Back Lining System

This section presents the preliminary design for the lining system in piggy back areas. The piggy back areas are those shaded in Drawing D012, comprising Piggy Back Cells 1, 2A, 2B and 3. This section concludes with Table 11 which presents the major components and key properties of the piggy back lining system.

Settlement and Deformation Analyses

The potential for settlement and deformations in the existing waste below the piggy back lining system to affect the integrity of the system was discussed in Section 3.3.3. Therefore, settlement and deformation analyses have been conducted to predict the magnitude of long-term tensile strains for the preliminary design of the piggy back lining system (refer Appendix C), comprising: (i) settlement analyses along cross sections through the proposed landform; (ii) deformation analyses, by the finite element method, along a





critical cross section through the proposed landform; and (iii) deformation analyses, by the finite element method, at hypothetical local areas of higher deformation in the existing waste (i.e. soft spots).

For the cross-sectional analyses (i) and (ii), the existing waste is assumed to be homogenous such that differential settlements/deformations arise from the changes in waste geometry along the cross section. For the local soft spot analysis, differential settlements/deformations arise from the predicted formation of a circular settlement depression centred on the soft spot. It is noted that the analyses were conducted in stages, with initial results leading to design changes which were then reflected in the final analyses results that are presented in Appendix C.

Results of the analyses are summarised in the following tables. The results indicate that the soft spot scenario is the most severe with respect to tensile strains in the piggy back lining system and that the design features given in the following subsection are required to address this scenario.

Table 9: Cross-Sectional Settlement & Deformation Analysis Results - Piggy Back Liner (Long-Term)

Analysis Type ¹	Cross Section Location ²	Max. Settlement	Max. Tensile Strain in Lining System
Settlement	W. Gully centreline (Section F-F')	4.0 m	0.5 % ³
Settlement	E. Gully centreline (Section H-H')	5.0 m	0.2 % ³
Deformation	W. Gully centreline (Section F-F')	3.1 m	2.2 %

Notes: 1. Settlement analysis considers vertical displacements only. Deformation analysis considers both horizontal and vertical displacements.

2. Cross section locations indicated in Appendix C (i.e., within App. A of that document)

3. Strain reflects average value in 25 m intervals between settlement calculation points.

Table 10: Local 'Soft Spot' Deformation Analysis Results - Piggy Back Liner (Long-Term)

Scenario	Max. Tensile Strain in LLDPE Geomembrane ¹ and GCL ²	Max. Tensile Strain in Geogrid Reinforcement ¹	Max. Settlement at Centre of Soft Spot ³	Radius of Settlement Depression (approx.)	Max. Settlement at Edge of Settlement Depression ³
Soft Spot – 'Base' case	2.7 %	1.1 %	2.2 m	8 m	1.9 m
Soft Spot – 'Softened Landfill' case	8.8 %	3.6 %	3.3 m	6 m	2.2 m

Notes: 1. Computed max. tensile strain occurs at the 'shoulder' of the circular settlement depression.

2. GCL strain assumed equal to that in adjacent LLDPE geomembrane

3. Settlement of LLDPE geomembrane at indicated location

The waste compressibility parameters used in the settlement and deformation analyses were based on the indicative value range presented by Gourc and Olivier (2005) for waste of 'intermediate' compressibility, with values from the 'high to very high' range used for the soft spot waste. These analyses may be revised at the time of detailed landfill design to reflect any design changes and to consider site-specific waste compressibility parameters obtained from the results of the settlement measurements and loading trials that are underway at the site at the time of preparation of this preliminary design report.

Design of Foundation Layer

The maximum long-term tensile strain for the LLDPE geomembrane and GCL from the analyses is 8.8%, as given in Table 10 above. This value can be compared to a maximum allowable tensile strain value of 8% for textured LLDPE geomembranes as identified in the Victoria BPEM guidance (Table D2 in BPEM). For GCL materials, no specific tensile strain limits are identified in the Victoria BPEM, however, published technical



information indicates that typical GCL materials are capable of undergoing more than 10% tensile strain without significant reduction in ability to maintain very low permeability performance, including performance across GCL overlap joints (LaGatta et al., 1997). For the purpose of preliminary design, the computed tensile strains are considered to be acceptable, subject to further design refinement during detailed design regarding strain in the LLDPE geomembrane.

The analyses indicate that a relatively stiff foundation layer for the piggy back lining is required to be constructed on the prepared subgrade material in order to attenuate the differential deformations arising from compression of the soft spot waste. The foundation layer also provides additional separation distance between the soft spot waste material and the lining system. The foundation layer adopted for the preliminary design has the following characteristics:

- 500 mm thick layer of compacted soil that is well-graded and predominately coarse-grained, with significant gravel content to interlock with the reinforcement material (see note regarding layer thickness at end of this sub-section); and
- incorporating at mid-layer a geosynthetic reinforcement material, most likely a biaxial geogrid, with a minimum long-term design tensile stiffness of 500 kN/m in the relevant tensile strain range (i.e., max. 5% strain); note: the stiffness value is to reflect the average for the four principal directions in the plane of the material, being MD (machine direction), XMD (cross machine direction), and the two diagonal directions between the MD and XMD.

These design features will be used in all piggy back lining areas because the hypothetical occurrence of a soft spot is taken as equally likely in all areas.

The analyses in Appendix C also considered whether differential movements in the piggy back lining system could reverse drainage grades within the leachate collection system. The cross-sectional analyses concluded that there were no grade reversals for the piggy back lining system suggested by the analysis results. This issue will be further considered during detailed design, including assessment of leachate drainage along additional cross sections perpendicular to the centrelines of the Eastern and Western Gully.

The soft spot analyses indicate potential for the LLDPE geomembrane to settle up to 1.1 m more at the centre of the soft spot than at the edge of the settlement depression approximately 6 m away (refer 'Softened Landfill' case in Table 10). This indicates a differential settlement of 1:5.5, suggesting that positive leachate drainage will be maintained where the overall slope of the piggy back liner is steeper than this value, which is the case for the large majority of the piggy back liner area. This result supports the need for the foundation layer design features outlined above. For the purpose of preliminary design, the computed grade changes are considered to be acceptable, subject to further consideration during detailed design of grade changes arising from hypothetical soft spots in the flatter portions of the piggy back liner.

It is noted that the soft spot analyses in Appendix C have been performed using a foundation layer thickness of 300 mm, rather than the thickness of 500 mm that has been conservatively adopted for preliminary design. One aspect of detailed design will be to assess the effect of this favourable thickness difference on calculated tensile strains and grade changes in the lining system.

LLDPE Geomembrane

The piggy back lining system design includes a 1.5 mm textured LLDPE geomembrane. LLDPE material has been selected, in preference to HDPE, primarily due to its higher allowable tensile strain. Specifically, the Victoria BPEM identifies, as indicated in the previous sub-section, a maximum allowable tensile strain of 8% for textured LLDPE geomembrane but only 4% for textured HDPE geomembrane. The difference in allowable strain arises because LLDPE has superior multi-axial strain characteristics, and in particular has an indistinct tensile yield point and therefore more resistance to stress cracking.

Although HDPE is known to have superior resistance to chemical degradation, and higher stiffness and strength that gives it superior ability to span foundation voids, these advantages are considered insufficient to outweigh the higher allowable strain of LLDPE. The higher extensibility of LLDPE is a major advantage for tolerating significant foundation differential settlement, as is expected in the piggy back lining system. A





potential disadvantage of LLDPE, its greater susceptibility than HDPE to local puncture due to its lower stiffness and strength, has been addressed in the design through selection of non-aggressive geosynthetics and soils as the surrounding materials in the lining system. The potential for the LLDPE geomembrane to be indented by the ribs of the geonet component (HDPE) of the geocomposite drain has been identified as a hypothetical risk and will be assessed during detailed design, and addressed if necessary.

Leachate Collection System for Piggy Back Liner

The preliminary design of the piggy back lining system includes placement of a blanket leachate collection layer over the entire piggy back lining area, as indicated in Section 4.3.1. Candidate materials for this blanket layer were discussed in Section 3.3.3.4 and comprise a drainage aggregate layer or a geocomposite drain. For the relatively steep slopes of the piggy back lining, up to 4H:1V, we consider that a geocomposite drain will provide the better balance of flow capacity, constructability, and shear strength. The system also includes a network of slotted leachate collection pipes to intercept and remove leachate flowing within the geocomposite drain.

The preliminary arrangement for the Leachate Collection System is shown on Drawing D041. The contours on this drawing are from Drawing D012 and represent the top of prepared subgrade for lining system construction, and therefore reflect the design grades for leachate drainage. The operational concept for leachate collection from new waste is via drainage solely under gravity as follows: (a) migration downward into the blanket geocomposite drainage layer; (b) lateral flow within the geocomposite in the direction of the top of liner grade with an approximate 50 m (maximum) flow distance from point of entry into the blanket to the nearest slotted leachate collection pipe; (c) flow into a pipe and then along the leachate collection pipe network; and (d) flow (within pipe) across the cell base liner area into one of four leachate sumps in Cells 1 to 4. Leachate flow out of the sumps is described in Section 4.3.4.

This operational concept generally presumes that leachate flowing within the geocomposite drain will be intercepted at the nearest slotted leachate collection pipe. Flow interception promotes: (i) rapid removal of leachate, through pipe flow; (ii) minimising leachate head build up on the geomembrane; and (iii) reducing the required flow capacity of the geocomposite drain because leachate collected in higher areas of the geocomposite drain does not need to be conveyed through lower areas of the geocomposite drain (i.e., downslope flows are not additive). The detail shown in Drawing D043 "leachate collection pipe for piggy back cell cross-slope pipes" promotes flow interception because the geocomposite drain for the higher area terminates at the leachate collection pipe, and is not directly connected into the geocomposite for the lower area. The detail indicates a gap of approximately 1 m between the higher and lower geocomposite drains.

Geocomposite Drainage Layer: The preliminary design includes a geocomposite drain comprising a nonwoven filter geotextile bonded to both sides of an HDPE geonet drainage core. The primary purpose of the lower geotextile, which will be placed in contact with the underlying textured LLDPE geomembrane, is to enhance the shear strength of the geocomposite-geomembrane interface. A secondary purpose is to cushion the geomembrane from contact with the geonet core. The primary purpose of the upper geotextile is to act as a filter to restrict migration of fine particles into the leachate collection system and therefore provide protection against blinding and/or clogging of the system. Internal and interface shear strength of the geocomposite drain is discussed in Section 4.8

The type of geocomposite products suitable for the project will be manufactured with selvage (roll edge) construction with both geotextiles extending beyond the geonet core. This allows secure joining of adjacent sheets by overlapping the lower geotextiles, butting and tying together the geonet cores, and overlapping and seaming the upper geotextiles via field sewing or hot-air (thermal) tacking.

For the preliminary design, the required geocomposite drainage material flow capacity has not been selected. This will be done during detailed design, taking into account potential leachate collection rates and factors that affect geocomposite design flow capacity, such as clogging potential, intrusion of the upper and lower geotextile into the geonet core, normal stress and expected temperature range (relevant to compression and creep of the geonet core), and drainage grades/gradients. It is noted that typical presettlement grades in the piggy back lining will be 5H:1V or steeper, but that minimum grades will be approximately 3% in the upper portion of the Western Gully landfill. Suitable geocomposite drains for the piggy back lining system will likely be from the high end of available product ranges.



Leachate Collection Pipes: The preliminary design includes cross-slope and down-slope perforated leachate collection pipes, with the layout in Drawing D041. The pipes will be manufactured with high grade HDPE to provide chemical durability and high flexibility. Each pipe will be installed with a gravel surround, as shown in the details on Drawing D043, in order to provide physical protection for the pipe as well as provide a contingency flow path in the case of local pipe failure or blockage. Pipe socks will not be permitted due to their known clogging potential in landfill leachate collection systems – rather the gravel surround will include a non-woven geotextile wrap for filtration protection. Pipe perforations will be relatively large, approximately 10 mm to 15 mm diameter drilled holes, to minimise clogging potential.

For the preliminary design, the pipes have not been sized. This will be done during detailed design, taking into account potential leachate flow rates, clogging potential, dimensions/wall thickness needed for long-term crushing resistance under piggy back fill loads, and pipe grades. It is noted that typical pre-settlement pipe grades will be 2% or greater. Based on project experience, it is likely that HDPE leachate pipes in commonly available diameters (typically 200 mm to 300 mm) and wall thicknesses will be suitable. This diameter range is also large enough to allow pipe inspection and clean out.

The pipe system layout provides for access to main collection pipes for inspection and clean out tools, such as water jetting rigs, at fifteen perimeter points and at the five leachate sump risers. These locations allow for major segments of the pipe system to be accessed without having to negotiate sharp bends or corners.

Landfill Gas Collection

The preliminary design includes a landfill gas venting system to provide for drainage of gas present immediately beneath the piggy back lining system in order to prevent pressure build up and discourage lateral migration (refer Section 3.3.2). This system can be considered to provide a contingency in the case that the planned active gas extraction systems for the existing waste are incomplete, ineffective, or out of service. The preliminary design of the gas venting system comprises (i) cross-slope gas venting trenches on relatively close spacing, approximate 20 m centres; with the trenches connected into (ii) upslope gas venting header pipes (refer Drawing D071). The venting trench spacing will be finalised during detailed design.

- Each gas venting trench will comprise a shallow trench, excavated into the prepared subgrade for the piggy back lining system, containing a perforated gas collection pipe surrounded by gas drainage gravel. A gas venting trench detail is shown as part of the piggy back liner detail on Drawing D031. . The gas collection pipes will be perforated 110 mm diameter HDPE pipes. The gravel will be durable natural gravel, crushed rock, or recycled concrete.
- The design includes seven gas venting header pipes. These pipes will be will be solid wall and designed and sized during detailed design. The top of each header pipe will be connected to the active gas extraction system infrastructure. The bottom of each header pipe will be connected to the leachate collection system (Drawing D071) to provide free drainage of any leachate/gas condensate entering the header pipe.

Internal Bunds

Internal bunds between cells and sub-cells in the piggy back lining system will be constructed to provide a physical barrier to waste and water movement during sequential lining and landfilling. An example is illustrated in Section F on Drawing D013. The location of the primary internal bunds is shown on Drawing D012. An internal bund detail is presented in Drawing D031.

Lining System Components

Each primary component of the piggy back lining system and leachate collection system is described in Table 11. Additional material requirements are provided in the preliminary Technical Specification (Appendix B).



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Table 11: Piggy Back Lining System Primary Components

Key Material Requirements [refer Drawing D031]	Purpose	Discussion		
Foundation Layer [500 mm thickness]				
 Clean (uncontaminated), well-graded sandy or gravelly soil; free of organic matter Gradation: max. particle size 40 mm; retained on 4.75 mm sieve > 30 %; Fines > 5% and < 25% Compacted to > 98% SMDD Mid-layer geosynthetic reinforcement material (e.g., biaxial geogrid) with stiffness properties as discussed in sub-section above "Design of Foundation Layer" 	 Provide stiff layer to attenuate differential deformations arising from waste 'soft spots' Provide surface to facilitate compaction of the overlying liner bearing layer 	Refer sub-section above "Design of Foundation Layer"		
Liner Bearing Layer [200 mm thickness]				
 Clean (uncontaminated) clayey soil; free of organic matter Gradation: Max. particle size 16 mm; Passing 2.4 mm sieve > 90%; Fines > 30% Plasticity index>15%; Liquid Limit > 25% Emerson crumb classification > 4 Compacted to > 95% SMDD and within ±2% SOMC 	 Provide appropriate surface for deployment of GCL Supplement composite liner effect achieved by GCL-geomembrane liner 	<i>Surface Preparation</i> : The bearing layer material must be compacted and prepared to provide an appropriately smooth and even surface for deployment of the GCL. The maximum particle protrusion from the prepared surface will be limited to 10 mm. The maximum particle size limitation will minimise installation damage to the GCL. <i>Clayey Soil</i> : A clayey soil is specified for the bearing layer to provide an additional layer of relatively low-permeability soil to supplement the composite liner effect of the primary liner (i.e., GCL and geomembrane).		
GCL - Geosynthetic Clay Liner [reinforced] [Layer of bentonite clay sandwiched between geotextile	GCL - Geosynthetic Clay Liner [reinforced] [Layer of bentonite clay sandwiched between geotextile layers; overlapped sheets]			
 GCL Product: Internally reinforced by needle punching mass (dry): total> 4000 g/m²; bentonite >3700 g/m² tensile strength > 4 kN/m; peel strength > 360 N/m permeability (cross-plane): 100kPa effective confining stress: tap water: k < 5 x 10⁻¹¹ m/s; deionised water with 0.1M CaCl₂ : k < 5 x 10⁻¹⁰ m/s, conducted after permeation with tap water 	 Provide very low permeability mineral barrier layer Produce composite liner effect in combination with overlying geomembrane Provide smooth surface for deployment of geomembrane 	Refer to the Technical Specification regarding requirements for: <i>GCL deployment</i> : overlap dimensions and treatment between adjacent rolls; orientation such that the upper surface of the GCL comprises a non-woven geotextile to enhance interface shear strength with the overlying textured geomembrane <i>Covering</i> : immediate placement of overlying geomembrane to prevent premature hydration; placement of layer of protection material within 24 hours to prevent unconstrained swell; and prohibition on trafficking on GCL <i>Permeability Testing</i> : Permeability testing will be performed at an effective confining stress representative of base liner conditions. The permeability testing includes		





Key Material Requirements [refer Drawing D031]	Purpose	Discussion
 Internal shear strength: refer Section 4.8 Bentonite clay: swell index> 24 ml/2g ; fluid loss< 18 ml form: natural sodium bentonite or >80% sodium as activated bentonite Geotextiles: at least one geotextile is nonwoven mass of nonwoven geotextile > 200 g/m² mass of woven geotextile (if any) > 100 g/m² 	 Protect geomembrane from puncture by underlying materials 	 permeation with a calcium chloride solution to confirm that any increase in permeability upon exposure to divalent cations (i.e. calcium) is relatively small. The requirements for GCL properties are consistent with international standards, including Victoria BPEM (Section E3 in BPEM), and are intended to reflect a high quality "standard" GCL product. Technical publications indicate that these requirements are capable of providing GCL physical performance as indicated below: <i>Extensibility:</i> The installed GCL product is expected to be capable of undergoing at least 10% tensile strain without significant increase in permeability. <i>Internal Shear Strength and Interface Shear Strength:</i> refer to Section 4.8.
LLDPE Geomembrane [1.5 mm thick, textured] [linear low-density polyethylene; welded sheets]		
 LLDPE product density < 0.939 g/cm3 Base resin: density > 0.915 g/cm3 and < 0.926 g/cm3; melt flow index < 1.0 g/10min Product textured both sides; asperity height >0.25mm Tensile strength at break > 16 kN/m Elongation at break > 250% Modulus at 2% strain < 630 kN/m Tear resistance > 150 N Puncture resistance > 300 N Axi-symmetric break resistance strain > 30% Oxidative Induction Time (OIT): >100 minutes at std. pressure >400 minutes at high pressure Oven aging at 85°C for 90 days: OIT retained >35% at std. pressure OIT retained >60% at high pressure 	 Provide very low permeability geosynthetic layer with very high chemical resistance Produce composite liner effect in combination with underlying GCL 	Refer to the Technical Specification regarding requirements for: - Deployment: installation requirements are provided to protect the geomembrane from puncture, scratching or other construction damage during deployment on the GCL, and also to protect the GCL from damage; the geomembrane will be rolled out in an upslope-downslope alignment to minimise seaming in a cross slope orientation. - Wrinkles: Wrinkles will form in the geomembrane prior to covering due to installation stresses and to thermal expansion of the material. The Technical Specification includes requirements to reduce and manage wrinkle formation - Seaming: CQA requirements for seam welding, seam testing and documentation - Covering: requirements are provided to protect the geomembrane from puncture, scratching or other construction damage during placement of the leachate drainage geocomposite and leachate collection pipes; restriction of trafficking on geomembrane - Intimate Contact: Intimate contact must be achieved and maintained between the geomembrane and the GCL to achieve the favourable composite liner effect. The LLDPE material requirements for physical, chemical and durability characteristics are consistent with international standards, including Victoria BPEM (Section D4 in BPEM), and reflect a high quality material with robustness, strength, and chemical resistance suitable for long-term service in municipal landfill lining systems, and particularly under deformable foundation conditions. Technical publications indicate these requirements provide geomembrane physical performance as indicated below: - Extensibility: The installed LLDPE geomembrane product is expected to be capable of undergoing at least 8% tensile strain without significant increase in permeability





Key Material Requirements [refer Drawing D031]	Purpose	Discussion		
		(refer sub-section above "Design of Foundation Layer") - Interface Shear Strength: Material is textured on both sides. Refer to Section 4.8.		
Leachate Collection Layer [Geocomposite drain comprising geonet drainage core	sandwiched between two filt	er geotextile layers; overlapped sheets]		
 Geocomposite Product: Geonet –HDPE material Geotextiles thermally bonded to geonet Ply adhesion (i.e., peel strength) >180 g/cm Requirements to be established during detailed design: Thickness and Mass per unit area Hydraulic flow rate; and Hydraulic Flow Rate Reduction Factor for Creep, RF_{CR} Tensile strength and elongation Geotextiles: Geotextiles - non-woven structure, PET or PP material Mass per unit area > 130 g/m² (note: > 200 g/m² if sheets joined by hot-air seaming) Equivalent Opening Size < 90 μm 	 Drain leachate from above the liner to reduce potential for migration of leachate through liner Protect underlying geomembrane from direct contact with overlying materials Note: Leachate collection pipes discussed in sub- section above "Leachate Collection System for Piggy Back Liner" 	Refer to the Technical Specification for material and installation requirements. <i>Deployment:</i> The leachate collection layer material will be placed directly on the geomembrane. Installation requirements are given to avoid geomembrane damage. <i>Joining:</i> Adjacent sheets will be joined by overlapping the lower geotextile, overlapping and tying the geonet core, and seaming the upper geotextile. Upper geotextile seaming may be by sewing or hot-air (thermal) seaming. The required properties provide for a durable material that will be essentially non- reactive with anticipated leachate and will have very high initial permeability, high clogging resistance due to the large spaces in uniform net, and ability to withstand long-term stresses. Additional discussion of physical properties is given below. - <i>Resistance to creep under compressive load</i> – Manufacturers' data indicates that geocomposite products are available that can reliably sustain the maximum long-term compressive loads anticipated within the cell, in the order of 500 kPa. - <i>Internal Shear Strength and Interface Shear Strength:</i> refer to Section 4.8.		
Lining System Cover [Protection Material: 300 mm thickness]	Lining System Cover [Protection Material: 300 mm thickness]			
 Soil material with max. particle size 13.2 mm. Natural or recycled material acceptable Capable of being spread smoothly in a 300mm layer without damaging underlying geocomposite drain Compaction limited to tracking with the spreading plant Strength sufficient to maintain layer stability from the time of installation until the start of waste placement Permeability: 5 x 10⁻⁵ m/s < k < 1 x 10⁻³ m/s 	 Protect lining system from physical disturbance, temperature changes, and UV degradation Provide ballasting weight to prevent wind uplift Provide confining stress to restrict potential for GCL swelling and to promote 	Refer to the Technical Specification for material and installation requirements. <i>Placement:</i> The material will be placed directly on the geocomposite drain. Installation requirements include spreading in a single layer and compaction by tracking with the spreading plant in order to avoid disturbance of the geocomposite. <i>Stability:</i> Material (as placed) must have sufficient internal friction and cohesion to maintain stability for the range of piggy back liner slope angles and heights. Note: These slopes are generally 4H:1V or flatter, but local slopes are as steep as 1H:1V at internal bunds. Different material may be required in different areas. <i>Permeability.</i> Material (as placed) must have a min. permeability to maintain free		





4.3.4 Cell Base Lining System

This section presents the preliminary design for the lining system in cell base areas. The cell base areas comprise Cells 1 to 4 (southern extension cells) and Cells 2A, 2B and 4A (natural ridge cells) (refer Drawing D012). This section concludes with Table 14 which presents the major components and key properties of the cell base lining system.

Settlement Analyses

Lining system foundation materials in the cell base areas comprise natural soils, with some fill soils (nonlandfill) in portions of Cells 1 to 4, as described in Section 2.3.2. These foundation materials are significantly less prone to settlement and deformation than the existing landfill wastes which form the foundation in the piggy back liner areas. In a large portion of the base liner areas, soils are of limited thickness and unlikely to undergo significant settlement, and settlement analysis was not considered necessary in these areas. Settlement analyses have been conducted, however, for preliminary design in the Cells 1 to 4 area where the thickness of colluvial/alluvial foundation soils is significant, up to 16 m. These analyses were performed to predict the magnitude of long-term tensile strains and grade reversal induced by differential foundation settlement of the base liner system. These analyses were performed along a critical cross section through the proposed final landform (Refer Appendix C).

Results of the analyses are summarised in the following table. The results indicate that computed differential settlements are relatively insignificant with respect to lining system strain, but potentially significant with respect to lining system grade reversal. It is noted that the calculated maximum grade reversal occurred in a generally north-south direction and within 75 m of the southern edge of Cells 1 to 4. Grade reversal is discussed in the "Leachate Collection System for Cell Base Liner" sub-section below.

Cross Section	Max. Settlement	Max. Tensile Strain in	Max. Grade Reversal in
Location ¹		Lining System	Lining System
W. Gully centreline (Section F-F')	0.8 m	0.2 % ²	1.4 % ²

Table 12: Settlement Analysis Results – Cell Base Liner in Cells 1 to 4 Area (Long-Term)

Notes: 1. Cross section location indicated in Appendix C (i.e., within App. A of that document)

2. Strain and grade reversal reflects average value in 25 m intervals between settlement calculation points.

HDPE Geomembrane

The cell base lining system design includes a 2.0 mm textured HDPE geomembrane. HDPE has been selected, given the relatively small lining system tensile strains indicated in the previous sub-section and the maximum allowable tensile strain of 4% for textured HDPE geomembrane identified in the Victoria BPEM guidance (Table D2 in BPEM).

Leachate Collection System for Cell Base Liner

The preliminary design of the cell base lining system includes a blanket leachate collection layer over the entire area, as indicated in Section 4.3.1. The leachate collection blanket includes a network of slotted leachate collection pipes to intercept and remove leachate flowing within the blanket. The leachate collection blanket differs in the Cells 1 to 4 area versus the natural ridge areas (Cells 2A, 2B and 4A) as indicated below.

- Cells 1 to 4: The leachate collection blanket will comprise a 300 mm thick layer of high porosity drainage aggregate. This layer will also include an underlying cushion geotextile to protect the HDPE geomembrane and an overlying filter geotextile.
- Cells 2A, 2B and 4A (natural ridge areas): The leachate collection blanket will comprise a geocomposite drainage layer. This will be the same material as in the piggy back lining system (refer Section 4.3.3).

Factors affecting the selection of drainage aggregate for the leachate collection blanket in Cells 1 to 4 area are: (i) constructability - The area generally has flat lining system slopes where stable placement of a drainage aggregate layer is straightforward as opposed to sloping areas where placement may be



problematic; (ii) resistance to clogging - The area forms the lowest portion of the overall leachate collection system and contains the leachate sumps; (iii) geomembrane puncture protection – Use of drainage aggregate creates a puncture risk for the HDPE geomembrane, requiring a cushion geotextile between the aggregate and geomembrane. Overall, the substantial clogging and blinding resistance provided by the large total pore space within a high-porosity drainage aggregate layer is preferred in this area to the lesser pore space within a geocomposite drainage layer. The detailed design will also confirm, as a matter of course, that the blanket 300 mm thick drainage aggregate layer has sufficient leachate flow capacity. The detailed design will consider the guidance in the Victorian BPEM regarding cushion geotextile functions and properties (Appendix F in BPEM).

The preliminary arrangement for the Leachate Collection System is shown on Drawing D041. The contours on this drawing are from Drawing D012 and represent the top of prepared subgrade for lining system construction, and therefore reflect the design grades for leachate drainage. The operational concept for leachate collection within the cell base areas is via drainage solely under gravity as follows: (a) migration downward into the blanket drainage aggregate layer; (b) lateral flow within the layer in the direction of the top of liner grade with an approximate 50 m (maximum) flow distance from point of entry into the blanket to the nearest slotted leachate collection pipe; (c) flow into a pipe and then along the leachate collection pipe network into one of four leachate sumps in Cells 1 to 4.

The preliminary design for the base lining in the Cells 1 to 4 area provides minimum pre-settlement grades of 2% toward the leachate sumps, with grades typically 3% or steeper. This will allow for positive north-south drainage to be maintained, after foundation settlement, within the leachate collection blanket layer and along leachate collection pipes. The previous sub-section indicated that settlement-induced grade reversal could be as high as 1.4% within 75 m of the southern edge of Cells 1 to 4. Therefore, the 2% minimum design grade is considered suitable for preliminary design and will be confirmed during detailed design.

Leachate Sumps: The leachate sumps are essentially local depressions within the leachate collection blanket (refer Drawing D042). The sumps are relatively shallow, only 500 mm deep, in order to facilitate maintaining the target groundwater separation distance (refer Section 3.3.5). Other key features of the sumps are indicated below.

- The cell base lining design is enhanced at the leachate sumps because, although the footprint area of the sumps is small, the sumps are considered high risk areas for leachate leakage for the following reasons: (i) being the lowest points in the leachate collection system, it is more likely that leachate will be present in the sump than in other areas; and (ii) the intricate geometry of the relatively small sump area increases the likelihood of geomembrane installation defects. The lining enhancements comprise the placement of a double thickness of GCL (i.e. two layers placed together) below the HDPE geomembrane and the addition of a 500 mm thick low-permeability (i.e., k<1x10⁻⁹ m/s) compacted clay liner below the double GCL layer.
- Each sump drains via gravity through a leachate sump outlet pipe to a leachate sump riser outside the perimeter bund. This requires the leachate sump outlet pipe to penetrate the cell base lining system, as indicated in Detail 1 on Drawing D042.
- The leachate sump outlet pipe includes a elbow bend as it enters the leachate sump riser to provide a water seal (trap) so that atmospheric oxygen is restricted from entering the leachate sump and landfill gas is restricted from entering the leachate sump riser.
- The elbow bend in the leachate sump outlet pipe is removable to improve access for pipe clean out and inspection. Further, the leachate sump outlet pipe is continuous with the north-south leachate collection pipe entering the sump to provide access to the north-south pipe.

Each leachate sump riser is subsequently drained via gravity through the leachate drainage pipe, which is external to the landfill lining system (i.e., completely outside the perimeter bund). The leachate drainage pipe flows to a single external leachate pumping pit for pumping to the leachate ponds, at the point labelled "to new leachate pond" on Drawing D041. It is noted that for the first stages of the New Landfill Cell Project,





the existing leachate well east of the leachate ponds will be the pumping location; while in subsequent stages a new pumping pit will be constructed at the identified point.

The design features of the leachate sump outlet pipes and leachate drainage pipe are presented in a subsection below.

Leachate Collection Pipes: The preliminary design for the leachate collection system in the cell base lining areas includes a network of perforated leachate collection pipes, with the layout in Drawing D041. The pipes will be manufactured of the same material used for the leachate pipes in the piggy back lining system, i.e. high grade HDPE. Placement of the pipes differs in the Cells 1 to 4 area versus the natural ridge areas (Cells 2A, 2B and 4A) as indicated below and in the details on Drawing D043.

- Cells 1 to 4: The leachate collection pipes will be placed within 300 mm thick leachate collection blanket.
- Cells 2A, 2B and 4A (natural ridge areas): The leachate collection pipes will be installed with a gravel surround, similar to that used in the piggy back lining system.

Pipe socks will not be permitted due to their known clogging potential in landfill leachate collection systems – rather the leachate collection blanket or gravel surround will include a non-woven geotextile for filtration protection. Pipe perforations will be relatively large, approximately 10 mm to 15 mm diameter drilled holes, to minimise clogging potential.

For the preliminary design, the pipes have not been sized. This will be done during detailed design, taking into account potential leachate flow rates, clogging potential, dimensions/wall thickness needed for long-term crushing resistance under new waste fill loads, and pipe grades. Based on project experience, it is likely that HDPE leachate pipes in commonly available diameters (typically 200 mm to 300 mm) and wall thicknesses will be suitable. This diameter range is also large enough to allow pipe inspection and clean out.

The pipe system layout provides for access to main collection pipes for inspection and clean out tools, such as water jetting rigs, at fifteen perimeter points and at the five leachate sump risers. These locations allow for major segments of the pipe system to be accessed without having to negotiate sharp bends or corners.

Connection of Existing Leachate Collection System Pipes

The preliminary design provides for connection of existing leachate drainage lines into a new Leachate Drainage Pipe within Cell 1, as summarised in the table below and in Section 3.3.4, and as indicated on Drawings D041 and D071.

Item to be Connected	No.	Status	Discussion
Deep Leachate Drainage Pipes from Eastern Gully Landfill	2	existing	Connection point will be outside of the limit of the existing HDPE geomembrane liner.
Deep Groundwater Drainage Pipe from Eastern Gully Landfill	1	existing	Pipe is beneath existing HDPE geomembrane liner. Flow in pipe is likely impacted by leachate.
Shallow leachate drainage line from Western Gully Landfill	1	existing, replacement proposed	Replacement of the existing drainage line is proposed to occur prior to start of Stage 1 construction.
Deep leachate drainage pipe from Western Gully Landfill	1	proposed	Construction is proposed to occur prior to start of Stage 1 construction.
Gas Header Pipes (refer Section 4.3.3)	3	landfill preliminary design	Connect lower end of header pipe to provide drainage for any leachate and/or gas condensate.

Table 13: Leachate Drainage Pipe in Cell 1– Connections beneath Cell Base Lining System





The invert levels of the pipes to be connected are such that, in order to maintain gravity drainage, the connections must occur beneath the cell base lining system in Cell 1. Therefore, because any leakage at the connections, or from the Leachate Drainage Pipe itself, would not be contained by the lining system, the design of the connections and pipe must be suitably robust and leak resistant. The design features of the leachate drainage pipe are discussed in the sub-section "Leachate Drainage Pipe" below.

It is noted that lowering the cell base lining system design grades so that the pipe connections could be made above the cell base lining system is not compatible with lining system design goals of full gravity drainage (refer 3.3.4) and groundwater separation (refer 3.3.5). Such an approach would also require undesirable pipe penetrations through the cell base lining system.

The pipes indicated in the above table that are to be connected from the Eastern Gully Landfill were installed at the time of liner construction for Stage 1 (1993) and Stage 2 (2001) of the Eastern Gully Landfill. One element of the New Landfill Cell project design is to consider whether these pipes will maintain their structural stability when subjected to the additional loading from the new piggy back waste fill to be placed in Eastern Gully. Information regarding the magnitude of vertical stress that the pipes were originally designed to accommodate is not available.

In terms of total thickness of landfill overlying the alignment of these pipes, the current Eastern Gully Landfill design has a maximum thickness of approximately 50 m, increasing to a maximum of approximately 65 m with the addition of the proposed piggy back fill for the New Landfill Cell project. This suggests that the proposed piggy back fill may result in maximum vertical stresses on the pipes that are approximately 30% larger than would be present without the piggy back fill. Based on the pipe material (HDPE) and pipe bedding materials (clean sand and fine gravel) as indicated in Section 2.6.2 and the modern dates of pipe design and installation, and considering that the increase in maximum vertical stress due to piggy back filling is limited to approximately 30%, we consider it likely that the pipes will maintain their structural stability under piggy back filling and capping. Further, in the unlikely case that pipe collapse were to occur in highly stressed areas, multiple alternate leachate flow paths are available through the bedding materials. The issue of structural stability of the existing Eastern Gully pipes will be considered further, to the degree practicable, during detailed design.

Leachate Sump Outlet Pipes

The leachate sump outlet pipes will connect each of the leachate sumps to the adjacent leachate sump riser, as indicated on Drawings D041. These pipes are shown in Drawing D042 and have discussed above in the sub-section "Leachate Sumps." Each pipe will be solid wall and approximately 10 m long.

For the preliminary design, the leachate sump outlet pipes have not been sized. This will be done during detailed design, taking into account potential leachate flow rates, clogging potential, dimensions/wall thickness needed for long-term crushing resistance, and pipe grades. Based on project experience, it is likely that HDPE leachate pipes in commonly available diameters (typically 200 mm to 300 mm) and wall thicknesses will be suitable. This diameter range is also large enough to allow pipe inspection and clean out.

Detailed design will evaluate the inclusion of specific leak protection measures, such as low-permeability pipe bedding to reduce leak potential and use of a stainless steel pipe section at the penetration into the sump riser pipe to reduce the thermal expansivity contrast between the pipe (HDPE) and the riser pipe (concrete). The inclusion of such measures will be considered with respect to the pipes' leakage risk and accessibility for inspection and repair, noting that the accessibility of these pipes is generally good because of their short length and relatively small depth of burial. It is noted that inclusion of specific leak protection measures for the sump riser pipes will also be evaluated during detailed design.

Leachate Drainage Pipe

The leachate drainage pipe (Drawing D041) has two distinct portions:

Portion within Cell 1: This portion of the leachate drainage pipe has a length of approximately 250 m and is designed to gravity drain the leachate collection pipes from the existing waste, as well as the gas header pipes beneath the piggy back lining system, as indicated in Table 13 above. This portion of the





pipe will be positioned beneath the cell base lining system in Cell 1. This portion of the pipe terminates at the eastern most leachate sump riser pipe.

Portion outside southern edge of Cells 1 to 4: This portion of the leachate drainage pipe has a length of approximately 350 m and is designed to connect and gravity drain the leachate sump risers toward the pumping point labelled "to new leachate pond" on Drawing D041. This portion of the pipe will be positioned outside of the landfill perimeter bund, i.e. external to the landfill lining system. The design provides for the invert of this pipe to remain above the groundwater table.

For the preliminary design, the leachate drainage pipe has not been sized. This will be done during detailed design, taking into account potential leachate flow rates, clogging potential, dimensions/wall thickness needed for long-term crushing resistance, and pipe grades. Based on project experience, it is likely that HDPE leachate pipes in commonly available diameters (typically 200 mm to 300 mm) and wall thicknesses will be suitable. This diameter range is also large enough to allow pipe inspection and clean out

Detailed design for the leachate drainage pipe will evaluate the inclusion of specific leak protection measures, similar to the approach for the leachate sump outlet pipes discussed in the previous sub-section. With respect to pipe leakage risk and accessibility for inspection and repair, conditions will differ in the two portions of the pipe. The portion outside the southern edge of Cells 1 to 4 will be highly accessible in that it has no overlying waste or landfill liner/cap and is at shallow depth. Conversely, the portion of the leachate drainage pipe within Cell1 is essentially inaccessible because it will be overlain by the cell base lining system, up to 30 m of new waste, and the landfill capping system. Therefore, it is expected that design of the portion of the leachate drainage pipe within Cell1 will incorporate substantially more robust connections and leak protection measures than the portion outside the southern edge of Cells 1 to 4.

Bunds

Internal Bunds: Internal bunds between cells and sub-cells in the cell base lining system will be constructed to provide a physical barrier to waste and water movement during sequential lining and landfilling. The location of the primary internal bunds is shown on Drawing D012. An internal bund detail is presented in Drawing D022.

Perimeter Bund: The perimeter bund along the southern edge of Cells 1 to 4 provides the perimeter termination point for the cell base liner, and also for the final capping system. The bund is 1 m high, with a 4 m crest width, and will be not only a barrier to waste and water movement during lining system construction, but also a prominent physical feature indicating the limit of landfilling. The perimeter bund is illustrated in Drawing D042. The perimeter bund material will be clayey soil that generally meets the same specification as that for the bearing layer material (refer Table 14).

Lining System Components

Each primary component of the cell base lining system and leachate collection system is described in Table 14. Additional material requirements are provided in the preliminary Technical Specification (Appendix B).





Table 14: Cell Base Lining System Primary Components

Key Material Requirements [refer Drawing D022]	Purpose	Discussion	
Liner Bearing Layer [200 mm thickness] Liner bearing layer is the same as in the piggy back lining system. Refer to Table 11.			
GCL - Geosynthetic Clay Liner [reinforced] [Layer of bentonite clay sandwiched between geotextile layers; overlapped sheets] GCL is the same as in the piggy back lining system. Refer to Table 11.			
HDPE Geomembrane [2 mm thick, textured] [high-density polyethylene; welded sheets]			
 HDPE product density > 0.94 g/cm3 Base resin: density > 0.932 g/cm3; melt flow index < 1.0 g/10min Product textured both sides; asperity height >0.25mm Yield tensile strength> 29 kN/m; yield elongation> 12% Tear resistance > 249 N; Puncture resistance > 534 N Oxidative Induction Time (OIT): >100 minutes at std. pressure >400 minutes at high pressure Oven aging at 85°C for 90 days: OIT retained >55% at std. pressure OIT retained >80% at high pressure Stress Cracking Resistance (performed on smooth portion of sheet) NCTL>300hr 	 Provide very low permeability geosynthetic layer with extremely high chemical resistance Produce composite liner effect in combination with underlying GCL 	Refer to the Technical Specification for material and installation requirements. Requirements for HDPE geomembrane installation, including deployment, wrinkle management, seaming, covering, and maintaining intimate contact will be similar to those for the LLDPE geomembrane in the piggy back lining system (refer Table 11). The HDPE material requirements for physical, chemical and durability characteristics are consistent with international standards, including Victoria BPEM (Section D3 in BPEM), and reflect a high quality material with robustness, strength, and chemical resistance suitable for long-term service in municipal landfill lining systems. Technical publications indicate these requirements provide geomembrane physical performance as indicated below: - <i>Extensibility:</i> The installed HDPE geomembrane product is expected to be capable of undergoing at least 4% tensile strain without significant increase in permeability (refer sub-section above "HDPE Geomembrane") - <i>Interface Shear Strength:</i> Material is textured on both sides. Refer to Section 4.8.	
Leachate Collection Layer in Cells 1 to 4 [Drainage Aggregate: 300 mm thickness, with over	lying filter geotextile and und	erlying cushion geotextile]	
 Drainage Aggregate: Washed uniform gravel or crushed rock of natural geologic origin and high durability 	 Drainage aggregate: (i) Drain leachate from above the liner to reduce 	Refer to the Technical Specification for installation requirements. -Placement: installation requirements are provided to protect the underlying geomembrane from puncture, scratching or other construction damage during	





Key Material Requirements [refer Drawing D022]	Purpose	Discussion
 Free of organics, carbonates and clay balls Permeability: k > 1 x 10⁻³ m/s Particle Angularity: no high angularity particles Gradation: uniform (high porosity) 20 mm gravel max. particle size 26.5 mm retained on 19 mm sieve < 20% retained on 13.2 mm sieve < 10% percentage fines < 3% Aggregate strength/durability: min. wet strength 80 kN max. wet/dry strength variation 30% Filter Geotextile: non-woven, PET or PP material Mass per unit area > 200 g/m² CBR puncture strength > 2100 N Equivalent Opening Size < 110 µm Cushion Geotextile: non-woven, PET or PP material Requirements to be established during detailed design: Mass per unit area- indicative value > 550 g/m² Trapezoidal tear strength- indicative value > 6000 N 	 potential for migration of leachate through liner; (ii) Provide protection and confining stress for liner, as indicated for the "Lining System Cover" layer in Table 11. Filter geotextile: Restrict migration of fine particles into drainage aggregate Cushion geotextile: (i) Protect underlying geomembrane from damage or puncture; (ii) minimise local strains in geomembrane at drainage aggregate contact points Note: Leachate collection pipes discussed in sub- section above "Leachate Collection System for Base Liner" 	 drainage aggregate placement and geotextiles deployment. <i>Trafficking</i>: Restrictions on trafficking on the surface of the drainage aggregate after placement are included to minimise potential for damage to the underlying geomembrane. Refer to the Technical Specification for material requirements. The required drainage aggregate properties provide for a strong, durable, and high porosity material that is suitable for long-term service in municipal landfill lining systems. Gradation and angularity requirements may be revised depending on the detailed design of the cushion geotextile The required filter geotextile properties provide a material with suitable physical properties to withstand installation stresses and suitable geometry to restrict fines migration into the drainage aggregate and therefore reduce the potential for clogging within the leachate collection blanket and pipes. The cushion geotextile properties provided reflect a typical heavy non-woven geotextile material, often suitable for cushion applications. Cushion geotextile requirements may be revised during detailed design.

Leachate Collection Layer in Cells 2A, 2B and 4A (natural ridge areas)

[Geocomposite drain comprising geonet drainage core sandwiched between two filter geotextile layers; overlapped sheets]

Geocomposite drain is the same as in the piggy back lining system. Refer to Table 11.

Lining System Cover in Cells 1 to 4

Lining system cover not used because functions are fulfilled by the leachate collection layer.

Lining System Cover in Cells 2A, 2B and 4A (natural ridge areas)

[Protection Material: 300 mm thickness]

Protection material is the same as in the piggy back lining system. Refer to Table 11.





4.3.5 Lining System Subgrade Preparation

The preliminary design includes different types of subgrade preparation for the lining system across the site, as indicated in Drawings D012 and D013, and discussed below. Subgrade preparation is also summarised in Table 8 above. In general, design subgrade levels for the lining system are established to provide suitable grades for liner installation and leachate drainage (refer Sections 4.3.3 and 4.3.4), to achieve the target groundwater separation distance of 2m (refer Section 3.3.5), to minimise fill placement, and to allow excavated material recovery where appropriate.

The top of subgrade levels for the preliminary design are shown on Drawing D012. The contour levels on this drawing represent the top of prepared subgrade for lining system construction, and therefore reflect the design grades for leachate drainage. This drawing indicates the location of cross sections A to E, which depict different subgrade preparation approaches on Drawing D013. Each subgrade preparation approach from Drawing D013 is described below.

- Cross-Section A: Western Gully Landfill (piggy back lining system). Subgrade preparation generally comprises smoothing (i.e. minor cut/fill) of the existing cover soils on the landfill surface to create continuous grades (3% min) for lining system installation and leachate drainage. This will also involve cutting to form small benches for cross-slope leachate collection pipes as indicated in detail "Leachate Collection Pipe for Piggy Back Cell Cross-Slope Pipes" on Drawing D043. Comparison of the existing levels on Drawing D003 and the top of subgrade levels on Drawing D012 indicates that Western Gully subgrade preparation will involve an average cut of approximately 0.3 m, generating approximately 25,000 m3 of non-VENM (virgin excavated natural material) materials that are assumed suitable for use as daily cover for landfill operations.
- Cross-Sections B and E: Natural Ridges Cells 2A, 2B and 4A (cell base lining system). Subgrade preparation generally comprises excavation of natural materials to approximate 5 m depth using 1.5H:1V excavation batters. This slope batter was identified as an acceptable temporary excavation batter for these areas in the geotechnical report in Appendix C. Excavation depth reduces to zero along the southern edges of these areas to maintain downslope leachate drainage. Comparison of the existing levels on Drawing D003 and the top of subgrade levels on Drawing D012 indicates that Cells 2A, 2B and 4A subgrade preparation will involve an average cut of approximately 4 m, generating approximately 225,000 m3 of VENM materials that are assumed suitable for use as daily cover for landfill operations or as general fill for landfill construction.
- Cross-Section C: Eastern Gully Landfill (piggy back lining system). Subgrade preparation generally comprises excavation to remove the existing cover soil terrace bunds on the landfill surface to create continuous grades (4H:1V average) for lining system installation and leachate drainage. This will also involve cutting to form small benches for cross-slope leachate collection pipes as indicated in detail "Leachate Collection Pipe for Piggy Back Cell Cross-Slope Pipes" on Drawing D043. Comparison of the existing levels on Drawing D003 and the top of subgrade levels on Drawing D012 indicates that Eastern Gully subgrade preparation will involve an average cut of approximately 0.9 m, generating approximately 55,000 m3 of non-VENM (virgin excavated natural material) materials that are assumed suitable for use as daily cover for landfill operations.
- Cross-Section D: Southern extension area- Cells 1 to 4 (cell base lining system). Subgrade preparation in this area is further illustrated in cross-sections G to K on Drawing D021. Subgrade preparation generally comprises cut and fill of existing natural soils and previous fill soils to create continuous grades (2% min) for lining system installation and leachate drainage. Comparison of the existing levels on Drawing D003 and the top of subgrade levels on Drawing D012 indicates that Cells 1 to 4 subgrade preparation will involve an average fill of approximately 0.2 m, requiring approximately 20,000 m3 of VENM fill. Maximum cut and fill depths are approximately 8 m and 4 m, respectively, generally with cutting in the northern portions and filling in the southern portions.

In all areas, subgrade preparation will begin with vegetation and topsoil removal. Proof rolling, followed with excavation and replacement of any identified soft soil areas, will be performed on all excavated surfaces. All imported materials used as fill will be VENM.







4.4.1 Cover for Landfill Operations

The use of daily and intermediate cover materials during landfilling operations provides a number of environmental benefits including minimisation of: (i) windblown litter: (ii) water infiltration, leading to leachate generation; (iii) runoff from exposed waste, leading to leachate generation; (iv) landfill fire potential; (v) access for animal vectors such as sea gulls or rodents; and (vi) gas emissions and odour generation. With respect to landfill design, operational cover use primarily affects leachate generation, as indicated below.

Daily Cover: Daily cover is placed on exposed waste areas at the end of each day of landfill operations (hence the term "daily"). It typically comprises soil, or other granular material, placed in a minimum 150 mm thick layer. Plastic sheets or tarps are also used at some sites. Daily cover materials are stripped for re-use, to the degree practicable, at the start of the next day of landfilling in order to preserve landfill airspace and to avoid the development of relatively impermeable layers within the landfill that could potentially lead to local perched leachate zones. Landfill lids, which are moveable roof structures that serve as daily cover, have also been used in local areas of waste placement at the Whytes Gully RRP site.

The rate of leachate generation from infiltrating rainfall can be very high in soil daily cover areas because daily cover is generally not well controlled with respect to gradation, degree of compaction, and surface grading. This is reflected in the infiltration rate of 60% of incident rainfall used in the leachate water balance calculations described in Section 4.7. To mitigate the high infiltration rate, landfill operation measures include for maintaining daily cover areas at the smallest practicable size.

Intermediate Cover: Intermediate cover is placed over daily cover in areas where landfilling has been temporarily completed and where no additional waste will be placed for more than 90 days. For example, the west-facing interim landfill batters that will be present during project (eg. Drawing D013, Section F) will have intermediate cover. Intermediate cover will be stripped for re-use, to the degree practicable, at the resumption of landfilling in the area in order to preserve landfill airspace and to avoid the development of relatively impermeable layers within the landfill that could potentially lead to local perched leachate zones. By definition, intermediate cover will remain in place for at least 90 days and, in some areas, it will remain in place for several years until waste placement resumes in the area.

Intermediate cover typically comprises soil placed in a minimum 300 mm thick layer. The rate of leachate generation from infiltrating rainfall is generally moderate in intermediate cover areas because intermediate cover material generally excludes high permeability granular soils, has controlled compaction, and is graded to promote runoff and direct it away from daily cover areas. This is reflected in the infiltration rate of 20% of incident rainfall used in the leachate water balance calculations described in Section 4.7.

4.4.2 Final Capping System

Overview

The final capping system profile for the preliminary design is shown in Figure B below (refer Drawing D061). The system will be constructed upon the uppermost intermediate cover layer in each landfill area. The system incorporates measures for infiltration control, landfill gas control, and support of vegetation growth, as described in the following sub-sections.

The design presumes that the post-capping land use will be as passive open space, with no development other than, possibly, local access tracks and footpaths. No services are to be installed.



NEW LANDFILL CELL - PRELIMINARY DESIGN





CAP PROFILE

Infiltration Control

Infiltration Barrier: The primary purpose of the infiltration barrier within the final capping system is to provide a continuous barrier to limit rainwater infiltration into the landfill, thus reducing the potential for leachate generation. The infiltration barrier also serves to limit movement of atmospheric oxygen into the landfill thus reducing fire potential and increasing landfill gas collection efficiency. The current NSW Landfill Guideline standards for capping indicate a single clay liner (500m thick with maximum permeability 1 x 10^{-8} m/s).

The infiltration barrier design comprises two components as given below.

- Bearing Layer: Comprises a 200 mm thickness of compacted clayey soil with a maximum particle size of 9.5 mm to limit puncture potential for the overlying geomembrane. The soil will have gradation and plasticity requirements such that it would classify as an SC or CL soil in the USCS classification system. Although the design does not specify a maximum permeability value for this soil, the material and compaction requirements are expected to result in a material with an as-placed permeability in the order of 1 x 10⁻⁸ m/s.
- Geomembrane: Comprises a 1.0 mm thick LLDPE geomembrane. The geomembrane will be textured on both sides to provide high interface shear strength, as discussed in the sub-section below "Capping System Stability".

The bearing layer serves two functions as follows: (i) it provides an appropriate surface for deployment of the geomembrane and protects the geomembrane from puncture damage because it will be smoothly compacted and will not contain significant gravel particles; and (ii) it works in combination with the geomembrane to provide a composite liner effect whereby the rate of water leakage through any defects in the geomembrane will be significantly less than if the geomembrane was placed on more permeable soil. Because the development of a full composite liner effect (i.e., an order of magnitude or more reduction in leakage rate) is typically known for clayey soil layers that are thicker than 200 mm, we consider that only a partial composite effect will be effectively achieved with the design. However, such a partial composite effect is expected to result in an infiltration rate at least several times lower than for a single clay liner or single geomembrane. In addition, because the upper component is a geomembrane the design infiltration barrier will not be vulnerable to desiccation or root penetration, as are single clay liners.





Additional description regarding material and installation requirements is provided in Table 15 below.

On this basis, and considering that a blanket subsurface drainage system is incorporated in the final capping system (refer next paragraph) to provide further infiltration control, the proposed infiltration barrier design is considered to exceed current NSW Landfill Guideline standards and reflect good practice.

Subsurface Drainage: The primary purpose of the subsurface drainage system within the final capping system is to remove infiltrating rainwater from above the infiltration barrier and thereby limit the potential for leakage through the infiltration barrier and into the landfill and associated leachate generation. A secondary benefit of the system is that removal of infiltrating rainwater from above the infiltration barrier increases the slope stability of the capping system on the landfill batters through reduction in downslope seepage forces.

The system design comprises a blanket drainage layer installed overlying the infiltration barrier. The drainage material will be a geocomposite drainage layer. A subsoil drainage pipe will be connected to the geocomposite drainage layer along the toe of each of the 10 m-high batter sections of the final landform, with the drainage pipe connected to outlet pipes that discharge collected infiltration water to the surface drainage system on the final landform benches (refer Drawing D052).

Additional information on the components of the subsurface drainage system is given below.

Geocomposite Drainage Layer: The preliminary design includes a geocomposite drainage layer comprising a non-woven filter geotextile bonded to both sides of an HDPE geonet drainage core. The primary purpose of the lower geotextile, which will be placed in contact with the underlying textured LLDPE geomembrane, is to enhance the shear strength of the geocomposite-geomembrane interface. The primary purpose of the upper geotextile is to act as a filter to restrict migration of fine particles into the system and therefore provide protection against blinding and/or clogging of the system. Internal and interface shear strength of the geocomposite drain is discussed in the sub –section below "Capping System Stability".

The type of geocomposite products suitable for the project will be manufactured with selvage (roll edge) construction with both geotextiles extending beyond the geonet core. This allows secure joining of adjacent sheets by overlapping the lower geotextiles, butting and tying together the geonet cores, and overlapping and seaming the upper geotextiles via field sewing or hot-air (thermal) tacking.

For the preliminary design, the required geocomposite drainage material flow capacity has not been selected. This will be done during detailed design, taking into account potential rainwater infiltration rates and factors that affect geocomposite design flow capacity, such as clogging potential, intrusion of the upper and lower geotextile into the geonet core, normal stress and the typical drainage grades/gradients of 4H:1V on the landform batters. It is noted that the normal stress within the final capping system will be small, approximately 10 to 20 kPa, and have much less impact on geocomposite drainage material selection than within the piggy back lining system. Numerous geocomposite drainage products are likely to be suitable for subsurface drainage of the capping system.

Subsoil Drainage Pipes: The preliminary design includes subsoil pipes to convey and discharge the water that infiltrates into the geocomposite drainage layer. These pipes and their connections are shown in the detail on Drawing D052 and will be manufactured with polyethylene or PVC.

A perforated pipe will run along the toe of each batter section and will be connected to the geocomposite drainage layer on the batter. The fall along the pipe will be equal to the fall of the surface water drain along each bench. Efficient transfer of water flowing within the geocomposite drainage layer into the pipe at each landform bench level is important to minimise the potential for water pressure build up within the geocomposite drainage layer, which could result in undesirable local effects such as surface seepage ta benches or reduction in capping system stability. The connection detail includes the following features to promote efficient water transfer: (i) geocomposite drainage layer terminates at pipe and is not continuous under the bench to the next lower batter section; (ii) the pipe has a drainage aggregate surround to provide a large contact area with the geocomposite drainage layer; (iii) the upper geotextile of the geocomposite drainage layer is removed within the drainage aggregate surround so as not to impede flow into the drainage aggregate; (iv) the drainage aggregate surround is wrapped by a





welded geomembrane flap that creates a very low permeability barrier to restrict water flow out of the drainage aggregate surround (except flow into the pipe). Pipe socks will not be permitted.

Solid wall outlet pipes will be connected to the perforated pipe. The distance between outlet pipes will be determined during detailed but is expected to be in the order of 10 m to 20 m, likely selected based on providing redundant drainage outlets rather than on required flow capacity. Each outlet pipe will be approximately 2 m long and will be installed with a minimum 2% fall toward its discharge into the surface water drain along the bench.

For the preliminary design, the subsoil drainage pipes have not been sized. This will be done during detailed design, taking into account potential flow rates, dimensions/wall thickness needed for crushing resistance under construction and installation loads, and pipe grades. Based on project experience, it is likely that the pipe diameters will be approximately 100 mm.

Landfill Gas Control

The final capping system is intended to promote effective landfill gas management during active landfill gas extraction (the predominant condition) as well as during any periods when active extraction is absent. During active extraction the final capping system will need to restrict air entry into the landfill in order to reduce landfill fire potential and avoid diluting the energy content of collected landfill gas . During periods when active extraction is absent the final capping system will need to minimise uncontrolled passive emissions of landfill gas. and also to minimise gas pressure build up which could reduce capping system stability. Both of these functions are enhanced when the final capping system includes a reliable near-airtight element, such as the LLDPE geomembrane included in the preliminary design as described above.

The preliminary design also includes gravel-filled gas venting trenches, with HDPE gas collection pipes, installed beneath the infiltration barrier. These venting trenches will allow for passive removal of any gas accumulating beneath the final capping system and generating higher-than-atmospheric pressures. The gravel material for these trenches may be recycled concrete or aggregate material because it will be placed beneath the capping system and subjected to relatively low applied stresses. It is noted that these venting trenches may need to be equipped with one-way venting valves to prevent their acting as air entry points during active gas extraction, when lower-than-atmospheric pressures may be imposed. The spacing and layout of the venting trenches, provision for drainage of any perched leachate, gas collection pipe sizing, and any one-way valve requirements will be determined during detailed design, after consultation with the landfill gas extraction system designer.

The gas extraction system designer will consider the need for gas infrastructure components such as wells, flow lines, manifolds, and headers to penetrate the final capping system and will minimise penetrations to the degree practicable. Where penetrations are required, appropriate design and construction details will be needed to preserve the integrity and function of the final capping system.

Vegetation Support

Revegetation Layer: The primary purpose of the revegetation layer is to support vegetation growth that will: (i) limit erosion from the cell landform; and (ii) provide suitable visual amenity. The layer also provides substantial thickness that will reduce the potential for unanticipated human and animal contact with landfill materials. Further, the combination of vegetation growth, layer thickness, and capillary break achieved at the interface with the subsurface drainage layer, will enhance removal of infiltrating rainwater by plant evapotranspiration, thus reducing leachate generation potential within the landfill.

The revegetation layer will comprise two sub-layers as described below.

Lower Topsoil: Soil layer with thickness 350 mm to 850 mm placed on top of the geocomposite drainage layer drain in the subsurface drainage system. Material to be clean (uncontaminated) soil with physical characteristics and nutrient content appropriate for deep support of the plant species planned for revegetation.





Upper Topsoil: Soil layer with thickness 150 mm placed on top of the lower topsoil. Material to be clean (uncontaminated) soil with physical characteristics and organic and nutrient content appropriate for germination and shallow support of the plant species planned for revegetation.

The total thickness of the revegetation layer is 500 mm to 1000 mm. When combined with the thickness of the other elements of the final capping system (200 mm) and with the underlying intermediate cover material layer (300 mm minimum), the total separation distance between the final surface and landfilled waste materials will be approximately 1.0 m to 1.5 m. This separation distance is considered suitable based on the planned site end use as passive open space.

Plants: Plants for revegetation will be shallow rooted native grasses and shrubs and small tress that are of local provenance in accordance with the Landscape Strategy (Appendix N of EA document). Engineered erosion and sediment control measures for the final landform can be decommissioned once revegetation is successfully completed.

Infiltration Rate

The leachate water balance calculations described in Section 4.7 have used an assumed infiltration rate of 1% of incident rainfall for areas with final capping. This infiltration rate will be further assessed during detailed design using HELP model calculations. Based on project experience, the assumed rate is considered to be conservative for the designed final capping system, which includes a blanket subsurface drainage system and an LLDPE geomembrane installed with modern construction quality management control.

Capping System Stability

Slope stability is a key design issue for the final capping system. The potential failure mechanism to be considered is downslope sliding of the capping system between benches along a surface within the capping system. This mechanism is sometimes referred to as 'veneer' stability. The veneer stability of multi-layer capping systems is known to depend on the shear strength of capping materials and interfaces between materials and on the effectiveness of the subsurface drainage and gas venting systems in minimising pore pressure build up within the system.

Veneer stability calculations will be performed during detailed design. These calculations will consider potential slip surfaces both above and below the textured LLDPE geomembrane component and will include static stability, earthquake stability, and stability during large storm events. Potential slip surfaces above the geomembrane could potentially be subjected to destabilising water forces from infiltrating rainwater (pore pressures and seepage forces), although no significant pore pressure build up is anticipated given the blanket subsurface drainage system design described above. Potential slip surfaces below the geomembrane can potentially be subjected to destabilising gas pressures from within the cell, although no significant gas pressure accumulation is anticipated given the gas venting trench design described above.

Target slope stability factors of safety for the veneer stability analyses will the same as those given previously in Table 4 for global stability of the final landform.

The slope inclination between benches of the final landform for the preliminary design is predominantly 4H:1V, or 14 degrees, but as steep as 3.5H:1V, or 16 degrees, in some areas (refer Table 6). Numerous features of the preliminary design will promote veneer stability at these slope inclinations, including the following: (i) maximum vertical interval of 10 m between benches; (ii) subsurface drainage system design (refer above); (iii) gas venting system design (refer above); and (iv) use of LLDPE geomembrane with texturing on both sides to increase interface shear strength. Given these features, and project experience, we consider that the detailed design will provide suitable veneer stability within the final capping system through typical specifications for capping products, soil materials, and capping system construction methods.

Capping System Settlement

The final capping system will be subject to substantial settlement arising from ongoing decomposition of emplaced waste. Settlement analyses at points along the upper ridge of the final landform indicated total





settlement magnitudes ranging from 1.5 m to 3.0 m (Appendix C). Differential settlements were not estimated. Additional analyses of total and differential settlements of the final capping system will be performed during detailed design.

For preliminary design, the approach adopted to address potential differential settlement of the final capping system is to specify strain-tolerant components, specifically the LLDPE geomembrane component of the infiltration barrier and the geocomposite drainage layer component of the subsurface drainage system.

System Components

Each primary component of the final capping system is described in Table 15. Additional material requirements are provided in the preliminary Technical Specification (Appendix B).





Table 15: Final Capping System Primary Components

Key Material Requirements [refer Drawing D061]	Purpose	Discussion	
Liner Bearing Layer [200 mm thickness]			
 Clean (uncontaminated) clayey soil; no organic matter Gradation: Max. particle size 9.5 mm; Passing 2.4 mm sieve > 90%; Fines > 30% Plasticity index>15%; Liquid Limit > 25% Emerson crumb classification > 4 Compacted to > 95% SMDD and within 0% to =3% SOMC 	 Provide appropriate surface for deployment of geomembrane Produce partial composite liner effect in combination with overlying geomembrane 	Surface Preparation: The bearing layer material must be compacted and prepared to provide an appropriately smooth and even surface for deployment of the geomembrane. The maximum particle protrusion from the prepared surface will be limited to 5 mm. The maximum particle size limitation will minimise installation damage to the geomembrane. <i>Clayey Soil</i> : A clayey soil is specified for the bearing layer to produce a partial composite liner effect in combination with the overlying geomembrane.	
LLDPE Geomembrane [1.0 mm thick, textured] [linear low-density polyethylene; welded sheets]			
 LLDPE product density < 0.939 g/cm3 Base resin: density > 0.915 g/cm3 and < 0.926 g/cm3; melt flow index < 1.0 g/10min Product textured both sides; asperity height >0.25mm Tensile strength at break > 11 kN/m Elongation at break > 250% Modulus at 2% strain < 420 kN/m Tear resistance > 100 N Puncture resistance > 200 N Axi-symmetric break resistance strain > 30% Oxidative Induction Time (OIT): >100 minutes at std. pressure >400 minutes at high pressure Oven aging at 85°C for 90 days: OIT retained >35% at std. pressure OIT retained >60% at high pressure 	 Provide very low permeability geosynthetic layer with very high chemical resistance Produce partial composite liner effect in combination with underlying liner bearing layer 	Refer to the Technical Specification for material and installation requirements. Requirements for LLDPE geomembrane installation, including deployment, wrinkle management, seaming, covering, and maintaining intimate contact will be similar to those for the LLDPE geomembrane in the piggy back lining system (refer Table 11). As with the piggy back lining system, the material requirements for the LLDPE geomembrane in the final capping system for physical, chemical and durability characteristics are consistent with international standards, including Victoria BPEM (Section D4 in BPEM), and reflect a high quality material with robustness, strength, and chemical resistance suitable for long-term service in municipal final capping systems. Technical publications indicate these requirements provide geomembrane physical performance as indicated below: - <i>Extensibility:</i> The installed LLDPE geomembrane product is expected to be capable of undergoing at least 8% tensile strain without significant increase in permeability (refer sub-section above "Capping System Settlement") - <i>Interface Shear Strength:</i> Material is textured on both sides. Refer to refer sub- section above "Capping System Stability".	





Key Material Requirements [refer Drawing D061]	Purpose	Discussion	
Subsurface Drainage Layer [Geocomposite drain comprising geonet drainage core sandwiched between two filter geotextile layers; overlapped sheets]			
 Geocomposite Product: Geonet –HDPE material Geotextiles thermally bonded to geonet Ply adhesion (i.e., peel strength) >180 g/cm Requirements to be established during detailed design: Thickness and Mass per unit area Hydraulic flow rate Tensile strength and elongation Geotextiles: Geotextiles - non-woven structure, PET or PP material Mass per unit area > 130 g/m² (note: > 200 g/m² if sheets joined by hot-air seaming) Equivalent Opening Size < 90 µm 	 Drain infiltrating rainwater from above the infiltration barrier to: reduce potential for leakage into landfill increase slope stability of the capping system Provide limited puncture protection for underlying geomembrane Note: Subsurface drainage system pipes discussed in sub-section above "Infiltration Control" 	Refer to the Technical Specification for material and installation requirements. Requirements for geocomposite drain installation, including deployment, protection of the underlying geomembrane, and joining will be similar to those for the geocomposite drain in the piggy back lining system (refer Table 11). The required properties provide for a durable material that will have very high initial permeability and high clogging resistance due to the large spaces in uniform net. , and ability to withstand long-term stresses. Internal shear strength and Interface shear strength requirements will be confirmed during detailed design.	
Revegetation Layer [Topsoil: 500 mm to 1000 mm thickness]			
 Lower topsoil portion - 350 mm to 850 mm thick Clean (uncontaminated) soil Capable of being spread smoothly without damaging underlying geocomposite drain with max. particle size for first lift of 13.2 mm Requirements to be established during detailed design: organic and mineral nutrient content gradation and permeability Upper topsoil portion - 150 mm thick Clean (uncontaminated) soil Requirements to be established during detailed design: organic and mineral nutrient content gradation and permeability 	 Support plant growth for erosion protection and visual amenity Protect capping system from physical disturbance Provide confining stress to promote intimate contact between geomembrane and liner bearing layer 	Refer to the Technical Specification for material and installation requirements. Lower Topsoil: <i>Placement:</i> The lower topsoil material will be placed directly on the geocomposite drain. Installation requirements include spreading of first lift in a single layer to minimise potential for damage of the underlying geocomposite drainage layer. <i>Compaction:</i> Light compaction by tracking only to minimise the potential for damage of the underlying geocomposite drainage layer and to preserve the vegetation support capability of the material. Upper Topsoil: <i>Placement:</i> The material will be spread with no compaction to preserve the vegetation support capability of the material.	





4.5 Surface Water Management

Overview

Required features for surface water drainage are presented in Section 3.3.7. Concepts for surface water drainage paths for each stage of landfill development are discussed in Section 4.2.5 and illustrated in Drawing D051.

The preliminary design of surface water management features for the project, consistent with the identified concepts and required features, is discussed in the Surface Water Assessment Report that is presented in Appendix G of the EA document. A summary is provided below.

Three main types of stormwater would be generated by the project :

- Clean stormwater runoff from undisturbed and rehabilitated / revegetated areas of the site;
- Potentially sediment-laden stormwater runoff from disturbed areas of the site; and
- Leachate that has come into contact with waste (including runoff from daily cover).

Staging

The surface water management controls would be progressively developed as the landfilling areas are developed. A drainage philosophy has been designed based on the construction staging of the proposed project and offsite discharge constraints. The following summarises the staged approach.

Stage 1 and Stage 2A: The drainage philosophy up to the completion of Stage 2A is to discharge the entire 50 ha catchment to the existing sediment pond. There is sufficient capacity in the existing surface water management system for the whole 50 ha catchment. A minor existing discharge offsite from the Western Ridge would be maintained.

Stage 2B: After completion of Stage 2B the Eastern Gully would become fully capped and therefore surface runoff would become 'clean' runoff. During Stage 2B a new 'clean' drain can be constructed to bypass the sediment pond and discharge directly to the Dapto creek outfall. This drain would be constructed between the existing leachate treatment plant and the surface water ponds. On completion of stage 2B, approximately 24 ha will discharge directly to Dapto Creek and 26 ha to the existing sediment pond.

Stage3: On completion of Stage 3, approximately 30 ha will be discharged directly to Dapto Creek and 20 ha to the existing sediment pond. Due to the extent of the Stage 4 works the existing leachate ponds will require relocating towards the end of Stage 3. At this stage it is proposed that the leachate pond is relocated to the footprint of the two reed bed ponds and downsize the existing surface water pond. The downsizing of the surface water pond at this stage is possible due to approximately 60 percent of the original 50 ha catchment now discharging directly to the Dapto Creek outfall.

Stage 4: The downsized surface water pond is designed for a 20 ha catchment. The clean 30 ha catchment would discharge unrestricted to the Dapto Creek outfall. The surface water pond would be made up of sediment pond and onsite surface water detention pond. The outflow from the pond to the Dapto Creek outfall would be restricted to meet discharge constraints and the resultant attenuated runoff detained within the surface water pond.

Landfill Benches and Drop Structures

The preliminary approach and design details for surface water drainage from the landfill final cap, including drainage benches and drop structures, are illustrated in Drawings D051 and D052.

The benches will be 5 m wide with a cross fall of 5%. The benches will be gravel surfaced and will include a 500 mm high safety bund on the outer edge to protect vehicles, which will also act as a flow channel boundary. The bench has been designed to convey up to a 100 yr ARI storm event.

A series of drop structures will convey surface water runoff from the bench structures to the perimeter drainage at the landfill toe. These drop structures will be constructed using a rock-filled Reno mattress to





reduce water velocities and prevent riling. The drop structures will be trapezoidal in cross section with a 1m base width and a depth of 300 mm to 400 mm. The drop structures are also designed for up to a 100 yr ARI storm event.

Perimeter Drainage Channels

The preliminary design for perimeter drainage channels are illustrated in Drawings D017 to D019. A temporary channel on the existing Western Gully Landfill surface is illustrated in Drawing D013 (Section F).

The drawings indicate that two perimeter drainage channels (cell side and outer side) on each side of a perimeter access road have been allowed for in most areas. The two channels are provided for separation of 'clean ' and 'potentially sediment-laden' runoff. In some areas a combined single drainage channel and access track is required due to lack of space at the property boundary.

The drainage channels will be vegetated with grass to stabilise the form and trapezoidal shape of the open channel. A grassed channel would also increase the friction coefficient of the drain and therefore reduce the potential for scouring caused by high velocities surface runoff and sediment migration. A flow velocity check carried out as part of the preliminary drainage design confirmed that a normal cover of grass will provide sufficient erosion resistance. However, at channel junctions and areas where there is a change in flow direction, the need for more robust erosion-resistant surfaces will be assessed during final design.

4.6 Landfill Gas Extraction and Management

Current plans are for active landfill gas (LFG) extraction to be implemented at the site according to the following phased approach:

- Phase 1 Prior to start of the New Landfill Cell Project: Repair and/or replace the remnant LFG collection system in the existing Western Gully Landfill, install new vertical gas wells within the existing Western Gully Landfill, and commission a flare.
- Phase 2 Prior to piggy back liner construction in the existing Eastern Gully Landfill : Install new vertical gas wells within the existing Eastern Gully Landfill.
- Phase 3 During new waste placement: Collection of LFG from new landfill cells including the installation of sacrificial horizontal gas wells (initially) followed by vertical gas wells.

The scope of the preliminary design does not include the LFG extraction and management system. However, LFG management features have been included in the preliminary design of the piggy back lining system and the final capping system as described in Sections 3.3.2, 3.3.3, 4.3.3, and 4.4.2 of this report. These include (i) potential design features in the piggy back lining system to accommodate the continuing operation of vertical gas wells in the existing waste that will be installed in Phase 1 and Phase 2; (ii) gas collection vents beneath the piggy back lining system to reduce the risk of increased lateral gas migration developing after lining construction; and (iii) gas collection vents beneath the final capping system.

4.7 Leachate Management

Leachate Collection

Key issues for leachate collection system design are presented in Section 3.3.4. These issues include maintaining gravity-only drainage within the landfill footprint and connecting all existing leachate drainage pipes from the existing landfill. Preliminary design of the leachate collection and transmissions system, including features addressing these issues, is described in Section 4.3.3 for the piggy back areas and in Section 4.3.4 for the Cells 1 to 4 area. The design description for the Cells 1 to 4 area includes the leachate sumps, the leachate transmission pipes and risers outside the southern toe of the landfill, and connection of existing leachate drainage pipes.

Leachate Management

The capacity of the existing leachate management system (storage, treatment, and disposal) to function effectively for the New Landfill Cell project has been assessed as part of the preliminary design. The





assessment is presented in the Leachate Generation and Water Balance Modelling Report that is included in Appendix G of the EA document. A summary is provided below.

The two existing leachate ponds were designed in 2003 and are lined with 1.5 mm HDPE geomembrane liner and have a combined storage capacity of 18,000 cu.m. with a 300 mm freeboard. Both ponds contain surface aerators on pontoons. The primary pond also contains an axial mixer. The integrity of the ponds and liner is monitored through regular visual inspection and monitoring of down-gradient groundwater bores. Monitoring to date has not detected any groundwater contamination and will continue during the Project.

During the first year of the Project it is proposed there would be works undertaken at the site including operational changes that are expected to reduce current leachate generation rates. These works include capping and reprofiling the existing Eastern Gully landfill batter, capping of the current landfilling area, and commencement of the Piggy Back Liner in Stage 1.

Leachate generation rates over the lifetime of the project have been predicted using a site water balance model using a monthly time step and considering existing and proposed design conditions. Key model assumptions are indicated below.

- Annual rainfall: mean 1279 mm; 90th % 1767 mm. Annual evaporation from pond: 1385 mm.
- Project staging as outlined in Table 7, including progressive intermediate cover and final capping.
- Area of active filling (daily cover) maintained at 10,000 m² throughout the operational life of the landfill.
- Surface infiltration (% of incident rainfall): daily cover 60%; intermediate cover: 20%, final capping 1%.
- Leachate generation from existing waste reduces to 5% of current value after piggy back lining.
- No leachate recirculation.
- Discharge rate from the leachate ponds is 250 kL/day based on leachate treatment plant capacity.

The monthly leachate water balance using mean rainfall indicates that the existing leachate ponds have adequate capacity for Stages 1 to 3. For Stage 4, the existing ponds will have to be removed and new ponds constructed with a similar capacity and footprint would be adequate for Stage 4. Sensitivity analyses indicate that the existing leachate ponds have adequate capacity for two consecutive years of 90th percentile rainfall.

4.8 Slope Stability

Overview

Slope stability is a major design issue for the project (refer Section 3.3.6). Slope stability analyses are needed to demonstrate that the preliminary design will achieve suitable levels of stability. These analyses must take into account key design factors such as final landform geometry, soil stratigraphy, groundwater and leachate levels, existing and new waste characteristics, and design details for the piggy back lining system, cell base lining system and final capping system.

This section presents the results of slope stability analyses for the final landform slopes. Additional slope stability analyses will be performed during detailed design to consider: (i) interim landfill slopes that will be present at various stages of landfill development (refer Sections 4.2.5 and 5.3); (ii) final capping system stability (refer Section 4.4.2).

Final Landform Slopes

A summary of the slope stability analyses presented in Appendix C is provided below.

Slope stability analyses have been carried out on four cross-sections that are considered to present the highest relative risk of slope instability, based on geometry and subsurface conditions. The four sections encompass conditions across the entire final landform. The analyses considered a range of potential slip





surface shapes including deep and shallow circular surfaces and non-circular surfaces passing along existing and new lining systems.

The analyses used two-dimensional limit equilibrium methods, as typically employed in geotechnical slope stability calculations. The analyses considered peak and residual shear strength of soil and lining system materials and interfaces. Both long-term (static) loading and earthquake loading were analysed.

A summary of results of the slope stability analyses is provided in Table 16 below. The target factor of Safety (FoS) values in the table are the same as given in Section 3.3.6. Based on the analysis results, the preliminary design achieves the target factors of safety for global slope stability.

Potential Slip Surface Shape	Conditions	Target FoS	Calculated FoS
	Long-term	1.50	2.66 – 2.99
Circular through new landfill waste	Earthquake	1.10	2.14 - 2.41
Non-circular (sliding) along proposed piggy back and	Long-term	1.50	1.51 – 2.06
cell base liners at peak strength	Earthquake	1.10	1.24 – 1.47
Non-circular (sliding) along proposed piggy back and	Long-term	1.20	1.24 – 1.49
cell base liners at residual strength	Earthquake	1.00	1.01 - 1.09
Circular through existing landfill waste	Long-term	1.50	2.87 – 3.10
	Earthquake	1.10	2.23 – 2.50
Non-circular (sliding) along existing base liner in Eastern	Long-term	1.50	1.99
Gully Landfill	Earthquake	1.10	1.63
Circular below existing landfill waste (through natural	Long-term	1.50	2.09 – 2.29
soil)	Earthquake	1.10	1.25 - 1.67
Non-circular (sliding) below existing landfill waste	Long-term	1.50	1.66
(through natural soil)	Earthquake	1.10	1.31

Table 16: Summary of Slope Stability Analysis Results for Final Landform Slopes

For all of the four cross-sections analysed, the critical slip surface shapes for global stability of the final landform are non-circular surfaces passing along piggy back and cell base lining systems, predominantly on the cell base lining system in Cells 1 to 4. This is the case for both long-term conditions and under earthquake loading. Consequently, the stability of the final landform is sensitive to the shear strength of the weakest interface or component within the lining systems. The minimum lining system shear strengths required to support the design for global slope stability are given in Table 17.

Table 17: Shear Strength Requirements for Piggy Back and Cell Base Lining Systems

	Equivalent Shear Strength Parameters Required for Weakest Interface or Material within Lining System ¹			
Lining System Area	Peak Strength		Residual Strength	
	Friction Angle (degrees)	Cohesion (kPa)	Friction Angle (degrees)	Cohesion (kPa)
Piggy Back Lining System - overall	17	0	7	0





Lining System Area	Equivalent Shear Strength Parameters Required for Weakest Interface or Material within Lining System ¹				
	Peak Strength		Residual Strength		
Piggy Back Lining System – lower portion of Eastern Gully	17	0	14	0	
Cell Base Lining System – Cells 1 to 4	17	0	11	0	

Notes: 1. Shear strength requirement applies to both long-term (drained) loading and earthquake (undrained) loading

It should be noted that laboratory testing (interface shear and internal shear strength testing of each lining system component) will be required as part of the selection process of the components to confirm that the above shear strength requirements are met. This includes geomembranes, GCLs, and geocomposite drains. These requirements are included in the Technical Specification (Appendix B).





5.0 LANDFILL CONSTRUCTION

This Chapter outlines significant construction issues that have been considered for the preliminary design. In addition, requirements for construction of key landfill components are provided in the Technical Specification (Appendix B). Additional construction requirements and constraints will be documented during the course of detailed design.

5.1 Construction Quality Management

A construction quality management system will be in place for landfill construction because the performance of these environmental protection systems, particularly the lining and capping systems, is strongly dependent on the quality of their construction. This section summarises the system by providing an excerpt from the construction quality management portion of the Technical Specification (Appendix B). The excerpt comprises the remainder of this section including Table 18.

The construction quality management system for construction comprises Contractor requirements and Superintendent actions. Contractor requirements include preparing management plans, preparing work method statements, material testing, compaction testing, surveying, notifying for Inspection Points, and preparing Hold Point documentation and works-as-executed (WAE) documentation. Superintendent actions include review and approval of Contractor submittals and documentation, inspecting construction works, conducting audit testing, attending Inspection Points, and releasing Hold Points. Superintendent actions are typically referred to as Construction Quality Assurance (CQA).

A description of the approach for quality management of material properties is provided in Section 2.1.2 (of Appendix B), including description of approval of material sources, confirmation of as-delivered material properties, and audit testing. One example from Section 2.1.4 (of Appendix B) is that all material test results submitted to the Superintendent by the Contractor must be from a laboratory with NATA-accreditation for all tests performed; and all survey results submitted to the Superintendent by the Contractor must be from a registered surveyor.

Quality management requirements are summarised in the following table, with definition of the table headings given below.

- Hold Point: An identified point in the landfill construction sequence where the Contractor must halt work and provide required information to the Superintendent. The Contractor must not resume work until the Hold Point is released, in writing, by the Superintendent.
- Full Time Inspection: The Superintendent or in some cases the GITA (Geotechnical Inspection and Testing Authority), will be present on a full-time (continuous) basis for certain construction activities to provide additional confidence that construction is proceeding in accordance with Technical Specification requirements and design intent. Activities where full-time inspection is planned to be undertaken are identified in the Table 18 below.
- Field Testing: Certain cell construction activities will require real-time field testing during construction. Examples include testing for confirmation of as-delivered material properties, testing of geomembrane welds, and compaction testing (refer following bullet point).
- Compaction Testing: Testing for as-constructed density and moisture content will be routinely performed on all soil construction materials. The Contractor will be required to engage an independent GITA from a specified short list to inspect earthworks construction and perform compaction testing.
- Survey: Numerous requirements for surveying of constructed alignments, inverts, and constructed soil and geosynthetic material surfaces are include in the Technical Specification. The survey provides data for Works-as-Executed (WAE) documentation and for confirming that design layer thicknesses have been achieved in liner and capping systems.





Audit Testing: The Superintendent will arrange, at his discretion, for sampling and testing of delivered and emplaced construction materials, including soils and geosynthetics, to provide material property measurements that are independent of measurements by the Contractor. Activities where audit testing is likely to be undertaken are identified in Table 18 below.


Table 18: Construction Quality Management System Summary

No.	Activity/Material	Hold Point	Full-Time Inspection	Field Testing	Survey	Audit Testing
Α	CONSTRUCTION MATERIALS					
1	Source Approval (each material)	X				X
2	Confirmation of as-delivered material properties (each material)			X		X
в	CONSTRUCTION ACTIVITIES					
1	Excavation of Onsite Materials and Formation of Subgrade					
1.1	Removal of Vegetation and Topsoil, Work Method Statement	х				
1.2	Structures Demolition, Work Method Statement	x				
1.3	Excavation of Existing Eastern Gully Capping Materials, Work Method Statement, and WAE drawings	x		x	x	
1.4	Subgrade Preparation					
а	Work Method Statement	x				
b	Proof roll and placement of Unit 2 – general fill		X	x	X	x
С	Submission of subgrade WAE drawings and surface analysis	X			X	
2	Cell Base Lining System Construction (Cells 1 to 4)					
2.1	Bearing Layer					
а	Placement of Unit 4 – Clay Rich Material to form bearing layer		X	X		X
b	Survey and WAE	X			X	
2.2	Perimeter Bund					
а	Setout survey of perimeter bund alignment	X			X	
b	Placement of Unit 4 – Clay Rich Material for the bund		x	x	x	
С	Survey and WAE	x			x	
2.3	Internal Bunds (refer item 2.2)					
2.4	Geosynthetics					
а	Approval of qualified sub-contractor	X				
b	Geosynthetics quality control procedures manual	х				
С	Submission of data, statements, reports and certificates	x				







No.	Activity/Material	Hold Point	Full-Time Inspection	Field Testing	Survey	Audit Testing
d	Panel layout drawings for GCL and geomembrane	X				
е	Surface preparation for GCL placement	х				
f	Anchor trench				X	
g	Placement of Unit 17 – GCL		X			X
h	Placement of Unit 16 – HDPE Geomembrane		X	X	x	x
i	Placement of Unit 12 – Cushion Geotextile		X	X		X
2.5	Leachate Collection System					
а	Placement of Unit 23 – Leachate Collection Pipe		X			
b	Installation of leachate clean out access points	х	x			
с	Leachate collection pipe WAE drawings				x	
d	Unit 7 – Drainage Aggregate Work Method Statement	х				
е	Field placement trial		x	x		x
f	Placement of Unit 7 – Drainage Aggregate		x	X		x
g	Placement of Unit 11 – Filter Geotextile		x	X		x
h	Leachate collection layer WAE drawings	x			x	
2.6	Construction of Leachate Sump					
а	Leachate Sump Construction Work Method Statement	х				
b	Excavation of sump and formation of sump base		X	X	x	
с	Placement of Clay Material and Clay WAE	х	X	х	x	x
d	Geosynthetic Materials Installation		X	х		x
е	Installation of Unit 24 – Leachate Sump Outlet Pipe with liner penetration		X		X	
f	Placement of Unit 23 - Leachate Collection Pipe within sump		X		x	
g	Backfilling the sump by Unit 7 – Drainage Aggregate and covering by Unit 11 – Filter Geotextile		x	x	x	x
h	Leachate Collection WAE drawings (included in item 2.5 h)					
2.7	Construction of Leachate Drainage System					
а	Leachate Drainage System Construction Work Method Statement	x				
b	Installation of Unit 25 – Leachate Drainage Pipe and connection with existing leachate drainage pipes		x		x	
с	Excavation and Installation of Unit 27 – Leachate Sump Riser		x		X	
d	Connection of Unit 27 – Leachate Sump Riser with Unit 25 – Leachate Drainage Pipe		x		x	
ρ	WAE drawings (included in item 2.5 c)					

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No.	Activity/Material	Hold Point	Full-Time Inspection	Field Testing	Survey	Audit Testing
3	Piggy Back Lining System Construction					
3.1	Gas Venting System					
а	Placement of Unit 8 – Gas Drainage Gravel			X	X	
b	Placement of Unit 21 – Gas Collection Pipes				x	
С	Placement of gas venting header pipes				X	
d	Gas Venting System WAE and backfill pipes	x			x	
3.2	Base Layer					
а	Work Method Statement	X				
b	Placement of Unit 6 – Base Material and Unit 18 Geogrid	X		x		X
С	Submission of base layer WAE drawings and surface analysis	X			X	
3.3	Bearing Layer (refer item 2.1)					
3.4	Perimeter Bund (refer item 2.2)					
3.5	Internal Bunds (refer item 2.3)					
3.6	Geosynthetics					
a-f	Documentation and submittals (refer item 2.4, sub-items a to f)					
g	Placement of Unit 17 – GCL		X			X
h	Placement of Unit 15 – LLDPE Geomembrane		X	x	x	X
3.7	Leachate Collection System					
а	Placement of Unit 14 – Geocomposite Drainage Net (Leachate)		X	X		x
b	Placement of Unit 23 – Leachate Collection Pipe		X			
С	Installation of leachate clean out access points	X	X			
d	Leachate collection pipe WAE				x	
е	Placement of Unit 7 – Drainage Aggregate and Unit 11 – Filter geotextile pipe surrounds		x	x		x
3.8	Protection Layer					
а	Unit 9 – Protection Material Work Method Statement	X				
b	Field placement trial		X	x		X
С	Placement of Unit 9 – Protection Material		X	x		x
d	Protection layer WAE drawings	X			X	





No.	Activity/Material	Hold Point	Full-Time Inspection	Field Testing	Survey	Audit Testing
4	Capping System					
4.1	Gas Venting System (refer item 3.1)	X			x	
4.2	Bearing Layer for Cap					
а	Placement of Unit 4 – Clay Rich Material to form bearing layer		X	X		x
b	Submission of WAE drawings and documentation	х			x	
4.3	Placement of Unit 15 – LLDPE Geomembrane		X	X		x
4.4	Placement of Drainage Layer					
а	Placement of Unit 13 – Geocomposite Drainage Net (Surface Water)	X	X			X
b	Placement of Unit 26 – Subsoil Drainage Pipe and Unit 7 – Drainage Aggregate		X		x	
С	WAE drawings and documentation	х			x	
4.5	Placement of Unit 1 – Topsoil					
а	Work Method Statement for Unit 1 – Topsoil Installation	x				
b	Placement of Unit 1 – Topsoil		X	X	X	X
С	WAE drawings and documentation				x	
4.6	Revegetation					
а	Revegetation Plan	X				
b	Drop Structures	х		X	x	
С	Final Capping levels WAE	X			X	
	Additional Construction Quality Management items from future revegetation specification (to be determined)					



5.2 Eastern Waste Cutback

The preliminary design includes excavation of existing waste from the Eastern Gully Landfill and relocation during Stage 1 of the New Landfill Cell project, referred to as the 'Eastern Waste Cutback.' The quantity of existing waste involved is 300,000 cu.m. These works will provide for gravity drainage of surface water around the eastern perimeter of the final landform while also satisfying other site design constraints. The rationale for and scope of these works have been discussed in Sections 3.3.7 and 4.2.3 and shown in Drawings D011 and D019.

The waste excavation and relocation work during Stage 1 of the proposed new landfill cell will be undertaken over a period of approximately twelve months. The works will be staged to manage potential environmental impacts. In addition to landfilling environmental controls identified within the Draft LEMP (Appendix P of the EA document), additional environmental controls for the Eastern Waste Cutback will likely include those given below.

- Leachate: Leachate would be controlled at each excavation stage by constructing a leachate sump at a low point in the excavation floor. Leachate sumps may also be needed in local areas at the base of the excavation batter if perched leachate is encountered. The leachate collected at sumps would be pumped to the existing landfill leachate system.
- Landfill Fire: Test pitting would occur in advance of each excavation stage. The test pits would identify any high temperature waste with the potential to ignite on exposure to air. Prior to the main excavation, this material would be excavated and transported to a clay pad area where it would be watered down to cool the waste material prior to draining and placing it into the proposed new landfill cell at the tipping face.
- Landfill Gas: Landfill gas emissions would be monitored during the works in the waste excavation
 areas. If elevated readings are obtained work methods would be reviewed and changed as necessary.
- Odour. Odour generation would be minimised by keeping the exposed area of waste under excavation to approximately 2,500 m² and placement of intermediate cover over each excavation stage prior to commencing the next excavation stage.
- Leachate Generation: Temporary bunds would be constructed at the top of batters prior to batter excavation to stop clean surface runoff water running down excavation batters and onto the excavation floor and becoming impacted by the waste.
- Run On: Excavation will be staged such that runoff from upstream catchments does not drain along the eastern edge of the landform flow until the entire batter cutback is complete. This approach ensures major overland flows will not disrupt the works.

A detailed Construction Environmental Management Plan (CEMP) will be prepared for the works prior to construction.

5.3 Staging

The preliminary design for the New Landfill Cell provides for staged landfill construction and placement of landfill waste in order that the site can be progressively developed and rehabilitated Staging will generally proceed from east to west, in the five major stages shown in Drawings D012 and D051. Key issues for staging include landfill airspace availability, surface water management, and suitability of access roads for landfilling and liner and capping construction. Overall staging requirements, constraints and feasibility issues have been discussed in Sections 3.3.9 and 4.2.5, with staging for surface water management discussed in Section 4.5.

As indicated in Section 4.2.5, a series of staging drawings have been developed for the preliminary design to confirm staging feasibility. The staging drawings, which show liner construction areas, landfilling areas, final capping areas, access roads, and surface water drainage paths, depict the site at eleven points of time





during project development. These eleven points of time correspond to approximately two sub-stages for each of the five major stages. The preliminary staging drawings are presented in the Landfill Master Plan which is part of the Draft LEMP (Appendix P of the EA document).

The effect of site weather patterns on project staging, and sub-staging, will be considered during detailed design. Although weather issues will not affect the overall staging sequence, it is possible that schedule requirements for construction of some landfill sub-stages will be affected. This is because seasonal variations in rainfall and wind velocity/direction at the site (refer Section 2.4) will make some times of year more favourable for lining system and/or final capping system construction.

5.4 Surface Water Management

Design requirements and features for surface water management have been discussed in Sections 3.3.7 and 4.5. The preliminary design provides for separation of surface water into the following three categories at each stage of construction: (i) clean stormwater runoff from undisturbed and rehabilitated areas of the site (suitable for direct offsite discharge); (ii) potentially sediment-laden stormwater runoff from disturbed areas of the site (requiring retention/sediment removal prior to offsite discharge); and (iii) stormwater runoff that has come into contact with waste (requiring treatment as leachate). Overall drainage paths for different stages of the project are illustrated in Drawing D051 and channel and bench drain sections are depicted in Drawings D017 to D019, D013 (Section F), and D052. The full preliminary design assessment is given the Surface Water Assessment Report that is presented in Appendix G of the EA document.

Surface water management control measures will be progressively developed as lining system construction and landfilling proceeds. Key design principles for these control measures include those given below.

- Water in different quality categories will be kept separated.
- Clean runoff from areas that are unaffected by the development would be discharged directly to Dapto Creek. Runoff from fully rehabilitated areas, two years after rehabilitation, would also be discharged directly to Dapto Creek.
- Runoff from areas that are likely to generate sediment such as the new cell construction areas and stockpile areas would be directed into sedimentation ponds.
- Construct a perimeter bund and drain around the entire existing landfill area to prevent surface water run on. Extend the perimeter bund and drain as new areas are landfilled.
- Construct temporary diversion bunds and drains within the perimeter bund to separate and collect runoff from disturbed areas and runoff from active waste areas.

These principles will be incorporated into the detailed Construction Environmental Management Plan (CEMP) to be prepared for the works prior to construction.



6.0 LANDFILL OPERATION AND MAINTENANCE

6.1 Landfill Systems Monitoring and Maintenance

Monitoring and maintenance activities are required for some of the landfill systems in order to promote acceptable long-term performance.

The following table presents a summary of key requirements to be considered for landfill inspection, monitoring, and maintenance and/or repair. Many of these items are included in the Draft LEMP (Landfill Environmental Management Plan) that is presented as Appendix P of the Environmental Assessment document. This table does not include structures external to the landfill landform which are not included in the preliminary landfill design drawings (e.g., leachate ponds, surface water ponds, leachate treatment plant, landfill gas infrastructure).

ITEM	ACTIVITY	FREQUENCY
Landfill Final Cap (where ins	stalled)	
Vegetation		
Vegetation and erosion inspections	 Inspect benches and batters Locate, document & remediate erosion areas > 10 sq.m. Reseed areas without vegetation > 10 sq.m. 	Quarterly during year 1, then annually
Weed Control	 Target invasive and/or deep rooted species and trees 	Quarterly during year 1, then annually
Tree and Shrub Sapling Removal	 Remove unwanted tree and shrub saplings 	24-monthly
Final Surface Levels and Subsurface Drainage		
Site Walkover Inspection	 Backfill depressions > 200 mm; Remediate Depressions > 500 mm including geomembrane replacement; Assess additional remedial measures if re-occurring Identify and document wet areas or seepage and assess remedial measures if re-occurring Inspect cap following strong earthquakes and maintain and repair cap if required 	Quarterly during year 1, then 6-monthly and within 24 h of heavy rain (>100 mm/d)
Inspect subsurface drain pipe outlets within 24 h of heavy rain (>100 mm/d)	 Visually assess flow and document outlets with anomalously low flow; Assess additional remedial measures if re-occurring 	within 24 h of heavy rain (>100 mm/d)
Leachate Collection System		
Leachate Collection Pipe Cleaning	 Water jetting (or similar) over accessible pipe length Use perimeter access points Use leachate sump risers for access; note: may require confined space entry and sump dewatering CCTV inspection of any uncleared blockages 	After 1 year, then 5- yearly
Desimeter Dreine		
Inspect Drain	 Remove thick vegetation and sediment >75mm Repair areas of erosion; Install erosion control mats where >100mm of erosion Repair drop structures or replace disturbed sections if required 	6-monthly and within 24 h of heavy rain (>100 mm/d)

Table 19: Summary of Potential Requirements for Landfill Systems Monitoring and Maintenance





ITEM	ACTIVITY	FREQUENCY			
Other Maintenance					
Maintain Site Security	Maintain fencing, gates, locksReview and/or maintain other security measures	Ongoing			
Environmental Monitoring					
Groundwater Levels and Quality					
Surface Water Quality					
Leachate Quality and Quantity	Pafer to Section 6.2 below	Refer to Section 6.2			
Landfill Gas Collections	Refer to Section 0.2 below.	below.			
Landfill Gas Surface Emissions					
Landfill Gas Subsurface Migration					

6.2 Site Monitoring

The proposed environmental monitoring system for the site is presented in the Draft LEMP (Appendix P of EA document). During the operating life of the landfill, and after landfill closure, environmental monitoring is proposed as outlined below.

- Groundwater quality: Monitoring is proposed at approximately ten dedicated monitoring wells that are outside the final landfill footprint. In addition, approximately ten dedicated monitoring wells that are within the landfill expansion areas may continue to be monitored until they are decommissioned prior to landfill construction. The proposed monitoring wells comprise both existing and proposed wells located in both up gradient and down gradient locations.
- Surface water quality: Monitoring is proposed at six points along Dapto creek and the un-named channel draining from the landfill site into Dapto Creek. The six points include both upstream and downstream locations.
- Leachate characteristics: Monitoring is proposed for leachate quality and quantity at the terminal point of the leachate collection system. Leachate characteristics are needed to assist in identification of potential groundwater impacts and for leachate treatment plant operations.
- Landfill gas: Landfill gas collection volumes and emissions from the landfill surface would be measured as a matter of course for operation of the planned active landfill gas extraction system. A subsurface landfill gas monitoring network is proposed at the site to monitor potential gas migration. The proposed network would comprise an initial installation of 12 dedicated shallow monitoring wells in the eastern portion of the site, followed by approximately 25 additional wells installed progressively with the east-towest landfill expansion.

Any additional monitoring specified in the site Environment Protection License would also be conducted.

The Draft LEMP also provides for monitoring of final capped areas to include site walkovers to detect potential areas of cap degradation, excessive settlement, erosion and slumping, as reflected in Table 19 above. It also describes procedures for maintenance of the landfill surface and repairing damage to the capping system



The Draft LEMP also outlines contingency and remediation measures should environmental monitoring indicate that the landfill is impacting upon air quality, surface water quality, groundwater quality, or amenity of nearby residents.





7.0 **REFERENCES**

Gourc, J.P, and Olivier, F., March 2005, "Calibration of the Incremental Settlement Prediction Model (ISPM) from field monitoring campaigns," *International Workshop on Hydro-Physic- Mechanics of Landfills*, Grenoble University.

LaGatta, M.D., Boardman, B.T., Daniel, D.E., and Cooley, B.H., 1997, "Geosynthetic Clay Liners Subjected to Differential Settlement," *Journal of Geotechnical and Geoenvironmental Engineering*, Vol. 123, No. 5, pp. 402-410.

Rowe (2005) "Long-Term Performance of Contaminant Barrier Systems," *Geotechnique*, v. 55, no. 9, pp. 631-678.





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Report Signature Page

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APPENDIX A Preliminary Design Drawings



WOLLONGONG CITY COUNCIL WHYTES GULLY LANDFILL - NEW CELL DESIGN MATERIAL LIST

DRAWING LIST

DRAWING No. D001 D002 D003 D004	TITLE SITE LOCALITY AND DRAWING LIST SITE PLAN EXISTING CONTOURS AND EASEMENTS APPROXIMATE BOTTOM OF EXISTING WASTE PLAN
D011 D012 D013 D014 D015 D016 D017 D018 D019	WASTE CUTBACK PLAN AND SECTIONS STAGING AND SUBGRADE PREPARATION PLAN SUBGRADE PREPARATION SECTIONS FINAL CAP PROFILE FINAL LANDFORM INDICATIVE SECTIONS - SHEET 1 FINAL LANDFORM INDICATIVE SECTIONS - SHEET 2 INDICATIVE SECTIONS ALONG LANDFORM EDGE - SHEET 1 INDICATIVE SECTIONS ALONG LANDFORM EDGE - SHEET 2 INDICATIVE SECTIONS ALONG LANDFORM EDGE - SHEET 3
D021 D022	NEW CELL CROSS SECTIONS CELL BASE LINER DETAILS
D031	PIGGY BACK LINER DETAILS
D041 D042 D043	LEACHATE COLLECTION SYSTEM PLAN LEACHATE COLLECTION SYSTEM DETAILS - SHEET 1 LEACHATE COLLECTION SYSTEM DETAILS - SHEET 2
D051 D052	SURFACE WATER MANAGEMENT SYSTEM CONCEPT PLAN BENCH AND DROP STRUCTURE DETAILS
D061	CAPPING DETAILS
D071	PIGGY BACK GAS VENTING SYSTEM PLAN

LEGEND

	EXISTING MINOR CONTOUR
	EXISTING MAJOR CONTOUR
	DESIGN MINOR CONTOUR

DESIGN MAJOR CONTOUR



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6. LOCATION AND DEPTH OF ALL SERVICES TO BE VERIFIED BY THE CONTRACTOR PRIOR TO COMMENCEMENT OF WORKS.

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NOTES:

3.

SPECIFICATION.

OF WORKS.

MGA94, ZONE 56

	UNIT 1	TOP SOIL
	UNIT 2	GENERAL FILL
	UNIT 3	COVER MATERIAL
	UNIT 4	CLAY RICH MATERIAL
	UNIT 5	CLAY MATERIAL
	UNIT 6	BASE MATERIAL
	UNIT 7	DRAINAGE AGGREGATE
	UNIT 8	GAS DRAINAGE AGGREGATE
	UNIT 9	PROTECTION MATERIAL
	UNIT 11	FILTER GEOTEXTILE
· · · · · ·	UNIT 12	CUSHION GEOTEXTILE
x · x · x · x · x · x · x · x · x · x ·	UNIT 13	GEOCOMPOSITE DRAINAGE NET (SURFACE WATER)
x•x•x•x•x•x•x•x•x•x•x•x•x•x•x•x•x•	UNIT 14	GEOCOMPOSITE DRAINAGE NET (LEACHATE)
	UNIT 15	
	UNIT 16	HDPE GEOMEMBRANE
	UNIT 17	GCL
0 0 0 0 0 0 0	UNIT 18	GEOGRID
—— GAS ——— GAS ——	UNIT 21	GAS COLLECTION PIPE
D	UNIT 22	GROUNDWATER DRAINAGE PIPE
L L	UNIT 23	LEACHATE COLLECTION PIPE
	UNIT 24	LEACHATE SUMP OUTLET PIPE
	UNIT 25	LEACHATE DRAINAGE PIPE
	UNIT 26	SUBSOIL DRAINAGE PIPE
0	UNIT 27	LEACHATE SUMP RISER
	UNIT 31	BENTONITE



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NOTES:

- REFER TO DRAWING D001 FOR GENERAL NOTES AND LEGEND 1.
- SPACING BETWEEN SUBSOIL OUTLET PIPES TO BE DETERMINED 2.
- DETAILED DESIGN. TOPSOIL THICKNESS MAY BE VARIED FROM 500mm TO 1000mm 3. DEPENDING ON VEGETATION TYPE.

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APPENDIX B Preliminary Technical Specification



April 2012

WHYTES GULLY LANDFILL - NEW CELL DESIGN

Preliminary Technical Specification

Submitted to: Wollongong City Council

Report Number.

117625003_145_S_RevC



CHNICAL SPECIFICATION





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SECTION 1 – PRELIMINARIES 1.0

1.1 Introduction

The basic concept for the proposed expansion of the Whytes Gully Landfill is that future waste will be placed within a lined and capped expansion area constructed over the existing landfill site, including:

- Overfilling of the existing Eastern and Western Gully Landfills (note: the term "piggy back liner" is used to refer to the proposed liner system to be constructed in overfill areas);
- Filling within existing natural areas on the Central Ridge and Western Ridge; and
- Filling within existing natural areas at the toe of the existing Eastern and Western Gully Landfills.

The proposed landfill expansion also includes: (i) capping of existing landfilled areas where no future waste is to be placed; and (ii) excavation and relocation of existing waste from a portion of the Eastern Gully Landfill ("Eastern Waste Cutback").

This Preliminary Technical Specification provides material and construction requirements for the project, including Construction Quality Management requirements. It has been prepared along with the Preliminary Design Drawings (refer Section 1.3 below). Landfill expansion construction will be staged to satisfy the landfilling constraints and requirements over an estimated period of approximately 40 years.

This Preliminary Technical Specification does not provide requirements for the proposed Eastern Waste Cutback. Relevant construction and environmental management requirements for this activity will be provided in separate documents to be prepared during detailed design.

Background information on site conditions, and the purpose of project can be found in the Preliminary Design Report for the project which provides a detailed description of design intent.

Design Report - "Whytes Gully New Landfill Cell - Report for Preliminary Design" prepared by Golder Associates, April 2012, ref. 117625003 - 058 - R - RevA.

1.2 **Definitions**

The following parties are referred to in this Technical Specification.

Table 1: Parties relevant to the project			
Superintendent	The party designated by the site owner to manage the Contractor in accordance with the construction contract. The Superintendent may delegate appropriate tasks to a Technical Superintendent.		
Contractor The party awarded the contract to complete the works described in this Specification.			
GITA	Geotechnical Inspection and Testing Authority: The party undertaking Level 1 inspection and testing of landfill earthworks in accordance with AS3798 -2007. The GITA shall be engaged by the Contractor, subject to Superintendent short list and approval, and shall be independent of the Contractor.		
Regulator	The NSW state agency responsible for oversight of landfill construction and environmental management. This is anticipated to be OEH, the NSW Office of Environment and Heritage.		

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This Technical Specification includes 'Hold Points' and 'Inspection Points'. These are defined as follows:

- Hold Point An identified point in the landfill construction sequence where the Contractor must halt work and provide required information to the Superintendent. The Contractor must not resume work until the Hold Point is released, in writing, by the Superintendent.
- Inspection Point An identified point in the landfill construction sequence where the Contractor is required to provide written notification in advance of commencing work on identified items in order to allow the opportunity for the Superintendent to directly inspect the work; the notification must be provided when indicated and in no case less than 24 hours in advance of commencing the work.

The specific meaning of the term "Site" is defined in the construction contract.





1.3 Preliminary Design Drawings

Preliminary Design Drawings prepared along with this Technical Specification are listed in Table 2 below.

Table 2: Drawing List

Drawing No	Revision	Drawing Title			
	No.				
Existing Info	Existing Information				
D001	В	Site Locality and Drawing List			
D002	В	Site Plan			
D003	В	Existing Contours and Easements			
D004	В	Approximate Bottom of Existing Waste Plan			
Final Landfor	'n				
D011	В	Waste Cutback Plan and Sections			
D012	В	Staging and Subgrade Preparation Plan			
D013	В	Subgrade Preparation Sections			
D014	В	Final Cap Profile			
D015	В	Final Landform Indicative Sections – Sheet 1			
D016	В	Final Landform Indicative Sections – Sheet 2			
D017	В	Indicative Sections Along Landform Edge – Sheet 1			
D018	В	Indicative Sections Along Landform Edge – Sheet 2			
D019 B		Indicative Sections Along Landform Edge – Sheet 3			
Cell Base					
D021	В	New Cell Cross Sections			
D022 B		Cell Base Liner Details			
Piggy Back					
D031	В	Piggy Back Liner Details			
Leachate Col	lection				
D041	В	Leachate Collection System Plan			
D042	В	Leachate Collection System Details – Sheet 1			
D043	В	Leachate Collection System Details – Sheet 2			
Surface Water Management					
D051	В	Surface Water Management System Concept Plan			
D052 B		Bench and Drop Structure Details			
Final Capping					
D061	В	Capping Details			
Landfill Gas I	Landfill Gas Management				
D071	В	Piggy Back Gas Venting System Plan			





1.4 Construction Materials

The table below presents the primary materials for cell construction. These materials are referred to in this Technical Specification by unit number. Additional construction materials are also named in this Technical Specification.

Table 3: Material List
GRANULAR MATERIALS
Unit 1 – Topsoil
Unit 2 – General Fill
Unit 3 – Intermediate Cover Material
Unit 4 – Clay Rich Material
Unit 5 – Clay Material
Unit 6 – Base Material
Unit 7 – Drainage Aggregate
Unit 8 – Gas Drainage Gravel
Unit 9 – Protection Material
GEOSYNTHETIC
Unit 11 – Filter Geotextile
Unit 12 – Cushion Geotextile
Unit 13 – Geocomposite Drainage Net (Surface Water) (for cap)
Unit 14 – Geocomposite Drainage Net (Leachate)
Unit 15 – LLDPE Geomembrane
Unit 16 – HDPE Geomembrane
Unit 17 – Geosynthetic Clay Liner (GCL)
Unit 18 – Geogrid
PIPE MATERIALS
Unit 21 – Gas Collection Pipe
Unit 22 – Groundwater Drainage Pipe
Unit 23 – Leachate Collection Pipe
Unit 24 – Leachate Sump Outlet Pipe
Unit 25 – Leachate Drainage Pipe
Unit 26 – Subsoil Drainage Pipe
Unit 27 – Leachate Sump Riser





OTHERS

Unit 31 – Bentonite

1.5 **Responsibilities**

Superintendent

Specific tasks for which the Superintendent is responsible include, but are not limited, those listed below. The Superintendent may delegate some tasks to a Technical Superintendent.

- Review and assessment of Contractor quality control test results, Work Method Statements, and Contractor information and submittals;
- Release of Hold Points;
- Implementation of Inspection Points;
- Auditing of the Contractor quality control procedures, conformance and validation testing;
- Design clarifications and nomination of additional Works;
- Monitoring Contractor compliance with the Contract and other contract administration requirements;
- Checking of Contractor compliance with site management plans (e.g., Environmental Management Plan, Safety Management Plan); and
- Certification of completed works and review of Contractor's construction documentation.

Contractor

The Contractor's responsibilities include but are not limited to the following:

- Compliance with site management plans (e.g., Environmental Management Plan, Safety Management Plan) throughout the duration of the Works;
- Implementation and compliance with the materials tracking system;
- Implementation of the Quality Plan required for the Works;
- Completion of all Works specified in this Specification and additional Works approved by the Superintendent in accordance with the requirements of the Contract;
- Development and implementation of appropriate construction procedures for all construction activities;
- Earthworks conformance testing for all filling operations (through GITA);
- Preparation of Work Method Statements for Superintendent review;
- Preparation of Hold Point Reports and other construction documentation for Superintendent review;
- Ensuring that it does not hinder, obstruct or disrupt other parties working at the site; and
- Comply with all requirements of the Contract.





1.6 Pre-Construction Submittals

The Contractor shall prepare, and submit for Superintendent review, prior to establishment at the Site, all information and management plans as indicated in the Contract. These plans shall meet Contract requirements and be consistent with the project approval and consent conditions, and any other relevant approvals. The Contractor shall be liable for all costs resulting from the failure to meet submittal deadlines or arising from determination, notifications of non-compliance, request for additional information, and/or rejection by the reviewing parties.

The management plans outlined below are anticipated to be included in the Contract requirements.

- Construction Program: The Contractor shall prepare a Construction Program in Gantt Chart format showing sufficient detail to allow monitoring of progress, including all necessary approvals, and demonstrating consistency with project staging plans compliance with Contract requirements.
- Safety Plan: The Contractor shall prepare a detailed Safety Management Plan, taking into account any existing Whytes Gully Landfill requirements.
- Construction Environmental Management Plan (CEMP): The Contractor shall prepare a detailed CEMP.
- Surface Water Management Plan: The Contractor shall prepare a detailed Surface Water Management Plan, including erosion protection and sediment control measure, and taking into account the requirements of the Surface Water Management Strategy by others that is part of the Part 3A application submission.
- Construction Traffic Management Plan: The Contractor shall prepare a detailed Construction Traffic Management Plan for the site, taking into account any existing Whytes Gully Landfill requirements.
- Construction Material Quality Control Procedures Manual: The Contractor shall prepare a Construction Material Quality Control Procedures Manual as one element of his overall Quality Plan. The Manual will address the requirements as outlined in the Construction Quality Assurance Plan.

1.7 Site Preparation

Site preparation works shall be carried out by the Contractor in successive stages in accordance with the Contractor's approved Construction Program (refer Section 1.6).

1.7.1 Removal of Vegetation and Topsoil

Prior to the construction of the liner system of each area, existing vegetation shall be removed and disposed by the Contractor.

After vegetation removal, the upper layer of soil (topsoil) shall be removed by shallow scrape to a depth of approximately 200mm. The shallow scrape is intended to remove any remnant vegetation, shallow plant roots, and other shallow organic materials. The soil collected from the shallow scrape shall be stockpiled separately by the Contractor in designated areas for use by the site owner for landfill construction or operations.

The Contractor shall provide a work method statement presenting proposed methods for these activities, including vegetation disposal and methods to maximise topsoil recovery. Submission of the work method statement constitutes a HOLD POINT. These activities shall not commence until the Hold Point is released.

1.7.2 Services

The Contractor is responsible for confirming service locations, and also locating any unknown services, and establishing whether services are active or inactive prior to initiating work in any area of the site.

Active services are currently present within the construction area and vicinity. Known active services include power, water, and communication lines to the existing staff amenities building in the Cell 1 footprint (also potentially to the adjacent previous weighbridge building), power and communication lines along the Old Redalls Road alignment in the footprint of Cells 2 to 4, and power and control lines to the existing leachate ponds in the Cell 4 footprint.

These known active services will be decommissioned and/or de-energised by others prior to construction. The Contractor shall completely remove these services, including all service trench bedding materials.

In addition, 132 kVA overhead power lines are present along the southern edge of the proposed landfill construction area. These power lines are owned by Endeavour Energy and are to remain in service at all times. The Contractor must use appropriate work methods in the vicinity of these lines.

Known inactive services at the site include the overhead power line along the Western Ridge, owned by BHP Billiton. This line will be removed by others prior to construction.

In the case that previously unknown services are encountered during the course of works, the Contractor shall immediately take appropriate safety precautions, and shall inform the Superintendent. The Contractor is responsible for protecting any active services identified by the Contractor at the time of construction until they are decommissioned and/or de-energised by others. Once decommissioned and/or de-energised, the Contractor shall completely remove services, including all service trench bedding materials.

The Contractor shall prepare and submit documentation of all his activities to confirm, locate and remove services..

1.7.3 Structures Demolition

Prior to the construction of the lining system in each area, existing structures shall be demolished and removed by the Contractor. Structures include the existing staff amenities building and previous weighbridge in the footprint of Cell1, as well as small concrete items in other areas (i.e., pads, slabs, channel lining, pits).

The Contractor shall provide a work method statement presenting proposed methods for structure demolition, including identification of hazardous materials (if any), environmental management of demolition materials, and material disposal. Submission of the work method statement constitutes a HOLD POINT. These activities shall not commence until the Hold Point is released.



2.0 SECTION 2 – MATERIALS

2.1 General Material Requirements

2.1.1 Contractor Supply and Protection of Materials

The Contractor shall be responsible for supply, delivery, storage, placement and installation of all materials required to carry out the works in this Technical Specification. However, the Superintendent may direct that some materials will be supplied by others. Once incorporated in the Works, the Contractor shall protect the materials throughout the duration of construction to ensure they do not degrade or become damaged so as to change the intended performance or function of the materials.

2.1.2 Material Approval

Source Approval

The Contractor shall demonstrate that all materials proposed by the Contractor for the works will meet the requirements of this Technical Specification. This constitutes a HOLD POINT for <u>each</u> of the materials identified in the Technical Specification and in the Design Drawings. No material shall be imported to the site, and no on-site materials shall be handled, placed or stockpiled, until the Hold Point for the material is released.

Materials that are considered by the Superintendent to have excessive settlement potential, or the potential to undergo or contribute to chemical reactions adverse to landfill performance, will not be approved.

The Contractor shall prepare a submittal for Superintendent review for each material to demonstrate that the proposed material will comply with all requirements of this Technical Specification. Hold Point release will be dependent on the submittal providing a satisfactory demonstration. Each submittal shall identify the material source, or sources, and include relevant test results that satisfy the testing requirements of this Technical Specification, description of material uniformity, and other information needed to confirm required properties, including waste classification for soil materials. For manufactured products, manufacturer's specifications and quality control information shall also be submitted.

Confirmation of Properties of Materials Delivered to Site

The Contactor is responsible for confirming that all materials delivered to site from approved sources meet the material property requirements of this Technical Specification. This includes complying with all sampling and testing requirements in this Technical Specification, as well as performing additional sampling and testing as needed to confirm as-delivered material properties. This item is also referred to as 'field testing' in this Technical Specification.

The Superintendent may, at his discretion, conduct Audit sampling and testing of any materials at source or as-delivered to site. The Contractor must assist and facilitate the Superintendent in such activities. If Audit test results indicate that materials do not meet requirements then the Superintendent may direct that the materials be replaced at the Contractor's expense and that the Contractor pay the Audit sampling and testing costs.

2.1.3 VENM or ENM Requirement

All soil materials imported to the site and used to construct any portion of the landfill must meet the definition of virgin excavated natural material (VENM) or excavated natural material (ENM) under the Protection of the Environment Operations Act 1997 and the Protection of the Environment Operations Amendment 2008, unless otherwise permitted by this Technical Specification, consistent with the project approval conditions, and agreed with the Superintendent. If material other than VENM or ENM is proposed for import to the site, the Contractor shall be responsible for obtaining all relevant approvals, such as from the Regulator, prior to importing.

The Contractor shall commission a VENM/ENM assessment and waste classification for all imported soil material. The assessment and classification must be performed by a qualified person and be to the



satisfaction of the Superintendent. The assessment and classification shall comprise a material source inspection, an assessment of historical land use at the source site, and chemical testing at a frequency of at least one sample per material source or at least one sample per 1,000 m³. The Superintendent may require more frequent sampling and testing at the Contractor's expense if the classification is considered incomplete or inadequate. Chemical testing shall comprise analysis for heavy metals, total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene, xylenes (BTEX), polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) and Organochlorine pesticides (OCPs). The provisions of NSW DECC Waste Classification Guidelines – Parts 1 & 2 (April 2008) shall apply.

The Contractor shall keep records of waste classification and quantity of all soil materials imported to site.

The Contractor may submit non-VENM or non-ENM soil materials from on site to be considered for use in landfill construction, provided that these materials meet Technical Specification requirements. The Contractor submittal for on-site materials must address the requirements in Section 2.1.2, as for import materials.

2.1.4 Reporting

Reporting of all material test results shall be in accordance with the Contractor's Construction Material Quality Control Procedures Manual (refer Section 1.6) and other contract requirements. However, in all cases material test results shall be made available to the Superintendent no later than 1 week after each test is performed.

All material test results submitted to the Superintendent by the Contractor must be from a laboratory with NATA-accreditation for all tests performed. All survey results submitted to the Superintendent by the Contractor must be from a registered surveyor.

2.2 Material Properties

2.2.1 Unit 1 – Topsoil

The required properties of Unit 1 – Topsoil will be provided in a detailed revegetation specification that will be issued for the cell construction tender. The specification will include a requirement for Emerson Class No. (AS1289.3.8.1) greater than four (4) in order to provide a soil with relatively low dispersion potential. The specification will include different requirements for upper and lower topsoil sub-layers.

A general description of the required characteristics of Unit 1 is provided in Section 4.4 of the Design Report.

The following table shows the testing requirements for this material.

Table 4: Material Testing R	equirements for Unit 1 - Topsoil
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Bronorty	Toot mothod	Frequency		
Property	rest method	Source approval	As-delivered	
In accordance with future revegetation specification	Various	Two tests per source	One test per 500 m ³ , minimum 2 tests per source	
Emerson Class Number	AS 1289.3.8.1	Two tests per source	One test per 500 m ³ , minimum 2 tests per source	





2.2.2 Unit 2 – General Fill

Unit 2 – General Fill shall comprise clay, silt, sand, gravel or any combination thereof or other approved materials. This material shall contain no organic matter. This material shall have a low erosion potential with an Emerson Class number greater than 4 (AS 1289.3.8.1), although the Superintendent may agree to reduce the Emerson Class number requirement where the fill will not be exposed to potential erosion. This material shall have a maximum particle size of 53mm and a smooth gradation that results in minimal visible voids once compacted.

Source approval for Unit 2 will primarily require the Contractor to identify the source, describe the material, provide two representative Emerson Class test results and gradation test results (AS1289.3.6.1), and, for import material, provide an acceptable VENM/ENM classification.

Confirmation of the properties of as-delivered Unit 2 shall be by Contractor inspection and documentation of each incoming load, and by sampling and Emerson Class testing and gradation testing at a frequency of at least one testing event per 1,000 m³ of material placed, with a minimum of one testing event per source.

2.2.3 Unit 3 – Intermediate Cover Material

The Unit 3 – Intermediate Cover Material is material will be sourced, handled and placed by the landfill operator. The Contractor will not be responsible for this material.

2.2.4 Unit 4 – Clay Rich Material

Unit 4 Clay Rich Material shall clayey soil, free of organic matter, capable of being compacted to a dense condition. The material shall have the following index properties:

- Index properties:
 - Plasticity Index > 15%;
 - Liquid Limit > 25%.
- Emerson crumb classification > 4

The material shall have differing gradation requirements in different applications as indicated below.

A. Bearing Material in Cell Base: This application provides a surface for GCL placement

- Gradation:
 - Maximum particle size 16 mm;
 - Passing 2.4 mm sieve > 90%;
 - Percentage fines (passing 0.075mm sieve)> 30%.

B. Bund – Main Body of Bund. This application is for perimeter bund material that is not in contact with GCL material

- Gradation:
 - Maximum particle size 26.5 mm;
 - Passing 19 mm sieve > 90%;
 - Percentage fines (passing 0.075mm sieve) > 30%.





- C. Bund Batters and top surface: This application provides a surface for GCL placement
 - Gradation: same as category A above.

D. Bearing Layer in Final Capping System: This application provides a surface for LLDPE Geomembrane placement

- Gradation:
 - Maximum particle size 9.5 mm;
 - Passing 2.4 mm sieve > 90%;
 - Percentage fines (passing 0.075mm sieve)> 30%.

The following table shows the testing requirements for this material.

Bronorty	Toot mothod	Frequency		
Property	rest method	Source approval	As-delivered	
Atterberg Limits	AS1289.3.2.1	Two tests per source	One test per 2,000 m ³ material used on site, minimum 4 tests per source	
Gradation	AS1289.3.6.1	Two tests per source	One test per 2,000 m ³ material used on site, minimum 4 tests per source	
Emerson Class Number	AS1289.3.8.1	Two tests per source	One test per 2,000 m ³ material used on site, minimum 4 tests per source	

Table 5: Material Testing Requirements for Unit 4 – Clay Rich Material

2.2.5 Unit 5 – Clay Material

Unit 5 Clay Material shall clayey soil, free of organic matter, capable of being compacted to a dense condition. The material shall have the following index properties:

- Gradation:
 - Maximum particle size 9.5 mm;
 - Percentage fines (passing 0.075mm sieve)> 50%.
- Index properties:
 - Plasticity Index > 20%;
 - Liquid Limit > 40%.
- Emerson crumb classification > 4.
- When remoulded to a Standard Maximum Dry Density (SMDD) of 95% in accordance with AS1289.5.1.1 at Standard Optimum Moisture Content (SOMC) have a co-efficient of permeability, measured in a triaxial cell at an effective confining pressure of 50 kPa in accordance with AS1289.6.7.3 ,of no greater than 1 x 10⁻⁹ m/s.

The following table shows the testing requirements for this material.

Table 6: Material Testing Requirements for Unit 5 – Clay Material

Property	Tost mothod	Frequency		
Flopenty	rest method	Source approval	As-delivered	
Atterberg Limits	AS1289.3.2.1	Two tests per source	One test per 200 m ³ material used	

Dronorty	Toot mothed	Frequency		
Property	rest method	Source approval As-delivered		
			on site, minimum 4 tests per source	
Gradation	AS1289.3.6.1	Two tests per source	One test per 200 m ³ material used on site, minimum 4 tests per source	
Emerson Class Number	AS1289.3.8.1	Two tests per source	One test per 200 m ³ material used on site, minimum 4 tests per source	
Permeability	AS1289.6.7.3	Two tests per source	One test per 200 m ³ material used on site, minimum 1 test per leachate sump, minimum 4 tests per source	

2.2.6 Unit 6 – Base Material

Unit 6 Base Material shall be well-graded sandy or gravelly materials, free of organic matter, carbonates and clay balls and capable of being compacted to a dense condition. The material shall have a USCS classification of GW, GW-GM, GM, GW-GC, GC, SW, SW-SM, SM, SW-SC, or SC.

The material shall have the following index properties:

- Gradation:
 - Max. particle size 40 mm;
 - Percentage gravel (retained on 4.75 mm sieve) > 30%
 - Percentage Fines (passing 0.075 mm sieve) >5% and < 25%</p>

Note: Gradation not yet finalised. Gradation may be revised during detailed design to be consistent with identified suitable material sources,

Source approval for Unit 6 will primarily require the Contractor to identify the source, describe the material, provide two representative gradation test results (AS1289.3.6.1), and, for import material, provide an acceptable VENM/ENM classification.

Confirmation of the properties of as-delivered Unit 6 shall be by Contractor inspection and documentation of each incoming load, and by sampling and gradation testing at a frequency of at least one testing event per 1,000 m³ of material placed, with a minimum of one testing event per source.

The material shall have a minimum shear strength, at 25 kPa effective confining stress, equivalent to that of a drained friction angle of 32 degrees.

2.2.7 Unit 7 – Drainage Aggregate

The Unit 7 – Drainage Aggregate shall consist of high durability gravel or crushed rock of natural geologic origin, free of organic matter, carbonates and clay balls. The material shall be washed to remove fines. Recycled materials or materials of ash/slag origin are not permitted.

The material shall have particle characteristics such that the placed drainage layer is stable under compaction using a smooth drum roller. However, the material shall not include any high angularity particles.

The material shall have the following properties

- Gradation:
 - Max. particle size 26.5 mm;





- Passing 19 mm sieve < 20%</p>
- Passing 13.2 mm sieve < 10%</p>
- Percentage Fines (passing 0.075 mm sieve) < 3%</p>
- Permeability > 1×10^{-3} m/s
- Strength (in accordance with AS.2758.1 1998):
 - minimum wet strength: 80 kN;
 - maximum wet/dry strength variation: 30%

The following material shall not be used as Unit 7 – Drainage Aggregate: volcanic breccia, mudstone, sandstone, shale and highly weathered or altered rocks.

The following table shows the testing requirements for this material.

_			Frequency	
Property	Test method	Source approval	As-delivered	
Geologic Origin	NA	Certificate is required for each material source	Inspect and document each batch delivered to site to confirm composition and lack of organics, carbonates, and clay	
Strength	AS1141.22 - 2008	Two tests per source	One test per 500 m ³ material used on site, minimum 2 tests per source	
Gradation	AS1141.11 / AS1141.12	Two tests per source	One test per 500 m ³ material used on site, minimum 2 tests per source	
Permeability	AS1289.6.7.1	Two tests per source	One test per 1,000 m ³ material used on site, minimum 2 tests per source	

Table 7: Material Testing Requirements for Unit 7 – Drainage Aggregate

2.2.8 Unit 8 – Gas Drainage Gravel

The Unit 8 – Gas Drainage Gravel shall consist of recycled concrete, natural gravel, crushed rock or combination thereof or other approved materials. This material shall be free of organic matter, carbonates and clay balls.

The material shall have the following properties

- Gradation:
 - Max. particle size 37.5 mm;
 - Passing 19 mm sieve < 20%</p>
 - Passing 13.2 mm sieve < 10%</p>
 - Percentage Fines (passing 0.075 mm sieve) < 2%</p>
- Permeability > 1 x 10⁻³ m/s
- Strength (in accordance with AS.2758.1 1998):
 - minimum wet strength: 40 kN;

The following material shall not be used as Unit 8 – Gas Drainage Gravel: shale and highly weathered or altered rocks.





The following table shows the testing requirements for this material.

		Frequency	
Property	Test method	Source approval	As-delivered
Geologic Origin	NA	Certificate is required for each material source	Inspect and document each batch delivered to site to confirm composition and lack of organics, carbonates, and clay
Strength	AS1141.22 - 2008	Two tests per source	One test per 500 m ³ material used on site, minimum 2 tests per source
Gradation	AS1141.11 / AS1141.12	Two tests per source	One test per 500 m ³ material used on site, minimum 2 tests per source
Permeability	AS1289.6.7.1	Two tests per source	One test per 1,000 m ³ material used on site, minimum 2 tests per source

Table 8: Material Testing Requirements for Unit 8 – Gas Drainage Gravel

2.2.9 Unit 9 – Protection Material

Unit 9 Protection Material shall comprise a material:

- capable of being spread smoothly in a 300mm thick layer without damaging underlying geocomposite drain;
- with compaction limited to tracking by the spreading plant;
- with sufficient strength and cohesion to maintain a stable long-erm orientation on piggyback liner slopes, generally 4H:1V to 5H:1V; and
- with as- placed permeability within the identified range.

Natural and recycled materials will be considered.

The material shall have the following index properties:

- Gradation:
 - Max. particle size 13.2 mm;
- Permeability > 5 x 10-5m/s and < 1 x 10-3 m/s</p>

Note: The intent of the required permeability range is to provide and intermediate permeability between that of the emplaced landfill waste and the drainage geocomposite.

Source approval for Unit 9 will primarily require the Contractor to identify the source, describe the material, provide two representative gradation test results (AS1289.3.6.1), and, two permeability test results (AS. 1289.6.7.1.

Confirmation of the properties of as-delivered Unit 9 shall be by Contractor inspection and documentation of each incoming load, and by sampling and gradation testing at a frequency of at least one testing event per 1,000 m³ of material placed, with a minimum of one testing event per source.

2.2.10 Unit 11 – Filter Geotextile

Unit 11 – Filter Geotextile shall be woven or non-woven, polyester or polypropylene which has the following properties:

Equivalent Opening Size < 110 μm (Typical Value)







- CBR puncture strength > 2100 N (Minimum Average Roll Value, MARV)
- Flow rate > 100 L/s/m² (cross-plane flow under 100 mm head) (Typical Value)
- Mass per unit area > 200 g/m² (MARV)

The following table shows the testing requirements for this material.

Table 9: Material Testing Requirements for Unit 11 – Filter Geotextile

Dueneytry	Toot mothod	Frequency	
Property	rest method	Source approval	As-delivered
Mass	AS3706.1	Two tests per source	One test per roll used on site
Flow Rate (cross- plane flow under 100mm head)	AS3706.9	Two tests per source	One test per manufacturer batch
Equivalent Opening Size	AS3706.7	Two tests per source	One test per manufacturer batch
CBR Puncture Strength	AS3706.4	Two tests per source	One test per roll used on site

2.2.11 Unit 12 – Cushion Geotextile

Unit 12 – Cushion Geotextile shall be a non-woven, needle-punched polyester or polypropylene material. The material shall have the following properties:

- Thickness > 4 mm (Typical value)
- Mass per unit area> 550 g/m² (Minimum Average Roll Value, MARV)
- Trapezoidal tear strength > 900 N (MARV)
- CBR puncture strength > 6000 N (MARV)

The following table shows the testing requirements for this material.

Table 10: Material Testing Requirements for Unit 12 - Cushion Geotextile

Droporty	Tast mathod	Frequency			
Property	rest method	Source approval	As-delivered		
Thickness	AS3706.1	Two tests per source	One test per roll used on site		
Mass	AS3706.1	Two tests per source	One test per roll used on site		
Trapezoidal Tear	AS3706.3	Two tests per source	One test per 1,000 m ² material placed on site		
CBR Puncture Strength	AS3706.4	Two tests per source	One test per 1,000 m ² material placed on site		

2.2.12 Unit 13 – Geocomposite Drainage Net (Surface Water) (for cap)

Unit 13 – Geocomposite Drainage Net (Surface Water) shall be a geocomposite material comprising an HDPE geonet core (biplanar or triplanar) with non-woven, polyester or polypropylene needle punched, resin



or heat bonded geotextiles thermally bonded to both sides of the geonet core. The material shall have the following properties:

- Thickness > xxx mm at 20 kPa normal stress (Minimum Average Roll Value, MARV)
- Mass > xxx g/m² (MARV)
- Hydraulic flow rate for as-delivered material ≥ xxx m³/s per metre width at 20 kPa with hydraulic gradient i = 0.25 (measured between rigid plates)
- Hydraulic flow rate for source approval ≥ xxx m³/s per metre width at 20 kPa with hydraulic gradient i = 0.25 (measured between LLDPE geomembrane and Unit 1 Top Soil)
- Tensile strength > xxx kN/m (MARV)
- Elongation at peak > xxx% (MARV)
- Ply adhesion (peel strength of geotextile from geonet) > 180 g/cm (MARV); with no unbonded areas permitted

Note: xxx: indicates that value to be established during detailed design.

The geotextiles shall have the following properties:

- Mass per unit area> 130 g/m² (MARV) or 200 g/m² if sheets are to be joined by hot-air seaming
- Equivalent Opening Size < 90 μm (Typical value)

The following table shows the testing requirements for this material.

Table 11: Material Testing Requirements for Unit 13 - Ge	eocomposite Drainage Net (Surface Water)
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Droporty	Toot mothod	Frequency	
Property	rest method	Source approval	As-delivered
Thickness at 20 kPa	AS 3706.1 / ISO 9863 / ASTM D- 5199-01 / EN 964- 1	Two tests per source	One test per 2 rolls used on site
Mass per unit area	AS3706.1 / ISO 9864 / ASTM D- 5261-92 / EN 965	Two tests per source	One test per 2 rolls used on site
Tensile strength	AS3706.2 / ISO 10319 / ASTM 4595-01	Two tests per source	One test per 3,000 m ² geocomposite material placed on site
Elongation	AS3706.2 / ISO 10319 / ASTM 4595-01	Two tests per source	One test per 3,000 m ² geocomposite material placed on site
Hydraulic flow rate	AS 3706.10 / D- 4716-01 / ISO- 12958	Two tests per source	One test per 10,000 m ² geocomposite material placed on site
Ply Adhesion	ASTM D7005	Two tests per source	One test per 1,000 m ² geocomposite material placed on site Inspect and document each roll used on site to confirm requirement for no unbonded areas
Geotextile (both			



Golder

Dronorty	Toot mothod	Frequency		
Property	Test method	Source approval As-delivered		
sides)				
- Mass per unit area	AS3706.1 / ISO 9864 / ASTM D- 5261-92	Two tests per source	One test per 1,500 m ² geocomposite material placed on site	
- Opening size	AS 3706.7 / D- 4751-95 / ISO 12956	Two tests per source	One test per 10,000 m ² geocomposite material placed on site	

2.2.13 Unit 14 – Geocomposite Drainage Net (Leachate)

Unit 14 –Geocomposite Drainage Net (Leachate) shall be a geocomposite material comprising HDPE triplanar geonets and double-sided non-woven, polyester or polypropylene needle punched, resin or heat bonded geotextiles. The material shall have the followings properties:

- Thickness ≥ xxx mm at 200 kPa normal stress (Typical value)
- Mass > xxx g/m² (MARV)
- Hydraulic flow rate for as-delivered material ≥ xxx m³/s per metre width at 500 kPa with hydraulic gradient i = 0.25 (measured between rigid plates)
- Hydraulic flow rate for source approval ≥ xxx m³/s per metre width at 500 kPa with hydraulic gradient i = 0.25 (measured between LLDPE geomembrane and Unit 9 Protection Material)
- Hydraulic Flow Rate Reduction Factor for Creep, RF_{CR} < xxx (at 500 kPa normal stress, 100 years, 20°C) (Typical value)</p>
- Tensile strength > xxx kN/m (MARV)
- Elongation at peak > xxx% (MARV)
- Ply adhesion (peel strength of geotextile from geonet) > 180 g/cm (MARV); with no unbonded areas permitted

Note: xxx: indicates that value to be established during detailed design.

The geotextiles shall have the following properties:

- Mass per unit area > 130 g/m² (MARV) or 200 g/m² if sheets are to be joined by hot-air seaming
- Equivalent Opening Size < 90 μm (Typical value)

The following table shows the testing requirements for this material.

Table 12: Material Testing Requirements for Unit 14 – Geocomposite Drainage Net (Leachate)

Property	Tost mothod	Frequency		
	rest method	Source approval As-delivered		
Thickness	AS 3706.1 / ISO 9863 / ASTM D- 5199-01 / EN 964- 1	Two tests per source	One test per 2 rolls used on site	
Mass	AS3706.1 / ISO	Two tests per source	One test per 2 rolls used on site	





Property	Toot mothod	Frequency	
Property	rest method	Source approval	As-delivered
	9864 / ASTM D- 5261-92 / EN 965		
Tensile strength	AS3706.2 / ISO 10319 / ASTM 4595-01	Two tests per source	One test per 3,000 m ² geocomposite material placed on site
Elongation strength	AS3706.2 / ISO 10319 / ASTM 4595-01	Two tests per source	One test per 3,000 m ² geocomposite material placed on site
Hydraulic flow rate	AS 3706.10 / D- 4716-01 / ISO- 12958	Two tests per source	One test per 10,000 m ² geocomposite material placed on site
Hydraulic Flow Rate Reduction Factor for Creep	extended AS 3706.10 / D-4716- 01 / ISO-12958	Two tests per source	Not required
Ply Adhesion	ASTM D7005	Two tests per source	One test per 1,500 m ² geocomposite material placed on site Inspect and document each roll used onsite to confirm requirement for no unbonded areas
Geotextile			
- Mass per unit area	AS3706.1 / ISO 9864 / ASTM D- 5261-92	Two tests per source	One test per 1,500 m ² geocomposite material placed on site
- Opening size	AS 3706.7 / D- 4751-95 / ISO 12956	Two tests per source	One test per 10,000 m ² geocomposite material placed on site

2.2.14 Unit 15 – LLDPE Geomembrane

Unit 15 –Linear Low Density Polyethylene (LLDPE) Geomembrane with a nominal thickness of 1.5mm for the piggy back liner system and 1.0 mm for the capping system shall have the following properties:

A. Piggy Back Liner System:

- Thickness > 1.45mm (minimum average roll value, MARV)
- LLDPE product density < 0.939 g/cm³ (MARV)
- Base resin: density >0.915 g/cm³ and <0.926 g/cm³; melt flow index <1.0 g/10min
- Product textured on both sides with asperity height > 0.25mm (MARV)
- Tensile strength at break > 16 kN/m (MARV)
- Elongation at break > 250% (MARV)
- Modulus at 2% strain < 630 kN/m (max)
- Tear resistance > 150 N (MARV)
- Puncture resistance > 300 N (MARV)





- Axi-symmetric break resistance strain > 30% (min)
- Oxidative Induction Time (OIT):
 - > 100 minutes at standard pressure (MARV); and
 - > 400 minutes at high pressure (MARV)
- Oven aging at 85°C for 90 days:
 - OIT retained > 35% at standard pressure (MARV); and
 - OIT retained > 60% at high pressure (MARV)
- Shear Strength Requirements Refer to Section 2.2.17.

B. Capping System:

- Thickness > 0.95mm (minimum average roll value, MARV)
- LLDPE product density < 0.939 g/cm³ (MARV)
- Base resin: density >0.915 g/cm³ and <0.926 g/cm³; melt flow index <1.0 g/10min
- Product textured on both sides with asperity height > 0.25mm (MARV)
- Tensile strength at break > 11 kN/m (MARV)
- Elongation at break > 250% (MARV)
- Modulus at 2% strain < 420 kN/m (max)</p>
- Tear resistance > 100 N (MARV)
- Puncture resistance > 200 N (MARV)
- Axi-symmetric break resistance strain > 30% (min)
- Oxidative Induction Time (OIT):
 - > 100 minutes at standard pressure (MARV); and
 - > 400 minutes at high pressure (MARV)
- Oven aging at 85°C for 90 days:
 - OIT retained > 35% at standard pressure (MARV); and
 - OIT retained > 60% at high pressure (MARV)
- Shear Strength Requirements Refer to Section 2.2.17.

The following table shows the testing requirements for this material.

Table 13: Material Testing Requirements for Unit 15 - Textured LLDPE Geomembrane

		Frequency	
Property	Test Method	Source approval	As-delivered





Thickness	ASTM D 5994		One test per roll
Density	ASTM D1505		One test per manufacture batch
Melt Flow Index	ASTM D 1238		One test per manufacture batch
Asperity Height (both sides)	GM12		Second roll or each roll if not in production sequence (note: to be measured at three or five locations across roll width)
Tensile Properties (each direction) - Strength at break - Elongation at break	ASTM D6693	Two tests per manufacture	One test for each property per roll
2% Modulus	ASTM D5323	source	One test per roll
Tear Resistance	ASTM D1004		One test per roll
Puncture Resistance	ASTM D4833		One test per roll
Axi-Symmetric Break Resistance Strain	ASTM D 5617		Not required
Oxidative Induction Time (OIT) - Standard OIT - High Pressure OIT	ASTM D 3895 ASTM D 5885		One test for each property per resin type or per 10,000 m ² of geomembrane
Oven Aging at 85°C for 90 days - Standard OIT - High Pressure OIT	ASTM D 5721 ASTM D 3895 ASTM D 5885		One test for each property per resin type or per 10,000 m ² of geomembrane

2.2.15 Unit 16 – HDPE Geomembrane

Unit 16 – High Density Polyethylene (HDPE) Geomembrane with nominal thickness of 2 mm shall have the following properties:

- Thickness > 1.9mm (minimum average roll value, MARV)
- density > 0.94 g/cm^3 (MARV)
- Base resin: density >0.932 g/cm³; melt flow index <1.0 g/10min
- Product textured on both sides with asperity height > 0.25 mm (MARV)
- Tensile strength at yield > 29 kN/m (MARV)
- Elongation at yield > 12% (MARV)
- Tear resistance > 249 N (MARV)





- Puncture resistance > 534 N (MARV)
- Oxidative Induction Time (OIT):
 - > 100 minutes at standard pressure (MARV); and
 - > 400 minutes at high pressure (MARV)
- Oven aging at 85°C for 90 days:
 - OIT retained > 55% at standard pressure (MARV); and
 - OIT retained > 80% at high pressure (MARV)
- Stress Cracking Resistance (performed on smooth portion of sheet) > 300hr (Typical value)
- Shear Strength Requirements Refer to Section 2.2.17.

The following table shows the testing requirements for this material.

Table 14: Material Testing Requirements for Unit 16 – Textured HDPE Geomembrane

Property		Frequency		
riopeny	Test Method	Source approval	As-delivered	
Thickness	ASTM D 5994		One test per roll	
Density	ASTM D 1505		One test per manufacture batch	
Melt Flow Index	ASTM D 1238		One test per manufacture batch	
Asperity Height	GM12		Every second roll or each roll if not in production sequence (note: to be measured at three or five locations across roll width)	
Tensile Properties (each direction) - Strength at yield - Elongation at yield	ASTM D 6693	Two tests per manufacture	One test for each property per roll	
Tear Resistance	ASTM D 1004	source	One test per roll	
Puncture Resistance	ASTM 4833		One test per roll	
Oxidative Induction Time (OIT) - Standard OIT - High Pressure OIT	ASTM D 3895 ASTM D 5885		One test for each property per resin type or per 10,000 m ² of geomembrane	
Oven Aging at 85ºC for 90 days - Standard OIT - High Pressure OIT	ASTM D 5721 ASTM D 3895 ASTM D 5885		One test for each property per resin type or per 10,000 m ² of geomembrane	
Environmental Tensile Load Crack Resistance	ASTM D 5397		One test per resin type, manufacture batch, or per geomembrane type	



2.2.16 Unit 17 – Geosynthetic Clay Liner (GCL)

Unit 17 – Geosynthetic Clay Liner shall be a reinforced multi-layered system comprising at least two layers of geotextile encapsulating a layer of dry, sodium bentonite. The GCL shall be reinforced by needle punchingand be free of broken needles.

The bentonite layer in the GCL shall have the following characteristics:

- form: natural sodium bentonite or >80% sodium as activated bentonite
- carbonate content < 1 to 2% (by weight)</p>
- montmorillonite content > 70% (by weight)
- particle size: if powdered >80% passing 0.075mm sieve; if granulated <1% passing 0.075mm
- cation exchange capacity > 70 meq/100g

The GCL material shall have the following properties:

- Total mass (dry) > 4000 g/m²;
- Bentonite clay:
 - Bentonite mass (dry) > 3700 g/m²;
 - Swell index > 24 ml/2g
- Fluid loss < 18 mlTensile strength > 4 kN/m
- Peel strength > 360 N/m
- Permeability: testing at 100kPa effective confining stress with the following permeants
 - a. tap water: $k < 5 \times 10^{-11}$ m/s
 - b. deionised water with 0.1M CaCl2 : k < 5 x 10⁻¹⁰ m/s
 Shear Strength Requirements Refer to Section 2.2.17.

Geotextiles component of the GCL shall have the following property:

- At least one geotextile is nonwoven
- Mass of nowoven geotextile >200 g/m²
- Mass of woven geotextile (if any) >100 g/m².

The following table shows the testing requirements for this material.

Table 15: Material Testing Requirements for Unit 17 - GCL

Property	Test Method	Frequency		
		Source approval	As-delivered	
Bentonite Clay:				

- Swell Index

- Fluid Loss	ASTM D5890 ASTM D5891	Two tests per manufacture	Manufacturer certification for each batch represented
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Total Mass (dry)	DIN 53854	source	One test per 2 rolls used on site
Bentonite Mass (dry)	ASTM D 5393		One test per 2 rolls used on site
Tensile Strength	ASTM D 4595		One test per 2 rolls used on site
Peel Strength	ASTM D 6496		One test per 2 rolls used on site
Permeability (using 100kPa effective confining stress): a. tap water b. deionised water, 0.1M CaCl ₂ Note: Test b. to be conducted after permeation with deionised water.	ASTM D 5887		For test (a) tap water, one test per 20,000 m ² of GCL installed at site, minimum 3 tests total For test (b) CaCl ₂ – as delivered tests not required

2.2.17 Lining System Shear Strength Requirements

Capping and Piggy Back Liner System Shear Strength Requirement

The Contractor must include direct shear test results (ASTM D5321) in the submittal for Unit 13, Unit 14, Unit 15, Unit 16, and Unit 17 source approval that demonstrate that the lining and capping systems will achieve the required shear strengths for the test conditions defined in Table 16 below.





No.	Lining or Capping System	Required Minimum Equivalent Shear Strength Parameters	Direct Shear Test Cross Section	Direct Shear Test Conditions
A	Piggy Back Lining (Typical)	Peak Strength: Φ'= 17º, c'= 0 kPa Residual Strength: Φ'= 7º, c'= 0 kPa	 lightly compacted sand to represent an initial lift of Unit 9 – Protection Material; specific geocomposite proposed by the Contractor as Unit 14 – Geocomposite Drainage Net (Leachate); specific 1.5mm thick textured geomembrane proposed by the Contractor as Unit 15 –LLDPE Geomembrane; specific GCL proposed by the Contractor as Unit 17 – GCL; well compacted clayey soil (95% standard compaction at +2% above optimum moisture) to represent the compacted Unit 4 – Clay Rich Material below the GCL; 	 Normal stress = 100, 300, and 500 kPa; Shear rate = 0.1 mm/min; Total shear displacement > 75mm Test specimen configuration: no pre-determined shear surface – construct test specimen to allow shearing to occur in actual weakest interface or material; and Hydration and Consolidation: Apply normal stress to test specimen and then, while maintaining the normal stress, soak specimen in tap water for 7 days to allow GCL and soils to hydrate. Shear the hydrated specimen without interrupting the applied normal stress. Provide information on shear response and shear plane location
В	Piggy Back Lining (Lower Eastern Gully)	Peak Strength: $\Phi'= 17^{\circ}$, c'= 0 kPa Residual Strength: $\Phi'= 14^{\circ}$, c'= 0 kPa	same as test no. A	same as test no. A
С	Cell Base Lining in Cells 1 to 4 (Typical)	Peak Strength: $\Phi'=17^{\circ}$, c'= 0 kPa Residual Strength: $\Phi'=11^{\circ}$, c'= 0 kPa	 specific gravel proposed by the Contractor as Unit 7 Drainage Aggregate; specific geotextile proposed by the Contractor as Unit 12 –Cushion Geotextile specific textured geomembrane proposed by the Contractor as Unit 16 –HDPE Geomembrane; specific GCL proposed by the Contractor as Unit 17 	 Normal stress = 100, 200, and 300 kPa; Shear rate = 0.1 mm/min; Test specimen configuration: no pre-determined shear surface – construct test specimen to allow shearing to occur in actual weakest interface or material; and Hydration and Consolidation: Apply normal stress

Table 16: Lining and Capping System Shear Strength Requirements





No.	Lining or Capping System	Required Minimum Equivalent Shear Strength Parameters	Direct Shear Test Cross Section	Direct Shear Test Conditions	
			 GCL; and well compacted clayey soil (95% standard compaction at +2% above optimum moisture) to represent the compacted Unit 4 – Clay Rich Material below the GCL. 	to test specimen and then, while maintaining the normal stress, soak specimen in tap water for 7 days to allow GCL and soils to hydrate. Shear the hydrated specimen without interrupting the applied normal stress. Provide information on shear response and shear plane location.	
D	Cell Base Lining (Cell 1 East)	Peak Strength: $\Phi'= 17^{\circ}$, c'= 0 kPa Residual Strength: $\Phi'= 14^{\circ}$, c'= 0 kPa	same as test no. C	same as test no. C	
Е	Cell Base Lining (Cell 2A, 2B, 4A)	same as test no. A	same as test no. A	same as test no. A	
F	Final Capping	to be determined during detailed design	 lightly compacted clayey, silty sand soil (90% standard compaction at optimum moisture) to represent the initial lift of the Unit 1 – Topsoil placed in the cap; specific geocomposite proposed by the Contractor as Unit 13 – Geocomposite Drainage Net (Surface Water); specific 1.0 mm thick textured geomembrane proposed by the Contractor as Unit 15 – LLDPE Geomembrane; and well compacted clayey soil (95% standard compaction at +2% above optimum moisture) to represent the compacted Unit 4 – Clay Rich Material below the LLDPE geomembrane. 	 Normal stress = 10, 15, and 20 kPa; Shear rate = 0.1 mm/min; Test specimen configuration: no pre-determined shear surface – construct test specimen to allow shearing to occur in actual weakest interface or material; and Hydration and Consolidation: Spray both sides of textured LLDPE geomembrane with a fine mist of water immediately prior to constructing the test specimen. Apply normal stress to constructed test specimen and allow 24 hours for consolidation. After the consolidation period, shear the hydrated specimen without interrupting the applied normal stress. Provide information on shear response and shear plane location 	





2.2.18 Unit 18 – Geogrid

Unit 18 – Geogrid shall have a minimum long-term multiaxial tensile stiffness of 500 kN/m at a tensile strain of 5%. The multiaxial stiffness value is to reflect the average value when the stiffness is assessed in four principal directions in the plane of the material, being MD (machine direction), XMD (cross machine direction), and the two diagonal directions between the MD and XMD. Geogrid shall be a single layer of material. Multiple layers may be considered if Contractor proposes acceptable alternate installation measures to those in Sections 3.3.4 and 3.3.13.

The long-term stiffness shall be based on an appropriate test method, to be specified during detailed design, accounting for a 100-year design life and the effects of construction damage, tensile creep, and environmental degradation in a buried environment with potential exposure to leachate.

Note: Tensile stiffness calculated as the tensile load estimated to induce 5% strain over the design life divided by 0.05 (i.e. 5%).

The following table shows the testing requirements for this material.

Table	17. Material	Testina I	Requirements	for Unit	18 – Geogrid
Table	I' . Materia	resung	nequirements		io – acogiia

Bronorty	Test method	Frequency		
Property		Source approval	As-delivered	
Tensile strength at 5% elongation (measured in 4 principal directions)	ISO 10319	Two tests per source	One test per 4,000 m ² geogrid material placed on site	
Evaluate stiffness reduction factors for long-term loading	[to be specified during detailed design]	One test per source	not required if manufacturer provides acceptable data	

Pipe Materials

2.2.19 Unit 21 – Gas Collection Pipe

Unit 21 – Gas Collection Pipe shall comprise 110 mm diameter rating PN 6.3, HDPE (PE 100 material class) pipe or approved equivalent.

Where the pipes are required to be perforated, the pipes shall be drilled in accordance with the detail shown on the design drawing. All drill cuttings, including loose attachments and burrs, shall be removed from the perforated pipes before installation.

The pipe shall have perforations of no more than 15 mm diameter as shown on design drawing.

All connections and fittings for the pipes shall be manufactured from the same material and strength class as the pipe, and shall be solid wall units. All ends of the pipes shall be capped with HDPE caps.

Pipe joins shall be carried out using full face fusion bonding. No filter sock shall be used.

Material property certificates from the manufacturer shall be submitted for approval for each source of material prior to construction.

The Contractor shall provide the Superintendent with manufacturer's documentation certifying the properties of the material for each manufacture batch used on site.





2.2.20 Unit 22 – Groundwater Drainage Pipe

Unit 22 – Groundwater Drainage Pipe shall comprise 110 mm diameter rating PN 6.3, HDPE (PE 100 material class) pipe or approved equivalent.

All connections and fittings for the pipes shall be manufactured from the same material and strength class as the pipe, and shall be solid wall units. All ends of the pipes shall be capped with HDPE caps.

Pipe joins shall be carried out using full face fusion bonding

Material property certificates from the manufacturer shall be submitted for approval for each source of material prior to construction.

The Contractor shall provide the Superintendent with manufacturer's documentation certifying the properties of the material for each manufacture batch used on site.

2.2.21 Unit 23 – Leachate Collection Pipe

Unit 23 – Leachate Collection Pipe shall comprise 200 mm diameter rating PN 12.5, HDPE (PE 100 material class) pipe with an SDR < 14 or approved equivalent.

Where the pipes are required to be perforated, the pipes shall be drilled in accordance with the detail shown on the design drawing. All drill cuttings, including loose attachments and burrs, shall be removed from the perforated pipes before installation.

The pipe shall have perforations of no more than 15 mm diameter as shown on design drawing.

All connections and fittings for the pipes shall be manufactured from the same material and strength class as the pipe, and shall be solid wall units. All ends of the pipes shall be capped with HDPE caps.

Pipe joins shall be carried out using full face fusion bonding. No filter sock shall be used.

Material property certificates from the manufacturer shall be submitted for approval for each source of material prior to construction.

The Contractor shall provide the Superintendent with manufacturer's documentation certifying the properties of the material for each manufacture batch used on site.

2.2.22 Unit 24 – Leachate Sump Outlet Pipe

Unit 24 – Leachate Sump Outlet Pipe shall comprise 250 mm diameter rating PN 12.5, HDPE (PE 100 material class) pipe with an SDR < 14 or approved equivalent.

The pipes shall be solid wall pipes.

All connections and fittings for the pipes shall be manufactured from the same material and strength class as the pipe, and shall be solid wall units.

Pipe joins shall be carried out using full face fusion bonding.

Material property certificates from the manufacturer shall be submitted for approval for each source of material prior to construction.

The Contractor shall provide the Superintendent with manufacturer's documentation certifying the properties of the material for each manufacture batch used on site.





2.2.23 Unit 25 – Leachate Drainage Pipe

Unit 23 – Leachate Drainage Pipe shall comprise 315 mm diameter rating PN 12.5, HDPE (PE 100 material class) pipe with an SDR < 14 or approved equivalent.

The pipes shall be solid wall pipes.

All connections and fittings for the pipes shall be manufactured from the same material and strength class as the pipe, and shall be solid wall units.

Pipe joins shall be carried out using full face fusion bonding.

Material property certificates from the manufacturer shall be submitted for approval for each source of material prior to construction.

The Contractor shall provide the Superintendent with manufacturer's documentation certifying the properties of the material for each manufacture batch used on site.

2.2.24 Unit 26 – Subsoil Drainage Pipe

Unit 25 – Subsoil Drainage Pipe shall be slotted or perforated nominal 100 mm diameter drain coil pipes, manufactured from polyethylene or uPVC, or other material approved by the Superintendent. The pipe strength shall conform to at least Class SN8 and shall be slotted as per pipe Type 1 or 2, in accordance with AS 2439.1 - 2007. Pipe outlets shall be solid wall. Joints and bends in pipe shall be formed with similar strength units and may be solid wall units. Pipe joints may be spigot and socket joints, glued or fusion bonded joints. No filter sock shall be used.

Material property certificates from the manufacturer shall be submitted for approval for each source of material prior to construction.

The Contractor shall provide the Superintendent with manufacturer's documentation certifying the properties of the material for each manufacture batch used on site.

2.2.25 Unit 27 – Leachate Sump Riser

Unit 27 – Leachate Sump Riser shall be 1200 mm diameter precast concrete pipe with step irons manufactured in accordance with AS 4058:2007.

The cover and surrounds which will be used on top of the leachate sump shall be reinforced concrete, ductile iron cover and frame, ductile iron cast into a concrete surround, or other variations. Covers and surrounds shall be suitable for Class C (150kN) ultimate load applications in accordance with AS3996.

The riser pipe shall be placed into the sump on a 200 mm thick concrete base. The base shall be precast concrete, or cast in place, and coated with similar epoxy system as for the pipe. The strength of the base concrete shall be equivalent to that of the concrete used for the pipe.

Material property certificates from the manufacturer shall be submitted for approval for each source of material prior to construction.

The Contractor shall provide the Superintendent with manufacturer's documentation certifying the properties of the material for each manufacture batch used on site.




Other Materials

2.2.26 Unit 31 – Bentonite

Unit 31 - Bentonite pellets shall be nominal 6 mm, compressed dry bentonite pellets of a type used for sealing boreholes and monitoring wells. The bentonite shall have a swell index of at least 15 mL / 2g.

Material property certificates from the manufacturer shall be submitted for approval for each source of material prior to construction.

The Contractor shall provide the Superintendent with manufacturer's documentation certifying the properties of the material for each manufacture batch used on site.





3.0 SECTION 3 – CONSTRUCTION

3.1 General Management

Construction of the cell shall be achieved in compliance with site management plans identified in Section 1.6 and all other contract requirements. This will by necessity require the Contractor to stage his construction activities, particularly to comply with Environmental Management Plan and surface water management requirements, but also to provide for cost-effective construction. Considerations for the Contractor with respect to staging include, but are not limited to, those given below.

- Minimise disturbed areas to reduce generation of dust.
- Minimise potential for runoff to enter previously lined and landfilling areas.

As indicated in Section 1.6, the Superintendent may supply the Contractor with a staging plan for cell construction and landfilling as a guide for the preparation of the Contractor's construction program.

3.1.1 Stockpile Management

The Contractor will manage stockpiles in accordance with the requirements of the Contractor's CEMP for the project. There must be no unacceptable impact of the site as a result of stockpiling.

As a minimum, the following requirements must be met by the Contractor:

- All stockpiles must be managed to minimise the generation of dust;
- All stormwater must be managed in the vicinity of the stockpiles to minimise the volume of water coming into contact with the stockpiles; and
- Runoff from all stockpiles, other than contaminated material or waste stockpiles, shall be managed in the same way as other stormwater on the site according to the Contractor's CEMP.

Upon completion of the use of an area for stockpiling, the Contractor shall:

- Remove all remaining stockpiled material for reuse or placement in accordance with this Technical Specification; and
- The reinstated stockpile area is to be assessed by the Contractor to the satisfaction of the Superintendent to ensure that no waste materials remain.

3.1.2 Water Management during Construction

3.1.2.1 Surface Water

The Contractor shall manage surface water within the construction site in accordance with the CEMP, and approved surface water management plan. The surface water drainage system on site includes clean and dirty (i.e., potentially sediment-laden) water drains. The surface water collected from the construction area shall be discharged to the dirty water drainage system of the site.

The Contractor shall divert surface run-on to the construction area, and must prevent uncontrolled discharge of water originating in the construction area to the site surface water drainage system.

The Contractor shall ensure that his operations do not result in chemical contamination of surface waters.

The Superintendent (site owner) will be responsible for management of the existing major surface water ponds at the Whytes Gully site, surface water treatment, and controlled discharges from the ponds.



3.1.2.2 Leachate

The Contractor will be responsible for maintaining delivery of leachate in the existing leachate collection system in the Eastern and Western Gully Landfills to the existing leachate ponds during all stages of cell base and piggyback liner construction. This responsibility will also extend to leachate collected in each stage of the new leachate collections systems. The Contractor shall install temporary sumps, pumps and pumping lines as needed to meet these requirements. All temporary items must comply with the CEMP and be acceptable to the Superintendent.

The Superintendent (site owner) will be responsible for management of the existing leachate ponds at the Whytes Gully site, leachate treatment, and leachate discharge to sewer.

3.1.2.3 Dewatering

The Contractor shall manage, at his cost, any waters arising from groundwater dewatering activities in accordance with the CEMP and Contract requirements. Management requirements are likely to depend on water quality and quantity. In regard to the potential to transfer water arising from groundwater dewatering activities into the existing site surface water management and/or leachate management systems, any such transfer would be at the discretion of the Superintendent (site owner) and would depend on water quality and quantity and the capacity of the systems at the time.

3.1.3 Excavation of Materials before construction

3.1.3.1 Removal of Vegetation and Topsoil

Refer to the information in Section 1.7.1, including requirements for a Work Method Statement and HOLD POINT.

3.1.3.2 Excavation on Eastern Gully

Prior to construction of the piggy back liner system on the existing Eastern Gully Landfill batter, the Contractor shall excavate the existing terraced surface as follows:

- Removal of any topsoil as outlined in Section 1.7.1 above.
- Conduct test pitting in each local area on the existing surface to identify the thickness and distribution of the existing cover material.
- Excavation of existing cover materials on the existing surface using the design subgrade surface and test pitting results as a guide. Excavated materials are to be stockpiled by the Contractor in designated areas for use by the site owner in landfilling operations.
- The final surface shall be at least 300 mm above the existing waste level and provide an appropriate surface to construct the base layer. In case of over-excavation of the material, the area shall be reinstated with the excavated material or with Unit 2 General Fill in the same manner as outlined in Section 3.3.1 at the Contractor cost to the satisfaction of the Superintendent.

The Contractor shall provide a work method statement presenting proposed methods for these activities. Submission of the work method statement constitutes a HOLD POINT. These activities shall not commence until the Hold Point is released.

The test pitting and excavation of the cover materials in each local area constitute INSPECTION POINTs. The Contractor is required to provide 24 hours notice before commencing or recommencing these activities.

The preparation of the excavated surface, including surveying, shall be in the same manner as outlined in Section 3.3.2.



3.2 Construction Quality Management

The Construction Quality Management system for construction comprises Contractor requirements and Superintendent actions. Contractor requirements include preparing management plans, preparing work method statements, material testing, compaction testing (through GITA), surveying, notifying for Inspection Points, and preparing Hold Point documentation and works-as-executed (WAE) documentation. Superintendent actions include review and approval of Contractor submittals and documentation, inspecting construction works, conducting audit testing, attending Inspection Points, and releasing Hold Points. Superintendent actions are typically referred to as Construction Quality Assurance (CQA).

A description of the approach for quality management of material properties is provided in Section 2.1.2, including description of approval of material sources, confirmation of as-delivered material properties, and audit testing. Details of material requirements and testing requirements are given in Chapter 2 of this document. For example, as indicated in Section 2.1.4, all material test results submitted to the Superintendent by the Contractor must be from a laboratory with NATA-accreditation for all tests performed; and all survey results submitted to the Superintendent by the Contractor must be from a very results submitted to the Superintendent by the Contractor must be from a registered survey.

Quality management requirements to be implemented during construction activities are described in the following section, with details provide in the remaining portions of Chapter 3 of this document.

Construction Quality Management Summary

Quality management requirements are summarised in Table 18, with definition of the table headings given below. Construction requirements are outlined in the following Section 3.3.

- *Hold Point*: This term is defined in Section 1.2.
- Full Time Inspection: The Superintendent or in some cases the GITA, will be present on a full-time (continuous) basis for certain construction activities to provide additional confidence that construction is proceeding in accordance with Technical Specification requirements and design intent. Activities where full-time inspection is planned to be undertaken are identified in Table 18 below.
- Field Testing: Certain cell construction activities will require real-time field testing during construction. Examples include testing for confirmation of as-delivered material properties, testing of geomembrane welds, and compaction testing (refer following bullet point).
- Compaction Testing: Testing for as-constructed density and moisture content will be routinely performed on all soil construction materials. The Contractor will be required to engage an independent GITA from a specified short list to inspect earthworks construction and perform compaction testing.
- Survey: Numerous requirements for surveying of constructed alignments, inverts, and constructed soil and geosynthetic material surfaces are include in the Technical Specification. The survey provides data for Works-as-Executed documentation and for confirming that design layer thicknesses have been achieved in liner and capping systems.
- Audit Testing: The Superintendent will arrange, at his discretion, for sampling and testing of deliverd and emplaced construction materials, including soils and geosynthetics, to provide material property measurements that are independent of measurements by the Contractor (refer Section 2.1.2). Activities where audit testing is likely to be undertaken are identified in Table 18 below.





No.	Activity/Material	Hold Point	Full-Time Inspection	Field Testing	Survey	Audit Testing
Α	CONSTRUCTION MATERIALS					
1	Source Approval (each material)	Х				x
2	Confirmation of as-delivered material properties (each material)			x		x
В	CONSTRUCTION ACTIVITIES					
1	Excavation of Onsite Materials and Formation	n of Subgra	de			
1.1	Removal of Vegetation and Topsoil, Work Method Statement	x				
1.2	Structures Demolition, Work Method Statement	x				
1.3	Excavation of Existing Eastern Gully Capping Materials, Work Method Statement, and WAE drawings	x		x	x	
1.4	Subgrade Preparation					
a	Work Method Statement	X				<u> </u>
b	Proof roll and placement of Unit 2 – general fill		X	X	X	x
С	surface analysis	x			x	
_						
2	Cell Base Lining System Construction (Cells	1 to 4)				
2.1	Placement of Unit 4 – Clay Rich Material to					
a	form bearing laver		x	X		x
b	Survey and WAE	x			X	
2.2	Perimeter Bund					
а	Setout survey of perimeter bund alignment	X			X	
b	Placement of Unit 4 – Clay Rich Material for the bund		x	x	x	
С	Survey and WAE	X			X	
2.3	Internal Bunds (refer item 2.2)					
2.4	Geosynthetics					
a	Approval of qualified sub-contractor	X				
b	Geosynthetics quality control procedures manual	x				
C	Submission of data, statements, reports and certificates	x				
d	Panel layout drawings for GCL and geomembrane	x				
e	Surface preparation for GCL placement	X				
†	Anchor trench				X	
g b	Placement of Unit 17 – GCL		X			X
<u>- n</u>	Placement of Unit 10 - HDPE Geometric		X	X	X	X
25	Leachate Collection System		X	X		X
2.J a	Placement of Unit 23 – Leachate Collection					
a 	Pipe		X			
D	Installation of leachate clean out access points	X	X			<u> </u>
d	Leachate collection pipe WAE drawings				X	
u		x				
е	Field placement trial		X	X		X

Table 18: Construction Quality Management System Summary



No.	Activity/Material	Hold Point	Full-Time Inspection	Field Testing	Survey	Audit Testing
f	Placement of Unit 7 – Drainage Aggregate		X	X		X
g	Placement of Unit 11 – Filter Geotextile		X	x		x
h	Leachate collection layer WAE drawings	x			x	
2.6	Construction of Leachate Sump					
а	Leachate Sump Construction Work Method Statement	x				
b	Excavation of sump; formation of sump base		X	x	x	
С	Placement of Clay Material and Clay WAE	X	X	x	X	x
d	Geosynthetic Materials Installation		X	x		x
е	Installation of Unit 24 – Leachate Sump Outlet Pipe with liner penetration		x		x	
f	Placement of Unit 23 - Leachate Collection Pipe within sump		x		x	
g	Backfilling the sump by Unit 7 – Drainage Aggregate and covering by Unit 11 – Filter Geotextile		x	x	x	x
h	Leachate Collection WAE drawings (included in item 2.5 h)					
2.7	Construction of Leachate Drainage System					
а	Leachate Drainage System Construction Work Method Statement	x				
b	Installation of Unit 25 – Leachate Drainage Pipe and connection with existing leachate drainage pipes		x		x	
С	Excavation and Installation of Unit 27 – Leachate Sump Riser		x		x	
d	Connection of Unit 27 – Leachate Sump Riser with Unit 25 – Leachate Drainage Pipe and Unit 24 – Leachate Sump Outlet Pipe		x		x	
е	WAE drawings (included in item 2.5 c)					
3	Piggy Back Lining System Construction					
3.1	Gas Venting System					
а	Placement of Unit 8 – Gas Drainage Gravel			x	X	
b	Placement of Unit 21 – Gas Collection Pipes				X	
С	Placement of gas venting header pipes				X	
d	Gas Venting System WAE and backfill pipes	X			X	
3.2	Base Layer					
а	Work Method Statement	X				
b	Placement of Unit 6 – Base Material and Unit 18 Geogrid	x		x		x
С	Submission of base layer WAE drawings and surface analysis	x			x	
3.3	Bearing Layer (refer item 2.1)					
3.4	Perimeter Bund (refer item 2.2)					
3.5	Internal Bunds (refer item 2.3)					
3.6	Geosynthetics					
a-f	Documentation and submittals (refer item 2.4, sub-items a to f)					
g	Placement of Unit 17 – GCL		X			x
h	Placement of Unit 15 – LLDPE Geomembrane		X	Х	X	х
3.7	Leachate Collection System					
а	Placement of Unit 14 – Geocomposite Drainage Net (Leachate)		x	x		x
b	Placement of Unit 23 – Leachate Collection		x			





No.	Activity/Material	Hold Point	Full-Time Inspection	Field Testing	Survey	Audit Testing
	Pipe					
С	Installation of leachate clean out access points	x	X			
d	Leachate collection pipe WAE				x	
е	Placement of Unit 7 – Drainage Aggregate and Unit 11 – Filter geotextile pipe surrounds		x	x		x
3.8	Protection Layer					
а	Unit 9 – Protection Material Work Method Statement	X				
b	Field placement trial		X	X		x
С	Placement of Unit 9 – Protection Material		X	X		х
d	Protection layer WAE drawings	x			х	
4	Capping System					
4.1	Gas Venting System (refer item 3.1)	X			X	
4.2	Bearing Layer for Cap					
а	Placement of Unit 4 – Clay Rich Material to form bearing layer		x	x		x
b	Submission of WAE drawings and documentation	x			x	
4.3	Placement of Unit 15 – LLDPE Geomembrane		X	X		x
4.4	Placement of Drainage Layer					
а	Placement of Unit 13 – Geocomposite Drainage Net (Surface Water)	x	x			x
b	Placement of Unit 26 – Subsoil Drainage Pipe and Unit 7 – Drainage Aggregate		x		x	
С	WAE drawings and documentation	x			x	
4.5	Placement of Unit 1 – Topsoil					
а	Work Method Statement for Unit 1 – Topsoil Installation	x				
b	Placement of Unit 1 – Topsoil		X	X	x	x
С	WAE drawings and documentation				х	
4.6	Revegetation					
а	Revegetation Plan	Х				
b	Drop Structures	X		X	X	
С	Final Capping levels WAE	X			X	
	Additional Construction Quality Management items from future revegetation specification (to be determined)					

3.3 Construction Activities

3.3.1 General Fill

Placement of Unit 2 - General Fill is required as part of several cell construction activities.

General Fill shall be placed with maximum 300 mm thick layers and compacted with suitable compaction equipment to achieve a minimum of 95% of SMDD (in accordance with AS1289.5.1.1 and 5.4.1) or a minimum HILF density ratio of 95% Standard (in accordance with AS1289.5.7.1) at a moisture content within the range of -3% to +3% of the Standard Optimum Moisture Content (SOMC). A trench roller is required for compaction within trenches.

The GITA shall provide "Level 1" supervision for material placement and moisture density testing. The frequency of field density and moisture testing during placement of all General Fill material shall as a minimum conform the following, whichever requires the most tests:





- 1 test per 500 m³ per material type; or
- 2 tests per batch of work.

If the required density and moisture is not achieved, the compacted material shall be reworked in-situ to meet the density and moisture content requirements. If the density and moisture content requirements again cannot be achieved after reworking, the failed layer shall be removed for moisture conditioning at the material borrow area or at an approved designated area, or be discarded.

3.3.2 Subgrade Preparation

Subgrade preparation by the Contractor comprises cutting and filling from the final surface to create the subgrade surface shown in the Design Drawings. This work includes the cell base area, the leachate sumps, the base of the perimeter bund, portions of the perimeter drains and associated cuttings, and the Central and Western ridge.

The Contractor shall provide a work method statement presenting proposed methods for subgrade preparation activities, including cutting, filling, proof rolling, and undercutting and replacement. Submission of the work method statement constitutes a HOLD POINT. These activities shall not commence until the Hold Point is released.

3.3.2.1 Cutting

Cutting of soil and/or rock materials will be required in some areas to establish the subgrade surface, with rock materials most likely to be encountered in three areas, Central Ridge, Western Ridge and Lower Western Ridge. It is possible that these areas will be excavated to approximately subgrade level by others prior to the cell construction.

Rock excavation may be required in some areas. The Design Report contains general information on subsurface conditions and references to documents with more detailed subsurface information.

Dewatering (groundwater) may be required in some areas. The Design Report contains general information on hydrogeological conditions and references to documents with more detailed information.

The Contractor shall not excavate deeper than the subgrade surface and shall be responsible for costs of excess dewatering, management of excess cut material, and for reinstating any over-excavation with Unit 2 – General Fill as per Section 3.3.1 at Contractor cost and to the satisfaction of the Superintendent.

The base of all excavations in soil shall be proof rolled to identify soft materials that would form an unsuitable surface for fill placement or for the perimeter swale drain alignment. Remove and replace any such materials with Unit 2 – General Fill as per Section 3.3.1. Proof rolling of the soil/fill surface in each local area constitutes an INSPECTION POINT. The Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

Excavated materials are to be stockpiled by the Contractor in designated areas for use by the site owner for landfill construction or operations.

Benches for cross-slope leachate collection pipe platform

Narrow benches for cross-slope leachate collection pipes will need to be formed on the subgrade surface of the existing Eastern Gully and/or Western Gully Landfill during the subgrade preparation of the piggy back liner system.

The Contractor shall cut into the existing ground surface to form benches along the proposed leachate collection pipe alignments as shown on the Design Drawings where the pipe alignments are not located on existing benches. The bench shall have minimum dimensions of 1.5 m wide and 1% longitudinal slope. Details of the bench and leachate collection pipe are shown in the detail Design Drawings.





In case wastes are required to be removed to from the bench, the Contractor shall directly transport the waste to the existing landfilling area in Whytes Gully Landfill. The exposed area shall be immediately covered with a minimum 300 mm thick of Unit 4 – Clay Rich Material.

3.3.2.2 Filling

In areas where filling is required to establish the subgrade surface, the remediation surface shall be proof rolled prior to fill placement to identify soft materials that would form an unsuitable surface for fill placement. Remove and replace any such materials with Unit 2 – General Fill as per Section 3.3.1.

Proof rolling of the soil/fill surface in each local area constitutes an INSPECTION POINT. The Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

After the proof rolling activity, Unit 2 – General Fill material shall be placed to achieve subgrade levels as per Section 3.3.1, except that the minimum degree of compaction shall be 98% rather than 95%.

3.3.2.3 Survey

The Contractor shall survey final subgrade levels to provide works-as-executed (WAE) drawings and to demonstrate that the design levels have been achieved. The survey shall be conducted on an approximate 10m grid with additional survey points along the benches and at the leachate sumps. The Contractor shall submit the WAE drawings, an accompanying analysis demonstrating compliance with design levels, and for all fill placement a GITA certification statement. WAE drawings shall also include surveyed alignments and depths of all backfilled service trenches as well as locations and dimensions of soft areas identified during proof rolling. Submission of these items constitutes a HOLD POINT. Construction of the base layer or placement of the bearing layer shall not commence in an area until the Hold Point has been released for that area.

3.3.3 Landfill Gas Venting System

Landfill gas venting trenches, comprising gravel and collection pipes, and header pipes shall be constructed under the piggy back liner system and under the final capping system.

The landfill gas venting trenches shall be constructed by excavation into the prepared subgrade of the piggy back liner and on the intermediate cover layer under the proposed cap, as shown in the design drawings.

Trenches shall be nominally 200 mm deep and 300 mm wide. The excavated material shall be used appropriately during further works.

The following construction sequence is required (unless alternatives are agreed with the Superintendent):

- Excavate trench;
- Partially backfill the trench with Unit 8 Gas Drainage Gravel;
- Place Unit 21 Gas Collection Pipe and backfill balance of trench, at one end of the trench the Gas Collection Pipe shall be connected with the Gas Header Pipe; and
- Place Unit 11 Filter Geotextile above the gravel and secure in place.

Placement of gas collection pipes constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

The Gas Header Pipes shall be installed in the same surface as the gas collection trenches as shown on the Design Drawings. The pipe shall be Unit 21 – Gas Collection Pipe but have solid wall and are not required to be surrounded with gravel. At the end of each header pipe, along the edge of the landform, the gas header shall be installed to connect with the active gas collection system (by others).



Installation of gas header pipe and connection the gas collection pipes constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

Following placement of gas collection and header pipes in each area, the Contractor shall survey all pipe alignments and inverts and submit works-as-executed (WAE) drawings demonstrating compliance with the design. Submission of this item constitutes a HOLD POINT. Construction of the base layer or bearing layer shall not commence in an area until the Hold Point has been released for that area.

3.3.4 Base Layer

The base layer shall be constructed within the piggy back liner footprint, in accordance with the design drawing. The Contractor shall provide a work method statement presenting proposed methods for base layer construction, including compaction and surface preparation, geogrid installation and joining, geogrid ballasting, and geogrid covering. Submission of the work method statement constitutes a HOLD POINT. Base layer construction shall not commence until the Hold Point is released.

The base layer shall be constructed with Unit 18 – Geogrid sandwiched in Unit 6 – Base Material to form a nominal 500 mm layer above the subgrade surface.

The material shall be placed in two lifts and compacted with suitable compaction equipment to achieve a minimum of 98% SMDD (in accordance with AS1289.5.1.1 and 5.4.1) or a minimum HILF density ratio of 98% Standard (in accordance with AS1289.5.7.1).

Placement of the first lift of Unit 6 - Base Material will include surface preparation to present a surface suitable for Unit 18 – Geogrid installation. Subsequently, Unit 18 – Geogrid shall be installed on the prepared surface as outlined in Section 3.3.13 of this Technical Specification.

The prepared surface with geogrid installation in each area shall constitute a HOLD POINT. The upper lift of Unit 6 – Base Material shall not be placed in the area until the Hold Point has been released by the Superintendent. Following the installation of Unit 18 – Geogrid, the second lift of Unit 6 – Base Material shall be placed and spread on top of the geogrid using a method that will not disrupt geogrid alignment and overlaps and will cause minimal damage to the geogrid. Placement and spreading of Unit 6 –Base Material on top of Unit 18 - Geogrid constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity. The Contractor shall survey the final levels to provide works-as-executed (WAE) drawings and to demonstrate that the design levels have been achieved. The survey shall be conducted on an approximate 10 m grid. The Contractor shall submit the WAE drawings, an accompanying analysis demonstrating compliance with design levels, and a GITA certification statement. Submission of the WAE drawings and accompanying analysis constitutes a HOLD POINT. Placement of the next layer shall not commence in an area until the Hold Point has been released for that area.

3.3.5 Bearing Layer

The bearing layer shall be constructed within the piggy back liner and cell base liner footprint, in accordance with the design drawings.

The bearing layer shall be constructed with Unit 4 – Clay Rich Material with a minimum as-compacted thickness of 200 mm.

The material shall be placed in one layer and compacted with suitable compaction equipment to achieve a minimum of 95% SMDD (in accordance with AS1289.5.1.1 and 5.4.1) or a minimum HILF density ratio of 95% Standard (in accordance with AS1289.5.7.1) at a moisture content within the range of -2% to +2% of the Standard Optimum Moisture Content (SOMC).





The GITA shall provide "Level 1" supervision for material placement and moisture density testing. The frequency of field density and moisture testing during placement of the material shall as a minimum conform the following, whichever requires the most tests:

- 1 test per 2,500 m² per layer of material type; or
- 1 test per 500 m³ per material type; or
- 3 tests per batch of work.

If the required density and moisture is not achieved, the compacted material shall be reworked in-situ to meet the density and moisture content requirements. If the density and moisture content requirements again cannot be achieved after reworking, the failed material shall be removed for moisture conditioning at the material borrow area or at an approved designated area, or be discarded.

The Contractor shall maintain the bearing layer in moist condition until Unit 17 - GCL is installed. Should the bearing layer surface have dried excessively (e.g. desiccation cracking>20mm depth) or wetted up excessively, as determined by the Superintendent, the affected materials shall be excavated to expose material that has moisture content within the specified tolerance. The excavated materials shall be returned to a designated area for moisture conditioning or be discarded, and the excavated bearing layer material replaced. Note that the surface of the bearing layer is designed to shed leachate and its shape should be maintained during formation in order to avoid temporary water ponding during construction. Consideration may be given to use of micro-mist sprayers to limit loss of moisture from the completed surface during hot weather.

Trafficked areas of the bearing layer surface are to be ripped, moisture conditioned and recompacted if, in the opinion of the Superintendent, the quality of these areas has deteriorated.

The finished surface shall be smooth and well-drained. Coarse materials shall not protrude from the surface of the bearing layer by more than 10 mm. No areas of ponding shall be accepted on the surface. Additional surface requirements are given in Section 3.3.9.3.

The Contractor shall survey the final levels to provide works-as-executed (WAE) drawings and to demonstrate that the design levels and layer thickness have been achieved. The survey shall be conducted on an approximate 10 m grid. The Contractor shall submit the WAE drawings, an accompanying analysis demonstrating compliance with design levels, and a GITA certification statement. Submission of the WAE drawings and accompanying analysis constitutes a HOLD POINT. Placement of GCL shall not commence in an area until the Hold Point has been released for that area, and all other contractual requirements have been fulfilled.

3.3.6 Perimeter Bund

The Contractor shall conduct a set-out survey of the alignment of the perimeter bund prior to construction and shall peg out the surveyed alignment. This constitutes a HOLD POINT. Construction of the bund shall not commence until the Hold Point has been released by the Superintendent.

The bund shall be constructed in accordance with the Design Drawings. The bund shall be constructed with Unit 4 -Clay Rich Material to form a 1-m high bund with a 4 m crest width and 2H:1V side batters. As indicated in Section 2.2.4, the required gradation of the Unit 4 material in the perimeter bund differs between the main body of the bund (i.e., max. particle size 26.5mm) and the inboard batter surface where the GCL will be placed (i.e., max. particle size 9.5mm). The finished surface where the GCL will be placed shall be smooth and well-drained with no protruding coarse materials, and with additional surface requirements given in Section 3.3.9.3.

The Unit 4 material shall be placed and compacted in nominal 200 mm thick lifts with suitable compaction equipment to achieve a minimum of 98% SMDD (in accordance with AS1289.5.1.1 and 5.4.1) or a minimum HILF density ratio of 98% Standard (in accordance with AS1289.5.7.1) at a moisture content within the range





of -2% to +2% of the Standard Optimum Moisture Content (SOMC). Prior to the placement of each lift of the bund, the top of the previous lift shall be thoroughly scarified and moisture conditioned if necessary to bond each lift together and prevent laminations at the lift interfaces.

Bund construction constitutes an INSPECTION POINT and the Contractor is required to provide 48 hours notice before commencing or recommencing this activity.

In addition, the GITA shall provide "Level 1" supervision for material placement and moisture density testing. If the GITA or Contractor detects material changes or variations then he shall undertake testing as necessary to assess the acceptability of the material. The frequency of field density and moisture testing during placement of the material shall as a minimum conform the following, whichever requires the most tests:

- 1 test per 2,500 m² per layer of material type; or
- 1 test per 500 m³ per material type; or
- 3 tests per batch of work.

If the required density and moisture is not achieved, the compacted material shall be reworked in-situ to meet the density and moisture content requirements. If the density and moisture content requirements again cannot be achieved after reworking, the failed material shall be removed for moisture conditioning at the material borrow area or at an approved designated area, or be discarded.

Upon completion of the bund, the Contractor shall maintain the integrity of the bund by limiting the traffic movement over the clay surface and maintaining the surface of the clay in a moist condition until covered by the base liner GCL and geomembrane. Should the bund surface have dried excessively (e.g. desiccation cracking>20mm depth) or wetted up excessively, as determined by the Superintendent, the affected materials shall be excavated to expose material that has moisture content within the specified tolerance. The excavated materials shall be returned to a designated area for moisture conditioning or be discarded, and the excavated bund material replaced.

Trafficked areas of the bund shall to be ripped, moisture conditioned and re-compacted if, in the opinion of the Superintendent, the quality of these areas has deteriorated.

Following bund placement, the Contractor shall survey the finished surface level to provide works-asexecuted (WAE) drawings and to demonstrate that the design geometry has been achieved. The WAE drawings shall include geosynthetic anchor trench alignments within the bunds. The Contractor shall submit the WAE drawings, an accompanying analysis demonstrating compliance with design geometry, and a GITA certification statement. Submission of the WAE drawings and documentation constitutes a HOLD POINT. Placement of liner materials or cap components on the surface of the berm shall not commence in an area until the Hold Point has been released for that area, and all other contractual requirements have been fulfilled.

3.3.7 Internal Bunds

Internal bunds between landfill cells and sub-cells will be constructed to provide a physical barrier for each stage and sub-stage of liner construction and waste filling. The locations of internal bunds between cells are shown on the Design Drawing, while the location of bunds between sub-cells are not shown but will be included for detailed design.

The internal bunds shall be constructed in the same manner as given in Section 3.3.6 for the perimeter bund.





3.3.8 General Requirements for Geosynthetics

3.3.8.1 Documentation

Specialist Installation Sub-Contractor

The Works described in the following sections shall be undertaken by an experienced geosynthetic installation specialist contractor approved by the Superintendent. The Contractor shall require that skilled sub-contractor personnel will supply, test and install all geosynthetic materials. The Contractor is responsible for all aspects of the work.

Prior to the installation of geosynthetics, the Contractor shall submit the proposed qualified subcontractor(s) to the Superintendent for approval. This submission constitutes a HOLD POINT. No geosynthetic material installation shall begin until the HOLD POINT is released. Any change to the geosynthetic supply or installation shall be subject to written approval from the Superintendent.

Alternative construction methods to those detailed in the following sections will be considered, subject to the approval of the Superintendent, provided they satisfy the intent of this Specification.

Quality Assurance and Quality Control

The Contractor shall be responsible for all quality assurance and quality control of the manufacture, transportation, storage and installation of the geosynthetic. This shall include the obtaining of material property details and certificates from the resin supplier and the geosynthetic manufacturer, the preparation of a quality control procedures manual and the undertaking of all inspections, non-destructive and destructive testing and repairs etc. and other activities detailed in this Specification.

The Contractor is responsible for compliance with this Specification; however, the Superintendent shall monitor installation of the geosynthetics. The Contractor shall accommodate all quality assurance activities described in this Specification and in the quality control procedures manual.

The Superintendent shall undertake audits of the quality control and assurance procedures. Should any areas of the works show non-conformances with the approved quality control procedures manual, then the Contractor shall cease work until the non-conformance is resolved by either presentation of the appropriate documentation or undertaking sampling and testing, or another activity approved by the Superintendent.

The Superintendent shall also undertake conformance tests on samples supplied by the Contractor in accordance with this Specification.

Quality Control Procedures Manual

The Contractor shall submit a quality control procedures manual to the Superintendent at least 10 days before the supply of any geosynthetic to the Site. The quality control procedures manual shall include the following items, as appropriate to each type of geosynthetic:

- The Contractor's organisational structure and personnel, and the qualifications and experience of the proposed installation personnel;
- Trial weld procedures;
- Measures to minimise wrinkles;
- Welding procedures, including equipment make and model;
- Weld repair procedures;
- Non-destructive testing procedures;
- Destructive testing procedures;
- Pro forma sheets for recording of installation and test results;





- Deployment equipment and procedures;
- Safety equipment;
- Supply transportation, storage and handling procedures;
- Vent flap details; and
- Any proposed changes with respect to this Specification.

The Superintendent will review this information to assess the suitability of the quality control procedures manual. Upon review of the quality control procedures manual, the Superintendent may request additional information specific to the project installation conditions.

The submission of the geosynthetic quality control procedures manual constitutes a HOLD POINT. No geosynthetic materials shall be imported to the Site until the HOLD POINT is released.

Data, Statements, Reports and Certificates

The Contractor shall submit the following information at least 7 days prior to the installation of any geosynthetic at the Site:

- The manufacturer's certifications, descriptive data, specification sheets;
- Manufacturer's test results for geosynthetic composition and properties;
- The origin (resin name and supplier's name, resin production plant), identification (brand name, number) and production date of the resin;
- A list of quantities and descriptions of materials other than the base polymer which comprise the geosynthetic;
- Copies of the quality control certificates issued by the resin supplier;
- A statement regarding recycled polymer content (if permitted by this Specification);
- A properties sheet including, at a minimum, all specified properties, measured using test methods indicated in these specifications, or equivalent;
- Reports of the tests, including sampling procedures, conducted by the manufacturer to confirm that the geosynthetic meets these Specifications. Tests shall be conducted at frequencies outlined in Chapter 2.0 of this Specification; and
- A quality control certification that property values given in the properties sheet are guaranteed by the geosynthetic manufacturer. The quality control certificate shall include roll numbers and identification, resin lot, batch numbers, sampling procedures and results of quality control tests.

The Superintendent will review this information to assess the suitability of the data, statements, reports and certificates. Upon review, the Superintendent may request additional information specific to the project conditions.

The submission of the data, statements, reports and certificates constitutes a HOLD POINT. Geosynthetic material installation shall not commence until the HOLD POINT is released.

3.3.8.2 Site Records and Drawings

The Contractor shall submit all quality forms, test results and other documentation indicated in the quality control procedures manual to demonstrate its compliance with the quality system for the project and to demonstrate compliance of the installed geosynthetics with this Specification.



Copies of these records and tests, as well as records of corrective action taken when results are unsatisfactory, shall be presented to the Superintendent in writing, within one working day following an inspection, test or action. To scale as-built drawings (i.e., WAE drawings) shall be provided of all panel layouts, anchor trenches, test positions and defects within 14 days of completing the liner.

The Contractor shall keep records sufficient to document in detail the progress and location of work undertaken.

3.3.8.3 Traffic over Geosynthetics

Construction traffic over geosynthetics is restricted or not permitted, to prevent damage and ensure the material performs its intended function. The construction of the different units with the general traffic limitations is as follows:

- GCL: No vehicle access over deployed GCL, only careful foot traffic, subject to footwear requirements.
- Geomembrane: No vehicle access over deployed geomembrane, only careful foot traffic, subject to footwear requirements.
- Geocomposite: No vehicle access over deployed geocomposite, only careful foot traffic, subject to footwear requirements.
- Geogrid: No vehicle access over deployed geogrid, only foot traffic.
- Geotextile: No vehicle access over deployed geotextile, only foot traffic.

The Contractor shall comply with geosynthetic manufacturer recommendations, as well as the requirements within this Specification, regarding limitations for periods of exposure for deployed geosynthetics prior to covering.

3.3.8.4 Anchor Trenches

The anchor trench for the base liner shall be used to anchor the GCL, geomembrane, and cushion geotextile at top of the perimeter bund. The installation of these units may require that the previous geosynthetic layer(s) is temporarily anchored while the next geosynthetic is installed.

The excavation of the anchor trench shall be presented to the Superintendent for inspection and approval before backfilling commences. This constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

The anchor trench for the base liner shall be located on top of the perimeter bund in accordance with the Design Drawings a dimension of 500 mm x 500mm. The anchor trenches of the cap liner shall be located on top of cap, having a dimension of 500mm x 300mm, and at the mid-slope bench and top of perimeter bund as shown in Design Drawings, having a dimension of 500mm x 500mm.

The geosynthetic placed in the anchor trench shall extend down one side. The geosynthetics shall not extend up the outer edge of the trench. Loose soil and ponded water shall not be permitted in the anchor trench. Anchor trenches shall be constructed and maintained so as to provide for free drainage of surface water flow and prevent ponding in or adjacent to anchor trenches.

The geosynthetics shall be placed against the side of the trench and the trench backfilled with excavated material. The backfill shall be placed in layers appropriate for the proposed construction equipment. The compaction shall be carried out in the presence of the GTA. The compacted material shall achieve at least dense or stiff consistency, as assessed by the GTA in accordance with AS 1726. Care shall be taken to not damage the geosynthetics during compaction of the backfill of the anchor trench. The Contractor shall propose equipment and method to demonstrate a low risk of damage to the geosynthetics.

The backfill of the trench shall be carried out using hand held compaction equipment, to achieve the consistency specified above.





3.3.9 Installation of Unit 17 – Geosynthetic Clay Liner (GCL)

3.3.9.1 Delivery, Storage and Handling

Unit 17 - GCL delivered to site shall be wrapped with weather and moisture resistant wrapping. The Contractor shall be responsible for the unloading, protection from the weather and storage of the delivered GCL. Rolls with damaged wrapping shall be inspected by the Superintendent to assess the extent of hydration of the GCL. Unit 17 - GCL with moisture content above 30% by weight (ASTM D5993) may be rejected. GCL rolls with damaged wrapping and moisture content lower than 30% shall be re-wrapped and sealed. All rolls of material shall be clearly marked with the type of GCL, unroll direction and batch number of manufacture.

All rolls of Unit 17 - GCL shall be delivered with the GCL tightly wrapped around a centre core, with the hole in the core suitable for the proposed spreader bar to be used during deployment. All rolls shall be stored off the ground on hard, dry, free-draining surface, with suitable bearers at closely spaced centres, suitably protected from runoff and other damage. Stacked rolls of GCL shall be covered with tarpaulins to promote runoff. GCL rolls shall not be rolled across the ground.

3.3.9.2 Acceptance Criteria for GCL

Delivery to Site

The Contractor shall supply, unload, store and protect the rolls of GCL.

Inspection of GCL after Unrolling

The Superintendent shall inspect the GCL as it is rolled out on the slope.

Where a roll of GCL has been damaged and the damaged area extends more than 300 mm across the deployed width of GCL, the roll may be rejected due to its reduced tensile strength. The Superintendent shall determine if the strength of the roll is unacceptable, based on the nature and location of the damage.

3.3.9.3 **General Surface Preparation**

Unit 17 - GCL shall be placed on the prepared surface of the liner subgrade. The liner subgrade comprises the upper surface of the bearing layer, the inboard slope of the perimeter bund, and internal bund slopes.

Portions of compacted liner subgrade that have deteriorated to an extent that has potentially compromised the quality of the layer, shall be reworked at the contractor's expense, and subjected to appropriate geotechnical testing in order to prove the required compaction.

The Contractor shall be responsible for preparing and maintaining the surface of the clay liner to provide a firm, unyielding foundation for the Unit 17 - GCL with no sudden, sharp or abrupt changes or breaks in grade, no wheel ruts/footprints, no standing water, and no voids and crack, to the satisfaction of the Superintendent.

The Contractor shall remove from the liner subgrade surface all particles that protrude from the surface by more than 10 mm, and sharp or angular particles to the satisfaction of the Superintendent. Significant voids created by removal of particles shall be filled with moist Unit 4 - Clay Rich Material. No standing water shall be allowed to accumulate on the surface of the base liner prior to installation of the Unit 17 - GCL. No GCL shall be placed onto an area that has become softened by prolonged precipitation.

The prepared surface shall constitute a HOLD POINT. No GCL shall be placed until the Hold Point has been signed off by the Superintendent. Only the area to be covered in the same day shall be signed off.

3.3.9.4 Placement

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Rolls of Unit 17 - GCL shall be moved or deployed with a suitable spreader bar that is stiff enough to limit deflection over the width of the roll to ensure smooth uniform deployment of the GCL layer. The orientation





of the GCL, that is which side is installed facing downward, is to be confirmed by the Superintendent prior to any GCL installation.

Unit 17 - GCL shall only be installed in dry weather conditions.

The Contractor shall submit a panel layout and their proposed installation method to the Superintendent for the installation at least 10 days prior to the commencement of the GCL placement for approval by the Superintendent. A minimum side and end overlay of 300 mm is required between panels. The submission of panel layout drawings and proposed installation method constitutes a HOLD POINT. GCL installation shall not commence until the HOLD POINT is released.

If manufacturer recommendations differ from procedures in this Specification, these differences shall be brought to the attention of the Superintendent prior to placement of any GCL in the facility. The requirements of this Specification will apply, unless a variation is approved in writing in consultation with the Superintendent.

Exposed Unit 17 - GCL shall not be trafficked by vehicles. Unit 17 - GCL is to be covered with Unit 15 – LLDPE Geomembrane or Unit 16 – HDPE Geomembrane, which shall be deployed concurrently with the GCL (i.e. roll width after roll width) and on the same day as the GCL. This requirement is to minimise the potential for wetting of the GCL by rainfall or runoff. Further, the Contractor must stage liner installation such that the Unit 7 Drainage Aggregate layer or the Unit 9 Protection Material is in place over each area of the liner system within 24 hours of GCL placement. This requirement is to minimise the potential for GCL swelling due to lack of confining pressure.

All rolls of GCL shall include 300 mm wide pre-treated side overlaps, which comprises bentonite powder encapsulated in the geotextile. Overlaps shall be placed in down slope direction (roof tile effect). If an alternative joining procedure is proposed, details are to be provided to the Superintendent for consideration at least 17 days prior to purchase of the materials.

The Superintendent shall inspect and approve all overlaps prior to covering the overlap.

If wrinkles greater than 50 mm high occur in Unit 17 - GCL or where wrinkles extend to the edge of the roll due to manufacturing tolerances, the wrinkle shall be cut at the crest of the wrinkle. A layer 10 mm thick of bentonite paste shall be spread over the top of one flap of the cut and the other flap pushed over the paste to form an overlap. A 20 mm thick layer of bentonite paste shall be placed over the top of the overlap extending 100 mm beyond the edges of the cut and overlap. The paste shall be covered with a patch of Unit 11 - Filter Geotextile, and squeezed into the paste.

The exposed edges of deployed GCL shall be protected from rainfall runoff to prevent erosion of bentonite. Special care shall be taken to prevent flow of runoff or seepage under and/or over the geomembrane to prevent erosion of the bentonite in the GCL.

3.3.9.5 Repairs

Rolls or panels of GCL that have been damaged shall be brought to the attention of the Superintendent, who shall judge if the panel or roll is to be removed from site, or may be repaired. If the Superintendent decides the damage is minor the hole may be patched. If a roll is deployed with manufacturing defects, the entire roll shall be removed from site.

All defects and repairs shall be recorded and locations measured as the panels are deployed, to facilitate the timely deployment of the overlying geomembrane.

A patch of GCL shall be placed over any hole with a minimum overlay over the adjoining area of 300 mm. The repairs shall be joined to the main GCL in accordance with the following requirements:

All overlaps shall be made using a 10 mm thick layer of hydrated sodium bentonite paste between the GCL and the patch GCL. The Contractor shall submit details of the proposed bentonite paste to the Superintendent for approval prior to commencement of the GCL installation.



3.3.10 Installation of Unit 15 and Unit 16 - Geomembrane 3.3.10.1 Transport, labelling, handling and storage

Transportation

The Contractor is responsible for transportation of the geomembrane to the Site.

Labelling

Each geomembrane roll shall be clearly labelled with the following information:

- Material of the geomembrane;
- Thickness of the material;
- Length and width of the roll;
- Manufacturer's Name;
- Direction to unroll the material;
- Product identification;
- Batch number; and
- Roll number.

Any roll delivered to the Site without labelling shall be rejected and removed from the site by the Contractor. Each package of welding rod or extrusion welding beads shall be clearly labelled and shall include the Manufacturers name, product identification name/number, resin lot or batch number and the package number.

The Contractor shall also cross-reference each batch number and roll number of geomembrane delivered to site to the resin used and date of manufacture of the geomembrane.

Handling and On-site Storage

The Contractor is responsible for handling, storage and care of the geomembrane before and after installation at the Site. The geomembrane rolls shall be protected from dirt, mud, dust, fire and damage before installation. Rolls shall be stacked to provide access for roll identification and conformance testing as required. The integrity and legibility of roll labels must be maintained during storage.

Geomembrane materials shall be stored in accordance with the quality control procedures manual and the Manufacturer's recommendations. This may include covering of geomembrane rolls.

3.3.10.2 Surface Preparation

Unit 15 – LLDPE Geomembrane and Unit 16 – HDPE Geomembrane shall be placed on top of the GCL in the piggy back and cell base lining systems, respectively. The Contractor is responsible for meeting the 24-hour time window requirements for GCL, geomembrane, and cover placement given in Section 3.3.9.4, and for maintaining the surface of the GCL to provide a firm, unyielding foundation for the geomembrane with no sudden, sharp or abrupt changes or break in grade. No standing water or excessive moisture shall be allowed to accumulate on the GCL prior to geomembrane installation. No geomembrane shall be placed onto an area that has become deteriorated due to moisture changes.

Unit 15 – LLDPE Geomembrane shall be placed on top of Unit 4 – Clay Rich Material in the capping system. The Contractor is responsible for maintaining the surface to provide a firm, unyielding foundation for the geomembrane with no sudden, sharp or abrupt changes or break in grade, no wheel ruts/footprints, no standing water, and no voids and crack to the satisfaction of Superintendent. The Contractor shall remove from the bearing layer surface all particles protruding more than 5 mm, and sharp or angular particles or water to the satisfaction of the Superintendent. Significant voids created by removal of particles shall be





filled with moist similar material. No standing water or excessive moisture shall be allowed to accumulate on the surface prior to geomembrane installation. No geomembrane shall be placed onto an area that has deteriorated due to moisture changes.

3.3.10.3 Geomembrane Placement

During geomembrane installation the Superintendent will provide direct input and involvement as indicated in the following sections of this Specification. The Contractor is required to accommodate and allow for the Superintendent's identified role.

Layout Drawings

The Contractor shall submit geomembrane panel layout drawings at least 7 days before installation starts. The drawings shall indicate the panel configuration, the location of seams and the staging/direction of deployment. The layout drawings shall be suitable for use as construction drawings, to scale and include dimensions and details.

The submission of the panel layout drawings constitutes a HOLD POINT. Geomembrane installation shall not commence until the HOLD POINT is released.

Panel Identification

A field panel is the unit area of geomembrane to be welded in the field and shall be bounded by field welds or anchor trenches. Each field panel shall be numbered and the panel layout drawings shall show the panel numbers and the dimensions and area of each panel.

Field Panel Placement

Field panels are to be placed so that the boundaries do not intersect at one point and form a cross seam. A minimum 150 mm is required to offset the occurrence of a cross seam. The Contractor shall allow for the effects of changes in temperature with the resulting expansion and contraction of the panel, to prevent occurrence of a cross seam.

Installation Procedure

Field panels shall be installed using any one of the following procedures:

- field panels for one day's installation may be placed prior to field welding (to protect the subgrade from erosion by rain, or desiccation).
- field panels are placed one at a time and welded immediately (to minimise the number of unwelded field panels exposed to wind), or
- any combination of the above.

Weather Conditions

Geomembrane seaming and welding shall not be started if the ambient temperature is below 10°C or above 35°C, unless the Contractor demonstrates what special measures will be applied for welding outside this temperature range, and is authorised by the Superintendent. Both panels of geomembrane to be welded shall be allowed to equilibrate to the same temperature, before starting to weld.

Geomembrane jointing shall not be undertaken;

- in the presence of excessive moisture (i.e. rain, fog, dew);
- in an area of ponded water;
- or during periods of high wind or excessive dust.

If geomembrane placement and jointing is to be carried out at night, the entire area of deployment shall be illuminated. Installation should preferably be carried out during daylight hours. Installation work carried out at night shall be inspected and tested during daylight hours. All joints shall be tested during daylight hours.





Method of Placement

The Contractor shall ensure that:

- No more geomembrane is installed at any one time than can be reasonably welded in one day.
- Geomembrane rolls and/or factory panels shall be unrolled or unfolded in accordance with the instructions and the direction shown on the boxes or wrapping.
- No equipment used shall damage the geomembrane by handling, trafficking, leakage of hydrocarbons or other means.
- Personnel working on the geomembranes shall not smoke, use footwear, or engage in other activities that could damage the geomembrane. The Contractor shall protect the geomembrane from damage by equipment or personnel traffic associated with construction.
- Methods used to unroll panels shall not cause scratches or crimps in the geomembrane and shall not damage the underlying compacted clay liner and other layers.
- The prepared surface awaiting covering by geomembrane shall not be allowed to deteriorate and shall be maintained in a condition suitable for geomembrane placement.
- Methods used to place panels shall preclude folds, wrinkles that may become folds, bridging (trampolining) and differential wrinkles between adjacent panels.
- Temporary ballast (such as sand bags) shall be applied to prevent uplift during high wind conditions. Such loading shall be spread out and shall not damage the geomembrane. It is the contractor's responsibility to ensure the geosynthetic liners are sufficiently loaded.
- Vent flaps shall be sealed once the geomembrane has been covered with heavier materials and air trapped under the geomembranes during installation has been expelled.
- Joints shall be orientated so that overlaps are in the downslope direction (roof tile effect).
- All cutting of the geomembrane during installation shall be with a hooked blade to avoid damage.
- The Contractor shall implement procedures with its staff, to the satisfaction of the Superintendent to manage the risk of sharp particles being trapped in footwear or equipment that may or will move over the geomembrane.

Damage and Defects

Damage

The Superintendent shall inspect geomembrane panels for damage, after placement and prior to welding. The Contractor shall replace or repair a field panel or portion of a panel that is damaged (torn, twisted or crimped). Damaged panels or portions of damaged panels that have been rejected shall be removed from the work area. The Superintendent shall decide on the need to repair or replace damaged field panels.

Inspection of Geomembrane

The geomembrane shall be inspected by the Contractor during installation from the roll to identify unacceptable areas of material. Irregularities in the geomembrane material identified during inspection shall be repaired, or if excessive, the roll shall be rejected. The decision to either repair unacceptable areas or reject the roll shall be the Superintendent's. This decision shall generally be based on the following considerations.

Defects

The acceptance of the geomembrane shall be based on a maximum number of manufacturing defects. Manufacturing defects include "fisheyes", blemishes and shallow scratches.



A "fisheye" is a thinning of the geomembrane. The specified minimum thickness of the geomembrane also applies to "fisheyes". The size of the fisheye is of no consequence, as it is the thinning or absence of the geomembrane inside the fisheye, which is of concern.

Surface blemishes are considered to be areas where the resin has not been properly mixed or filler can be noted on the geomembrane. The colour and surface texture of the geomembrane shall be uniform and consistent. Where changes occur in the surface texture or colour the contractor shall request the Superintendent to inspect the area. If the area is rejected as unacceptable, then the section of the geomembrane roll shall be removed and replaced.

Straight-line scratches that penetrate the geomembrane (approximately 0.1 mm) shall be pointed out to the Superintendent. The extent and depth of the scratch shall be examined by the Superintendent to decide if a defect is to be removed. The roll length where such a defect occurs shall be cut out and removed from site. All defects shall be patched or capped and subject to quality control testing, reporting and documentation by the Contractor.

If a roll has been rolled out and no fisheyes are present, the geomembrane will be accepted. If the end of a roll has a number of defects, then the end of the roll shall be cut off and removed from site. The Superintendent shall make the final decision on site.

Maximum number of manufacture defects per 300 m^2 of roll length shall be one, with the total number of manufacture defects for the liner to be less than 10 per ha. If more than one manufacture defect occurs over a local area of the geomembrane within a circular area of 0.5 m radius, the area shall be considered 'one defect' and be capped. Replacement of defective geomembrane is at the Contractor's expense.

Manufacturer defects are considered separate to installation defects. Manufacturing defects and installation defects are the Contractor's responsibility. The Superintendent shall decide if the number of installation defects over a certain area is too high, and whether the area should be cut out or capped.

All defects shall be patched or capped and subject to quality control testing, reporting and documentation by the Contractor.

3.3.10.4 Field Welding

Requirements of Personnel

Personnel performing welding operations shall be qualified as indicated below.

- Personnel performing welding operations shall be qualified by experience or by successfully passing welding tests and at least one welder shall have welded a minimum of 100,000 m² of geomembrane using the same type of welding apparatus in use at the site.
- The weld foreman, most experienced welder, shall directly supervise less experienced welders, as required.
- No field welding shall take place unless the weld foreman is present.

Welding Equipment and Products

Approved Processes for Field Welding.

Only extrusion welding or fusion welding, using equipment approved by make and model, shall be used. Alternative processes may be proposed and submitted to the Superintendent 14 days before the start of geomembrane deployment, for consideration for approval.

Extrusion Process

The extrusion apparatus shall be equipped with gauges giving the temperature in the apparatus and at the nozzle. The Contractor shall provide documentation for the extrudate to the Superintendent and shall certify that the extrudate is the same material as the geomembrane sheet to be welded. The extruder shall be purged before beginning a weld and until all heat-degraded extrudate has been removed from the barrel. Whenever, the extruder is stopped, the barrel shall be purged of all heat degraded extrudate.





Fusion Process

The fusion-welding apparatus must be automated vehicular-mounted devices. The fusion-welding apparatus shall be equipped with gauges giving the applicable temperatures and pressures. The edge of the cross seams to be fusion welded shall be ground to a smooth incline (top and bottom) prior to welding. A temporary movable protective layer shall be used directly below each overlap of geomembrane that is to be welded to prevent build up of moisture between the sheets.

Generator

The electric generator shall be placed on a smooth base such that no damage occurs to the geomembrane. Similarly, a smooth insulating plate or fabric shall be placed beneath the hot welding apparatus after usage to protect the geomembrane. The geomembrane should not be damaged during welding and the geomembrane shall be especially protected from damage in trafficked areas.

Seam Layout

The Contractor shall provide the Superintendent with a seam layout drawing i.e. a drawing of the area to be lined showing all expected seams. No panels shall be welded in the field without the Superintendent's approval. In addition, no panels not specifically shown on the seam layout drawing shall be used without the Superintendent's prior approval.

No seams shall be located in areas of potential stress concentrations.

No cross-shaped seams shall be allowed unless approved by the Superintendent. All fusion joints between panels are to form T-joints, with panel layouts being staggered to achieve this.

All seams and joints shall be surveyed and numbered or named, which shall be cross-referenced to field notes and records of the contractor. Seam numbers shall be marked on the seam layout drawing, and altered as required on the as-built drawings (refer Section 3.3.8.2).

Welding Method

The welding method to be employed shall be the dual-track fusion welding process. Extrusion welding shall be used for repairs and patches. Single-track fusion welding methods or possible other welding methods shall only be used with prior written approval from the Superintendent.

The Contractor shall maintain at least one spare, operable welding unit of each type employed on the project site at all times.

Weld Preparation

General weld preparation procedures, temporary bonding procedures, general equipment settings, including acceptable extrudate or wedge temperatures, rate or advancement, etc., and welding procedures, shall be specified in the quality control procedures manual.

Prior to welding, the weld area shall be clean and free of moisture, dust, dirt, debris, markings and foreign material.

Where abrading is required, the process shall be completed according to the Manufacturer's instructions within one hour of the welding operation and in a way that does not damage the geomembrane. Abrasion of the geomembrane surface shall not extend outside the weld bead or weld surface area.

Seams shall be aligned to minimise the number of wrinkles.

Artificially induced cooling of the extrudate welds using water or other means is not permitted. Care shall be exercised to ensure that non-destructive testing of the extrudate and/or other activities does not cause artificial cooling of the weld.

The Contractor shall record the following information on the geomembrane surface adjacent to the weld:





- Unique seam number.
- Welding device number and operating temperature.
- Welding technician's initials and
- Date and time.

This information must be recorded onto the Contractor's quality assurance documentation at the end of the day's welding activities.

Overlapping and Temporary Bonding

The panels of geomembrane shall be overlapped by a minimum of 75 mm for extrusion welding and 125 mm for fusion welding. The overlap shall be sufficient to allow peel tests to be performed on the weld, and to provide enough space to form a reliable air channel between dual fusion welds for testing.

The procedure used to temporarily bond adjacent panels together shall not damage the geomembrane; in particular, the temperature of the air at the nozzle of any spot welding apparatus shall be controlled such that the geomembrane is not damaged.

No solvent or adhesive shall be used unless the product is approved in writing by the Superintendent (samples shall be submitted for testing and evaluation).

General Welding Procedures

The general welding procedure used by the Contractor shall be as follows:

- For fusion welding, a movable protective layer of plastic shall be placed directly below each overlap of geomembrane that is to be welded. This is to prevent any moisture build-up between the sheets to be welded.
- Welding shall extend to the outside edge of panels to be placed in the anchor trench.
- Ends of dual fusion welds extending into anchor trenches and into joints or patches shall be welded closed.
- If required, a firm substrate shall be provided by using a flat board or similar hard surface directly under the seam overlap to achieve necessary support.
- Wrinkles at the seam overlaps shall be cut along the ridge of the wrinkle to achieve a flat overlap. The overlap shall be welded and any portion where the overlap is inadequate shall then be patched with an oval or round patch of the same geomembrane extending a minimum of 150 mm beyond the cut in all directions.
- All cuts and patches shall be formed with rounded edges and ends, to prevent stress concentrations in the geomembrane. All cuts shall be removed or be ended off with a round cut-out.

T-Joins

All T-joins shall be treated as a potential defect and be patched and subject to quality control procedures in accordance with this Specification.

3.3.10.5 Testing

Trial Welds

Each welding technician shall qualify to operate on a daily basis, by performing a trial weld prior to welding activities or at times designated by the Superintendent. These trial welds shall be performed using each type of welding device to be employed by the welding technician during that period. Additionally, a trial weld shall be made using each welding device on resumption of work after the lunch break or at an interval of no greater than five (5) hours, whichever is less. The Superintendent may also require that a trial weld be





performed using each device at the conclusion of welding activities. Welding devices that have not produced a passing trial weld will not be permitted to perform production welding.

Trial welds shall be made on "fragment" pieces of geomembrane liner to verify that welding conditions are adequate. The trial weld sample shall be at least 0.3 m wide and 3.0 m long for fusion welds or 1.0 m long for extrusion welds with 125 mm overlap, with the weld centred length-wise. All trial welds shall be performed under the same weather and subgrade conditions as production welding.

Three specimens each (25 mm) wide shall be cut by use of a die from the trial weld sample by the Contractor - one near each end and one near the mid-point. The two near end specimens shall be tested in peel and the mid-point sample tested in shear.

All trial weld specimens shall be tested in the field by the Contractor and in the presence of the Superintendent, using an electrically operated tensiometer where the force exerted is displayed. The Contractor shall supply evidence demonstrating that the tensiometer has been calibrated within the previous 12-month period.

The shear test specimen shall, at a minimum, meet a strength of ninety five percent (95%) of the tensile yield strength of the parent geomembrane material where it fails in the material (i.e. film tear bond). Both tracks of dual-track fusion welds shall be tested for peel adhesion. Peel strength of welds shall meet at least 65% of the tensile strength of the parent geomembrane material where it fails in the material.

All seams shall fail in the material, i.e. film tear bond. Trial seams shall meet the following minimum strength criteria:

Material (including weld type)	Peel	Shear	
HDPE (fusion welds)	65% ⁽¹⁾	95% ⁽¹⁾	
HDPE (extrusion weld)	60%(1)	95% (1)	
LLDPE (fusion weld)	220 N/25 mm	265 N/25 mm	
LLDPE (extrusion weld)	190 N/25 mm	265 N/25 mm	

Note (1): Test results relative to the strength of the parent sheet strength

The tensile yield strength of the parent material will be determined before testing the trial welds by testing a 25 mm wide strip cut with a dye.

If any one of the three specimens fails, the entire trial weld is considered to have failed.

In the event that a trial weld fails, the entire trial weld procedure shall be repeated after the appropriate adjustments to the welding device and/or operator has been made. If a second trial weld fails, the welding device and/or the welding technician shall be rejected and shall not be used for welding until such time as the deficiencies are resolved, verification of the resolution is provided, and a successful trial weld performed.

Non-destructive Weld Continuity Testing

General

The Contractor shall non-destructively test all field and factory welds over their full length by the vacuum box method for testing continuity of extrusion welds, and air pressure test for double fusion welds only, or other approved method. The Contractor will be required to have back-up vacuum testing apparatus on the Site. A trial will be required in the presence of the Superintendent to demonstrate the effectiveness of the contractor's apparatus and method prior to field welding commencing. Vacuum testing and air pressure testing are described below. The purpose of the non-destructive test is to check the continuity of welds. It does not provide any information on weld strength. Continuity testing shall be done as the welding work progresses. Any welds that fail non-destructive testing shall be repaired in accordance with this Specification. Welds, which cannot be non-destructively tested because of seam geometry, shall be capped.





All test equipment shall be in calibration and conform to manufacturer's specifications. The Contractor shall submit current calibration certificates.

Vacuum Testing

The equipment shall comprise the following:

- A vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole or valve assembly, and a vacuum gauge showing the pressure in the box;
- A steel vacuum tank and pump assembly equipped with a pressure controller and connections;
- A rubber pressure/vacuum hose with fittings, pressure gauge linked to the window housing and connections;
- A soapy solution to be applied over seam area.

Each section of the weld to be tested shall be tested to a vacuum pressure of at least minus 35 kPa. Each section of seam shall be vacuum tested for a period of not less than 10 seconds by examining the geomembrane through the viewing window for the presence of soap bubbles. Adjoining area shall to be tested with a minimum 75 mm overlap between sections.

Air Pressure Testing

The following procedures are applicable only to those processes that produce a double weld with an enclosed air channel. All double welds with an enclosed air channel shall be air pressure tested.

The equipment shall be comprised of the following:

- An air pump (manual or motor driven) capable of generating and sustaining a pressure of 180 to 200 kPa.
- A rubber hose with fittings and connections.
- A sharp hollow needle or other approved pressure feed device.
- A calibrated pressure gauge capable of reading pressures up to 250 kPa, with a tolerance of less than 5 kPa.

The following procedures shall be used for air pressure testing the HDPE Geomembrane:

- Seal both ends of the weld to be tested:
- Insert needle with pressure gauge, or other approved pressure feed device within 300 mm of one of the sealed ends, into the air channel created by the fusion weld:
- Energise the air pump and pressurise the channel to 200 kPa for a 25 mm wide channel or 350 kPa for a 13 mm wide channel. Close the valve and sustain the pressure for a minimum of 5 minutes. A pressure drop of less than 10 kPa is allowable, but the air pressure is still required to stabilise for a minimum of 5 minutes. Should a different width air channel be formed the Superintendent shall adjust the required minimum air pressure in the channel to achieve a similar stress on the weld as for a 25 mm wide channel.
- If loss of pressure exceeds 10 kPa, or does not stabilise, the faulty area should be located and repaired in accordance with this section. If, in the judgement of the Superintendent, significant changes in geomembrane temperature occur during the test (e.g., due to cloud cover), the test shall be repeated after the geomembrane temperature has stabilised.





- Cut end of weld opposite to the pressure gauge and observe that the pressure drops. If the pressure does not drop, locate the obstruction(s) in the weld, repair, and retest the weld.
- Remove needle or other approved pressure feed device and repair all holes and damage made to the air channel by extrusion welding over the damage.

The following procedures shall be used for air pressure testing the LLDPE geomembrane:

- Seal both ends of the weld to be tested.
- Insert needle with pressure gauge, or other approved pressure feed device within 300 mm of one of the sealed ends, into the air channel created by the fusion weld.
- Energise the air pump and pressurise the channel to 150 kPa for a 25 mm wide channel, or 200 kPa for a 13 mm wide channel. Close the valve and sustain the pressure for a minimum of 5 minutes. A pressure drop of less than 15 kPa is allowable, but the air pressure is still required to stabilise for a minimum of 5 minutes. Should a different width air channel be formed the Superintendent shall adjust the required minimum air pressure in the channel to achieve a similar stress on the weld as for a 25mm wide channel.
- If loss of pressure exceeds 10 kPa, or does not stabilise, the faulty area should be located and repaired in accordance with this section. If, in the judgement of the Superintendent, significant changes in geomembrane temperature occur during the test (e.g., due to cloud cover), the test shall be repeated after the geomembrane temperature has stabilised.
- Cut end of weld opposite to the pressure gauge and observe that the pressure drops. If the
 pressure does not drop, locate the obstruction(s) in the weld, repair, and retest the weld.
- Remove needle or other approved pressure feed device and repair all holes and damage made to the air channel by extrusion welding over the damage.

Alternative testing procedures may be considered by the Superintendent based on submission of relevant information by the Contractor. If an alternative testing procedure is to be considered the Contractor shall submit information to the Superintendent at least 14 days before the procedure is to be used.

Destructive Weld Continuity Testing

The Contractor shall perform destructive weld tests at selected locations. The Superintendent shall choose the test locations. The Superintendent reserves the right to vary the testing frequency depending on results of samples tested. The purpose of these tests is to evaluate field weld strength. Weld strength testing shall be done as the welding work progresses, not at the completion of all field welding.

Location and Frequency

Destructive test samples shall be collected at an average frequency of one test location per 150 m of seam length or at intervals designated by the Superintendent.

Test locations shall be determined during welding, and may be prompted by suspicion of excess crystallinity, contamination, offset welds, or any other potential cause of imperfect welding.

Sampling Procedure

The Contractor shall cut samples at locations designated by the Superintendent as welding progresses to obtain laboratory test results before the geomembrane is covered by another material. Each sample shall be numbered and the sample number and location surveyed and identified for inclusion on the as-built liner drawing (refer Section 3.3.8.2).

All holes in the geomembrane resulting from destructive weld sampling shall be repaired and tested in accordance with the repair procedures in this Specification. Cuts to remove the samples shall be rounded to prevent stress concentrations in the geomembrane.





Size of Samples

The samples shall be a minimum 0.3 m wide by 0.4 m long with the weld centred length-wise. The sample length shall be increased to provide material for additional laboratory testing or archiving. Two specimens shall be cut from each end of the sample for preliminary field tests. The remaining sample shall be retained by the Contractor pending instructions from the Superintendent which samples are to be subjected to laboratory testing.

Each portion of the test sample shall be labelled with a unique number for the sample, and referenced to the joint number from where the sample was taken. The sample number shall be noted on the as-built drawings (refer Section 3.3.8.2). The Superintendent may direct the Contractor to reduce the length of the sample removed from the welds, if the Superintendent is satisfied that field testing indicates high quality welds. Laboratory tests may be ordered by the Superintendent on random samples to compare to field test results.

Preliminary Field Testing

Weld Destructive Tests

Two (2) specimens, one from each end of the weld destructive sample, shall be removed and tested for peel adhesion by the Contractor in accordance with Standard GM13 while in the field. The results of this testing shall be evaluated in accordance with the criteria detailed in this Specification.

If either of the two field specimens fails, the entire destructive test is considered to have failed and additional destructive test samples shall be taken in accordance with the procedures of this specification.

If the laboratory destructive testing is to be performed on-site, the requirement for preliminary field weld destructive testing may be waived by the Superintendent.

Weld-end Tests

The Contractor may, if agreed by the Superintendent, perform an additional preliminary destructive test. This test shall take the form of a single specimen obtained from one end of the completed fusion weld. This will be a quality control test and, as such, shall be addressed in the quality control procedures manual.

Upon completion of a fusion weld, a specimen shall be removed from one or both ends and tested by the Contractor for peel adhesion in accordance with the procedures detailed in this Specification. Both tracks of the dual-track fusion weld shall be tested and evaluated. The weld shall not fail in the weld area. If one or both of these specimens fail, a complete destructive test sample shall be taken as previously detailed in this Specification.

Laboratory Weld Sample Destructive Testing

The destructive weld testing will be performed by the Contractor in an on-site or off-site geosynthetic testing laboratory, to be approved by the Superintendent. Typically tests performed by the laboratory shall be completed and the results reported to the Superintendent within 24 hours of receipt.

The Contractor shall conduct laboratory destructive testing on at least 10% of the destructive weld samples of the project, or at least five samples, whichever results in the greater number of tests.

Tests shall be performed on 10 specimens obtained from each field sample. From each sample 5 specimens shall be tested in shear and 5 specimens shall be tested in peel. The shear and peel specimens shall be selected from the sample alternately, so that no two adjacent specimens are tested in the same mode.

Weld Evaluation Criteria

Each weld sample must satisfy both the shear and peel criteria. All testing and evaluation shall be carried out in accordance with ASTM D 4437.

For both peel and shear tests the specimen shall fail in the geomembrane sheet and not in the weld area. This is referred to as "film tear bond," (FTB). The specimen shall be defined as failing in the weld if any portion of the weld exhibits separation across more than 10% of the width. Each track of a dual-track fusion





weld shall be considered to be a separate weld for the purpose of calculating the percentage separation. If more than one specimen fails in shear, the entire weld destructive test sample shall be considered as failing.

Failed Destructive Sample Procedure

The Contractor shall reconstruct the deficient weld once the extent has been determined. All welds that are to be reconstructed shall be bound by passing destructive tests.

The Contractor shall trace deficient welds by grinding through the top sheet of the seam air channel, extrusion weld the channel, and pressure test sections of the seam between channel seal welds. Deficient extrusion welds shall be traced by taking field specimens from the weld at 3 m intervals until the Contractor has confidence that destructive samples which pass laboratory testing can be obtained. A full laboratory destructive sample will then be taken at that location and tested. If one or both of these samples fail the laboratory weld destructive test, then the procedure is repeated in that direction until passing laboratory results are obtained. For the purposes of tracing a weld, the weld is considered to be the path of the given fusion welding apparatus or extrusion welding device/technician combination and may, if necessary, extend beyond any given welding period. Tracing which requires obtaining more than 2 specimens in either direction from the location of the initial failed destructive weld sample shall be brought to the attention of the Superintendent. The Superintendent shall decide if the whole seam is to be rejected, or if the Contractor may continue identifying the segment of the defective seam.

At such time that the initial destructive sample failure rate of 10% or greater is reached, the Superintendent shall be notified so that a review of the Contractor's performance may be conducted.

3.3.10.6 Repairs

General

All weld and non-weld areas of the geomembrane shall be visually inspected by the Contractor for signs of damage, defective welds, blisters, punctures, undispersed raw materials, and any sign of contamination by foreign matter. Defective welds shall include completed welds that have been formed using equipment that is subsequently identified as being defective.

Any defective or flawed areas observed shall be marked, repaired, tested; or removed from the installation and disposed of. Unless otherwise approved by the Superintendent, all air channels produced by the dual track fusion welding process shall be sealed at both ends and at any location where the air channel is severed and made discontinuous. The appropriate parties shall agree upon the method of sealing. All repairs (patches, caps, etc.) may, at the discretion of the Superintendent, be destructively tested.

All defect locations shall be surveyed for inclusion on the as-built liner drawing (refer Section 3.3.8.2).

Patching

Patches shall be used to repair defects such as holes (including areas from which destructive test samples were obtained) and pinholes (exclusive of non-destructive testing air pressure needle holes) which penetrate the entire geomembrane thickness, tears and crazing. Small surface blemishes and localised flaws which do not penetrate the entire thickness of the geomembrane shall also be patched, or as instructed by the Superintendent.

Areas of crazing shall be cut longitudinally (along the length). The ends of all holes shall be rounded, to prevent further propagation, prior to patching. Patches may be used to cover areas of undispersed raw material or contaminated by foreign substances (gasoline, oil, etc.), if approved by the Superintendent. Patches shall extend a minimum of 150 mm beyond the limits of the defect and all corners of patches shall be rounded. Patches shall follow the contour of the defect area and remain free of crimping or pinching. The geomembrane material used for patches must, at a minimum, meet the requirements of this Specification.

Patches and defect areas shall be free of dirt, moisture, debris and markings. Patches shall be temporarily bonded by heat welding. Chemical adhesives and tape are prohibited without prior approval of the Superintendent. The perimeter of the patch shall be abraded with a hand-held grinder to produce a bevelled



edge. Patches shall be temporarily installed by heat welding along the entire perimeter of the patch and defect areas. The patch shall be installed flat along all edges with no wrinkles or folds. The patch weld area shall be abraded no more than 1 hour in advance of permanent welding. Heat welding and abrasion shall not cause excessive melting, wear or puncturing of the geomembrane material; such occurrences shall be considered defects and shall be repaired by patching.

Patching or repairs that require more than two passes of a welding procedure shall be considered as a defect, and be covered by a patch. Patches covering parts of other patches are not acceptable.

Capping

A cap is a patch of extended length and may be used to repair failed welds. Caps shall extend a minimum of 150 mm beyond the limits of the defective weld and all corners shall be rounded. Caps shall be installed as detailed in this Specification for patches.

A cap used to repair a failed weld or portion of weld shall be destructively tested if it exceeds 35 m in length or if the weld is of questionable quality. Caps over failed welds shall be carried out only with the approval of the Superintendent if no other method of repair is feasible. Where welds are being repaired by caps, the failed weld shall be cut out, and the cap shall be welded using fusion welding over most of the joint. The length of extrusion weld required to close-off the cap shall be kept to a minimum, and shall be closed-off after the fusion weld has been pressure tested.

Grinding and Welding

Grinding and extrusion welding shall be used to repair sections of defective extrusion weld less than 0.3 m in length. Areas requiring repair shall be abraded no more than 1 hour prior to the repair being made.

In consultation with the Superintendent, where the reason for a failed dual-track fusion weld has been determined with certainty, and is not related to faulty welding equipment, the failed part of the weld may be repaired (if less than 5 m long) by bevelling the edge (if required), abrading the sheet surface and applying an extrusion weld along the exposed edge (flap) of the seam. Failed welds repaired in this manner must conform to the requirements of this Specification. If the length of the failed portion of the fusion weld exceeds 5 m, or if the flap is not wide enough to allow destructive testing of the extrusion weld (without first testing through the fusion weld), then the weld must be reconstructed by capping.

Geomembrane Wrinkles and Bridging

Geomembrane wrinkle and bridge size and extent shall be minimised to the satisfaction of the Superintendent. Covering the geomembrane with the specified materials early in the morning when the temperature of the liner is low will reduce the extent and size of wrinkles. Wherever possible wrinkles shall be kept small and spread over the panel. In general, wrinkles which, when loaded, will result in a fold in the geomembrane are too large. Wrinkles or bridging larger than 300 mm high shall be cut and welded as a seam if the overlap is sufficient, in accordance with this Specification. Where the overlap is not sufficient, the wrinkle shall be cut and patched or capped as detailed in this Specification. Whenever it is not possible to manage wrinkles to less than specified, wrinkles shall be combined through accumulation so as to minimise the number of repairs being made.

Care shall be taken to minimise the occurrence of wrinkles over or across joins and welds to reduce stress concentrations near heat affected zones in the geomembrane.

3.3.11 Geotextiles

3.3.11.1 Description

Once delivered to the Site the Contractor shall recover samples from the rolls of geotextile, as indicated by the Superintendent. Samples from on site rolls shall be recovered at a frequency of one sample per 2000 m², or as varied by the Superintendent. The Contractor shall arrange for the testing of the samples to compare to both the design specifications and to the list of typical values of the properties provided by the manufacturer.





As a minimum, the following tests shall be performed on geotextiles (each type):

- Mass;
- Trapezoidal tear; and
- CBR puncture strength.

Other tests may be specified by the Superintendent.

3.3.11.2 Storage and Handling and Installation of Geotextiles

During shipment and storage, the geotextiles shall be protected from ultraviolet light exposure, precipitation or other inundation, spills of hydrocarbons, mud, dirt, dust, puncture, cutting or other damaging deleterious conditions.

The Contractor shall be responsible for the storage of the geotextile on the Site.

The geotextiles shall be secured and then rolled down the slope in such a manner as to continually keep the geosynthetic tension to preclude folds and wrinkles. All geotextiles shall be weighted with sandbags or the equivalent. Such sandbags shall be installed during placement and shall remain until replaced with cover material. Geotextiles shall be cut using an approved cutting method and approved equipment only.

Cushion Geotextile Installation

Where geomembranes are in place care shall be taken to protect this material from any damage that could be caused by the cutting of the geotextiles. During placement, care shall be taken not to entrap soil, stones, excessive dust, or moisture that could damage the geotextiles or the geomembrane, or hamper subsequent seaming or joining. The surface of the geomembrane shall be free of any larger than silt size particles, prior to placement of the geotextile.

An examination of the geotextile over the entire surface, after installation, shall be conducted to ensure that no potentially harmful foreign objects are present. Any foreign objects encountered shall be removed or the geotextile shall be replaced. If white coloured geotextile is used, precautions shall be taken to avoid "snow-blindness" of personnel.

The geotextile shall be deployed by rolling out by hand, with no vehicular traffic permitted over the underlying geomembrane.

The panels of geotextile shall be overlapped by at least 200 mm, and the overlap shall be tacked together by heat bonding or stitching. Overlaps shall be placed in a down-slope direction (roof tile effect). Stitching shall be carried out using a hand held stitching machine with thread of similar material to the geotextile. The joint shall have a tensile strength of not less than 50 % of the strength of the geotextile being joined. Where stitching is to be carried out, the contractor shall implement a needle management system, to the satisfaction of the Superintendent, to ensure no parts of needles remain in the stitched geotextile joints or on Site.

The geotextile shall be held in place to prevent uplift by wind. Temporary anchorage may be required to prevent displacement of the free-end of the geotextile.

The installation of the geotextile shall be carried out under the supervision of the geomembrane contractor to ensure no damage occurs to the geomembrane.

Placement of Unit 12 – cushion geotextile constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

The Contractor shall submit documentation related to the delivered and installed rolls of cushion geotextile to demonstrate that only the approved batch of geotextile was installed in the Works.





3.3.11.3 Ballast System for Geotextile

The geotextile shall be held in place to prevent uplift by wind by a ballast system that shall remain in place until the overlying layer covers the geotextile.

Mounds of soil may be placed to satisfy the ballast requirement. Material used for soil mounds shall conform to the same requirements of the material to be permanently placed over the geotextile. Proposed ballast configuration and details shall be submitted to the Superintendent for consideration before implementation.

Ballast shall be gently lowered onto the geotextile, with a maximum drop height of 500 mm. Vehicle traffic is not permitted on the geosynthetics, so the ballast shall be placed as each roll of material is deployed.

3.3.12 Geocomposites

3.3.12.1 Description

Once delivered to the Site the Contractor shall recover samples from the rolls of geocomposite, as indicated by the Superintendent. Samples from on site rolls shall be recovered at a frequency of one sample per 4000 m^2 , or as varied by the Superintendent. The Contractor shall arrange for the testing of the samples in accordance with the testing requirements outlined in Section 2.2.12 or 2.2.13 of this Specification to compare to both the design specifications and to the list of typical values of the properties provided by the manufacturer.

3.3.12.2 Storage and Handling of Geocomposites

During shipment and storage, the geocomposites shall be protected from ultraviolet light exposure, precipitation or other inundation, spills of hydrocarbons, mud, dirt, dust, puncture, cutting or other damaging deleterious conditions. The Contractor shall be responsible for the storage of the geocomposite on the Site.

The geocomposites shall be handled in such a manner as to ensure it is not damaged in any way.

3.3.12.3 Installation of Geocomposites

The geocomposites shall be placed directly on top of the geomembrane. The surface of the geomembrane shall be free of any larger than silt size particles, prior to placement of the geocomposite.

Care should be taken during the placement to avoid damage to underlying geomembrane.

The geocomposites shall be secured and then rolled down the slope in such a manner as to continually keep the geosynthetic tension to preclude folds and wrinkles. All geocomposites shall be weighted with sandbags or the equivalent. Such sandbags shall be installed during placement and shall remain until replaced with cover material. Geocomposites shall be cut using an approved cutting method and approved equipment only. Where geomembranes are in place care shall be taken to protect this material from any damage that could be caused by the cutting of the geocomposites. During placement, care shall be taken not to entrap soil, stones, excessive dust, or moisture that could damage the geocomposites or the geomembrane, or hamper subsequent seaming or joining.

If there are any obstructions while deploying the geocomposite, the geocomposite shall be cut to fit around the obstruction. Care should be taken to make sure there is no gap between the obstruction and the geocomposite, to prevent any soil particles from migrating into the geonet core.

The geocomposite shall be deployed by rolling out by hand, with no vehicular traffic permitted over the underlying geomembrane.

The joining of geocomposites shall be in accordance with the manufacturer's specification. Adjacent edges of the geonet along the roll length of the geocomposites shall be overlapped a minimum of 50 mm and tied by plastic ties with a maximum of 1,500 mm intervals. Adjoining geocomposite rolls (end to end) along the roll width shall have the geonet overlapped a minimum of 300 mm across the roll width. Geonet shall be tied by plastic ties in 300 mm intervals across the roll width. The bottom layer of geotextile shall be overlapped.





The upper layer of geotextile shall be seamed by stitching or hot-air thermal sealing. Stitching shall be carried out using a hand held stitching machine with thread of similar material to the geocomposite. The contractor shall implement a needle management system, to the satisfaction of the Superintendent, to ensure no parts of needles remain in the stitched geocomposite joints or on Site.

The installation of the geocomposite shall be carried out under the supervision of the geomembrane contractor to ensure no damage occurs to the geomembrane.

The Contractor shall submit documentation related to the delivered and installed rolls of geocomposite to demonstrate that only approved geocomposite material was installed in the Works.

3.3.12.4 Ballast System for Geocomposite

The geocomposite shall be held in place to prevent uplift by wind by a ballast system, such as sand bags that shall remain in place until the overlying layer covers the geocomposite. Ballast shall be gently lowered onto the geocomposite, with a maximum drop height of 500 mm. Vehicle traffic is not permitted on the geosynthetics, so the ballast shall be placed as each roll of material is deployed.

3.3.13 Geogrid

3.3.13.1 Description

Once delivered to the Site the Contractor shall recover samples from the rolls of geogrid, as indicated by the Superintendent. Samples from on site rolls shall be recovered at a frequency of one sample per 4000 m^2 , or as varied by the Superintendent. The Contractor shall arrange for the testing of the samples in accordance with the testing requirements outlined in Section 2.2.18 of this Specification to compare to both the design specifications and to the list of typical values of the properties provided by the manufacturer.

3.3.13.2 Storage and Handling of Geogrid

During shipment and storage, the geogrid shall be protected from ultraviolet light exposure, precipitation or other inundation, spills of hydrocarbons, mud, dirt, dust, cutting or other damaging deleterious conditions. The Contractor shall be responsible for the storage of the geogrid on the Site.

The geogrid shall be handled in such a manner as to ensure it is not damaged in any way.

3.3.13.3 Installation of Geogrid

The geogrid shall be sandwiched in Unit 6 - Base Material (refer Section 3.3.4).

The geogrid shall be secured and then rolled down the slope in such a manner as to continually keep the geosynthetic tension to preclude folds and wrinkles. All geogrid shall be weighted with sandbags or the equivalent. Such sandbags shall be installed during placement and shall remain until replaced with cover material. Geogrid shall be cut using an approved cutting method and approved equipment only. No vehicular traffic permitted over the installed geogrid.

Adjacent edges of the geogrid along the roll length (side by side) shall be overlapped a minimum of 300 mm and tied by plastic ties at a maximum of 1,500 mm intervals. The Contractor is to note that although a smaller side by side overlap is used in many geogrid applications, a 300 mm side by side overlap is a specific requirement for the project. Adjoining geogrid rolls (end to end) along the roll width shall be overlapped similarly and tied at maximum 1,000 m intervals.

The Contractor shall submit documentation related to the delivered and installed rolls of geogrid to demonstrate that only approved materials are installed in the Works.

3.3.13.4 Ballast System for Geogrid

The geogrid shall be held in place to prevent uplift by wind by a ballast system, such as sand bags that shall remain in place until the overlying layer covers the geogrid. Ballast shall be gently lowered onto the geogrid,



with a maximum drop height of 500 mm. Traffic is not permitted on the geogrid, so the ballast shall be placed as each roll of material is deployed.

3.3.14 Leachate Collection System for Cell Base Lining in Cells 1 to 4

The Contractor shall construct the leachate collection system and leachate sumps in accordance with the Design Drawings and as given below. As the leachate collection system will likely be constructed in two or three sub-stages within each stage (to be confirmed during detailed design), the Contractor shall appropriately cap all temporary leachate pipe terminations to allow future connection.

The leachate collection system for the cell base lining in the Cells 1 to 4 area includes the following materials (bottom to top):

- Unit 12 Cushion Geotextile;
- 300 mm thick layer of Unit 7 Drainage Aggregate;
- Unit 23 Leachate Collection Pipe; and
- Unit 11 Filter Geotextile.

3.3.14.1 Leachate Collection Pipe

Unit 23 - Leachate Collection Pipe shall be placed by hand or machinery on top of Unit 12 – Cushion Geotextile. The pipes shall be installed with the perforations at 45 degrees off the vertical and horizontal axes of the pipe. Minor adjustments to the alignment of the pipes are permitted to facilitate the use of standard angled bends and junctions. The ends of all pipes shall be capped during construction activities to prevent ingress of foreign materials.

Initial placement of leachate collection pipes, or the subsequent connection of a new portion of the piping system to a previously placed portion, constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

Following placement of each portion of leachate collection piping, the Contractor shall survey all pipe alignments and inverts, including leachate outlet pipes (Section 3.3.14.3) and leachate clean out access pipes (Section 3.3.14.4), and submit works-as-executed (WAE) drawings demonstrating compliance with the design within 7 days of completion of each portion of the system. It is noted the a Hold Point has not been established at this point because it would likely preclude the Contractor from covering all areas of the liner with Unit 7 – Drainage Aggregate quickly enough to comply with the 24-hour time window requirements for GCL, geomembrane, and cover placement given in Section 3.3.9.4.

3.3.14.2 Leachate Drainage Layer

The Contractor shall place the Unit 7 – Drainage Aggregate over Unit 12 - Cushion geotextile using appropriate methods and equipment to prevent damage to the geotextile cushion, underlying geomembrane, and leachate collection pipes.

The Contractor shall provide a work method statement presenting the proposed method of placement of the Unit 7 – Drainage Aggregate. The work method statement must include, but not necessarily be limited to, the minimum requirements listed below.

- The minimum thickness of the layer shall be 300 mm as measured perpendicular to the surface of the underlying layer. The entire thickness shall be placed as one lift.
- The drainage aggregate covering the leachate collection pipe shall be in accordance with the Design Drawings with a minimum thickness of 300 mm above the top of the leachate collection pipe and a minimum width of 400 mm along the pipe alignment. Care shall be taken to ensure the granular



material extends all around the pipe to support the pipe. No vehicle traffic shall be permitted over the installed pipes unless the Contractor can demonstrate to the satisfaction of the Superintendent that sufficient cover material is in place to protect the pipe from traffic loads. Placement of Unit 7-Drainage Aggregate around the leachate collection pipes constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

- The maximum permitted machinery weight for drainage layer placement shall be 13T. At no point shall the placement equipment operate on a working platform of less than 300 mm thickness of material above the cushion geotextile. A field trial is required to confirm that the planned plant for use in hauling, spreading, and compacting the drainage aggregate can operate without damaging the geotextile cushion, underlying geomembrane, or leachate collection pipes and to establish minimum equipment setbacks from the leading edge of drainage aggregate placement.
- The Contractor shall compact the drainage layer using a suitable self propelled smooth drum roller, operated with the vibration turned off, and having a maximum combined static weight of no greater than 13T. Compaction equipment shall be operated such that passes are carried out in long parallel traverses. Turning or hard braking of the compaction equipment shall only be carried out off the drainage system.
- The drainage layer shall be compacted using 4 passes of the roller specified above.

The work method statement shall demonstrate to the satisfaction of the Superintendent that the proposed methods will be protective of the cushion geotextile, geomembrane, and leachate collection pipes. The work method shall include "Level 1" supervision and reporting by the GTA. Submission of the work method statement constitutes a HOLD POINT. Placement of the Unit 7- drainage aggregate shall not commence until the Hold Point is released.

Notwithstanding the above should any damage occur to the geotextile cushion, the leachate collection pipes or the geomembrane the Contractor shall make a full repair at his own cost to the satisfaction of the Superintendent.

After drainage layer placement, Unit 11 – Filter Geotextile shall be placed and secured over the drainage layer. Filter geotextile shall be installed in the same manner as outlined in Sections 3.3.11 of this Specification. Placement of Unit 11 – Filter geotextile constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

Following drainage layer placement and filter geotextile placement, the Contractor shall survey the finished surface level to provide works-as-executed (WAE) drawings and to demonstrate that the drainage layer design thickness has been achieved and that the constructed sump geometry is in accordance with the design. The survey shall be conducted on an approximate 10m grid with detailed survey of the sump. The Contractor shall submit the WAE drawings and an accompanying analysis demonstrating compliance with design thickness and sump geometry. Submission of the WAE drawings and accompanying analysis constitutes a HOLD POINT. Placement of any material above the drainage layer shall not commence until the Hold Point has been released, and all other contractual requirements have been fulfilled.

3.3.14.3 Leachate Sump and Outlet Pipe

The leachate sump and outlet pipe shall be constructed in accordance with the Design Drawings.

The Contractor shall provide a Work Method Statement for the installation of the leachate sump to the Superintendent for approval. This constitutes a HOLD POINT. No construction of the sump shall be carried out until the HOLD POINT has been released by the Superintendent.

The work method statement must include, but not necessarily be limited to, the minimum requirements as given in the remainder of this section.





Base and Lining Construction

The base surface on which the sump liner will be constructed shall be prepared to form a firm foundation. The surface shall be trimmed of all softened, loose and foreign materials, and formed to a uniform graded surface. Any depressions shall be filled with compacted Unit 4 – Clay Rich Material or Unit 2 – General Fill. No contaminated material shall be used for surface preparation.

Prior to liner placement, the Contractor shall survey the finished base surface level. This information shall be included in the works-as-executed (WAE) drawings of the leachate drainage layer (refer Section 3.3.14.2) and to demonstrate that the design levels have been achieved.

The sump liner shall comprise the following components:

- A 500 mm thick of Unit 5 Clay Material which have minimum permeability of 10⁻⁹ m/sec;
- Double layer of Unit 17 GCL;
- Unit 16 HDPE Geomembrane; and
- Unit 12 Cushion Geotextile.

Installation of Clay Material

The Contractor shall proposed method of moisture conditioning, placement and compaction, and maintenance of the leachate sump compacted clay liner to comply but not limit to the following requirements.

- The compacted clay liner layer shall be constructed in at least 3 layers. The clay liner shall be placed in layers of a nominal thickness of 170 mm. The clay liner layer shall have a minimum total thickness of 500 mm.
- The clay liner layer shall be compacted with a vibrating padfoot type roller, to achieve a minimum Dry Density Ratio (DDR) of at least of 98% standard (in accordance with AS1289.5.1.1 and 5.4.1) or a minimum HILF density ratio of 98% standard (in accordance with AS1289.5.7.1) at a moisture content within the range of 0% to +3% (wet) of the Standard Optimum Moisture Content (SOMC). The field density tests during placement of the material shall be minimum a test on each side of the base on each layer of as directed by Superintendent.
- If the required density and moisture is not achieved, the compacted material shall be reworked in-situ to meet the density and moisture content requirements. If the density and moisture content requirements again cannot be achieved after reworking, the failed layer shall be removed for moisture conditioning at the clay borrow area or at an approved designated area, or be discarded.
- Prior to the placement of each lift of the clay liner layer, the top of the previous lift shall be thoroughly scarified and moisture conditioned if necessary to bond each layer together and prevent laminations at the layer interfaces. Any areas where laminations occur, either between or within layers, shall be reworked such that all laminations and defects in the integrity of the clay liner layer are removed.
- Upon completion of the clay liner layer, the Contractor shall maintain the integrity of the layer by limiting the traffic movement over the clay surface and maintaining the surface of the clay in a moist condition, wet of SOMC, until covered by the geomembrane.
- Should the surface of a previously placed and compacted layer have dried or wetted up excessively, as determined by the Superintendent, the affected materials shall be excavated to expose material that has a moisture content within the specified tolerance. The excavated materials shall be returned to a designated area for moisture conditioning or be discarded.
- Trafficked areas are to be ripped, moisture conditioned and recompacted if in the opinion of the Superintendent the quality of these areas has deteriorated. Furthermore, any cracked clay that has formed due to desiccation shall be removed.





The placement of the leachate sump clay liner layer constitutes an INSPECTION POINT and the Contractor is required to provide 48 hours notice before commencing or recommencing this activity.

Following clay liner layer placement, the Contractor shall survey the finished surface level to include in the works-as-executed (WAE) drawings of the leachate sump and to demonstrate that the clay liner layer design thickness has been achieved and that design surface grades for geosynthetic placement have been achieved. The Contractor shall submit the WAE drawings and an accompanying analysis demonstrating compliance with design thickness and surface grades. This submission constitutes a HOLD POINT and geosynthetics installation for the sump shall not proceed until the Hold Point is released.

Geosynthetics Installation

The Contractor shall provide a rounded edge of the clay liner at the toe and crest of the side slope. The rounded edge shall be constructed to support the geomembrane so as to prevent stressing or creasing of the geomembrane under loads. In general, rounding shall be prepared over a length of approximately 300 mm.

The leachate sump shall be lined with the following layers:

- Two layers of Unit 17 GCL overlying the prepared Unit 5 Clay Material;
- A layer of Unit 16 HDPE Geomembrane above the GCL; and
- A layer of Unit 12 Cushion Geotextile.

The installation of the geosynthetic layers shall be as per Sections 3.3.9 to 3.3.11 of this Specification. This installation work constitutes an INSPECTION POINT and the Contractor is required to provide 48 hours notice before commencing or recommencing this activity.

Installation of Unit 24 – Leachate Sump Outlet Pipe and Sump Backfill

Unit 24 – Leachate Sump Outlet Pipe shall be connected to the leachate sump at the concrete outlet structure as shown in the Design Drawings. It is recommended that the outlet structure to be constructed prior to the installation of the liner system so that it will be ready to be connected with the geomembrane in the lining system.

Installation of Unit 24 – Leachate Sump Outlet Pipe constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

The backfilling of Unit 7 – Drainage Aggregate shall be by an excavator. The material shall be placed in a manner to minimise any impact on the geosynthetic layers underlain. Any damages shall be to be repaired to the satisfaction of the Superintendent at the Contractor's cost.

Backfilling shall occur within 24 hours of placement of the first GCL layer in the sump base in order to minimise potential GCL hydration swelling.

Installation of Unit 25 – Leachate Drainage Pipe and Unit 27 – Leachate Sump Riser

Unit 27 – Leachate Sump Riser shall be constructed outside of the perimeter bund and connected to the leachate sump outlet pipe. The Leachate Sump Riser adjacent to the Eastern Gully Landfill shall be connected with the existing leachate collection pipes and groundwater pipe from the existing Western and Eastern Gully Landfills as shown in the Design Drawings.

Requirements for bedding, sealing, pipe entrances (Unit 24 and Unit 25), and floor design for the Unit 27 – Leachate Sump Riser Pipes will be developed during detailed design.

Requirements for trenching, bedding and connection details for the Unit 25 – Leachate Drainage Pipe located: (i) within the Cell 1 footprint; and (ii) outside the southern boundary of Cells 1 to 4 will be developed during detailed design.

The Contractor will be required to prepare and Work Method Statement for for Unit 25 – Leachate Drainage Pipe and Unit 27 – Leachate Sump Riser installation and construction.




Installation of Unit 25 – Leachate Drainage Pipe and/or Unit 27 – Leachate Sump Riser constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing either activity.

3.3.14.4 Leachate Clean Out Access Point

Leachate Clean Out Access Points are the locations where the scouring equipment can be inserted into the leachate pipe to mechanically clean out the pipes to remove sediment and potential build-up of precipitates in the pipes.

The leachate clean out access point shall be constructed in accordance with the Design Drawings. In addition to these separate points, the leachate pipes which are connected in the leachate sump shall also have clean out access points where the pipes are extended into the riser pipe through the leachate sump outlet pipe.

Each leachate clean out access point shall comprise pipes extending to precast concrete boxes at the surface of the site. The end of the pipes includes removable caps that allow access to inside the pipes. The pipes shall have sweeping bends to maintain a minimum radius of curvature suitable for insertion/removal of scouring equipment.

The precast concrete boxes at the access points shall include lockable heavy duty concrete slabs with lifting points. Should the ground surface need to be raised, the collection pipes shall be extended in a straight line, and the concrete boxes re-located. The boxes shall have no floor to prevent collection of seepage in the boxes. The ends of the collection pipes shall be capped with airtight and watertight caps.

The Contractor shall submit the proposed materials required for the access point for approval prior to the construction. This constitutes a HOLD POINT and access point construction shall not commence until the Hold Point is released by the Superintendent.

Installation of leachate clean out access points constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

3.3.15 Leachate Collection System for Piggy Back Lining

The Contractor shall construct the leachate collection system for the piggy back lining areas in accordance with the Design Drawings and as given below. As the leachate collection system will likely be constructed in two or three sub-stages within each stage (to be confirmed during detailed design), the Contractor shall appropriately cap all temporary leachate pipe terminations to allow future connection.

The leachate collection system for the piggy back lining includes the following materials (bottom to top):

- Unit 14 Geocomposite Drainage Net (Leachate); and
- Unit 23 Leachate Collection Pipe covered with Unit 7 Drainage Aggregate and wrapped with Unit 11 – Filter Geotextile.

It is noted that this leachate collection system will also used in the cell base lining in the natural ridge areas (i.e., Cells 2A, 2B and 4A).

3.3.15.1 Leachate Drainage Layer

The Contractor shall place the Unit 14 – Geocomposite Drainage Net (Leachate) over the LLDPE geomembrane (HDPE geomembrane in the natural ridge areas) using appropriate methods and equipment to prevent damage to the underlying geomembrane and GCL, in accordance with Section 3.3.12 of this Specification.

Should any damage occur to the geomembrane or the GCL the Contractor shall make a full repair at his own cost to the satisfaction of the Superintendent.





The geocomposite net layer is discontinuous at leachate collection pipe locations (eg. at cross-slope leachate collection pipes), as shown on the Design Drawings, to encourage flow into the pipes. The upper geotextile layer of the geocomposite net underlying drainage aggregate shall be removed, as shown on the Design Drawings.

Placement of Unit 14 – Geocomposite Drainage Net (Leachate) constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

3.3.15.2 Leachate Collection Pipe

Unit 23 - Leachate Collection Pipe shall be placed by hand or machinery on top of Unit 14 – Geocomposite Drainage Net (Leachate). The pipes shall be installed with the perforations at 45 degrees off the vertical and horizontal axes of the pipe. Minor adjustments to the alignment of the pipes are permitted to facilitate the use of standard angled bends and junctions. The ends of all pipes shall be capped during construction activities to prevent ingress of foreign materials.

Initial placement of leachate collection pipes, or the subsequent connection of a new portion of the piping system to a previously placed portion, constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

Following placement of each portion of leachate collection piping, the Contractor shall survey all pipe alignments and inverts, including leachate outlet pipes (Section 3.3.14.3) and leachate clean out access pipes (Section 3.3.14.4), and submit works-as-executed (WAE) drawings demonstrating compliance with the design within 7 days of completion of each portion of the system. It is noted the a Hold Point has not been established at this point because it would likely preclude the Contractor from covering all areas of the liner with Unit 9 – Protection Material quickly enough to comply with the 24-hour time window requirements for GCL, geomembrane, and cover placement given in Section 3.3.9.4.

Prior to the placement of surrounds (Unit 7 – Drainage Aggregate) around the leachate collection pipes, the upper geotextile layer of Unit 14 – Geocomposite Drainage Net (Leachate) shall be removed within the zone which will be overlaid with the drainage aggregate.

Unit 7 – Drainage Aggregate shall then be placed around the pipes. Care shall be taken to ensure the granular material extends all around the pipe to support the pipe. No vehicle traffic shall be permitted over the installed pipes unless the Contractor can demonstrate to the satisfaction of the Superintendent that sufficient cover material is in place to protect the pipe from traffic loads. Placement of Unit 7 – Drainage Aggregate around the leachate collection pipes constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

Unit 11 – Filter Geotextile shall surround the drainage aggregate placed around the perforated leachate collection pipes. Filter geotextile shall be installed in the same manner as outlined in Sections 3.3.11.2 and 3.3.11.3 of this Specification and shall be placed concurrently with Unit 7.

Placement of Unit 11 – Filter geotextile constitutes an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.

3.3.15.3 Unit 9 – Protection Material

The Contractor shall place the Unit 9 – Protection Material over Unit 14 - Geocomposite Drainage Net (Leachate) using appropriate methods and equipment to prevent damage to the geocomposite drain, underlying geomembrane, and leachate collection pipes.

The Contractor shall provide a work method statement presenting the proposed method of placement of the Unit 9 – Protection Material. The work method statement must include, but not necessarily be limited to, the minimum requirements listed below.

The minimum thickness of the layer shall be 300 mm as measured perpendicular to the surface of the underlying layer. The entire thickness shall be placed as one lift.



- The maximum permitted machinery weight for protection layer placement shall be 13T. At no point shall the placement equipment operate on a working platform of less than 300 mm thickness of material above the geocomposite drain. A field trial is required to confirm that the planned plant for use in hauling and spreading the protection material can operate without damaging the geocomposite drain, underlying geomembrane, or leachate collection pipes and to establish minimum equipment setbacks from the leading edge of protection material placement.
- Compaction shall be only by trafficking with the spreading plant.

The work method statement shall demonstrate to the satisfaction of the Superintendent that the proposed methods will be protective of the geocomposite drain, geomembrane, and leachate collection pipes. The work method shall include "Level 1" supervision and reporting by the GTA. Submission of the work method statement constitutes a HOLD POINT. Placement of the Unit 7- drainage aggregate shall not commence until the Hold Point is released.

Notwithstanding the above should any damage occur to the geocomposite drain, the leachate collection pipes or the geomembrane the Contractor shall make a full repair at his own cost to the satisfaction of the Superintendent.

Following protection layer placement, the Contractor shall survey the finished surface level to provide worksas-executed (WAE) drawings and to demonstrate that the protection layer design thickness has been achieved. The survey shall be conducted on an approximate 10m grid. The Contractor shall submit the WAE drawings and an accompanying analysis demonstrating compliance with design thickness. Submission of the WAE drawings and accompanying analysis constitutes a HOLD POINT. Placement of any material above the protection layer shall not commence until the Hold Point has been released, and all other contractual requirements have been fulfilled.

3.3.16 Cap Components

3.3.16.1 Bearing Layer for Cap

The Contractor shall construct the bearing layer to provide a firm and smooth surface to support the Unit 15 – LLDPE geomembrane.

The bearing layer shall be constructed with Unit 4 – Clay Rich Material with a minimum as-compacted thickness of 200 mm.

The material shall be compacted to a minimum of 95 % SMDD (in accordance with AS1289.5.1.1 and 5.4.1) or a minimum HILF density ratio of 95 % standard (in accordance with AS1289.5.7.1) at a moisture content within the range of 0% to +3% of the Standard Optimum Moisture Content (SOMC) or as otherwise approved by the Superintendent.

The GITA shall provide "Level 1" supervision for material placement and moisture density testing. The frequency of field density and moisture testing during placement of the material shall as a minimum conform the following, whichever requires the most tests:

- 1 test per 2,500 m² per layer of material type; or
- 1 test per 500 m³ per material type; or
- 3 tests per batch of work.

If the required density and moisture is not achieved, the compacted material shall be reworked in-situ to meet the density and moisture content requirements. If the density and moisture content requirements again cannot be achieved after reworking, the failed material shall be removed for moisture conditioning at the material borrow area or at an approved designated area, or be discarded.



Placement of Unit 4 material constitutes an INSPECTION POINT and the Contractor is required to provide 48 hours notice before commencing or recommencing this activity.

The Contractor shall maintain the bearing layer in a moist condition until Unit 15 –LLDPE geomembrane is installed. Should the bearing layer surface have dried excessively (e.g. desiccation cracking>20mm depth) or wetted up excessively, as determined by the Superintendent, the affected materials shall be excavated to expose material that has moisture content within the specified tolerance. The excavated materials shall be returned to a designated area for moisture conditioning or be discarded, and the excavated bearing layer material replaced. Note that the surface of the bearing layer is designed to shed water and its shape should be maintained during formation in order to avoid temporary water ponding during construction. Consideration may be given to use of micro-mist sprayers to limit loss of moisture from the completed surface during hot weather.

Trafficked areas of the bearing layer surface are to be ripped, moisture conditioned and recompacted if, in the opinion of the Superintendent, the quality of these areas has deteriorated.

The finished surface shall be smooth and well-drained. Coarse materials shall not protrude from the surface of the bearing layer by more than 5 mm. No areas of ponding shall be accepted on the surface. Additional surface requirements are given in Section 3.3.10.2.

The Contractor shall survey the final levels to provide works-as-executed (WAE) drawings and to demonstrate that the design levels and layer thickness have been achieved. The survey shall be conducted on an approximate 10 m grid. The Contractor shall submit the WAE drawings, an accompanying analysis demonstrating compliance with design levels, and a GITA certification statement. Submission of the WAE drawings and accompanying analysis constitutes a HOLD POINT. Placement of LLDPE geomembrane shall not commence in an area until the Hold Point has been released for that area, and all other contractual requirements have been fulfilled.

3.3.16.2 LLDPE Geomembrane

The LLDPE geomembrane will be installed as per Section 3.3.10. This installation work constitutes an INSPECTION POINT and the Contractor is required to provide 48 hours notice before commencing or recommencing this activity.

3.3.16.3 Subsoil Drainage Layer

The subsoil drainage layer for the capping system comprises a layer of Unit 13 – Geocomposite Drainage Net (surface water) and Unit 26 – Subsoil Drainage Pipes, including cross-slope collection pipes and outlet pipes. The system arrangement is shown in the Design Drawings.

Unit 13 - Geocomposite Drainage Net (Surface Water) shall be placed on top of Unit 15 – LLDPE Geomembrane for the capping system as outlined in Section 3.3.12 of this Technical Specification.

Unit 26 - Subsoil Drainage Pipe shall be joined and placed on top of Unit 13 – Geocomposite Drainage Net. Minor adjustments to the alignment of the pipes are permitted to facilitate the use of standard angled bends and junctions. The ends of all pipes shall be capped to prevent ingress of drainage layer or topsoil materials. The cross-slope collection pipes shall be perforated or slotted and connected to the outlet pipes which shall be solid wall.

The cross-slope collection pipes will be covered by Unit 7 – Drainage Aggregate and wrapped with a Unit 15 –LLDPE Geomembrane flap. Details of joining Unit 15 itself or Unit 15 and Unit 13 together are shown in the Design Drawings. Unit 15 shall be installed in the same manner as outlined in Sections 3.3.10 of this Specification and shall be placed concurrently with Unit 7.

Installation of geomembrane and placement of Unit 7 – Drainage Aggregate around the perimeter pipes constitute an INSPECTION POINT and the Contractor is required to provide 24 hours notice before commencing or recommencing this activity.





No vehicle traffic shall be permitted over the installed pipes unless the Contractor can demonstrate to the satisfaction of the Superintendent that sufficient cover material is in place to protect the pipe from traffic loads.

Notwithstanding the above should any damage occur to the pipes the Contractor shall make a full repair at his own cost to the satisfaction of the Superintendent.

The Contractor shall survey the subsoil drainage pipe alignment to provide works-as-executed (WAE) drawings. The Contractor shall submit the WAE drawings and an accompanying analysis demonstrating compliance with design. Submission of the WAE drawings and accompanying analysis constitutes a HOLD POINT. Placement of Unit 1 - Topsoil above the Geocomposite Drainage Net shall not commence in an area until the Hold Point has been released for that area.

3.3.16.4 Unit 1 - Topsoil

The Contractor shall provide a Work Method Statement presenting the proposed method of moisture conditioning, placement and compaction of Unit 1 – Topsoil. The work method statement shall demonstrate to the satisfaction of the Superintendent that the proposed methods will achieve stable placement of these soils and maintain favourable conditions for the sewing of grass seed. Submission of the work method statement constitutes a HOLD POINT. Placement of Unit 1 soil shall not commence until the Hold Point is released.

The work method statement must address the following requirements:

- Unit 1 Topsoil shall be placed in two sub-layers of minimum total 500 mm thick and shall be placed by controlled pushing out of the material from the base of the batter slope toward the crest of the batter slope. Pushing up from the base of the batter is required to promote stability.
- The lower portion of Unit 1 Topsoil shall be minimum 350 mm thick and shall be placed without damaging or disturbing the underlying geocomposites and the drainage collection pipes. If the Contractor is aware of any such damage or disturbance he shall immediately take measures to repair the damage and prevent further damage, and immediately inform the Superintendent.
- The lower portion of the Unit 1 Topsoil shall be compacted as indicated subsequently while the upper portion shall remain uncompacted, except as occurs incidentally.
- The lower portion of Unit 1 Topsoil shall be nominally compacted with a sheep's foot or similar roller to a minimum SMDD of 90% standard (in accordance with AS1289.5.1.1 and 5.4.1) or a minimum HILF density ratio of 90% standard (in accordance with AS1289.5.7.1) at a moisture content within the range of -5% to +3% of the Standard Optimum Moisture Content (SOMC). No direct compaction shall occur over the crown of the pipes.
- The upper portion Unit 1 Topsoil shall be installed over the lower portion by tipping and retreating from the filled edge. An excavator or low bearing pressure bulldozer must be used to pull the stockpile towards itself and spread the 150 mm thick layer upper Unit 1 layer. The intention is that the upper soil horizon is not compacted and will provide favourable seeding conditions.
- As the lower portion of the topsoil layer is required to remain a low density, the Contractor shall arrange suitable plants and equipment for hauling, tipping and spreading material so that the layer shall not be over compacted. In case of any over compacted areas identified by GITA or Superintendent, the Contractor shall have to rework on the layer to the satisfaction of the Specification with his own cost. The Contractor may decide to assign specific hauling routes and working platforms for the upper portion of the topsoil placement. Those areas then shall be reworked to the satisfaction of the Specification prior to the placement of the upper portion of the topsoil on them.

Placement of each portion of Unit 1 – Topsoil constitutes an INSPECTION POINT and the Contractor is required to provide 48 hours notice before commencing or recommencing this activity.





The GITA shall provide "Level 1" supervision for material placement and moisture density testing. The frequency of field density and moisture testing during placement of the material shall as a minimum conform the following, whichever requires the most tests:

- 1 test per 2,500 m² per layer of material type; or
- 1 test per 750 m³ per material type; or
- 3 tests per batch of work.

If the required density and moisture is not achieved, the compacted material shall be reworked in-situ to meet the density and moisture content requirements. If the density and moisture content requirements again cannot be achieved after reworking, the failed material shall be removed for moisture conditioning at the material borrow area or at an approved designated area, or be discarded.

Following placement of the topsoil layer, the Contractor shall survey the final landform levels to provide works-as-executed (WAE) drawings and to demonstrate that the design thickness has been achieved and that final landform levels comply with design levels. The survey shall be conducted on an approximate 10 m grid. The Contractor shall submit the WAE drawings, an accompanying analysis demonstrating compliance with design thickness and design levels. The WAE drawings and accompanying analysis shall be submitted within 5 working days of completing topsoil placement.

3.3.16.5 Revegetation

The required procedures and activities for revegetation of the landform will be provided in a revegetation specification that will be prepared during detailed design. A general description of the goals and purpose of revegetation is provided in the Whytes Gully Resource Recovery Park – Landscape Strategy (Corkery Consultant, January 2012).

The revegetation specification will address issues including, but not limited to, the following:

- Surface and soil preparation;
- Soil conditioning and amelioration;
- Plant species, direct seeding rates, and target plant numbers;
- Seed sowing, germination, and watering;
- Pest control (rabbits/hares and birds);
- Temporary erosion protection requirements; and
- Requirements for ongoing monitoring and maintenance.

The revegetation specification will include a requirement for the Contractor to prepare a detailed revegetation plan, prior to revegetation works, that will satisfy specification requirements. Any differences between the approach in the revegetation plan and that in this specification shall be justified with appropriate technical documentation and discussion. The submittal of the revegetation plan shall comprise a HOLD POINT. Revegetation shall not commence in an area until the revegetation plan has been accepted and the Hold Point has been released for that area by the Superintendent.

3.3.16.6 Drop Structures

Drop structures shall be constructed as shown on the Design Drawings and comprise shaping of the cap, supply and installation of Reno Mattresses, supply, and installation of the HDPE geomembrane and cushion geotextile, supply and installation of the erosion protection gravel and construction of soil mounds.

The Reno Mattress shall be 170 mm thick and shall comprise hexagonal double twisted wire mesh, as per British Standards EN 10223-3 "Steel wire and wire products for fences. Hexagonal steel wire netting for





engineering purposes" and shall be filled with stones or crushed rock. The crushed rock shall have a minimum particle size of 75 mm and a maximum particle size of 113 mm or two thirds of the thickness of the Reno Mattress and shall be VENM.

The steel wire used to manufacture the mattress shall be coated with Galfan, a Zn-5%Al-MM (mischmetal) alloy or approved similar. In order to reinforce the structure, all mesh panel edges shall be selvedged with a wire having a greater diameter.

All tests on wire must be performed prior to manufacturing the mesh. The wire used for the Reno Mattresses shall have the following properties:

- Tensile strength: the wire used for the manufacture of Reno mattresses and the lacing wire, shall have a tensile strength between 350-500 N/mm².
- Elongation: Elongation shall not be less than 10%. Test must be carried out on a sample at least 250 mm long.

3.3.17 Other Requirements

3.3.17.1 Surveying

All references in this Specification to required survey or survey to be performed by the Contractor means survey performed and reported by a registered surveyor.

3.3.17.2 Tolerances

The Contractor shall construct the cell to the construction dimension tolerances and minimum layer thicknesses provided for specific items in individual sections of this Specification.

For other items, the Contractor shall construct the cell to the general construction dimension tolerances provided below.

Levels and grades for material surfaces:

- 1) Surfaces shall be within +/- 100 mm of design levels;
- 2) Grades shall be in the design direction at all locations; and
- 3) Thickness of material layers shall be equal or greater than the design thickness.

Pipes and open drains:

- 1) Invert levels shall be within +/- 50 mm of design levels; and
- 2) Grades shall be maintained in the design direction at all locations.

RH/GRS:JMc/rh

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APPENDIX C

Interpretative Geotechnical Investigation Report for 50% Design



April 2012

WHYTES GULLY RESOURCE RECOVERY PARK

Interpretative Geotechnical Investigation Report for 50% Design

Submitted to: Wollongong City Council

EPORT

Report Number.

117625003_059_R_Rev1



1 Copy - Wollongong City Council 1 Copy - Golder Associates Pty Ltd







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1.0 INTRODUCTION

1.1 Project Description

The Whytes Gully Resource Recovery Park (WGRRP) is owned and operated by Wollongong City Council (Council) under Environment Protection Licence 5862. Existing landfill airspace at the WGRRP is projected to expire in late 2013. As part of a coordinated delivery of resource recovery and waste services in the Wollongong Local Government Area (LGA), Council are proposing to increase landfill capacity at the site by constructing a new landfill cell within the existing WGRRP, to the south of the existing landfill footprint and piggy-backing waste over the existing western and eastern gully landfills. This is estimated to provide more than 5 million cubic metres of additional airspace, projected to extend the life of the landfill by up to 50 years.

1.2 **Previous Investigations**

A number of investigations have been carried out across the site prior to this current phase of work. Information from these previous investigations has been reviewed during the preparation of this study and is included in the Geotechnical Investigation Report for Whytes Gully New Landfill Cell prepared by Golder Associates Pty Ltd, reference 117625003_077_R_Rev1 dated March 2012.

A geotechnical investigation was undertaken at the WGRRP in July and August 2011 by Golder Associates (Golder) on behalf of the Council. The objectives of this geotechnical investigation were to inform planning and design development of the proposed new landfill cell. The geotechnical investigation was targeted to provide subsurface information for the foundation conditions for the proposed new landfill cell footprint.

1.3 Scope of Report

The interpretation and analysis detailed in this report has been prepared for the 50% concept design submission of the Whytes Gully New Landfill Cell.

The report documents the geotechnical design approach, material properties, loads, load factors, standards adopted for design, and the results of geotechnical analysis.





2.0 SCOPE OF WORK

The scope of work for the geotechnical investigation (refer to Golder Associates report 117625003_077_R_Rev1 dated March 2012) included the following:

- Review of available literature on the local and regional geological and geotechnical setting of the Site;
- Borehole drilling using solid augers fitted to a truck mounted drill rig, including soil sample collection and Standard Penetration Tests (SPTs);
- Rock coring, core photography and point load testing;
- Installation of monitoring wells and water level measurement;
- Test pit excavation and collection of soil samples;
- Geological observation and mapping of existing cuttings and other rock exposures;
- Laboratory testing of soil and rock samples for geotechnical purposes;
- Survey of test locations.

This interpretive report provides interpretation and recommendations on:

- Geotechnical site model and geotechnical cross-sections;
- Interpreted geotechnical design parameters;
- Settlement analyses;
- Slope stability analyses; and
- Excavation stability and excavatability of natural materials.





3.0 PHYSICAL SETTING & BACKGROUND INFORMATION

3.1 Site Location

The WGRRP is located approximately 10 km to the south west of the Wollongong Central Business District (CBD) and is approximately 50 ha in size. Figure 1 presents the site locality and identifies the WGRRP regional context.

The WGRRP is located on Reddalls Road, Kembla Grange NSW. The site is generally bounded by Reddalls Road to the south and west, rural residential lands to the north, north-east and north-west, and a water treatment plant to the south east. An industrial area lies to the south of Reddalls Road and Dapto Creek lies to the west.

The residential suburb of Farmborough Heights is located approximately 360 m to the north east over a ridgeline.

3.2 Existing Site

WGRRP includes historical and existing landfills (Western and Eastern Gully), a transfer station, private roads, stormwater ponds, a leachate management system (including treatment plant and ponds), a materials recovery facility, a recycling area, weighbridge and administration and amenities buildings, as shown on Figure 2. The site also includes buildings previously housing a solid waste to energy facility.

3.3 Topography

The northwest and eastern extents of the landfill are bounded by ridgelines, with a small central north-south trending ridgeline separating the two historical gullies, the upslope portion of which remains clearly visible today. The site rises from RL 15 m at the south west to RL 100 m at the north east.

3.4 Hydrology

The general surface water drainage direction on the site is from the north east towards the south west. The catchment area of the site is approximately 50 ha and extends from a ridge to the north of the site to Reddalls Road to the south. Runoff from this catchment is directed to the stormwater ponds at the south west corner of the site before discharge to Dapto Creek.

Currently (2011), stormwater runoff from the landfill is generally directed along the eastern and western edges of both the Eastern Gully landfill and the Western Gully landfill through a series of swales and benches and a drain along the central ridge. There is currently a pond system on site to capture and treat the sediment runoff generated from the landfill activities. Run-on to the site is minimal due to the site being bounded by ridgelines.

3.5 Hydrogeology

3.5.1 Regional Hydrogeological Setting

Regionally the site is located within the southern portion of the Sydney Basin, a geological basin stretching from the Illawarra Plateau in the south to the Lower Hunter Valley region in the north, and incorporating the topographically low Cumberland Basin in the centre. Generally, the dip of the geological formations within the Sydney Basin is from the topographically higher ground in the north and south towards the topographic low ground in the centre of the basin, although this varies locally based on structural features.

The regional hydrogeological setting of the site includes groundwater resources associated principally with the sandstone formations of the Hawkesbury Sandstone, Narrabeen Group, Illawarra Coal Measures and the Shoalhaven Group. Each of these geological groups generally comprises varying proportions of sandstone, siltstone, claystone, shale and coal. Groundwater resources are generally described as occurring as stacked aquifer systems associated with the sandstone formations, separated by lower permeability strata acting as aquitards. Structural contours presented on the 1:100,000 geological map 'Wollongong-Port Hacking' (Department of Primary Industries, 1985) indicate a local geological dip direction approximately





towards the north to northwest in the vicinity of the site, which would be expected to influence the regional groundwater flow direction.

3.5.2 Local Hydrogeological Setting

On the site scale, groundwater occurrence is generally associated with two shallow systems: groundwater present in the upper weathered and fractured profile of the local bedrock geology, and groundwater present in the unconsolidated deposits that infill the two gullies at the site at the toe of the sloping topography. Water levels measured in wells installed within the shallow weathered bedrock in the sloping northern portion of the site generally range from 5 to 10 metres below ground level (mbgl), whereas water levels in wells installed in both the shallow bedrock and unconsolidated material in the flatter southern portion of the site are shallower, generally on the order of 1 to 3 mbgl. The water level associated with borehole GABH03 is approximately 0.4 m above ground level, indicating local artesian conditions within the shallow bedrock at this location.

Shallow groundwater flow associated with the weathered bedrock horizon is inferred to be sympathetic to the sloping topography of the northern portion of the site, with a south to southwest flow direction. Anecdotal information indicates that a number of springs were present in the two former gullies in which the existing landfill cells were developed. Groundwater within the unconsolidated deposits on the southern portion of the site also exhibits a south-southwest flow direction. Where nested wells were installed, an upward vertical hydraulic gradient was evident between the shallow weathered bedrock and the overlying unconsolidated deposits, which is likely attributable to the significant hydraulic gradient from the sloping terrain on the northern portion of the site. On the basis of the lithological logs and water level observations, it is considered that the weathered bedrock groundwater system is semi-confined beneath the unconsolidated deposits, but there is likely to be a degree of hydraulic connectivity between the systems.

Hydraulic testing of wells completed within both the shallow weathered bedrock and in the unconsolidated deposits indicated hydraulic conductivity values on the order of 10^{-5} to 10^{-6} m/s, which is consistent with the range of published values for the lithologies encountered.

3.6 Geology and Soil

Based on the 1:100,000 geological map 'Wollongong-Port Hacking', the WGRRP is on the boundary of two major geological formations. The southern part of the site is underlain by alluvial sands, silts and clays associated with Dapto Creek, and sandstone of the Budgong Sandstone formation underlies these alluvial soils. The central part of the site is underlain by red, brown and grey lithic sandstone that forms part of the Budgong Sandstone formation. The northern portion of the site is underlain by interbedded lithic sandstone, coal, carbonaceous claystone, siltstone and claystone of the Pheasants Nest Formation. It appears that the Pheasants Nest formation is mainly encountered on the ridgelines.

The environmental impact statement (EIS) (1982) indicates that prior to land-filling, volcanic sandstone covered most of the site with a transition to andesitic sandstone with coal seams, carbonaceous shale and mudstone in the higher section (above approximately RL 100 mAHD) and a zone of alluvium, gravels and sands in the lower sections (below approximately RL 30 mAHD). Bedrock is reported to appear at the surface in the upper sections of the site. The EIS (1992) for the Eastern Gully also notes that a relatively thick layer of colluvium was found along the base of the Eastern Gully.

The "Geology and Natural Slope Stability Zones in the City of Greater Wollongong, Figure 19, Sheets 1 and 2" (Rec. Geol. Surv. NSW, 14(2): Bowman) characterise the upper natural slopes as "moderately unstable, generally topographically high-relief land underlain by potentially unstable material requiring thorough investigation before development" and the site area at the toe of the natural slopes as "stable land with no landslip problems."

Historical photographs taken from ground-level in the eastern gully at a time before landfill development have been provided to Golder by Council. The appearance of the surface topography and conditions in these photographs is generally consistent with the presence of colluvium and potentially perched groundwater levels within the gully slopes. We understand that colluvium was to be stripped from natural slopes prior to construction of the old landfill, but note that some materials could remain close to the toe of the natural slopes in the central and northern portions of the site.





4.0 GEOTECHNICAL CHARACTERISATION & DESIGN INPUTS

4.1 Geological Model

Golder Associates Geotechnical Investigation Report (Golder ref. 117625003_R_077_Rev0, issued January 2012) provides details of the subsurface conditions at the site.

We have inferred that subsurface conditions generally consist of fill, colluvial / alluvial soils, residual soil and sandstone and siltstone rock. The thickness of the different units varies throughout the site. A generalised description of the profile is provided in Table 1 below. Geological Sections indicating inferred Unit thickness and depths are provided in Figures 5 to 8.

Unit	Description
Unit 41a: Old landfill waste Unit 41b: New landfill waste Unit 41c: Soil fill	Fill was encountered in zones of the proposed new cell floor (up to about 1.2 m deep) and generally comprised clayey soils with some sands.Fill in the existing landfill cap is mixed soils (clays and sands) with pockets of gravels, slag and coal-wash. Landfill Waste including plastic and rubble is present beneath the capping material.
Unit 42a: Alluvial soils Unit 42b: Colluvial soils	Mostly silty clay and clay with zones of sands and gravels and traces of cobbles. Soils in the upper 2 m to 3 m are soft to firm in parts, and strength improves with depth. Distinction between the Colluvial soils on the lower slopes and the Alluvial soils at the very bottom of the slopes is often difficult.
Unit 43: Residual soil and Extremely weathered rock	Mostly clay with varying quantities of gravel, silt and sand. Clay has medium plasticity and is generally stiff to very stiff with zones of medium dense to dense sand. Extremely weathered rock has extremely low to very low strength, typically sandstone with some siltstone and can be remoulded into a soil by hand.
Unit 44: Weathered SANDSTONE	Fine to medium grained, brown, low to medium strength, highly weathered to moderately weathered, with some iron stained jointing, jointing frequency typically 100 mm to 300 mm.
Unit 45: Fresh SANDSTONE	Fine to medium grained, grey, medium to high strength, generally slightly weathered to fresh, fracture spacing typically between 300 mm to 1 m.
Unit 46: Weathered SILTSTONE	Light brown, very low strength to low strength, highly weathered to moderately weathered, some zones interbedded with sandstone
Unit 47: Fresh SILTSTONE	Grey, low to medium strength, slightly weathered to fresh, encountered sparsely throughout the site

Table 1: Summary of Generalised Subsurface Conditions





4.2 Hydrological Conditions

In conjunction with the geotechnical investigation, separate investigations were undertaken to investigate hydrogeological conditions at the site. These investigations are reported in the Hydrogeological Investigation Report 117625003-R_070_Rev0.

4.2.1 Leachate levels

Leachate is produced when water percolates through deposited waste. As it passes through the waste, the water becomes contaminated as it 'leaches' compounds from the waste. Leachate composition varies with the age of the waste from which it is generated; it also varies depending on the nature of the waste and the volume of water.

Water may enter the waste from several sources including: (i) rainfall; (ii) liquid as a result of breakdown of the landfill waste; (iii) surface water inflow (as run-off); and (iv) groundwater inflow. Liquid wastes and entrained water may also have been present in the waste when deposited.

For the Eastern and Western Gully Landfill, leachate levels have been assumed to be 5 m above the base of the existing old waste, based on preliminary information of water levels in abandoned landfill gas wells in the Western Gully landfill.

4.2.2 Groundwater levels

In conjunction with Variation #4, dated 4 November 2011, additional geotechnical investigations were undertaken in the area of the proposed new cell floor. The additional geotechnical investigations included installation of three standpipe piezometers within the Colluvial / Allluvial soils.

The groundwater levels measured to date, since December 2011, confirm a groundwater level in the new cell floor area of approximately 1 m to 3 m below existing ground level.

Details of the additional standpipe piezometers will be presented in a future addendum to the Hydrogeological Investigation Report 117625003-R_070_Rev0.

4.3 Seismicity

In accordance with Australian Standard AS1170.4-2007 Structural design action Part 4: Earthquake actions in Australia, to determine the Peak Ground Acceleration (PGA) the probability factor and hazard factor are required from AS1170.4 2007 Section 3, as follows:

- The design earthquake adopted for WGRRP is equivalent to an event with an annual probability of occurrence of 1 in 475;
- The Probability Factor (*kp*) associated with a 1/475 event is 1.0. Refer to Table 3.1 AS1170.4 2007 for values; and
- The earthquake hazard factor (z) is equivalent to an acceleration coefficient with an annual probability of exceedence in 1/475, and in Wollongong is equal to 0.09. Refer to Table 3.2 AS1170.4 2007 for values.

The proposed design PGA for WGRRP is therefore 0.09 g (α) assuming a 1 in 475 year event.





4.4 Geotechnical Design Parameters

4.4.1 Natural Materials, Fill & Waste

The soil properties for analysis were derived from typical values, based on classification of the soils encountered during borehole excavation. These values have then been compared with available laboratory test results from recent and historical investigations. Engineering judgement and published values were used to guide the geotechnical design parameters used for the analyses based on the soil and rock profiles encountered and on the expected materials within the containment cell, as described in Table 2 and Table 3 below.

We note that assigning geotechnical properties to waste is inherently uncertain due to the heterogeneous nature of the material and the varying amounts of cover soil incorporated into the waste mass. Typical values for municipal solid waste have been adopted as per Qian et al $(2002)^1$ comprising friction angle, $\Phi = 30^\circ$, cohesion, c = 0 kPa, and unit weight, $\gamma = 11 \text{ kN/m}^3$.

The adopted unit weight for the municipal solid waste is likely be considered further for 90 % design using site records of waste placement and appropriate sensitivity analysis for stability and settlement.

As indicated in Section 4.2.1, for the purposes of this preliminary assessment, a standing leachate head of 5 m has been assumed within existing waste in the existing Eastern and Western Landfill Gully cells. Leachate within the proposed cells has been generally assumed to be free-draining into the continuous blanket leachate collection drain above the proposed Piggy Back and Cell Liner Systems so that no pore pressures are present within the new waste mass.

Although the slope stability analysis results presented subsequently in this report were found to be relatively insensitive to leachate levels within the existing waste, the assumption of a 5 m head should be further assessed during detailed design considering implications for slope stability as well as leachate migration.

It is noted that the materials forming the landfill cap have not been included in the slope stability analyses because their effect on the stability of the overall waste mass is considered negligible.

¹ Qian, X, Koerner, R.M & Gray, D.H., (2002), *Geotechnical Aspects of Landfill Design and Construction*. Prentice-Hall, Inc., Upper Saddle River, New Jersey.



Geotechnical Unit	Drained Modulus E' (MPa)	Constrained Modulus E _s (MPa)	Poisson's Ratio v'	OCR	Pre consolidation Pressure P _c (kPa)	Void Ratio e _o	Compression Index C _c	Modified Compression Index Cc₅	Recompression Index C _r	Modified Recompression Index	Creep Coefficient C _{α} (%)
Unit 41a – New Landfill ²	-	-	0.3	1	-	2	0.6 ⁵	0.2 ⁵	-	0.02	0.06
Unit 41b – Old Landfill ³	-	-	0.3	1	-	2	0.6 ⁵	0.2 ⁵	-	0.02	0.06
Unit 41bb – Old Landfill soft zone ³	-	-	0.3	1	-	2	1.0	-	0.1	-	0.2
Unit 41c – Soil Fill	-	-	0.3	1	-	2	0.2	-	0.02	-	0.06
Unit 42a – Alluvium 0-4m depth	-	-	0.3	NA	75	1	0.27 ⁶	-	0.06 ⁷	-	0.01 ⁸
Unit 42a – Alluvium >4m depth	-	-	0.3	1.2	-	1	0.27 ⁶	-	0.06 ⁷	-	0.01 ⁸
Unit 42b – Colluvium	-	-	0.3	3	-	1.5	0.15	-	0.025	-	0.006
Unit 43 - Residual Soil / Extremely Weathered Rock ⁴	60	72	0.25	-	-	-	-	-	-	-	-
Unit 44 - Weathered Sandstone ⁴	300	360	0.25	-	-	-	-	-	-	-	-
Unit 45 - Fresh Sandstone ⁴	300	360	0.25	-	-	-	-	-	-	-	-
Unit 46 - Weathered Siltstone 4	300	360	0.25	-	-	-	-	-	-	-	-
Unit 47 - Fresh Siltstone ⁴	300	360	0.25	-	-	-	-	-	-	-	-

Table 2: Geotechnical Design Parameters - Compressibility Analysis

Notes:-

1. The above geotechnical compressibility design values are proposed for use as *design values* of soil and rock.

2. Unit 41a – New Landfill refers to compacted waste that will be placed as part of the proposed Whytes Gully New Landfill Cell (above Interface 1 – piggy back liner).

3. Unit 41b – Old Landfill refers to existing waste and waste that will be placed as part of the current filling plan (below Interface 1 – piggy back liner).

4. Assumed Rock Mass Parameters using Rocscience Roclab software.

5. Compression Index taken from published value in Gourc & Oliver (2005), and engineering judgment.

6. C_c derived from Liquid limit and C_c correlation, Terzaghi and Peck (1967).

7. Cr derived from Atterberg Limit laboratory testing correlation, Table 22, Lambe and Whitlam (1979).

8. C_{α} derived from C_{α} = 0.032 C_{c} , Mesri and Godlewski (1977).





Table 3: Geotechnical Design Parameters - Stability Analysis

Geotechnical Unit / Interface	Bulk Unit Drained Friction Angle Weight $(\gamma)^1$ $(\phi')^1$		Drained Cohesion (c') ¹	Undrained Shear Strength (c _u) ¹
	(kN/m³)	(°)	(kPa)	(kPa)
Unit 41a - New Solid Waste Landfill ²	11	30	0	N/A
Unit 41b - Old Landfill ³	11	30	0	N/A
Unit 41c - Soil Fill	17	26	2	N/A
Unit 42a - Alluvium	17	25	2	$0.25\sigma_v$ (min. 25) ⁴
Unit 42b - Colluvium	18	27	5	100 + 10z ⁵
Unit 43 - Residual Soil / Extremely Weathered Rock	20	30	5	130
Unit 44 - Weathered Sandstone ⁶	24	38	40	1000
Unit 45 - Fresh Sandstone ⁷	24	N/A	N/A	N/A
Unit 46 - Weathered Siltstone 6	23	36	20	750
Unit 47 - Fresh Siltstone ⁷	24	N/A	N/A	N/A
Interface 1 - Critical Interface within Proposed Piggy Back Liner ⁹	19	Peak = 17 Residual = 7 (slopes) Residual = 11 to 14 (flat) ⁸	0	N/A
Interface 2 - Critical Interface within Proposed Cell Liner ⁹	19	Peak = 17 Residual = 7 (slopes) Residual = 11 to 14 (flat) ⁸	0	N/A
Interface 3 - Critical Interface within Existing Eastern Gully Base Liner System (Slope steeper than 4H:1V) ⁹	19	30	0	N/A
Interface 4 - Critical Interface within Existing Eastern Gully Base Liner System (Slope shallower than 4H:1V) ⁹	19	18	0	N/A

Notes:

1. The above geotechnical strength design values are proposed for use as *design values* of soil and rock.

2. Unit 41a – New Solid Landfill refers to compacted landfill that will be placed as part of the proposed new cell (above Interface 1).

3. Unit 41b - Old Solid Landfill refers to existing landfill and landfill that will be placed as part of the current filling plan (below Interface 1).

4. Design value for undrained shear strength = 0.25 times the overburden stress (kPa), with a minimum shear strength of 25 kPa.

5. Design value for undrained shear strength = 100 kPa + 10z where z is the depth in metres below the top of Unit 2b.

6. Assumed Rock Mass Parameters

7. Assumed impenetrable for modeling purposes

8. Design value for drained friction angle = 14° for Eastern Gully Landfill, and 11° for Western Gully Landfill (refer Appendix A, Figure 1)

9. The shear strength of each liner system has been characterized by the minimum shear strength of each component or interface in each system. The shear strength parameters assigned to each component and interface is included in Appendix B1.



4.4.2 Proposed lining systems

Two lining systems are proposed for this 50% design:

- 1) The piggy back liner is proposed to be installed where the New Landfill will be located above the Old Landfill; and
- 2) The new cell liner is proposed to be installed in regions where the New Landfill will be located on natural material.

The proposed piggy back liner (from top to bottom) comprises:

- Unit 9: Protection Material (300 mm)
- Unit 14: Geocomposite Leachate Drainage Net
- Unit 15: Textured LLDPE Geomembrane
- Unit 17: GCL
- Unit 4: Compacted Clay Rich Bearing Material (200 mm)
- Unit 6: Base Material (min. 150 mm)
- Unit 18: Geogrid
- Unit 6: Base Material (min. 150 mm)
- Prepared Subgrade (existing cover soil)

The proposed new cell liner (from top to bottom) comprises:

- Selected waste (500 mm)
- Unit 11: Filter Geotextile
- Unit 7: Drainage Aggregate (300 mm)
- Unit 12: Cushion Geotextile
- Unit 16: Textured HDPE Geomembrane
- Unit 17: GCL
- Unit 4: Compacted Clay Rich Bearing Material (200 mm)
- Prepared Subgrade (existing cover soil)

Typical sections of the proposed arrangements are provided in the design drawings D022 and D031 (ref: 117625003_145_S_RevB). Note the proposed new cell liner is referred to as the base cell liner in the design drawings.

The proposed lining systems have been incorporated in the analysis using the parameters provided in Table 3 and Appendix B1.





4.4.3 Existing lining system

Based on the details of the existing Eastern Gully landfill base lining system provided to Golder by Council² and discussed with Council, the Eastern Gully landfill base lining is understood to comprise two systems; one on slopes steeper than 4H:1V, and one on slopes shallower than 4H:1V.

The existing Eastern Gully landfill base lining system (slope steeper than 4H:1V) is understood to comprise (from top to bottom):

- Leachate Drainage Layer (500 mm)
- Textured HDPE Geomembrane
- Groundwater Drainage Layer (500 mm)

The existing Eastern Gully landfill base lining system (slope shallower than 4H:1V) is understood to comprise (from top to bottom):

- Protective Layer (300 mm)
- Leachate Drainage Layer (300 mm)
- Smooth HDPE Geomembrane
- Groundwater Drainage Layer (500 mm)

The existing lining systems have been incorporated in the analysis using the parameters provided in Table 3 and Table B.1 in Appendix B1.

² Maunsell Drawing 14892-005 Rev02 "Whytes Gully Landfill, Construction Details", dated 16 February 1993





5.0 METHODOLOGY

5.1 Relationships with Concept Design

This report provides baseline geotechnical information which is used in the New Landfill Cell 50% design, as follows:

Design Stage	Design Component	Relationships
	Excavation depths and foundation preparation	Geotechnical input is required to assess material suitability, treatment requirements and settlement performance of the new landfill cell floor.
	Geometry	Geotechnical input is required to assess the final landform geometry.
	Earthworks	Geotechnical input is required to assess material suitability, treatment requirements and settlement performance.
50 % Design	Staging	Geotechnical input is required to assess temporary slope stability during waste placement. This aspect will be considered further at 90% Design, when the depth of temporary cuts and batters is better known.
Comprising approximately	Cell floor liner design	Geotechnical input is required to assess material suitability, soil/liner interaction, stability, settlement and strains at the interface with existing natural soil profile.
and technical specifications	Piggy back liner design	Geotechnical input is required to assess material suitability, soil/liner interaction, stability, settlement and strains at the interface with existing solid waste.
	Surface water design	Geotechnical data is required for analysis of final landform drainage bench design
	Landfill gas (piggy back liner interface only)	None, except as consequence of piggy back liner design
	Leachate collection	None, except as consequence of geometry
	Leachate storage sizing	None
	Leachate treatment plant augmentation	None

Table 4: Relationships betweer	geotechnical information and design components
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5.2 Slope Stability

5.2.1 Analytical Method

Stability of the proposed landform has been assessed using the limit-equilibrium program $SLOPE/W^3$ for Spencer circular and non-circular failure mechanisms for both static and earthquake stability. Global stability analysis checks are conducted at the serviceability limit state. Consequently overall Factors of Safety (FoS) are applied in the global stability analysis, as follows:

- Target FoS for the overall slope of 1.5 or greater to provide acceptable long term stability under static loading, where the landfill liner is at peak strength;
- Target FoS for the overall slope of 1.2 or greater to provide acceptable long term stability under static loading where the landfill liner is at residual strength (such as post earthquake conditions). Considered a conservative test of stability, as residual strengths are unlikely to develop simultaneously across the whole area of the liner;
- Target FoS for the overall slope of 1.1 or greater to provide acceptable stability under earthquake loading, where the landfill liner is at peak strength; and
- Target FoS for the overall slope of 1.0 or greater to provide acceptable stability under earthquake loading, where the landfill liner is at residual strength.

Long term (effective) material parameters were used as these govern design, but a check of the undrained condition under earthquake loading was also carried out, using the undrained shear strength parameters (where applicable, such as for cohesive materials) as described in Section 4.4.

Additional notes regarding the slope stability analysis methods are:

- Analysis has been performed for the selected cross-section geometries, thus providing a twodimensional (2-D) representation of the actual (3-D) conditions. Although this is consistent with standard geotechnical practice, it is known that 2-D analysis of valley landfills, such as the eastern gully landfill, when performed for critical cross sections, is generally a conservative approach because it does not account for beneficial 3-D geometry effects. Slope stability analyses that fully account for 3-D effects can be performed but are significantly more costly and complex than 2-D analyses.
- The critical surface search algorithms in Slope/W can converge on insignificant shallow veneer failures. To prevent this, a minimum slip surface depth within the waste mass was selected as required for the condition analysed.
- Where required for ease of slope stability modelling, the base liner layers are collectively represented by the properties of the "weakest material or interface in liner system" as indicated in Appendix B1.
- Results are based on the optimised Spencer limit equilibrium search methods as implemented in Slope/W.

5.2.2 Seismicity

To simulate potential seismic forces, a pseudo-static slope stability approach has been adopted wherein potential seismic effects are modelled as additional (destabilising) horizontal forces. Although this approach simplifies complex, dynamic seismic loading as static forces, it is commonly applied for slope stability analysis of landfill embankments, with more complex analysis generally justified only in cases where the simplified analysis indicates stability concerns.

As per Table 3.2 in AS1170.4 (2007), a peak horizontal acceleration of 0.09g (the peak horizontal acceleration for Wollongong) has been identified; and subsequently modified to 50% (i.e. 0.045g) in the horizontal direction



³ SLOPE/W, "Slope Stability Analysis", GeoStudio 2007, Geo-Slope International, 2007



for application to landfill embankment analysis. This represents an earthquake event with an approximate 475-year recurrence interval, a recurrence interval generally considered very conservative for landfill slope stability analysis.

As indicated in Table I2 in AS4678 (2002), a site amplification factor of 1.0 (for less than 30 m of medium dense coarse sands and gravels, firm to stiff clays or controlled fill under the landfill mass) has been applied to the horizontal acceleration of 0.045g. A horizontal acceleration coefficient of 0.045g has therefore been adopted for the pseudo-static slope stability analysis.

5.2.3 Slope Geometry

Slope stability analyses were carried out on four cross-sections that were considered to present the highest relative risk of slope instability, based on geometry and subsurface conditions. The location of these sections is shown in Appendix A, Figure A1. The sections are described as follows:

- Section E-E': This section extends north to south along the proposed 4.5H:1V slope of Western portion of the final landform.
- Section F-F': This section extends north-east to south-west along the centre of the natural Western Gully alignment.
- Section G-G': This section extends north-east to south-west through the Central Ridge between the two gullies and along the proposed 4.5H:1V slope of Eastern portion of the final landform.
- Section H-H': This section extends north-east to south-west along the centre of the natural Eastern Gully alignment.

These four sections are provided in Appendix A, Figures A2 to A5.

5.3 Settlement

Settlement analysis was carried out for design of liner and drainage systems, to assess the risk of grade reversal and settlement-related tensile strains. The analysis was broken down into four components, as follows:

- Settlement of natural soil profile at selected locations where there is appreciable thickness of natural soils likely to undergo settlement (equivalent to the position of parts of the cell floor liner). As these soils will form the landfill foundation for the new cell floor it is important to understand soil behaviour under the proposed new load and how this will affect the cell floor liner and final landform levels. The method of analysis used one-dimensional consolidation and elastic theory by proprietary software *Settle3D* (refer to section 5.3.1).
- Settlement of the piggy back liner system at selected locations. Analysis considered consolidation and degradation of the old waste, which were added to the settlements of the natural soil profile. Analysis was conducted using a Microsoft Office Excel spreadsheet to calculate the short and long term settlement equations referred to in section 5.3.2.
- Settlement of the final landform surface at selected locations. Analysis considered consolidation and degradation of the new waste, which were added to the settlements of the piggy back liner. Analysis used the same method described above, as referred to in section 5.3.2.
- Overall deformations and strains in the liners. To assess overall deformations and strains of the liner and to cross check the methods described above, finite element analysis was conducted using proprietary software PLAXIS (refer to section 5.3.3).

The cross sections adopted for slope stability assessment (refer to Section 5.2.3) were also considered appropriate for the settlement assessment. The four cross sections, Section E-E', Section F-F', Section G-G' and Section H-H', are provided in Appendix A, Figures A2 to A5.





The stratigraphy for the settlement analyses were taken from Golder factual geotechnical report, ref 117625003_077_R_Rev1.

5.3.1 Settlement of Natural Soil Profile

To assist in the settlement modeling of the natural soil profile, proprietary software program *Settle3D* (Roc Science) was used. *Settle3D* analysis includes the following assumptions:

- Applied loads are flexible, the stress at the surface is uniformly distributed but the displacement is not;
- Soil layers within Settle 3D are horizontal and continuous;
- The initial ground surface is horizontal; and
- Groundwater levels can be altered over the time stages to simulate drop in ground water Settle 3D modeling approach.

Settle3D analysis uses the following methods:

- Three dimensional stresses are calculated within a soil mass using elastic analysis;
- Consolidation analysis is performed for all Units in the soil profile; and
- Settlements and pore pressures are calculated in one dimension, assuming that only vertical displacements can occur.

The location where the settlement of natural soils is considered critical is defined by Section F-F' in the Western Gully Landfill between Ch425 m and Ch650 m, where the cell floor liner extends over natural soils. At this location the conceptual site model for the cell floor indicates that it is underlain by variable thicknesses of fill at shallow depths and increasing thicknesses of Colluvium to approximately Ch 525 m and Alluvium from Ch 500 m. At other sections, the natural soils were of limited thickness and unlikely to undergo significant settlement. Settlement analysis of these sections was therefore not considered necessary.

A summary of the five locations in Section F-F' selected for Settle3D analysis are shown in Table 5.

Analysis	Proposed thickness of new waste (m)	Comment
Section F-F' Ch 425 m	32.43	Toe of old solid waste placement (Western Gully Landfill)
Section F-F' Ch 475 m	25.30	Thickest profile Unit 41c Soil Fill and 42b Colluvium (3 & 12 m respectively)
Section F-F' Ch 570 m	11.15	Thickest profile Unit 42a Alluvium (16 m)
Section F-F' Ch 600 m	7.84	Mid point between Ch 570 m & 630 m
Section F-F' Ch 630 m	4.21	Near toe of new solid waste placement

Table 5: Summary of Settle3D critical analysis locations

The total settlements at each location were calculated from 1D consolidation analysis using the parameters described in Table 2. Where the thickness of Unit 42a exceeded 4 m it was divided into two layers for modeling purposes. The upper 4 m of Alluvium is assumed to be controlled by pre-consolidation pressure, whereas the Alluvium behavior below the upper 4 m is governed by the over-consolidation ratio.

The groundwater table for each model was assumed to be 2 m below existing ground level, dropping 1 m by 40 years post completion of filling. This drop is related to the controlling influence of the proposed concept design on the hydrological and hydrogeological conditions.





The placement of the new solid waste material was simulated by placing of time sequenced loads as a layer in an embankment. The embankment was modeled to have sufficient size as to minimise edge effects on the calculated 1D settlement.

Once the total soil settlements (primary and secondary settlements) had been calculated they were used in the liner-strain and grade change calculations for Section F-F' for the cell floor liner.

5.3.2 Settlement of Piggy Back Liner

The settlement of landfill waste was considered in the 'short term' and 'long term'. In the context of landfill waste settlement, short-term refers to settlement occurring in response to loading and generally within a few months of load application. The generally attributed mechanisms in the technical literature for short-term waste settlement are physical, primarily particle breakage and/or rearrangement into a denser structure.

The short term settlement of old solid waste was modelled using the following equation (Eq 12.9, Qian et al (2002)).

$$s = H \times C_{c\varepsilon} \times \log \frac{\sigma_0 + \Delta \sigma}{\sigma_0}$$

Where:

- *H* Initial thickness of the waste later of the existing landfill (m)
- $C_{c\epsilon}$ Modified primary compression index
- σ_0 Existing overburden pressure acting at the mid level of the waste layer, calculated using material parameters from Table 3.
- $\Delta\sigma$ Increment of overburden pressure due to vertical expansion or other extra load calculated from new design levels provided in Sections in Appendix A.

In the context of landfill settlement, long-term refers to settlement that generally occurs over a period of decades, at a diminishing rate, and is not directly associated with any load application. The generally attributed mechanisms in the technical literature for long-term waste settlement are chemical/biological rather than physical, being primarily decomposition of organic materials resulting in loss of solid mass.

The long term settlement of new and old solid waste was modelled using the following equation (Eq 12.11, Qian et al (2002)).

$$s = H \times C_{\alpha \varepsilon} \times \log \frac{t_{final}}{t_{initial}}$$

Where:

H Initial thickness of the waste later of the existing landfill (m).

 $C_{\alpha\varepsilon}$ Modified secondary compression index.

- $t_{initial}$ The starting time of secondary settlement (years). It is assumed to be equal to the age of the existing landfill for vertical settlement.
- t_{final} The time for the end of secondary settlement (years).

These equations were modelled using a Microsoft Office Excel spreadsheet to calculate the short and long term settlement, using the input parameters described in Section 4.4.





Settlement-induced strains for the liner systems were calculated directly as the average strain (tension or compression). Adjacent points along Section F-F' and Section H-H' were used in the calculation, and the distance between the points in their initial positions and post settlement positions were calculated. This method provided an estimate of the approximate strain along the profile provided in Section F-F' and H-H' to be compared with the components of the liner system.

For the Eastern and Western Gully landfill construction records indicate that most soils were stripped prior to commencement of filling thus there would be no compression of natural soil and rock materials underlying Unit 41b Old Solid Waste. The piggy back liner will therefore only be subjected to settlement from compression and decomposition of the existing waste (Unit 41b) underlying the piggy back liner.

Section F-F' (Western Gully Landfill) and Section H-H' (Eastern Gully Landfill) were selected for analyses of the piggy back liner settlement.

The proposed filling programme for the Whytes Gully Landfill Cell used to calculate initial and final ages for new solid waste placement was taken from the staging plans and programme revision 3, dated 11 January 2012. Staging plan drawings are presented in the 50% concept design report. A summary of the adopted filling programme used for settlement analysis is provided in Table 6.

Stage	Proposed Liner Construction Period	Proposed Capping Construction Period (*)	Operation Period (Waste Filling)		
			(from year to year)	Length (years)	
Stage 1	end 2012 - 2015 (3 years)	end 2015 - 2019	2013 - 2017	4.1	
Stage 2A	end 2016 - 2017 (1 year)	end 2019 - 2021	2017 - 2020	2.4	
Stage 2B	end 2019 - 2022 (3 years)	end 2022 - 2037	2020 - 2035	15.2	
Stage 3	end 2034 - 2037 (3 years)	end 2037 - 2048	2035 - 2046	11.3	
Stage 4	end 2045 - 2048 (3 years)	end 2048 - 2055	2046 - 2053	7.2	

Table 6: Filling programme adopted for settlement analysis

The historical filling programme for the existing Eastern and Western Gully landfills are provided as cross sections in Figures C.7 and C.9 in Appendix C.

For settlement predictions the proposed design life for the "extension" assessed for settlement analysis was forty years after completion of the final date of filling at the analysis section.

5.3.3 Settlement of Final Landform Surface

Settlement of the final landform surface has been assessed at three locations, which included long term settlement on old and new solid waste only. Settlement of the existing soil profile was not considered, as construction records for the Western and Eastern Gully Landfill showed this material to have been stripped during construction at the nominated chainages.

The three points were selected from cross sections F-F`, G-G` and H-H` as being representative of the thickness of new waste to be placed and at highest elevation proposed for the final landform. For Section G-G', the new solid waste will form part of a newly constructed cell, and we have assumed that unsuitable materials will be stripped from foundation level prior to waste filling.

The methods of analysis and assumptions for settlement of the final landform surface are described above in Section 5.3.2.





5.3.4 Comparative Finite Element Analysis

PLAXIS finite element analysis was carried out to assess forces and strains within the liner systems resulting from differential settlement of the existing landfill and natural materials under the overburden load of the proposed new landfill materials, and for the case of hypothetical soft spots below the liner.

The performance of the piggy back liner and the new landfill cell base liner was modelled during the various stages of construction and operation shown in Table 6 above.

Two PLAXIS models were developed, as follows:

- A two dimensional (2D) "global" model along the centerline of the western gully at cross-section F-F' to quantify overall time–displacement behavior, simplified single liner stresses and strains, total and differential settlements, operational surface slope gradients and potential failure mechanisms; and
- A "local" axisymmetric model examining more closely the interaction between the existing and proposed landfill at a critical liner location identified in the 2D analysis. This incorporates two geosythentic layers (Unit 18 geogrid and Unit 15/16 geomembrane) and a nominally sized buried soft spot to assess liner behaviour in response to localised deformations.

A full discussion of the modelling approach is provided in Appendix D of this report.





6.0 RESULTS AND DISCUSSION

6.1 Slope Stability

A summary of stability analysis results is provided in Table 7 below, which indicate that all sections analysed meet the target factors of safety. A full list of analysis results is contained in Appendix B2. The output figures referenced below are included in Appendix B3.

Failure Mechanism	Conditions	Target FoS	Calculated FoS	Analysed Sections	Output Figures
Circular through New Londfill	Long-term	1.50	2.66 – 2.99	E, G	B3.1, B3.17
Circular through New Landill	Earthquake	1.10	2.14 - 2.41	E, G	B3.2, B3.18
Non-circular (sliding) along proposed piggy back and	Long-term	1.50	1.51 – 2.06	E, F, G, H	B3.3, B3.9, B3.19, B3.25
new cell liners at peak strength	Earthquake	1.10	1.24 – 1.47	E, F, G, H	B3.4, B3.10, B3.20, B3.26
Non-circular (sliding) along proposed piggy back and	Long-term	1.20	1.24 – 1.49	E, F, G, H	B3.5, B3.11, B3.21, B3.27
new cell liners at residual strength	Earthquake	1.00	1.01 - 1.09	E, F, G, H	B3.6, B3.12, B3.22, B3.28
Circular through Old Landfill	Long-term	1.50	2.87 – 3.10	F, H	B3.13, B3.29
	Earthquake	1.10	2.23 – 2.50	F, H	B3.14, B3.30
Non-circular (sliding) along	Long-term	1.50	1.99	Н	B3.31
existing base liner in eastern landfill gully	Earthquake	1.10	1.63	Н	B3.32
Circular below Old Landfill	Long-term	1.50	2.09 – 2.29	E, F	B3.7, B3.15
(through natural soil)	Earthquake	1.10	1.25 - 1.67	E, F	B3.8, B3.16
Non-circular (sliding) below	Long-term	1.50	1.66	G	B3.23
soil)	Earthquake	1.10	1.31	G	B3.24

Table 7: Summary of Stability Analysis Results

Based on the analysis results, the concept design meets the target factors of safety assigned to the design of global slope stability.

For all of the four cross-sections analysed, the critical failure mode for global stability of the final landform is non-circular (sliding) failure along the proposed piggy back and new cell liners, predominantly on the new cell floor. This is the case for both long-term static conditions and under earthquake loading. Consequently, the stability of the final landform is dependent on the shear strength of the critical interface or component within the proposed liner systems. The concept design overcomes this stability constraint by specifying minimum liner shear strengths near the toe of the landfill, in order to buttress the middle and upper slopes.

The minimum liner shear strengths required to support the design for global slope stability are presented in Appendix B1 and summarised in Table 8 as follows:



	Minimum Shear Strength						
Zone ¹	Ре	ak	Residual				
Zone	Drained Friction Angle (φ') (°)	Drained Cohesion (c') (kPa)	Drained Friction Angle (φ') (°)	Drained Cohesion (c') (kPa)			
Slopes of old and new landfill	17	0	7	0			
Flat areas of new cell floor	17	0	11	0			
Eastern Gully (lower portion only)	17	0	14	0			

Table 8: Shear Strength Requirements for Piggy Back Liner and New Cell Liner

1. Refer to Appendix A, Figure A1.

It should be noted that laboratory testing (interface shear and internal shear strength testing of each liner component) will be required to confirm the above shear strength parameters are satisfied as part of the selection process of the liner components.

In addition to the above global stability assessment, the following stability assessments are recommended to be undertaken as part of the final design:

- Stability assessment of interim construction slopes including consideration of surface loads, construction plant on batter slopes, liner uplift and potential for landfill gas pressure below the piggy back liner;
- Rock slope stability assessment of excavations in borrow pit areas;
- Stability assessment of 4H:1V northern final landform slope; and
- Stability assessment of the capping system (veneer stability).

6.2 Settlement

6.2.1 Settlement of Natural Soil Profile

As described in Section 5.3.1, the cell floor liner extends onto natural soils in the Eastern and Western Gully Landfill. Section F-F' was assessed as the most critical location for the proposed cell floor liner, where there is approximately 100m of new liner to be placed on the natural soil profile.

The results of settlement analysis for the natural soil profile are provided in Appendix C.1 to C.6, and summarised in the table below.

Table 9: Summary of calculated natural soil profile settlement at base of Western Gully Landfill

Section Chainage	Filling Stages	Total Settlement at 40yrs post completion of filling (m)
Ch425	Stage 2B	0.58
Ch475	Stage 2B	0.48
Ch 570	Stage 2B & Stage 3	0.77
Ch600	Stage 2B & Stage 3	0.42
Ch625	Stage 2B & Stage 3	0.18

The predicted total settlements were used to calculate settlement-induced strain in the cell floor liner in Section F-F' due to the underlying natural soils. Results are provided in Appendix C.8, and summarised in the table below.





Section	Landfill	Settlement-induced strain (%)		
Section		Minimum	Maximum	
Section F-F'	Western Gully Landfill	-1.3 (compression)	0.2 (tension)	

Table 10: Summary of calculated tensile strains for the cell floor liner on natural ground

6.2.2 Piggy back Liner

As described in Section 5.3.2, Section F-F' (Western Gully Landfill) and Section H-H' (Eastern Gully Landfill) were analysed for settlement of Unit 41b Old solid waste. There was no inclusion of settlement due to a natural soil profile, which had been stripped during landfill construction prior to waste placement.

Detailed settlement results are provided in Appendix C.8 and C.10. A summary of the settlement analysis results in for the piggy back liner are provided in the table below.

Table 11: Summary of calculated total settlements for the piggy back liner

Santian	Location	Total Settlement at 40yrs post completion of filling (m)		
Section		Minimum	Maximum	
Section F-F'	Western Gully Landfill	0.00	3.98	
Section H-H'	Eastern Gully Landfill	0.07	4.98	

The predicted total settlements were used to calculate settlement-induced strain in the piggy back liner system. Results are provided in Appendix C.8 and C.10, and summarised in the table below.

Table 12: Summary of calculated tensile strains for the piggy back liner (using MS Excel)

Section	Landfill	Settlement-induced strain (%)		
		Minimum	Maximum	
Section F-F'	Western Gully Landfill	-0.60 (compression)	0.50 (tension)	
Section H-H'	Eastern Gully Landfill	-0.87 (compression)	0.15 (tension)	

The calculated liner system strains were compressive (from 0% to -0.6%) along most points in the cross section. However, maximum tensile strains of approximately 0% to 0.5% tension were also calculated.

Tensile strains are the primary concern with respect to maintaining liner system integrity. The calculation also indicates settlement-induced changes in liner system grades, however, there were no grade reversals suggested by the analysis results.

A limitation of using MS Excel to assess strain and grade reversal is that we cannot assess lateral deformation. These strains provide an indication of strain related to vertical movement only. Refer to Appendix C8 and C10 for MS Excel analysis results.

The results of the PLAXIS models and discussions will be presented in Revision 0 of this report.

6.2.3 Final Landform Surface

As described in Section 5.3.3, settlement of the final landform surface was assessed at three locations on selected from cross sections F-F', G-G' and H-H' as being representative of the thickness of new waste to be placed at the highest elevation proposed for the top deck and final landform.

The results of analysis are present in

Table 13, with detailed calculations presented in Appendix C.11 to C.13.





Section	Notes	Total Long Term Settlement (m)	Distance between points	Change in grade (%)
Section F-F' Ch 175 Design RL 110.22 m	Western Gully Landfill – Top Deck	3.0m	130m	1.0
Section G-G' Ch 200 Design RL 110.12 m	New Solid Waste Only – Top Deck	1.7m		0.1
Section H-H' Ch 200 Design RL 101 m	Eastern Gully Landfill	1.5m	150m	

Table 13: Summary of calculated total settlements at the final landform surface

The calculation indicates settlement-induced changes in final landform grades, with a predicted grade reversal across the proposed top deck final landform (Section F-F' and Section G-G'). There is a minor change in grade between Section G-G' and H-H' but not a grade reversal.

The predicted grade reversal is a product of the concept design staging programme, which sees waste placement and settlement at H-H' occurring before placement and settlement of waste at Section G-G' and Section F-F'. The presence of incompressible founding material at the new cell floor also contributes to a lower long term settlement prediction at Section G-G' compared to Section F-F'.

The grade reversal will need to be considered for final landform geometry and surface water design but is expected to be manageable with relatively small revision in final cap design grades.

6.3 Forces and Strains in the liner system

The results of the PLAXIS analyse indicate the following key findings:

- Landfill settlements do not result in excessive concentrated relative movements within the liner systems.
- Resulting forces and strains in the components of the proposed piggy back liner and new cell base liner systems are within acceptable limits.
- The geogrid (Unit 18) component within the piggy back liner provides necessary reinforcement required to maintain peak strains in the geomembrane component (Unit 15) to below 4 %.

General agreement was achieved between the PLAXIS, Slope/W and 1D settlement analyses.

A full discussion of the results of the analyses (including basic sensitivity cases) is provided in Appendix D.

6.4 Liquefaction

Based on the available geological information from the site, the natural soils below the landfill are generally clayey in nature. The fines content of soils affects liquefaction potential, with materials with higher fines contents generally having lower susceptibility to liquefaction.

The geological deposition of soils can give an indication of their susceptibility to liquefaction. Loose soils with uniform primarily sand grain sizes tend to have increased liquefaction susceptibility, compared to denser, well-graded soils. Saturated sandy soils formed by fluvial, colluvial and aeolian deposition processes generally have higher liquefaction susceptibility than alluvial-fan, alluvial-plain, beach, terrace, playa or estuarine deposits (Kramer (1996)). The subject site contains a range of soils from both depositional types, although the majority are clayey and therefore less susceptible to liquefaction. For the purposes of this assessment we consider it reasonable to assume that landfill waste (predominantly unsaturated) is not susceptible to liquefaction.

A layer of loose alluvial sand was identified in borehole GABH05 at 1.2m to 2.0m depth and other loose clayey sand layers were noted in the same borehole from 3m to 4m depth and in GMW107 from 0.5m to 1.2m depth.



Due to the variable depositional nature of the alluvium there is potential that there may be other discrete loose sandy layers near the toe of the proposed landfill that have not been encountered in boreholes.

As these loose sand soils may be susceptible to liquefaction we have completed an initial assessment of whether liquefaction may be triggered during the adopted design earthquake event. For this assessment we have adopted a horizontal ground motion for the site for a 1 in 475 year Annual Exceedence Probability (AEP) earthquake event for Wollongong (assuming z=0.09 and k_p =1.0) of 0.09g, based on AS1170.4, Tables 3.1 and 3.2. A magnitude 6.5 earthquake has been assumed.

Liquefaction potential of the loose sand layer from borehole GABH05 at 1.2m depth was assessed using the method of Robertson (2004). For this assessment we assumed that the layer has a density index (Dr) of 30% and used a cone penetration test (CPT) correlation (Baldi et al (1986)) to estimate an equivalent q_c value for use in the calculation.

We have assumed a friction ratio of 1 % x q_c which correlates to clean sand with typically \leq 5 % fines. The results of the initial liquefaction assessment calculations are shown in Appendix C, Figure C15. The range of Factor of Safety (FoS) values calculated indicate acceptable performance against liquefaction (i.e. FoS is greater than 1.1).

In summary, the initial assessment of liquefaction susceptibility indicates that there may be localised layers of loose sand at the base of the landfill, which have a liquefiable particle size distribution. An initial assessment of whether liquefaction is triggered in these layers indicates that performance against liquefaction is acceptable.

There may also be other similar layers that were not encountered in the exploratory locations that have been completed, given the expected lateral variability in these deposits. However, we consider based on the available information and inferred geotechnical model, that there is a low likelihood of extensive, persistent liquefiable layers. We consider that the overall risk associated with liquefaction instability is low.

6.5 Excavations

The concept design will require that some areas are excavated to provide appropriate grades for the new cell floors, for example Section G-G` Ch100 to Ch575 m, and Section F-F' Ch400 to 650 m.

In addition, to facilitate unrestricted movement of construction equipment during the new cell floor construction, areas underlain by soft to firm and loose soils may require subgrade treatment. This could include excavation of these poor soils to a depth of at least 500 mm below final levels and replacement with suitable fill. Alternatively, a working platform could be constructed by filling over the areas of poor subgrade soils with crushed granular materials, subject to the materials left in place meeting the requirements defined by slope stability considerations. The actual depth of granular fill that might be required (possibly also using geosynthetic separation or reinforcing layers) would depend on the condition of the subgrade at the time, and should be considered on a case-by-case basis during construction.

Groundwater levels encountered during the site investigation indicate that at some locations the fill may need to be removed from below groundwater level. Contractors should consider methods for excavation and backfilling the excavations below groundwater level, or alternatively pumping groundwater from sumps to holding ponds while excavation, validation and backfill takes place. Wet fill will likely need to be moisture conditioned (dried or mixed with drier soil) prior to incorporation in the containment cell to improve handling and compaction.

Excavation of the fill, natural soils and extremely weathered rock horizons could be carried out by a medium sized (or larger) excavator. Excavation of very low and low strength rock (particularly carbonaceous lenses and siltstone) may be possible using large excavators at low production rates. Where medium and high strength rock is encountered rock breakers would likely be required. Alternatively it may be feasible to use a medium to large dozer with ripping tyne, subject to the capabilities of the equipment.

For unsupported excavations, the batters indicated in Table 14: Maximum Temporary and Permanent Batter Slopes are recommended for temporary and permanent applications. Some shallow excavations in the stiff or better clays will stand unsupported vertically in temporary applications, provided the weather and soil at the





time of excavation are relatively dry. NSW Workcover requirements for maximum allowable depth of unsupported excavations should be adhered to at all times.

Unit	Material	Temporary Batter Slope (H:V)	Permanent Batter Slope (H:V)
Unit 41c	Soil FILL – variable silty clay, gravely sand or sandy gravel.	2 : 1	3 : 1
Unit 42a	Alluvium – loose sand or firm clay (and mixtures thereof)	2 : 1	3 : 1
Unit 42b	Colluvium – stiff to hard clay soil with varying portions of silt, sand and gravel	1.5 : 1	2 : 1
Unit 43	Residual soil and extremely weathered rock	1 : 1	2 : 1
Unit 44 / 46	Extremely to highly weathered carbonaceous siltstone, siltstone, sandstone, conglomerate	1 : 1	2 : 1
Unit 45/47	Slightly weathered to fresh siltstone, sandstone, conglomerate	0.5 : 1*	1 : 1*

Table 14: Maximum Temporary and Permanent Batter Slopes

* vertical slopes with localised rock bolting may be feasible in materials not susceptible to erosion, and subject to geological inspection during construction.

Drainage and vegetation will be required to reduce erosion and the risk of local instability in permanent batter slopes.




7.0 CLOSURE

Your attention is drawn to the document "Limitations", which is attachment in Appendix E. The statements presented in this document are intended to advise you of what your realistic expectations of this report should be. The document is not intended to reduce the level of responsibility accepted by Golder Associates, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing.

8.0 **REFERENCES**

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Report Signature Page

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Rachael Prosser Engineering Geologist

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Craig Curnow Principal Geotechnical Engineer



APPENDIX A

Cross Sections

- Cross Section E-E'
- Cross Section F-F'
- Cross Section G-G'
- Cross Section H-H'





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NATURAL SURFACE	104.81	102.42	99.11	96.03	91.80	90.57	86.65	83.36	79.44	75.91	70.66	65.48	60.13	53.44	47.53	41.88	37.84	34.81	32.19	29.74	26.79	25.53	23.16	23.16	24.33	24.71	26.97	26.95	26.74	26.29
DESIGN SURFACE						96.21	102.38	108.62	110.12	106.05	100.49	94.94	89.39	83.84	78.29	72.74	67.18	61.63	56.08	50.53	44.98	39.43	33.87	28.03						
BOT. WASTE										76.43	70.79	65.40																		
STAGE 1														60.99	64,65	66.11	67.18	61.63	56.08	50.53	44.98	39 <u>.</u> 43	33.87	28.03						
DEPTH						-5.63	-15.73	-25.26	-30.68	-30.14	-29.83	-29.47	-29.26	-30.40	-30.76	-30.86	-29.35	-26.82	-23.89	-20.79	-18.18	-13.90	-10.71	-4.87						
CHAINAGE	00.0	25.00	50.00	75.00	100.00	125.00	150.00	175.00	200.00	225.00	250.00	275.00	300.00	325.00	350.00	375.00	400.00	425.00	450.00	475.00	500.00	525.00	550.00	575.00	600.00	625.00	650.00	675.00	700.00	725.00

SECTION H - H SCALE 1:3000 F00A1 F00A1

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29.74	26.79	25,53	23.16	23.16	24.33	24.71	26.97	26.95	26.74	26.29	23.78	23.23	23.14	21.92	20.98	20.43	19.55	18.45	16.75	
50.53	44.98	39.43	33.87	28.03																
50.53	44.98	39.43	33.87	28.03																
-20.79	-18.18	-13.90	-10.71	-4.87																
475.00	500.00	525.00	550.00	575.00	600.00	625.00	650.00	675.00	700.00	725.00	750.00	775.00	800.00	825.00	850.00	875.00	00.006	925.00	938.56	
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	<b>.</b>			CLIEN	WO	LLONG	ONG (		OUNCI	L	PROJECT	TITLE	N	WHYTE	S GUL	LY NE	W LAN	IDFILL	CELL	-
E		<b>Gold</b> ssoci	ates	E JI CHEC CSC	EET Ked by C			17.01.201 DATE 17.01.201	2						SE	СТІОІ	N H -	Н		
GOLE	www.ę DER ASSO	golder.com DCIATES P	TY. LTD.	SCALI	E	1:	3000		\$	SHEET SIZE	PROJECT	[№] 7625	003	^{DOC №}	) DOC	TYPE FI	^{gure n₀}	5 (	0	FIGURE A5









#### **APPENDIX B1**

Geotechnical Design Parameters - Stability Analysis - Liner Components and Interfaces

Liner System	Component/ Interface	Bulk Unit Weight (γ) (kN/m³)	Drained Friction Angle (φ') (°)	Drained Cohesion (c') (kPa)	Undrained Shear Strength (Cu) (kPa)	Comment
Proposed Piggy	Unit 9: Protection Materials (300 mm)	19	30	0	N/A	Typical value for track rolled sandy soil
Back Liner System	Interface between Unit 9 and Unit 14	N/A	27	0	N/A	Reduction Factor of 0.9 applied to Unit 9 friction angle ( $\phi$ ['] = tan ⁻¹ (0.9 tan 30°))
	Unit 14: Geocomposite Leachate Drainage Net	10	Peak = 25 Residual = 8	Peak = 21 Residual = 32	N/A	Typical values
	Interface between Unit 14 and Unit 15	N/A	Peak = 24 Residual = 15	0	N/A	Typical values for textured geomembrane-geotextile interface
	Unit 15: Textured LLDPE Geomembrane	10	N/A	N/A	N/A	Assumed not to shear internally
	Interface between Unit 15 and Unit 17 or Internal Shearing of Unit 17: GCL	19	Peak = 17 Residual = 7 (slope) – 11 (flat) ¹	0	N/A	Typical range of values based on Zornberg et al (2005) ² , McCartney et al (2009) ³ and Koerner and Narejo (2005) ⁴
	Interface between Unit 17 and Unit 4	N/A	23	0	N/A	Reduction Factor of 0.8 applied to Unit 4 friction angle ( $\varphi'$ = tan ⁻¹ (0.8 tan 28°))
	Unit 4: Compacted Clay Rich Bearing Material (200 mm)	19	28	0	0.25γv⁵	Typical values for clay-rich compacted soil
	Unit 6: Base Material (150 mm) (well, graded, compacted soil)	18	32	0	N/A	Qian et al (2002) ⁶
	Interface between Unit 6 and Unit 18	N/A	29	0	N/A	Reduction Factor of 0.9 applied to Unit 6 friction angle ( $\phi$ ' = tan ⁻¹ (0.9 tan 32°))
	Unit 18: Geogrid	10	N/A	N/A	N/A	Assumed not to shear internally
	Interface between Unit 18 and Unit 6	N/A	29	N/A	N/A	Reduction Factor of 0.9 applied to Unit 6 friction angle ( $\phi$ ' = tan ⁻¹ (0.9 tan 32°))

⁴ Koerner, G.R. & Narejo, D., (June 2005), "Direct Shear Database of Geosynthetic-to-Geosynthetic and Geosynthetic-to-Soil Interfaces" In Geosynthetic Research Institute Report #30.



¹ Design value for drained friction angle = 14° for particular zone in the Eastern Gully (refer Appendix A, Figure 1)

² Zornberg, J.G., McCartney, J.S. & Swan, R.H.(Jr), (March 2005), "Analysis of a Large Database of GCL Internal Shear Strength Results" In *Journal of Geotechnical and Geoenvironmental Engineering*, pp367-380.

³ McCartney, J.S., Zornberg, J.G. & Swan, R.H.(Jr), (February 2009), "Analysis of a Large Database of GCL -Geomembrane Interface Shear Strength Results" In *Journal of Geotechnical* and Geoenvironmental Engineering, pp209-223.

⁵ Design value for undrained shear strength =  $0.25\gamma v$  where  $\gamma$  = unit weight of overburden (kN/m³) and v = depth of overburden (m)

⁶ Qian, X, Koerner, R.M & Gray, D.H., (2002), Geotechnical Aspects of Landfill Design and Construction. Prentice-Hall, Inc., Upper Saddle River, New Jersey.



#### **APPENDIX B1**

Geotechnical Design Parameters - Stability Analysis - Liner Components and Interfaces

Liner System	Component/ Interface	Bulk Unit Weight (γ) (kN/m³)	Drained Friction Angle (φ') (°)	Drained Cohesion (c') (kPa)	Undrained Shear Strength (Cu) (kPa)	Comment
	Unit 6: Base Material (150 mm) (coarse soil)	18	32	0	-	Qian et al (2002) ⁶
	Existing cover soil (reshaped, proof - rolled soil)	19	30	0	0.25γv ⁵	Typical values
	Interface 1 - Critical Interface within Proposed Piggy Back Liner System ⁹	19	Peak = 17 Residual = 7 (slope) – 11 (flat) ¹	0	N/A	
Proposed New Cell	Unit 11: Filter Geotextile	10	N/A	N/A	N/A	Assumed not to shear internally
Liner System	Interface between Unit 11 and Unit 7	N/A	25	0	N/A	Assumed typical value
	Unit 7: Drainage Aggregate (300 mm)	18	38	0	N/A	Qian et al (2002) ⁶
	Interface between Unit 7 and Unit 12	N/A	25	0	N/A	Assumed typical value
	Unit 12: Cushion Geotextile	10	N/A	N/A	N/A	Assumed not to shear internally
	Interface between Unit 12 and Unit 16	N/A	Peak = 24 Residual = 15	0	N/A	Typical values for textured geomembrane-geotextile interface
	Unit 16: Textured HDPE Geomembrane	10	N/A	N/A	N/A	Assumed not to shear internally
	Interface between Unit 15 and Unit 17 or Internal Shearing of Unit 17: GCL	19	Peak = 17 Residual =  7 - 11 ¹	0	N/A	Typical range of values based on Zornberg et al (2005) ² , McCartney et al (2009) ³ and Koerner and Narejo (2005) ⁴
	Interface between Unit 17 and Unit 4	N/A	23	N/A	N/A	Reduction Factor of 0.8 applied to Unit 4 friction angle ( $\phi$ ' = tan ⁻¹ (0.8 tan 28°))
	Unit 4: Compacted Clay Rich Bearing Material (200 mm)	18	28	0	0.25γν⁵	Typical values for clay-rich compacted soil
	Interface 2 - Critical Interface within Proposed Cell Liner System ⁹	19	Peak = 17 Residual = 7 (slope) – 11 (flat) ¹	0	N/A	
Existing Eastern Gully Landfill Base	A. Leachate Drainage layer 500mm thick (assume clean sand)	18	38	0	N/A	Qian et al (2002) ⁶
Liner System (Slope steeper than 4H:1V)	B. Interface between materials A. and C.	N/A	30	0	N/A	Assumed typical published interface
	C. Textured HDPE Geomembrane	10	N/A	N/A	N/A	shear strength values (eg. Dixon &







#### **APPENDIX B1**

Geotechnical Design Parameters - Stability Analysis - Liner Components and Interfaces

Liner System	Component/ Interface	Bulk Unit Weight (γ) (kN/m³)	Drained Friction Angle (φ') (°)	Drained Cohesion (c') (kPa)	Undrained Shear Strength (Cu) (kPa)	Comment
	D. Interface between materials C. and E.	N/A	30	0	N/A	Jones (2003) ⁷ )
	E. Groundwater Drainage layer 500mm thick (assume gravel)	18	38	0	N/A	Qian et al (2002) ⁶
	Interface 3 - Critical Interface within Existing Eastern Gully Base Liner System (Slope steeper than 4H:1V) ⁹	19	30	0	N/A	
Existing Eastern Gully Landfill Base	A. Protective layer 300mm thick (assume coarse soil)	19	32	0	N/A	Qian et al (2002) ⁶
Liner System (Slope shallower than 4H·1V)	B. Leachate Drainage layer 300mm thick (assume clean sand)	18	38	0	N/A	Qian et al (2002) ⁶
	C. Interface between materials B. and D.	N/A	18	0	N/A	Assumed typical published interface
	D. Smooth HDPE Geomembrane	10	N/A	N/A	N/A	shear strength values (eg. Dixon &
	E. Interface between materials D. and F.	N/A	18	0	N/A	Jones (2003)')
	F. Groundwater Drainage layer 500mm thick (assume gravel)	18	38	0	N/A	Qian et al (2002) ⁶
	Interface 4 - Critical Interface within Existing Eastern Gully Base Liner System (Slope shallower than 4H:1V) ⁹	19	18	0	N/A	

http://aupws/117625003wollongongcitycouncilnewcellwhytesgully/project doc/215 slope stability/report/appendix b1 - liner stability parameters/appendix b1 - liner stability parameters.docx





⁷ Dixon, N. & Jones, D.R.V. (Golder Associates (UK) Ltd and Loughborough University Consultants Ltd.), (2003). Stability of Landfill Lining Systems: Report No. 2 Guidance (R&D Technical Report P1-385/TR2). Environmental Agency, Bristol.



Client:	Wollongong City Council
Project No:	117625003
Project:	Whytes Gully Landfill - New Landfill Cell
Reference:	117625003_059_R_Rev0-Interpretive Geotechnical Report

Analysed Cross-Section	Analysis	Target FoS	Calculated FoS	Checked By	Figure Number	Comments
	CR through New Landfill DR (P)	1.5	2.99	CSC	B3.1	CR through New LF (Entry & Exit method selected to focus on failure through waste & confirmed by a selection of fully specified failure paths)
	CR through New Landfill UD & EQ (P)	1.1	2.41	csc	B3.2	CR through New LF (selection of fully specified failure paths to focus on failure through waste)
	NC along Proposed Liner DR (P)	1.5	1.80	CSC	B3.3	Block failure along proposed liner at toe
Section E-E'	NC along Proposed Liner UD & EQ (P)	1.1	1.47	CSC	B3.4	Block failure along proposed liner at toe
	NC along Proposed Liner DR (R)	1.2^	1.35	CSC	B3.5	Block failure along proposed liner at toe
	NC along Proposed Liner UD & EQ (R)	1.0	1.10	CSC	B3.6	Block failure along proposed liner at toe
	CR below Old Landfill DR*	1.5	2.29	CSC	B3.7	CR through natural soil below LF (selection of fully specified failure paths to focus on failure below waste)
	CR below Old Landfill UD & EQ	1.1	1.67	CSC	B3.8	CR through natural soil below LF (selection of fully specified failure paths to focus on failure below waste)
	NC along Proposed Liner DR (P)	1.5	2.06	CSC	B3.9	Block failure at toe along proposed liner
	NC along Proposed Liner UD & EQ (P)	1.1	1.45	CSC	B3.10	Block failure at toe along proposed liner
	NC along Proposed Liner DR (R)	1.2^	1.49	CSC	B3.11	Block failure at toe along proposed liner
	NC along Proposed Liner UD & EQ (R)	1.0	1.06	CSC	B3.12	Block failure at toe along proposed liner
Section F-F'	CR through Old Landfill DR	1.5	2.87	CSC	B3.13	CR through New LF (Entry & Exit method selected to focus on failure through waste & confirmed by a selection of fully specified failure paths)
	CR through Old Landfill UD & EQ	1.1	2.23	CSC	B3.14	CR through New LF (selection of fully specified failure paths to focus on failure through waste - still optimises along liner)
	CR below Old Landfill DR*	1.5	2.09	CSC	B3.15	CR through natural soil under toe of new LF
	CR below Old Landfill UD & EQ	1.1	1.25	CSC	B3.16	CR through natural soil under toe of new LF
	CR through New Landfill DR (P)	1.5	2.66	CSC	B3.17	CR through New LF (Entry & Exit method selected to focus on failure through waste & confirmed by a selection of fully specified failure paths)
	CR through New Landfill UD & EQ (P)	1.1	2.14	CSC	B3.18	CR through New LF (Entry & Exit method selected to focus on failure through waste)
	NC along Proposed Liner DR (P)	1.5	1.96	CSC	B3.19	Block failure at toe along proposed liner
Section G-G'	NC along Proposed Liner UD & EQ (P)	1.1	1.60	CSC	B3.20	Block failure at toe along proposed liner
Section d-d	NC along Proposed Liner DR (R)	1.2^	1.24	CSC	B3.21	Block failure at toe along proposed liner
	NC along Proposed Liner UD & EQ (R)	1.0	1.18	CSC	B3.22	Block failure at toe along proposed liner
	NC below Old Landfill DR (P)	1.5	1.66	CSC	B3.23	Block failure along natural soil under proposed liner (selection of block & fully specified analyses)
	NC below Old Landfill UD & EQ (P)	1.1	1.31	CSC	B3.24	Large scale block failure along natural soil under proposed liner (selection of block & fully specified analyses)
	NC along Proposed Liner DR (P)	1.5	1.51	CSC	B3.25	Block failure at toe along proposed liner
	NC along Proposed Liner UD & EQ (P)	1.1	1.24	CSC	B3.26	Block failure at toe along proposed liner
	NC along Proposed Liner DR (R)	1.2^	1.24	CSC	B3.27	Block failure at toe along proposed liner
	NC along Proposed Liner UD & EQ (R)	1.0	1.01	CSC	B3.28	Block failure at toe along proposed liner
Section H-H'	CR through Old Landfill DR	1.5	3.10	CSC	B3.29	CR through Old LF (Entry & Exit method selected to focus on failure through waste & confirmed by a selection of fully specified failure paths)
	CR through Old Landfill UD & EQ	1.1	2.50	CSC	B3.30	CR through Old LF (Entry & Exit method selected to focus on
	NC along Existing Liner DR	1.5	1.99	CSC	B3.31	Large block failure at toe along existing liner
	NC along Existing Liner UD & EQ	1.1	1.63	CSC	B3.32	Large block failure at toe along existing liner

CR: Circular

NC: Non-Circular

DR: Drained (Long-term)

UN: Undrained

EQ: Earthquake

P: Peak interface shear strength (liner)

R: Residual interface shear strength (liner)

^ Factor of Saftey of 1.2 adopted for long-term (drained) scenarios where failure occurs along the proposed liner at residual shear strength conditions. Note that residual conditions are unlikely to develop across all areas of the liner simultaneously.

Results based on optimised Spencer limit equilibrium analyses, unless optimised slip appeared kinematically inadmissable (*).

For ease of modelling, all liner layers are characterised by the shear strength properties of the critical interface.

Earthquake loading assumes a horizontal acceleration of 0.045g (refer Section 5.2.2 of main report).

A 5 m limit of slip surface depth was added to the Landfill mass to prevent SlopeW converging on shallow veneer failures as required.

 $\label{eq:linear} $$ 117625003wollongongcitycouncilnewcellwhytesgully\Project Doc\215 Slope stability\SLOPE-W Analysis 117625003_059_R_Rev0_Analysis register.xlsx$ 

Prepared by: PR Date: 29/02/2012 Reviewed: CSC Date: 1/03/2012



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## Whytes Gully SlopeW - Section E-E' Name: NC along Proposed Liner_DR (P)

Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Unit Weight: 17 kN/m³ Cohesion: 2 kPa Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Phi: 26 ° Name: Unit 42a - Alluvium Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 ° Name: Unit 42b - Colluvium Unit Weight: 18 kN/m³ Cohesion: 5 kPa Model: Mohr-Coulomb Phi: 27 ° Name: Unit 43 - Residual Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 5 kPa Phi: 30 ° Name: Unit 44 - Weathered Sandstone Model: Mohr-Coulomb Unit Weight: 24 kN/m³ Cohesion: 40 kPa Phi: 38 ° Model: Bedrock (Impenetrable) Name: Unit 45 - Fresh Sandstone Name: Unit 46 - Weathered Siltstone Model: Mohr-Coulomb Unit Weight: 23 kN/m³ Cohesion: 20 kPa Phi: 36 ° Name: Interface 1 - Proposed Piggy Back Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 °



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## Name: NC along Proposed Liner_DR (R)

Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 26 ° Name: Unit 42a - Alluvium Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 ° Name: Unit 42b - Colluvium Model: Mohr-Coulomb Unit Weight: 18 kN/m³ Cohesion: 5 kPa Phi: 27 ° Name: Unit 43 - Residual Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 5 kPa Phi: 30 ° Model: Mohr-Coulomb Unit Weight: 24 kN/m³ Cohesion: 40 kPa Name: Unit 44 - Weathered Sandstone Phi: 38 ° Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Name: Unit 46 - Weathered Siltstone Model: Mohr-Coulomb Unit Weight: 23 kN/m³ Cohesion: 20 kPa Phi: 36 ° Name: Interface 1 - Proposed Piggy Back Liner System (Residual - Slopes) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 7 ° Name: Interface 2 - Proposed Cell Liner System (Residual - Slopes) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 7 ° Name: Interface 2 - Proposed Cell Liner System (Residual - Flat) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 11 °



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## Whytes Gully SlopeW - Section E-E' Name: Below Old Landfill_DR

Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Unit Weight: 17 kN/m³ Cohesion: 2 kPa Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Phi: 26 ° Name: Unit 42a - Alluvium Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 ° Model: Mohr-Coulomb Name: Unit 42b - Colluvium Unit Weight: 18 kN/m³ Cohesion: 5 kPa Phi: 27 ° Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 5 kPa Phi: 30 ° Name: Unit 43 - Residual Model: Mohr-Coulomb Name: Unit 44 - Weathered Sandstone Model: Mohr-Coulomb Unit Weight: 24 kN/m³ Cohesion: 40 kPa Phi: 38 ° Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Name: Unit 46 - Weathered Siltstone Model: Mohr-Coulomb Unit Weight: 23 kN/m³ Cohesion: 20 kPa Phi: 36 ° Name: Interface 1 - Proposed Piggy Back Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 °



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## Whytes Gully SlopeW - Section E-E' Name: Below Old Landfill_UD & EQ

Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 26 ° Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Name: Interface 1 - Proposed Piggy Back Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Model: S=f(overburden) Unit Weight: 17 kN/m³ Tau/Sigma Ratio: 0.25 Name: Unit 42a - Alluvium (UD) Minimum Strength: 25 Name: Unit 42b - Colluvium (UD) Model: S=f(depth) Unit Weight: 18 kN/m³ C-Top of Layer: 100 kPa C-Rate of Change: 10 kPa/m Limiting C: 1000 kPa Model: Undrained (Phi=0) Unit Weight: 20 kN/m³ Cohesion: 130 kPa Name: Unit 43 - Residual (UD) Name: Unit 44 - Weathered Sandstone (UD) Model: Undrained (Phi=0) Unit Weight: 24 kN/m³ Cohesion: 1000 kPa Name: Unit 46 - Weathered Siltstone (UD) Model: Undrained (Phi=0) Unit Weight: 23 kN/m³ Cohesion: 750 kPa



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Associates	CHECKED	CSC	DATE:	17/01/12	
	SCALE: As shown				





#### Name: NC along Proposed Liner_DR (P)

Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 26 ° Name: Unit 42a - Alluvium Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 ° Name: Unit 42b - Colluvium Model: Mohr-Coulomb Unit Weight: 18 kN/m³ Cohesion: 5 kPa Phi: 27 ° Name: Unit 43 - Residual Soil Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 5 kPa Phi: 30 ° Name: Unit 44 - Weathered Sandstone Model: Mohr-Coulomb Unit Weight: 24 kN/m³ Cohesion: 40 kPa Phi: 38 ° Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Name: Unit 46 - Weathered Siltstone Model: Mohr-Coulomb Unit Weight: 23 kN/m³ Cohesion: 20 kPa Phi: 36 ° Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Name: Interface 1 - Proposed Piggy Back Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 °



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	SCALE:	SCALE: As shown				





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## Name: NC along Proposed Liner_DR (R)

Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 26 ° Name: Unit 42a - Alluvium Unit Weight: 17 kN/m³ Model: Mohr-Coulomb Cohesion: 2 kPa Phi: 25 ° Name: Unit 42b - Colluvium Cohesion: 5 kPa Phi: 27 ° Model: Mohr-Coulomb Unit Weight: 18 kN/m³ Name: Unit 43 - Residual Soil Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 5 kPa Phi: 30 ° Name: Unit 44 - Weathered Sandstone Model: Mohr-Coulomb Unit Weight: 24 kN/m³ Cohesion: 40 kPa Phi: 38 ° Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Name: Unit 46 - Weathered Siltstone Model: Mohr-Coulomb Unit Weight: 23 kN/m³ Cohesion: 20 kPa Phi: 36 ° Name: Interface 1 - Proposed Piggy Back Liner System (Residual - Slopes) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Name: Interface 2 - Proposed Cell Liner System (Residual - Flat) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 11 °



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### Name: NC along Proposed Liner_UD & EQ (R) (CSC)





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	SCALE:	As sh	own		PROJECT N



### Name: CR through Old Landfill_DR

Name: Unit 41a - New Landfill Model: Mohr-Coulomb Cohesion: 0 kPa Phi: 30 ° Unit Weight: 11 kN/m³ Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 26 ° Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Name: Unit 42a - Alluvium Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 ° Unit Weight: 18 kN/m³ Cohesion: 5 kPa Name: Unit 42b - Colluvium Model: Mohr-Coulomb Phi: 27 ° Unit Weight: 20 kN/m³ Cohesion: 5 kPa Phi: 30 ° Name: Unit 43 - Residual Soil Model: Mohr-Coulomb Unit Weight: 24 kN/m³ Cohesion: 40 kPa Name: Unit 44 - Weathered Sandstone Model: Mohr-Coulomb Phi: 38 ° Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Cohesion: 20 kPa Phi: 36 ° Name: Unit 46 - Weathered Siltstone Model: Mohr-Coulomb Unit Weight: 23 kN/m³ Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Name: Interface 1 - Proposed Piggy Back Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 °



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### Name: Below Old Landfill_DR

Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 26 ° Name: Unit 42a - Alluvium Unit Weight: 17 kN/m³ Model: Mohr-Coulomb Cohesion: 2 kPa Phi: 25 ° Name: Unit 42b - Colluvium Model: Mohr-Coulomb Unit Weight: 18 kN/m³ Cohesion: 5 kPa Phi: 27 ° Name: Unit 43 - Residual Soil Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 5 kPa Phi: 30 ° Name: Unit 44 - Weathered Sandstone Unit Weight: 24 kN/m³ Cohesion: 40 kPa Model: Mohr-Coulomb Phi: 38 ° Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Name: Unit 46 - Weathered Siltstone Model: Mohr-Coulomb Unit Weight: 23 kN/m³ Cohesion: 20 kPa Phi: 36 ° Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Name: Interface 1 - Proposed Piggy Back Liner System (Peak) Model: Mohr-Coulomb



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#### Name: CR through New Landfill_DR

Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 26 ° Phi-B: 0 ° Piezometric Line: 1 Name: Unit 43 - Residual Soil Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 5 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1 Name: Unit 42a - Alluvium Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 ° Phi-B: 0 ° Piezometric Line: 1 Name: Unit 44 - Weathered Sandstone Model: Mohr-Coulomb Unit Weight: 24 kN/m³ Cohesion: 40 kPa Phi: 38 ° Phi-B: 0 ° Piezometric Line: 1 Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Piezometric Line: 1 Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1 Name: Unit 46 - Weathered Siltstone Model: Mohr-Coulomb Unit Weight: 23 kN/m³ Cohesion: 20 kPa Phi: 36 ° Phi-B: 0 ° Piezometric Line: 1 Name: Interface 1 - Proposed Piggy Back Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Phi-B: 0 ° Piezometric Line: 1 Name: Unit 42b - Colluvium Model: Mohr-Coulomb Unit Weight: 18 kN/m³ Cohesion: 5 kPa Phi: 27 ° Phi-B: 0 ° Piezometric Line: 1



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#### Name: CR through New Landfill_UD & EQ

http://aupws/117625003wollongongCityCouncilnewCellwhytesGully/Project Doc/215 Slope stability/Report/Appendix B3 - SlopeW Results/[Slope W Summary Figures.xls]B3.32

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Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 26 ° Phi-B: 0 ° Piezometric Line: 1 Name: Unit 43 - Residual Soil Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 5 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1 Name: Unit 42a - Alluvium Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 25 ° Phi-B: 0 ° Piezometric Line: 1 Name: Unit 44 - Weathered Sandstone Model: Mohr-Coulomb Unit Weight: 24 kN/m³ Cohesion: 0 kPa Phi: 38 ° Phi-B: 0 ° Piezometric Line: 1 Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Piezometric Line: 1 Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1 Name: Unit 46 - Weathered Siltstone Model: Mohr-Coulomb Unit Weight: 23 kN/m³ Cohesion: 0 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1 Name: Unit 46 - Weathered Siltstone Model: Mohr-Coulomb Unit Weight: 23 kN/m³ Cohesion: 0 kPa Phi: 36 ° Phi-B: 0 ° Piezometric Line: 1 Name: Interface 1 - Proposed Piggy Back Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Phi-B: 0 ° Piezometric Line: 1 Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Phi-B: 0 ° Piezometric Line: 1 Name: Unit 42b - Colluvium Model: Mohr-Coulomb Unit Weight: 18 kN/m³ Cohesion: 0 kPa Phi: 27 ° Phi-B: 0 ° Piezometric Line: 1



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### Name: NC along Proposed Liner_DR (P)

Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 26 ° Phi-B: 0 ° Piezometric Line: 1 Name: Unit 43 - Residual Soil Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 5 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1 Name: Unit 42a - Alluvium Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 ° Phi-B: 0 ° Piezometric Line: 1 Phi: 38 ° Name: Unit 44 - Weathered Sandstone Model: Mohr-Coulomb Unit Weight: 24 kN/m³ Cohesion: 40 kPa Phi-B: 0 ° Piezometric Line: 1 Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Piezometric Line: 1 Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1 Name: Unit 46 - Weathered Siltstone Model: Mohr-Coulomb Unit Weight: 23 kN/m³ Cohesion: 20 kPa Phi: 36 ° Phi-B: 0 ° Piezometric Line: 1 Name: Interface 1 - Proposed Piggy Back Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Phi-B: 0 ° Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Phi-B: 0 ° Piezometric Line: 1 Name: Unit 42b - Colluvium Model: Mohr-Coulomb Unit Weight: 18 kN/m³ Cohesion: 5 kPa Phi: 27 ° Phi-B: 0 ° Piezometric Line: 1





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			Wollongong City Council			Report for 50% Design				
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		SCALE:	As show	/n	PROJECT	^{No.} 117625003	FIGURE No. B3.19	A3		

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Piezometric Line: 1
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#### Name: NC along Proposed Liner_UD & EQ (P)

Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 26 ° Phi-B: 0 ° Piezometric Line: 1 Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Piezometric Line: 1 Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1 Name: Interface 1 - Proposed Piggy Back Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kNm³ Cohesion: 0 kPa Phi: 17 ° Phi-B: 0 ° Piezometric Line: 1 Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Phi-B: 0 ° Piezometric Line: 1 Name: Unit 42b - Colluvium (UD) Model: S=f (depth) Unit Weight: 18 kN/m³ C-Top of Layer: 100 kPa C-Rate of Change: 10 kPa/m Limiting C: 1000 kPa Piezometric Line: 1 Name: Unit 43 - Residual Soil (UD) Model: Undrained (Phi=0) Unit Weight: 20 kWm³ Cohesion: 130 kPa Piezometric Line: 1 Name: Unit 44 - Weathered Sandstone (UD) Model: Undrained (Phi=0) Unit Weight: 24 kN/m³ Cohesion: 1000 kPa Flezometric Line: 1 Name: Unit 46 - Weathered Siltstone (UD) Model: Undrained (Phi=0) Unit Weight: 23 kNm³ Cohesion: 750 kPa Piezometric Line: 1



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#### Name: NC along Proposed Liner_DR (R)

Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 26 ° Phi-B: 0 ° Piezometric Line: 1 Name: Unit 43 - Residual Soil Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 5 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1 Name: Unit 42a - Alluvium Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 ° Phi-B: 0 ° Piezometric Line: 1 Name: Unit 44 - Weathered Sandstone Model: Mohr-Coulomb Unit Weight: 24 kN/m³ Cohesion: 40 kPa Phi: 38 ° Phi-B: 0 ° Piezometric Line: 1 Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Piezometric Line: 1 Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1 Name: Unit 46 - Weathered Siltstone Model: Mohr-Coulomb Unit Weight: 23 kN/m³ Cohesion: 20 kPa Phi: 36 ° Phi-B: 0 ° Piezometric Line: 1 Name: Unit 42b - Colluvium Model: Mohr-Coulomb Unit Weight: 18 kN/m³ Cohesion: 5 kPa Phi: 27 ° Phi-B: 0 ° Piezometric Line: 1 Name: Interface 1 - Proposed Piggy Back Liner System (Residual - Slopes) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 7 ° Name: Interface 2 - Proposed Cell Liner System (Residual - Slopes) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 7 ° Name: Interface 2 - Proposed Cell Liner System (Residual - Flat) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 11 ° Phi-B: 0 °



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#### Name: NC along Proposed Liner_UD & EQ (R)

Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 26 ° Phi-B: 0 ° Piezometric Line: 1 Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Piezometric Line: 1 Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1 Name: Unit 42b - Colluvium (UD) Model: S=f(depth) Unit Weight: 18 kN/m³ C-Top of Layer: 100 kPa C-Rate of Change: 10 kPa/m Limiting C: 1000 kPa Piezometric Line: 1 Name: Unit 43 - Residual Soil (UD) Model: Undrained (Phi=0) Unit Weight: 20 kN/m³ Cohesion: 130 kPa Piezometric Line: 1 Name: Unit 44 - Weathered Sandstone (UD) Model: Undrained (Phi=0) Unit Weight: 24 kN/m³ Cohesion: 1000 kPa Piezometric Line: 1 Name: Unit 46 - Weathered Siltstone (UD) Model: Undrained (Phi=0) Unit Weight: 23 kN/m³ Cohesion: 750 kPa Piezometric Line: 1 Name: Interface 1 - Proposed Piggy Back Liner System (Residual - Slopes) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 7 ° Phi-B: 0 ° Piezometric Line: 1 Name: Interface 2 - Proposed Cell Liner System (Residual - Slopes) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 7 ° Phi-B: 0 ° Piezometric Line: 1 Name: Interface 2 - Proposed Cell Liner System (Residual - Slopes) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 7 ° Phi-B: 0 ° Piezometric Line: 1 Name: Interface 2 - Proposed Cell Liner System (Residual - Slopes) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 7 ° Phi-B: 0 ° Piezometric Line: 1



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Wollongong City Council	PROJECT



#### Name: Below Old Landfill_DR (Block)

Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 26 ° Phi-B: 0 ° Piezometric Line: 1 Name: Unit 43 - Residual Soil Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 5 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1 Name: Unit 42a - Alluvium Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 ° Phi-B: 0 ° Piezometric Line: 1 Name: Unit 44 - Weathered Sandstone Model: Mohr-Coulomb Unit Weight: 24 kN/m³ Cohesion: 40 kPa Phi: 38 ° Phi-B: 0 ° Piezometric Line: 1 Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Piezometric Line: 1 Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Piezometric Line: 1 Phi-B: 0 ° Name: Unit 46 - Weathered Siltstone Model: Mohr-Coulomb Unit Weight: 23 kN/m³ Cohesion: 20 kPa Phi: 36 ° Phi-B: 0 ° Piezometric Line: 1 Name: Interface 1 - Proposed Piggy Back Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Phi-B: 0 ° Piezometric Line: 1 Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Phi-B: 0 ° Piezometric Line: 1 Name: Unit 42b - Colluvium Model: Mohr-Coulomb Unit Weight: 18 kN/m³ Cohesion: 5 kPa Phi: 27 ° Phi-B: 0 ° Piezometric Line: 1



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F.	KE	eport for 50%	Design	
-		Section G-	·G'	
	Below Old I	_andfill - Long	g-term	
JECT No.	117625003	FIGURE No.	B3.23	A3
### Whytes Gully SlopeW - Section G-G'

### Name: Below Old Landfill_UD & EQ

Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 26 ° Phi-B: 0 ° Piezometric Line: 1 Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Piezometric Line: 1 Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1 Name: Interface 1 - Proposed Piggy Back Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Phi-B: 0 ° Piezometric Line: 1 Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kNm³ Cohesion: 0 kPa Phi: 17 ° Phi-B: 0 ° Piezometric Line: 1 Name: Unit 42a - Alluvium (UD) Model: S=f (overburden) Unit Weight: 17 kN/m³ Tau/Sigma Ratio: 0.25 Minimum Strength: 25 Piezometric Line: 1 Name: Unit 42b - Colluvium (UD) Model: S=f (depth) Unit Weight: 18 kNm³ C-Top of Layer: 100 kPa C-Rate of Change: 10 kPa/m Limiting C: 1000 kPa Piezometric Line: 1 Name: Unit 43 - Residual Soil (UD) Model: Undrained (Phi=0) Unit Weight: 20 kN/m³ Cohesion: 130 kPa Piezometric Line: 1 Name: Unit 44 - Weathered Sandstone (UD) Model: Undrained (Phi=0) Unit Weight: 24 kN/m³ Cohesion: 1000 kPa Piezometric Line: 1 Name: Unit 46 - Weathered Siltstone (UD) Model: Undrained (Phi=0) Unit Weight: 23 kN/m³ Cohesion: 750 kPa Piezometric Line: 1



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## Whytes Gully SlopeW - Section H-H'

# Name: NC along Proposed Liner_DR (P)

Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 26 ° Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 ° Name: Unit 42a - Alluvium Model: Mohr-Coulomb Name: Unit 43 - Residual Soil Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 5 kPa Phi: 30 ° Name: Unit 44 - Weathered Sandstone Model: Mohr-Coulomb Unit Weight: 24 kN/m³ Cohesion: 40 kPa Phi: 38 ° Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Name: Interface 1 - Proposed Piggy Back Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Name: Interface 3 - Eastern Gully Base Liner System (Steep) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Name: Interface 4 - Eastern Gully Base Liner System (Shallow) Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 18 ° Model: Mohr-Coulomb



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## Whytes Gully SlopeW - Section H-H'

## Name: NC along Proposed Liner_DR (R)

Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Unit 41b - Old Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 26 ° Unit Weight: 17 kN/m³ Cohesion: 2 kPa Phi: 25 ° Name: Unit 42a - Alluvium Model: Mohr-Coulomb Name: Unit 43 - Residual Soil Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 5 kPa Phi: 30 ° Name: Unit 44 - Weathered Sandstone Model: Mohr-Coulomb Unit Weight: 24 kN/m³ Cohesion: 40 kPa Phi: 38 ° Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Name: Interface 1 - Proposed Piggy Back Liner System (Residual - Slopes) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 7 ° Name: Interface 3 - Eastern Gully Base Liner System (Steep) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Name: Interface 4 - Eastern Gully Base Liner System (Shallow) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 18 ° Name: Interface 2 - Proposed Cell Liner System (Residual - Eastern Gully) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 14 ° Name: Interface 1 - Proposed Piggy Back Liner System (Residual - Eastern Gully) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 14 °



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http://aupws/117625003wollongongCityCouncilnewCellwhytesGully/Project Doc/215 Slope stability/Report/Appendix B3 - SlopeW Results/[Slope W Summary Figures.xls]B3.32

### Whytes Gully SlopeW - Section H-H'

## Name: CR through Old Landfill_UD & EQ

Name: Unit 41a - New Landfill Model: Mohr-Coulomb Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Name: Unit 41b - Old Landfill Unit Weight: 11 kN/m³ Cohesion: 0 kPa Phi: 30 ° Model: Mohr-Coulomb Name: Unit 41c - Soil Fill Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 26 ° Name: Unit 45 - Fresh Sandstone Model: Bedrock (Impenetrable) Name: Interface 2 - Proposed Cell Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Name: Interface 1 - Proposed Piggy Back Liner System (Peak) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 17 ° Name: Interface 3 - Eastern Gully Base Liner System (Steep) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 ° Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 18 ° Name: Interface 4 - Eastern Gully Base Liner System (Shallow) Name: Unit 42a - Alluvium (UD) Model: S=f(overburden) Unit Weight: 17 kN/m³ Tau/Sigma Ratio: 0.25 Minimum Strength: 25 Name: Unit 43 - Residual Soil (UD) Model: Undrained (Phi=0) Unit Weight: 20 kN/m³ Cohesion: 130 kPa Name: Unit 44 - Weathered Sandstone (UD) Model: Undrained (Phi=0) Unit Weight: 24 kN/m³ Cohesion: 1000 kPa



<u>~</u>	CLIENT	Wollon	gong Ci	ty Council	PROJECT
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	SCALE:	As sh	own		PROJECT No.

http://aupws/117625003wollongongCityCouncilnewCellwhytesGully/Project Doc/215 Slope stability/Report/Appendix B3 - SlopeW Results/[Slope W Summary Figures.xls]B3.32





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# **APPENDIX C** Settlement Analysis Results



### INTERPRETATIVE GEOTECHNICAL INVESTIGATION REPORT

Appendix C Figure No.	Description
C.1	Settle3D Model Inputs
C.2	Settle 3D Result - Section F-F' - CH425 m Existing Soil Profile - Total Settlement
C.3	Settle 3D Result - Section F-F' - CH475 m Existing Soil Profile - Total Settlement
C.4	Settle 3D Result - Section F-F' - CH570 m Existing Soil Profile - Total Settlement
C.5	Settle 3D Result - Section F-F' - CH600 m Existing Soil Profile - Total Settlement
C.6	Settle 3D Result - Section F-F' - CH630 m Existing Soil Profile - Total Settlement
C.7	Western Gully Landfill – Historical Filling Stages
C.8a	Long Term Waste Settlement Results - Section F-F' - Western Gully Landfill Geometry data
C.8b	Long Term Waste Settlement Results - Section F-F' -Western Gully Landfill Geometry of waste filling stages (graph)
C.8c	Long Term Waste Settlement Results - Section F-F' – Western Gully Landfill Existing waste settlement calculations
C.8d	Long Term Waste Settlement Results - Section F-F' – Western Gully Landfill Settlement induced liner strains & liner grade change calculations
C.8e	Long Term Waste Settlement Results - Section F-F' – Western Gully Landfill Old landfill waste compression after new landfill waste placement (graph).
C.9	Eastern Gully Landfill – Historical Filling Stages
C.10a	Long Term Waste Settlement Results - Section H-H' - Western Gully Landfill Geometry data
C.10b	Long Term Waste Settlement Results - Section H-H' -Western Gully Landfill Geometry of waste filling stages (graph)
C.10c	Long Term Waste Settlement Results - Section H-H' – Western Gully Landfill Existing waste settlement calculations
C.10d	Long Term Waste Settlement Results - Section H-H' – Western Gully Landfill Settlement induced liner strains & liner grade change calculations
C.10e	Long Term Waste Settlement Results - Section H-H' – Western Gully Landfill Old landfill waste compression after new landfill waste placement (graph).
C.11	Long Term New Waste Settlement Results – Section F-F' – Ch 175 m
C.12	Long Term New Waste Settlement Results – Section G-G' – Ch 200 m
C.13	Long Term New Waste Settlement Results – Section H-H' – Ch 220 m
C.14	Long Term New Waste Settlement Results – Cross Final Landform Settlement induced strains & grade change calculations
C.15	Liquefaction Assessment Calculations



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UNIT 4(c)	5.5m	3-0M	Om	Om	25m			
Umr 42(a)	1	1	16 m	9m	25m		-	
UNIT 4203)	4.5m	9m	1	1	1	++++++		
UNIT 43	4m	4m	4111	4m	4111		1	
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Stage 26 2020 Assume that 60 Assume that 60 Assume that 6 Assume that 6 Assume that 6 Loading sequent $\frac{CL 425}{t=0} = 2013$ t=15 (town) t=16 (Hyr) t=.17 (H271) t=20 (tSyrs) t=40 (tSyrs) t=40 (tSyrs) t=40 (tSyrs) t=20 (tS	- 2035 (15 of weste w t=0 ground t= to ground t= to ground t= to ground (ayes = 0 Layer = 0 Layer = 18 Layer = 18 Layer = 0 AH = 30m 8 = 11m al Load = 330 Emboutment layer = 0 Mayer = 0 Layer = 0 AH = 30 AH	(h) (h) (h) (h) (h) (h) (h) (h)	$\frac{0.475}{t=0}$ $\frac{0.475}{t=0}$ $\frac{1}{t=15}$ $\frac{1}{t=17}$ $\frac{1}{t=18}$ $\frac{0}{t=2}$ $\frac{0}{t=2}$	t = 22 year of 2mbgl. 3mbgl. 3mbgl. 3mbgl. (+1yr) (+2yrs) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (-1) (+1y93) (-1) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2) (-2	Entertain Ma Entertain Ma Entertain Ma Entertain Ma Entertain Ma Entertain Ma Entertain Ma Entertain Ma Entertain Ma Entertain An Entertain Entert Entertain Entertain Entert Entertain Entertain Entert	u Anges resations. del lond as emi t = 0 = t = 22 t = 23 t = 24 t = 27 t = 40	2013 = Stat3 (+ 14r) (+ 24R) (+ 24R) (+ 444R)	Entontonento to change hochange hyer En hochange Hochange Hochange Hochange
Stage 26 2020 Assume that 60 Assume that 60 Assume that 6 Assume that 6 Assume that 6 Loading sequent $\frac{C+425}{t=0} = 2013$ t=15 (toyos) t=16 (tlyo) t=17 (t271) t=20 (tSyrs) t=40 (t4091s) (STAGE 26) (STAGE 26) (d) C(600) =22(0) = =23 (tlyo) =27 (tSure)	- 2035 (15 of weste w t=0 ground t= 10 ground t= 10 ground (ayer = 0 Layer = 0 Layer = 18 Layer = 18 Layer = 18 Layer = 0 AH = 30m 8 = 11m al Load = 330 Emboutment Layer = 0 Layer = 7.84 Layer = 7.84 Layer = 7.84	(4) (1) (1) (1) (1) (1) (1) (1) (1	$\frac{CL475}{t=0}$ $\frac{CL475}{t=0}$ $\frac{T=15}{t=16}$ $\frac{T=16}{t=18}$ $\frac{T=16}{t=2}$ $\frac{CL}{t=2}$ $\frac{CL}{t=2}$	t = 22 year of 2mbgl. 3mbgl. 3mbgl. 3mbgl. 2013 = SlortZ (+1yr) (+2yrs) (+3yrs) (+1yrs) (+1yrs) (+1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs) (-1yrs	Ententment (N) Ententment (N) Ententment (N) Ententment (N) Enger = On Bayer = On Bayer = En Bayer = En Bayer = En Bayer = En Bayer = On Bayer = On Entention Entention Entention Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enternion Enterni Enternion Enternion Enternion Enterni	(L570 t=0= t=22 t=22 t=23 t=24 t=27 t=40 - - - - - - - - - - - - -	2013 = Stat3 (+ 14r) (+ 24re) (+ 54rs) (+ 49rs) (+ 49rs)	E layers. E layers. To Change No change Inger S. Sin Ho Change Ho Change. Ho Change. Ho Change. Ho Change. Ho Change. Ho Change. Ho Change.
Stage 26 2020 • Assume that 6a • Assume that 6a • Assume that 6 • Assume that 6 • Assume that 6 • $\frac{1}{4330000}$ that 6 $\frac{1}{200000000000000000000000000000000000$	- 2035 (15 of Weste W t= 0 ground t= 40 ground t= 40 ground (ayes = 0 Layer = 0 Layer = 6 Layer = 7 SH = 30m 8 = 11m al Load = 330 Emboutment layer = 0 Layer = 7.84 Layer = 7.84 Layer = 7.84 Layer = 7.84 Layer = 7.84	(h) (h) (h) (h) (h) (h) (h) (h)	$\frac{d}{d} = \frac{d}{d} = \frac{d}$	t = 22 year of 2mbgl. 3mbgl. 3mbgl. 3mbgl. (+1yr) (+2yrs) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93) (+1y93	Entertant (N) Entertant (N) Operation. Ma Entertant (N) Dayer = Om Dayer = Om Sayer = Om Sayer = Om Dayer = Om Sayer = Om Dayer	u Ange 3 resations. del lond as emi t = 0 = t = 22 t = 23 t = 24 t = 24 t = 27 t = 40	2013 = Stat3 (+ 14r) (+ 24R) (+ 24R) (+ 444R)	Entontonenta Entontonenta nochange Nochange Jage S. Sin Nochange Hochange Hochange Hochange S. = Ukulat ad = 122-6512

	CLIENT	Wollong	ong City	Council	PROJECT	Whytes Gully Ne	ew Landfill Cel	1
Coldon	DRAWN	GS/RMP	ATE:	16/01/11	TITLE:	Western Gully Lan	ndfill	
Associates	CHECKED		ATE:	16/01/11		Settle3D Model Inputs		
	SCALE:	N/A	Ą		PROJECT No.	117625003	JRE No. <b>C.1</b>	A3













### <u>117625003 Whytes Gully New Landfill Cell</u> <u>Western Gully Landfill - Section F-F'</u> <u>Geometry data (cross section elevations) for existing waste settlemen</u>t

Proposed Liner Thickness

0.8 m

Point	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Chainage	25	50	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500	525	550	575	600	625	650
Elevation (mRL) - New Waste																										
Stage 1 (a)																										
Stage 1 (b)																										
Stage 1 (c)																										
Stage 1 (d)																										
Stage 2 (a)			95.61	99.76	103.75	107.56	110.22	107.48	102.61	97.53	92.74	87.96	83.07	78.23	72.95											
Stage 2 (b)		90.25	91.42	91.65	92.51	91.43	89.69	86.73	83.4	80.58	77.47	74.87	74.51	73.69	71.27	67.99	60.44	52.56	45.05	37.53	30					
Stage 2 (c)																										
Stage 2 (d)																										
Stage 2 (e)																										
Stage 3 (a)																	63.21	58.08	52.93	48.03	43	37.93	32.86	27.78	23.16	18.77
Stage 3 (b)																										
Stage 3 (c)																										
Stage 4 (a)																										
Stage 4 (b)																										
Stage 4 (c)																										
Top of Liners	87.16	86.5	85.92	84.84	83.23	79.44	75.1	70.21	66.29	62.14	57.71	53.63	49.46	44.94	42.06	38.33	31.59	29.41	28.42	25.53	27.14	24.47	22.51	20.75	19.75	19.57
Top of stage 3 waste		85.7	85.12	84.04	82.43	78.64	74.3	69.41	65.49	61.34																
Top of stage 2 waste					60	60	60	60	60	60	56.91	52.83	48.66	44.14	41.26											
Top of stage 1 waste									40	40	40	40	40	40	40	37.53										
Base of old waste	86.36	76.75	69.14	61.47	55.31	49.38	46.84	41.28	38.45	34.42	32.72	31.13	30.99	30.85	30.84	30.8	30.79	28.61	27.62	24.73	26.34	23.67	21.71	19.95	18.95	18.77
Calculated Thickness (m)																										
Stage 1 (a)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 1 (b)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 1 (c)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 1 (d)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 2 (a)	0	0	4.19	8.11	11.24	16.13	20.53	20.75	19.21	16.95	15.27	13.09	8.56	4.54	1.68	0	0	0	0	0	0	0	0	0	0	0
Stage 2 (b)	0	3.75	5.5	6.81	9.28	11.99	14.59	16.52	17.11	18.44	19.76	21.24	25.05	28.75	29.21	29.66	28.85	23.15	16.63	12	2.86	0	0	0	0	0
Stage 2 (c)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 2 (d)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 2 (e)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 3 (a)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.77	5.52	7.88	10.5	13	37.93	32.86	27.78	23.16	18.77
Stage 3 (b)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 3 (c)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 4 (a)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 4 (b)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 4 (c)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Piggyback liner	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
stage 3	0	8.95	15.98	22.57	22.43	18.64	14.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
stage 2	0	0	0	0	4.69	10.62	13.16	18.72	20	20	16.91	12.83	8.66	4.14	1.26	0	0	0	0	0	0	0	0	0	0	0
stage 1	0	0	0	0	0	0	0	0	1.55	5.58	7.28	8.87	9.01	9.15	9.16	6.73	0	0	0	0	0	0	0	0	0	0



# 117625003 - Section F-F' - Western Gully Landfill Geometry of waste filling stages

### 117625003 Whytes Gully New Landfill Cell 2. EXISTING WASTE SETTLEMENT CALCULATION Western Gully Landfill - Section F-F

Waste Materials		Old w	aste	New Waste	Basis of adopted value								
Material	stage 1	stage 2	stage 3										
waste type	MSW	MSW	MSW	New	from available site information								
Unit Weight (kN/m3)	11	11	11	11	assumed based on waste type								
C-ce (mod primary)	0.2	0.2	0.2	NA	range from Gourc & Olivier (2005) is 0.12 to >0.24								
C-c alph (mod secondary)	0.06	0.06	0.06	NA	range from Gourc & Olivier (2005) is 0.02 to >0.14								
average age in 2017(yr)	33	29.5	26	-	from available site information								

### 2.1 SHORT-TERM "PRIMARY CONSOLIDATION"

Section 12.4.2 Settlement of existing solid waste: Eq 12.9, Ref Xuede, Koerner and Gray P.451

$$s = H \times C_{cs} \times \log \frac{\sigma_0 + \Delta \sigma}{\sigma_0}$$

Assumptions

use Sigma-0 = current vertical stress at layer midpoint use delta-sigma = vertical stress increase from new waste placement

 $C_{carepsilon}$  - Modified primary compression index

2.2 LONG-TERM "SECONDARY CONSOLIDATION"

Section 12.4.2 Settlement of existing solid waste: Eq 12.11, Ref Xuede, Koerner and Gray P.451

$$s = H \times C_{a\varepsilon} \times \log \frac{t_{final}}{t_{initial}}$$

Assumptions

use t-initial= average age in 2017 at start of Stage 2 use t-final= t-initial plus 40 years

 $C_{lphaarepsilon}$  - Modified secondary compression index

t initial starting time of the secondary settlement. Assumed to be equal to the age of the existing landfill for vertical expansion. t final ending time of the secondary settlement

### 2.1 Short-Term "Primary" Settlement of Liner

Point	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Chainage (m)	25	50	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500	525	550	575	600	625	650
Thickness of New Landfill Waste Filling Stage	es (m)																									
Stage 1 (a)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 1 (b)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 1 (c)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 1 (d)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 2 (a)	0	0	4.19	8.11	11.24	16.13	20.53	20.75	19.21	16.95	15.27	13.09	8.56	4.54	1.68	0	0	0	0	0	0	0	0	0	0	0
Stage 2 (b)	0	3.75	5.5	6.81	9.28	11.99	14.59	16.52	17.11	18.44	19.76	21.24	25.05	28.75	29.21	29.66	28.85	23.15	16.63	12	2.86	0	0	0	0	0
Stage 2 (c)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 2 (d)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 2 (e)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 3 (a)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.77	5.52	7.88	10.5	13	37.93	32.86	27.78	23.16	18.77
Stage 3 (b)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 3 (c)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 4 (a)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 4 (b)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 4 (c)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total thickness of new waste	0	3.75	9.69	14.92	20.52	28.12	35.12	37.27	36.32	35.39	35.03	34.33	33.61	33.29	30.89	29.66	31.62	28.67	24.51	22.5	15.86	37.93	32.86	27.78	23.16	18.77
Thickness Western Gully Filling Stage3	0.00	8.95	15.98	22.57	22.43	18.64	14.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.77	5.52	7.88	10.50	13.00	37.93	32.86	27.78	23.16	18.77
Sigma-0 (kN/m2)	NA	49.23	87.89	124.14	123.37	102.52	78.65	NA	15.24	30.36	43.34	57.75	71.50	208.62	180.73	152.79	127.38	103.24								
Delta-sigma (kN/m2)	NA	41.25	106.59	164.12	225.72	309.32	386.32	NA	347.82	315.37	269.61	247.50	174.46	417.23	361.46	305.58	254.76	206.47								
Calc settlement of layer (m)	0.00	0.47	1.10	1.65	2.03	2.25	2.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.76	1.17	1.35	1.52	1.40	3.62	3.14	2.65	2.21	1.79
Thickness Western Gully Filling Stage2	0.00	0.00	0.00	0.00	4.69	10.62	13.16	18.72	20.00	20.00	16.91	12.83	8.66	4.14	1.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sigma-0 (kN/m2)	NA	NA	NA	NA	272.53	263.45	229.68	102.96	110.00	110.00	93.01	70.57	47.63	22.77	6.93	NA										
Delta-sigma (kN/m2)	NA	NA	NA	NA	225.72	309.32	386.32	409.97	399.52	389.29	385.33	377.63	369.71	366.19	339.79	NA										
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.25	0.72	1.13	2.61	2.66	2.63	2.41	2.06	1.63	1.02	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thickness Western Gully Filling Stage1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.55	5.58	7.28	8.87	9.01	9.15	9.16	6.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sigma-0 (kN/m2)	NA	NA	NA	NA	NA	NA	NA	NA	228.53	250.69	226.05	189.92	144.82	95.87	64.24	37.02	NA									
Delta-sigma (kN/m2)	NA	NA	NA	NA	NA	NA	NA	NA	399.52	389.29	385.33	377.63	369.71	366.19	339.79	326.26	NA									
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.45	0.63	0.84	0.99	1.25	1.46	1.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total "Primary" settlement (m)	0.00	0.47	1.10	1.65	2.27	2.97	3.33	2.61	2.80	3.08	3.03	2.90	2.62	2.27	1.89	1.34	0.76	1.17	1.35	1.52	1.40	3.62	3.14	2.65	2.21	1.79

2.2 Long-Term "Secondary" Settlement of Liner Note: for the purpose of this secondary settlement calculation, all piggy back liner and overlying new waste is assumed to be placed at the same time. This is choes to corrspond of the start

Point	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
New Waste																										
Total Thickness	0.00	3.75	9.69	14.92	20.52	28.12	35.12	37.27	36.32	35.39	35.03	34.33	33.61	33.29	30.89	29.66	31.62	28.67	24.51	22.50	15.86	37.93	32.86	27.78	23.16	18.77
Old Waste																										
Thickness Western Gully FIlling Stage3	0.00	8.95	15.98	22.57	22.43	18.64	14.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.77	5.52	7.88	10.50	13.00	37.93	32.86	27.78	23.16	18.77
T-initial (yr)	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00
T-final (yr)	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00
Calc settlement of layer (m)	0.00	0.22	0.39	0.55	0.54	0.45	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.13	0.19	0.25	0.32	0.92	0.80	0.67	0.56	0.46
Thickness Western Gully Filling Stage2	0.00	0.00	0.00	0.00	4.69	10.62	13.16	18.72	20.00	20.00	16.91	12.83	8.66	4.14	1.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T-initial (yr)	29.50	29.50	29.50	29.50	29.50	29.50	29.50	29.50	29.50	29.50	29.50	29.50	29.50	29.50	29.50	29.50	29.50	29.50	29.50	29.50	29.50	29.50	29.50	29.50	29.50	29.50
T-final (yr)	69.50	69.50	69.50	69.50	69.50	69.50	69.50	69.50	69.50	69.50	69.50	69.50	69.50	69.50	69.50	69.50	69.50	69.50	69.50	69.50	69.50	69.50	69.50	69.50	69.50	69.50
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.10	0.24	0.29	0.42	0.45	0.45	0.38	0.29	0.19	0.09	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thickness Western Gully FIlling Stage1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.55	5.58	7.28	8.87	9.01	9.15	9.16	6.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T-initial (yr)	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00
T-final (yr)	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.12	0.15	0.18	0.19	0.19	0.19	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total "Secondary" settlement(m)	0.00	0.22	0.39	0.55	0.65	0.69	0.64	0.42	0.48	0.56	0.53	0.47	0.38	0.28	0.22	0.14	0.07	0.13	0.19	0.25	0.32	0.92	0.80	0.67	0.56	0.46
Natural Soil Profile Total Settlement (m) (Settle3D outputs)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.53	0.45	0.41	0.50	0.55	0.65	0.67	0.39	0.17	0.15
Sum of calculated "Primary" and "Secondary" settlement (m)	0.00	0.69	1.49	2.20	2.92	3.66	3.98	3.03	3.28	3.64	3.56	3.37	3.00	2.55	2.11	1.47	0.83	1.75	1.96	2.27	2.26	5.19	4.60	3.71	2.94	2.40

117625003 Whytes ( Western Gully Land 3. CALCULATE S	Gully Ne fill - Sec SETTL	w Landfill Cell tion F-F EMENT-INDUC	ED LI	NER STRAINS &	& LINI	ER GRADE CHAN	IGES					
Point	1		2		3		4		5		6	
interval		1-2		2-3		3-4		4-5		5-6		6-7

Point	1	2		3	4		5		6	7		8	9			10	11		12	13		14	15		16		17	18		19	20		21	22		23	24	25	.5	26
interval	1-2		2-3		3-4	4-5		5-6	6-7		7-8		8-9	9	9-10		10-11	11-12	12-1	13	13-14		14-15	15-16		16-17	17-18		18-19		19-20	20-21		21-22	22-23	23-24	24-	25	25-26	
Distance (m) Existing Elevation (m) Existing interval surface length (m) Existing interval grade (%)	25 36.36 25.000 0.6	50 86.50	25.007 -2.3	75 85.92	10 84.1 25.023 -4.3	0 4 25.052 -6.4	125 83.23	25 296 -15 2	150 79.44 25.374 -17.4	175 75.10	25.474 -19.6	200 70.21	25.305 -15.7	29 29 2	2 5.342 16.6	250 2.14	275 57.71 25.389 -17.7	25.331 -16.3	300 53.63 25.3 -16	325 49.4 7	5 16 25.405 -18.1	350 44.94	375 42.06 -11.5	25.277 -14.9	400 38.33	25.893 -27.0	425 31.59 25.09 -8.7	451 29.4	0 1 25.020 -4.0	475 28.42	500 25.53 25.166 -11.6	25.052 6.4	525 27.14	550 24.47 25.142 -10.7	25.077 -7.8	575 22.51 25.062 -7.0	600 20.75 25.0 4.	62 19.7 0	5 75 25.001 -0.7	650 19.57
Total calculated primary and secondary settlement (m) Elevation after primary and secondary settlement (m) Post-settlement surface length of interval (m)	6.360 25.006	0.7 85.810	25.038	1.5 84.430	2: 82.6 25.084	25.109	2.9 80.309	7 25.406	3.7 5.783 25.430	4.0 71.124	25.309	3.0 67.181	3 63.0 25.345	3 112 24	5.405	3.6 3.496	3.6 54.147 25.375	25.301	3.4 50.256 25.2	3.0 46.45 87	25.329	2.6 42.388	2.1 38.951 25.118	25.191	1.5 36.856	25.732	0.8 30.760 25.19	1.8 27.61	25.029	2.0 26.464	2.3 23.257 25.205	25.053	2.3 24.879	5.2 19.28 25.819	25.038	4.6 17.910 25.015	3.7 17.040 25.0	2.5 16.8	2 311 25.003	2.4 17.173
Settlement-induced strain (%), [positive=tension]	0.0		0.1		0.2	0.2		0.5	0.2		-0.6		0.2		0.2		-0.1	-0.1	-02	2	-0.30		-0.19	-0.34		-0.62	0.38		0.04		0.15	0.00		1.90	-0.16	-0.19	-0.	80	0.01	
Post-settlement interval grade (%)	-2.2		-5.5		-7.2	-9.3		-18.1	-18.6		-15.8		-16.7	-	18.1		-17.4	-15.6	-15	2	-16.3		-9.7	-12.4		-24.4	-12.4		-4.8		-12.8	6.5		-22.4	-5.5	-3.5	-0.	9	1.4	
Settlement-induced grade change (%)	-2.8		-3.2		-2.8	-2.9		-2.9	-1.3		3.8		-1.0		-1.5		0.3	0.8	1.4	8	1.81		1.77	2.54		2.58	-3.68		-0.82		-1.27	0.05		-11.72	2.36	3.56	3.0	16	2.17	
Grade Change?	Grade Rever	sal	No Grade Reversal		No Grade Reversal	No Grade Reversal		No Grade Reversal	No Grade Revers	sai	No Grade Reversal	No	Grade Reversal	No Grad	de Reversal	No Gr	rade Reversal	No Grade Reversal	No Grade I	Reversal	No Grade Reversal	No	o Grade Reversal	No Grade Reversal		No Grade Reversal	No Grade R	eversal	No Grade Reversal		No Grade Reversal	No Grade Reversa		No Grade Reversal	No Grade Reversal	No Grade Reversa	No Grade	Reversal	Grade Reversal	

105.00 95.00 Liner (existing) Liner (post-settlement) 85.00 75.00 65.00 55.00 45.00 35.00 25.00 15.00 5.00 100 200 300 400 0



Elevation (m)

Dist (m)





CALE:

N/A

				310	
	PROJECT No.	117625003	FIGURE No.	C.9	A3
1/11		Filling	Stages		
1/11		Eastern Gully I	_andfill		

### <u>117625003 Whytes Gully New Landfill Cell</u> <u>Eastern Gully Landfill - Section H-H'</u> <u>Geometry data (cross section elevations) for existing waste settlement</u>

Proposed Design Thickness of Piggyback Liner: 0.8 m

Point	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Chainage	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500	525
Elevation (mRL) - New Waste																			
Stage 1 (a)		80.87	86.21	92.01	98.02	101.05	99.8												
Stage 1 (b)							94.59	94.41	89.02	83.62	78.23	72.84	67.45	62.01	56.46	50.91	45.36	39.25	34.16
Stage 1 (c)																			
Stage 1 (d)																			
Stage 2 (a)																			
Stage 2 (b)																			
Stage 2 (c)																			
Stage 2 (d)																			
Stage 2 (e)																			
Stage 3 (a)																			
Stage 3 (b)																			
Stage 3 (c)																			
Stage 4 (a)																			
Stage 4 (b)																			
Stage 4 (c)																			
Top of Liners	$\sim$	$\sim$	88.26	89.31	89.82	89.91	85.2	78.8	74.99	71.13	66.44	63.12	59.99	53.13	47.2	38.84	31.68	30.05	26.8
Top of stage 4 waste			87.46	88.51	89.02	89.11	84.4												
Top of stage 3 waste					80	80	80	78	74.19	70.33	65.64	62.32	59.19	52.33					
Top of stage 2 waste								50	50	50	50	50	50	50	46.4	38.04	30.88	29.25	
Top of stage 1 waste	76.54	79.96	80	80	70	60	50	40	35										
Base of old waste	74.41	62.9	52.5	45	39	36.9	34.3	30	30	30	26	26	26	26	26	26	26	26	26
Calculated Thickness (m)	•																		
Stage 1 (a)	0	0.91	-2.05	2.7	8.2	11.14	5.21	0	0	0	0	0	0	0	0	0	0	0	0
Stage 1 (b)	0	0	0	0	0	0	9.39	15.61	14.03	12.49	11.79	9.72	7.46	8.88	9.26	12.07	13.68	9.2	7.36
Stage 1 (c)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 1 (d)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 2 (a)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 2 (b)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 2 (c)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 2 (d)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 2 (e)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 3 (a)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 3 (b)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 3 (c)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 4 (a)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 4 (b)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 4 (c)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Piggyback liner			0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
stage 4	0	0	7.46	8.51	9.02	9.11	4.4	0	0	0	0	0	0	0	0	0	0	0	0
stage 3	0	0	0	0	10	20	30	28	24.19	20.33	15.64	12.32	9.19	2.33	0	0	0	0	0
stage 2	0	0	0	0	0	0	0	10	15	20	24	24	24	24	20.4	12.04	4.88	3.25	0
stage 1	2.13	17.06	27.5	31	31	23.1	15.7	10	5	0	0	0	0	0	0	0	0	0	0



# 117625003 Whytes Gully New Landfill Cell Eastern Gully Landfill - Section H-H' 2. EXISTING WASTE SETTLEMENT CALCULATION

Waste Materials		Old w	aste		New Waste	basis of adopted value
Material	stage 1	stage 2	stage 3	stage 4	-	
waste type	MSW	MSW	MSW	MSW	MSW	from available site information
Unit Weight (kN/m3)	11	11	11	11	11	assumed based on waste type
C-ce (mod primary)	0.2	0.2	0.2	0.2	NA	range from Gourc & Olivier (2005) is 0.12 to >0.24
C-c alph (mod secondary)	0.06	0.06	0.06	0.06	NA	range from Gourc & Olivier (2005) is 0.02 to >0.14
average age in 2013(yr)	16	10.5	7.5	1.5	-	from available site information

### 2.1 SHORT-TERM "PRIMARY CONSOLIDATION"

2.2 LONG-TERM "SECONDARY CONSOLIDATION"

Section 12.4.2 Settlement of existing solid waste: Eq 12.9, Ref Xuede, Koerner and Gray P.451

$$s = H \times C_{c\varepsilon} \times \log \left| \frac{\sigma_0 + \Delta \sigma}{\sigma_0} \right| C_{c\varepsilon}$$
 - Modified primary compression index  
C'c = 0.17 ~ 0.36

Section 12.4.2 Settlement of existing solid waste: Eq 12.11, Ref Xuede, Koerner and Gray P.451

$$s = H \times C_{\alpha \varepsilon} \times \log \frac{t_{final}}{t_{initial}}$$

 $C_{lphaarepsilon}$  - Modified secondary compression index

Assumptions use Sigma-0 = current vertical stress at layer midpoint use delta-sigma = vertical stress increase from new waste placement

Assumptions use t-initial= average age in 2013 use t-final= t-initial plus 40 years

t initial starting time of the secondary settlement. Assumed to be equal to the age of the existing landfill for vertical expansion. t final ending time of the secondary settlement

### 2.1 Short-Term "Primary" Settlement of Liner

Point	1	2	2	4	5	6	7	0	0	10	11	12	12	14	15	16	17	10	10
Chainage (m)	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500	525
Proposed Staged Filling Programme Fle	vations (m	)	120	100	110	200	220	200	210	000	020	000	0/0	400	420	400	410	000	020
Stage 1 (a)		0.91	-2.05	27	82	11 14	5.21	0	0	0	0	0	0	0	0	0	0	0	0
Stage 1 (b)	ő	0.01	0	0	0.2	0	9.39	15.61	14.03	12 49	11 79	9.72	7.46	8 88	9.26	12.07	13.68	92	7 36
Stage 1 (c)	ő	0	0	0	0	0	0.00	0	0	0	0	0.72	0	0.00	0.20	0	0	0	0
Stage 1 (d)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	ő	0	0	ő	ő
Stage 2 (a)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 2 (a)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 2 (b)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 2 (d)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 2 (e)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 3 (a)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 3 (b)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 3 (c)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 4 (a)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 4 (b)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stage 4 (c)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total thickness of new waste	0	0.91	-2.05	2.7	8.2	11.14	14.6	15.61	14.03	12.49	11.79	9.72	7.46	8.88	9.26	12.07	13.68	9.2	7.36
Thickness Old Waste Stage4	0.00	0.00	7.46	8.51	9.02	9.11	4.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sigma-0 (kN/m2)	NA	NA	41.03	46.81	49.61	50.11	24.20	NA	NA										
Delta-sigma (kN/m2)	NA	NA	-22.55	29.70	90.20	122.54	160.60	NA	NA										
Calc settlement of layer (m)	0.00	0.00	-0.52	0.36	0.81	0.98	0.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thickness Old Waste Stage3	0.00	0.00	0.00	0.00	10.00	20.00	30.00	28.00	24.19	20.33	15.64	12.32	9.19	2.33	0.00	0.00	0.00	0.00	0.00
Sigma-0 (kN/m2)	NA	NA	NA	NA	154.22	210.21	213.40	154.00	133.05	111.82	86.02	67.76	50.55	12.82	NA	NA	NA	NA	NA
Delta-sigma (kN/m2)	NA	NA	NA	NA	90.20	122.54	160.60	171.71	154.33	137.39	129.69	106.92	82.06	97.68	NA	NA	NA	NA	NA
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.40	0.80	1.46	1.82	1.62	1.42	1.25	1.01	0.77	0.44	0.00	0.00	0.00	0.00	0.00
Thickness Old Waste Stage2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	15.00	20.00	24.00	24.00	24.00	24.00	20.40	12.04	4.88	3.25	0.00
Sigma-0 (kN/m2)	NA	NA	NA	NA	NA	NA	NA	363.00	348.59	333.63	304.04	267.52	233.09	157.63	112.20	66.22	26.84	17.88	NA
Delta-sigma (kN/m2)	NA	NA	NA	NA	NA	NA	NA	171.71	154.33	137.39	129.69	106.92	82.06	97.68	101.86	132.77	150.48	101.20	NA
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.48	0.60	0.74	0.70	0.63	1.01	1.14	1.15	0.80	0.54	0.00
Thickness Old Waste Stage1	2.13	17.06	27.50	31.00	31.00	23.10	15.70	10.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sigma-0 (kN/m2)	11.72	93.83	233.31	264.11	379.72	447.26	464.75	363.00	293.59	NA	NA								
Delta-sigma (kN/m2)	0.00	10.01	-22.55	29.70	90.20	122.54	160.60	171.71	154.33	NA	NA								
Calc settlement of layer (m)	0.00	0.15	-0.24	0.29	0.57	0.49	0.40	0.34	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total "Primary" settlement (m)	0.00	0.15	0.00	0.65	1.79	2.26	2.64	2.49	2.28	2.01	1.99	1.71	1.40	1.44	1.14	1.15	0.80	0.54	0.00

### 2.2 Long-Term "Secondary" Settlement of Liner

Point	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
New Waste																			
Total Thickness	0.00	0.91	-2.05	2.70	8.20	11.14	14.60	15.61	14.03	12.49	11.79	9.72	7.46	8.88	9.26	12.07	13.68	9.20	7.36
Old Waste																			
Thickness Old Waste Stage4	0.00	0.00	7.46	8.51	9.02	9.11	4.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T-initial (yr)	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
T-final (yr)	41.50	41.50	41.50	41.50	41.50	41.50	41.50	41.50	41.50	41.50	41.50	41.50	41.50	41.50	41.50	41.50	41.50	41.50	41.50
Calc settlement of layer (m)	0.00	0.00	0.65	0.74	0.78	0.79	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thickness Old Waste Stage3	0.00	0.00	0.00	0.00	10.00	20.00	30.00	28.00	24.19	20.33	15.64	12.32	9.19	2.33	0.00	0.00	0.00	0.00	0.00
T-initial (yr)	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50
T-final (yr)	47.50	47.50	47.50	47.50	47.50	47.50	47.50	47.50	47.50	47.50	47.50	47.50	47.50	47.50	47.50	47.50	47.50	47.50	47.50
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.48	0.96	1.44	1.35	1.16	0.98	0.75	0.59	0.44	0.11	0.00	0.00	0.00	0.00	0.00
Thickness Old Waste Stage2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	15.00	20.00	24.00	24.00	24.00	24.00	20.40	12.04	4.88	3.25	0.00
T-initial (yr)	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50
T-final (yr)	50.50	50.50	50.50	50.50	50.50	50.50	50.50	50.50	50.50	50.50	50.50	50.50	50.50	50.50	50.50	50.50	50.50	50.50	50.50
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.41	0.61	0.82	0.98	0.98	0.98	0.98	0.83	0.49	0.20	0.13	0.00
Thickness Old Waste Stage1	2.13	17.06	27.50	31.00	31.00	23.10	15.70	10.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T-initial (yr)	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00
T-final (yr)	56.00	56.00	56.00	56.00	56.00	56.00	56.00	56.00	56.00	56.00	56.00	56.00	56.00	56.00	56.00	56.00	56.00	56.00	56.00
Calc settlement of layer (m)	0.07	0.56	0.90	1.01	1.01	0.75	0.51	0.33	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total "Secondary" settlement(m)	0.07	0.56	1.54	1.75	2.27	2.50	2.34	2.08	1.94	1.80	1.73	1.57	1.42	1.09	0.83	0.49	0.20	0.13	0.00
Sum of calculated "Primary" and	0.07	0.71	1.54	2.40	4.06	4 77	4.09	4 59	4.22	2.01	2.72	2.20	2 02	2.54	1.09	1.64	1.00	0.67	0.00
Secondary Settlement (III)	0.07	0.71	1.04	2.40	4.00	4.77	4.90	4.00	4.22	3.01	3.72	3.29	2.02	2.04	1.90	1.04	1.00	0.07	0.00

117625003 Whytes Gully New Landfill Cell Eastern Gully Landfill - Section H-H 3. CALCULATE SETTLEMENT-INDUCED PIGGY BACK LINER STRAINS & LINER GRADE CHANGES

Point	1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18		19
interval		1-2		2-3		3-4		4-5		5-6		6-7		7-8		8-9		9-10		10-11		11-12															
Distance (m) Existing Elevation (m) Existing interval surface length (m)	75 0.00	25.000	100 0.00	91.732	125 88.26	25.022	150 89.31	25.005	175 89.82	25.000	200 89.91	25.440	225 85.20	25.806	250 78.80	25.289	275 74.99	25.296	300 71.13	25.436	325 66.44	25.219	350 63.12	25.195	375 59.99	25.924	400 53.13	25.694	425 47.20	26.361	450 38.84	26.005	475 31.68	25.053	500 30.05	f 2 25.210	525 26.80
Existing interval grade (%)		0.0		353.0		4.2		2.0		0.4		-18.8		-25.6		-15.2		-15.4		-18.8		-13.3		-12.5		-27.4		-23.7		-33.4		-28.6		-6.5		-13.0	
Total calculated primary and secondary settlement (m) Elevation after primary and secondary settlement (m)	0.1		0.7		1.5 86.717		2.4 86.912		4.1 85.761		4.8 85.143		5.0 80.220		4.6 74.223		4.2 70.770		3.8 67.319		3.7 62.716		3.3 59.831		2.8 57.167		2.5 50.594		2.0 45.220		1.6 37.197		1.0 30.680		0.7 29.382	2	0.0
Post-settlement surface length of interval (m)		25.008		90.928		25.001		25.026		25.008		25.480		25.709		25.237		25.237		25.420		25.166		25.142		25.850		25.571		26.256		25.835		25.034		25.133	
Settlement-induced strain (%), [positive=tension] Post-settlement interval grade (%)		0.0		-0.9 349.7		- <b>0.1</b> 0.8		<b>0.1</b> -4.6		0.0		0.2		-0.4 -24.0		-0.2 -13.8		- <b>0.2</b> -13.8		-0.1 -18.4		-0.2 -11.5		-0.2 -10.7		-0.29 -26.3		-0.48 -21.5		-0.40 -32.1		-0.65 -26.1		-0.08 -5.2		-0.31 -10.3	
Settlement-induced grade change (%), [positive=steeper grade]		-2.6		-3.3		-3.4		-6.6		-2.8		-0.9		1.6		1.4		1.6		0.3		1.7		1.86		1.15		2.22		1.34		2.57		1.33		2.67	
Grade Change?		Grade Reversal		No Grade Reversal		No Grade Reversal		Grade Reversal		Grade Reversal		No Grade Reversal		No Grade Reversal		No Grade Reversal		No Grade Reversal		No Grade Reversal		No Grade Reversal		No Grade Reversal		No Grade Reversal		No Grade Reversal		No Grade Reversal		No Grade Reversal		No Grade Reversal		No Grade Reversal	



1	
	Golder
	Associates

SUBJECT SECTION F-F'-	VEW WASTE LONG TERM	SETTLEMENT
Job No.: 117625003	Made by RMP	Date 13/01/2012
Ref. QIAN /KOERNER/GRAY	Checked by	Sheet of

GEOMETRY TAKEN FROM CH 17

EOMETRY	TALEN PR	om Ch17				
RL		DATE				
110-27	2m	- 2046		į.,		
H 10 C	2					
110, = 20-50	Sm	New Waste	ON O OF = 145 @ 2046			
1			At 6 2046 = 0			
89-6	59m-	2024	bi = . lyr			
		2034	62 at 2086 = 41yrs			
$Ho_2 = 15 \cdot 17$ m	n	New Waste	av. age = 15405 e 2034			
21. 50		2031 /	$t_1 = 12 + 1.5 \text{ yrs} = 13.5 \text{ yrs}$			
74.00		- 1993	tz at 2086 - 53-5415			
63 = 14-5 m	<b>n</b>	oldwaste	av. age - 140 @ 1993			
			$\Delta t = 53 yrs$			
60m		- 1991	$t_1 = 53 + 1 = 54 y_{15}$			
		ald waste	$E_2 = 2080 = 1775$			
$H_{04} = 13.6 m$	-	C COT M Care	$\Delta t + 2046 = 55 \text{ yrc}$			
46.8	400	- 19.96	8, = 55 + 2.5 = 57-Syrs			
			E2 at 2086 = 97.5415			
ONGTERM	SECOND MEY	GETTLEMENT				
A 11	a)	1 1. 62	(a 450 an 1977)			
2164 =	C ~ 1	o. 109 4	(p. 400 eg. 12 4)			
where :						
62 =	time at 2	086 (+40yrs)				
t1 =	ave. age of	waste at 2046.				њ. В. Ц.
G =	= 0.06	hader one				
110	= intria ing	el inickness,				
- 1 I I I I I I I I I I I I I I I I I I		, (41)				
0-0	06 · 20 - 53 ·	log (T) =	4.0m			
1.1	15.19	lan (53.5) =	Ar55m			
00	/6 • (3-( ) •	(13.5)				
0-0	06.14.5 .	log (94) =	0-21 m			
		(925)				
0-	06 - 13-6 -	log ( 57.5)	= 0.19m			
4		<b>v</b>			1 1	
	C.,	10.40				
	Sum of	f Settlement	2.95 m			
	Sum of	Settlement	2.95 m			
	Sum of	Settlement	2.95 m			
	Sum og	Settlement	2.95 m			



SUBJECT SECTION 9-9'-	- NEW WASTE LONG	TERM SETTLEMENT
Job No.: 1176 25003	Made by RMP	Date 13 /01/12
Ref. OLAN/ KOERNER/GRAY	Checked by	Sheet / of /

110.12 .	NEW 410100	ave. age = 2046 = 2.5/2 = 125413	G= 1.25415
07 = 15.34m	"Store 3"	de la pono pogis	2- 11-27
1/0 = 30.68m 94.68	2020/2043.	av. age @ 2020 = 4/2 = 2415.]"stag At to 2048 = 26415	e 24**
	Stage 2.1"		
$10_2 = 15.34 \text{ m}$		: t1 = 28415	
79-44	Assumets Incomfessible MATERIAL.	tz = 66 yrs (t@ 2006)	
LONG TERM SETTLE	ment (p.450 eq. 12-7)		
4 H2 = C.	x. No. Log (tz.)		
Where !			
$t_2 = age al$	+ 2060 (+40yrs)		
ti = ave.ag	e at 2020		
()L = 0.06	( Rof Golde report: 55_ Rev	0. Interpreport)	
$H_o = lnifia$	I layer hickness		
:. AH2			
Stage 3 =	0.06 × 15.34 × log (41.25	) = 1.40 m	
Stage 2 =	0.06 × 15.34 x log ( 28 )	= 0-34m	
	Sum of settlem	unt = <u>1.74m</u>	
ASSUMPTION			
New waste has	been modelled in two stage	(2 and 3) as staging plan allows M.	nor



SUBJECT SECTION H-H'-	NEW WASTE LONG TERM	SETTLEMENT
Job No.: 17625003	Made by RMP	Date 13/01/2012
Ret. QIAN/KOCRNER/GRAY	Checked by	Sheet / of /

SECTION H-H' C.	h220 m		
PL (m)	DALE		
101	2035	AV OOF - 15/2 = 7-5400	$t_1 = 7.5yrs$
$l_0 = 10.15 \text{ WAST}$	E	At to 2035 = 0	$t_2 = 47.5_{75}$
90-85 Star	e 2(B) 2017/2020	ave age = 5/2 = 2-5415	t, = 20 . Syis
10 = 5-85 85m - 010	10 2012 WASIE 2012	At to 2035 = 18 yrs	E2 = 60 . 54 rs
lo = 5m "Ilag	c4"	ave age = 8/2 = 1.5415	: ti = 24-5415
		A C 10 2035 = 2043	E2 = 64-5415
80.m "Sta	2009	ave see = 2/2 = 14+	1. Er = 274rs
10 = 19	<b>j</b> e 2	0 E 60 2035 = 26415	t2 = 6tyrs
1			
61 m - 201	1996/2007	ave age = 3/2 = 1.5415	1, t1 = 40.5415
39.43	1993	4 th 2035 = 39	62 = 80.5413
ONG TERM SECON	NDARY SETTIEMENT	(p. 450 eg 12-7)	
si y num			
Allah = C'a	· Ho· log (t2)		
h 1 1.5.	+ 1-75 /2025. 40	<u>.</u>	
$t_1 = av, a$	ge of waste @ 2035	s j	
('2 = 0.0)	6		
No = Inits	ial layer thickness		
Stage 2(B)	= 0.05 × 10.15 × log	$\left(\frac{475}{75}\right) = 0.49m$	
Stage 7	= 0.06 x 5.85 x lo	$g\left(\frac{60.5}{20.5}\right) = 0.16m$	
"Stage 4"	= 0.06 × 5 × 6g	$\left(\frac{64-5}{24-5}\right) = 0.13m$	
"Stage 3"	= 0.00 × 19 × 609	$\left(\frac{67}{17}\right) = 0.45m$	
"Stage 1"	= 0.06 x 21.57 x lo	$g\left(\frac{80.5}{40.5}\right) = 0.39m$	
	Sum of sett	lement 1.62 m	
1+1+1+			

117625003 Whytes Gully New Landfill Cell CROSS FINAL LANDFORM NEW AND EXISTING WASTE SETTLEMENT -INDUCED CAPPING SYSTEM GRADE CHANGES

Point	1		2		3
Profile	Section F-F'		Section G-G'		Section H-H'
Section Chainge (m)	CH175		Ch200		Ch200
Interval		1-2		2-3	
Distance (m)	0		130		280
Existing Elevation (m)	110.22		110.12		101.15
Existing interval surface length (m)		130.000		150.268	
Existing interval grade (%)		-0.1		-6.0	
Total calculated primary and secondary settlement (m)	3.0		1.7		1.6
Elevation after primary and secondary settlement (m)	107.270		108.380		99.530
Post-settlement surface length of interval (m)		130.005		150.261	
Settlement-induced strain (%), [positive=tension]		NA		NA	
Post-settlement interval grade (%)		0.9		-5.9	
Settlement-induced grade change (%)		0.9		0.1	
Grade Change?		Grade Reversal		No Grade Reversal	

					Sheet	1	of	1
Colden	Whytee Gully		Job No. :	117625003	Ref.	Interpretative Report		
Golder		vviiyte	5 Guil	y	Made by :	JDM	Date :	17 January 2012
Associates					Checked by:	PRED	Date :	17 January 2012
Liquefaction Assessment using CPT								
Beference : Bobertson P.K. 2004 Evaluating Soil Liquefaction :	and Post-Farthqual	ke deformations	using the CP	т				
Version - 01.00		ke deformations	using the of	•				
Location : GABH05 - 1.2m								
Input Data :					Note			
Cone penetration resistance	qc (kPa)	2200.00						
CPT sleeve friction stress	fs (kPa)	22.00						
Depth of Reported qc values	Depth (m)	1.20						
Total vertical overburden stress	σ _{vo} (kPa)	21.60						
Effective vertical overburden stress	σ' _{vo} (kPa)	21.60						
Additional Surcharge on top	g (kPa)	0.00						
	11 17							
Maximum horizontal acceleration at ground surface	a _{max} /q	0.09						
Farthquake magnitue	M	6.50						
		0.00						
Stress reduction factor	rd	0.99			Eg. 2			
Magnitude Scaling Factor	MSE	1.44			=q. = Fg. 9			
ing intere county i actor					-4. 0			
Stress exponent	n	1.00	0.50	0.75				
Normalised cone penetration resistance (dimensionless)	0	100.85	46.87	68.75	Eg. 5			
Normalised friction ration in per cent	F	1.01			-4			
Soil behavioiur type index	l c	1.91	2.18	2.04				
Normalised cone penetration resistance (dimensionless)	a c1N	101.85	47.34	69.44	l c iteration using a	c1N		
	l c	1.91	2.17	2.04				
Correction factor	k c	1.20	1.61	1.36	Eq. 7 (if 2.6>lc>	1.64, kc=1 if lc<1.64	1	
Normalised cone penetration resistance (dimensionless)	g c1N	47.34			(k c=1)			
Equivalent clean sand normalise cone penetration resistance	(q_c1N) cs	122.08	76.23	94.22	Eq. 4			
					-			
	(q_c1N)_cs	76.23			If Ic>2.6 use n=1, Ic<	2.6 use n=0.5, lc ~2.6	6 use n=0.75	
					IF Ic>2.6 pageible CI	avev SILT evaluate	using other criteria	
Son classification			Sana		Unlikely to liquefy if	F>1% as well	using other criteria	
Cvclic Stress Ratio for M = 7.5	CSR 7.5	0.0404			Eq. 1 and Eq 9.			
Cyclic Resistance Ratio for M = 7.5	CRR 7.5	0.1212			Eq. 3	for 50<(g_c1N) cs<	<160	
,		0.1135			Eq. 3	for (g c1N) cs<50		
					-4			
Factor of Safety	FoS	3.00						
		0.00						
J:\civ\2011\Whytes Gully - Amendments to Report\Technical\[Liguef	action-Robertson W	hytes Gully.xls1G	ABH05-Loose	SAND 1.2m to 2m				



# **APPENDIX D** Deformation Analysis Results

April 2012 Report No. 117625003_059_R_Rev1





### **PLAXIS Analysis**

To assist in quantifying landfill behaviour for liner design, finite element PLAXIS analyses were carried out to model the performance of the piggy back liner and the new landfill cell base liner during the various stages of construction and operation.

Specifically, the modelling was carried out to assess forces and strains within the liner systems resulting from differential settlement of the existing landfill and natural materials under the overburden load of the proposed new landfill materials, and for the case of hypothetical soft spots below the liner.

In addition, PLAXIS modelling was used to cross-check critical stability mechanisms against those obtained from limit equilibrium slope stability (Slope/W) models and to cross check global settlements against those obtained from one-dimensional settlement spreadsheet analyses.

### 1.1.1 Modelling approach

Two PLAXIS finite element models were developed, as follows:

- A two dimensional (2D) "global" model along the centerline of the western gully to quantify overall timedisplacement behavior, simplified single liner stresses and strains, total and differential settlements, operational surface slope gradients and potential failure mechanisms; and
- A "local" axisymmetric model examining more closely the interaction between the existing and proposed landfill at a critical liner location identified in the 2D analysis. This incorporates two geosythentic layers (geogrid and geomembrane) and a nominally sized buried soft spot to assess liner behavior in response to localised deformations.

Generic liner properties were adopted for the PLAXIS analyses, with frictional interface properties that were adjusted according to the case being analysed, viz:

- 2D Geogrid assessment for liner forces: These are utilized in the 2D model at the new/old landfill interface where a default geogrid (Unit 18) was included with relatively high 'peak' geogrid/gravel friction interface values. We note that the geogrid is present in the piggy back liner but not the new cell base liner.
- 2D Geomembrane assessment for slope stability: Potential slip surfaces between liner components and the low interface friction geomembrane component (Unit 15-LLDPE where it occurs in the piggy back liner, or Unit 16-HDPE in the new cell base liner) were interrogated in the 2D model by substituting the geogrid properties (above) with geomembrane properties, and replacing gravel/geogrid interface values with appropriate liner/soil or liner/composite properties. Residual friction angles were adopted for interfaces to assess critical failure mechanisms.

A graphical summary of the geogrid, geomembrane and interface combinations used in the analyses are summarised in Table D1, overleaf.

Typical sections of the proposed new cell liner and piggy back liner are included in design drawings D022 and D031, respectively (ref: 117625003_001_D_RevA).




### Table D1 – PLAXIS Cases 1 to 3

	Piggy back liner	New Landfill Cell base liner
	(placed on top of existing landfill) ¹	(placed below new landfill in the toe area) ¹
PLAXIS 2D Model for Global Behaviou	ur using single, simplified liner (Sett	lement, Liner forces, Stability)
<b>Case 1</b> Simplified Liner Model (for 2D strain and axial force check)	Base/Geogrid Interface: Units 6/18 (29°) Geogrid Base/Geogrid Interface: Units 18/6 (29°)	Cushion/HDPE Interface ² : Units 16/12 (24°) HDPE HDPE/GCL Interface ² : Units 16/17 (15°)
Case 2 Simplified Liner Model (for 2D stability check) PLAXIS Axisymmetric Model for Local	Geocomposite Drainage/LLDPE Interface ³ : Units 14/15 (15°) LLDPE LLDPE/GCL Interface ³ : Units 15/17 (12°) Piggy back Liner Design (Liner ford	Cushion/HDPE Interface ³ : Units 16/12 (15°) HDPE HDPE/GCL Interface ³ : Units 16/17 (12°) Ces) – soft spot
Case 3 (Combined Geogrid and Geomembrane) LLDPE/GCL Into Base/Geogrid In	Geocomposite Drainage /LLDPE Interface ² : Units 14/15 (24°) Compacted Protection Laye LLDPE erface ² : Units 15/17 (20°) Clay Rich Layer terface: Units 6/18 (29°) Base Material (Gravel) Geogrid Base/Geogrid Interface: Units 6/18 (29°)	N/A

Notes:

1. Refer to parameters in Table 2-4 (of main report) for detailed description of interface materials and friction values

2. Peak values used in Case 1 to provide increased friction (i.e. load transfer) for strength/strain checks

3. Residual type values used in Case 2 to use reduce friction for stability checks

### **1.1.2 Material properties**

Material properties used in the analyses are summarised in Tables 2 and 3 (of main report), and in Appendix D1, attached. Compressibility parameters were selected based on the results of limited laboratory testing and experience at similar sites. The adopted set of input variables for the base case analyses are





considered to represent "moderately conservative" strength and stiffness properties for homogeneous landfill material.

The moderately conservative, homogeneous landfill compressibility values used in the PLAXIS model could be calibrated against field data from the proposed settlement pad trial. In lieu of this data, the sensitivity of key input design parameters (landfill stiffness, geogrid stiffness and geogrid on/off) have been assessed to a limited degree to quantify the impact on settlements, liner forces and strains. We anticipate that additional sensitivity analyses will be completed for key input parameters (including landfill compressibility, soft spot geometry and soft spot stiffness) in subsequent, detailed design stages.

As the landfill behaviour is expected to be dominated by global creep settlements resulting from ongoing decomposition of the landfill, the "soft soil creep" constitutive model in PLAXIS was adopted for the landfill materials (Unit 41) including the prepared cohesive subgrade overlying the existing landfill. This model was also adopted for the clayey (i.e. consolidating) materials including soil fill (Unit 41c), alluvium (Unit 42), and colluvium (Unit 42).

An elasto-plastic Mohr-Coulomb constitutive model was adopted for the residual soil (Unit 43), base material (Unit 6) within the liner system and compacted clay-rich bearing material (Unit 4). The rock was assumed to behave as a linear-elastic material.

The geogrid and geomembrane components were modelled using structural 'Geogrid' elements provided in PLAXIS. The stress-strain characteristics for these components were estimated from typical laboratory test data from manufacturers and published literature. In the PLAXIS model, stiffness is input as modulus x cross sectional area (EA) properties. Factored base case EA values of 500 kN/m and 80 KN/m have been adopted for the geogrid and LLDPE membrane layers, respectively, based on values used in previous projects. These factored design values correspond to equivalent stiffness material reduction factors (in the direction of the geogrid bars) of 1.6 on a medium-weight geogrid product such as <u>Global Synthetics Secugrid</u> 40/40 Q1, and a factor of approximately 8 for the 1.5mm thick LLDPE gemomembrane liner <u>Permathene L200</u>. We note that these factors are intended to reflect a stiffness reduction due to installation damage, creep and other factors, and are considered reasonable for the purpose of this modelling.

The soil/geotextile interfaces in PLAXIS are modelled as having zero thickness, along which sliding can occur, according to user-defined strength and stiffness properties. Interfaces were modelled using the appropriate interface element shear strength properties summarised in Table D1, above. The soil/geotextile interface stiffness properties which apply before yielding are equal to the adjacent host soil properties. The sensitivity of the design to interface stiffness was checked by doubling the interface stiffness, but this had an insignificant effect on mobilised liner forces.

### 1.1.3 PLAXIS 2D analysis for global behaviour

The profile for Cross-Section F through the Western Gully was adopted for the PLAXIS 2D analysis, as this section represents significant and variable thicknesses of both the existing landfill and new landfill materials. The schematic layout of the model is shown in Figure D1 below.





Figure D1: General layout of PLAXIS 2D analysis

The simplified construction sequence used in the model comprised: construction of the old landfill to existing levels (end 2011), installation of liner elements (end 2013), placement of landfill in the new landfill cell (end 2060), and ongoing consolidation to 40 years from end of filling. Displacements in the model were zeroed at the time of liner placement.

A sketch summarising the modelled construction sequence is summarised in Figure D2, below. The modelled sequence underestimates the age of the existing waste above RL 70, which was actually placed between 1991 and 1993, but this is considered to be conservative as the younger landfill in the as-modelled condition will experience larger post-construction creep settlements. We note also that an area at the base of the landfill has conservatively been modelled as Stage 4 filling but this would in fact be older Stage 4 filling. We consider this would have a minor effect on the modelled outcomes.





Figure D2: PLAXIS 2D Construction Sequence

The finite element mesh was re-constructed ("re-meshed") between calculation stages to account for the high displacements experienced in the landfill materials. Outputs from the PLAXIS model are presented at '40 years after filling', corresponding to a point in time 40 years after completion of new landfill to RL 112m AHD (year 2100). We note that this is 87 years following placement of initial geotextiles and commencement of new filling at the toe of the existing landfill. In the base case outputs provided below, no account of liner stiffness reduction over time is allowed for because a relatively low, factored stiffness is used from the outset. The effect of liner stiffness is assessed separately in the sensitivity section.

Leachate levels were modelled as approximately 2m above the base of the existing landfill, although we note that the modelling results are not expected to be highly sensitive to this assumption, as liner forces and displacements are governed principally by creep behaviour.

Geosynthetic stiffness properties for the liner and geogrid have been entered in the PLAXIS model as linear elastic values (kN/m). These factored values have been based on product data sheets for commonly available products and are representative of the material properties when operating within serviceability limits. Normal and frictional loads are transferred to the geosynthetic layers through interface elements which have user defined properties discussed in Section 1.1.2.

The resulting geogrid liner and geomembrane strains and forces are then obtained from the PLAXIS model in the following ways:

Liner/geogrid Forces: These are output directly from the PLAXIS model at relevant time intervals without manipulation. A single liner/geogrid stress value is generated for each 'stress point' within the nominated liner/geogrid. Stress points are spaced at automatically generated finite element mesh intersections and at intermediate nodes.





Liner/geogrid Strains: These are simply obtained by dividing the Liner/Geogrid Forces (above) by the user-defined (factored) stiffness (EA) value to obtain the strain at a given location. In places where lateral compression occurs, strains are non-zero (negative). For the purposes of this assessment, these compressive strains are ignored (assigned zero values on plots) and only tensile strains are shown on plots as positive values.

### 1.1.3.1 Results

The results of the 2D PLAXIS analyses indicate settlements at the liner interface of up to about 3m at 40 years from completion of filling with new landfill materials. Large-scale (i.e. non-soft-spot) differential settlements of up to 1 in 30 were identified at this end-of-life time step near the crest of the existing landfill, which is considered satisfactory because this is unlikely to result in surface grade reversals.

Using the methodology discussed above, zones of concentrated elevated liner stress and tensile strain were identified at the following locations along the liner, as shown in Figure D3 and as described below:

- A. Near the crest of the existing landfill, where the liner is relatively restrained against downwards movement, and incremental strains accumulate towards upslope areas;
- B. Near the proposed location of maximum height of new landfill materials; and
- C. Near the new cell base liner, where consolidating natural materials (colluvium and alluvium) materials underlie the liner.

The distribution of axial forces and strains in the liner (modeled below as a single, continuous geogrid) at 40 years after completion of filling are shown in Figures D3 to D5 below.



Figure D3: Schematic distribution of axial force in the geogrid 40 years after filling





Figure D4: Distribution of axial force in the geogrid at 40 years after filling



Figure D5: Distribution of strains in the geogrid at 40 years after filling





As shown in Figure D4 above, the maximum mobilised axial force near the upslope end of the geogrid is approximately 8 kN/m and the maximum tensile strains are in the order of 2 %. These strains are well within the typical operational range for geogrids, being in the order of up to 5 %. Excess pore pressures in the alluvium near the landfill toe are largely dissipated at the end of the design life (2100) and result in generally lower geogrid forces compared to upslope areas.

### 1.1.3.2 Comparison with 1D settlement analysis

A comparison was carried out between the results of the 2D PLAXIS model and the 1D spreadsheet settlement analysis, at 40 years after full height of filling. The results are summarised in Table D2 below, and generally indicate that results are within agreement to approximately 20 %. This is considered reasonable given the intrinsic differences in theoretical approach.

Model Chainage	Spreadsheet Prediction (m)	PLAXIS Prediction (m)	% Difference (PLAXIS Vs. XLS)	Year end
75	1.49	1.5	1	2053
Average at 60-90	1.46	1.54	5	2033
180	3.98	3.04	-24	2060
Average at 170-190	3.5	3.01	-14	2000
205	3.03	3.09	2	2066
Average at 145-260	3.5	2.94	-16	2000
320	3	2.38	-21	2073
Average at 230-410	2.65	2.13	-20	2013
435	0.83	0.30	-64*	2079

### Table D2- Piggy back liner Settlements (m), 40 years after full height filling at that location

Note * 1-D 'blanket loading' approach is likely to significantly over-estimate settlement in this 'locally loaded' area.

### 1.1.3.3 PLAXIS Slope stability analysis

A slope stability analysis was carried out for the stage of final filling using the c-phi reduction feature in PLAXIS 2D. During the c-phi reduction analysis, the strength of the soil strata is incrementally reduced until a failure mechanism forms, as determined using nominated strain criteria. The calculated incremental displacement obtained from a c-phi reduction analysis in the model incorporating the geomembrane identifies a most probable slip mechanism, while the magnitude of the reduction indicates how much reserve capacity (or global Factor of Safety, FoS) is available. This is not directly comparable to a limited equilibrium FoS value, which is a measure of the ratio of disturbing force to available resistance, but the two FoS values should typically match to within about 10%.

The PLAXIS global Factor of Safety calculated for the stage of final filling is approximately 1.8. This is comparable to the limit equilibrium FoS results obtained from Slope/W analysis for Cross-Section F to within approximately 10 % (refer Section 6.1). The critical failure mechanism predicted by PLAXIS is shown in Figure D6 below and almost exactly matches the comparable SLOPE/W mechanism. The corresponding predicted relative movement along the liner (geomembrane) interface associated with the PLAXIS failure analysis is approximately 3m. In other words, the factor of safety against a 3m slip displacement developing is approximately 1.8.





Figure D6: Displacement contours at induced failure from PLAXIS stability analysis

### 1.1.4 PLAXIS axisymmetric analysis for local behaviour

The results of the 2D analysis were interrogated to identify areas of high axial forces and strains within the geogrid. The axisymmetric model was then accordingly created at the location of maximum new landfill height, as shown in Figure D3 above, to explore geogrid and liner behaviour at a more localised level of detail. The main purpose of the axisymmetric model is to assess the impact of a potential softer area within the landfill, as opposed to the global liner behaviour from the 2D model.

To perform an upper bound assessment of variation in landfill compressibility over a short distance, a hypothetical zone of "soft landfill" was introduced into the model as a zone measuring 6m in diameter and 5m thick, buried 2m below the piggy back liner in an area of higher stiffness existing landfill. A study carried out for a similar landfill in Victoria¹ identified this soft spot geometry as reasonable in terms of differential settlements on the basis that excavation and compaction of existing landfill materials will be carried out to shallow depths below the liner (Manassero, 2006). Although such excavation and compaction of existing waste is likely to be minimal for the Whytes Gully project, we consider that this soft spot geometry provides a reasonable basis for analysing the effects of potential landfill variability on liner performance.

The construction sequence and timing used in the 2D analysis was also adopted for the axisymmetric analysis, with the exception that the new landfill was applied as a surcharge load. Stresses and strains within the liner were then obtained using the methodology developed for the 2D model, described in Section 1.1.3.

Given the shallow depths represented in the axisymmetric model, leachate levels did not apply. The axisymmetric model geometry is shown below in Figures D7 and D8.

Manassero, M. 2006. 'Geosynthetic Reinforced Composite Clay Liner Performace Evaluation Under Differential Settlements 07217-PPPXVVE06-MAR', Studio Geotecnico Italiano, Milan







Figure D7: General layout of PLAXIS axisymmetric analysis



Figure D8: Detail View of Liner Components in PLAXIS axisymmetric analysis

### 1.1.4.1 Results

As shown in Figures D9 and D10 overleaf, maximum differential settlements across the piggy back liner are less than 1/15. The settlement profile reflects the presence of the soft landfill material, as expected. We note that as the gradient of the differential settlement is less than the proposed slope gradient, and so a surface depression resulting from this hypothetical soft spot settlement is not likely to result in ponding.

As shown in Figures D11 and D12, the localised maximum axial force in the geogrid due to the soft spot is approximately 6 kN/m, which is less than the peak global forces developed in the 2D model. The corresponding maximum tensile geogrid strain is approximately 1 %. The maximum strain in the geomembrane at 40 years is approximately 3 %.

Conservatively superimposing the peak global 2D strains of about 2 % with the peak hypothetical local soft spot strains at up to 1 % at the end of cell design life (40 years after completion of filling), the predicted





maximum geogrid liner strain is predicted to be less than 4 %. This is within the typical limiting value of 5% for geogrid products and, in practice, it is unlikely that these two conditions would occur at the same location on the landfill.

Similarly, the maximum geomembrane strains at the end of cell design life (40 years after completion of filling) in the base case soft-spot model, are predicted to be less than 3 %. This is within the typical limiting value of 8% to 10% for geosynthetic liner products.



Figure D9: Displacement contours at 40 years from end of filling (from time of liner placement)

The computed shear stress levels along the soil/geogrid interface are highest near the edge of the soft spot, where tensile forces and strains are highest, and are within about 50% of the yield shear stress value (i.e. within the elastic range of deformation). Corresponding relative movements at the soil/geogrid interface are very small, being only fractions of a millimetre.











Figure D11: Base Case axial forces at 40 years from end of filling (Axisymmetric model)







Figure D12: Base Case strains at 40 years from end of filling (Axisymmetric model)





### 1.1.5 Sensitivity analyses

Basic sensitivity analyses have been carried out to quantify the effect of varying landfill and liner stiffness, and removal of the geogrid. Sensitivity cases were undertaken as follows:

- Softened landfill stiffness sensitivity: Compressibility parameters in the axisymmetric model were increased from Cc=0.6, Ca=0.06 (representing "intermediate compressibility", Gourc 2005) to Cc =0.72, Ca =0.14 (representing "high to very high compressibility"). The compressibility of the soft spot was increased from Cc=1.0, Ca=0.2 (representing "high to very high" compressibility) to Cc=2, Ca=0.4 (representing "very high" compressibility). This change effectively made the soft spot relatively softer compared to the host material in the sensitivity case.
- Softened geogrid stiffness sensitivity: The reduced waste stiffness sensitivity case above was concurrently analysed with a range of geogrid stiffness values of 500 kN/m (base case), 360 kN/m (reduced stiffness) and for the case of no geogrid.

[m] 5.00 4.75 4.50 4.25 4.00 3.75 3,50 3 25 3.00 2.75 2.50 2.25 2.00 1.75 1.50 1.25 1.00 0.75 0.50 0.25 0.00 Total displacements |u| Maximum value = 4.938 m (Element 149 at Node 7657) Whytes Gully Axisymmetric 9/02/2012 PLAXIS Axi Whytes Gully (softer) - ... 393 Golder Associates Pty Ltd

The results are shown in Figures D13 to D15, below.

Figure D13: Displacements for softened landfill stiffness (includes settlement before liner placement)





Figure D14: Sensitivity analyses for liner force with varying geogrid stiffness and softened landfill stiffness (Axisymmetric model)



Figure D15: Sensitivity analyses for liner strain with varying geogrid stiffness and softened landfill stiffness (Axisymmetric model)





Figure D16: Total vertical and horizontal geomembrane displacements (after liner placement) with softened landfill stiffness (Axisymmetric model)

Key outcomes of the sensitivity analyses shown in Figures 14, 15 and 16, are summarised below:

- Increasing landfill compressibility in the softened sensitivity model nearly doubles the overall vertical settlements at the geomembrane centerline compared to the base case model. Tensile forces in the geogrid increase from the base case value of about 5 kN/m to 18 kN/m, and forces in the geomembrane liner increase from the base case value of about 2 kN/m to 7 kN/m. Corresponding strains increase proportionately in the geogrid and geomembrane from values of 1 % and 2.5% to approximately 3.5 % and 9 %, respectively. We consider that these liner strains are just within tolerable values for the softened landfill sensitivity case.
- Decreasing the geogrid stiffness in the axisymmetric model from 500 kN/m to 360 kN/m in the softened sensitivity model results in similar geogrid forces (within 15 %), but because the geogrid is softer, the geogrid strains increase significantly to a maximum of approximately 6 %. This suggests that a 360 kN/m geogrid may not be suitable for use in the case that softened sensitivity parameters apply.
- Removal of the geogrid completely from the softened sensitivity model increases the peak geomembrane forces to about 10 kN/m, compared to 9 kN/m for the case with 360 kN/m geogrid and 9 kN/m for the case with 500 kN/m geogrid. Corresponding geomembrane strains for the no-geogrid case increase to about 13 %, compared to 11 % for the case with 360 kN/m geogrid and 9% for the case with 500 kN/m geogrid. Adopting a limiting tensile strain 8 to 10 % for LLDPE geomembrane means that having no geogrid or 360 kN/m geogrid would likely not be tolerable in the case that softened sensitivity parameters apply.
- Vertical geomembrane displacements remain essentially unchanged in the softened landfill sensitivity model when comparing the cases with and without geogrid. However there is a difference in horizontal geomembrane displacements (Figure D16), which reflects the lateral extension and correspondingly higher strains of the case without geogrid.





The above results are consistent with overall expectations of liner behaviour, and demonstrate that the combination of 500 kN/m geogrid with the nominated geomembrane provides necessary reinforcement required to keep peak strains in the geogrid and geomembrane layers to below 5 % and 8 to 10 %, respectively – even for the sensitivity case of softened landfill stiffness.

### 1.1.6 Conclusions

The results of the PLAXIS analyses indicate that landfill settlements do not result in excessive concentrated relative movements within the liner system. The resulting forces and strains in the components of the proposed piggy back liner and new cell base liner systems are considered to be within acceptable limits.

General agreement was achieved between the PLAXIS, Slope/W and 1D settlement analyses.

### **1.1.7** For further assessment

We consider that further assessment is warranted at detailed design stage for the following:

- Material properties calibrated against field settlement trials; and
- Variations in liner stiffness over time.

Assessment of deformation effects for the landfill final capping system should also be carried out.





# APPENDIX D1 Material Properties used in PLAXIS analysis



### Appendix D1 2D params

| Geogrid                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                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Residual Soil<br>Mohr-Coulomb<br>Drained                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 0<br>0<br>Interface Unit 12-16P<br>Mohr-Coulomb<br>Drained                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Unit 6 - 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Residual Soll<br>Mohr-Coulomb<br>Drained<br>RGB 244, 31, 230                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 0<br>8<br>Interface Unit 12-16P<br>Mohr-Coulomb<br>Drained<br>RGB 195, 229, 249                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Unit 6 - Base Material<br>Mohr-Coulomb<br>Drained<br>RGB 164, 241, 101                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                
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(psi)<br>Advanced<br>Set to default values<br>Stiffness                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  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| K, Q, determination<br>K, Q, X<br>Flow parameters<br>Material set<br>identification number<br>identification<br>Material model<br>Drainage type<br>Colour<br>Colour                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    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Residual Soli<br>Drained<br>Mohr-Coulomb<br>Drained<br>RGB 244, 31, 230<br>Automatic<br>0.5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 0 0<br>8<br>Interface Unit 12-16P<br>Mohr-Coulomb<br>Drained<br>RGB 195, 229, 249<br>Automatic<br>0.5933                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Unit 6 - Base Material<br>Mohr-Coulomb<br>Drained<br>RGB 164, 241, 101<br>Automatic<br>0.470                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Automatic     Automatic     Automatic                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          
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Residual Soll<br>Mohr-Coulomb<br>Drained<br>R6B 244, 31, 230<br>Automatic<br>0.5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 0 0<br>8<br>Interface Unit 12-16P<br>Mohr-Coulomb<br>Drained<br>RGB 195, 229, 249<br>Automatic<br>0.5933<br>8                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Unit 6 - 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a<br>e_init<br>Strength<br>C_ref<br>\$\\$(ph)<br>\$\\$(ps)]<br>Advanced<br>Set to default values<br>Sutfness<br>V_ur<br>K_0^nn<br>M<br>interfaces<br>Material set<br>identification number                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               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Residual Soli<br>Mohr-Coulomb<br>Drained<br>RGB 244, 31, 230<br>Automatic<br>0.5<br>Unit 43 - Residual Soli<br>Unit 43 - Residual Soli                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 0<br>0<br>Interface Unit 12-16P<br>Mohr-Coulomb<br>Drained<br>RGB 195, 229, 249<br>Automatic<br>0.5933<br>Interface Unit 12-16P<br>8<br>Interface Unit 12-16P                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Unit 6 - Base Material<br>Mohr-Coulomb<br>Drained<br>RGB 164, 241, 101<br>Automatic<br>0.470<br>Unit 6 - Base Material<br>Unit 6 - Base Material                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      
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     1           0.5152           3           1           0.5152           3           1           0.5152                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                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                                                                                                                                               | 1<br>13<br>Interface Unit 16-17R<br>Mohr-Coulomb<br>Drained<br>RGB 134, 234, 162<br>Automatic<br>0.7921<br>13<br>Interface Unit 16-17R<br>Hohr Coulomb                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  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a<br>e_init<br>Strength<br>C_ref<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$                                                                                                                                                                                                                            | kN/m^2<br>*                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
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Residual Soll     Mohr-Coulomb     Drained     RGB 244, 31, 230     Automatic     O.5     Unit 43 - Residual Soll     Mohr-Coulomb     Drained     Drained     Drained                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 8<br>Interface Unit 12-16P<br>Mohr-Coulomb<br>Drained<br>RGB 195, 229, 249<br>Automatic<br>0.5933<br>Interface Unit 12-16P<br>Mohr-Coulomb<br>Drained                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Unit 6 - Base Material<br>Mohr-Coulomb<br>Drained<br>RGB 164, 241, 101<br>Automatic<br>Unit 6 - Base Material<br>Mohr-Coulomb<br>Drained                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              
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       100           Interface Unit 6-18         Mohr-Coulomb           Drained         Drained                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          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a<br>e_init<br>Strength<br>C_ref<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$\overline\$<br>\$                                                                                                                                                                                                                            | kN/m^2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| K, Q, O determination           K, Q, X           Flow parameters           Material set           Identification number           Identification           Identification           Data set           Colour           Model           Data set           Soll           Type           2 μm           S0 μm           Set to default values           k                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             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Residual Soli           Drained           RGB 244, 31, 230           Automatic           0.5           Unit 43 - Residual Soli           Mohr-Coulomb           Drained           RGB 244, 31, 230                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 8<br>Interface Unit 12-16P<br>Mohr-Coulomb<br>Drained<br>Automatic<br>0.5933<br>8<br>Interface Unit 12-16P<br>Mohr-Coulomb<br>Drained<br>RGB 195, 229, 249                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Unit 6 - Base Material<br>Mohr-Coulomb<br>Drained<br>RGB 164, 241, 101<br>Automatic<br>Unit 6 - Base Material<br>Mohr-Coulomb<br>Drained<br>RGB 164, 241, 101                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         
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           | 1<br>13<br>Interface Unit 16-17R<br>Mohr-Coulomb<br>Drained<br>RGB 134, 234, 162<br>Automatic<br>0.7921<br>Interface Unit 16-17R<br>Mohr-Coulomb<br>Drained<br>RGB 134, 234, 162                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            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                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Unit 6 - Base Material<br>Mohr-Coulomb<br>Drained<br>RGB 164, 241, 101<br>Automatic<br>Unit 6 - Base Material<br>Mohr-Coulomb<br>Drained<br>RGB 164, 241, 101<br>Standard<br>Coarse                                                                                                                                                                                                                                                                                                                                                                                     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interface Unit 6-18         Mohr-Coulomb           Drained         RGB 184, 250, 61           Standard         Crasse                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    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                                                                                                           | 1<br>0<br>12<br>Unit 4 - Clay Rich bearing<br>Mohr-Coulomb<br>Drained<br>RGB 161,226,232<br>0.5305<br>12<br>Unit 4 - Clay Rich bearing<br>Mohr-Coulomb<br>Drained<br>RGB 161,226,232<br>Standard<br>Coarse                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  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                                                                                                                                                                                                   | 0.67<br>0<br>0<br>14<br>Interface Unit 12-16R<br>Mohr-Coulomb<br>Drained<br>RGB 88, 245, 15<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412 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156<br>Automatic<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0.5933<br>0 | Interface Unit 14-1 Mohr-Coulomb Drained RGB 182, 226, 190 Automatic      Mohr-Coulomb Drained RGB 182, 226, 190 Coulomb Drained RGB 182, 226, 190 Standard Coarse                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 0<br>0<br>16<br>5<br>0.7412<br>16<br>5<br>16<br>5                                                                                          | C
a<br>e_init<br>Strength<br>C_ref<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)<br>(ph)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | kN/m^2_<br>*                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Section(3)           K, O, &           K, O, X           Flow parameters           Material set           identification number           identification           Material model           Drainage type           Colour           Material model           Data set           Soli           Type           2 µm - S0 µm           Soli µm - 2 µm           Parameters           Set to default values           k, x         m/day           k, x         m/day           k, x         m/day           k, not quercement         m           Change of permeability         m                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Automatic           1           1           7           Unit 44 to 47 - Rock           Unare elastic           Drained           RGB 5, 60, 138           Standard           Coarse           10           13           77           No           8.60E-03           8.60E-03           0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   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15-17R<br>Mohr-Coulomb<br>Drained<br>RGB 241, 39, 120<br>Standard<br>Coarse<br>10         | 1<br>0<br>12<br>Unit 4 - Clay Rich bearing<br>Mohr-Coulomb<br>Drained<br>RGB 161, 226, 232<br>Unit 4 - Clay Rich bearing<br>Mohr-Coulomb<br>Drained<br>RGB 161, 226, 232<br>Standard<br>Coarse<br>10                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         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N                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 1           Unit 43 - Residual Soli           Mohr-Coulomb           Drained           RGB 244, 31, 230           Automatic           Unit 43 - Residual Soli           Mohr-Coulomb           Drained           RGB 244, 31, 230           Standard           Hedium           19           41           40                                                                                                    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232<br>Automatic<br>0.5305<br>Unit 4 - Clay Rich bearing<br>Mohr-Coulomb<br>Drained<br>RGB 161, 226, 232<br>Standard<br>Coarse<br>10<br>13<br>77                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         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11<br>interface Unit 16-17P<br>Mohr-Coulomb<br>Drained<br>RGB 236, 232, 156<br>Automatic<br>0.5933<br>11<br>interface Unit 16-17P<br>Mohr-Coulomb<br>Drained<br>RGB 236, 232, 156<br>Standard<br>Coarse<br>11<br>77                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      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Residual Soli<br>Mohr-Coulomb<br>Drained<br>RGB 244, 31, 230<br>Automatic<br>0.5<br>Unit 43 - Residual Soli<br>Mohr-Coulomb<br>Drained<br>RGB 244, 31, 230<br>Standard<br>Standard<br>Medium<br>19<br>41<br>40<br>No                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 8 Interface Unit 12-16P Mohr-Coulomb Drained RGB 195, 229, 249 Automatic 0.5933 8 Interface Unit 12-16P Mohr-Coulomb Drained RGB 195, 229, 249 Standard Coarse 10 13 77 No 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | U.8<br>Unit 6 - Base Material<br>Unit 6 - Base Material<br>Drained<br>RGB 164, 241, 101<br>Automatic<br>0.470<br>Unit 6 - Base Material<br>Mohr-Coulomb<br>Drained<br>RGB 164, 241, 101<br>Standard<br>Coarse<br>1<br>7<br>No                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            
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(phi)           ψ (psi)           Advanced           Set to default values           Stiffness           V_ur           K_Onc           M           Material set           Identification number           Identification           Material model           Drainage type           Colour           Strength           R_inter           Real interface thickness           6_inter           Initial           Material set           Identification number           Identification number           Identification number           Toriange type                                                                                                                                                                                                                                                                                                                                                                                                                                                                             
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| Science           K, O. determination           K, O.x           Flow parameters           Material set           Uidentification number           Uidentification           Data set           Dorainage type           Colour           Data set           Soil           Type           2 µm - S0 µm           % 50 µm - 2 µm           % Parameters           Set to default values           k_x           k_y.x           Model           Change of permeability           C_k.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  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        Interface Unit 12-16R           Mohr Coulomb           Drained           RGB 88, 245, 15           14           Interface Unit 12-16R           Mohr Coulomb           Drained           RGB 88, 245, 15           Standard           Coarse           10           13           77           No           0           0           0           10                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                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| Secting3           K, O, & determination           K, O, X           Flow parameters           Material set           identification           Drainage type           Colour           Drainage type           Colour           Data set           Soil           Type           2 µm - 50 µm           %           2 µm - 50 µm           %           50 µm - 2 mm           %           51 µm - 50 µm           %           52 µm - 50 µm           %           54 µm - 80 µm           %           7 µm - 8           Parameters           Set to default values           k,x           m/day           w,y.vs           w/day                                                                                                                                                                                                                                                                                                                                                                                                    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  Unit 44 to 47 - Rock         7           Drained         RGB 5, 60, 138           Standard         7           Coarse         10           Coarse         10           No         8.60E-03           8.60E-03         0           0         0.5           1.00E+15         1.00E+15                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    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Residual Soli           Mohr-Coulomb           Drained           RGB 244, 31, 230           Unit 43 - Residual Soli           Mohr-Coulomb           Drained           RGB 244, 31, 230           Standard           19           41           400           0           0           10           0           0.5           1.00E+04           1.00E+15                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Unit 6 - Base Material<br>Mohr-Coulomb<br>Drained<br>RGB 164, 241, 101<br>Automatic<br>Unit 6 - Base Material<br>Unit 6 - Base Material<br>Nohr-Coulomb<br>Drained<br>RGB 164, 241, 101<br>Standard<br>Coarse<br>1<br>No<br>0.8<br>0.8<br>0.8<br>0.8<br>0.0<br>1.00E+1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                
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    14           Interface Unit 12-16R           Mohr-Coulomb           Drained           RGB 88, 245, 15           Standard           Coarse           0           0           0           0           0           0           0           0           0           0           0           0           0           0           0           0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            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| Secting3           K, Q, K           K, Q, K           Flow parameters           Material set           Identification           Identification           Data set           Drainage type           Colour           Model           Data set           Soil           Type           Qum           Soil           Type           Salum - S0 µm           % S2 µm - S0 µm           % S0 µm - 2 µm           Set to default values           k, x           k, y           m           e_int           Change of permeability           C ₂ k           C ₂ k                                                                                                                                                                                                                                                                                                                                                                                                                                                                         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Residual Soli           Mohr-Coulomb           Drained           RGB 244, 31, 230           Automatic           0.5           Unit 43 - Residual Soli           Mohr-Coulomb           Drained           RGB 244, 31, 230           Standard           Standard           Medium           19           1.00           No           8.60E.00           8.60E.00           8.60E.00           0.5           1.00e+15                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Unit 6 - Base Material<br>Unit 6 - Base Material<br>Drained<br>RGB 164, 241, 101<br>Automatic<br>Unit 6 - Base Material<br>Mohr-Coulomb<br>Drained<br>RGB 164, 241, 101<br>Standard<br>Coarse<br>1<br>1<br>Coarse<br>1<br>0.8<br>0.8<br>0.8<br>0.8<br>0.8<br>0.0<br>1.00E+1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 3         1           1         0         0           10         100         0           10         100         100           10         100         100           Drained         RGE 184, 250, 61         100           1         0.5152         100           1         0.5152         100           1         0.5152         100           1         0.5152         100           1         0.5152         100           1         0.5152         100           1         0.5152         100           1         0.5152         100           1         0.5152         100           1         0.5152         1.00E+15                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              
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    RGB 161, 226, 232           Automatic           0.5305           12           Unit 4 - Clay Rich bearing<br>Mohr-Coulomb           Drained           RGB 161, 226, 232           Standard           Coarse           10           0           0           0           0           0           0           0           0           0           0           0           0           0           0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      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       0           0           14           Interface Unit 12-16R           Mohr-Coulomb           0           14           Interface Unit 12-16R           Mohr-Coulomb           Drained           R68 88, 245, 15           Standard           Coarse           0           13           7           No           0           0           0           13           7           No           0           10           11           12           13           7           14           15           16           17           18           19           10           10           13           77           No           0           10           10           10           10           10                                                                                                                                                                                                                                                                                                                                             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11     11     11     11                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Interface Unit 14-1     Mohr -Coulomb     Drained     RGB 182, 226, 190     Automatic     Automatic     Interface Unit 14-1     Mohr-Coulomb     Drained     RGB 182, 226, 190     Standard     Coarse     D     Standard     Coarse     D     Standard     No     D     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S   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                                                                                                                                                                                                                                                                                                                                                                                | kN/m^2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Section(3)           K, Q, K, O determination           K, Q, X           Flow parameters           Material set           Identification number           Identification           Identification           Data set           Data set           Soll           Data set           Soll           Type           Qum - So µm           % 2 µm           Yam           % 30 µm - 2 µm           % 4           Parameters           Set to default values           K, X           May           -9, unsat           m           e_int           Charge of permeability           C, k           Image: Ima                                                                                                                                                                                                                                                                                                                                                                                                                            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set<br>Identification number<br>Identification number<br>Identification<br>Material model<br>Drainage type<br>Colour<br>Model<br>Data set<br>Soil<br>Type<br>< 2 µm<br>2 µm - 2 µm<br>Parameters<br>Set to default values<br>k_y<br>- 4_unsat<br>e_init<br>Change of permeability<br>C, k                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                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101<br>Standard<br>Coarse<br>1<br>1<br>1<br>7<br>No<br>0.8<br>0<br>0.8<br>0<br>0.9<br>0<br>1.00E+1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               
                                                                              | a)         1           b)         0           b)         0           coulomb         0           b)         0           coulomb         0           coarse         0      <                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              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                                                                                                                                                                                                                                                                                                                                                   | Interface Unit 14-1           Mohr-Coulomb           Drained           RGB 182, 226, 190           Automatic           3           C           Interface Unit 14-1           Mohr-Coulomb           Drained           RGB 182, 226, 190           Interface Unit 14-1           Mohr-Coulomb           Drained           RGB 182, 226, 190           Standard           Coarse           0           3           7           No           0           5           1.0                                                                                                                                                                                                               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| Sectors         A           K, O, &         Image: Comparation           K, O, &         Image: Comparation           K, O, &         Image: Comparation           Material solution         Image: Comparation           Material model         Image: Comparation           Drainage type         Image: Comparation           Drainage type         Image: Comparation           Data set         Image: Comparation           Soli         Type           2 µm         %           2 µm         %           3 µm         Soli           Soli         Type           2 µm         %           3 µm         Soli           Soli         Type           Calcult values         K.x           K_x         m/day           K_y         m/day           K_y         Model           Image: Comparation         Image: Comparation           Canage: Opermeability         Image: Comparation           Image: Comparation         Image: Comparation           Image: Comparation         Image: Comparation           Image: Comparation         Image: Comparation           Image: Comparation         Image: Comparation <t< td=""><td>Automatic         1           Automatic         1           Unit 44 to 47 - Rock         7           Unit 44 to 47 - Rock         7           Drained         RGB 5, 60, 138           Standard         7           Coarse         10           Coarse         10           No         8.60E-03           8.60E-03         8.60E-03           0         0.5           1.00E+15         1.00E+15           1.00E+15         1.00E+15</td><td>Real interface thickness<br/>6_inter<br/>Material set<br/>lidentification number<br/>lidentification number<br/>lidentification<br/>Material model<br/>Drainage type<br/>Colour<br/>KO settings<br/>K_0 determination<br/>K_0,X<br/>Flow parameters<br/>Material at<br/>lidentification number<br/>lidentification number<br/>lidentification<br/>Material model<br/>Drainage type<br/>Colour<br/>Model<br/>Data set<br/>Soil<br/>Type<br/>4 µm - 2 µm<br/>Parameters<br/>Soil<br/>Type<br/>4 µm - 2 µm<br/>Parameters<br/>Soil<br/>Type<br/>4 µm - 2 µm<br/>Parameters<br/>Set to default values<br/>k_X<br/>4 µunsat<br/>e_init<br/>Change of permeability<br/>C,k</td><td>%           %           %           %           %           m/day           m/day           m</td><td></td><td>0.00     0     0     100F-Coulomb Drained RGB 195, 229, 249 Automatic     0.5933     100F-Coulomb Drained RGB 195, 229, 249 Standard Coarse     100     13     77 No     0     0     0     0     0     1.00E+15</td><td>Unit 6 - Base Material<br/>Mohr-Coulomb<br/>Drained<br/>RGB 164, 241, 101<br/>Automatic<br/>Unit 6 - Base Material<br/>Mohr-Coulomb<br/>Drained<br/>RGB 164, 241, 101<br/>Standard<br/>Coarse<br/>1<br/>1<br/>7<br/>No<br/>0.8<br/>0.8<br/>0.8<br/>0.8<br/>0.8<br/>0.0<br/>1.00E+1</td><td>3         1           0         0           0         0           1         100           1         100           1         100           1         100           1         100           1         100           1         0.5152           1         0.5152           1         0.5152           1         100           1         100           1         100           1         100           1         100           1         100           1         100           1         100           1         100           1         100           1         100           1         100           1         100           1         100</td><td>1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1</td><td>1     1     1     0     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1   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15<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.7412<br/>0.777<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.00<br/>0.</td><td>( (  11  11  11  11  11  11  11  11  11</td><td>Interface Unit 14-1           Mohr-Coulomb           Drained           RGB 182, 226, 190           Automatic           3           (C)           Sinterface Unit 14-1           Interface Unit 14-1           Interface Unit 14-1           Interface Unit 14-1           Mohr-Coulomb           Drained           RGB 182, 226, 190           Standard           Coarse           O           S           No           O           S           S           1.0</td><td>0<br/>0<br/>16<br/>5<br/></td><td>C a           c_init           Strength           c_ref           de (phi)           Var           K.           Var           K.           Material set           Identification number           Identification           Material model           Drainage type           Colour           Strength           R_inter           Real interface thickness           Beal interface thickness           Material set           Identification number           Identification           Material set           Material set           Settings           K_0 determination           K_0.0           Overconsolitation           OR           PoP           Flow parameters</td><td>kN/m^2 *</td></t<>                                                                                                                                                                                                                                                                      
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44 to 47 - Rock         7           Unit 44 to 47 - Rock         7           Drained         RGB 5, 60, 138           Standard         7           Coarse         10           Coarse         10           No         8.60E-03           8.60E-03         8.60E-03           0         0.5           1.00E+15         1.00E+15           1.00E+15         1.00E+15                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               
                                                                                                                                                                                                                                                                      | Real interface thickness<br>6_inter<br>Material set<br>lidentification number<br>lidentification number<br>lidentification<br>Material model<br>Drainage type<br>Colour<br>KO settings<br>K_0 determination<br>K_0,X<br>Flow parameters<br>Material at<br>lidentification number<br>lidentification number<br>lidentification<br>Material model<br>Drainage type<br>Colour<br>Model<br>Data set<br>Soil<br>Type<br>4 µm - 2 µm<br>Parameters<br>Soil<br>Type<br>4 µm - 2 µm<br>Parameters<br>Soil<br>Type<br>4 µm - 2 µm<br>Parameters<br>Set to default values<br>k_X<br>4 µunsat<br>e_init<br>Change of permeability<br>C,k                                                                                                                                    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                                                                                                                                                                                                                                                                 | Unit 6 - Base Material<br>Mohr-Coulomb<br>Drained<br>RGB 164, 241, 101<br>Automatic<br>Unit 6 - Base Material<br>Mohr-Coulomb<br>Drained<br>RGB 164, 241, 101<br>Standard<br>Coarse<br>1<br>1<br>7<br>No<br>0.8<br>0.8<br>0.8<br>0.8<br>0.8<br>0.0<br>1.00E+1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         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     | 0.07<br>0<br>0<br>14<br>Interface Unit 12-16R<br>Mohr-Coulomb<br>Drained<br>RGB 88, 245, 15<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.7412<br>0.777<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0.00<br>0. 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                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Interface Unit 14-1           Mohr-Coulomb           Drained           RGB 182, 226, 190           Automatic           3           (C)           Sinterface Unit 14-1           Interface Unit 14-1           Interface Unit 14-1           Interface Unit 14-1           Mohr-Coulomb           Drained           RGB 182, 226, 190           Standard           Coarse           O           S           No           O           S           S           1.0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 0<br>0<br>16<br>5<br>                                                                                                                      | C a           c_init           Strength           c_ref           de (phi)           Var           K.           Var           K.           Material set           Identification number           Identification           Material model           Drainage type           Colour           Strength           R_inter           Real interface thickness           Beal interface thickness           Material set           Identification number           Identification           Material set           Material set           Settings           K_0 determination           K_0.0           Overconsolitation           OR           PoP           Flow parameters                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | kN/m^2 *                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Science         Science           K, O, &         Science           K, O, &         Science           Flow parameters         Material set           Uidentification number         Identification           Material model         Drainage type           Colour         Material model           Drainage type         Science           Colour         Model           Data set         Science           Soli         Type           2 µm > 0 µm         %           2 µm > 0 µm         %           3 µm - 2 µm         %           2 µm > 0 µm         %           3 µm - 2 µm         %           Arrameters         %           Soli µm - 2 µm         %           Change of permeability         C           C_k         Science           Science         Science <td>Automatic         1           Automatic         7           Unit 44 to 47 - Rock         7           Standard         7           Coarse         10           13         77           No         8.60E-03           0         0           0.5         0           1.00E+15         1.00E+15           1.00E+15         1.00E+15           1.00E+15         1.00E+15</td> <td>Real interface thickness<br/>6_inter<br/>initial set<br/>ildentification number<br/>ildentification number<br/>ildentification number<br/>ildentification number<br/>Colour<br/>K0 settings<br/>K_0 determination<br/>K_0 determination<br/>K_0 act<br/>flow parameters<br/>Material set<br/>ildentification number<br/>ildentification number<br/>ildentification<br/>Material set<br/>Drainage type<br/>Colour<br/>Model<br/>Data set<br/>Soil<br/>Type<br/>&lt; 2 µm<br/>2 µm &gt; 0 µm<br/>2 µm &gt; 0 µm<br/>Soil<br/>Type<br/>&lt; 2 µm<br/>2 µm &gt; 0 µm<br/>Parameters<br/>Set to default values<br/>k_x<br/>k_y<br/>4 µunsat<br/>e_init<br/>Change of permeability<br/>C_k</td> <td>%<br/>%<br/>%<br/>%<br/>%<br/>%<br/>%<br/>%<br/>%</td> <td></td> <td>0           0           8           Interface Unit 12-16P           Mohr-Coulomb           Drained           RGB 195, 229, 249           Automatic           0.5933           Drained           RGB 195, 229, 249           Mohr-Coulomb           Drained           RGB 195, 229, 249           Standard           Coarse           10           13           77           No           0           0           0           1.00E+15</td> <td>Unit 6 - Base Material<br/>Mohr-Coulomb<br/>Drained<br/>RGB 164, 241, 101<br/>Automatic<br/>Unit 6 - Base Material<br/>Mohr-Coulomb<br/>Drained<br/>RGB 164, 241, 101<br/>Standard<br/>Coarse<br/>1<br/>1<br/>7<br/>No<br/>0.8<br/>0.8<br/>0.8<br/>0.8<br/>0.8<br/>1.00E+1</td> <td>3         1           3         1           3         0           3         10           1         10           1         10           1         10           1         0           1         0.5152           1         0.5152           1         10           1         10           1         0.5152           1         10           1         10           1         10           1         10           1         10           1         10           1         10           1         10           1         10           1         10           1         10           1         10           1         10           1         10           1         10           1         10           1         10           1         10           1         10           1         10           1         10           1         10      <t< td=""><td>1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1</td><td>1     0     0     1     1     1     1     0     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     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        Automatic           Jorained           RGB 182, 226, 190           Mohr-Coulomb           Drained           RGB 182, 226, 190           Standard           Coarse           D           Standard           Solution           Solution           Solution           Solution           Standard           Coarse           D           Solution           Solution</td><td>0<br/>0<br/>16<br/>5<br/></td><td>C a           c_init           Strength           c_ref           4 (ph)           5 (ph)           6 (ph)           6 (ph)           6 (ph)           6 (ph)           6 (ph)           6 (ph)           7 (ph)           8 (p</td><td>kN/m^2 * * * * * * * * * * * * * * * * * * *</td></t<></td>                                                                                                                                                                                                                                                                                                                 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1.00E+15                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 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act<br>flow parameters<br>Material set<br>ildentification number<br>ildentification number<br>ildentification<br>Material set<br>Drainage type<br>Colour<br>Model<br>Data set<br>Soil<br>Type<br>< 2 µm<br>2 µm > 0 µm<br>2 µm > 0 µm<br>Soil<br>Type<br>< 2 µm<br>2 µm > 0 µm<br>Parameters<br>Set to default values<br>k_x<br>k_y<br>4 µunsat<br>e_init<br>Change of permeability<br>C_k                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        
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                                          | 0           0           8           Interface Unit 12-16P           Mohr-Coulomb           Drained           RGB 195, 229, 249           Automatic           0.5933           Drained           RGB 195, 229, 249           Mohr-Coulomb           Drained           RGB 195, 229, 249           Standard           Coarse           10           13           77           No           0           0           0           1.00E+15                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        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101<br>Standard<br>Coarse<br>1<br>1<br>7<br>No<br>0.8<br>0.8<br>0.8<br>0.8<br>0.8<br>1.00E+1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             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1 1 1 1 1 1 1 1 1</td><td>1     0     0     1     1     1     1 
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    1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1</td><td>1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1</td><td>0.07<br/>0<br/>0<br/>0<br/>14<br/>Interface Unit 12-16R<br/>Mohr-Coulomb<br/>Drained<br/>RGB 88, 245, 15<br/>14<br/>Interface Unit 12-16R<br/>Mohr-Coulomb<br/>Drained<br/>RGB 88, 245, 15<br/>Standard<br/>Coarse<br/>0<br/>10<br/>13<br/>777<br/>No<br/>0<br/>0<br/>0<br/>0<br/>0<br/>0<br/>0<br/>0<br/>0<br/>0<br/>0<br/>0<br/>0</td><td>( ( ( ( ( ( ( ( ( ( ( ( ( ( ( ( ( ( (</td><td>Interface Unit 14-1           Mohr-Coulomb           Jorained           RGB 182, 226, 190           Automatic           Jorained           RGB 182, 226, 190           Mohr-Coulomb           Drained           RGB 182, 226, 190           Standard           Coarse           D           Standard           Solution           Solution           Solution           Solution           Standard           Coarse           D           Solution           Solution</td><td>0<br/>0<br/>16<br/>5<br/></td><td>C a           c_init           Strength           c_ref           4 (ph)           5 (ph)           6 (ph)           6 (ph)           6 (ph)           6 (ph)           6 (ph)           6 (ph)           7 (ph)           8 (p</td><td>kN/m^2 * * * * * * * * * * * * * * * * * * *</td></t<> | 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1                                                                                                                                                                               | 1     0     0     1     1     1     1     0     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1 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                                                                       | Interface Unit 14-1           Mohr-Coulomb           Jorained           RGB 182, 226, 190           Automatic           Jorained           RGB 182, 226, 190           Mohr-Coulomb           Drained           RGB 182, 226, 190           Standard           Coarse           D           Standard           Solution           Solution           Solution           Solution           Standard           Coarse           D           Solution                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 0<br>0<br>16<br>5<br>                                                                                                                      | C a           c_init           Strength           c_ref           4 (ph)           5 (ph)           6 (ph)           6 (ph)           6 (ph)           6 (ph)           6 (ph)           6 (ph)           7 (ph)           8 (p                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               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| Sector         Sector           K, O, X         File           K, O, X         File           Flow parameters         Material set           Material set         Identification           Material model         Drainage type           Drainage type         Colour           Data set         Solit           Type         Image type           Solit         Parameters           Yun - S0 µm         %           S0 µm - S0 µm         %           S2 µm - S0 µm         %           S4 µm - S0 µm         %                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Automatic         1           Automatic         7           Unit 44 to 47 - Rock         7           Standard         7           Standard         7           Coarse         10           13         77           No         8.60E-03           8.60E-03         8.60E-03           0         0.5           1.00E+15         1.00E+15           1.00E+15         1.00E+15           1.00E+15         1.00E+15                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            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type<br>Colour<br>K. 0 etermination<br>K. 0 etermination<br>K. 0 etermination<br>K. 0 etermination<br>Material set<br>identification number<br>identification number<br>identification number<br>identification<br>Material model<br>Drainage type<br>Colour<br>Material model<br>Data set<br>Soil<br>Type<br>4 µm 50 µm<br>50 µm - 2 nm<br>Parameters<br>Set to default values<br>k_x<br>k_x<br>k_y<br>e_jnit<br>Change of permeability<br>C.k                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          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                                                                                                        | 0           0           8           Interface Unit 12-16P           Mohr-Coulomb           Drained           RGB 195, 229, 249           Automatic           0.5933           Interface Unit 12-16P           Mohr-Coulomb           Drained           RGB 195, 229, 249           Standard           Coarse           10           13           77           No           0           0           1.00E+15                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    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Material<br>Coarse<br>Coarse<br>1<br>0<br>0.8<br>0.8<br>0.8<br>0.8<br>0.8<br>0.8<br>0.8<br>0.8<br>0.8<br>0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               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Mohr-Coulomb     Drained     RGB 182, 226, 190     Automatic     Mohr-Coulomb     Drained     RGB 182, 226, 190     Standard     Coarse     Coarse     S     Interface Unit 14-1     Nohr-Coulomb     Standard     Coarse     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S    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2 µm<br>Set to default values<br>k_x<br>k_y<br>+y unsat<br>e_init<br>Change of permeability<br>C_k                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       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                                                                                                                                                                                                   | 0.07           0           0           0           14           Interface Unit 12-16R           Mohr-Coulomb           Drained           R66 88, 245, 15           Standard           Coarse           0           10           11           Interface Unit 12-16R           Mohr-Coulomb           Drained           R66 88, 245, 15           Standard           Coarse           0           10           13           77           No           0           10           13           77           No           0           10           11           11           12           13           77           No           0           0           0           0           0           0           1.00E+15                                                                                                                         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   Interface Unit 14-1     Nohr-Coulomb     Standard     Coarse     D     Standard     S     S     S     S     S     S     S     S     S     S     S     S     S                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         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     Strength         Strength           Strength         C, ref           4 (ph)         (ph)           5 (to effault values         Stiffness           5 (to effault values)         Stiffness           6 (to effault values)         Stiffness           7 (to effault values)         Stiffness           6 (to effault values)         Stiffness           7 (to effault values)         Stiffness           7 (to effault values)         Stiffness           6 (to effault values)         Stiffness           7 (to effault values)         Stiffness           8 (to effault values)         Stiffness           8 (to effault values)         Stiffness           8 (to effault values)         Stiffness           9 (to effault values)         Stiffness           9 (to effau                                                                                                                                                                                                                                 
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| Section(3)           K, Q, K           K, Q, K           Flow parameters           Material set           Identification           Identification           Identification           Drainage type           Colour           Material model           Drainage type           Colour           Model           Data set           Soll           Type           Agum - S0 µm           Soll           Parameters           Set to default values           k, x           K, y           m           e_int           Change of permeability           C.g.k           C.g.k           Image type           Image type </td <td>Automatic         1           Automatic         1           Unit 44 to 47 - Rock         1           Unit 44 to 47 - Rock         1           Bandard         1           Standard         1           Coarse         10           Coarse         10           No         8.60E-03           8.60E-03         0           0         0.5           1.00E+15         1.00E+15           1.00E+15         1.00E+15           1.00E+15         1.00E+15           1.00E+15         1.00E+15</td> <td>Real interface thickness<br/>6_inter<br/>Material set<br/>Identification number<br/>Identification on the<br/>Identification and<br/>Material model<br/>Drainage type<br/>Colour<br/>K0 settings<br/>K 0 determination<br/>K 0, x<br/>Flow parameters<br/>Material set<br/>Identification number<br/>Identification number<br/>Identification<br/>Material model<br/>Drainage type<br/>Colour<br/>Model<br/>Data set<br/>Soil<br/>Type<br/>&lt; 2 µm<br/>2 µm - 20 µm<br/>S0 µm<br/>S0</td> <td>%<br/>%<br/>%<br/>%<br/>%<br/>%<br/>%<br/>%<br/>%<br/>%<br/>%<br/>%<br/>%<br/>%<br/>%<br/>%<br/>%<br/>%<br/>%</td> <td>1           0           0           1           0           1           0           1           1           0           1           0           0           0           0           0           0           0           0           0           0           0           0           0           0           0           0           0           0           0           0           0           0           0           0           0           0           0           0           0           0           0           0           0           0           0           0           0           0           0           0           0           0           0</td> <td>0     0     0     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1</td> <td>Unit 6 - Base Material<br/>Unit 6 - Base Material<br/>Mohr-Coulomb<br/>Drained<br/>RGB 164, 241, 101<br/>Automatic<br/>Unit 6 - Base Material<br/>Mohr-Coulomb<br/>Drained<br/>RGB 164, 241, 101<br/>Standard<br/>Coarse<br/>1<br/>1<br/>1<br/>1<br/>1<br/>1<br/>1<br/>1<br/>0<br/>1.00E+1</td> <td>a)         1           b)         0         0           b)         0         0           c)         100         100           interface Unit 6-18         Mohr-Coulomb         0           Automatic         0         0.5152           a)         100         100           b)         100         100           b)         100         100           b)         100         100           coarse         0         100           b)         0         0           coarse         0         0           <td< td=""><td>1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1</td><td>1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1</td><td>1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1</td><td>0.07           0           0           0           14           Interface Unit 12-16R           Mohr-Coulomb           Drained           0.7412           0.7412           0.7412           0.7412           0.7412           0.7412           0.7412           0.7412           0.7412           0.7412           0.7412           0.7412           0.7412           0.7412           0.7412           0.7412           0.7412           0.7412           0.7412           0.7412           0.7412           0.7412           0.7412           0.7412           0.7412           0.7412           0.7412           0.7412           0.7412           0.7412           0.7412           0.777           No           0           0           0           0           0           0           0           <t< td=""><td>( ( 11 11 11 11 11 11 11 11 11 11 11 11</td><td>Interface Unit 14-1 Mohr -Coulint     Drained     RGB 182, 226, 190     Automatic     Automatic     Interface Unit 14-1 Mohr -Coulomb Drained RGB 182, 226, 190 Standard Coarse D Interface Unit 14-1 Mohr Coulomb Drained Coarse D Interface Unit 14-1 Nohr Coulomb Interface Unit 14-1 Mohr Coulomb Interface Unit 14-1 Mohr Coulomb Interface Unit 14-1 Mohr Coulomb Interface I</td><td>0<br/>0<br/>16<br/>5<br/>0.7412<br/>16<br/>5<br/>5<br/>10<br/>10<br/>10<br/>13<br/>77<br/>0<br/>0<br/>0<br/>0<br/>0<br/>0<br/>0<br/>0<br/>0<br/>0<br/>0<br/>0<br/>0</td><td>C a           c, ref           4 (phi)           Advanced           Set to default values           Suffness           Suffness           V. ur           K. 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| Science         Science           K, O, &         Science           K, O, &         Science           Science         Science           Material set         Science           Identification         Material model           Drainage type         Science           Colour         Material model           Drainage type         Science           Colour         Material model           Data set         Science           Solid         Type           2 µm         %           2 µm         %           3 µm - 2 µm         %           9 µm - 2 µm         %<                                                                                                                                                                                                                                                                                                                                                                                                                                                                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parameters<br>Material set<br>lidentification number<br>lidentification number<br>lidentification<br>Material model<br>Drainage type<br>Colour<br>Model<br>Drainage type<br>Colour<br>Soli<br>Type<br>2 µm - 2 µm<br>2 µm - 2 µm<br>2 µm - 2 µm<br>Sol µm - 2 µm<br>Parameters<br>Sol µm - 2 µm<br>Parameters<br>Set to default values<br>k_x<br>k_y<br>4 µunsat<br>e_init<br>Change of permeability<br>C, k                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             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                                                                   | 0           0           8           Interface Unit 12-16P           Mohr-Coulomb           Drained           RGB 195, 229, 249           Automatic           0.5933           RGB 195, 229, 249           Mohr-Coulomb           Drained           RGB 195, 229, 249           Standard           Coarse           10           13           77           No           0           0           1.00E+15                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             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101<br>Standard<br>Coarse<br>1<br>1<br>7<br>No<br>0.8<br>0.8<br>0.8<br>0.8<br>0.8<br>0.8<br>0.8                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         
                                                                                                                          | a)         1           b)         0           c)         0           c)         0           c)         10           interface Unit 6-18         Mohr-Coulomb           Drained         RGB 184, 250, 61           Automatic         10           interface Unit 6-18         Mohr-Coulomb           Drained         RGB 184, 250, 61           Standard         Coarse           c)         10           coarse         0           c)         0                                                                                                                                                                                                                                                                                                                                                                                                                                                             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          0           0           0           0           0           0           0      0           0 <td>( (  11  11  11  11  11  11  11  11  11</td> <td>Interface Unit 14-1           Mohr-Coulomb           Drained           RGB 182, 226, 190           Automatic           3           Coulomb           Drained           RGB 182, 226, 190           Mohr-Coulomb           Drained           RGB 182, 226, 190           Standard           Coarse           D           Coarse           D           S           No           D           S           1.0</td> <td>000<br/>0<br/>16<br/>5<br/></td> <td>C α           c_init           Strength           c_ref           φ (ph)           ψ (pi)           Advanced           Set to default values           Stiffness           V_ur           K_0^nc           M           Material set           Identification number           Identification           Material model           Drainage type           Colour           Strength           R_inter           Real interface thickness           δ_inter           Material model           Drainage type           Colour           Strength           Material set           Identification number           Identification           Material model           Drainage type           Colour           K_0 a termination           K_0, a termination           K_0 a termination           K_0 a termination           K_0 a tereminatet           Identification nu</td> <td><pre>kN/m^2 * * * * * * * * * * * * * * * *</pre></td>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    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190           Mohr-Coulomb           Drained           RGB 182, 226, 190           Standard           Coarse           D           Coarse           D           S           No           D           S           1.0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     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| C α           c_init           Strength           c_ref           φ (ph)           ψ (pi)           Advanced           Set to default values           Stiffness           V_ur           K_0^nc           M           Material set           Identification number           Identification           Material model           Drainage type           Colour           Strength           R_inter           Real interface thickness           δ_inter           Material model           Drainage type           Colour           Strength           Material set           Identification number           Identification           Material model           Drainage type           Colour           K_0 a termination           K_0, a termination           K_0 a termination           K_0 a termination           K_0 a tereminatet           Identification nu                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <pre>kN/m^2 * * * * * * * * * * * * * * * *</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Sectoring3         Image: Sectoring 2016           K, O, &         Image: Sectoring 2016           K, O, &         Image: Sectoring 2016           K, O, &         Image: Sectoring 2016           Material model         Image: Sectoring 2016           Drainage type         Image: Sectoring 2016           Drainage type         Image: Sectoring 2016           Data set         Image: Sectoring 2017           Soli         Image: Sectoring 2017           Type         Image: Sectoring 2017           Soli         Image: Sectoring 2017           Yum - S0 µm         %           Soli Image: Sectoring 2017         Material model           Sectoring 100 µm         %           Sectoring 100 µm         % <t< td=""><td>Automatic         1           Automatic         7           Unit 44 to 47 - Rock         7           Unit 44 to 47 - Rock         7           Unit 44 to 47 - Rock         7           RGB 5, 60, 138         7           Standard         7           Coarse         10           Coarse         10           No         8.60E-03           8.60E-03         8.60E-03           0         0.5           1.00E+15         1.00E+15           1.00E+15         1.00E+15           1.00E+15         1.00E+15           1.00E+15         1.00E+15           1.00E+15         1.00E+15           1.00E+15         1.00E+15           1.00E+15         1.00E+15</td><td>Real interface thickness<br/>6_inter<br/>Material set<br/>lidentification number<br/>lidentification number<br/>lidentification number<br/>lidentification number<br/>K 0 etermination<br/>K 0 x<br/>Flow parameters<br/>Material set<br/>lidentification number<br/>lidentification number<br/>lidentification number<br/>lidentification number<br/>lidentification number<br/>lidentification number<br/>lidentification number<br/>lidentification<br/>Material set<br/>Soli<br/>Type<br/>Colour<br/>Model<br/>Data set<br/>Soli<br/>Type<br/>2 µm - 50 µm<br/>50 µm - 2 nm<br/>Parameters<br/>Set to default values<br/>k_x<br/>k_y<br/>k_y<br/>k_y<br/>Charge of permeability<br/>C_k</td><td>%           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %</td><td></td><td>0     0      8     Interface Unit 12-16P     Mohr-Coulomb     Drained     0.5933     0.5933     0.5933     0.5933     0.5933     0.5933     0.5933     0.5933     0.5933     0.5933     0.5933     0.5933     0.5933     0.5933     0.5933     0.5933     0.5933     0.5933     0.5933     0.5933     0.5933     0.5933   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10           1         0.5152           3         10           1         0.5152           3         10           1         10.5152           3         10           1         0.5152           3         10           1         0.5152           3         10           1         0.5152           3         13           7         77           No         0           3         1.007           3         1.006+15           3         1.006+15</td><td>1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1</td><td>1 0 0 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1</td><td>1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1</td><td>0.07<br/>0<br/>0<br/>0<br/>14<br/>Interface Unit 12-16R<br/>Mohr-Coulomb<br/>Drained<br/>RGB 82, 245, 15<br/>Automatic<br/>0.7412<br/>14<br/>Interface Unit 12-16R<br/>Mohr-Coulomb<br/>Drained<br/>RGB 82, 245, 15<br/>Standard<br/>Coarse<br/>0<br/>10<br/>13<br/>7777<br/>No<br/>0<br/>0<br/>10<br/>10<br/>10<br/>10<br/>10<br/>10<br/>10<br/>10</td><td>( 11 11 11 11 11 11 11 11 11 11 11 11 11</td><td>Interface Unit 14-1     Mohr-Coulomb     Drained     RGB 182, 226, 190     Automatic     Interface Unit 14-1     Interfac</td><td>0<br/>0<br/>16<br/>5<br/></td><td>C a           e_init           Strength           C_ref           4 (ph)           4 (pi)           Advanced           Set to default values           Suffness           Sylfness           V_UT           K, O'nc           M           Interfaces           Material set           Identification number           Identification           Trainage type           Colour           Sterength           Strength           Golour      &lt;</td><td><pre>kkl/m^2* * * * * * * * * * * * * * * * *</pre></td></t<>                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Automatic         1           Automatic         7           Unit 44 to 47 - Rock         7           Unit 44 to 47 - Rock         7           Unit 44 to 47 - Rock         7           RGB 5, 60, 138         7           Standard         7           Coarse         10           Coarse         10           No         8.60E-03           8.60E-03         8.60E-03           0         0.5           1.00E+15         1.00E+15                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            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15<br>Standard<br>Coarse<br>0<br>10<br>13<br>7777<br>No<br>0<br>0<br>10<br>10<br>10<br>10<br>10<br>10<br>10<br>10                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        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Residual Soli           Drained           RGB 244, 31, 230           Automatic           0.5           0.1           Unit 43 - Residual Soli           Mohr-Coulomb           Drained           RGB 244, 31, 230           Standard           40           19           41           40           Needium           10           No           1.00e+04           0.5           1.00e+15           1.00e+15           1.00e+15           1.00e+15                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 0     0     0     8     1nterface Unit 12-16P     Mohr-Coulomb Drained     RGB 195, 229, 249     Automatic     0.5933     0.5933     0.5933     100Prained     RGB 195, 229, 249     Standard     Coarse     100     100E415     1.00E415     1.00E415                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Unit 6 - 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18           Mohr Coulomb         Drained           RGE 184, 250, 61         10           Drained         RGE 184, 250, 61           Standard         Coarse           0         10           3         133           7         77           No         0           0         0           0         0           0         0           0         0           0         0           0         0           0         0           0         0           0         0           0         0           0         0           0         0           0         0           0         0           0         0           0                                                                                                                                                                                                                                                                                                                                                
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        0           0.5         0           1.00E+15         1.00E+15           1.00E+15                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 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| Unit 6 - Base Material<br>Mohr-Coulomb<br>Drained<br>RGB 164, 241, 101<br>Automatic<br>Unit 6 - Base Material<br>Mohr-Coulomb<br>Drained<br>RGB 164, 241, 101<br>Standard<br>Coarse<br>1<br>1<br>7<br>No<br>0.8<br>0.8<br>0.0<br>1.00E+1<br>1.00E+1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    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Drained           RGB 182, 226, 190           Automatic           3           Coarse           D           Drained           RGB 182, 226, 190           Mohr-Coulomb           Drained           RGB 182, 226, 190           Standard           Coarse           0           3           Coarse           0           5           10           Standard           Coarse           0           5           10           5           10           10           10           10           10           10           10           10           10           10           10           10           10           10           10           10           10           10           10           10           10           10                                                                                                                                                                                                                                                                                                                 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0<br>0<br>16<br>5<br>                                                                                                                      | C α           c_init           Strength           c_ref           φ (phi)           ψ (psi)           Advanced           Set to default values           Suffness           Suffness           V_ur           K_0^nc           M           Material set           Identification number           Identification           Material model           Drainage type           Colour           Strength           R_inter           Real interface thickness           6_inter           Initial           Material set           Identification number           Identification number           Identification           Material set           Identification number           Identi                                                                                                                                                                                                      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| Science         Science           K, O, &         Science           K, O, &         Science           Science         Science           Material set         Science           Identification         Science           Material set         Science           Science         Science           Drainage type         Science           Data set         Science           Solid         Type           2 µm > Science         Science           Solid         Type           2 µm > Soly µm > Zm         Science           Solid         Type           Science         Science           Solid         Type           Science         Science           Solid         Type           Science         Science           Scie                                                                                                                                                                                                                                                                                                         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Rock       7         Standard       7         Coarse       10         13       13         Coarse       0         No       8.60E-03         8.60E-03       0         0       0.5         0       0.5         1.00E+15       1         1.00E+15       1 <td>Real interface thickness<br/>6_inter Material set lidentification Material model Drainage type Colour K0 settings K 0 determination K 0,x Flow parameters Material model Drainage type Colour Material at Identification number Identification Material at Identification Material model Drainage type Colour Model Data set Sol Type C 2 µm 2 µm - 2 nm Parameters Sol m- 2 nm Parameters Sol m- 2 nm Parameters Sol m- 2 nm Parameters K_X 4 µunsat L 4 interfact L 4 interfact</td> <td>%           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %</td> <td></td> <td>000<br/>000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>1000<br/>10</td> <td>Unit 6 - Base Material<br/>Mohr-Coulomb<br/>Drained<br/>RGB 164, 241, 101<br/>Automatic<br/>Unit 6 - Base Material<br/>Mohr-Coulomb<br/>Drained<br/>RGB 164, 241, 101<br/>Standard<br/>Coarse<br/>1<br/>1<br/>1<br/>7<br/>No<br/>0.8<br/>0.8<br/>0.8<br/>0.8<br/>0.0<br/>1.00E+1</td> <td>3         1           0         0           0         0           0         100           Interface Unit 6-18         Mohr-Coulomb           Drained         RGB 184, 250, 61           Automatic         3           1         0.5152           2         100           Interface Unit 6-18           Mohr-Coulomb         Drained           RGB 184, 250, 61         Standard           Coarse         0         100           3         13         77           No         0         0           5         0         0.5           5         1.00E+15         1.00E+15           1         1.00E+15         1.00E+15</td> <td>1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1</td> <td>1     1     1     0     1     1     1     1     0     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1</td> <td>1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1</td> <td>0.07<br/>0<br/>0<br/>14<br/>Interface Unit 12-16R<br/>Mohr-Coulomb<br/>Drained<br/>RG6 88, 245, 15<br/>Automatic<br/>0.7412<br/>0.7412<br/>11<br/>12-16R<br/>Mohr-Coulomb<br/>Drained<br/>RG6 88, 245,
15<br/>Standard<br/>Coarse<br/>10<br/>13<br/>1777<br/>No<br/>0<br/>0<br/>0<br/>0<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15<br/>1.00E+15</td> <td>(     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     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 (     (     (     (     (     (     (     (</td> <td>Interface Unit 14-1           Mohr-Coulomb           Drained           RGB 182, 226, 190           Automatic           3           (Coulomb           Drained           RGB 182, 226, 190           Mohr-Coulomb           Drained           RGB 182, 226, 190           Coarse           D           Coarse           D           S           Standard           Coarse           D           S           S           S           S           S           S           S           S           S           S           S           S           S           S           S           S           S           S           S           S           S           S           S           S           S           S           S           S           S           S</td> <td>0<br/>0<br/>16<br/>5<br/></td> <td>C α<br/>c, init<br/>Sirrength<br/>C, ref<br/>4 (phi)<br/>4 (phi)<br/>4 (phi)<br/>5 et to afault values<br/>5 to afault value<br/>6 to afault value<br/>7 to a strong th<br/>7 to a strong th<br/>7</td> <td>kN/m^2         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *</td> | Real interface thickness<br>6_inter Material set lidentification Material model Drainage type Colour K0 settings K 0 determination K 0,x Flow parameters Material model Drainage type Colour Material at Identification number Identification Material at Identification Material model Drainage type Colour Model Data set Sol Type C 2 µm 2 µm - 2 nm Parameters Sol m- 2 nm Parameters Sol m- 2 nm Parameters Sol m- 2 nm Parameters K_X 4 µunsat L 4 interfact                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           % |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              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| Unit 6 - Base Material<br>Mohr-Coulomb<br>Drained<br>RGB 164, 241, 101<br>Automatic<br>Unit 6 - Base Material<br>Mohr-Coulomb<br>Drained<br>RGB 164, 241, 101<br>Standard<br>Coarse<br>1<br>1<br>1<br>7<br>No<br>0.8<br>0.8<br>0.8<br>0.8<br>0.0<br>1.00E+1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 3         1           0         0           0         0           0         100           Interface Unit 6-18         Mohr-Coulomb           Drained         RGB 184, 250, 61           Automatic         3           1         0.5152           2         100           Interface Unit 6-18           Mohr-Coulomb         Drained           RGB 184, 250, 61         Standard           Coarse         0         100           3         13         77           No         0         0           5         0         0.5           5         1.00E+15         1.00E+15           1         1.00E+15         1.00E+15                                                                                   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                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 0.07<br>0<br>0<br>14<br>Interface Unit 12-16R<br>Mohr-Coulomb<br>Drained<br>RG6 88, 245, 15<br>Automatic<br>0.7412<br>0.7412<br>11<br>12-16R<br>Mohr-Coulomb<br>Drained<br>RG6 88, 245, 15<br>Standard<br>Coarse<br>10<br>13<br>1777<br>No<br>0<br>0<br>0<br>0<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15<br>1.00E+15 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  (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (     (                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Interface Unit 14-1           Mohr-Coulomb           Drained           RGB 182, 226, 190           Automatic           3           (Coulomb           Drained           RGB 182, 226, 190           Mohr-Coulomb           Drained           RGB 182, 226, 190           Coarse           D           Coarse           D           S           Standard           Coarse           D           S           S           S           S           S           S           S           S           S           S           S           S           S           S           S           S           S           S           S           S           S           S           S           S           S           S           S           S           S           S                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 0<br>0<br>16<br>5<br>                                                                                                                      | C α<br>c, init<br>Sirrength<br>C, ref<br>4 (phi)<br>4 (phi)<br>4 (phi)<br>5 et to afault values<br>5 to afault value<br>6 to afault value<br>7 to a strong th<br>7                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | kN/m^2         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *  |
| Scientification         Image: Scientification           K, O.X         Image: Scientification           Material set         Image: Scientification           Identification number         Image: Scientification           Identification number         Image: Scientification           Data set         Image: Scientification           Scientification         Image: Scientification           Data set         Image: Scientification           Solid         Image: Scientification           Type         Image: Scientification           Scientification         Image: Scientification           Solid         Image: Scientification           Type         Image: Scientification           Scientification         Image: Scientification                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Automatic         1           Automatic         7           Unit 44 to 47 - Rock         7           Unit 44 to 47 - Rock         7           Unit 44 to 47 - Rock         7           Grained         8           RGB 5, 60, 138         7           Standard         7           Coarse         10           Coarse         10           No         8.60E-03           8.60E-03         8.60E-03           0         0.5           1.00E+15         1.00E+15           1.00E+15 <td>Real interface thickness<br/>6_inter<br/>Material set<br/>identification number<br/>identification and<br/>Material model<br/>Drainage type<br/>Colour<br/>K 0 settings<br/>K 0 determination<br/>K 0 x<br/>Flow parameters<br/>Material set<br/>identification number<br/>identification number<br/>identif</td> <td>%           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %</td> <td></td> <td>0     0     8     104e7dace Unit 12-16P     Mohr-Coulomb     Drained     0.5933     0.5933     1024     1024     1024     1024     1024     1024     1024     1024     1024     102     1024     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102</td> <td>Unit 6 - Base Material<br/>Mohr-Coulomb<br/>Drained<br/>RGB 164, 241, 101<br/>Automatic<br/>Unit 6 - Base Material<br/>Mohr-Coulomb<br/>Drained<br/>RGB 164, 241, 101<br/>Standard<br/>Coarse<br/>1<br/>1<br/>7<br/>No<br/>0.8<br/>0.8<br/>0.8<br/>1.00E+1</td> <td>3         1           3         1           3         10           1         10           1         10           1         10           1         10           1         0           1         0.5152           1         0.5152           1         10           1         10           1         0.5152           1         10           1         10           1         10           1         10           1         10           1         10           1         10           1         10           1         10           1         10           1         10           1         10           1         10           1         10           1         10           1         10           1         10           1         10           1         10           1         10           1         10           1         10      &lt;</td> <td>1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1</td> <td>1     1     1     0     1     1     1     0     1     1     1     1     0     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1</td> <td>1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1</td> <td>0.07<br/>0<br/>0<br/>14<br/>Interface Unit 12-16R<br/>Mohr-Coulomb<br/>Drained<br/>RGB 88, 245, 15<br/>14<br/>Interface Unit 12-16R<br/>Mohr-Coulomb<br/>Drained<br/>RGB 88, 245, 15<br/>Standard<br/>Coarse<br/>0<br/>10<br/>13<br/>777<br/>No<br/>0<br/>0<br/>0<br/>0<br/>0<br/>0<br/>0<br/>0<br/>0<br/>0<br/>0<br/>0<br/>0</td> <td>(</td> <td>Interface Unit 14-1     Interface Unit 14-1     Mohr-Coulomb     Drained     RGB 182, 226, 190     Automatic     Torained     RGB 182, 226, 190     Torained     RGB 182, 226, 190     Standard     Coarse     D     Standard     Coarse     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S
    S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S</td> <td>000<br/>0<br/>16<br/>5<br/>16<br/>5<br/>10<br/>10<br/>10<br/>13<br/>77<br/>0<br/>0<br/>0<br/>0<br/>0<br/>0<br/>0<br/>0<br/>0<br/>0<br/>0<br/>0<br/>0</td> <td>C a           e_init           Strength           C, ref           4 (ph)           44 (pi)           Advanced           Set to default values           Suffness           Sylfness           V, Ur           K, O'nc           M           Material set           Material set           Material set           Material model           Orainage type           Colour           Strength           R_ inter           Rainterface thickness           6_inter           Initial           Material set           Identification number           Id</td> <td><pre>kkl/m^2 2 * * * * * * * * * * * * * * * * * *</pre></td>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       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and<br>Material model<br>Drainage type<br>Colour<br>K 0 settings<br>K 0 determination<br>K 0 x<br>Flow parameters<br>Material set<br>identification number<br>identification number<br>identif                                                                                                                                                                                                                                                                                                                                                                                                                                                              | %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           % |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      
                                                                                                                                                                                                                                                                                                                                         | 0     0     8     104e7dace Unit 12-16P     Mohr-Coulomb     Drained     0.5933     0.5933     1024     1024     1024     1024     1024     1024     1024     1024     1024     102     1024     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102     102  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                                                         | Unit 6 - Base Material<br>Mohr-Coulomb<br>Drained<br>RGB 164, 241, 101<br>Automatic<br>Unit 6 - Base Material<br>Mohr-Coulomb<br>Drained<br>RGB 164, 241, 101<br>Standard<br>Coarse<br>1<br>1<br>7<br>No<br>0.8<br>0.8<br>0.8<br>1.00E+1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      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15<br>Standard<br>Coarse<br>0<br>10<br>13<br>777<br>No<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  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                                                                                                                                                                                                                                                                                                                                                                 | Interface Unit 14-1     Interface Unit 14-1     Mohr-Coulomb     Drained     RGB 182, 226, 190     Automatic     Torained     RGB 182, 226, 190     Torained     RGB 182, 226, 190     Standard     Coarse     D     Standard     Coarse     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     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                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <pre>kkl/m^2 2 * * * * * * * * * * * * * * * * * *</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Science       K, O. determination       K, O. X       Flow parameters       Material set       identification       Material model       Drainage type       Colour       Data set       Solit       Type       Jata set       Solit       Type       2 µm - S0 µm       %       2 µm       %       4 µmost       6 µmost       6 µmost       6 µmost       1 µmost       1 µmost       1 µmost       1 µmost       1 µmost       1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    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         Coarse         10           No         8.60E-03           Scote-03         8.60E-03           Scote-03         0.5           1.00E+15         0           1.00E+15         1.00E+15           1.00E+15                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          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set<br>Soli<br>Type<br>2 µm - 2 µm<br>Set to default values<br>k. x<br>k. y<br>4µ unsat<br>e_init<br>Change of permeability<br>C.k<br>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   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 0.6           0.7           0.8           0.6           0.7           0.8           0.7           0.7           0.7           0.8           0.00           0.5           0.5           0.5           0.5           0.5           0.5           0.5           0.5           0.5           0.5           0.5           0.5           0.5           0.5           0.5           0.5           0.5           0.5           0.5           0.5           0.5           0.5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    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      Mohr Coulomb           Darined         0.5152           1         0.5152           1         0.5152           1         0.116 - 18           Mohr Coulomb         Drained           RGE 184, 250, 61         10           Drained         RGE 184, 250, 61           Standard         Coarse           0         10           3         133           7         77           No         0           0         0           0         0           0         0           0         0           0         0           0         0           0         0           0         0           0         0           0         0           0         0           0         0           0         0           0         0           0         0           0                                                                                                                                                                                                                                                                                    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                                                                                                                                                                                                                                                                                       | 0.07 0 0 0 0 14 Interface Unit 12-16R Mohr-Coulomb Drained RGB 88, 245, 15 Automatic 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412 0.7412
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Mohr-Coulomb     Drained     RGB 182, 226, 190     Standard     Coarse     D     Standard     Coarse     D     Standard     Coarse     D     Standard     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     S     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                          | C α<br>e, init<br>Strength<br>C, ref<br>(4 (ph))<br>Advanced<br>Advanced<br>Set to default values<br>Stiffness<br>V, Ur<br>K, O'nc<br>Material set<br>V, Ur<br>K, O'nc<br>Material set<br>V, Ur<br>Material model<br>Drainage type<br>Colour<br>Drainage
type<br>Colour<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Strength<br>Stren                                                                                                                                                                               | kkl/m^2         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         *         * |

	Unit 41a - New Landfill Soft soil creep Drained	Unit 41b - Old Landfill Soft soil creep Drained	Unit 41a - Soil Fill Soft soil creep Drained	Unit 42b - Alluvium Soft soil creep Drained	Unit 42b - Colluvium Soft soil creep Drained
	11	11	17	17	18
	No 2	No 2	No 2	No 1	No 1.5
	0 999	0 999	0 999	0 999	0 999
	0	0	0	0	0
	0	0	0		0
	2 Unit 41a - New Landfill	3 Unit 41b - Old Landfill	4 Unit 41a - Soil Fill	5 Unit 42b - Alluvium	6 Unit 42b - Colluvium
	Soft soil creep Drained	Soft soil creep Drained	Soft soil creep Drained	Soft soil creep Drained	Soft soil creep Drained
	0.08696	0.08696	0.02899	0.0587	0.02609
	0.01739	0.01739	5.80E-03	0.02609	8.70E-03
	No 0.6	No 0.6	No 0.2	No 0.27	No 0.15
	0.06	0.06	0.02	0.06	0.025
	2	2	2	2	2
	30	30	26	25	27
	Yes	Yes	Yes	Yes	Yes
	0.15	0.15	0.15	0.15	0.15
	1.589	1.589	1.407	1.221	1.379
	2	3	4	5	6
	Unit 41a - New Landfill Soft soil creep	Unit 41b - Old Landfill Soft soil creep	Unit 41a - Soil Fill Soft soil creep	Unit 42b - Alluvium Soft soil creep	Unit 42b - Colluvium Soft soil creep
	Drained RGB 95, 112, 114	Drained RGB 58, 73, 74	Drained RGB 236, 136, 14	Drained RGB 228, 248, 13	Drained RGB 202, 176, 7
	0.08696	0.08696	0.02899	0.0587	0.02609
	0.01739 8.70E-03	0.01739 8.70E-03	5.80E-03 8.70E-03	0.02609 2.17E-03	8.70E-03 1.04E-03
	No	No	No	No	No
	0.6	0.6	0.2	0.27	0.15
	0.06	0.06	0.06	0.01	6.00E-03 1.5
	2	2	2	2	2
	30 0	30 0	26	25	27
	Yes	Yes	Yes	Yes	Yes
	0.15	0.15	0.15	0.15	0.15
	0.5	0.5	0.5616	0.5774	0.546
	2 Unit 41a - New Landfill	3 Unit 41b - Old Landfill	4 Unit 41a - Soil Fill	5 Unit 42b - Alluvium	6 Unit 42b - Colluvium
	Soft soil creep Drained	Soft soil creep Drained	Soft soil creep Drained	Soft soil creep Drained	Soft soil creep Drained
	RGB 95, 112, 114	RGB 58, 73, 74	RGB 236, 136, 14	RGB 228, 248, 13	RGB 202, 176, 7
	1	1	1	1	1
	0	0	0	0	0
	2	3	4	5	6
	Unit 41a - New Landfill Soft soil creep	Unit 41b - Old Landfill Soft soil creep	Unit 41a - Soil Fill Soft soil creep	Unit 42b - Alluvium Soft soil creep	Unit 42b - Colluvium Soft soil creep
	Drained RGB 95, 112, 114	Drained RGB 58, 73, 74	Drained RGB 236, 136, 14	Drained RGB 228, 248, 13	Drained RGB 202, 176, 7
	Automatic	Automatic	Automatic	Automatic	Automatic
	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.285
	1.1 20	1.1 20	1.5	1.2	3
	2 Unit 41a - New Landfill	3 Unit 41b - Old Landfill	4 Unit 41a - Soil Fill	5 Unit 42b - Alluvium	6 Unit 42b - Colluvium
	Soft soil creep Drained	Soft soil creep Drained	Soft soil creep Drained	Soft soil creep Drained	Soft soil creep Drained
	KGB 95, 112, 114	кыз 58, 73, 74 Standard	кыз 236, 136, 14 Standard	кый 228, 248, 13 Standard	кыз 202, 176, 7 Standard
	Standard	Coarse	Coarse	Sine	Standard Madium fine
	10	Loarse 10	Loarse 10	rme 46	meaium fine
	13	13	13	26	74
-	No 0 64	No	No 8 605.02	No 8 605 04	No 9 605 02
	No 8.64 8.64	No 8.64 8.64	No 8.60E-03 8.60E-03	No 8.60E-04 8.60E-04 1.00E+04	No 8.60E-03 8.60E-03 1.00E+04
	No 8.64 0 2	No 8.64 0 2	No 8.60E-03 0 2	No 8.60E-04 8.60E-04 1.00E+04 1	No 8.60E-03 8.60E-03 1.00E+04 1.5

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I<br>Mohr-Coulomb N<br>Drained C<br>RGB 244, 31, 230 P<br>Automatic A<br>0.5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             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Residual Soil           Unit 43 - Residual Soil           Unit 43 - Residual Soil           Drained           C GB 244, 32, 320           RGB 244, 32, 320                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 8 hterface Unit 12-16 Gh7-Coulomb GB 195, 229, 249 Utomatic GB 195, 229, 249 Utomatic B terface Unit 12-16 Kohr-Coulomb Kained GB 195, 229, 249                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Init 6 - 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Residual Soil         1           Unit 43 - Residual Soil         1           Mohr-Coulomb         N           Drained         C           RGB 244, 31, 230         R                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | terface Unit 12-16     tofhr-Coulomb     for Coulomb     for Tarlied     GB 195, 229, 249     tofhr-Coulomb     terface Unit 12-16     tofhr-Coulomb     tofhr-Coulomb     tofhr-Coulomb     GB 195, 229, 249                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Init 6 - Base Material<br>Aohr-Coulomb<br>Tarlied<br>GB 10, 205, 45<br>0.470<br>Unit 6 - Base Material<br>Aohr-Coulomb<br>Tarlied<br>GB 10, 205, 45                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 9 1 1<br>Interface Unit 6-18<br>Mohr-Coulomb<br>Drained<br>RGB 184, 250, 61<br>Automatic<br>1 0.515<br>9 1<br>Interface Unit 6-18<br>Mohr-Coulomb<br>Drained<br>RGB 184, 250, 61                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               
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16-17<br>Mohr-Coulomb<br>Drained<br>RGB 134, 234, 162                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    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  Mohr           RGB 85, 93, 252         RGB           Automatic         Autor           J         0.5           J         10           Mohr-Coulomb         Mohr           Mohr-Coulomb         Mohr           Drained         Drained           Drained         Drained           Standard         Standard                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            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Onc<br>M<br>M<br>M<br>Material set<br>Identification number<br>Identification number<br>Identification number<br>Identification number<br>Identification number<br>Identification<br>Material model<br>Drainage type<br>Colour<br>Strength                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | MMm2         Mathematical Mathematinde Mathematical Mathanelex Mathematical Mathematical                                   |
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45<br>Unit 6 - Base Material<br>Aohr-Coulomb<br>Init 6 - Base Material<br>Aohr-Coulomb<br>GB 10, 205, 45<br>Tandard                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      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6-18<br>Mohr-Coxiomb<br>Drained<br>Actionate<br>Automatic<br>Automatic<br>Interface Unit 6-18<br>Mohr-Coxiomb<br>Drained<br>RGB 184, 50, 61<br>Standard                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  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     Automatic         Automatic           Joint 9 - Protection Mater Interf           Mohr-Coulom Mohr           Mohr-Coulom Mohr           Drained         Drained           Standard         Standard           Standard         Standard           Standard         Standard           1         7 mit                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               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| Nov parameters           Invo parameters           Identification number           Identification number           Identification number           Identification number           Data set           Data set <td>Unt 44 to 47 - Rock<br/>Linear elastic<br/>Orained<br/>AG 5 5, 60, 138<br/>Standard<br/>Coarse<br/>1<br/>Coarse<br/>No<br/>No<br/>8, 600-00<br/>8, 600-00<br/>0<br/>(<br/>0<br/>0<br/>0<br/>0</td> <td></td> <td>Initial Material set Material set Material set destification number destification Material model Drainage type Colour K 0 determination Material model Data set Solar Model Data set Solar Solar</td> <td></td> <td>1           Unit 43 - Residual Soil II           Mohr-Coulomb M           Mohr-Coulomb M           Paraleed           RGB 244, 31, 230           Automatic           J           Unit 43 - Residual Soil II           Mohr-Coulomb M           Mohr-Coulomb M           Paraleed           RGB 244, 31, 230           I           Unit 43 - Residual Soil II           Mohr-Coulomb M           Standard           Standard           Standard           Medium           41           4.00E+01</td> <td>8           thefr-coulomb           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           &lt;</td> <td>Init 6 - Base Material<br/>Adolr - Coulomb<br/>Adolr - Coulomb<br/>Varined<br/>6 (8 10, 205, 45<br/>uutomatic<br/>0.4700<br/>Unit 6 - Base Material<br/>Adolr - Coulomb<br/>Trained<br/>GG 10, 205, 45<br/>tandard<br/>GG 10, 205, 45<br/>tandard<br/>Carse<br/>1<br/>7.70E+0</td> <td>9         1           Interface Unit 6-18         Nohr-Coulomb           Drained         R661184, 250, 61           Automatic         0.515           9         1           0.515         0           9         1           Drained         R68184, 250, 61           R68184, 250, 61         Standard           Coarse         0           0         1           10         7.706-60           10         7.706-70</td> <td>0 Interface Unit 15-17 Interface Unit 15-17 Mohr-Coulomb Drained RGB 24, 19, 120 Interface Unit 15-17 Mohr-Coulomb Drained RGB 241, 39, 120 Standard Coarse 0 Interface Unit 15-17 Mohr-Coulomb Coarse 0 Interface Unit 15-17 Interface Unit 15-</td> <td>1         11           Unit 4 - Cay Rob 2000         Drained           Drained         0           Bride 48, 227, 243         Automatic           Automatic         0.5300           Unit 4 - Cay Rob 2000         0.5300           Unit 4 - Cay Rob Dearing         Moter Coulomb           Drained         0.014 - Cay Rob Dearing           Moter Coulomb         Drained           Goard         Course           10         11           13         17</td> <td>2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1</td> <td>3         1           Unit 9 - Protection Mater Interf         Mohr           Drained         Drain           Rols 85, 93, 252         Rols 7           Automatic         Automatic           Junit 9 - Protection Mater Interf           Nutri 9 - Protection Mater Interf           Notif 9 - Protection Mater Interf           Mohr - Coulomb         Mohr           Standard         Standard           Standard         Standard           Standard         Standard           1         10           3         10</td> <td>16           ace 14-15           -Coulomb           ed           18, 135, 27           natic           ace 14-15           -Coulomb           ed           18, 135, 27           ard           e           10           37, 70E+01</td> <td>17 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Residual Soil II           Mohr-Coulomb M           Mohr-Coulomb M           Paraleed           RGB 244, 31, 230           Automatic           J           Unit 43 - Residual Soil II           Mohr-Coulomb M           Mohr-Coulomb M           Paraleed           RGB 244, 31, 230           I           Unit 43 - Residual Soil II           Mohr-Coulomb M           Standard           Standard           Standard           Medium           41           4.00E+01                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 8           thefr-coulomb           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           1           <                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Init 6 - 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                                                                                     | 1         1           Unit 43 - Residual Soil         In           Mohr-Coulomb         Mohr           R68 244, 31, 230         In           Automatic         0.3           Mohr-Coulomb         Mohr           Mohr-Coulomb         N           Mohr-Coulomb         N           Drained         E68 244, 31, 230           R68 244, 31, 230         R           Standard         S           Mohr-Coulomb         N           Standard         S           Medium         C           19         41           4,00E+01         No           No         8.60E-04           8.60E-04         0.55           1.00E+15         1.00E+15                                                                                                                                                                                                                                                                                                            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                                                                                                       | Unit 43 - Residual Soli         1           Morine Constromb         N           Morine Constromb         N           Morine Constromb         N           Morine Constromb         N           Automatic         A           Automatic         A           Mother Constromb         N           No         8.507-04           Note+15         .00E+15                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | terface Unit 22-16     Adot-Coulomb     Adot-Coulomb     Adot-Coulomb     Adot-Coulomb     Adot-Coulomb     Adot     Adot    | Init 6 - Base Material           Adolr - Coulomb           Adolr - Coulomb           Init 6 - Base Material           0.470           O.470           Init 6 - Base Material           Adolr - Coulomb           Trained           GG 10, 205, 45           tandard           GG 10, 205, 45           tandard           Coarse           1           7.700±0           0           0           0           0           0           0           0           1.000±1                                                                                                                                                                                                                                                                                                                                                                              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                                                                                                                                                                                                                                              | 1<br>Unit 43 - Residual Soil II<br>Mohr-Coulomb D<br>Parained C<br>Ride 244, 31, 230 /r<br>Automatic A<br>Unit 43 - Residual Soil II<br>Unit 43 - Residual Soil II<br>Unit 43 - Residual Soil II<br>II<br>Unit 43 - Residual Soil II<br>II<br>II<br>Ride 244, 31, 230 /r<br>II<br>II<br>Nobr-Coulomb N<br>Ride 244, 31, 230 /r<br>II<br>II<br>Nobr-Coulomb N<br>Ride 244, 31, 230 /r<br>II<br>II<br>II<br>II<br>II<br>II<br>II<br>II<br>II<br>I                                                                                                                                                                                                                                                                                                                                          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152<br>Automatic<br>1 12<br>Interface Unit 16-17<br>Drained<br>RGB 134, 234, 162<br>Standard<br>Coarse<br>0 10 10<br>1 2<br>Coarse<br>0 0 0 10<br>1 2<br>1 2<br>Coarse<br>0 0 0 10<br>1 3<br>1 2<br>1 3<br>1 0 0 0 0 0<br>1 3<br>1 1<br>1 1<br>1 1<br>1 1<br>1 1<br>1 1<br>1 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           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number<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph-<br>G-ph 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Residual Sol I<br/>Moth - Caulomb II<br/>Moth - Caulomb II<br/>No 8, 666 - 61<br/>1, 000E - 415<br/>1, 00</td> <td>terface Unit 32-16     terface Unit 32-1</td> <td>2nit 6 - Base Material<br/>Adolr - Coulomb<br/>Adolr - Coulomb<br/>Trained<br/>0.470<br/>0.470<br/>0.470<br/>1016 - Base Material<br/>Adolr - Coulomb<br/>Trained<br/>GG 10, 205, 45<br/>110 - Coulomb<br/>7.70te4<br/>0.0<br/>0.0<br/>0.0<br/>1.00E+1</td> <td>9 1 1 Interface Unit 6-18 Mohr-Coulomb Drained Ric6 1384, 250, 61 Automatic 9 0 0.0515 9 0 0.0515 9 0 0.0515 9 0 0.051 9 0 0.051 9 0 0.051 9 0 0.051 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.05 9 0 0.0</td> <td>0 0 1 1nterface Unit 15-17 1nterface Unit 15-17 0 0 1 Automatic 2 0 0 1 1nterface Unit 15-17 Mohr-Coulomb 0 0 1 1nterface Unit 15-17 Mohr-Coulomb 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1</td> <td>1        </td> <td>2 1 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014 1 1 1474-2014</td> <td>3         1           Unit 9 - Protection Matter Interf         Mohr           Drained         Mohr           Stationaria         Mohr           Stationaria         Mohr           Automatic         Nater           Automatic         Nater           Multi 9 - Protection Mater         Mohr           Unit 9 - Protection Mater         Mohr           Mohr-Coulomb         Mohr           Mohr<coulomb< td="">         Mohr           Mohr<coulomb< td="">         Mohr           Mohr<coulomb< td="">         Mohr           Mohr         Onitinet         Terr           Standard         Standard         Standard           Standard         Standard         Standard           No         No         No           0         0.86         O           0         0.086         O</coulomb<></coulomb<></coulomb<></td> <td>16 27 27 27 27 27 27 27 27 27 27 27 27 27</td> <td>17 17 18 19 19 19 19 19 19 19 19 19 19 19 19 19</td> <td>C - ref<br/>G - (ph)<br/>G - (ph)<br/>Material set<br/>G - (ph)<br/>G - (ph)<br/>Material set<br/>G - (ph)<br/>Material set<br/>G - (ph)<br/>Material set<br/>Material model<br/>D - (ph)<br/>Material model<br/>D - (ph)<br/>Materi</td> <td>Number         Number         Number&lt;</td>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              
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19<br>10<br>401-10<br>8.600-04<br>1.000-101<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115<br>1.000-115                                                                          | terface tunit 2:16     terface tunit 12:16     terface tunit     terface tunit 12:16     terface tunit | Unit 6 - Base Material<br>Adohr-Coulomb<br>Trained<br>68 10, 205, 45<br>0.470<br>Unit 6 - Base Material<br>Adohr-Coulomb<br>Trained<br>GGB 10, 205, 45<br>tandard<br>Coarse<br>1<br>1, 205, 45<br>1<br>1, 205, 45<br>1, 205, 451, 205, 45<br>1, 205, 451, 205,                                                                                                                                                                                                                                                                                                                                                                                                                                         | 9         1           Interface Unit 6-18         Automatic           Drained         Mohr-Coutomb           Drained         Mohr-Coutomb           9         1           10         0.515           11         0.515           12         0.515           13         1           14         Automatic           15         0.515           16         6           17         7.708+0           18         0           10         1           11         7.708+0           15         0.000+1           16         0           10         1           10         1           11         7.708+0           12         1           13         1           14         1           15         0.000+1           15         1           16         1           17         1           18         1           19         1           100         1           100         1           100         1           <                                                                                                                                                                                                                                                                             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1.00E+15         1           Jamatic         Jamatic         Her           Jamatic         Jamatic         He                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            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| Nov parameters       Invo parameters       Material acts       Material acts       Material acts       Material model       Dataset       Colour       Material model       Dataset       Oppe       Law       K       Jum-3b unders       Solum       Solum       Solum       Solum       Setto fealut values       L_x       Material       Calarge of permeability       C.k       Calarge of permeability       Solum       Solum <td>Unit 44 to 47 - Rock<br/>Linear elastic<br/>Orained<br/>RoE 5, 60, 138<br/>Standard<br/>Coarse<br/>10<br/>0<br/>0<br/>0<br/>0<br/>0<br/>0<br/>0<br/>0<br/>0<br/>0<br/>0<br/>0<br/>0</td> <td></td> <td>Initial Material set Material set Material set Material model Generification number Identification Material model Countings Co</td> <td>5<br/>5<br/>5<br/>5<br/>5<br/>5<br/>5<br/>5<br/>5<br/>5<br/>5<br/>5<br/>5<br/>5</td> <td>1         1           Unit 43 - Residual Soli         In           Motor Costomo         N           Motor Costomo         N           RGB 244, 31, 230         A           Automatic         A           Motor Costomo         N           Medium         C           Standard         8.606-01           No         8.606-01           1.0001-01         0.507-01           1.0001-01         0.507-01           1.0001-01         0.507-01           1.0001-01         0.507-01           1.0001-01         0.507-01           1.0001-01         0.507-01           1.0001-01         0.507-01           1.0001-01         0.507-01           1.0001-01         0.507-01           1.0001-01         0.507-01           1.0001-01         0.507-01           1.0001-01         0.507-01           &lt;</td> <td>B     terface Unit 32-16     terface Uni</td> <td>2nit 6 - Base Material<br/>Adolr - Coulomb<br/>Adolr - Coulomb<br/>Varianed<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>0.4700<br/>0.470<br/>0.470<br/>0.470000000000</td> <td>9         1           Interface Unit 6-18         Mohr-Coulomb           Drained         R661184, 250, 61           Automatic         0.515           9         1           0.515         0           9         1           0.515         0           9         1           10         0.515           0         1           11         0.515           0         1           10         7.004           10         7.704           10         7.704           10         7.704           10         1.002+1           10         1.002+1           10         1.002+1           10         1.002+1           10         1.002+1</td> <td>0 0 1 1nterface Unit 15-17 Nobr-Coulomb Drained RGB 241, 39, 120 5 1nterface Unit 15-17 Nobr-Coulomb Drained RGB 241, 39, 120 5 1nterface Unit 15-17 Nobr-Coulomb D 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1</td> <td>1        </td> <td>2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1</td> <td>3         1           Unit 9 - Protection Matter Interf         Mohr           Drained         Mohr           Stationards         Mohr           Mohr-Coulomb         Mohr           Automatic         Rol 3           Automatic         Rol 3           Mohr-Coulomb         Mohr           Multi 9 - Protection Mater Interf         Mohr           Mohr-Coulomb         Mohr           Mohr-Coulomb         Mohr           Mohr Coulomb         Mohr           No         No           0         0.86           0         0.086           0         0.086           0         0.086           0         0.086           1.006+04         1           1.006+05         1           1.006+05         1           1.006+15         1<td>16 27 27 27 27 27 27 27 27 27 27 27 27 27</td><td>17 interface 15-17 (peak) Motin Control [15:17 (peak) No 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td><td>c _rel<br/>c _rel<br/>c _rel<br/>c _rel<br/>c _ (ph)<br/>c _</td><td>Num         International state         International state         International state         International state         International state         International state           Num         &lt;</td></td>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Unit 44 to 47 - Rock<br>Linear elastic<br>Orained<br>RoE 5, 60, 138<br>Standard<br>Coarse<br>10<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                           | Initial Material set Material set Material set Material model Generification number Identification Material model Countings Co | 5<br>5<br>5<br>5<br>5<br>5<br>5<br>5<br>5<br>5<br>5<br>5<br>5<br>5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        
                                                                                                                                                                                                                                                    | 1         1           Unit 43 - Residual Soli         In           Motor Costomo         N           Motor Costomo         N           RGB 244, 31, 230         A           Automatic         A           Motor Costomo         N           Medium         C           Standard         8.606-01           No         8.606-01           1.0001-01         0.507-01           1.0001-01         0.507-01           1.0001-01         0.507-01           1.0001-01         0.507-01           1.0001-01         0.507-01           1.0001-01         0.507-01           1.0001-01         0.507-01           1.0001-01         0.507-01           1.0001-01         0.507-01           1.0001-01         0.507-01           1.0001-01         0.507-01           1.0001-01         0.507-01           <                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | B     terface Unit 32-16     terface Uni | 2nit 6 - Base Material<br>Adolr - Coulomb<br>Adolr - 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| 9         1           Interface Unit 6-18         Mohr-Coulomb           Drained         R661184, 250, 61           Automatic         0.515           9         1           0.515         0           9         1           0.515         0           9         1           10         0.515           0         1           11         0.515           0         1           10         7.004           10         7.704           10         7.704           10         7.704           10         1.002+1           10         1.002+1           10         1.002+1           10         1.002+1           10         1.002+1                                                                                                                                                                                                                                                                                                                                                                                                       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                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 3         1           Unit 9 - Protection Matter Interf         Mohr           Drained         Mohr           Stationards         Mohr           Mohr-Coulomb         Mohr           Automatic         Rol 3           Automatic         Rol 3           Mohr-Coulomb         Mohr           Multi 9 - Protection Mater Interf         Mohr           Mohr-Coulomb         Mohr           Mohr-Coulomb         Mohr           Mohr Coulomb         Mohr           No         No           0         0.86           0         0.086           0         0.086           0         0.086           0         0.086           1.006+04         1           1.006+05         1           1.006+05         1           1.006+15         1 <td>16 27 27 27 27 27 27 27 27 27 27 27 27 27</td> <td>17 interface 15-17 (peak) Motin Control [15:17 (peak) No 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td> <td>c _rel<br/>c _rel<br/>c _rel<br/>c _rel<br/>c _ (ph)<br/>c _</td> <td>Num         International state         International state         International state         International state         International state         International state           Num         &lt;</td>                                                                                                                                                                                                                                                                                                                      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                                                                                                                                                                                                                                                                                                           | 1<br>Unit 43 - Residual Soil II<br>Mohr-Coulomb D<br>Parained C<br>RGB 244, 31, 230 IF<br>Automatic A<br>Unit 43 - Residual Soil II<br>Unit 43 - Residual Soil II<br>Unit 43 - Residual Soil II<br>II<br>Unit 43 - Residual Soil II<br>II<br>II<br>RGB 244, 31, 230 IF<br>II<br>II<br>RGB 244, 31, 230 IF<br>II<br>II<br>II<br>II<br>II<br>II<br>II<br>II<br>II                                                                                                                                                                                                                                                                                                                                                             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45<br>tandard<br>0.08<br>0.08<br>0.08<br>0.08<br>0.00<br>1.000 ± 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 9         1           Interface Unit 6-18         Automatic           Drained         Hofe 184, 250, 61           Mohr-Coulomb         Drained           9         1           10         0.515           9         1           9         1           11         0.515           0         1           0         1           0         1           0         1           0         1           10         7.708+0           10         1           11         7.708+0           15         0.0           16         1           10         1           11         7.708+0           12         1           13         1           14         1           15         0.0           15         1           100         1           10         1           10         1           11         1           12         1           13         1           14         1           100         1 <td>0 0 1 1nterface Unit 13-17 Mohr-Coulomb Drained Rois 241, 39, 120 2 2 0 0 1 1nterface Unit 13-17 Mohr-Coulomb Drained Rois 241, 39, 120 0 1 1nterface Unit 13-17 Mohr-Coulomb Drained Rois 241, 39, 120 Standard Coarse 0 1 7,70t+ No 0 1 7,70t+ No 0 1 1,7,70t+ No 0 1,00t+ 1,00t</td> <td>1         Umit 4 - Cargo Rub and Marker Concentre           Muit 4 - Cargo Rub and Marker Concentre         Monter Concentre           Million Concentre         0.5302           Automatik         0.5302           11         Unit 4 - Cargo Rub Reserving           Monter Concentre         0.5302           Daramed         Daramed           Daramed         Daramed           Daramed         Concentre           Daramed         Concentre           Doramed         Concentre           D0         Automatik           D0         Rofe Ascott 200           Doramed         Concentre           D0         Rofe Ascott 200           D         Automatik           D0         Rofe Ascott 200           D0         Rofe Ascott 200           D1         TO TOREOR           D2         OC           D3         DO Concentre           D4         DO Concentre           D5         J.000E+12           D6         Scott 200           D7         D7           D8         D7           D8         D7           D9         J.000E+12           D8         D7</td> <td>2 1 13<br/>1647ac UR1 54, 234, 152<br/>Molvi-Coulomb<br/>Drained<br/>RGB 134, 234, 152<br/>10<br/>10<br/>10<br/>10<br/>10<br/>10<br/>10<br/>10<br/>10<br/>10</td> <td>3         1           Unit 9 - Protection Mater Interf         Mode           Drained         Drained           Moles 5, 9, 252         R6 3           Moles 5, 9, 252         R6 5           Moles 5, 9, 252         R6 3           Moles 7, 9, 252         R6 5           Moles 7, 705 + 01         Moles 7           No         R6 8           Coarse         Coarse           Coarse         Coarse           Moles 7, 705 + 01         R6 8           Moles 7, 705 + 01         &lt;</td> <td>16 16 1415 Crotemb d d ac 1415 Crotemb d d d ac 1415 Crotemb d d d d d d d d d d d d d d d d d d d</td> <td>17 interface 15-17 (peak) Motr Contenties 15-17 (peak) Motr Contentie 0.058 0.058 0.058 0.058 0.058 0.058 0.058 0.058 0.058 0.05 0.05</td> <td>C_rel<br/>6 (ph)<br/>6 (ph)<br/>6 (pa)<br/>6 (pa)<br/>6 (pa)<br/>6 (pa)<br/>7 (</td> <td>Num2         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1</td> | 0 0 1 1nterface Unit 13-17 Mohr-Coulomb Drained Rois 241, 39, 120 2 2 0 0 1 1nterface Unit 13-17 Mohr-Coulomb Drained Rois 241, 39, 120 0 1 1nterface Unit 13-17 Mohr-Coulomb Drained Rois 241, 39, 120 Standard Coarse 0 1 7,70t+ No 0 1 7,70t+ No 0 1 1,7,70t+ No 0 1,00t+ 1,00t | 1         Umit 4 - 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| Nov parameters       Invo parameters       Material acts       Material acts       Material acts       Material model       Dataset       Colour       Material model       Dataset       Golge       Calour       Jum 30       Setto featural       Setto featural       Setto featural       Material       Material       Setto featural       Setto featural       Calage of permeability       C.k       Calage of permeability       C.k       Setto featural       Setto featural <t< td=""><td>Unit 44 to 47 - Rock<br/>Linear elastic<br/>Orained<br/>RoE 5, 60, 138<br/>Standard<br/>Coarse<br/>10<br/>0<br/>0<br/>0<br/>0<br/>0<br/>100Fe11<br/>10<br/>100Fe11<br/>10<br/>100Fe11<br/>10<br/>100Fe11<br/>10<br/>100Fe11<br/>10<br/>10<br/>10<br/>10<br/>10<br/>10<br/>10<br/>10<br/>10</td><td></td><td>Initial Material set Material set Material set Material model Generification number Identification Material model Courtings Co</td><td>5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5</td><td>1<br/>Unit 43 - Residual Sol II<br/>Molin - Coulomb II<br/>Coulomb II<br/>1<br/>Molin - Coulomb II<br/>1<br/>Automatic A<br/>0.5<br/>1<br/>1<br/>Moth - Coulomb II<br/>Moth - Coulomb II<br/>1<br/>Moth - Coulomb II<br/>1<br/>Moth - Coulomb II<br/>1<br/>1<br/>1<br/>1<br/>1<br/>1<br/>1<br/>1<br/>1<br/>1<br/>1<br/>1<br/>1</td><td>terface Unit 32-16     terface Unit 32-1</td><td>2nit 6 - Base Material<br/>Adolr - Coulomb<br/>Adolr - Coulomb<br/>Trained<br/>0.470<br/>0.470<br/>0.470<br/>1016 - Base Material<br/>Adolr - Coulomb<br/>Trained<br/>GG 10, 205, 45<br/>1<br/>101 - 7.70t-0<br/>7.70t-0<br/>10<br/>0.08<br/>0.08<br/>0.09<br/>1.00E+1</td><td>9         1           Interface Unit 6-18         Mohr-Coulomb           Drained         R661184, 250, 61           Automatic         0.515           9         0           9         0.515           9         0           9         0.515           9         0.515           0         0           9         0.618           0         1           10         0.7014           13         1           14         0.77014           15         0           16         0           15         0.000±1           10         1.00€±1           10         1.00€±1           11         1.00€±1</td><td>0 0 1 1nterface Unit 15-17 1nterface Unit 15-17 1nterface Unit 15-17 2 0 0 1 1nterface Unit 15-17 Nohr-Coulomb Drained RGB 241, 39, 120 Standard Coarse 0 1 1 1 2 1 2 1 1 1 1 1 1 1 1 1 1 1 1 1</td><td>Image: Second Second</td><td>2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1</td><td>3         1           Unit 9 - Protection Mater Interf         Mohr           Drained         Mohr           Battomatic         Mohr           Statomatic         R68           Jutit 9 - Protection Mater         Mohr           Jutitomatic         R67           Jutitomatic         R67           Jutiti 9 - Protection Mater         Mohr           Volti 9 - Protection Mater         Mohr           Mohr-Coulomb         Mohr           Mohr Coulomb         Mohr           Onained         Drained           Coarse         Coarse           O         0.86           O         0.086           O         0.086           O         0.086           S         1.006+04           S         1.006+</td><td>16 27 27 27 27 27 27 27 27 27 27 27 27 27</td><td>17  17  17  17  17  17  17  17  17  17</td><td>c _rel<br/>c _rel<br/>c _rel<br/>c _ pain<br/>c _ pain<br/>c</td><td>Mym²         1         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I      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                                                                                                                                                                                                                                                                                    | 1<br>Unit 43 - Residual Soil II<br>Mohr-Coulomb D<br>Ride 244, 31, 230 F<br>Automatic A<br>Unit 43 - Residual Soil II<br>Unit 43 - Residual Soil II<br>Unit 43 - Residual Soil II<br>Unit 43 - Residual Soil II<br>Ride 244, 31, 230 F<br>Ride 244, 31, 230 F<br>Ride 244, 31, 230 F<br>Standard S<br>Medium D<br>Standard S<br>Medium 19<br>401<br>100 + 04<br>8.660 - 04<br>1.000 + 03<br>1.000 + 15<br>1.000 + 15<br>1.                                                                                                    | terface tunit 22-16     terface tunit 12-16     t | Unit 6 - Base Material<br>Adohr-Coulomb<br>Trained<br>66 10, 205, 45<br>0.470<br>Unit 6 - Base Material<br>Adohr-Coulomb<br>Trained<br>GG 10, 205,
45<br>tandard<br>Coarse<br>1<br>1<br>7.70E+0<br>0<br>0<br>0.8<br>0.8<br>0.0<br>1.00E+1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   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| Nov parameters       Invo parameters       Material acts       Material acts       Material acts       Material model       Dataset       Golar       Material model       Dataset       Gone       La set       Gone       La set       Sope       Sope <td>Unit 44 to 47 - Rock<br/>Linear elastic<br/>Orained<br/>RG5 5, 60, 138<br/>Standard<br/>Coarse<br/>Coarse<br/>No<br/>No<br/>8, 600:0<br/>8, 600:0<br/>1, 000 + 11<br/>1, 11<br/>0, 2, 700 + 00<br/>1, 000 + 11<br/>1, 10<br/>1, 1</td> <td></td> <td>Initial Material set Material set Material set Material set Material model Countings C</td> <td>%           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %           %</td> <td>1<br/>Unit 43 - Residual Sol II<br/>Molin - Coulomb II<br/>Dolmod J C C<br/>RGB 244, 31, 230 II<br/>Automatic II<br/>Unit 43 - Residual Sol II<br/>Unit 43 - Residual Sol II<br/>Molin - Coulomb II<br/>Molin - Coulomb II<br/>Molin - Coulomb II<br/>II<br/>Unit 43 - Residual Sol II<br/>II<br/>Unit 43 - Residual Sol II<br/>II<br/>Unit 43 - Residual Sol II<br/>II<br/>Molin - Coulomb II<br/>Drained II<br/>II<br/>Molin - Coulomb II<br/>II<br/>Molin - Coulomb II<br/>II<br/>II<br/>II<br/>II<br/>II<br/>II<br/>II<br/>II<br/>II</td> <td>B     terface Unit 32-16     terface Uni</td> <td>2nit 6 - Base Material<br/>Adolr - Coulomb<br/>Adolr - Coulomb<br/>Trained<br/>0.470<br/>0.470<br/>0.470<br/>0.470<br/>1016 - Base Material<br/>Adolr - Coulomb<br/>Trained<br/>GG 10, 205, 45<br/>1<br/>101 - 10<br/>7.70te4<br/>0<br/>0<br/>0<br/>0<br/>0<br/>0.0<br/>1.00E+1</td> <td>9         1           Interface Unit 6-18         Mohr-Coulomb           Drained         R66 184, 250, 61           Automatic         0.515           9         0           9         0           9         0.515           9         0           9         0.515           0         0           10         0.515           0         0           13         1           13         1           13         1           10         7.704           10         7.704           10         7.704           10         1.002+1           10         1.002+1           10         1.002+1           10         1.002+1           10         1.002+1           10         1.002+1           10         1.002+1           10         1.002+1</td> <td>0 0 1 1nterface Unit 15-17 1nterface Unit 15-17 0 0 0 1 Automatic 2 0 0 1 1nterface Unit 15-17 Mohr-Coulomb Drained RGB 241, 39, 120 1 1nterface Unit 15-17 Mohr-Coulomb Drained RGB 241, 39, 120 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1</td> <td>Image: Second Second</td> <td>2 1 11<br/>Interface Unit 2, 24, 162<br/>Automatic 5 0.5931<br/>2 11 11 11 11 11 11 11 11 11 11 11 11 11</td> <td>3         1           Unit 9 - Protection Mater Interf         Mohr           Drained         Mohr           Stationaria         Mohr           Stationaria         Mohr           Automatic         Rol 8, 9, 32, 23           Automatic         No           Stationaria         Mohr           Junit 9 - Protection Mater Interf         Mohr           Volti 9 - Protection Mater Interf         Mohr           Volti 9 - Protection Mater Interf         Mohr           Mohr Coulomb         Mohr           Orained         Drain           Standard         Standard           Standard         Standard           Standard         Standard           No         No           0         0.86           0         0.086           0         0.086           0         0.086           0         0.086           0         0.086           0         0.086           0         0.086           0         0.086           0         0.086           0         0.086           0         0.086           0         0.086     <!--</td--><td>16 27 27 27 27 27 27 27 27 27 27 27 27 27</td><td>17 interface 15-17 (peak) Motin Control [5:17 (peak) No 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td><td>c _rel<br/>c _rel<br/>c _rel<br/>c _rel<br/>c _ (ph)<br/>c _</td><td>MMM*2         I.A.         Math         <t< td=""></t<></td></td>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   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Residual Sol II<br>Molin - Coulomb II<br>Dolmod J C C<br>RGB 244, 31, 230 II<br>Automatic II<br>Unit 43 - Residual Sol II<br>Unit 43 - Residual Sol II<br>Molin - Coulomb II<br>Molin - Coulomb II<br>Molin - Coulomb II<br>II<br>Unit 43 - Residual Sol II<br>II<br>Unit 43 - Residual Sol II<br>II<br>Unit 43 - Residual Sol II<br>II<br>Molin - Coulomb II<br>Drained II<br>II<br>Molin - Coulomb II<br>II<br>Molin - Coulomb II<br>II<br>II<br>II<br>II<br>II<br>II<br>II<br>II<br>II                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | B     terface Unit 32-16     terface Uni | 2nit 6 - Base Material<br>Adolr - Coulomb<br>Adolr - Coulomb<br>Trained<br>0.470<br>0.470<br>0.470<br>0.470<br>1016 - Base Material<br>Adolr - Coulomb<br>Trained<br>GG 10, 205, 45<br>1<br>101 - 10<br>7.70te4<br>0<br>0<br>0<br>0<br>0<br>0.0<br>1.00E+1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 9         1           Interface Unit 6-18         Mohr-Coulomb           Drained         R66 184, 250, 61           Automatic         0.515           9         0           9         0           9         0.515           9         0           9         0.515           0         0           10         0.515           0         0           13         1           13         1           13         1           10         7.704           10         7.704           10         7.704           10         1.002+1           10         1.002+1           10         1.002+1           10         1.002+1           10         1.002+1           10         1.002+1           10         1.002+1           10         1.002+1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                
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| Flow parameters       Investigation       Material set       Identification number       Material andel       Darinage type       Colour       Material model       Darinage type       Colour       Material model       Darinage type       Calour       Soli       Dype       2 Jum 5       Soli material       Califit       Califit       Soli material       Soli material <td>Unit 44 to 47 - Rock           Unit 44 to 47 - Rock           Urare ellistic           Drained           Rols 5, 60, 138           Standard           Carree           11           7,706-00           8,000-01           8,000-01           8,000-01           0           0           10           10           10           10           10           10           10           10           1000-10           1000-10           1000-10           1000-10           1000-10           1000-10           1000-10           1000-10           1000-10           1000-10           1000-10           1000-10           1000-10           1000-10           1000-10           1000-10           1000-10           1000-10           1000-10           1000-10           1000-10           1000-10           1000-10           1000-10           1000-10<td></td><td>Initial Material set Material set Material set Material model Gentification number Identification Material model Colour K of determination K of determination K of determination K of determination Material set Gentification number Identification number Identification number Identification number Identification number Colour Model Drainage type Colour Anded Drainage type Colour Colour</td><td>-         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -</td><td>1<br/>Unit 43 - Residual Soil II<br/>Mohr-Coulomb D<br/>Ride 244, 31, 230 F<br/>Automatic A<br/>Unit 43 - Residual Soil II<br/>Unit 43 - Residual Soil II<br/>Unit 43 - Residual Soil II<br/>Unit 43 - Residual Soil II<br/>Nohr-Coulomb N<br/>Drained C<br/>Ride 244, 31, 230 F<br/>Ride 244, 31, 230 F<br/>Standard S<br/>Medium D<br/>Standard S<br/>Medium 19<br/>0<br/>Standard S<br/>Medium 19<br/>0<br/>10<br/>0<br/>10<br/>0<br/>10<br/>10<br/>10<br/>10<br/>10<br/>1</td><td>terface tunit 22-16     terface tunit 12-16     t</td><td>Unit 6 - Base Material<br/>Adohr-Coulomb<br/>Trained<br/>68 10, 205, 45<br/>0.470<br/>Unit 6 - Base Material<br/>Adohr-Coulomb<br/>Trained<br/>GG 10, 205, 45<br/>1<br/>1<br/>7.70E+0<br/>0<br/>0<br/>0.8<br/>0.8<br/>0<br/>0.0<br/>1<br/>00E+1</td><td>9         1           Interface Unit 6-18         Automatic           Drained         Hofe 340, 50, 61           Mohr-Coulomb         Drained           9         1           9         2           9         1           10         0.515           0         3           11         Drained           R68 184, 250, 61         Standard           Coarse         0           10         1           7.702±0         0           15         0.0           16         1           10         1           10         1           11         7.702±0           12         0           13         1           14         1           15         0.0           15         1.00E+1           1         1           1         1           1         1.00E+1           1         1           1         1           1         1.00E+1           1         1.00E+1</td><td>0 0 1 1nterface Unit 13-17 Mohr-Coulomb Drained Rois 241, 39, 120 2 2 0 2 0 1 1nterface Unit 13-17 Mohr-Coulomb Drained Rois 241, 39, 120 0 1 1nterface Unit 13-17 Mohr-Coulomb Drained Rois 241, 39, 120 Standard Coarse 0 1 7,70t+ No 0 0 1 7,70t+ No 0 1 1,7,70t+ No 0 1,00t+ 1</td><td>1         Unit 4 - Cargo the basic<br/>Metric Conforme           1001 4 - Cargo the basic<br/>Metric Conforme         Metric Conforme           1005 48, 227, 243         Juttomatic           Juttomatic         0.5302           11         0.11           12         0.5302           Juttomatic         0.5302           13         0.11           14         0.5302           Jutta - Cargo Rich basing<br/>Metric Accounds         Daraned           10         0.11           11         0.11           12         Standard           13         11           14         Course           10         10           11         0.11           12         Course           10         1.000-11           13         1.000-11           14         Course           15         1.000-11           1         1.000-11           1         1.000-11           1         1.000-11           1         1.000-11           1         1.000-11           1         1.000-11           1         1.000-11           1         1.000-11  &lt;</td><td>2 1 13<br/>1 Interface UR1 54, 234, 152<br/>Molvi-Coulomb<br/>Drained<br/>RGB 134, 234, 152<br/>1 Interface UR1 54, 234, 152<br/>1 Interface UR1 54, 234<br/>1 Interfac</td><td>3         1           Unit 9 - Protection Mater Interf         Mode           Drained         Drained           Molessian         Automatic           Molessian         Automatic           Molessian         Automatic           Automatic         Molessian           Molessian         Automatic           Molessian         Molessian           Coaree         Coare           Coaree         Coare           Coaree         Coare           Molessian         Molessian           Molessian         Molessian           Molessian         Molessian           Molessian         Molessian           Molessian         Molessian           Mo</td><td>are 1415<br/>Croutemb<br/>ded<br/>18, 135, 27<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.059333<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>a</td><td>17 interface 15-17 (peak) Moti Columnol Moti Columnol Mici 243, 73, 84  Uniterface 15-17 (peak) Moti Columnol Motion
Moti</td><td>C_rel<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_</td><td>Num2         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         <th1< th="">         1         1         1</th1<></td></td> | Unit 44 to 47 - Rock           Unit 44 to 47 - Rock           Urare ellistic           Drained           Rols 5, 60, 138           Standard           Carree           11           7,706-00           8,000-01           8,000-01           8,000-01           0           0           10           10           10           10           10           10           10           10           1000-10           1000-10           1000-10           1000-10           1000-10           1000-10           1000-10           1000-10           1000-10           1000-10           1000-10           1000-10           1000-10           1000-10           1000-10           1000-10           1000-10           1000-10           1000-10           1000-10           1000-10           1000-10           1000-10           1000-10           1000-10 <td></td> <td>Initial Material set Material set Material set Material model Gentification number Identification Material model Colour K of determination K of determination K of determination K of determination Material set Gentification number Identification number Identification number Identification number Identification number Colour Model Drainage type Colour Anded Drainage type Colour Colour</td> <td>-         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -</td> <td>1<br/>Unit 43 - Residual Soil II<br/>Mohr-Coulomb D<br/>Ride 244, 31, 230 F<br/>Automatic A<br/>Unit 43 - Residual Soil II<br/>Unit 43 - Residual Soil II<br/>Unit 43 - Residual Soil II<br/>Unit 43 - Residual Soil II<br/>Nohr-Coulomb N<br/>Drained C<br/>Ride 244, 31, 230 F<br/>Ride 244, 31, 230 F<br/>Standard S<br/>Medium D<br/>Standard S<br/>Medium 19<br/>0<br/>Standard S<br/>Medium 19<br/>0<br/>10<br/>0<br/>10<br/>0<br/>10<br/>10<br/>10<br/>10<br/>10<br/>1</td> <td>terface tunit 22-16     terface tunit 12-16     t</td> <td>Unit 6 - Base Material<br/>Adohr-Coulomb<br/>Trained<br/>68 10, 205, 45<br/>0.470<br/>Unit 6 - Base Material<br/>Adohr-Coulomb<br/>Trained<br/>GG 10, 205, 45<br/>1<br/>1<br/>7.70E+0<br/>0<br/>0<br/>0.8<br/>0.8<br/>0<br/>0.0<br/>1<br/>00E+1</td> <td>9         1           Interface Unit 6-18         Automatic           Drained         Hofe 340, 50, 61           Mohr-Coulomb         Drained           9         1           9         2           9         1           10         0.515           0         3           11         Drained           R68 184, 250, 61         Standard           Coarse         0           10         1           7.702±0         0           15         0.0           16         1           10         1           10         1           11         7.702±0           12         0           13         1           14         1           15         0.0           15         1.00E+1           1         1           1         1           1         1.00E+1           1         1           1         1           1         1.00E+1           1         1.00E+1</td> <td>0 0 1 1nterface Unit 13-17 Mohr-Coulomb Drained Rois 241, 39, 120 2 2 0 2 0 1 1nterface Unit 13-17 Mohr-Coulomb Drained Rois 241, 39, 120 0 1 1nterface Unit 13-17 Mohr-Coulomb Drained Rois 241, 39, 120 Standard Coarse 0 1 7,70t+ No 0 0 1 7,70t+ No 0 1 1,7,70t+ No 0 1,00t+ 1</td> <td>1         Unit 4 - Cargo the basic<br/>Metric Conforme           1001 4 - Cargo the basic<br/>Metric Conforme         Metric Conforme           1005 48, 227, 243         Juttomatic           Juttomatic         0.5302           11         0.11           12         0.5302           Juttomatic         0.5302           13         0.11           14         0.5302           Jutta - Cargo Rich basing<br/>Metric Accounds         Daraned           10         0.11           11         0.11           12         Standard           13         11           14         Course           10         10           11         0.11           12         Course           10         1.000-11           13         1.000-11           14         Course           15         1.000-11           1         1.000-11           1         1.000-11           1         1.000-11           1         1.000-11           1         1.000-11           1         1.000-11           1         1.000-11           1         1.000-11  &lt;</td> <td>2 1 13<br/>1 Interface UR1 54, 234, 152<br/>Molvi-Coulomb<br/>Drained<br/>RGB 134, 234, 152<br/>1 Interface UR1 54, 234, 152<br/>1 Interface UR1 54, 234<br/>1 Interfac</td> <td>3         1           Unit 9 - Protection Mater Interf         Mode           Drained         Drained           Molessian         Automatic           Molessian         Automatic           Molessian         Automatic           Automatic         Molessian           Molessian         Automatic           Molessian         Molessian           Coaree         Coare           Coaree         Coare           Coaree         Coare           Molessian         Molessian           Molessian         Molessian           Molessian         Molessian           Molessian         Molessian           Molessian         Molessian           Mo</td> <td>are 1415<br/>Croutemb<br/>ded<br/>18, 135,
27<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>attice<br/>0.059333<br/>attice<br/>0.05933<br/>attice<br/>0.05933<br/>a</td> <td>17 interface 15-17 (peak) Moti Columnol Moti Columnol Mici 243, 73, 84  Uniterface 15-17 (peak) Moti Columnol Motion Moti</td> <td>C_rel<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_phi<br/>G_</td> <td>Num2         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         <th1< th="">         1         1         1</th1<></td> |                           | Initial Material set Material set Material set Material model Gentification number Identification Material model Colour K of determination K of determination K of determination K of determination Material set Gentification number Identification number Identification number Identification number Identification number Colour Model Drainage type Colour Anded Drainage type Colour | -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -           -         -    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                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 1<br>Unit 43 - Residual Soil II<br>Mohr-Coulomb D<br>Ride 244, 31, 230 F<br>Automatic A<br>Unit 43 - Residual Soil II<br>Unit 43 - Residual Soil II<br>Unit 43 - Residual Soil II<br>Unit 43 - Residual Soil II<br>Nohr-Coulomb N<br>Drained C<br>Ride 244, 31, 230 F<br>Ride 244, 31, 230
F<br>Standard S<br>Medium D<br>Standard S<br>Medium 19<br>0<br>Standard S<br>Medium 19<br>0<br>10<br>0<br>10<br>0<br>10<br>10<br>10<br>10<br>10<br>1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | terface tunit 22-16     terface tunit 12-16     t | Unit 6 - Base Material<br>Adohr-Coulomb<br>Trained<br>68 10, 205, 45<br>0.470<br>Unit 6 - Base Material<br>Adohr-Coulomb<br>Trained<br>GG 10, 205, 45<br>1<br>1<br>7.70E+0<br>0<br>0<br>0.8<br>0.8<br>0<br>0.0<br>1<br>00E+1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 9         1           Interface Unit 6-18         Automatic           Drained         Hofe 340, 50, 61           Mohr-Coulomb         Drained           9         1           9         2           9         1           10         0.515           0         3           11         Drained           R68 184, 250, 61         Standard           Coarse         0           10         1           7.702±0         0           15         0.0           16         1           10         1           10         1           11         7.702±0           12         0           13         1           14         1           15         0.0           15         1.00E+1           1         1           1         1           1         1.00E+1           1         1           1         1           1         1.00E+1           1         1.00E+1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          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       Course           15         1.000-11           1         1.000-11           1         1.000-11           1         1.000-11           1         1.000-11           1         1.000-11           1         1.000-11           1         1.000-11           1         1.000-11  <                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   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54, 234<br>1 Interfac                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 3         1           Unit 9 - Protection Mater Interf         Mode           Drained         Drained           Molessian         Automatic           Molessian         Automatic           Molessian         Automatic           Automatic         Molessian           Molessian         Automatic           Molessian         Molessian           Coaree         Coare           Coaree         Coare           Coaree         Coare           Molessian         Molessian           Molessian         Molessian           Molessian         Molessian           Molessian         Molessian           Molessian         Molessian           Mo                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               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# **APPENDIX E** Limitations





### LIMITATIONS

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# JP GIROUD, INC.

Dr. Gary Schmertmann Golder Associates 124 Pacific Highway, St. Leonards, New South Wales 2065, Australia 2012 April 25

PROJECT: Whytes Gully New Cell Design, Preliminary (50%) Design Review

Dear Dr. Schmertmann,

During the past three months, I performed a review of the design as it was progressing, and I gave my comments. I believe this interactive approach is far more effective than reviewing a voluminous report at the last minute. Indeed, an interactive approach can prevent expenditure of effort on inappropriate design options and streamlines the final review process.

My involvement in the review began in September 2011 when I visited the Whytes Gully site and participated in a project design workshop with the design team. I was provided with draft sections of the design as soon as January 2012. Furthermore, considering the importance of the project and knowing that your team was working diligently, I took advantage of being in New Zealand in January to spend four days in Sydney with your team. I must say that this interactive review was productive, because I have noted in reviewing the documents I have received from you since March 2012 that all of the comments I had made during these intensive four days in Sydney had been implemented or had been used to improve drawings, refine analyses and clarify descriptions.

As a result, in the final stage of my review of the 50% design, I have only minor suggestions, which do not affect my review conclusions.

This letter summarizes my review of the 50% design.

### Documents used for the preliminary (50%) design review

To perform my review, I was provided with the Report for Preliminary Design, dated April 2012. In fact, I received various sections of this report as soon as March 2012, as they became available, which was helpful.

I was also provided with the Appendices A, B and C to the Report for Preliminary Design: Appendix A, Drawings; Appendix B, Technical Specifications; and Appendix C, Geotechnical Interpretation and Analyses.

### **Review of the Report for Preliminary Design**

In reviewing the Report for Preliminary Design, I noted the following:

- The Report is well written and well organized.
- Key issues are properly identified. For example, the decision regarding including the piggyback lining system in the eastern gully is appropriate and I completely agree with this decision.
- The technical issues related to the piggyback lining system have been properly identified, namely: impact on leachate, impact on landfill gas, impact of settlement on the piggyback lining system, etc.
- The piggyback design issues have been addressed using state-of-the-art methods, as discussed later in this letter.
- The regulatory aspects are adequately addressed. I fully agree with the decision of following the Victoria BPEM guidelines for landfill lining, which are consistent with international regulations and practice. In particular, the composite liner concept is clearly presented and adequately used.
- Great attention has been paid to design details. This is important, because, in the disciplines of waterproofing and drainage, one detail that is incorrect from a conceptual or constructability standpoint may have detrimental consequences.

In conclusion, the Report for Preliminary Design is satisfactory. In fact, in my opinion, it contains more details than normally needed at the 50% design stage. This is beneficial as it will certainly facilitate the preparation of the 90% design.

### **Review of Appendix A, Drawings**

I reviewed three successive sets of Drawings, starting in mid-January. During my visit in January, I made numerous comments and recommendations to improve the clarity of the drawings and the consistency between the different drawings. I also made important technical comments on design details such as connections between different drainage materials. My general evaluation of the drawings is that the final set of drawings I reviewed has appropriate technical content and contains all the drawings needed for a 50% design.

### **Review of Appendix B, Technical Specification**

I did not review in detail Appendix B, Technical Specification. However, I reviewed Chapter 2, the material property requirements, and Chapter 3, the requirements for construction activities and construction quality management.

In reviewing the material property requirements (i.e. Chapter 2), I made sure that the specifications were consistent with international practice. It is important to note that that the scope of the technical specification at the 50% design stage is necessarily limited because some

properties cannot be specified before the 90% design is completed. This is the case in particular of the drainage geocomposite material.

Regarding the requirements for construction activities and construction quality management (i.e. Chapter 3), my evaluation is that key items such as geomembrane installation, testing and documentation (items which were examined during the course of the review) have been adequately considered for this stage of the design.

In conclusion, Appendix B addresses all the materials that need to be specified and the important aspects of construction and construction quality that need to be addressed at the 50% design stage. However, more work is needed to finalize this appendix at the 90% design stage.

### **Review of Appendix C, Geotechnical Interpretation and Analyses**

I did not review in detail all parts of Appendix C, Geotechnical Interpretation and Analyses. However, during the course of the interactive review process, I reviewed key items such as settlement analysis, piggyback liner deformation analysis/geogrid design and landfill slope stability. I discussed my comments with the design team. The comments were used to improve the analyses and my evaluation is that these comments have been adequately considered.

I was particularly interested in the "Deformation Analysis Results" section because it is essential to the piggy-back design, and because state-of-the-art methodology used. This is due in great part to the fact that you are very knowledgeable about all important publications on the subject of deformation analysis, as I could see during our discussions in January.

I noted that Appendix C does not contain a section on liquid control/drainage design. I indicated to the design team that I agree that such a section is not required at this stage, because it is more appropriate to do the drainage design last (i.e. after settlement and deformation analyses). A section on drainage design will need to be added at the 90% design stage. In the meantime, I noted that the leachate collection drainage length shown in the 50% design drawings is reasonable and no drastic change should be needed as a result of the calculations to be performed for the 90% design.

In conclusion, my evaluation is that Appendix C addresses all the issues that need to be considered at the 50% design stage. In particular, important issues such as slope stability, settlement and liner deformation are addressed thoroughly. Furthermore, Appendix C contains all of the numerical results needed at the 50% design stage.

### General evaluation of the design

In the process of my review, I made numerous comments on non-technical points (e.g. terminology, consistency, clarity of explanations) to make sure the work product would be

presented in a manner that is well accepted by landfill experts and would be informative for nonexpert readers.

It is important to note that, while making non-technical comments, I was not distracted from my essential mission which is to ensure that the landfill cell design is technically sound. From this viewpoint, my impression is very positive and can be summarized as follows:

- The set of drawings contains all the drawings needed for a 50% design and the drawings are presented in a clear and consistent manner. Technical details in the drawings are adequate.
- The geotechnical design report will address all design aspects when a section on liquid control/drainage design is added at the 90% design stage.
- The methodology used for all aspects of design relevant to the 50% design (i.e. stability, settlement, and deformation) is correct, and the analyses are performed with advanced analytical and numerical tools and an excellent knowledge of the state of the art.

This last comment is perhaps my most important comment on the review I performed of the 50% design.

### Conclusion

Based on this review, I can state that the 50% design is satisfactory. All the important issues have been identified. All the design methods used are correct and are implemented with the latest published information available and advanced analytical and numerical tools, particularly for the piggyback lining system. My experience indicates that the design is consistent with international practice and is likely to be adequate from a regulatory standpoint.

In my opinion and based on my experience, the degree of detail in the design report and in the numerical analyses exceeds what is typically expected for a 50% design.

I am very pleased that the interactive approach to design review, as we have practiced since January, has been fruitful. As a result, I have no suggestion for changes.

I thank you for the opportunity that was given to me to review this excellent work.

Sincerely,



J.P. Giroud



# **APPENDIX J**

**Bore Logs and Monitoring Well Construction Logs** 





# **REPORT OF BOREHOLE: GABH01**

CLIENT:Wollongong City CouncilPROJECT:Whytes GullyLOCATION:WollongongJOB NO:117625003

COORDS: 297751.8 m E 6184473.9 m N MGA94 56 SURFACE RL: 30.34 m DATUM: AHD INCLINATION: -90° HOLE DEPTH: 6.48 m SHEET: 1 OF 2 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: TZ DATE: 15/8/11 CHECKED: BJF DATE: 13/9/11

	Dri	lling		Sampling				Field Material Des	criptio	n	
PENETRATION	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
		0	30.34 0.20	0.00-0.20 m				ASPHALT			ASPHALT PAVEMENT
		-	30.14 0.40	GABH01-001_0.0-0.2				FILL: Silty SAND			Inferred pavement base
M		-	29.94	PID = 0.1  ppm				SANDSTONE	$\frown$		WEATHERED ROCK
		-	-					fine grained, yellow, inferred very low to low strength, highly weathered			
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### **REPORT OF CORE PHOTOGRAPHS: GABH01**

Wollongong City Council	COC
Whytes Gully	SUR
Wollongong	INCL
117625003	HOL
	Wollongong City Council Whytes Gully Wollongong 117625003

### COORDS: 297751.8 m E 6184473.9 m N MGA94 56 SURFACE RL: 30.34 m DATUM: AHD INCLINATION: -90° HOLE DEPTH: 6.48 m

### SHEET: 1 OF 2 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: TZ DATE: 15/8/11 CHECKED: BJF DATE: 13/9/11

# 117625003

WCC

# Whytes Gully

# GABH01 00.85 to 04.00m Box 1 of 2



This report of core photographs must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.



### **REPORT OF CORE PHOTOGRAPHS: GABH01**

CLIENT:	Wollongong City Council	COORDS: 297751.8 m E 6184473.9 m N MGA94 56
PROJECT:	Whytes Gully	SURFACE RL: 30.34 m DATUM: AHD
LOCATION:	Wollongong	INCLINATION: -90°
JOB NO:	117625003	HOLE DEPTH: 6.48 m

### SHEET: 2 OF 2 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: TZ DATE: 15/8/11 CHECKED: BJF DATE: 13/9/11

# 117625003GABH01WCC04.00 to 06.48mWhytes GullyBox 2 of 2

GAP gINT FN. F31 RL1

# REPORT OF BOREHOLE: GABH02

CLIENT: Wollongong City Council PROJECT: Whytes Gully LOCATION: Wollongong JOB NO: 117625003 COORDS: 297754.9 m E 6184377.3 m N MGA94 56 SURFACE RL: 22.96 m DATUM: AHD INCLINATION: -90° HOLE DEPTH: 12.40 m SHEET: 1 OF 3 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: TZ DATE: 11/8/11 CHECKED: BJF DATE: 13/9/11

Brining	Sampling		Field Material Desc	riptic	n	
METHOD PENETRATION RESISTANCE WATER WATER DEPTH (metres) H1dad	SAMPLE OR FIELD TEST	GRAPHIC LOG USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
	0.00-0.20 m R = 0A GABH02-001_0.0-0.2 PID = 0.6 ppm 0.50-0.70 m R = 0A GABH02-002_0.5-0.7 PID = 0.2 ppm 1.00-1.20 m		FILL: CLAY high plasticity, dark brown, trace fine rounded gravel	м		FILL
L 21.76	R = 0A GABH02-003_1.0-1.2 PID = 0.2 ppm GABH02-004 SPT 1.20-1.65 m 2, 2, 4 N=6 U75 1.80 m GABH02-005		CLAY high plasticity, brown	м	F	INFERRED ALLUVIUM
H	GABH02-006 SPT 3.00-3.25 m 20, 14/100mm HB	                                                                                                                                                                                                                                                                                                    	Silty CLAY low plasticity, pale yellow to pale brown	D	VSt	INFERRED RESIDUAL
	GABH02-007 SPT 4.00-4.14 m 30/140mm	× ×	For Continuation Refer to Sheet 2			INFERRED WEATHERED ROCK
7						
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	his report of borehole mu echnical purposes only, v information only and	ist be read ii vithout atten do not nece	n conjunction with accompanying notes and abbreviations. npt to assess possible contamination. Any references to pot ssarily indicate the presence or absence of soil or groundwa	It has tentia	bee l con contar	n prepared for tamination are for mination. GAP gINT FN. F

(			As	Folo	der	es			R	٤E	P	0	SHEET: 2 OF 3	вH	02	2
CLIENT: PROJECT: LOCATION:			Wollongong City Co Whytes Gully Wollongong			ouncil	COORDS: 297754.9 m E 61	18437 тн м-	7.3′ ⊿⊦	m -D	ΝN	ЛGA	A94 56 DRILL RIG: Drill Cat			
							INCLINATION: -90°	LOGGED: TZ DATE:	11/8/11							
JOB NO:		117625003				HOLE DEPTH: 12.40 m						CHECKED: BJF DATE:	13/	9/1 <i>°</i>	1	
			Drilli	ng	Γ		Field Material Description		Т				Defect Information			
METHOD	WATER	TCR	RQD (SCR)	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	ROCK / SOIL MATERIAL DESCRIPTION	WEATHERING	EL 0.03	NFE TRE Is ₍₅₀	ERF ENC	RED GTH Pa	DEFECT DESCRIPTION & Additional Observations	AV D SF	YER EFE PAC (mr	AGE ECT JNG n)
				0												
	11/08/11	80	30 (30)		<u>4.10</u> <u>4.25</u> 18.71		Continuation of Sheet 1 CORE LOSS SANDSTONE fine to medium grained, brown, bedding at 0 - 5 ⁰	EW					4.25 m: DZ, 0°, clay 100 mm 4.47 m: DS, 0°, clay 50 mm 4.58 m: B, 0°, Un, Ro, Vr, clay 4.60 m: DS, 0°, clay 70 mm 4.72 m: DZ, 0°, clay 180 mm 4.73 m: J, 60°, St, Ro, Vr, clay 4.81 m: J, 60°, St, Ro, Vr, clay			
		70	0 (5)	-	5.40 17.56 5.72 17.24		CORE LOSS SANDSTONE	ни	-				5.73 m: DZ, 0°, clayey gravel 170 mm			
		100	0 (0)	6 — - -	-		tine to medium grained, brown, bedding at U - 5°						5.90-6.84 m: B, 0-5°, sp = 10-50 mm, PI-Un, Sm-Ro, Sn 5.90-6.84 m: J, 30-60°, sp = 30-110 mm, PI, Sm-Ro, Sn 5.90-6.84 m: J, 90°, PI, Sm, Sn			-
HQ3		100	35 (50)		-						*		6.84-7.94 m: J, 10-45°, sp = 20-150 mm, Pl-Un, Sm, Sn 6.97 m: J, 60°, Pl, Sm, Sn 7.16 m: B, 5°, Pl, Ro, Sn 7.20 m: B, 5°, St, Ro, Sn 7.35 m: B, 0°, St, Ro, Sn 7.43 m: J, 80°, Pl, Sm, Sn			-
5		100	30 (40) 30 (45)	8 — - - - 9 — - - - - - - - -					•		•		7.94 m: DS, gravel, medium to coarse, 60 mm 8.00 m: B, 0°, Pl, Sm, Sn 8.00-8.28 m: J, 90°, Pl, Sm, Sn 8.08 m: B, 0°, Pl, Ro, Sn 8.14 m: B, 0°, pn, Ao, Sn 8.27 m: B, 0-5°, Pl, Ro, Vr, clay 8.35 m: J, 30°, Pl, Ro, Vr, clay 8.50-8.77 m: B, 0-5°, sp = 50-110 mm, Pl, Sm-Ro, Sn 8.63 m: J, 10°, Pl, Ro, Sn 8.76 m: DS, 0°, highly weathered rock 40 mm 8.84-9.40 m: B, 0-5°, sp = 40-100 mm, Pl, Sm-Ro 8.84 -9.29 m: J, 85°, Pl, Sm, Sn 8.85 m: J, 10°, Pl, Ro, Sn 9.40-11.35 m: B, 0-5°, sp = 30-100 mm, Pl-Un, Sm, Sn 9.55-869 m: J, 80°, partially closed			
				9 10	This re eotechn i	eport of ical pui nforma	f borehole must be read in conjunction with accom rposes only, without attempt to assess possible co tion only and do not necessarily indicate the prese	ipany ntam ence o	ing inat or al	not ion. bse	es a . A ence	and ny re e of	abbreviations. It has been prepared for eferences to potential contamination are for soil or groundwater contamination. GAP g	INT	FN.	. F02a RL3

GAP 8_051.1 LIB.GLB Log GAP CORED BOREHOLE 117625003 LOGS.GPJ <<DrawingFile>> 04/11/2011 13:36 8.2.856

(				Folo	ler	26			RI	EP	0	rt of Borehole: Ga	BH02
CL PF LC JC	CLIENT: PROJECT: LOCATION: JOB NO:			Wollongong City Counc Whytes Gully : Wollongong 117625003			COORDS: 297754.9 m E 61 SURFACE RL: 22.96 m DAT INCLINATION: -90° HOLE DEPTH: 12.40 m	8437 ⁻ UM:	SHEET: 3 OF 3 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: TZ DATE: 11/8/11 CHECKED: BJF DATE: 13/9/11				
			Drilli	na			Field Material Description					Defect Information	
METHOD	WATER	TCR	RQD (SCR)	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	ROCK / SOIL MATERIAL DESCRIPTION	WEATHERING	INF STF Is	ERF REN (50) M	RED GTH IPa	DEFECT DESCRIPTION & Additional Observations	AVERAGE DEFECT SPACING (mm)
HQ3		100	30 (45) 15 (50)	10 — - - 11 — - - - 12 —	12.40		SANDSTONE fine to medium grained, brown, bedding at 0 - 5 ⁰	HW		•	-	9.87 m: J, 60°, PI, Sm, Sn 10.20 m: J, 70°, PI, Sm, Sn 10.38 m: J, 30°, PI, Sm, Sn 10.67-11.35 m: J, 80°, PI, Sm, Sn, partially closed 10.97-11.10 m: J, 80-85°, PI, Sm, Sn 11.35-12.40 m: B, 0-5°, sp = 25-200 mm, PI, Sm, Sn 11.54 m: J, 20°, partially closed 11.60 m: J, 60°, PI, Sm, Sn 11.65 m: J, 30°, PI, Sm, Sn 12.10 m: J, 70°, PI, Ro, Sn 12.24 m: DZ, 60°, highly weathered rock 100 mm	
				13 — - - - - - - - - - - - - - - - - - - -			REACHED TARGET DEPTH PIEZOMETER INSTALLED 12/08/11						
				20	This re eotechn i	eport of ical pur nforma	f borehole must be read in conjunction with accomp poses only, without attempt to assess possible cor tion only and do not necessarily indicate the preser	banyii ntamii nce o	ng no natio r abs	otes n. A sence	and any re	abbreviations. It has been prepared for eferences to potential contamination are for soil or groundwater contamination. GAP	gINT FN. FC






#### **REPORT OF CORE PHOTOGRAPHS: GABH02**

CLIENT:	Wollongong City Council	COORDS: 297754.9 m E 6184377.3 m N MGA94 56
PROJECT:	Whytes Gully	SURFACE RL: 22.96 m DATUM: AHD
LOCATION:	Wollongong	INCLINATION: -90°
JOB NO:	117625003	HOLE DEPTH: 12.40 m

#### SHEET: 2 OF 2 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: TZ DATE: 11/8/11 CHECKED: BJF DATE: 13/9/11

# 117625003 WCC

## Whytes Gully

## GABH02

## 09.00 to 12.40m

#### Box 2 of 2



CI Pf LC JC	LIEN ROJ DCA	IT: ECT: TION: IO:	Ass Wollor Whyte Wollor 11762	oci ngong C s Gully ngong 5003	ates ity Council			CO SUI INC HO	ORDS: 297793.8 m E 6184315.2 m N MGA94 56 RFACE RL: 18.66 m DATUM: AHD CLINATION: -90° LE DEPTH: 17.00 m		Shee Drili Con ⁻ Logo Cheo	ET: 1 OF 3 _ RIG: Drill Cat IRACTOR: Terratest GED: TZ DATE: 29/7/11 CKED: BJF DATE: 13/9/11
	1	Dri	illing	1	Sampling	1			Field Material Desc	riptio	on I.	
METHOD	PENETRATION	WATER	DEPTH (metres)	DEPTH RL	Sample or Field test	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
	L	29/07/11		18.66 <u>1.20</u> 17.46	$\begin{array}{c} 0.00\mbox{-}0.20\mbox{ m} \\ R = 0\mbox{A} \\ GABH03\mbox{-}001\mbox{-}0.0\mbox{-}0.2\mbox{-}0.2\mbox{-}PID = 0.4\mbox{-}prm \\ 0.50\mbox{-}0.70\mbox{ m} \\ R = 0\mbox{A} \\ GABH03\mbox{-}002\mbox{-}0.5\mbox{-}0.7\mbox{-}PID = 0.5\mbox{-}ppm \\ 1.00\mbox{-}1.20\mbox{-}m \\ R = 0\mbox{A} \\ GABH03\mbox{-}003\mbox{-}1.0\mbox{-}1.2\mbox{-}PID = 3.4\mbox{-}ppm \\ GABH03\mbox{-}004\mbox{-}SPT 1\mbox{-}2.0\mbox{-}1.65\mbox{-}m \\ SPT 1\mbox{-}2.0\mbox{-}1.65\mbox{-}m \\ 1, 2, 2\mbox{-}N=4 \end{array}$			СН	FILL: CLAY high plasticity, dark brown, trace fine rounded gravel CLAY high plasticity, dark brown	_	S-F	FILL INFERRED ALLUVIUM
ADV			3   4 	3.00	GABH03-005 SPT 3.00-3.45 m 11, 21, 25 N=46 GABH03-006 SPT 4.00-4.45 m 2, 9, 13 N=22			CI	Silty CLAY medium plasticity, brown, trace fine sub-angular gravel	м	VSt - H	
	L-N	1	5— - - 6— - - - - - - -	7.00	GABH03-007 SPT 5.00-5.45 m 8, 10, 10 N=20 GABH03-008 SPT 6.00-6.45 m 6, 9, 13 N=22			СН	CLAY high plasticity, brown to grey, trace medium gained sub-rounded sand		VSt	
			8-	8.20 10.46	GABH03-009 SPT 7.00-7.45 m 15, 16, 19 N=35 GABH03-010 SPT 8.00-8.45 m 4, 8, 13 N=21			GP	Gravelly CLAY high plasticity, brown, fine to medium angular gravel Sandy GRAVEL fine to medium angular brown to grey, fine to medium grained sand		MD	
			9	-					For Continuation Refer to Sheet 2			

C P L J		r: :ct: 10N: D:	Woll Why Woll 1176	ongong ongong tes Gul ongong 525003	ler jati g City Ci lly g	es	COORDS: 297793.8 m E 6184 SURFACE RL: 18.66 m DATU INCLINATION: -90° HOLE DEPTH: 17.00 m	1318 M:	<b>RI</b> 5.2 r AHI		PO	SHEET: 2 OF 3 GA94 56 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: TZ DATE: 20 CHECKED: BJF DATE: 13	<b>103</b> 9/7/11 8/9/11
		_	Drillir	ng			Field Material Description	ŋ	INF	ERI	RED	Defect Information	VERAGE
METHOD	WATER	TCR	RQD (SCR)	DEPTH (metres)	<i>DEPTH</i> RL	GRAPHIC LOG	ROCK / SOIL MATERIAL DESCRIPTION	WEATHERIN	STI Is	REN (50) №	GT⊢ IPa	TH a DEFECT DESCRIPTION & Additional Observations	DEFECT SPACING (mm)
* <u>0</u> 05/11 LB GLB Log GAP CORED BOREHOLE 117625003 LOGS.GPU < <drawingfile>&gt; 04/11/2011 13:37 8.2.856 Η Q3</drawingfile>		100	0 (10) 0 (10)		<i>8.45</i> 10.21 9.20 9.26		Continuation of Sheet 1         Gravely CLAY         medium plasticity, brown and pale grey         orange brown	RS		otes	and	d abbreviations. It has been prepared for yreferences to potential contamination are for	
GAP 8_05J.1 LIB.GLB Log GAP CORED BO		100	0 (10) 0 (10)	9   10 gu	9.40 9.26 This r	eport of	orange brown borehole must be read in conjunction with accompan poses only, without attempt to assess possible conta tion only and do not necessarily indicate the presence	nyir ımir e or	ng ne natio r abs	otes n. A senc	and Any ro	nd abbreviations. It has been prepared for y references to potential contamination are for of soil or groundwater contamination. GAP gIN	T FN. F02 RI

(			As	folo	ler	es			RE	P	OI	RT OF BOREHOLE: GAE	BH	03
CLI PR	ENT	: CT:	Woll Why	longong rtes Gul	g City Co Ily	ouncil	COORDS: 297793.8 m E 61 SURFACE RL: 18.66 m DA	8431: TUM:	5.2 m AHD	N MO	GAS	OHEET: 3 OF 3 DRILL RIG: Drill Cat CONTRACTOR: Terratest		
LO JOI	CATI 3 NO	ON: :	Woll	longong 625003	9		INCLINATION: -90° HOLE DEPTH: 17.00 m					LOGGED: TZ DATE: CHECKED: BJF DATE:	29/7 13/9	7/11 9/11
			Drillir	ng			Field Material Description					Defect Information		
METHOD	WATER	TCR	RQD (SCR)	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	ROCK / SOIL MATERIAL DESCRIPTION	WEATHERING	INFE STRE Is ₍₅₀ ^{50,0} 1	RRE ENG MPa S = m S = m	TH a	DEFECT DESCRIPTION & Additional Observations	AV DE SP ₽ %	ERAGE EFECT ACING (mm)
		100	0 (10)	10	11 15		Gravelly CLAY medium plasticity, brown and pale grey	RS						
	-	100	25 (60)	- - - 12 —	12.35		SANDSTONE fine grained, brown, with ironstaining, bedding at 0 - $5^{\circ}$	HW		Ŧ		11.15-11.83 m: B, 0-5°, sp = 30-100 mm, Pl, Sm, Sn 11.31 m: DS, 5 mm clay 11.58 m: DS, 20 mm clay 11.68 m: B, 0°, Pl, Sm, Sn 11.73 m: J, 20°, Pl, Sm, Vr 11.85 m: J, 90°, Pl, Ro, Sn 12.00 m: B, 0°, St, Ro, Sn 12.04 m: B, 0°, St, Ro, Sn 12.04 m: B, 0°, St, Ro, Sn		
НQ3	-			- - 13 -	6.31 13.40 5.26		brown and pale grey	HW - MW			t	12.14 m: 1, 60°, PI, Sm, Sn 12.17 m: B, 0°, St, Ro, Sn 12.19 m: B, 0°, St, Ro, Sn 12.25 m: 1, 70°, PI, Ro, Sn 12.27 m: B, 0°, PI, Ro, Sn 12.32 m: B, 0°, PI, Ro, Sn 12.36 m: B, 0°, PI, Ro, Sn 12.45-12.50 m: B, 0°, sp = 5-10 mm, PI, Ro, Sn 12.78 m: 1, 50°, PI, Sm, Sn 12.80 m: B, 5°, PI, Sm, Sn 13.80 m		
		100	50 (85)	- 14 - - 15	<u>13.80</u> 4.86 <b>14.30</b> 4.36		SANDSTONE fine grained, pale grey, trace ironstaining, bedding at 0 - 5 ⁶	SW		*		12.00 - 12.90 fm, Sn, Sn 13.91 m; B, 0°, PI, Sm, Sn 13.10 m; B, 0°, PI, Sm, Sn 13.13 - 13.16 m; B, 0°, sp = 10-20 mm, PI, Sm, Sn 13.19 m; DS, 10 mm clay 13.28 m; B, 0°, PI, Sm, Sn 13.41 m; J, 0-5°, PI, Ro, Vr 13.51 m; DS, 15 mm clay 13.62 m; J, 90°, PI, Sm, Sn 13.65 m; DS, 0°, 10 mm clay 13.89 m; DS, 0°, 15 mm clay		
	-	100	75 (85)	- - - - - - - -	17.00					*		14.21 m: B, 0°, SI, Ro, Vr 14.23 m: D, 0°, PI, Ro, Vr 14.33 m: J, 80°, PI, Sm, Sn 14.34-15.35 m: J, 0-10°, sp = 80-200 mm, PI, Sm, Sn 15.60 m: B, 0°, PI, Sm, Sn 15.63 m: B, 5°, PI, Sm, Sn 15.71 m: B, 0°, PI, Sm, Sn 15.75 m: B, 0°, PI, Sm, Sn 15.79 m: B, 0°, PI, Sm, Sn 16.18 m: B, 0-5°, PI, Sm, Sn 16.24 m: B, 0-5°, PI, Sm, Sn 16.25 m: B, 0-5°, PI, Sm, Sn 16.26 m: B, 0-5°, PI, Sm, Sn 16.32 m: B, 0-5°, PI, Sm, Sn 16.32 m: B, 0-5°, PI, Sm, Sn 16.32 m: B, 0-5°, PI, Sm, Sn		
					1.66		END OF BOREHOLE @ 17.00 m REACHED TARGET DEPTH PIEZOMETER INSTALLED 29/07/11					16.77 m: B, 0-5°, PI, Ro, Sn 16.90 m: B, 0-5°, PI, SI, Vr		
				20 — 94	This re eotechn i	eport of ical pur nforma	borehole must be read in conjunction with accom poses only, without attempt to assess possible co tion only and do not necessarily indicate the prese	panyir ntamir nce o	ng notonation.	es ar Any	nd a y re of s	abbreviations. It has been prepared for ferences to potential contamination are for oil or groundwater contamination. GAP g		FN. F02:

GAP 8_05J.1 LIB.GLB Log GAP CORED BOREHOLE 117625003 LOGS.GPJ <<DrawingFile>> 04/11/2011 13:37 8.2.856

CL PF LC JC	LIENT ROJE DCATI DB NC	": W CT: W ION: W D: 1	/ollongo /hytes G /ollongo 1762500	ng City Council Gully ng 03			COORDS: 297793.8 m E 6184315.2 m N MGA94 56 SURFACE RL: 18.66 m DATUM: AHD INCLINATION: -90° HOLE DEPTH: 17.00 m	6	D C L C	RILL RIG: Drill ONTRACTOR: OGGED: TZ HECKED: BJF	Cat Terratest DATE: 29/7/11 DATE: 13/9/11
	C	Drilling	1	Sampling	_		Field Material Descriptio	n and l	nstrume	ntation	
METHOD	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	AIRLIFT YIELD (L/s)		CON	STRUCTION
ADV	29/02/14		18.66 1.20 17.46 3.00 15.66 5.00 13.66 7.00 11.66	$\begin{array}{c} 0.00-0.20 \mbox{ m} \\ R = 0A \\ GABH03-001_0.0-0.2 \\ PID = 0.4 \mbox{ ppm} \\ 0.50-0.70 \mbox{ m} \\ R = 0A \\ GABH03-002_0.5-0.7 \\ PID = 0.5 \mbox{ ppm} \\ 1.00-1.20 \mbox{ m} \\ R = 0A \\ GABH03-003_1.0-1.2 \\ PID = 3.4 \mbox{ ppm} \\ SPT 1.20-1.65 \mbox{ m} \\ 1, 2, 1.25 \mbox{ N=4} \\ GABH03-004 \\ SPT 3.00-3.45 \mbox{ m} \\ 11, 21, 25 \mbox{ N=4} \\ GABH03-005 \\ SPT 4.00-4.45 \mbox{ m} \\ 2, 9, 13 \mbox{ N=22} \\ GABH03-006 \\ SPT 5.00-5.45 \mbox{ m} \\ 8, 10, 10 \mbox{ N=22} \\ GABH03-008 \\ SPT 7.00-7.45 \mbox{ m} \\ 15, 16, 19 \mbox{ N=35} \\ GABH03-009 \\ \end{array}$			FILL: CLAY         high plasticity, dark brown, trace fine rounded gravel moist         CLAY         high plasticity, dark brown moist, soft to firm         Silty CLAY         medium plasticity, brown, trace fine sub-angular gravel moist, very stiff to hard         CLAY         high plasticity, brown to grey, trace medium gained sub-rounded sand moist, very stiff         Gravelly CLAY         high plasticity, brown, fine to medium angular gravel moist, very stiff				<ul> <li>Monument (0.67m stickup)</li> <li>Top of casing (0.55m stickup)</li> <li>Tot of casing (0.55m stickup)</li> <li>Cement grout</li> </ul>
		- - - - 10 - -	8.20 8.45 10.21 9.40 9.26 <u>11.15</u> 7.51	SPT 8.00-8.45 m 4, 8, 13 N=21 GABH03-010			Sandy GRAVEL fine to medium angular brown to grey, fine to medium grained sand moist, medium dense Gravelly CLAY medium plasticity, brown and pale grey orange brown				- 10.5m - Bentonite - 11.0m
НЦЗ		- 12 - - - 14	<u>12.35</u> 6.31 <u>13.40</u> <u>5.26</u> <u>13.80</u> 4.86				fine grained, brown, with ironstaining, bedding at 0 - 5 ^o extremely weathered to moderately weathered, extremely low to high strength brown and pale grey				- 11.5m - Sand - Slotted pvc
		- - - 16	14.30				SANDSTONE fine grained, pale grey, trace ironstaining, bedding at 0 - 5 ⁰ slightly weathered, medium to high strength	-			- End cap
		- 18	1.66				END OF BOREHOLE @ 17.00 m REACHED TARGET DEPTH PIEZOMETER INSTALLED 29/07/11				



#### **REPORT OF CORE PHOTOGRAPHS: GABH03**

CLIENT:	Wollongong City Council	CO
PROJECT:	Whytes Gully	SUF
LOCATION:	Wollongong	INC
JOB NO:	117625003	HOI

#### COORDS: 297793.8 m E 6184315.2 m N MGA94 56 SURFACE RL: 18.66 m DATUM: AHD INCLINATION: -90° HOLE DEPTH: 17.00 m

#### SHEET: 1 OF 2 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: TZ DATE: 29/7/11 CHECKED: BJF DATE: 13/9/11

GABH03

Box 1 of 2

08.45 to 12.00m

## 117625003

# WCC

## Whytes Gully



This report of core photographs must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

GAP gINT FN. F31 RL1

Golder
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#### **REPORT OF CORE PHOTOGRAPHS: GABH03**

CLIENT:	Wollongong City Council	COORDS: 297793.8 m E 6184315.2 m N MGA94 56
PROJECT:	Whytes Gully	SURFACE RL: 18.66 m DATUM: AHD
LOCATION:	Wollongong	INCLINATION: -90°
JOB NO:	117625003	HOLE DEPTH: 17.00 m

#### SHEET: 2 OF 2 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: TZ DATE: 29/7/11 CHECKED: BJF DATE: 13/9/11

## 117625003

WCC

### Whytes Gully

## GABH03

12.00 to 17.00m

Box 2 of 2



#### **REPORT OF BOREHOLE: GABH04**

CLIENT: Wollongong City Council PROJECT: Whytes Gully LOCATION: Wollongong JOB NO: 117625003 COORDS: 297844.8 m E 6184306.2 m N MGA94 56 SURFACE RL: 18.23 m DATUM: AHD INCLINATION: -90° HOLE DEPTH: 16.26 m SHEET: 1 OF 3 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: TZ DATE: 11/8/11 CHECKED: BJF DATE: 13/9/11

No.         No.         Part PLOT DEST         Operation of the second			Drii	ling		Sampling				Field Material Desc	riptic	m	
L         -         18.25 R + QA R + Q	METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	Sample or Field test	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
1         17.03         CEBI04.002         1-12         CH         CLAY           1         12.05         PT 2.00 m         F         F         F           1         17.25         CEBI04.002         F         F         F           1         1.2.3         CEBI04.002         F         F         F           1         1.2.3         CEBI04.002         F         CLAY         F           1         1.2.3         CEBI04.002         F         F         F           1         1.2.3         CEBI04.002         F         CLAY         F           1         1.2.3         CEBI04.002         F         F         F           1         1.3.0         CLAY         F         F         F           1         1.3.0         CLAY         F         F         F           1         CEBI04.000         SF 1.0.0.4.6 m         F		L	11/08/11	0   1	18.23 1.20	0.00-0.20 m R = 0A GEBH04-001_0.0-0.2 PID = 0 ppm 0.50-0.70 m R = 0A GEBH04-002_0.5-0.7 PID = 0 ppm 1.00-1.20 m R = 0A				FILL: CLAY high plasticity, dark brown, trace fine rounded gravel			
1         3         2.00 15.23         GEBH04.006 SPT 3.00.3.65 m 11, 11, 8 N=19	AUV			- - 2	17.03	GEBH04-003_1.0-1.2 PID = 0 ppm GEBH04-004 SPT 1.20-1.65 m 1, 1, 2 N=3 U75 2.00 m GEBH04-005			СН	CLAY high plasticity, dark brown			INFERRED ALLUVIUM
LM				- - 3 -	<u>3.00</u> 15.23	GEBH04-006 SPT 3.00-3.45 m 11, 11, 8 N=19			СН	CLAY high plasticity, dark brown, trace fine rounded gravel	-	F	INFERRED RESIDUAL SOIL
St- St St S				- 4 - -	<u>4.00</u> 14.23	GEBH04-007 SPT 4.00-4.45 m 3, 6, 8 N=14				with some coarse grained sub-rounded sand	-		
8     6     GEBH04-009 SPT 6.00-6.45 m 6.6, 9 N=15     7     7     7     7     7     7     7     7     7     7     7     7     7     7     7     7     7     7     7     7     7     7     7     7     7     7     7     7     7     7     11.23     GEBH04-010 SPT 7.00-7.45 m 8, 11, 12 N=23     7     CH high plasticity, pale brown to grey, with some fine grained sub-rounded sand     8     7     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1		L-M		5 - - -	<u>5.20</u> 13.03	GEBH04-008 SPT 5.00-5.45 m 6, 14, 27 N=41			CI	Sandy CLAY medium plasticity, brown, coarse grianed sub-rounded sand, with some fine sub-rounded gravel	м	St-	
8       GEBH04-011 SPT 7.00-7.45 m 8, 11, 12 N=23       GEBH04-011 SPT 8.00-845 m 8, 9, 11 N=20       GEBH04-011 SPT 8.00-845 m 8, 9, 11 N=20       GEBH04-011 SPT 8.00-845 m Sand         8       GEBH04-011 SPT 8.00-845 m 8, 9, 11 N=20       GEBH04-011 SPT 8.00-845 m Sand       Sandy CLAY medium grained, grey, fine to medium grained sub-rounded sand       INFERRED WEATHERED ROCK	- 190			6	7.00	GEBH04-009 SPT 6.00-6.45 m 6, 6, 9 N=15						VSt	
8.20       SPT 8.00-845 m 8, 9, 11 N=20       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -				- - - 8—	11.23	GEBH04-010 SPT 7.00-7.45 m 8, 11, 12 N=23			СН	CLAY high plasticity, pale brown to grey, with some fine grained sub-rounded sand			
				- - - 9	8.20 10.03 8.80 9.43	GEBH04-012			CI SC	Sandy CLAY medium plasticity, grey, fine to medium grained sub-rounded sand Clayey SAND fine to medium grained, grey, high plasticty clay, trace medium angular grayel	-		INFERRED WEATHERED ROCK

	Gol	der			REPORT	OF BOREHOLE:	GABH04
CLIENT: PROJECT: LOCATION: JOB NO [.]	ASSOC Wollongon Whytes Gu Wollongon 117625003	g City Cou Illy g	S ncil	COORDS: 297844.8 m E 6 SURFACE RL: 18.23 m DA INCLINATION: -90° HOLE DEPTH: 16.26 m	184306.2 m N MGA94 56 TUM: AHD	SHEET: 2 OF 3 DRILL RIG: Drill Cat CONTRACTOR: Terrat LOGGED: TZ CHECKED: B.IE	est DATE: 11/8/11 DATE: 13/9/11
	Drilling	, 		Field Material Description		Defect Information	
METHOD WATER TCR	DEPTH (metres)	DEPTH RL	ROCK / SOIL N	IATERIAL DESCRIPTION	SINFERRED STRENGTH IS(50) MPa	DEFECT DESCRIPTION & Additional Observations	AVERAGE DEFECT SPACING (mm)
		9.50	Continuation of Shee	<u>1</u>			
	g	This rep eotechnica inf	ort of borehole must be re al purposes only, without ormation only and do not	ead in conjunction with accon attempt to assess possible or necessarily indicate the pres	npanying notes and abbre ontamination. Any referen ence or absence of soil or	eviations. It has been prepared for nces to potential contamination are for r groundwater contamination.	GAP gINT FN. F02ء RL

		r: :ct: :ion: :	Wol Why Wol 117	longon longon 625003	g City Ca Illy g	es	COORDS: 297844.8 m E 61 SURFACE RL: 18.23 m DA  INCLINATION: -90° HOLE DEPTH: 16.26 m	84306 TUM:	RE 6.2 m AHD		OI 1GA9	RT OF BOREHOLE: GA SHEET: 3 OF 3 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: TZ DAT CHECKED: BJF DAT	<b>BH</b> E: 11/8 E: 13/9	<b>0</b> 4 8/11 9/11	<b>1</b>
			Drilli (2)	ng		PHIC G	Field Material Description	ERING	INF STF		ED STH	Defect Information	AV	EFE	AGE
METHO	WATER	TCR	RQD (S(	DEPTH (metres)	DEPTH RL	GRAF LO	ROCK / SOIL MATERIAL DESCRIPTION	WEATHE	ש <b>פו</b> גר ^{0.1} יר ^{0.1}	i0) IVII S ← i J ∑ I	°a °° [₽] ⊞	& Additional Observations	S⊢ ₽ ®	AC (mn) ۋ ۋ	ING n)
		20	0 (0)		- <u>11.10</u> 7.13		CORE LOSS CLAY high plasticity, brown	RS							-
		90	10 (40)	12 — - - - - 13 —	<u>11.84</u> <u>12.00</u> 6.23		CORE LOSS SANDSTONE fine to medium grained, brown, bedding at 0 - 5 ⁰	HW		Ŧ		12.00-12.40 m: B, 0-5°, sp = 40-140 mm, Pl, Sm, Sn 12.18 m: DB 12.20 m: J, 45°, Un, Sm, Vr, clay 12.40 m: DS, gravel clay 70 mm 12.48 m: B, 0°, Pl, Sm, Sn 12.48 m: J, 85°, Pl, Sm, Sn 12.52 m: DS, 0°, clay 60 mm 12.58 m: J, 20°, Un, Ro, Sn 12.62 m: J, 30°, Un, Ro, Sn			-
HQ3		100	65 (90)	14 — - - - - - - - - - - - - - - - - - - -	<u>13.20</u> 5.03 <u>14.00</u> 4.23		brown and grey SANDSTONE fine grained, grey, bedding at 0 - 5 ⁰ , trace siltstone laminations 10 - 30 mm	FR		*	+	12.67 m: B, 0-5°, PI, Sm, Vr, clay 12.67 m: B, 0-5°, PI, Sm, Vr, clay 12.74-13.00 m: B, 0-5°, sp = 5-60 mm, Un, Ro, Sn 12.93 m: J, 10°, PI, Sm, Sn 13.00-13.29 m: B, 0°, sp = 50-100 mm, PI, Sm, Sn 13.29-13.34 m: B, 0-5°, sp = 10-20 mm, Un, Sm, Sn 13.41-13.88 m: B, 0-5°, sp = 40-140 mm, Un, Sm, Sn 13.41-13.88 m: B, 0-5°, sp = 40-140 mm, Un, Sm, Sn 13.41-13.88 m: B, 0-5°, sp = 40-140 mm, Un, Sm, Sn 13.41-13.88 m: B, 0-5°, sp = 40-140 mm, Un, Sm, Sn 13.41-13.88 m: B, 0-5°, sp = 40-140 mm, Un, Sm, Sn 13.41-13.88 m: B, 0-5°, sp = 40-140 mm, Un, Sm, Sn 13.41-13.88 m: B, 0-5°, sp = 40-140 mm, Un, Sm, Sn 13.41-13.88 m: B, 0-5°, sp = 40-140 mm, Un, Sm, Sn 13.42 m: D, 0°, 30 mm highly weathered rock 14.10 m: B, 5°, PI, Sm, Sn 14.24 m: DB 15.57 m: J, 35°, PI, Ro, Sn 15.59 m: J, 10°, PI, Sm, Cn			-
· · · · · · · · · · · · · · · · · · ·				16	<u>16.26</u> 1.97		END OF BOREHOLE @ 16.26 m REACHED TARGET DEPTH PIEZOMETER INSTALLED 11/08/11					15.59 m: J, 10°, PI, Sm, Cn 15.63-15.87 m: 2 x DB			-

CL PF LC JC	LIENT ROJE DCATI	": W CT: W ION: W D: 1	/ollongo /hytes G /ollongo 176250(	ng City Council Gully ng J3			COORDS: 297844.8 m E 6184306.2 m N MGA94 5 SURFACE RL: 18.23 m DATUM: AHD INCLINATION: -90° HOLE DEPTH: 16.26 m	6			L RIG: D TRACTO GED: TZ CKED: E	Drill Cat DR: Terrate SJF	DATE: 11/8/11 DATE: 13/9/11
		Drilling		Sampling			Field Material Description	n and li	nstrum	entat	ion		
METHOD	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	AIRLIFT YIELD (L/s)				JNSTRUC	HON
	1	- - 0	18.23	0.00-0.20 m R = 0A GEBH04-001_0.0-0.2			FILL: CLAY high plasticity, dark brown, trace fine rounded gravel moist					— Monum — Top of stickup	ent (0.63m stickup) casing (0.50m )
ADV	11/08/1	- - 2—	<u>1.20</u> 17.03	PID = 0 ppm 0.50-0.70 m R = 0A GEBH04-002_0.5-0.7 PID = 0 ppm 1.00-1.20 m R = 0A GEBH04-003_1.0-1.2 PID = 0 ppm			CLAY high plasticity, dark brown moist, firm	_					
	-	- - - 4	3.00 15.23 <u>4.00</u> 14.23	SPT 1.20-1.65 m 1, 1, 2 N=3 GEBH04-004 U75 2.00 m GEBH04-005 SPT 3.00-3.45 m 11, 11, 8 N=19 GEBH04-006 SPT 4.0-4.45 m			CLAY high plasticity, dark brown, trace fine rounded gravel moist, stiff to very stiff	_					
		- - - 6	<u>5.20</u> 13.03	SPT 5.00-5.45 m 6, 14, 27 N=41 GEBH04-007 SPT 5.00-5.45 m 6, 14, 27 N=41 GEBH04-008 SPT 6.00-6.45 m 6, 6, 9 N=15			Sandy CLAY medium plasticity, brown, coarse grianed sub-rounded sand, with some fine sub-rounded gravel moist, stiff to very stiff	_				— Cemen	t grout
HQ3		- - 8—	GEBH04-009           7.00           11.23           SPT 7.00-7.45 m           8.11, 12 N=23           GEBH04-010           8.20           SPT 8.00-8.45 m           10.03           GEBH04-011			CLAY high plasticity, pale brown to grey, with some fine grained sub-rounded sand moist, stiff to very stiff							
		- - - 10	8.80 9.43 9.50 8.73	GEBH04-011 SPT 9.00-9.45 m 1, 16, 24 N=40 GEBH04-012			Sandy CLAY medium plasticity, grey, fine to medium grained sub-rounded sand moist, stiff to very stiff Clayey SAND fine to medium grained, grey, high plasticty clay, trace medium angular gravel moist, dense					── 9.0m ← Benton ── 9.5m ── 10.0m	ite
		-	<u>11.10</u> 7.13				CORE LOSS CLAY high plasticity, brown						
HQ3		12	<u>11.84</u> 6.23 <u>13.20</u>				CORE LOSS SANDSTONE fine to medium grained, brown, bedding at 0 - 5 ⁰ highly weathered to moderately weathered, low to medium strength					Sand	
		- - 14 -	5.03 14.00 4.23				SANDSTONE fine grained, grey, bedding at 0 - 5°, trace siltstone laminations 10 - 30 mm fresh, high strength	_				Slotted	рус
		- - 16—	<u>16.26</u> 1.97				END OF BOREHOLE @ 16.26 m					— End ca	p



information only and do not necessarily indicate the presence or absence of soil or groundwater contamination

04/11/2011 13-38 117625003 LOGS GP.I GricTbl GAP CORE PHOTO 1 PER PAGE 05J.1 LIB.GLB S D D

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GAP gINT FN. F31 RL1



#### **REPORT OF CORE PHOTOGRAPHS: GABH04**

CLIENT:	Wollongong City Council	COORDS: 297844.8 m E 6184306.2 m N MGA94 56
PROJECT:	Whytes Gully	SURFACE RL: 18.23 m DATUM: AHD
LOCATION:	Wollongong	INCLINATION: -90°
JOB NO:	117625003	HOLE DEPTH: 16.26 m

#### SHEET: 2 OF 2 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: TZ DATE: 11/8/11 CHECKED: BJF DATE: 13/9/11

# 117625003 GABH04 WCC 14.00 to 16.26m Whytes Gully Box 2 of 2



#### **REPORT OF BOREHOLE: GABH05**

CLIENT: Wollongong City Council PROJECT: Whytes Gully LOCATION: Wollongong JOB NO: 117625003

COORDS: 297921.4 m E 6184312.8 m N MGA94 56 SURFACE RL: 20.33 m DATUM: AHD INCLINATION: -90° HOLE DEPTH: 18.45 m

SHEET: 1 OF 3 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: TZ CHECKED: BJF

DATE: 27/7/11

DATE: 13/9/11

		Dril	ling		Sampling				Field Material Desc	riptio	n	
METHOD	PENETRATION	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	<b>USCS SYMBOL</b>	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
	L	IK	0   1	20.33	0.00-0.20 m R = 0A GABH05-001_0.0-0.2 PID = 0.3 ppm 0.50-0.70 m R = 0A GABH05-002_0.5-0.7 PID = 0.4 ppm 1.00-1.20 m				FILL: Clayey SAND fine to medium grained, black, with roots	D - N	1	FILL
		27/07/1	-	<u>1.20</u> 19.13	R = 0A GABH05-003_1.0-1.2 PID = 0.3 ppm GABH05-004 SPT 1.20-1.65 m 9, 6, 3 N=9			SP	SAND fine grained, sub-rounded, brown to dark brown		L	INFERRED ALLUVIUM
			2	18.33	GABH05-005 SPT 2.00-2.45 m 0, 3, 3 N=6			CH	Silty CLAY high plasticity, dark brown, trace organic content	м	F	
			3	<u>3.00</u> 17.33	GABH05-006 SPT 3.00-3.45 m 4, 4, 9 N=13			SC	Clayey SAND medium grained, rounded to sub-rounded, grey to brown, with some gravel	w	MD	
			- 4 -	<u>4.00</u> 16.33	GABH05-007 SPT 4.00-4.45 m 9, 27, 29 N=56		× ×	SC / SM	Clayey Silty SAND medium grained, rounded to sub-rounded, brown to dark brown, with trace gravel		VD	-
			5		GABH05-008 SPT 5.00-5.45 m 7, 12, 16 N=28		× · · · × · · · × · · · ×				MD	· · · · · · · · · · · · · · · · · · ·
e>> 04/11/2011 13:38 8.2.8			6  - -		GABH05-009 SPT 6.00-6.45 m 8, 16, 20 N=36		*   * *   * *   * *   *				D	- - - - -
-UGS.GPJ <			- 7 - -	7.00 13.33	GABH05-010 SPT 7.00-7.45 m 9, 12, 16 N=28		× · · · × × · · · × × · · · × × · · · × × · · · ×	СН	Silty CLAY high plasticity, brown to dark brown, trace fine grained rounded to sub-rounded sand	м		· · · · · · · · · · · · · · · · · · ·
			- 8 - -		GABH05-011 SPT 8.00-8.45 m 8, 11, 13 N=24		×				VSt - H	
OB GAP NON-CORED F			9		GABH05-012 SPT 9.00-9.45 m 10, 24, 24 N=48		×					
			- 10—	<u>10.00</u> T geot	his report of borehole echnical purposes onl information only a	mus y, wi	x x x t be re thout a lo not	ead ir atterr nece	n conjunction with accompanying notes and abbreviations. I pt to assess possible contamination. Any references to pot ssarily indicate the presence or absence of soil or groundwa	t has entia ater c	beer I cont ontar	n prepared for tamination are for nination. GAP gINT FN. F01a RL3

Golder
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#### **REPORT OF BOREHOLE: GABH05**

CLIENT: Wollongong City Council PROJECT: Whytes Gully LOCATION: Wollongong JOB NO: 117625003 COORDS: 297921.4 m E 6184312.8 m N MGA94 56 SURFACE RL: 20.33 m DATUM: AHD INCLINATION: -90° HOLE DEPTH: 18.45 m SHEET: 2 OF 3 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: TZ DATE: 27/7/11 CHECKED: BJF DATE: 13/9/11

		Dril	lling		Sampling				Field Material Desc	riptic	on	
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			10— -	10.33	GABH05-013 SPT 10.00-10.45 m 11, 10, 12 N=22			СН	CLAY high plasticity, pale brown to brown, with some fine sub-rounded to sub-angular gravel		St -	INFERRED ALLUVIUM
ADV	L		- - 11—	11.00				80.1		м	VSt	
				9.33	SPT 11.00-11.45 m 8, 15, 35 N=50		×	SM	Silty Clayey SAND fine grained, brown, trace medium sub-angular gravel For Continuation Refer to Sheet 3			INFERRED WEATHERED ROCK
			- 12									
			-									
			- 13									
			-									
			 14									
			-									
			15 —									
3 8.2.856			-									
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625003 LOGS			- - 18									
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			20—									
GAP 8_05J.1				T geot	his report of borehole echnical purposes on information only a	must ly, wit and de	t be re thout o not	ead ii atten nece	n conjunction with accompanying notes and abbreviations. npt to assess possible contamination. Any references to po ssarily indicate the presence or absence of soil or groundw	It has tentia ater c	beer cont ontan	n prepared for amination are for nination. GAP gINT FN. F0 R

CLIENT: PROJECT LOCATION JOB NO:	Wol Wol Wol Wol 117 Drilli Wol 00 00 00 00 00 00 00 00 00 0	Ilongon tes Gu Ilongon fg HLdan	der g City Co illy g g g	COG	COORDS: 297921.4 m E 61 SURFACE RL: 20.33 m DAT INCLINATION: -90° HOLE DEPTH: 18.45 m Field Material Description ROCK / SOIL MATERIAL DESCRIPTION	VEATHERING	AHD	RRED NGTH MPa	RT OF BOREHOLE: GA	ABH	/7/11 /9/11 /EFE PAC (mm	
24           10           10           10           10           10           10           10           10           10           10           10           10           10           10           10           10           10           10           10           10           10           10	5         0           0         (100)           0         (100)           0         (100)           0         (100)           0         (100)           0         (100)           0         (100)           0         (100)           0         (100)           0         (100)           0         (100)           0         (100)           0         (100)           0         (100)           0         (100)           0         (100)           0         (100)           0         (100)           0         (100)           0         (100)           0         (100)           0         (100)           0         (100)           0         (100)           0         (100)           0         (100)           0         (100)           0         (100)           0         (100)           0         (100)           0         (100)           0         (100)           0	10- 11- 11- 11- 12- 12- 13- 13- 13- 14- 15- 15- 16- 16- 17- 18- 18- 19- 19- 19- 19-	11.45 11.60 8.73 12.05 8.28 12.45 7.88 13.50 6.83 14.45 5.88 15.45 4.88 17.00 3.33	port of	Continuation of Sheet 2         SANDSTONE         fine grained, brown, with ironstaining         CORE LOSS         SANDSTONE         fine grained, brown, with ironstaining, bedding dips 0 - 5°         with siltstone laminations, 0 - 5°, 10 - 20 mm thick, sp         = 50 - 150 mm         SANDSTONE         pale grey, with siltstone laminations, 1 - 10 mm thick, sp         = 50 - 250 mm, bedding dips 0 - 5°         SANDSTONE         fine grained, pale grey and brown, with ironstaining, bedding dips 0 - 5°         SANDSTONE         fine grained, pale grey, bedding dips 0 - 5°         SANDSTONE         fine grained, pale grey, bedding dips 0 - 5°         with siltstone laminations, 1 - 5 mm thick, sp = 5 - 20 mm         with siltstone laminations, 1 - 5 mm thick, sp = 5 - 20 mm         Fine grained, pale grey, bedding dips 0 - 5°         with siltstone laminations, 1 - 5 mm thick, sp = 5 - 20 mm         for POREHOLE @ 18.45 m         REACHED TARGET DEPTH         PIEZOMETER INSTALLED 28/07/11	HW HW SW			<ul> <li>11.52-11.59 m: B, 0°, PI, Ro, Vr</li> <li>12.15 m: B, 0-5°, PI, Sm, Sn</li> <li>12.32 m: B, 0°, PI, Sm, Sn</li> <li>12.56 m: DS, 0°, 20 mm clay</li> <li>12.60 m: DS, 0°, 60 mm clay</li> <li>12.88 m: B, 0°, PI, Sm, Sn</li> <li>13.29 m: DS, 0°, 20 mm clay</li> <li>13.34 m: B, 0-5°, PI, Sm, Sn</li> <li>13.36 m: DS, 0°, 20 mm clay</li> <li>13.46 n: D, 0°, PI, Sm, Sn</li> <li>14.50-14.60 m: J, 70°, PI, Sm, Sn</li> <li>14.50 m: J, 5°, PI, Sm, Sn</li> <li>15.66 m: B, 0-5°, PI, Sm, Sn</li> <li>15.66 m: B, 0-5°, PI, Sm, Sn</li> <li>15.76 m: J, 50°, PI, Sm, Sn</li> <li>15.77 m: J, 70°, PI, Sm, Sn</li> <li>15.77 m: J, 70°, PI, Sm, Sn</li> <li>16.88 m: B, 0°, PI, Ro, Sn</li> <li>16.88 m: B, 0°, PI, Ro, Sn</li> <li>16.88 m: B, 0°, PI, Ro, Sn</li> <li>16.91 m: DS, 0°, 5 mm sand</li> <li>17.73 m: B, 0°, PI, Sm, Sn</li> <li>17.40 m: DB</li> <li>17.73 m: B, 0°, PI, Sm, Sn</li> <li>17.40 m: DB</li> <li>17.73 m: B, 0°, PI, Sm, Sn</li> <li>18.28 m: B, 0°, PI, Sm, Sn</li> <li>18.24 m: DS, 0°, 50 mm sand</li> </ul>			

Drilling         Sampling         Field Material Description and instrumentation           01         30.911 E GR Pair D Test Pair D T	CL PF LC JC	IENT ROJE CATI	CT: W ON: W ON: W	/ollongo /hytes G /ollongo 176250(	clates ng City Council Gully ng D3			COORDS: 297921.4 m E 6184312.8 m N MGA94 56 SURFACE RL: 20.33 m DATUM: AHD INCLINATION: -90° HOLE DEPTH: 18.45 m	5	SHEET: 1 OF 1 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: TZ DATE: 27/7/ CHECKED: BJF DATE: 13/9/						
Status         Solution         <		D	rilling		Sampling		Field Material Description and Instrumentation									
Op         20.37 + 100 - 1000 - 100 - 100 - 100 - 100 - 100 - 10	METHOD	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	AIRLIFT YIELD (L/s)		CON	STRUCTION				
00         10:13         R=0.4         SAND           01         2         4         30:10:10         Regardled, sub-rounded, brown to dark brown, the gamed, sub-rounded, brown to dark brown, the set organic content           01         10:10:10         Regardled, sub-rounded, brown to dark brown, the set organic content           10:00:10:00         10:10:10         Regardled, sub-rounded, grey to brown, with set organic content           10:00:10:00         10:10:10         Regardled, sub-rounded, grey to brown, with set organic content           10:00:10:00         10:10:10         Regardled, sub-rounded, brown to dark brown, with set organic content           10:00:10:00:10:00         10:10:10         Regardled, sub-rounded, brown to dark brown, with set organic content           10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:00:10:1		, N	-   -	20.33	0.00-0.20 m R = 0A GABH05-001_0.0-0.2 PID = 0.3 ppm 0.50-0.70 m			FILL: Clayey SAND fine to medium grained, black, with roots dry to moist				<ul> <li>Monument (0.60m stickup)</li> <li>Top of casing (0.47m stickup)</li> </ul>				
Oc         Construction         Institution         Instititititititititititititititititititi		27/07/1	2—	19.13 2.00 18.33	R = 0A GABH05-002_0.5-0.7 PID = 0.4 ppm 1.00-1.20 m R = 04		· · · · · · · · · · · · · · · · · · ·	SAND fine grained, sub-rounded, brown to dark brown moist, loose Sitty CLAY	-							
00         4         4.00         0.3 3 Me6           13.3         GABHOS 000 SPT 8.00-845 m 5.4 k104.00 r SPT 8.00-845 m 5.1 k10.445 m 5.4 k106 000 SPT 8.00-845 m 5.1 k10.445 m 5.4 k106 000 SPT 8.00-845 m 5.1 k10.445 m 5.1 k			-	<u>3.00</u> 17.33	GABH05-003_1.0-1.2 PID = 0.3 ppm SPT 1.20-1.65 m 9, 6, 3 N=9 GABH05-004 SPT 2.00-2.45 m			high plasticity, dark brown, trace organic content moist, firm Clayey SAND medium grained, rounded to sub-rounded, grey to brown, with some gravel	-							
00         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0			4	<u>4.00</u> 16.33	0, 3, 3 N=6 GABH05-005 SPT 3.00-3.45 m 4, 4, 9 N=13 GABH05-006 SPT 4.00-4.45 m			wet, medium dense Clayey Silty SAND medium grained, rounded to sub-rounded, brown to dark brown, with trace gravel moist, medium dense to very dense				- Cement grout				
9       7.00 (ABH05:006 SPT 80:0-45 m 8, 12, 16 N=28 (ABH05:0-10       518/ CLAY high plasticity, hown to dark brown, trace fine grained rounded to sub-oncide sand most, very stiff to hard         8       SPT 8:0:0-45 m 10, 24, 24 N=48 (ABH05:011       X         9       10       SPT 8:0:0-45 m 10, 24, 24 N=48 (ABH05:012       X         10       10.33 (ABH05:012       X       Note of the sub-oncide sand most, very stiff to hard         10       10.33 (ABH05:012       X       Note of the sub-oncide sand most, series sand most, ser	ADV		- 6—		GABH05-007 SPT 5.00-5.45 m 7, 12, 16 N=28 GABH05-008 SPT 6.00-6.45 m 8, 16, 20 N=36 GABH05-009		$\begin{array}{c} \begin{array}{c} 1 \\ \times \end{array} \\ \begin{array}{c} \cdot \\ \cdot \end{array} \\ \begin{array}{c} \cdot \\ \cdot \\ \cdot \end{array} \\ \end{array} \\ \begin{array}{c} \cdot \\ \cdot \\ \cdot \end{array} \\ \begin{array}{c} \cdot \\ \cdot \\ \cdot \end{array} \\ \begin{array}{c} \cdot \\ \cdot \\ \cdot \end{array} \\ \end{array} \\ \begin{array}{c} \cdot \\ \cdot \\ \cdot \end{array} \\ \begin{array}{c} \cdot \\ \cdot \\ \cdot \end{array} \\ \end{array} \\ \begin{array}{c} \cdot \\ \cdot \\ \cdot \end{array} \\ \end{array} \\ \begin{array}{c} \cdot \\ \cdot \\ \cdot \end{array} \\ \end{array} \\ \begin{array}{c} \cdot \\ \cdot \\ \cdot \end{array} \\ \end{array} \\ \end{array} \\ \begin{array}{c} \cdot \\ \cdot \\ \cdot \end{array} \\ \end{array} \\ \end{array} \\ \end{array} \\ \begin{array}{c} \cdot \\ \cdot \\ \end{array} \\$									
10			- - 8—	7.00	6, 10, 20 N-30 GABH05-009 SPT 7.00-7.45 m 9, 12, 16 N=28 GABH05-010 SPT 8.00-8.45 m 8, 11, 13 N=24 GABH05-011			Sity CLAY high plasticity, brown to dark brown, trace fine grained rounded to sub-rounded sand moist, very stiff to hard								
0       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -			- - 10—	<u>10.00</u> 10.33	SPT 9.00-9.45 m 10, 24, 24 N=48 GABH05-012 SPT 10.00-10.45 m 11, 10, 12 N=22			CLAY	-							
12       12.05 Regardless       12.07 Regardless       12.07 Regardless       12.07 Regardless         13.50 6.83       13.50 6.83       13.50 Regardless       13.07 Regardless       13.07 Regardless       13.07 Regardless         14       14.45 5.88       5.88 Regardless       5.88 Regardless       13.07 Regardless       13.07 Regardless         16       15.45 8.80 16       15.45 Regardless       15.45 Regardless       15.45 Regardless       5.88 Regardless       13.07 Regardless         18       18       18.45       18.45       18.45       18.45         18       18.45       18.45       18.45       18.45			-	11.00 9.33 11.45 8.73	GABH05-013 SPT 11.00-11.45 m 8, 15, 35 N=50 GABH05-014		  	high plasticity, pale brown to brown, with some tine sub-rounded to sub-angular gravel moist, stiff to very stiff Silty Clayey SAND fine grained, brown, trace medium sub-angular gravel moist								
PD       13.50 (6.83) 14 14 14.45 5.88 14 14.45 5.88 16 16 16.43 14 14.45 5.88 16 16 16 18.45 16 18.45 16 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.45 18.4			12— - -	12.05 828 12.45 7.88			· · · · · · · · · · · · · · · · · · ·	SANDSTONE fine grained, brown, with ironstaining highly weathered, very low strength CORE LOSS SANDSTONE				– 12.0m – Bentonite – 12.5m – 13.0m				
Sand       15.45         16       15.45         16       16         17.00       50         3.33       SANDSTONE         18       18         18       18.45         18       END OF BOREHOLE @ 18.45 m         REACHED TARGET DEPTH       PECOMETER INSTALLED 28/07/11			- 14 —	13.50 6.83 14.45 5.88				fine grained, brown, with ironstaining, bedding dips 0 - 5° highly weathered, low strength with sittstone laminations, 0 - 5°, 10 - 20 mm thick, sp = 50 - 150 mm SANDSTONE								
18-     18-     Imoderately weathered to slightly weathered, low to medium       18-     18-       18-     18-       18-     Imoderately weathered, medium strength       Imoderately weathered, medium strength     Imoderately weathered, medium strength       Imoderately weathered, medium st	HQ3		- - - 16	<u>15.45</u> 4.88				pale grey, with siltstone laminations, 1 - 10 mm thick, sp = 50 - 250 mm, bedding dips 0 - 5° moderately weathered to slightly weathered, medium strength SANDSTONE fine grained, pale grey and brown, with ironstaining, bedding dips 0 - 5°				<ul> <li>Sand</li> <li>Slotted pvc</li> </ul>				
18-     18-     Image: Single of Borner and Single of Born			-	<u>17.00</u> 3.33			• • • • • • • • • • • • • • • • • • • •	moderately weathered to slightly weathered, low to medium strength SANDSTONE fine grained, pale grey, bedding dips 0 - 5° slightly weathered, medium strength								
			18	. <u>18.45</u> 1.88			• • • •	END OF BOREHOLE @ 18.45 m REACHED TARGET DEPTH PIEZOMETER INSTALLED 28/07/11				- End cap				



#### **REPORT OF CORE PHOTOGRAPHS: GABH05**

CLIENT:	Wollongong City Council	COC
PROJECT:	Whytes Gully	SUR
LOCATION:	Wollongong	INCL
JOB NO:	117625003	HOL

#### COORDS: 297921.4 m E 6184312.8 m N MGA94 56 SURFACE RL: 20.33 m DATUM: AHD INCLINATION: -90° HOLE DEPTH: 18.45 m

#### SHEET: 1 OF 2 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: TZ DATE: 27/7/11 CHECKED: BJF DATE: 13/9/11

## 117625003

WCC

## Whytes Gully

## GABH05 11.45 to 15.00m

Box 1 of 2





#### **REPORT OF CORE PHOTOGRAPHS: GABH05**

CLIENT:	Wollongong City Council	COORDS: 297921.4 m E 6184312.8 m N MGA94 56
PROJECT:	Whytes Gully	SURFACE RL: 20.33 m DATUM: AHD
LOCATION:	Wollongong	INCLINATION: -90°
JOB NO:	117625003	HOLE DEPTH: 18.45 m

#### SHEET: 2 OF 2 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: TZ DATE: 27/7/11 CHECKED: BJF DATE: 13/9/11

# 117625003

## WCC

## Whytes Gully

# GABH05

## 15.00 to 18.45m

## Box 2 of 2





#### REPORT OF BOREHOLE: GABH06 D

CLIENT: Wollongong City Council PROJECT: Whytes Gully LOCATION: Wollongong JOB NO: 117625003 COORDS: 297975.6 m E 6184322.0 m N MGA94 56 SURFACE RL: 22.05 m DATUM: AHD INCLINATION: -90° HOLE DEPTH: 15.45 m SHEET: 1 OF 3 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: TZ DATE: 27/7/11 CHECKED: BJF DATE: 13/9/11

		Dril	ling		Sampling				Field Material Desc	riptic	n		
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	Sample or Field test	RECOVERED	GRAPHIC LOG	<b>USCS SYMBOL</b>	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS	
			-0	22.05			×	СН	Silty CLAY high plasticity, dark brown / black, inferred soft to firm			INFERRED ALLUVIUM	Τ
		$\bigtriangledown$	-	-			×						
	L	07/11	-	-			×			м	S - F		
		27,	1—	-			×						
			-	1.20 20.85	GABH06_001		× —	CI	Silty CLAY				
			-	-	4, 6, 7 N=13		×		medium plasticity, brown		St		
			-	2.00			<u> </u>						
			2	20.05	GABH06_002 SPT 2.00-2.45 m		× –	CI	Sandy Silty CLAY medium plasticity, brown, fine to medium grained sub-rounded	1			
			-	-	8, 14, 24 N=38		×		sand, with some fine grained sub-rounded gravel		VSt		
			-	-									
			3—	<u>3.00</u> 19.05	GABH06 003		e <u> </u>	SC					
			-		SPT 3.00-3.45 m 13, 21, 23 N=44		,		fine grained, sub-rounded, brown, with some fine grained sub-rounded gravel				
			-				,			D - N	D		
			-	-			×						
			4	-	GABH06_004 SPT 4.00-4.45 m		×						
ADV	L-M		-	-	9, 10, 18 N=28		××				MD		
			-				× · · · ×						
			5—	5.00 17.05	GABH06 005		× ·	CI	Silty CLAV				.
			-		SPT 5.00-5.45 m 9, 13, 16 N=29		—×		medium plasticity, brown, trace fine grained sub-rounded sand				
			-				×						
			-	6.00			X						
		$\overline{\nabla}$	6	16.05	GABH06_006 SPT 6.00-6.45 m		* * * *	СН	Sandy CLAY high plasticity, brown, coarse grained sub-rounded sand, trace		VSt		
		11/20/	-	-	8, 9, 14 N=23		 		organics (black)	м			
		28	-				• • • •						
			7 —	7.00	GABH06 007		••••••••••••••••••••••••••••••••••••••	SC	Clavery SAND	-			
			-	-	SPT 7.00-7.45 m 9, 19, 25 N=44				fine to medium grained, sub-rounded, brown / dark brown, trace organics, trace fine grained sub-rounded gravel	M - W	D		
			-						For Continuation Refer to Sheet 2				1
			-										
			8										
			-										
			-										
			9										
			-										
			-										
			-										
	1	<u> </u>	10 —	T geot	his report of borehole echnical purposes or	e mu nly, w	st be re	ead i atten	n conjunction with accompanying notes and abbreviations. In to assess possible contamination. Any references to po	It has tentia	beer	n prepared for tamination are for GAP dINT EN EV	⊥_ )1∙
					information only	and	uo not	nece	essanily indicate the presence of absence of soil or groundwa	ater c	untar	ninauon. Ora girti i N. F	<u>۲۲</u>

(			As	Folo	der iat	es		R	E	PC	DR'	T OF BOREHOLE: G	ABH	06	D
CI PI LC JC	LIENT ROJE DCAT DB NO	Г: :CT: 'ION: D:	Wol Why Wol 117	longoną /tes Gu longoną 625003	g City C Ily g	ouncil	COORDS: 297975.6 m E SURFACE RL: 22.05 m D INCLINATION: -90° HOLE DEPTH: 15.45 m	618432 ATUM:	22.0 Ał	) m N HD	I MGA	A94 56 DRILL RIG: Drill Cat CONTRACTOR: Terra LOGGED: TZ CHECKED: BJF	test DATE DATE	: 27/7 : 13/9	7/11 9/11
			Drilli	ng			Field Material Description	1				Defect Information	n		
METHOD	WATER	TCR	RQD (SCR)	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	ROCK / SOIL MATERIAL DESCRIPTION	WEATHERING	EL O S	NFEF TREI Is ₍₅₀₎ I	RRED NGTH MPa	D H DEFECT DESCRIPTION & Additional Observations		AVI DE SP ( ₽ 8	ERAGE EFECT ACING (mm)
5/1 LIB GLB Log GAP CORED BOREHOLE 117825003 LOGS.GPJ < <drawingfile>&gt; 04/11/2011 13:39 8.2.856 HO2 APD CORED BOREHOLE 117825003 LOGS.GPJ &lt;<drawingfile>&gt; 04/11/2011 13:39 8.2.856 HO2 APD CORED BOREHOLE 11782503 LOGS.GPJ &gt; 04/11/2011 13:39 8.2.856 HO2 APD CORED BOREHOLE 11782503 LOGS.GPJ &gt; 04/11/2011 13:39 8.2.856 HO2 APD CORED BOREHOLE 11782503 LOGS.GPJ &gt; 04/11/2011 13:39 8.2.856 HO2 APD CORED BOREHOLE 11782503 LOGS.GPJ &gt; 04/11/2011 13:39 8.2.856 HO2 APD CORED BOREHOLE 11782503 LOGS.GPJ &gt; 04/11/2011 13:39 8.2.856 HO2 APD CORED BOREHOLE 11782503 LOGS.GPJ &gt; 04/11/2011 13:39 8.2.856 HO2 APD CORED BOREHOLE 11782503 LOGS.GPJ &gt; 04/11/2011 13:39 8.2.856 HO2 APD CORED BOREHOLE 11782503 LOGS.GPJ &gt; 04/11/2011 13:39 8.2.856 HO2 APD CORED BOREHOLE 11782503 LOGS.GPJ &gt; 04/11/2011 13:39 8.2.856 HO2 APD CORED BOREHOLE 11782503 LOGS.GPJ &gt; 04/11/2011 13:39 8.2.856 HO2 APD CORED BOREHOLE 11782503 LOGS.GPJ &gt; 04/11/2011 13:39 8.2.856 HO2 APD CORED BOREHOLE 11782503 LOGS.GPJ &gt; 04/11/2011 13:39 8.2.856 HO2 APD CORED BOREHOLE 11782503 LOGS.GPJ &gt; 04/11/2011 13:39 8.2.856 HO2 APD CORED BOREHOLE 11782503 LOGS.GPJ &gt; 04/11/2011 13:39 8.2.856 HO2 APD CORED BOREHOLE 11782503 LOGS.GPJ &gt; 04/11/2011 13:39 8.2.856 HO2 APD CORED BOREHOLE 11782503 LOGS HO2 APD CORED BOREHOLE 11782504 HO2 APD CORE</drawingfile></drawingfile>		45	25 (35) 20 (65) 40 (60)			*	Continuation of Sheet 1         CORE LOSS         Silty CLAY         brown and pale brown, with ironstaining         SANDSTONE         brown and pale brown, with clay seams and ironstaining, bedding dips 0 - 5 ^o Source to brown and pale brown, with clay seams and ironstaining, bedding dips 0 - 5 ^o	RS EW HW HW		notes	s and	9.00 m: DS, 0°, clay 10 mm 9.10 m: DS, 0°, clay 10 mm 9.10 m: DS, 0°, clay 5 mm 9.20-9.45 m: DZ, 0°, clay 9.35 m: J, 10°, PI, Ro, Vr 9.48 m: J, 5-10°, PI, Ro, Vr 9.48 m: J, 5-10°, PI, Sm, Vr 9.48 9.58 m: DZ, 0°, clay 9.48 m: J, 5-10°, PI, Sm, Vr 9.48-9.58 m: DZ, 0°, clay 9.48 m: J, 5-10°, PI, Sm, Vr			
GAP 8_0(				g	eotechr	iical pui informa	poses only, without attempt to assess possible on the second seco	contam sence o	inat or a	ion. bsen	Any r ce of	references to potential contamination are for soil or groundwater contamination.	GAP	gINT F	FN. F02a RL3



CLIENT: Wollongong City Council PROJECT: Whytes Gully LOCATION: Wollongong JOB NO: 117625003						SHEET:         1 OF 1           COORDS:         297975.6 m E 6184322.0 m N MGA94 56         DRILL RIG:         Drill Cat           SURFACE RL:         22.05 m DATUM:         AHD         CONTRACTOR:         Terratest           INCLINATION:         -90°         LOGGED:         TZ         DATE:         27/7/11           HOLE         DEPTH:         15.45 m         CHECKED:         BJF         DATE:         13/9/11							
	D	rilling		Sampling			Field Material Descriptio	n and l	nstrum	entat	ion		
METHOD	WATER	DEPTH (metres)	DEPTH RL	Sample or Field test	RECOVERED	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	AIRLIFT YIELD (L/s)			сс	DNSTRUCTION	
		-								1	-	Monument (0.69m sti	ickup)
	7/11	- 0	22.05			*	Silty CLAY high plasticity, dark brown / black, inferred soft to firm moist, soft to firm				•	— Top of casing (0.57m stickup)	I
	27/0	- - 2—	<u>1.20</u> 20.85 <u>2.00</u> 20.05	SPT 1.20-1.65 m 4, 6, 7 N=13 GABH06_001 SPT 2 00-2 45 m		×	Silty CLAY medium plasticity, brown dry to moist, stiff						
		-	<u>3.00</u> 19.05	8, 14, 24 N=38 GABH06_002 SPT 3.00-3.45 m 13, 21, 23 N=44			Clayey Silty SAND Clayey Silty SAND						
ADV		- 4	5.00	GABH06_003 SPT 4.00-4.45 m 9, 10, 18 N=28 GABH06_004		×··· ×··· ×··· ×···	sub-council of gravel sub-council of gravel dry to moist, medium dense to dense					— Cement grout	
		- - 6—	6.00	SPT 5.00-5.45 m 9, 13, 16 N=29 GABH06_005 SPT 6.00-6.45 m		×	Silty CLAY medium plasticity, brown, trace fine grained sub-rounded sand dry to moist, very stiff						
	28/07/11	-	7.00	8, 9, 14 N=23 GABH06_006 SPT 7.00-7.45 m 9, 19, 25 N=44			high plasticity, brown, coarse grained sub-rounded sand, trace organics (black) moist, very stiff Clayey SAND					— 6.5m — Bentonite	
		- 8—	8.25 13.80	GABH06_007		× —	mile to medium grained, sub-rounded, prown / dark brown, trace organics, trace fine grained sub-rounded gravel moist to wet, dense CORE LOSS Sitty CLAY					— 7.5m — 8.0m	
		-	8.95 13.10 9.45 12.60			× · · · · · · · · · · · · · · · · · · ·	SANDSTONE brown and pale brown, with ironstaining extremely weathered to highly weathered, extremely low strength					— Sand	
		10— - -	12.05 11.05				SANDSTONE brown and pale brown, with clay seams and ironstaining, bedding dips 0 - 5° highly weathered, low to medium strength SANDSTONE fine grained, brown, with clay seams and ironstaining, bedding					— Slotted pvc	
HQ3		- - 12	<u>12.45</u> 9.60				dips 0 - 5° signature of the second s					— End cap	
		- - 14 —					fine grained, pale grey, with seams of coarse grained to conglomeratic, bedding dips 0 - $5^{\circ}$ fresh, high strength					— Sand	
		-	15.45										
			6.60				END OF BOREHOLE @ 15.45 m REACHED TARGET DEPTH PIEZOMETER INSTALLED 27/07/11						





#### **REPORT OF CORE PHOTOGRAPHS: GABH06 D**

CLIENT:	Wollongong City Council	COORDS: 297975.6 m E 6184322.0 m N MGA94 56
PROJECT:	Whytes Gully	SURFACE RL: 22.05 m DATUM: AHD
LOCATION:	Wollongong	INCLINATION: -90°
JOB NO:	117625003	HOLE DEPTH: 15.45 m

SHEET: 2 OF 2		
DRILL RIG: Drill Cat		
CONTRACTOR: Terrates	t	
LOGGED: TZ	DATE:	27/7/11
CHECKED: BJF	DATE:	13/9/11

## 117625003

## WCC

## Whytes Gully

## GABH06 D

## 12.00 to 15.45m

#### Box 2 of 2



#### REPORT OF BOREHOLE: GABH06 S

CLIENT: Wollongong City Council PROJECT: Whytes Gully LOCATION: Wollongong JOB NO: 117625003 COORDS: 297977.0 m E 6184322.3 m N MGA94 56 SURFACE RL: 22.08 m DATUM: AHD INCLINATION: -90° HOLE DEPTH: 8.35 m SHEET: 1 OF 1 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: TZ DATE: 15/8/11 CHECKED: BJF DATE: 13/9/11

Dri				ling		Sampling				Field Material Description				
	METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	<b>USCS SYMBOL</b>	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS	
F				0	22.08			[	СН	CLAY high plasticity, dark brown, inferred stiff			INFERRED ALLUVIUM	
				-										
		I-M		-								St		
					-									
				-										
				2	2.00	U.50.0.00 m								-
				-	20.08	GABH06 S-001				with some fine to medium grained sub-rounded sand, inferred very stiff				
				-										
				3				[						-
				-										
				-								VSt		
				4				[			м			-
ļ	AD			-										
				-				[						
			$ \ge $	5—	5.00 17.08	U50 5.00 m				grey, trace coarse grained sand, inferred stiff	-			-
		M-H	15/08/11	-		GABH06 S-002		 						
8.2.856				-	-									
1 13:39				6—	-									-
4/11/201				-	-							St		
File>> 0				-										
<drawing< td=""><td></td><td></td><td></td><td>7—</td><td></td><td></td><td></td><td> </td><td></td><td></td><td></td><td></td><td></td><td>-</td></drawing<>				7—										-
s.GPJ <				-										
303 LOG				-				[						
E 117625				8	8.00 14.08	U50 8.00 m GABH06 S-003			SC	Clayey SAND fine grained, yellow, high plasticity clay			INFERRED EXTREMEMLY WEATHERED ROCK	-
ULL PAG				-	13.73					END OF BOREHOLE @ 8.35 m REACHED TARGET DEPTH DIEZOMETER INSTALLED 15/08/11				
ORED F				- 9										
P NON-C				-										.
Log GA				-										
LIB.GLB				- 10 —	-									.
8_05J.1					T geot	his report of borehole echnical purposes only	mu y, w	st be r	ead i atten	n conjunction with accompanying notes and abbreviations. npt to assess possible contamination. Any references to po	It has tentia	bee l con	n prepared for tamination are for	)12
GAP						information only a	Ind	uo not	nece	essarily indicate the presence or absence of soil or groundw	ater c	ontar	nination. On given N. Fo	(L3





#### **REPORT OF BOREHOLE: GMW101**

CLIENT: Wollongong City Council PROJECT: Whytes Gully LOCATION: Wollongong

COORDS: 298159.8 m E 6184848.3 m N MGA94 56 SURFACE RL: 90.15 m DATUM: AHD INCLINATION: -90° HOLE DEPTH: 10.30 m

SHEET: 1 OF 2 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: HMC CHECKED: BJF

G	DATE:	11/7/11

JOB NO: 117625003 DATE: 13/9/11 Drilling Sampling **Field Material Description** MOISTURE CONDITION CONSISTENCY DENSITY PENETRATION RESISTANCE USCS SYMBOL RECOVERED STRUCTURE AND SAMPLE OR FIELD TEST GRAPHIC LOG METHOD SOIL/ROCK MATERIAL DESCRIPTION ADDITIONAL OBSERVATIONS WATER DEPTH (metres) DEPTH RL -0 90.15 SP Gravelly SAND fine to medium grained, brown, medium sub-rounded gravel, with some angular cobbles up to 80 mm diameter Inferred residual soil ·0' D ....................... 0.50 89.65 ADV м × · · · × SN Silty SAND fine grained, brown, trace medium sub-angular gravel D - M For Continuation Refer to Sheet 2 2 4 6 GAP 8_05J.FOR RAIL JOBS LIB.GLB_Log_GAP_NON-CORED FULL PAGE_117625003 LOGS.GPJ_<<DrawingFile>> 02/11/20/116:13_8:2.856 8 10 12 This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination. GAP gINT FN. F01a RL3

CL PF LC JC		r: :ct: :10N: ::	Wol Why Wol 117	longon vtes Gu longon 625003	g City Ca g City Ca g	es	COORDS: 298159.8 m E 61 SURFACE RL: 90.15 m DA  INCLINATION: -90° HOLE DEPTH: 10.30 m	8484{ FUM:	<b>RE</b> 3.3 m AHD	POI N MGA	RT OF BOREHOLE: GMV SHEET: 2 OF 2 94 56 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: HMG DATE: CHECKED: BJF DATE:	<b>V10</b> 11/7/ 13/9/	11 11
	1	1	Drilli	ng	1		Field Material Description	1			Defect Information		
METHOD	WATER	TCR	RQD (SCR)	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	ROCK / SOIL MATERIAL DESCRIPTION	WEATHERING		ERRED ENGTH MPa	DEFECT DESCRIPTION & Additional Observations	AVE DEI SPA (n	RAGE FECT (CING nm)
		100	70 (80)	2-	<u>1.00</u> 89.15		Continuation of Sheet 1 SANDSTONE coarse grained, brown, bedding at 0 - 5°	HW		*	1.10 m: J, 70°, PI, closed 1.32 m: B, 0°, Un, Sm, Sn 1.36-1.40 m: J, 90°, Un, Ro, Sn, 40 mm long 1.75 m: B, 0°, Un, Ro, Sn 1.78 m: B, 0°, Un, Ro, Sn 1.85 m: B, 0°, PI, Sm-Ro, Vr, clay 2.00 m: HB 2.10 m: J, 30°, PI-Un, Ro, Sn 2.34 m: B, 0°, PI-Un, Ro, Sn 2.46 m: DS, 5 mm clay 2.46 m: DS, 5 mm clay 2.50 m: DS, 30°, two clay seams of 5 mm and 10 mm thick within sand matrix 2.55 m: J, 30°, PI, Ro, Sn		
НОЗ		95	80 (80)	4	3.89 86.09 4.71 85.22		CORE LOSS SANDSTONE Coarse grained, brown becoming blue grey, ironstaing covering bedding partings	- - - - - - - - - - - - - - - - - - -		••	2.62 m: B, 5°, PI, closed 2.69 m: B, 0°, Un, Ro, Sn 2.72 m: J, 30°, PI, closed 2.91 m: B, 10°, Un, Ro, Sn 3.00 m: HB 3.08-3.37 m: B, 5°, sp = 30-100 mm, Un, Ro, Sn 3.45 m: J, 0-40°, St, Ro, Sn 3.45 m: J, 0-40°, St, Ro, Sn 3.84 m: J, 10°, PI, Ro, Sn 3.89 m: J, 60°, Un, Ro, Sn 4.02 m: J, 70°, Un, Ro, Sn 4.17 m: B, 0°, PI, Ro, Sn 4.57 m: J, 90°, Un, Ro, Sn 4.53 m: B, 0°, Un, Ro, Sn 4.53 m: B, 0°, Un, Ro, Sn 4.80-4.88 m: B, 0°, sp = 10-30 mm, Un, Ro, Sn 4.94 m: HB		
PJ < <drawingfile>&gt; 02/11/2011 16:13 8.2.856</drawingfile>		100	95 (100)	6 — - - 8 —	-					*	5.38 m: B, 0°, PI, Ro, Sn 5.66 m: B, 0°, PI, Ro, Sn 5.75 m: DB 6.00 m: HB 6.21 m: B, 10°, PI, Ro, Sn 6.37 m: B, 0°, Un, Ro, Sn 6.44 m: HB 6.51 m: HB 6.697-00 m: B, 0°, sp = 100-300 mm, PI, Ro, Sn 7.28 m: B, 5°, PI, Ro, Sn 7.75 m: B, 5°, Un, Ro, Sn 7.82 m: B, 10°, Ro, Sn 7.95 m: HB 8.04 m: HB		
1 Log GAP CORED BOREHOLE 117625003 LOGS.G.	11/07/11	100	100 (100)		- - - - - - - - - - -		END OF BOREHOLE @ 10.30 m REACHED TARGET DEPTH PIEZOMETER INSTALLED 12/07/11			*	8.14 m: B, 0°, Un, Ro, Sn 8.40 m: J, 0-55°, St, Ro, Sn 8.52 m: J, 20°, St, Ro, Sn 8.60 m: J, 20°, Un, Ro, Sn 8.67 m: J, 15°, Un, Ro, Cn 8.66 m: DB 9.02 m: B, 10°, PI, Ro, Sn 9.30 m: B, 5°, Un, Ro, Cn 9.38 m: HB 9.41 m: HB 9.80 m: B, 0°, Un, Ro, Cn 9.91 m: B, 0°, Un, Ro, Cn 9.91 m: B, 0°, Un, Ro, Cn		
				- 	This r	eport of ical pui	f borehole must be read in conjunction with accom rposes only, without attempt to assess possible co tion only and do not necessarily indicate the prese	panyir ntamir nce o	ng not nation	es and a rece of s	abbreviations. It has been prepared for ferences to potential contamination are for soil or groundwater contamination. GAP g	gINT FI	N. F02

(			Gol	der ciates		REPORT	SHEET: 1 OF 1
CL		: W	/ollongor	ng City Council		COORDS: 298159.8 m E 6184848.3 m N MGA94 5	56 DRILL RIG: Drill Cat
	CAT	ION: W	/ollongor	ng		INCLINATION: -90°	LOGGED: HMG DATE: 11/7/11
JC	)B NC	D: 1	1762500	3		HOLE DEPTH: 10.30 m	CHECKED: BJF DATE: 13/9/11
		Drilling		Sampling		Field Material Descriptio	on and Instrumentation
METHOD	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	AIRLIFT YIELD (L/S)
		-	-				Monument (0.62m stickup)
HQ3 ADV ADV			90.15 0.50 89.65 1.00 89.15 3.89 86,06 86.09 4.71 86335 85.22			Gravelly SAND fine to medium grained, brown, medium sub-rounded gravel, with some angular cobbles up to 80 mm diameter dry Sitty SAND fine grained, brown, trace medium sub-angular gravel dry to moist SANDSTONE coarse grained, brown, bedding at 0 - 5° highly weathered to moderately weathered, medium strength blue grey band CORE LOSS highly weathered to moderately weathered, medium strength SANDSTONE coarse grained, brown highly weathered to moderately weathered, medium strength becoming blue grey, ironstaing covering bedding partings	Top of casing (0.52m stickup) Cement grout Cement grout Since a stickup of screen Top of screen Top of screen Sand, 2mm Slotted pvc 50mm
	11/07/11	- - - 10	10.30			END OF BOREHOLE @ 10.30 m REACHED TARGET DEPTH PIEZOMETER INSTALLED 12/07/11	End cap
		-		This report of bore geotechnical purpose information o	ehole must s only, w only and o	t be read in conjunction with accompanying notes and abbr thout attempt to assess possible contamination. Any refere lo not necessarily indicate the presence or absence of soil o	reviations. It has been prepared for ences to potential contamination are for or groundwater contamination. GAP gINT FN. F0 RL

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#### **REPORT OF CORE PHOTOGRAPHS: GMW101**

CLIENT:	Wollongong City Council	COORDS: 298159.8 m E 6184848.3 m N MGA94 56
PROJECT:	Whytes Gully	SURFACE RL: 90.15 m DATUM: AHD
LOCATION:	Wollongong	INCLINATION: -90°
JOB NO:	117625003	HOLE DEPTH: 10.30 m

SHEET: 1 OF 3		
DRILL RIG: Drill Cat		
CONTRACTOR: Terrates	t	
LOGGED: HMG	DATE:	11/7/11
CHECKED: BJF	DATE:	13/9/11





#### **REPORT OF CORE PHOTOGRAPHS: GMW101**

CLIENT:	Wollongong City Council	COORDS: 298159.8 m E 6184848.3 m N MGA94 56
PROJECT:	Whytes Gully	SURFACE RL: 90.15 m DATUM: AHD
OCATION:	Wollongong	INCLINATION: -90°
JOB NO:	117625003	HOLE DEPTH: 10.30 m

SHEET: 2 OF 3 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: HMG DATE: 11/7/11 CHECKED: BJF DATE: 13/9/11



GAP gINT FN. F31

RL1



#### **REPORT OF CORE PHOTOGRAPHS: GMW101**

SHEET: 3 OF 3	
DRILL RIG: Drill Ca	at
CONTRACTOR: T	erratest
LOGGED: HMG	DATE: 11/7/11
CHECKED: BJF	DATE: 13/9/11





#### REPORT OF BOREHOLE: GMW102

CLIENT: Wollongong City Council PROJECT: Whytes Gully LOCATION: Wollongong JOB NO: 117625003 COORDS: 297952.6 m E 6184807.2 m N MGA94 56 SURFACE RL: 88.24 m DATUM: AHD INCLINATION: -90° HOLE DEPTH: 12.50 m SHEET: 1 OF 2 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: TZ DATE: 9/8/11 CHECKED: BJF DATE: 13/9/11

			Dril	lling		Sampling		Field Material Description									
	METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS				
	ADV	М		-0	88.24			×	CI	Silty CLAY medium plasticity, yellow brown, trace fine angular gravel	D	VSt	INFERRED RESIDUAL				
_						GMW102-001 SPT 1.00-1.07 m 25/70mm		×		For Continuation Refer to Sheet 2							
				2													
				-													
				4													
				-													
				6—													
16:14 8.2.856				-													
ile>> 02/11/2011				8													
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17625003 LOGS				10													
ED FULL PAGE 1				-													
GAP NON-CORE				- 12													
BS LIB.GLB Log				-													
5J.FOR RAIL JO				- 14 —	т	his report of borehole	mu	st be re	ead ii	n conjunction with accompanying notes and abbreviations. I	t has	beer	n prepared for				
GAP 8_0					geot	echnical purposes only information only a	y, w nd o	ithout do not	atten nece	pt to assess possible contamination. Any references to pot ssarily indicate the presence or absence of soil or groundwa	ential iter ci	l cont ontar	tamination are for GAP gINT FN. F01 RL				

C Pl L( J(	CLIENT: PROJECT: LOCATION: JOB NO:		Woll Why Woll 1176	longong rtes Gu longong 625003	g City C Ily g	ouncil	COORDS: 297952.6 m E 6 [,] SURFACE RL: 88.24 m DA [,] INCLINATION: -90° HOLE DEPTH: 12.50 m	SHEET: 2 OF 2 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: TZ DATE: 9/8/11 CHECKED: BJF DATE: 13/9/11									
Q	~		Drillir (Y)	ng		APHIC OG	Field Material Description	<b>FRING</b>		RRED NGTH MPa	Defect Information	AV DE SP	ERAG EFEC				
METHO	WATER	TCR	Rad (S	OEPTH (metres	DEPTH RL	GR/ L		WEATH	EL 0.03	<u>5°5</u>		8 9	(mm)				
		100	85 (90)	- - - 2 - - - -	<u>1.25</u> 86.99 <u>2.40</u> 85.84		Continuation of Sheet 1 SANDSTONE fine to medium grained, pale brown, bedding at 0 - 5°	MW SW - FR		•	1.25-2.40 m: B, 0-5°, sp = 120-270 mm, Pl, Sm, Sn 1.27 m: B, 0°, Un, Sm, Sn 2.00 m: B, 0°, Pl, Ro, Sn 2.04 m: J, 15°, Un, Ro, Sn 2.04 m: J, 20°, Pl, Sm, Sn 2.09 m: B, 0°, St, Sm, Sn 2.14 m: DS, 0°, Cay 40 mm 2.40 m: DS, 0°, Cay 40 mm 2.54 m: J, 40°, St, Ro, Sn 3.00 m: B, 0-5°, Pl, Ro, Sn						
	N110000	100	80 (100)	- 4 - 6	<u>4.95</u> 83.29		coarse grained	FR -		+	3.50 m: J, 20°, PI, Ro, Cn 3.65 m: B, 0°, PI, Ro, Sn 3.66 m: J, 20°, PI, Sm, Sn 3.79 m: J, 20°, PI, Sm, Sn 3.80 m: B, 0°, PI, Sm, Sn 4.45 m: J, 10°, PI, Ro, Sn 4.60 m: B, 0-5°, PI, Ro, Sn						
HQ3		100	100 (100)	- - 8 - -	7.00 81.24		CONGLOMERATE fine grained, grey			*	7.46 m: B, 0-5°, Pl, Sm, Sn 7.63 m: B, 0-5°, Pl, Ro, Sn						
		100	85 (100)		- 78.74		SANDSTONE fine to medium grained, pale grey			*	9.50 m: DB 9.60 m: J, 70°, Un, Ro, Sn 9.70-10.50 m: J, 70°, partially closed 10.50 m: J, 10°, PI, Ro, Sn						
				12 — - - -	<u>12.10</u> 76.14 <u>12.50</u> 75.74		CONGLOMERATE fine grained, grey END OF BOREHOLE @ 12.50 m REACHED TARGET DEPTH PIEZOMETER INSTALLED 09/08/11			<b>▼</b>	11.94 m: B, 0-5°, Un, Ro, Cn-Sn 11.94 m: B, 0-5°, Un, Ro, Cn-Sn 12.20 m: DB						
CL PF LC JC	IENT OJE CATI B NC	: W CT: W ION: W D: 1 [/]	/ollongo /hytes G /ollongo 176250(	ng City Council Gully ng 03			COORDS: 297952.6 m E 6184807.2 m N MGA94 5 SURFACE RL: 88.24 m DATUM: AHD INCLINATION: -90° HOLE DEPTH: 12.50 m	56	SHEET: 1 OF 1 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: TZ DATE: 9/8/11 CHECKED: BJF DATE: 13/9/1								
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	C	rilling		Sampling			Field Material Description	on and l									
METHOD	WATER	DEPTH (metres)	DEPTH RL	Sample or Field test	RECOVERED	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	AIRLIFT YIELD (L/s)		CON	ISTRUCTION						
ADV		-   	88.24	SPT 1.00-1.07 m		*   ×   ×	Silty CLAY medium plasticity, yellow brown, trace fine angular gravel dry, very stiff				<ul> <li>Monument (0.70m stickup)</li> <li>Top of casing (0.50m stickup)</li> </ul>						
		2	86.99 2.40 85.84	(GMW102-001			SANDSTONE fine to medium grained, pale brown, bedding at 0 - 5 ^o moderately weathered to fresh, low to high strength 	_			— Cement grout						
		- 4 - -	<u>4.95</u> 83.29				coarse grained	_									
HQ3		- 6 - -	<b>7.00</b> 81.24				CONGLOMERATE fine grained gray				— 5.5m — Bentonite — 6.0m — 6.5m Top of screen						
	09/08/11	-  - -	9 50				fresh, high strength				<ul> <li>— Sand</li> <li>— Slotted pvc 50mm</li> </ul>						
		- 10 - -	78.74				SANDSTONE fine to medium grained, pale grey fresh, high strength										
		- 12— -	<u>12.10</u> 76.14 <u>12.50</u> 75.74				CONGLOMERATE fine grained, grey fresh, high strength END OF BOREHOLE @ 12.50 m				— End cap						
		-					REACHED TARGET DEPTH PIEZOMETER INSTALLED 09/08/11										



information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

GAP gINT FN. F31 RL1





# **REPORT OF BOREHOLE: GMW103**

CLIENT: Wollongong City Council PROJECT: Whytes Gully LOCATION: Wollongong JOB NO: 117625003 COORDS: 298470.2 m E 6184602.6 m N MGA94 56 SURFACE RL: 80.78 m DATUM: AHD INCLINATION: -90° HOLE DEPTH: 10.00 m SHEET: 1 OF 2 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: HMG DATE: 12/7/11 CHECKED: BJF DATE: 13/9/11

		Dri	lling		Sampling				Field Material Desc	riptio	on	
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	<b>USCS SYMBOL</b>	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			0	80.78					FILL: Sandy CLAY medium plasticity, dark brown, fine grained sand, trace fibrous material (roots)	D - N	a	
ADV	L		- - 1—	80.28 0.80 79.98			· · · · · · · · · · · · · · · · · · ·	SC SP	Clayey SAND fine grained, pale brown, low to medium plasticity clay SAND fine grained, pale brown orange, inferred stiff	D - N D	St	INFERRED RESIDUAL SOIL
			-	-					For Continuation Refer to Sheet 2			
			2	-								
			-	-								
			3—	-								
			-									
			-	-								
0.00.7			- 5—									
2011 10.14 O			-	-								
			- 6—	-								
			-	-								
			7									
			-	-								
חירטאבט רט			-	-								
LUG GAF NU			- - 9—									
JUDS LID.GLD			-	-								
			- 10 -									
			- 10	T geot	his report of borehole echnical purposes onl information only a	mu: y, w ind o	st be r ithout do not	ead i atten nece	n conjunction with accompanying notes and abbreviations. npt to assess possible contamination. Any references to po ssarily indicate the presence or absence of soil or groundw	It has tentia ater c	s bee Il con contar	n prepared for tamination are for mination. GAP gINT FN. FC F

		T: CT: 10N: D:	Wol Why Wol 1177	longong tes Gu 625003	g City C Ily		COORDS: 298470.2 m E 6 SURFACE RL: 80.78 m DA INCLINATION: -90° HOLE DEPTH: 10.00 m Field Material Description	184602 TUM:	RE 2.6 m AHD	ERRED RERRED RENGTH	RT OF BOREHOLE: GMV SHEET: 2 OF 2 ORILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: HMG DATE CHECKED: BJF DATE Defect Information	<b>N1</b> : 12/7 : 13/9 AVI DE SP	<b>D3</b> 7/11 9/11 ERAGE	E.
METHC	WATEF	TCR	RQD (S	DEPTH (metres	DEPTH RL	GR/ L(		WEATH	EL 0.03	лянуц 6 - ° - 6 20 - 20 20 - 20	& Additional Observations	9.9	mm)	~~~~
		80	45 (50)		<u>1.20</u> 79.58 <u>1.55</u> 79.23 <u>1.85</u> 78.93		Continuation of Sheet 1 CORE LOSS SILTSTONE grey brown, subhorizontal bedding SANDSTONE medium grained, brown orange, subhorizontal bedding, trace of up to 10 mm sub-rounded gravel	HW MW		•	1.55-1.60 m: core rubbled 1.65 m: B, 0°, PI, Sm, Sn 1.71 m: B, 0°, Un, Sm, Sn 1.77 m: B, 0°, St, Sm, Sn, iron 1.82 m: B, 0°, Sp = 10 mm, PI, Sm, Sn, iron 1.84 m: B, 0°, PI, Ro, Vr, clay 2.06 m: B, 0°, PI, Ro, Vr, clay 2.26 m: DS, 80 mm sitty sand 2.58 m: DS, 80 mm sitty sand 2.81 2.84 m; core subbled			- - - - - - - -
		100	30 (30)	3	4.00					*	2.81-2.84 m: core rubbled 2.90 m: B, 0°, PI, Ro, Sn 3.00 m: HB 3.14 m: B, 5°, Un, Ro, Sn, iron 3.20 m: B, 0°, Un, Ro, Sn, iron 3.56 m: J, 10°, Un, Ro, Cn 3.84 m: J, 50°, Un, Sn, iron 3.95 m: J, 50°, Un, Sn, iron			-
911/2011 08:51 8.2.856 HQ3		100	75 (80)	- - - 5 - - - - - - - - -	<u>5.48</u> 75.22 5.97 74.78		SILTSTONE grey, subhorizontal bedding SANDSTONE fine to medium grained, pale brown, with subhorizontal laminations of sittstone, < 3 mm	r f		*	4.00 m: HB 4.04 m: B, 0°, St, Ro, Sn, iron 4.10 m: B, 0°, St, Ro, Sn, iron 4.33 m: J, 20°, Pl, Ro, Sn, iron 4.68 m: J, 20°, Un, Ro, Sn, iron 4.88-5.00 m: J, 80°, Pl, Ro, Sn, iron 4.83-5.00 m: 2 x HB 5.08 m: J, 10°, Un, Ro, Sn, iron 5.50-5.60 m: J, 90°, Pl, Sm, Sn, iron 5.50-5.56 m: B, 0°, sp = 5-10 mm, Pl, Sm-Ro, Sn, iron 5.73 m: B, 0°, Un, Ro, Sn, iron 6.00 m: HB 0.40 m: PD			-
GLB LOG GAP CURED BUREHOLE 11/625003 LUGS GPJ < <ur></ur>	X 12021	100	75 (75)		6.88 7.05 73.73 7.40 73.38		SILTSTONE grey, subhorizontal bedding SANDSTONE fine grained, pale brown, with subhorizontal siltstone laminations SILTSTONE grey SANDSTONE medium to coarse grained, pale brown grey becoming pale grey and white	SW - FR			6.19 m: DB 6.49 m: B, 0-10°, Un, Ro, Sn, iron 6.59 m: B, 10°, Un, Ro, Sn 6.70 m: DS, 0°, 40 mm clay 6.80 m: B, 0°, St, Sn, iron 6.84 m: B, 0°, St, Sn, iron 6.90-7.05 m: J, 90°, PI, Ro, Sn, iron 7.10 m: B, 0°, Un, Ro, Sn, iron 7.16 m: B, 0°, PI, Ro, Ch 7.36 m: B, 10°, PI, Ro, Cn 7.68 m: B, 10°, Un, Ro, Cn 7.74 m: B, 10°, Un, Ro, Cn 8.00 m: HB 8.22 m: J, 40°, PI, Ro, Cn 8.40 m: B, 20°, Un, Ro, Cn 8.51 m: J, 20°, PI, Ro, Cn 8.94 m: B, 10°, Un, Ro, Cn 9.00 m: HB 9.25 m: B, 0°, PI, Ro, Cn			- - - - - - - - - - - - - - - - -
KAIL JOBS LIB		100	90 (90)	- - —10—	10.00		END OF BOREHOLE @ 10.00 m REACHED TARGET DEPTH PIEZOMETER INSTALLED 14/07/11				9.92 m: DB			-
	1			g	This r eotechr	eport of nical pur informa	f borehole must be read in conjunction with accom poses only, without attempt to assess possible co tion only and do not necessarily indicate the prese	panyii ntamir nce o	ng no natior r abs	tes and n. Any r ence of	abbreviations. It has been prepared for eferences to potential contamination are for soil or groundwater contamination. GAP	gINT F	=N. F0: RI	2a L3

CI PI L( J(	LIENT ROJE DCATI	: W CT: W ION: W ): 1	/ollongong /hytes Gully /ollongong 17625003	City Council			Coords: 298470.2 m E 6184602.6 m N MGA94 56 Surface RL: 80.78 m Datum: AHD Inclination: -90° Hole Depth: 10.00 m	3		SHEET: DRILL RIG CONTRA LOGGED CHECKE	1 of 1 G: Drill ( Ctor: : HMG D: BJF	Cat Terratest DATE: 12/7/11 DATE: 13/9/11
	D	Drilling		Sampling			Field Material Descriptio	n and l	nstrum	entation		
METHOD	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	AIRLIFT YIELD (L/s)			CONS	STRUCTION
		-										Monument (0.79m stickup)
ADV			80.78 0.50 80.28 0.80 79.98 1.20 79.58				FILL: Sandy CLAY medium plasticity, dark brown, fine grained sand, trace fibrous material (roots) dry to moist Clayey SAND fine grained, pale brown, low to medium plasticity clay dry to moist, stiff SAND					Top of casing (0.53m stickup)
		- 2—	1.55 79.23 1.85 78.93			• • • • • • • • • • • • • • • • • • • • • • • •	CORE LOSS SILTSTONE grey brown, subhorizontal bedding highly weathered, medium strength SANDSTONE medium grained, brown orange, subhorizontal bedding, trace of					Cement grout
		- - - 4 —-	<u>4.00</u> 76.78				becoming coarse grained with sub-rounded gravel up to 15 mm					3.5m Bentonite
HQ3		- - 6 —	<u>5.48</u> 75.22 <u>5.97</u> 74.78				SILTSTONE grey, subhorizontal bedding moderately weathered, low to medium strength SANDSTONE	-				4.7m 5.5m Top of screen
		-	6.88 7.05 73.73 7.40 73.38				Ine to medium grained, pale brown, with subhorizontal laminations of sittstone, < 3 mm moderately weathered, low to medium strength SILTSTONE grey, subhorizontal bedding moderately weathered, low to medium strength SANDSTONE fine grained, pale brown, with subhorizontal siltstone laminations moderately weathered, low to medium strength					2 mm sand
	12/07/11 K	- 8 - -					SIL ISTONE grey moderately weathered, low to medium strength SANDSTONE Imedium to coarse grained, pale brown grey Imoderately weathered to fresh, low to medium strength becoming pale grey and white					
		- 	10.00				END OF BOREHOLE @ 10.00 m REACHED TARGET DEPTH PIEZOMETER INSTALLED 14/07/11					End cap

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Golder
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CLIENT:	Wollongong City Council	COORDS: 298470.2 m E 6184602.6 m N MGA94 56
PROJECT:	Whytes Gully	SURFACE RL: 80.78 m DATUM: AHD
OCATION:	Wollongong	INCLINATION: -90°
JOB NO:	117625003	HOLE DEPTH: 10.00 m

SHEET: 1 OF 3 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: HMG DATE: 12/7/11 CHECKED: BJF DATE: 13/9/11



Ð	Golder		REPOR	RT OF CORE PHOTO	SHEET: 2 OF 3	GMW103
CLIENT:	Wollongong City Council	COORDS: 298470.2 m E 6184602.6 m N MGA94 56			DRILL RIG: Drill Cat	
PROJECT: LOCATION:	Whytes Gully Wollongong	SURFACE RL: 80.78 m DATUM: AHD INCLINATION: -90°			CONTRACTOR: Terrat LOGGED: HMG	DATE: 12/7/11
JOB NO:	117625003	HOLE DEPTH: 10.00 m			CHECKED: BJF	DATE: 13/9/11
	Golde	JOB No JOB JOB CLIENT DATE	5003 BOI les Guilly COF	REHOLE DEPTH RE TYPE	May 1036 +08m	
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	7	OLYMPUS DIG	TAL CAMERA			
		This report of core photographs must be read in conjunction with a geotechnical purposes only, without attempt to assess possible o information only and do not necessarily indicate the pres	ccompanying notes and abbreviation ontamination. Any references to pote ence or absence of soil or groundwat	s. It has been prepared for ntial contamination are for er contamination		GAP gINT FN. F31 RL1



RL1



# **REPORT OF BOREHOLE: GMW104**

CLIENT: Wollongong City Council PROJECT: Whytes Gully LOCATION: Wollongong JOB NO: 117625003

GAP 8_05J.FOR RAIL JOBS LIB.GLB Log GAP NON-CORED FULL PAGE 117625003 LOGS.GPJ <<DrawingFile>> 02/11/2011 16:15 8.2.856

COORDS: 297597.7 m E 6184508.5 m N MGA94 56 SURFACE RL: 33.43 m DATUM: AHD INCLINATION: -90° HOLE DEPTH: 9.05 m 
 SHEET:
 1 OF 2

 DRILL RIG:
 Drill Cat

 CONTRACTOR:
 Terratest

 LOGGED:
 TZ
 DATE:
 10/8/11

 CHECKED:
 BJF
 DATE:
 13/9/11

00		-						10					_
		Dri	lling		Sampling				Field Material Descr	iptic	n		
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOI	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE	CONSISTENC) DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS	
			0	33.43			<u>× –</u>	СН	Silty CLAY			INFERRED RESIDUAL	
ADV	м		-	0.70 32.73	DS 0.50-0.70 m GMW104-001 DS 0.70-0.80 m		×			М	F - St		-
			1_	-	GMW104-002		×						-
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				T geote	his report of borehole echnical purposes onl information only a	mu y, w ind i	st be r vithout do not	ead i atten nece	n conjunction with accompanying notes and abbreviations. In to assess possible contamination. Any references to pote ssarily indicate the presence or absence of soil or groundwa	t has entia ter c	beer I cont ontan	n prepared for amination are for nination. GAP gINT FN. F0 R	1a L3





GAP 8_05J.FOR RAIL JOBS LIB.GLB Log GAP WELL 117625003 LOGS.GPJ <<DrawingFile>> 02/11/2011 12:36 8.2.856





CLIENT:	Wollongong City Council
PROJECT:	Whytes Gully
LOCATION:	Wollongong
JOB NO:	117625003

#### COORDS: 297597.7 m E 6184508.5 m N MGA94 56 SURFACE RL: 33.43 m DATUM: AHD INCLINATION: -90° HOLE DEPTH: 9.05 m

#### SHEET: 2 OF 2 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: TZ DATE: 10/8/11 CHECKED: BJF DATE: 13/9/11

# 117625003

# WCC

# Whytes Gully

# GMW104

# 06.00 to 09.05m

# Box 2 of 2

# <image><page-footer>



# **REPORT OF BOREHOLE: GMW105**

CLIENT: Wollongong City Council PROJECT: Whytes Gully LOCATION: Wollongong JOB NO: 117625003 COORDS: 298433.3 m E 6184397.2 m N MGA94 56 SURFACE RL: 87.14 m DATUM: AHD INCLINATION: -90° HOLE DEPTH: 12.35 m SHEET: 1 OF 2 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: TZ DATE: 8/8/11 CHECKED: BJF DATE: 13/9/11

METHOD	NETRATION	ANCE						OL			Σ		
		WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERE	GRAPHIC LOG	USCS SYMB	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE	CONSISTEN( DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS	
			0	87.14			×	CI	Silty CLAY			INFERRED RESIDUAL	Τ
¥	М		-	0.60			—_× 		medium plasticity, pale brown, trace of roots, inferred firm	р-м	F		
			-	86.54			×		trace grey coarse grained sub-angular sand				
	+	-	-			+	×		For Continuation Refer to Sheet 2				+
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10 2 000 L		1	י 14 <i>—</i>	T geot	his report of borehole echnical purposes onl information only a	mu: y, w	st be re ithout a	ead ir atterr nece	n conjunction with accompanying notes and abbreviations. I pt to assess possible contamination. Any references to pot ssarily indicate the presence or absence of soil or groundwa	t has ential ter co	beer cont	n prepared for tamination are for nination. GAP gINT FN. F(	01;

it: Ect Tion Io:	Wo Wh I: Wo 117	llongon ytes Gu llongon 625003	g City Co Illy g	ouncil	COORDS: 298433.3 m E 6 SURFACE RL: 87.14 m D INCLINATION: -90° HOLE DEPTH: 12.35 m	6184393 ATUM:	7.2 r AH[	n N MC D	SHEET: 2 OF 2 GA94 56 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: TZ DATE: 8/8/11 CHECKED: BJF DATE: 13/9/11
	Drill	ng	1		Field Material Description	1	-		Defect Information
TCR	RQD (SCR)	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	ROCK / SOIL MATERIAL DESCRIPTION	WEATHERING			ED TH a DEFECT DESCRIPTION & Additional Observations 양료 (mm) 우용 응용 응 응 응 응 응 응 응 응 응 응 응 응 응 응 응 응 응
] 20	) <u>10</u> (10)		<u>1.15</u> 85.99		Continuation of Sheet 1 CORE LOSS				
10	0 25 (25)		<u>2.75</u> 84.39		SANDSTONE fine to medium grained, brown, bedding at 0 - 5 ⁰ , siltstone laminations	EW		*	2.78 m: J, 5°, PI, Ro, Sn, iron 2.81 m: DB 3.00-3.28 m: recovered as gravel 3.28-3.45 m: B, 0-5°, sp = 10-30 mm, PI, Sm, Sn 3.28-3.84 m: J, 80°, PI, Sm, Sn 3.45-3.56 m: recovered as gravel 3.61 m: B, 0-5°, Un, Ro, Sn 3.70 m: B, 0-5°, PI, Ro, Sn
90	45 (65)	6	4.20 4.40 82.74 82.74 - 6.10 81.04 6.35 80.79		CORE LOSS SANDSTONE fine to medium grained, brown, bedding at 0 - 5 ⁰ grey, siltstone laminations 1 - 2 mm thick brown	HW		•	3.79 m; J, 60°; St, Ro, Sn 3.85 m; B, 0°, Un, Ro, Sn 3.97 m; DB 4.11 m; B, 0°, Un, Ro, Sn 4.114, 20 m; recovered as gravel 4.40-4.50 m; recovered as gravel 4.40-4.50 m; recovered as gravel 4.50-4.90 m; B, 0-5°; sp = 45-100 mm, Un, Ro, Sn 4.93 m; J, 10°, Un, Ro, Sn 5.00 m; HB 5.20 m; B, 0°, Un, Ro, Sn 5.40 m; HB 5.75 m; B, 5°, PI, Sm, Sn 5.78 m; B, 0°, PI, Sm, Sn 5.78 m; B, 0°, PI, Sm, Sn 5.78 m; B, 0°, PI, Sm, Sn 5.95 m; B, 0-5°, PI, Sm, Sn 5.95 m; H2 5.95 m; Ch 20, PL, Sm, Sn 5.95 m; B, 0-5°, PI, Sm, Sn 5.95 m; H2 6.05
95	55 (90)	8	7.82 79.32 8.54 78.50		siltstone laminations 15 - 20 mm thick CORE LOSS SANDSTONE fine to medium grained, brown, bedding at 0 - 5 ⁰			*	6.33-6.61 m: B, 0-5', sp = 10-80 mm, PI, Sm, Sn 6.33-6.61 m: B, 0-5', sp = 10-80 mm, PI, Sm, Sn 6.81 m: B, 0 ⁰ , Un, Ro, Sn 7.00 m: J, 10 ^o , PI, Sm, Yr, sand 7.12 m: B, 0 ^o , Un, Sm, Sn 7.58 m: J, 5-10 ^o , Un, Sm, Sn 7.69 m: B, 0 ^o , PI, Sm, Sn 7.78 m: J, 70 ^o , PI, Sm, Sn 7.85 m: B, 0 ^o , PI, Sm, Sn 7.85 m: B, 0 ^o , PI, Sm, Sn 7.93 m: J, 10 ^o , St, Sm, Sn 7.97 m: J, 10 ^o , St, Sm, Sn 7.97 m: J, 60 ^o , Un, Sm, Sn 7.97 m: B, PI, Sm, Sn 7.97 m: B, PI, Sm, Sn 7.97 m: B, PI, Sm, Sn 8.00 m: HB
10	0 60 (70)		-					<b>↓</b> ★	8.12 m: B, 0°, PI, Ro, Vr, sand 8.20 m: J, 50°, PI, Sm, Sn 8.28-8.33 m: DS, 0°, gravel 8.53 m: B, 0-5°, PI, Sm, Sn 9.00-9.20 m: B, 0°, sp = 20-60 mm, PI, Sm, Sn 9.00-9.20 m: B, 0°, sp = 50-150 mm, PI, Sm, Sn 9.62-9.84 m: J, 70°, partially closed 9.98 m: J, 60°, PI, Sm, Sn 10.31-10.73 m: J, 30-70°, sp = 80-100 mm, Un, Sm, Sn 10.31-10.76 m: B, 0°, sp = 10-110 mm, PI, Sm, Sn 10.98 m: B, 0°, PI, Sm, Sn 11.00 m: J, 60°, PI, Sm, Sn 11.02 m: B, 0°, PI, Sm, Sn
		12	<u>11.66</u> 75.48 <u>12.35</u> 74.79		SANDSTONE fine to medium grained, grey, with conglomerate seams END OF BOREHOLE @ 12.35 m REACHED TARGET DEPTH PIEZOMETER INSTALLED 08/08/11	FR			11.12 m J, 60°, Un, Ro, Sn 11.12 m J, 60°, Un, Ro, Sn 11.13 m J, 60°, Un, Ro, Sn 11.23 m J, 85°, partially closed 11.39+11.51 m: recovered as gravel 11.61-11.67 m: B, 0-5°, sp = 10-15 mm, Pl, Sm, Sn
		T: Wo ET: Wh III CO: 117 Drilli 20 10 100 25 (55) 90 45 (55) 90 45 (55)	T:       Wollongon         C:       Whytes Gu         FION:       Wollongon         O:       117625003         TITR       Wites Gu         Q:       117625003         TITR       Q         Q:       Q:       Q:         Q:       Q:       Q:       Q:         Q:       Q:       Q:       Q:         Q:       Q:       Q:       Q:       Q:         Q:       Q:       Q:       Q:       Q:       Q:         Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:         Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:       Q:	T: Wollongong City Co ECT: Whytes Gully FION: Wollongong 0: 117625003	T: Wollongong City Council ECT: Whytes Gully FION: Wollongong O: 117625003 TOPIIIING R D D D D D D D D D D D D D	T: Wollongong City Council COORDS: 298433.3 m E I ECT: Whytes Gully SURFACE RL: 87.14 m D. TION: Wollongong INCLINATION: 90° C: 117625003 HOLE DEPTH: 12.35 m Drilling Field Material Descriptor I 17625003 HOLE DEPTH: 12.35 m Drilling C Field Material Descriptor I 17625003 HOLE DEPTH: 12.35 m Continuation of Sheet 1 CORE LOSS 100 25 100 25 100 25 100 25 100 45 100 4	T: Wollingong City Council COORE LOSS ECT: Whytes Guly SURFACE RL: 87.14 m DATUM: ITON: Wollongong INCLINATION: 90° C: 117625003 HOLE DEPTH: 12.35 m Drilling Field Material Description $\hline Drilling Field Material Description \hline Drilling Fie$	T.       Wollongong City Council       COORDS: 298433.3 m E 6184397.2 r         CD       Whytes Gully       SURFACE RL: 87.14 m DATUM: AHD         IDN:       Wollongong       INCLINATION: 90°         C1       117625003       HOLE DEPTH: 12.35 m         Drilling       Field Material Description       INCLINATION: 90°         IDN:       IDN:       IDN:       IDN:         IDN:       IDN:       IDN:       IDN:	T: Wollongong City Council CORDS: 298433.3 m E 6184397.2 m NM SURFACE RL: 87.14 m DATUM: AHD SURFACE RL: 87.14 m DATUM: AH

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CLIENT:Wollongong City CouncilPROJECT:Whytes GullyLOCATION:WollongongJOB NO:117625003							COORDS: 298433.3 m E 6184397.2 m N MGA94 5 SURFACE RL: 87.14 m DATUM: AHD INCLINATION: -90° HOLE DEPTH: 12.35 m	SHEET: 1 OF 1 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: TZ DATE: 8/8/11 CHECKED: BJF DATE: 13/9/11						
	D	rilling		Sampling	_		Field Material Description	n and l	nstrum	entati	on			
	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	AIRLIFT YIELD (L/s)			C	ONS	TRUCTION	
		- - 0 —	87.14			*	Silty CLAY medium plasticity, pale brown, trace of roots, inferred firm						Monument (0.70m stickup Top of casing (0.56m stickup)	
		-	0.60 86.54 1.15 85.99			× × 	dry to moist, firm trace grey coarse grained sub-angular sand							
	$\bigtriangledown$	- 2 -	<u>2.75</u> 84.39				SANDSTONE						Cement grout	
		- - 4	4.20				CORE LOSS	_						
		-	82.74				Iow strength SANDSTONE fine to medium grained, brown, bedding at 0 - 5° highly weathered to moderately weathered, low to medium strength						5.2m Bentonite 5.7m	
		6 — - - -	6.10 81.04 80.79				grey, siltstone laminations 1 - 2 mm thick						6.2m Top of screen	
		8—	7.82 79.32 8.54 78.50				siltstone laminations 15 - 20 mm thick							
		- - 10—					SANDSTONE fine to medium grained, brown, bedding at 0 - 5 ^o moderately weathered, medium to high strength						Sand Slotted pvc 50mm	
		-	11 66											
		- 12	75.48 12.35 74.79				SANDSTONE fine to medium grained, grey, with conglomerate seams fresh, medium to high strength END OF BOREHOLE @ 12.35 m						End cap	
		-					REACHED TARGET DÉPTH PIEZOMETER INSTALLED 08/08/11							



Wollongong City Council	COORDS: 298433.3 m E 6184397.2 m N MGA94 56
Whytes Gully	SURFACE RL: 87.14 m DATUM: AHD
Wollongong	INCLINATION: -90°
117625003	HOLE DEPTH: 12.35 m
	Wollongong City Council Whytes Gully Wollongong 117625003

#### SHEET: 1 OF 3 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: TZ DATE: 8/8/11 CHECKED: BJF DATE: 13/9/11



Golder
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CLIENT:	Wollongong City Council	COORDS: 298433.3 m E 6184397.2 m N MGA94 56
PROJECT:	Whytes Gully	SURFACE RL: 87.14 m DATUM: AHD
LOCATION:	Wollongong	INCLINATION: -90°
JOB NO:	117625003	HOLE DEPTH: 12.35 m

SHEET: 2 OF 3 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: TZ DATE: 8/8/11 CHECKED: BJF DATE: 13/9/11







# **REPORT OF BOREHOLE: GMW106**

CLIENT:Wollongong City CouncilPROJECT:Whytes GullyLOCATION:WollongongJOB NO:117625003

COORDS: 298356.8 m E 6184294.2 m N MGA94 56 SURFACE RL: 77.94 m DATUM: AHD INCLINATION: -90° HOLE DEPTH: 9.00 m SHEET: 1 OF 2 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: HMG DATE: 14/7/11 CHECKED: BJF DATE: 13/9/11

		Dri	lling		Sampling				Field Material Desc	riptio	n	
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
	L		0	77.94					FILL: Slity CLAY low plasticity, dark brown, trace roots	D - M		
ADV	м		- - 1—	77.39	GMW106-001 SPT 0.50-0.95 m 4, 6, 9 N=15			CI	CLAY medium plasticity, brown - pale brown	м	St	INFERRED RESIDUAL SOIL
									For Continuation Refer to Sheet 2			
			-									
			2—									
			_									
			-									
			3									
			-									
			4									
			-									
			_									
002			- 5—									
10:17 8.7			-									
1107/11			-									
			6 —									
urawingr			-									
20 20 20 20 20 20 20 20 20 20 20 20 20 2			-									
103 LUGS			7 —									
1070/11			-									
ILL PAGE												
			-									
			_									
Log GA			9									
LIB.GLB			-									
AIL JUBS			-									
2.FUR R			10 —	т	his report of borehole	 e mu	st be re	ead i	n conjunction with accompanying notes and abbreviations	 t has	beer	n prepared for
				geot	echnical purposes on information only	ily, v and	vithout do not	atten nece	npt to assess possible contamination. Any references to pot essarily indicate the presence or absence of soil or groundwa	entia iter c	l cont ontar	iamination are for nination. GAP gINT FN. F0 RI

CL		F: 2CT: 10N: 2:	Wol Why Wol 117	longon longon 625003	g City C g City C llly g	<b>es</b> ouncil	COORDS: 298356.8 m E 6 SURFACE RL: 77.94 m DA INCLINATION: -90° HOLE DEPTH: 9.00 m	184294 TUM:	<b>RE</b> 4.2 m AHD	<b>РО</b> N MG.	APART OF BOREHOLE: GMW106 SHEET: 2 OF 2 A94 56 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: HMG DATE: 14/7/11 CHECKED: BJF DATE: 13/9/11
			Drilli	ng			Field Material Description				Defect Information
METHOD	WATER	TCR	RQD (SCR)	OEPTH (metres)	DEPTH RL	GRAPHIC LOG	ROCK / SOIL MATERIAL DESCRIPTION	WEATHERING	INFE STRI Is ₍₅₀		D H DEFECT DESCRIPTION & Additional Observations C mm) ₽ 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8
		40	0 (0)	1- - - 2- -	<u>1.25</u> 76.69 <u>2.00</u> 75.94		Continuation of Sheet 1 SANDSTONE fine to medium grained, brown - pale brown, 60% Silty SAND, fine grained CORE LOSS	RS ĒW			
VZTITZUTI 16.17 0.2.856 HQ3		100	0 (0)	3 — - - 4 — - - - - - - - - - - - - - - - - - - -	3.21 74.73 3.54 74.40 4.00 73.84 4.41 73.53 4.41 73.53 73.34 73.34 73.34 73.34 73.34		INTERBEDDED SILTSTONE & SANDSTONE sandstone is typically fine grained, brown and orange, siltstone is grey, subhorizontal bedding SANDSTONE fine grained, pale brown, horizontal bedding siltstone laminations becoming medium grained SANDSTONE fine to medium grained, sub-horizontal bedding, becoming pale brown with bands of up to 200 mm of pale blue-grey siltstone laminations, bedding at 0 - 10 ⁰	HW HW MW SW		1	3.21-3.25 m: J, 85°, PI, Sm, Vr, clay, trace roots 3.31 m: HB 3.47 m: J, 20°, PI, Sm, Vr, clay 3.55 m: B, 0-10°, Un, Ro, Cn 3.70-4.02 m: 4 x HB 4.05 m: B, 10°, Un, Ro, Sn, iron 4.25 m: J, 80°, PI, Ro, Sn, iron, 160 mm long 4.32 m: J, 80°, PI, Ro, Sn, iron, 90 mm long 4.32 m: J, 80°, PI, Ro, Sn, iron, 90 mm long 4.41 m: B, 5°, Un, Ro, Vr, clay 4.84 m: B, 10°, PI, Ro, Cn 5.00 m: HB 5.06 m: B, 5°, Un, Ro, Sn, iron 5.12 m: B, 0-5°, Un, Ro, Sn, iron 5.28 m: B, 5°, Un, Ro, Sn, iron 5.70 m: B, 0°, PI, Sm-Ro, Cn 5.91 m: B, 10°, Un, Ro, Sn 6.00 m: B, 5°, PI, Sm, Vr, clay 6.05 m: B, 0°, Un, Ro, Sn, iron
און אסט געסט אין	14,007/11	100	70 (70)	7	6.80 71.14 7.00 70.94 9.00 68.94		becoming medium grained becoming pale blue-grey END OF BOREHOLE @ 9.00 m REACHED TARGET DEPTH PIEZOMETER INSTALLED 15/08/11	sw		•	8.14 m: B, 0°, Un, Ro, Cn         6.23 m: B, 10°, Un, Ro, Cn         6.23 m: B, 10°, Un, Ro, Cn         6.23 cm: Core rubbled from drilling process         6.57 e.65 m: B, 0-5°, sp = 10-20 mm, Pl, Sm-Ro, Sn         6.70 m: B, 0°, Pl, Ro, Cn         6.77 m: J, 80°, Un, Ro, Sn, iron         6.82-7.62 m: J, 85°, Un, Ro, Sn, iron         8.00 m: HB         8.21 m: HB         8.63 m: B, 5°, Pl, Ro, Sn, iron         8.63 m: B, 5°, Pl, Ro, Sn, iron
	14/07/11			9   10 g	9.00 68.94 This r eotechr	eport of nical put informa	END OF BOREHOLE @ 9.00 m REACHED TARGET DEPTH PIEZOMETER INSTALLED 15/08/11 f borehole must be read in conjunction with accom poses only, without attempt to assess possible co tion only and do not necessarily indicate the prese	ipanyir intamir	ng not nation	es and . Any ence of	8.63 m: B, 5°, PI, Ro, Sn, iron 8.68 m: B, 5°, PI, Ro, Sn, iron d abbreviations. It has been prepared for references to potential contamination are for f soil or groundwater contamination. GAP gINT i



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CLIENT:	Wollongong City Council	COORDS: 298356.8 m E 6184294.2 m N MGA94 56
PROJECT:	Whytes Gully	SURFACE RL: 77.94 m DATUM: AHD
LOCATION:	Wollongong	INCLINATION: -90°
JOB NO:	117625003	HOLE DEPTH: 9.00 m

SHEET: 1 OF 3		
DRILL RIG: Drill Cat		
CONTRACTOR: Terrates	t	
LOGGED: HMG	DATE:	14/7/11
CHECKED: BJF	DATE:	13/9/11



geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination

Golder
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CLIENT:	Wollongong City Council	COORDS: 298356.8 m E 6184294.2 m N MGA94 56
PROJECT:	Whytes Gully	SURFACE RL: 77.94 m DATUM: AHD
LOCATION:	Wollongong	INCLINATION: -90°
JOB NO:	117625003	HOLE DEPTH: 9.00 m

SHEET: 2 OF 3 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: HMG DATE: 14/7/11 CHECKED: BJF DATE: 13/9/11





CLIENT:	Wollongong City Council	COORDS: 298356.8 m E 6184294.2 m N MGA94 56
PROJECT:	Whytes Gully	SURFACE RL: 77.94 m DATUM: AHD
OCATION:	Wollongong	INCLINATION: -90°
JOB NO:	117625003	HOLE DEPTH: 9.00 m

SHEET: 3 OF 3 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: HMG DATE: 14/7/11 CHECKED: BJF DATE: 13/9/11



# REPORT OF BOREHOLE: GMW107

CLIENT: Wollongong City Council PROJECT: Whytes Gully LOCATION: Wollongong JOB NO: 117625003 COORDS: 298155.6 m E 6184248.3 m N MGA94 56 SURFACE RL: 41.09 m DATUM: AHD INCLINATION: -90° HOLE DEPTH: 10.00 m SHEET: 1 OF 2 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: HMG DATE: 13/7/11 CHECKED: BJF DATE: 13/9/11

			ling		Sampling				Field Material Desc	iipuo		
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADV	L	GWNE	0   1	41.09 0.50 40.59 1.20 39.89	GMW107-001 DS 0.50-0.88 m (1 bag) GMW107-002 SPT 0.50-0.95 m 2, 3, 7 N=10				FILL: CLAY         medium plasticity, dark brown, trace fine grained sand         Clayey SAND         fine grained, pale brown orange	D - N		
	м		-	39.69				SP	SAND fine to medium grained, pale brown orange, trace silt			INFERRED RESIDUAL SUIL
			2						For Continuation Refer to Sheet 2			
			3									
			4									
			5— – –									
			6— - - -									
			7									
			8									
			9									



CLIENT: Wollongong City Council PROJECT: Whytes Gully LOCATION: Wollongong JOB NO: 117625003							COORDS: 298155.6 m E 6184248.3 m N MGA94 5 SURFACE RL: 41.09 m DATUM: AHD INCLINATION: -90° HOLE DEPTH: 10.00 m	SH DR CC LO CH	SHEET: 1 OF 1 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: HMG DATE: 13/7/11 CHECKED: BJF DATE: 13/9/11				
	C	rilling		Sampling			Field Material Descriptio	n and l	nstrument	tation			
METHOD	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	AIRLIFT YIELD (L/s)		CO	NSTRUCTION		
		-	-								— Monument (0.72m stickup)		
ADV	GWNE		41.09 <u>0.50</u> 40.59 <u>1.20</u> 39.89 <u>1.75</u>	SPT 0.50-0.95 m 2, 3, 7 N=10 GMW107-001 DS 0.50-0.88 m (1 bag) GMW107-002			FILL: CLAY medium plasticity, dark brown, trace fine grained sand dry to moist Clayey SAND fine grained, pale brown orange SAND fine to medium grained, pale brown orange, trace silt dry to moist	-		-	— Top of casing (0.63m stickup)		
		2	39.34 2.16 38.93 3.00 3.20 37.89				CORE LOSS SANDSTONE fine grained, brown, subhorizontal bedding, siltstone laminations (< 1 mm) highly weathered, very low to low strength SILTSTONE grey brown, with subhorizontal sandstone laminations highly weathered, low to medium strength CANECTORE	-			— Cement grout		
	ved	- 4 -	<u>3.90</u> 37.19				fine grained, brown, with siltstone laminations highly weathered, medium to high strength becoming medium grained, no siltstone laminations				— 4.0m — Bentonite — 5.0m		
CDL	Groundwater Not Obser	- 6— -	5.70 35.39 6.20 34.89 6.67 <u>34.42</u> 6.88 34.21				SILTSTONE grey brown, subhorizontal bedding, with sandstone laminations highly weathered, medium strength SANDSTONE fine grained, brown, with bands of pale blue grey (up to 200 mm), laminations of siltstone highly weathered to slightly weathered, medium to high strength becoming medium grained	-			— 5.5m Top of screen		
		- 8—					becoming fine grained				— 2 mm sand — Slotted pvc 50mm		
		- - 	10.00				END OF BOREHOLE @ 10.00 m REACHED TARGET DEPTH PIEZOMETER INSTALLED 15/07/11				— End cap		
		-	_										

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CLIENT:	Wollongong City Council	COORDS: 298155.6 r
PROJECT:	Whytes Gully	SURFACE RL: 41.09
OCATION:	Wollongong	INCLINATION: -90°
JOB NO:	117625003	HOLE DEPTH: 10.00

#### OORDS: 298155.6 m E 6184248.3 m N MGA94 56 URFACE RL: 41.09 m DATUM: AHD ICLINATION: -90° OLE DEPTH: 10.00 m

SHEET: 1 OF 3 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: HMG DATE: 13/7/11 CHECKED: BJF DATE: 13/9/11





CLIENT:	Wollongong City Council	COORDS: 298155.6 m E 6184248.3 m N MGA94 56
PROJECT:	Whytes Gully	SURFACE RL: 41.09 m DATUM: AHD
LOCATION:	Wollongong	INCLINATION: -90°
JOB NO:	117625003	HOLE DEPTH: 10.00 m

SHEET: 2 OF 3 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: HMG DATE: 13/7/11 CHECKED: BJF DATE: 13/9/11





CLIENT:	Wollongong City Council	COORDS: 298155.6 m E 6184248.3 m N MGA94 56
PROJECT:	Whytes Gully	SURFACE RL: 41.09 m DATUM: AHD
LOCATION:	Wollongong	INCLINATION: -90°
JOB NO:	117625003	HOLE DEPTH: 10.00 m

SHEET: 3 OF 3 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: HMG DATE: 13/7/11 CHECKED: BJF DATE: 13/9/11



			As			es	COORDS: 297871.4 m E 6	<b>RI</b> 18420	<b>EF</b>	<b>&gt;C</b>	<b>) R</b>	T	SHEET: 1 OF 1 DRILL RIG: Drill Cat
PF LC JC	ROJE DCAT DB NC	CT: ION: D:	Why Wol 117	/tes Gu longon 625003	lly 9		SURFACE RL: 18.98 m DA INCLINATION: -90° HOLE DEPTH: 15.00 m	TUM:	A	HD			CONTRACTOR: Terratest LOGGED: HMG DATE: 19/7/11 CHECKED: BJF DATE: 13/9/11
			Drilli	ng	r		Field Material Description		_				Defect Information
METHOD	WATER	TCR	RQD (SCR)	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	ROCK / SOIL MATERIAL DESCRIPTION	WEATHERING	EL ^{0.03}		RRE NGT MPa	D TH a	H     DEFECT DESCRIPTION & Additional Observations     AVERAGE DEFECT SPACING (mm)       E
		80 75 75	0 (0) 0 (0)		6.88 12.45 6.53 12.85 6.13 14.05 14.27 4.71 14.87 4.71 14.87 4.11 3.98		REFER TO "GMW108 S" FOR         GROUND CONDITIONS BETWEEN         0.0 AND 12.0m DEPTH         Start Cored Borehole @ 12.00 m         CORE LOSS         SANDSTONE         fine grained, brown, sub-horizontal bedding         CORE LOSS         SANDSTONE         fine grained, brown         CORE LOSS         SANDSTONE         fine grained, brown         becomes blue grey         END OF BOREHOLE @ 15.00 m         REACHED TARGET DEPTH         PIEZOMETER INSTALLED 19/07/11				*		12.10-12.45 m: core rubbled due to drilling process         12.85-13.00 m: core rubbled due to drilling process         13.00 m: J. 90°. Un, Ro, Sn, iron 440 nmm long         13.00 m: Auger and the second sec
GAP 8_0				g	eotechr	ical pui nforma	poses only, without attempt to assess possible control of the presention only and do not necessarily indicate the presention only and do not necessarily indicate the presention of the presenti	ontam ence o	inat or a	tion. Ibsei	Any nce c	/ re of s	eferences to potential contamination are for soil or groundwater contamination. GAP gINT FN. F0.

CL PF LC JC		: W CT: W ION: W D: 1	Gol SSO /ollongor /ollongor 1762500	der ciates ng City Council ully ng 13			REPORT O COORDS: 297871.4 m E 6184261.8 m N MGA94 5 SURFACE RL: 18.98 m DATUM: AHD INCLINATION: -90° HOLE DEPTH: 15.00 m	9 <b>F B</b>		EHOLE SHEET: 1 OF DRILL RIG: DI CONTRACTOR OGGED: HM CHECKED: B.	<b>GMW108 D</b> 1 1 1 1 1 1 1 1 1 1 1 1 1
	0	Drilling		Sampling			Field Material Descriptio	n and li	nstrume	ntation	
METHOD	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	AIRLIFT YIELD (L/s)		CC	NSTRUCTION
			<u>12.45</u> 6.13 <u>14.05</u> <u>14.27</u> <u>4.11</u> <u>14.87</u> <u>4.11</u> <u>3.98</u>				REFER TO "GMW108 S" FOR GROUND CONDITIONS BETWEEN 0.0 AND 12.0m DEPTH         CORE LOSS         SANDSTONE fine grained, brown, sub-horizontal bedding highly weathered, low strength         CORE LOSS         SANDSTONE fine grained, brown moderately weathered, low strength         CORE LOSS         SANDSTONE fine grained, brown moderately weathered         CORE LOSS         SANDSTONE fine grained, brown moderately weathered         CORE LOSS         SANDSTONE fine grained, brown incoderately weathered         SANDSTONE fine grained, brown incoderately weathered         SANDSTONE fine grained, brown incoderately weathered, low to medium strength         LOCRE LOSS         SANDSTONE fine grained, brown incoderately weathered, low to medium strength         Lecomes blue grey         END OF BOREHOLE @ 15.00 m REACHED TARGET DEPTH PIEZOMETER INSTALLED 19/07/11				<ul> <li>Monument (0.71m stickup)</li> <li>Top of casing (0.58m stickup)</li> <li>stickup)</li> <li>Top of casing (0.58m stickup)</li> <li>Top of streen</li> <li>12.25m</li> <li>12.5m Top of screen</li> <li>2mm sand</li> <li>Slotted pvc 50mm</li> <li>End cap</li> </ul>
				This report of bore geotechnical purpose information o	ehole es or only	e must nly, with and do	be read in conjunction with accompanying notes and abbrinout attempt to assess possible contamination. Any refere not necessarily indicate the presence or absence of soil o	eviations nces to r ground	s. It has potential lwater co	been prepare contamination ontamination.	d for n are for GAP gINT FN. F0 RL



Wollongong City Council	COORDS: 297871.4 m E 6184261.8 m N MGA94 56
Whytes Gully	SURFACE RL: 18.98 m DATUM: AHD
Wollongong	INCLINATION: -90°
117625003	HOLE DEPTH: 15.00 m
	Wollongong City Council Whytes Gully Wollongong 117625003

SHEET: 1 OF 1		
DRILL RIG: Drill Cat		
CONTRACTOR: Terrates	t	
LOGGED: HMG	DATE:	19/7/11
CHECKED: BJF	DATE:	13/9/11



geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for

information only and do not necessarily indicate the presence or absence of soil or groundwater contamination

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117625003

PROJECT: Whytes Gully

LOCATION: Wollongong

Wollongong City Council

CLIENT:

JOB NO:

# **REPORT OF BOREHOLE: GMW108 S**

COORDS: 297870.2 m E 6184262.4 m N MGA94 56 SURFACE RL: 18.89 m DATUM: AHD INCLINATION: -90° HOLE DEPTH: 18.25 m

SHEET: 1 OF 3 DRILL RIG: Drill Cat CONTRACTOR: Terratest DATE: 15/7/11 LOGGED: HMG DATE: 13/9/11 CHECKED: BJF

		וווע	ling		Sampling				Field Material Desc	npuc	л	
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	<b>USCS SYMBOL</b>	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			0   1	18.89	CM/W/108.001				FILL: Silty CLAY low plasticity, dark brown, trace fine grained sand, inferred soft to firm	D - N	n	
			-	17.79	SPT 1.00-1.45 m 3, 6, 9 N=15			CI	CLAY medium plasticity, dark brown - black		St - VSt	INFERRED ALLUVIUM
		18/07/11 1 🛛	2	2.00 16.89 2.30 16.59	GMW108-002 SPT 2.00-2.45 m - 2, 5, 7 N=12			СІ	CLAY medium to high plasticity, brown, with some fine to medium grained sand			
			3	<u>3.00</u> 15.89	GMW108-003 SPT 3.00-3.45 m			CI	Sandy CLAY Sandy CLAY	_	St	
		$\nabla$	-	4.00	4, 7, 10 N=17				Theurum plasticity, brown with searns of grey, line grained sand			
		15/07/11	4	4.00 14.89 4.30 14.59	GMW108-004 SPT 4.00-4.45 m 7, 8, 9 N=17			SC CI	Clayey SAND fine to medium grained, brown, medium plasticity clay Sandy CLAY medium plasticity, grey, fine grained sand	-	MD St	
ADV	L		5	5.00 13.89 5.30 13.59	GMW108-005 SPT 5.00-5.45 m 17, 15, 12 N=27			SC CH	Clayey SAND fine to medium grained, brown, trace medium gravel CLAY	-	MD	
			- - 6	<u>6.00</u> 12.89	GMW108-006 SPT 6.00-6.45 m 5, 9, 14 N=23				high plasticity, grey	M	St	
			- 7 -	<u>7.00</u> 11.89	GMW108-007 SPT 7.00-7.45 m 9, 16, 18 N=34			SC	Clayey SAND fine to medium grained, brown with some grey, clay is high plasticity, trace medium gravel	_		
			- 8— -		GMW108-008 SPT 8.00-8.45 m 6, 12, 13 N=25						MD - D	
			- - 9 -	<u>9.40</u> 9.49	GMW108-009 SPT 9.00-9.45 m 14, 15, 13 N=28			CI				
			-	10.00				G	Sandy CLAY medium plasticity, brown, with gravel		St	
# **REPORT OF BOREHOLE: GMW108 S**

CLIENT: Wollongong City Council PROJECT: Whytes Gully LOCATION: Wollongong JOB NO: 117625003 COORDS: 297870.2 m E 6184262.4 m N MGA94 56 SURFACE RL: 18.89 m DATUM: AHD INCLINATION: -90° HOLE DEPTH: 18.25 m SHEET: 2 OF 3 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: HMG DATE: 15/7/11 CHECKED: BJF DATE: 13/9/11

		Drii	ling		Sampling				Field Material Desc	riptic	n		
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	Sample or Field test	RECOVERED	GRAPHIC LOG	<b>USCS SYMBOL</b>	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS	
			10 —	8.89	GMW108-010 SPT 10 00-10 45 m		× —	СН	Silty CLAY			INFERRED ALLUVIUM	Т
			_	10.40	9, 11, 14 N=25		, 						
			-	0.49			<u> </u>		trace of fine grained sand				
			-	11.00									
ADV	L		-	7.89	GMW108-011 SPT 11.00-11.45 m		• —	CL	Gravelly CLAY low plasticity, brown / grey, white, fine to medium gravel	м	VSt		
			-	-	12, 20, 16 N=36								
			-				0						
			12 —	-									
			-			-	- <b>o</b>		For Continuation Refer to Sheet 3				_
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	<u>I</u>		20 —	ا geot	his report of borehole echnical purposes on information only a	e mus nly, w and o	st be r ithout do not	ead i atten nece	n conjunction with accompanying notes and abbreviations. npt to assess possible contamination. Any references to pol assarily indicate the presence or absence of soil or groundwa	It has entia ater c	beer l cont	n prepared for amination are for nination. GAP gINT FN. I	

		r: :CT: 10N: D:	Wol Why Wol	longong longong 625003	der jato g City Co lly	<b>ES</b> ouncil	COORDS: 297870.2 m E 61 SURFACE RL: 18.89 m DA [*] INCLINATION: -90° HOLE DEPTH: 18.25 m	<b>RE</b> 84262 ГUM:	2.4 r AHI	ORT n N MGA	SHEET: 3 OF 3 94 56 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: HMG DATE: CHECKED: BJF DATE:	<b>08</b>	7/1	<b>S</b>	
			Drilli	na			Field Material Description			Defect Information					
METHOD	WATER	TCR	RQD (SCR)	DEPTH 01 (metres)	DEPTH RL	GRAPHIC LOG	ROCK / SOIL MATERIAL DESCRIPTION	WEATHERING	INF STI Is	FERRED RENGTH	DEFECT DESCRIPTION & Additional Observations	۹/ Sl و ه	/ER DEFI PAC (mi		JE T G
		20	5 (15)		<u>12.25</u> 6.64 <u>14.60</u> 15.00		Continuation of Sheet 2 CORE LOSS SANDSTONE fine grained, brown, bedding at 0 - 5°	MW			14.60-15.00 m: B, 0-5°, PI, Sm, Sn, sp = 50-200 mm 15.00 m: J. 30°, PI, Ro, Sn				
IFOR RAIL JOBS LIBIGLB Log GAP CORED BOREHOLE 117625003 LOGS GPU < NALC RAIL JOBS LIBIGLB Log GAP CORED BOREHOLE 117625003 LOGS GPU <		100	0(0)		15.20 3.69 18.25 0.64		SANDSTONE fine grained, grey, bedding at 0 - 5°, trace gravel sized particles (conglomeritic)	FR			15.20 m: J, 50°, PI, Sm, Sn 15.30 m: B, 0°, Un, Sm, Sn 15.35 m: B, 0°, Un, Sm, Sn 17.48 m: DB 17.70 m: DB 18.05 m: DB				

CLIENT: Wollongong City Council PROJECT: Whytes Gully LOCATION: Wollongong JOB NO: 117625003					REPORT OF BOREHOLE: GMW108 SSHEET: 1 OF 1COORDS: 297870.2 m E 6184262.4 m N MGA94 56SURFACE RL: 18.89 m DATUM: AHDDRILL RIG: Drill CatSURFACE RL: 18.89 m DATUM: AHDCONTRACTOR: TerratestINCLINATION: -90°LOGGED: HMGDATE: 15/7/11HOLE DEPTH: 18.25 mCHECKED: BJFDATE: 13/9/11						
		Drilling	-	Sampling			Field Material Description	on and I	Instrum	entation	
METHOD	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	AIRLIFT YIELD (L/s)		CO	NSTRUCTION
		- - 0 - -	18.89 <u>1.10</u> 17.79	SPT 1.00-1.45 m			FILL: Silty CLAY low plasticity, dark brown, trace fine grained sand, inferred soft to firm dry to moist				Monument (0.68m stickup)     Top of casing (0.58m     stickup)     Cement grout     1.0m     Bentonite
	$\nabla$	- 2—	2.00	3, 6, 9 N=15 GMW108-001			medium plasticity, dark brown - black moist, stiff to very stiff				— 1.5m     — 2.0m Top of screen
	18/07/11	-	2.30 16.59 3.00	2, 5, 7 N=12 GMW108-002			CLAT medium to high plasticity, brown, with some fine to medium grained sand moist, stiff				
		-	4.00	SPT 3.00-3.45 m 4, 7, 10 N=17 GMW108-003			CLAY high plasticity, brown to grey, trace fine grained sand moist, stiff Sandy CLAY				
	15/07/11	4	4.30 14.59	SPT 4.00-4.45 m 7, 8, 9 N=17 GMW108-004			medium plasticity, brown with seams of grey, fine grained sand moist, stiff Clayey SAND				
		-	5.00 5.30 13.59	SPT 5.00-5.45 m 17, 15, 12 N=27 GMW108-005			fine to medium grained, brown, medium plasticity clay moist, medium dense Sandy CLAY medium plasticity, gray, fine grained sand				
ADV		6 — -	6.00 12.89	SPT 6.00-6.45 m 5, 9, 14 N=23 GMW108-006			Clayey SAND fine to medium grained, brown, trace medium gravel				— Sand
		- - 8	7.00	SPT 7.00-7.45 m 9, 16, 18 N=34 GMW108-007 SPT 8.00-8.45 m 6, 12, 13 N=25			Il moist, medium dense CLAY CLAY Ihigh plasticity, grey moist, stiff with some brown, trace fine grained sand Clayey SAND fine to medium grained, brown with some grey. clay is high				— Slotted pvc 50mm
		- - - 10—	9.40 9.49 <u>10.00</u> 8.89	GMW108-008 SPT 9.00-9.45 m 14, 15, 13 N=28 GMW108-009 SPT 10.00-10.45 m			plasticity, trace medium gravel moist, medium dense to dense Sandy CLAY medium plasticity, brown, with gravel moist, stiff				
			10.40 8.49 11.00 7.89	9, 11, 14 N=25 GMW108-010 SPT 11.00-11.45 m 12, 20, 16 N=36 GMW108-011		× ×	Silty CLAY medium to high plasticity, brown / grey moist, very stiff trace of fine grained sand Gravelly CLAY low plasticity, brown / grey, white, fine to medium gravel moiet very stiff				
		12— - -	<u>12.25</u> 6.64				CORE LOSS				
LC		14 — -	14.60 4.29 15.00			••••	SANDSTONE fine grained, brown, bedding at 0 - 5 ⁶			4	— Bentonite
IWN		- 16 - -	3.69				CORE LOSS SANDSTONE fine grained, grey, bedding at 0 - 5 [°] , trace gravel sized particles (conglomeritic) slightly weathered to fresh, medium to high strength				
		- 18— -	<u>18.25</u> 0.64			••••	END OF BOREHOLE @ 18.25 m REACHED TARGET DEPTH PIEZOMETER INSTALLED 18/07/11				
				This report of bor geotechnical purpose information	ehole es or only	e must nly, witl and do	be read in conjunction with accompanying notes and abbr nout attempt to assess possible contamination. Any refere on the necessarily indicate the presence or absence of soil c	eviation nces to or ground	ns. It has potentia dwater c	s been prepare al contamination contamination.	d for are for GAP gINT FN. FC

CLIENT:	Wollongong City Council	C
PROJECT:	Whytes Gully	SI
LOCATION:	Wollongong	IN
JOB NO:	117625003	Н

COORDS: 297870.2 m E 6184262.4 m N MGA94 56 SURFACE RL: 18.89 m DATUM: AHD INCLINATION: -90° HOLE DEPTH: 18.25 m

#### SHEET: 1 OF 2 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: HMG DATE: 15/7/11 CHECKED: BJF DATE: 13/9/11

117625003 WCC Whytes Gully	GMW108 Shallow 12.25 to 16.00m Box 1 of 2
GMW 108 CORE LOSS	CORE LOSS
CORE	L055
CORE LOSS	Cale Me De De
CORE LOSS	

This report of core photographs must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

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CLIENT:	Wollongong City Council	COORDS: 297870
PROJECT:	Whytes Gully	SURFACE RL: 18.
LOCATION:	Wollongong	INCLINATION: -90
JOB NO:	117625003	HOLE DEPTH: 18.

#### .2 m E 6184262.4 m N MGA94 56 .89 m DATUM: AHD .25 m

#### SHEET: 2 OF 2 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: HMG DATE: 15/7/11 CHECKED: BJF DATE: 13/9/11





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(			G	iolo	ler	25		RE	P	OR	Т	T OF BOREHOLE: GMW109 D
CI PF	LIENT ROJE	: CT:	Woll Why	longong rtes Gu	g City Co Ily	ouncil	COORDS: 297604.9 m E 618 SURFACE RL: 17.29 m DATI	A94 56 DRILL RIG: Drill Cat CONTRACTOR: Terratest				
LC JC	LOCATION: Wollongong JOB NO: 117625003			9		INCLINATION: -90° HOLE DEPTH: 21.50 m	LOGGED:         TZ         DATE:         25/7/11           CHECKED:         BJF         DATE:         13/9/11					
			Drillir	ng	1		Field Material Description					Defect Information
METHOD	WATER	TCR	RQD (SCR)	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	ROCK / SOIL MATERIAL DESCRIPTION	WEATHERING	INF STF Is ₍₁		ED TH a	D DEFECT DESCRIPTION & AVERAGE DEFECT SPACING (mm)
9.05J.FOR RAIL JOBS LIB GLB LOG GAP CORED BOREHOLE 117625003 LOGS.GPJ < <drawingfile>&gt; 02/11/2011 16:21 8.2.856 WB WB</drawingfile>				0 — 0 — - - - - - - - - - - - - -	This neetechn		REFER TO "GMW109 S" FOR GROUND CONDITIONS BETWEEN 0.0 AND 10.05m Start Cored Borehole @ 10.05 m Sady Sitly CLAY high plasticity, grey brown, fine grained sand, inferred stiff	anyir	ng na tion	tes an	nd a	d abbreviations. It has been prepared for references to potential contamination are for
GAP 8				g	eotecnn i	nforma	tion only and do not necessarily indicate the presen	ce ol	r abs	i. Any ence	y ret of so	f soil or groundwater contamination. GAP gINT FN. F02: RL:

Field Material Description         P         P         P         Sandy Silty CLAY         high plasticity, grey brown, fine grained sand, inferred         Silf         P         P         P         P         P         P         P         P         P         P         P         P         P         P         P         P         P         P         P         P         P         P         P         P         P         P         P         P         P         P         P         P         P         P         P         P         P         P         P         P         P         P         P         P         P         P         P	Defect Information Defect Information INFERRED STRENGTH Is ₍₅₀₎ MPa STRENGTH Is ₍₅₀₎ MPA STRE	AVERAGE DEFECT SPACING (mm) e & e & e & e & e & e & e & e & e & e &
Sandy Silty CLAY       Sandy Silty CLAY       high plasticity, grey brown, fine grained sand, inferred       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X       X	INFERRED STRENGTH Is(50) MPa       DEFECT DESCRIPTION & Additional Observations	AVERAGE DEFECT SPACING (mm) © ® © ® © ®
Sandy Silty CLAY       high plasticity, grey brown, fine grained sand, inferred       stiff		
$ \begin{array}{c} & & & \\ \hline \hline & & & \\ \hline \hline \\ \hline & & & \\ \hline \hline \hline \\ \hline & & & \\ \hline \hline \\ \hline \hline \\ \hline \hline \hline \\ \hline \hline \hline \hline$		
SANDSTONE fine grained, brown and pale grey, bedding dips 0 - 5 ⁰	EW HW HW 19.09 m: J, 60°, St, Ro, Vr, clay 19.09 m: J, 60°, St, Ro, Vr, clay 19.19 m: J, 60°, St, Ro, Vr, clay 19.19 m: J, 60°, St, Ro, Vr, clay	vr, clay
brown to grey, with ironstaining, bedding dips $0$ - $5^{\circ}$	HW         19.59 m: D, 0 ⁻ , 54, Ko, Vr, day           19.59 m: D, 0 ⁻ , 30 mm clay           19.60 m: DS, 0°, 10 mm clay           19.60 m: DS, 0°, 30 mm clay           19.60 m: DS, 0°, 20 mm clay           20.05 m: D, 0-5°, 35, mm clay           20.08 m: DS, 0°, 25 mm clay           20.13 m: DS, 0°, 20 mm clay           20.18 m: DS, 0°, 20 mm clay           20.46 m: DS, 0°, 15 mm clay           20.46 m: DS, 0°, 20 mm clay           20.46 m: DS, 0°, 10 mm clay           20.46 m: DS, 0°, 10 mm clay           20.50 m: DS, 0°, 10 mm clay	o, Sn
END OF BOREHOLE @ 21.50 m REACHED TARGET DEPTH PIEZOMETER INSTALLED 26/07/11	20.82 m: J, 15°, Pl, Ro, Sn	
00 71 30 01 60 31 50 21	SANDSTONE         30       fine grained, brown         31       SANDSTONE         60       ine grained, brown and pale grey, bedding dips 0 - 5'         60       brown to grey, with ironstaining, bedding dips 0 - 5'         50       END OF BOREHOLE @ 21.50 m         71       END OF BOREHOLE @ 21.50 m         72       END OF BOREHOLE @ 21.50 m         73       PIEZOMETER INSTALLED 26/07/11	00       Fine grained, brown         30       SANDSTONE         30       SANDSTONE         30       SANDSTONE         11       SANDSTONE         12       SANDSTONE         13       B, 50, 50, 50, 50, 50, 50, 50, 50, 50, 50

CL PF LC		T: W CT: W ION: W D: 1	Gol SSO /ollongoi /ollongoi 1762500	der ciates ng City Council iully ng 13			COORDS: 297604.9 m E 6184068.2 m N MGA94 5 SURFACE RL: 17.29 m DATUM: AHD INCLINATION: -90° HOLE DEPTH: 21.50 m	<b>)F B</b>	SHEET: 1 OF 1 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: TZ DATE: 25/7/11 CHECKED: BJF DATE: 13/9/11
		Irilling		Sampling			Field Material Description	n and l	Instrumentation
METHOD	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	AIRLIFT YIELD (L/s)	CONSTRUCTION
.0GS.GPJ < <drawingfile>&gt; 0211/2011 15.41 8.2856 WB</drawingfile>	25/07/11		7.24				REFER TO "GMW109 S" FOR         GROUND CONDITIONS BETWEEN         J.0 AND 10.05m    Sandy Silty CLAY high plasticity, grey brown, fine grained sand, inferred stiff		Monument (0.67m stickup) Top of casing (0.57m stickup) Cement grout
IB.GLB Log GAP WELL 117625003 HQ3		20	<u>18.30</u> -1.01 <u>19.60</u> -2.31 <u>21.50</u>				SANDSTONE fine grained, brown extremely weathered, extremely low strength SANDSTONE fine grained, brown and pale grey, bedding dips 0 - 5 ⁰ (extremely weathered to moderately weathered, low to medium (strength	/	21.3m
GAP 8_05J.FOR RAIL JOBS L			-4.21	This report of bore geotechnical purpose information (	ehole es or only	e must nly, wit and do	ENU OF BOREHOLE @ 21.50 m REACHED TARGET DEPTH PIEZOMETER INSTALLED 26/07/11 be read in conjunction with accompanying notes and abbr nout attempt to assess possible contamination. Any refere not necessarily indicate the presence or absence of soil o	eviation nces to r ground	ns. It has been prepared for potential contamination are for dwater contamination. GAP gINT FN. F02 RL3



#### **REPORT OF CORE PHOTOGRAPHS: GMW109 D**

CLIENT:	Wollongong City Council	COORDS: 2976
PROJECT:	Whytes Gully	SURFACE RL:
LOCATION:	Wollongong	INCLINATION:
JOB NO:	117625003	HOLE DEPTH:

#### 604.9 m E 6184068.2 m N MGA94 56 17.29 m DATUM: AHD -90° 21.50 m

SHEET: 1 OF 3 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: TZ DATE: 25/7/11 CHECKED: BJF DATE: 13/9/11



Golder
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CLIENT:	Wollongong City Council	COORDS: 297604
PROJECT:	Whytes Gully	SURFACE RL: 17
OCATION:	Wollongong	INCLINATION: -90
JOB NO:	117625003	HOLE DEPTH: 21

#### 4.9 m E 6184068.2 m N MGA94 56 7.29 m DATUM: AHD 90° 1.50 m

SHEET: 2 OF 3 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: TZ DATE: 25/7/11 CHECKED: BJF DATE: 13/9/11



Golder
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CLIENT:	Wollongong City Council	COORDS: 297604.9 m
PROJECT:	Whytes Gully	SURFACE RL: 17.29 m
OCATION:	Wollongong	INCLINATION: -90°
JOB NO:	117625003	HOLE DEPTH: 21.50 m

# E 6184068.2 m N MGA94 56 DATUM: AHD

SHEET: 3 OF 3 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: TZ DATE: 25/7/11 CHECKED: BJF DATE: 13/9/11



P	Golder
CLIENT:	Wollongong City Council

117625003

PROJECT: Whytes Gully

LOCATION: Wollongong

JOB NO:

# **REPORT OF BOREHOLE: GMW109 S**

COORDS: 297605.7 m E 6184067.6 m N MGA94 56 SURFACE RL: 17.31 m DATUM: AHD INCLINATION: -90° HOLE DEPTH: 10.24 m SHEET: 1 OF 1 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: HMG DATE: 21/7/11 CHECKED: BJF DATE: 13/9/11

		Dril	ling		Sampling				Field Material Desc	riptic	m			
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS		
			0	17.31					FILL: CLAY medium plasticity, dark brown, trace medium grained sand, inferred soft					
			-	<u>1.00</u> 16.31	GMW109-001 SPT 1.00-1.45 m 7, 4, 4 N=8				with some medium angular gravel	-				
		11/02/11	2—		GMW109-002 SPT 2.00-2.45 m 1, 2, 5 N=7									
		5	-	<u>3.00</u> 14.31	GMW109-003 SPT 3 00-3 45 m				no sand or gravel	M				
			-	4.00	2, 4, 6 N=10									
			4	13.31	GMW109-004 SPT 4.00-4.45 m 4, 7, 11 N=18				becoming brown					
Ì	L		-	5.00 5.16 12.15	GMW109-005 SPT 5.00-5.45 m 5, 5, 5 N=10			SC CH	Clayey SAND fine grained, brown CLAY	/	MD	-		
			6—	<u>6.00</u> 11.31	GMW109-006 SPT 6.00-6.45 m 4 5 9 N=14		  		Sandy CLAY high plasticity, brown, fine grained sand, with some organic bands	_				
			-											
			-							м	St			
			8—	8	8		GMW109-007 SPT 8.00-8.45 m 4, 6, 8 N=14							
			-											
			- 10 —	-	GMW109-008 SPT 10.00-10.24 m				END OF BOREHOLE @ 10.24 m REACHED TARGET DEPTH PIEZOMETER INSTALLED 21/07/11			INFERRED WEATHERED ROCK		
			-		(9, 30/90mm HB									
			-											
			12—	T geot	his report of boreho echnical purposes o information only	le mu only, w	st be re vithout do not	ead ii atten nece	n conjunction with accompanying notes and abbreviations. Inpt to assess possible contamination. Any references to pot ssarily indicate the presence or absence of soil or groundwa	It has entia	bee l con contar	n prepared for tamination are for mination. GAP gINT FN		



<<DrawingFile>> 02/11/2011 15:47 JOBS LIB.GLB Log GAP WELL 117625003 LOGS.GPJ RAIL GAP 8 05J.FOR



# **REPORT OF BOREHOLE: GMW110**

CLIENT: Wollongong City Council PROJECT: Whytes Gully LOCATION: Wollongong JOB NO: 117625003 COORDS: 297572.6 m E 6184266.0 m N MGA94 56 SURFACE RL: 19.61 m DATUM: AHD INCLINATION: -90° HOLE DEPTH: 9.65 m SHEET: 1 OF 2 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: HMG DATE: 20/7/11 CHECKED: BJF DATE: 13/9/11

		Dri	lling		Sampling				Field Material Desc	riptio	on	
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	<b>USCS SYMBOL</b>	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADV	L M-H	-		19.61 0.30 19.31				SW	FILL: CLAY high plasticity, dark brown SAND fine to coarse grained, brown yellow, with some fine angular gravel, inferred medium dense to dense	M D - N	1 MD - D	
			-				<u>.</u>		For Continuation Refer to Sheet 2			
			2									
			- 3									
			-									
			4									
0.000			- 5—									
			- - 6									
			-									
			7									
			- - 8									
			-									
			9									
			10	T geote	his report of borehole echnical purposes on	e mu ily, y	ist be r	ead i atten	n conjunction with accompanying notes and abbreviations.	It has	s beer	n prepared for tamination are for
5					information only a	and		nece	source of absence of some of some of groundw	alei (	Unial	RL

CL PR LO JO	IENT OJE CAT B NC	-: CT: ION: D:	Wol Why Wol 117	longong /tes Gu longong 625003	g City C Ily g	ouncil	COORDS: 297572.6 m E 6' SURFACE RL: 19.61 m DA' INCLINATION: -90° HOLE DEPTH: 9.65 m	184266 TUM:	6.0 r AHI	m N M	MGA	SHEET: 2 OF 2 94 56 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: HMG DATE CHECKED: BJF DATE	: 20/7 : 13/9	7/11 9/11	
			Drilli	ng	1		Field Material Description					Defect Information			
METHOD	WATER	TCR	RQD (SCR)	OEPTH (metres)	DEPTH RL	GRAPHIC LOG	ROCK / SOIL MATERIAL DESCRIPTION	WEATHERING			RED GTH IPa	DEFECT DESCRIPTION & Additional Observations	AVERAG DEFEC SPACIN (mm)		
	X	100	50 (70)	- - - - - - - - - - - - - - - - - - -	<u>1.25</u> 18.36 <u>2.80</u> 16.81		Continuation of Sheet 1 SANDSTONE fine to medium grained, pale brown - yellow, bedding at 0 - 10 ⁰	HW		•		1.27-1.95 m: DS, sp = 40-150 mm, 5 - 40 mm of sandy clay 1.52 m: DB 1.61 m: DB 2.00 m: HB 2.20 m: DS, 10 mm sandy clay 2.24 m: DS, 10 mm sandy clay 2.27 m: DS, 30 mm sandy clay 2.51 m: DB 2.80 m: B, 0°, PI, Ro, Vr, clay 2.80 m: B, 0°, PI, Ro, Sn, iron 2.85 m: DB 2.91 m: B, 0°, PI, Ro, Sn 3.03 m: HB 3.03 m: B, 10°, Un, Ro, Sn			
нцз	20/07/11	100	15 (20)		<u>6.00</u> 13.61		becoming grey with ironstaining around defects	MW SW			•	3.03 m: J, 70°, PI, Ro, Sn 3.23 m: B, 10°, Un, Ro, Sn 3.33 m: J, 20°, Un, Ro, Sn 3.53-5.52 m: J, 90°, Un, Ro, Sn 4.00 m: HB 4.22 m: B, 10°, PI, Ro, Sn 4.46-4.77 m: DB, sp = 30-80 mm 4.84 m: B, 10°, St, Ro, Sn 4.46-4.77 m: DB, sp = 30-80 mm 4.84 m: B, 10°, St, Ro, Sn 5.12 m: B, 10°, PI, Ro, Sn 5.12 m: B, 10°, PI, Ro, Sn 5.24 m: B, 10°, PI, Ro, Sn 5.44 m: B, 10°, PI, Ro, Sn 5.44 m: B, 10°, PI, Ro, Sn 5.52 m: B, 10°, PI, Ro, Sn 5.59 m: DB 5.61 m: DB 5.81 m: A, 10°, Un, Ro, Sn 5.84 m: B, 10°, PI, Ro, Sn 5.84 m: B, 10°, PI, Ro, Sn 6.00 m: HB 6.13 m: B, 10°, Un, Ro, Sn 6.38-6.85 m: B, 10°, pI, Ro, Sn			
		100	60 (70)	- 7 - - 8 - - - - - - - - - - - - -	<u>8.00</u> 11.61 10.97		dark grey	sw		•		7.00 m: HB 7.09-8.00 m: B, 10°, sp = 20-140 mm, PI-Un, Ro, Sn 7.53 m: J, 50°, PI, Ro, Sn 7.71-7.81 m: J, 85°, PI, Ro, Sn 8.00 m: HB 8.13 m: B, 10°, Un, Ro, Sn 8.15 m: DB 8.44 m: B, 10°, PI, Ro, Sn 8.64 m: B, 10°, PI, Ro, Sn 8.75 m: B, 10°, PI, Ro, Sn 8.75 m: B, 10°, PI, Ro, Sn 8.80 m: B, 10°, PI, Ro, Sn 9.00 m: HB 9.02 m: B, 10°, St, Ro, Sn 9.03 m: J, 10°, PI, Ro, Sn 9.19 m: J, 20°, PI, Ro, Sn 9.23 m: B, 10°, PI, Ro, Sn			
				-	9.96		END OF BOREHOLE @ 9.65 m REACHED TARGET DEPTH			$\square$		9.34 m: DB 9.44 m: B, 10°, PI, Ro, Sn	$\prod$		

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CLIENT:	Wollongong City Council	COORDS: 297572.6 m E 6184266.0 m N MGA94 56
PROJECT:	Whytes Gully	SURFACE RL: 19.61 m DATUM: AHD
OCATION:	Wollongong	INCLINATION: -90°
JOB NO:	117625003	HOLE DEPTH: 9.65 m

SHEET: 1 OF 3 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: HMG DATE: 20/7/11 CHECKED: BJF DATE: 13/9/11



This report of core photographs must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.



CLIENT:	Wollongong City Council	COORDS: 297572.6 m
PROJECT:	Whytes Gully	SURFACE RL: 19.61 m
OCATION:	Wollongong	INCLINATION: -90°
IOB NO:	117625003	HOLE DEPTH: 9.65 m

DORDS: 297572.6 m E 6184266.0 m N MGA94 56 JRFACE RL: 19.61 m DATUM: AHD CLINATION: -90° DLE DEPTH: 9.65 m SHEET: 2 OF 3 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: HMG DATE: 20/7/11 CHECKED: BJF DATE: 13/9/11



This report of core photographs must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.



CLIENT:	Wollongong City Council	COOR
PROJECT:	Whytes Gully	SURFA
OCATION:	Wollongong	INCLIN
OB NO:	117625003	HOLE I

CORDS: 297572.6 m E 6184266.0 m N MGA94 56 URFACE RL: 19.61 m DATUM: AHD NCLINATION: -90° IOLE DEPTH: 9.65 m SHEET: 3 OF 3 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: HMG DATE: 20/7/11 CHECKED: BJF DATE: 13/9/11



This report of core photographs must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.



# **REPORT OF BOREHOLE: GMW111**

CLIENT: Wollongong City Council PROJECT: Whytes Gully LOCATION: Wollongong JOB NO: 117625003 COORDS: 297588.6 m E 6184384.9 m N MGA94 56 SURFACE RL: 22.03 m DATUM: AHD INCLINATION: -90° HOLE DEPTH: 8.25 m SHEET: 1 OF 2 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: HMG DATE: 20/7/11 CHECKED: BJF DATE: 13/9/11

		Dri	lling		Sampling				Field Material Des	criptio	on	-
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	<b>USCS SYMBOL</b>	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
	L		-0	22.03					FILL: CLAY high plasticity, dark brown	м		
ADV			-	0.40 21.63				SP	SAND fine to medium grained, pale brown - yellow, inferred medium			
	М-Н		- 1-	-					dense to dense	D - N	MD - D	
						-			For Continuation Refer to Sheet 2			
			-	-								
			2	-								
			-	-								
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			3—	-								
			-	-								
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			4	-								
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5			- 9—	-								
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				T geot	his report of borehole echnical purposes onl information only a	mu: ly, w and o	st be re /ithout / do not	ead i atten nec∈	n conjunction with accompanying notes and abbreviations. npt to assess possible contamination. Any references to p issarily indicate the presence or absence of soil or groundy	It has otentia vater c	s beei il cont contar	n prepared for tamination are for mination. GAP gINT FN. F01
j												RL

CL PF LC JC		-: CT: ION: ):	Wol Why Wol 117	SOC longong ytes Gu longong 625003	g City Co Ily g	buncil	COORDS: 297588.6 m E 61 SURFACE RL: 22.03 m DAT INCLINATION: -90° HOLE DEPTH: 8.25 m	84384 ⁻ UM:	4.9 m N AHD	I MGA	SHEET: 2 OF 2 94 56 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: HMG DA ^T CHECKED: BJF DA ^T	re: 20/7/11 re: 13/9/11
	-		Drilli	ng			Field Material Description	-			Defect Information	
METHOD	WATER	TCR	RQD (SCR)	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	ROCK / SOIL MATERIAL DESCRIPTION	WEATHERING	INFEF STRE Is ₍₅₀₎	RRED NGTH MPa	DEFECT DESCRIPTION & Additional Observations	AVERAGE DEFECT SPACING (mm)
		100	55 (60)	- - - - - - - - - - - - - - - - - - -	<u>1.15</u> 20.88 <u>2.51</u> 19.52 <u>3.02</u> 19.01		Continuation of Sheet 1 SANDSTONE fine to medium grained, brown, with bands of pale brown - yellow, bedding at 0 - 5° SILTSTONE grey SANDSTONE fine to medium grained, brown, with some siltstone laminations, bedding at 0 - 5°	EW HW			1.15 m: DS, 0°, 50 mm clay 1.23 m: DZ, 0°, 330 mm clay 1.74 m: DS, 0°, 60 mm clay 1.87 m: DS, 0°, 25 mm clay 1.95 m: DZ, 0°, 110 mm clay 2.20 m: DS, 0°, 40 mm clay 2.30 m: DS, 0°, 10 mm clay 2.33 m: DS, 0°, 10 mm clay 2.35 m: DZ, 0°, 100 mm clay 2.51 - 2.73 m: B, 30°, sp = 15-30 mm, PI, Ro, Sn 2.57-2.73 m: J, 90°, Un, Ro, Sn 2.73 m: DS, 20 mm clay 2.81 - 30°, sp = 10-100 mm, Un, Ro, Sn 3.20 - 4.00 m: HB's 3.00 - 4.00 m: HB's Sn	
НQ3		100	20 (65)	- - 4 — - - 5 —	<u>4.40</u> 17.63 <u>4.84</u> 17.19 <u>5.14</u> 16.89		becoming medium grained	MW		4~	3.23 fit. 3, 70 , Pi, Ro, Sit 3.61-3.67 m: J, 85°, Pl, Ro, Sn 3.67 m: DS, 20 mm clay 3.73 m: DS, 5 mm clay 3.76 m: DS, 5 mm clay 3.76 m: DS, 5 mm clay 3.76 m: DS, 5 mm clay 4.00 m: HB 4.00 - 4.31 m: B, 0-5°, sp = 30-80 mm, Pl, Ro, Sn 4.31 m: J, 50°, Pl, Ro, Sn 4.34 m: B, 5°, Un, Ro, Sn 4.51 m: HB 4.84-5.26 m: J, Pl-Un, Ro, Sn	
	20/07/11	100	55 (55)	- - 6 - - -	6.00 16.03		fine grained, brown, with siltstone laminations, bedding at 0 - 5° 	SW		•	5.29-7.63 m: B, 0-5°, sp = 50-160 mm, PI-Un, Ro, Sn 5.37-7.00 m: V, quartz 5.46-5.65 m: J, 80°, PI, Ro, Sn	
				7 — - - - - - - - - - - - - - - - - - - -	8.00 14.03 8.25 13.78		dark grey END OF BOREHOLE @ 8.25 m REACHED TARGET DEPTH PIEZOMETER INSTALLED 21/07/11	-		*	8.00 m: HB	
				- - - 10—	This n	eport of	f borehole must be read in conjunction with accom	panvir		s and a	abbreviations. It has been prepared for	

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		: W CT: W ION: W	Gol sso /ollongor /hytes Gi /ollongor	der ciates ng City Council ully 1g	REPORT OF BOREHOLE: GMW111SHEET: 1 OF 1COORDS: 297588.6 m E 6184384.9 m N MGA94 56DRILL RIG: Drill CatSURFACE RL: 22.03 m DATUM: AHDCONTRACTOR: TerratestINCLINATION: -90°HOLE DEPTH: 8.25 mCHECKED: B.JFDATE: 13/9/11										
				Compling											
_		rilling		Sampling				CONSTRUCTION							
МЕТНОD	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	AIRLIFT YIELD (L/s)							
		-1	22.03				FILL: CLAY		Monument (0.62m stickup) Top of casing (0.56m stickup)						
ADV		- - 1—	0.40 21.63 1.15				moist SAND fine to medium grained, pale brown - yellow, inferred medium dense to dense dry to moist, medium dense to dense								
		- - - 2 -	20.88				SANDSTONE fine to medium grained, brown, with bands of pale brown - yellow, bedding at 0 - 5° extremely weathered to highly weathered, very low to low strength		Cement grout						
		- 3 - - 4	<u>3.02</u> 19.01				SILTSTONE grey highly weathered, low strength SANDSTONE fine to medium grained, brown, with some siltstone laminations, bedding at 0 - 5° highly weathered to moderately weathered, low to medium strength	_	3.0m     Bentonite     3.5m     4.0m Top of screen						
3.2.856 HQ3		- - -	<u>4.40</u> 17.63 <u>4.84</u> 17.19				becoming medium grained								
	102/11	-	<u>5.14</u> 16.89				grey moderately weathered, low to medium strength SANDSTONE fine grained, brown, with siltstone laminations, bedding at 0 - 5° moderately weathered to slightly weathered, medium strength		Sand						
11/020000 E000010F0 - >>>	×	6 — - - 7 — -	16.03				pale grey		Slotted pvc 50mm						
		-  8 - - -	8.00 14.03 8.25 13.78				dark grey END OF BOREHOLE @ 8.25 m REACHED TARGET DEPTH PIEZOMETER INSTALLED 21/07/11		End cap						
		9—	(	This report of bor geotechnical purpose information	ehole es or only	e must ily, witi and do	be read in conjunction with accompanying notes and abbr nout attempt to assess possible contamination. Any refere not necessarily indicate the presence or absence of soil o	eviations nces to or ground	ns. It has been prepared for potential contamination are for ndwater contamination. GAP gINT FN. F0: RL:						



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## **REPORT OF CORE PHOTOGRAPHS: GMW111**

	Wollongong City Council	COODDS: 207599.6 m E 6194294.0 m N MCA04.56
LIENI.		COORDS. 297500.0 III E 0104504.9 III N MGA94 50
ROJECT:	Whytes Gully	SURFACE RL: 22.03 m DATUM: AHD
OCATION:	Wollongong	INCLINATION: -90°
OB NO:	117625003	HOLE DEPTH: 8.25 m

SHEET: 1 OF 3 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: HMG DATE: 20/7/11 CHECKED: BJF DATE: 13/9/11





CLIENT:	Wollongong City Council	COORDS: 297588.6 m E 6184384.9 m N MGA94 56
PROJECT:	Whytes Gully	SURFACE RL: 22.03 m DATUM: AHD
LOCATION:	Wollongong	INCLINATION: -90°
JOB NO:	117625003	HOLE DEPTH: 8.25 m

#### SHEET: 2 OF 3 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: HMG DATE: 20/7/11 CHECKED: BJF DATE: 13/9/11





CLIENT:	Wollongong City Council	COORDS: 297588.6 m E 6184384.9 m N MGA94 56
PROJECT:	Whytes Gully	SURFACE RL: 22.03 m DATUM: AHD
OCATION:	Wollongong	INCLINATION: -90°
IOB NO:	117625003	HOLE DEPTH: 8.25 m

SHEET: 3 OF 3 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: HMG DATE: 20/7/11 CHECKED: BJF DATE: 13/9/11



			G		er ates			PO		FE	<b>30</b> Shee	REHOLE: BH205	
PF	ROJE	CT:	Whyte	s Gully				SU	RFACE RL: DATUM: AHD	(		IRACTOR: Terratest	
		ΊΟΝ: Γ	New C	ell Flooi	r			INC	LINATION: -90°	l		GED: CJW DATE: 16/12/11	
		Dri	lina		Sampling		[		Field Material Desc	rintic	n		
	Nош					Q		30L			ζ		
METHOD	PENETRATI	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERE	GRAPHIC LOG	USCS SYME	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE	CONSISTER DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS	
% ADT ADT		7 16/12/11 14:00		2.00	U75 1.00-1.40 m BH205_001 BH205_002 SPT 2.00-2.45 m 4, 11, 16 N=27 U75 3.00-3.40 m BH205_003 BH205_004 SPT 4.00-4.45 m 5, 10, 14 N=24			CI	Silty Sandy CLAY medium plasticity, dark brown, fine to medium grained sand, trace organics (roots) Silty Sandy CLAY medium plasticity, orange mottled grey and white, fine to coarse grained sand, with fine to medium grained sub-angular to angular gravel	M (>>PL	VS F St-VSt	Inferred ALLUVIAL	
AP NON-CORED FULL PAGE 117825003 NEW CELL FLOOR LOGS GPJ <-DrawingFile>> 05(03/2012 14:18 8.2.85		16/12/2011 12:00	5 	6.00	U75 5.00-5.40 m BH205_005 BH205_006 SPT 6.00-6.45 m 14, 18, 21 N=39 BH205_007 SPT 7.50-7.91 m 25, 27, 30/110mm N>57			GC	Sandy Clayey GRAVEL fine to coarse grained, sub-angular to angular, orange mottled brown and white, medium plasticity clay, fine to coarse grained sand SANDSTONE fine to medium grained, orange mottled white and dark orange, inferred extremely weathered, inferred very low strength END OF BOREHOLE @ 7.90 m REACHED TARGET DEPTH STANDPIPE PIEZOMETER INSTALLED	M (>PL	D	RESIDUAL SOIL	
GAP 8_05J.1 LIB.GLB Log G			- - 10—	T geot	his report of borehol echnical purposes o information only	le mu nly, w	st be re rithout do not	ead ii atten nece	n conjunction with accompanying notes and abbreviations. In to assess possible contamination. Any references to pol issarily indicate the presence or absence of soil or groundwa	It has tentia	s beer l cont	n prepared for tamination are for nination. GAP gINT FN. F	:01a RL3



# **REPORT OF BOREHOLE: BH206**

CLIENT: Wollongong City Council PROJECT: Whytes Gully LOCATION: New Cell Floor JOB NO: 117625003

POSITION: Refer to Figure 4 SURFACE RL: DATUM: AHD INCLINATION: -90° 

SHEET: 2 OF 2 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: CJW DATE: 16/12/11 CHECKED: BJE DATE: 5/3/12

JUB NU. 117625003		HU		_		JKED: BJF DATE: 5/3/12	_						
Drilling	Sampling		Field Material Description										
METHOD PENETRATION RESISTANCE WATER MATER (metres)	SAMPLE OR FIELD TEST	GRAPHIC LOG USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE		STRUCTURE AND ADDITIONAL OBSERVATIONS							
		CI	Gravelly Sandy CLAY medium plasticity, orange mottled grey and black with white, fine to coarse grained sand, fine to coarse grained sub-angular to angular gravel	м	VSt	RESIDUAL SOIL							
-	BH206_009 SPT 10.50-10.76 m 14, 47/110mm N>47	· · · · · · · · · · · · · · · · · · ·	SANDSTONE fine to coarse grained, white mottled orange grey, inferred extremely weathered and very low strength, recovered as			WEATHERED ROCK							
			In the second se										
- - - 19 - - - - - - - - -													
20   	This report of borehole mu technical purposes only, w information only and	st be read i vithout atter do not nece	n conjunction with accompanying notes and abbreviations. npt to assess possible contamination. Any references to po essarily indicate the presence or absence of soil or groundwa	It has tentia ater c	s bee al con contar	n prepared for tamination are for mination. GAP gINT FN. F0 R	11: L						

CLIENT: Wollongong City Council PROJECT: Whytes Gully LOCATION: New Cell Floor JOB NO: 117625003					ity Council			PO SUI INC HO	SITION: Refer to Figure 4 RFACE RL: DATUM: AHD CLINATION: -90° LE DEPTH: 13.30 m	SHEET: 1 OF 2 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: RMP/CJW DATE: 14/12/11 CHECKED: BJF DATE: 5/3/12				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	Field Material Des		CONSISTENCY UC	STRUCTURE AND ADDITIONAL OBSERVATIONS		
								СН	CLAY high plasticity, brown black, with some roots and rootlets (1-10mm thick)	M (>PL	) S - F	Inferred ALLUVIUM Organic odour		
			1— - - 2— -	1.00	BH207_001 SPT 1.00-1.45 m 1, 1, 3 N=4 U75 1.50-1.80 m BH207_002 BH207_003 SPT 2.00-2.45 m 3. 5.8 N=13			CI	Sandy CLAY medium plasticity, pale brown, fine to medium grained sand, with some rootlets (1-5mm thick)		St - VSt	Inferred COLLUVIUM		
5	4/12/11 14:20	U75 2.50-2.95 m BH207_004 3	U75 2.50-2.95 m BH207_004 BH207_005 SPT 3.00-3.45 m 3, 7, 8 N=15					M ( <pl< td=""><td>)</td><td></td></pl<>	)					
	L	-	- BH207_006 BH207_007 SPT 4.30-4.75 m 4, 7, 9 N=16	U754.00-4.30 m BH207_006 BH207_007 SPT 4.30-4.75 m 4, 7, 9 N=16						St				
	$\land$	- 6 - - 7	6.00	2 U75 6.00-6.30 m BH207_008 BH207_009 SPT 6.50-6.95 m 4, 13, 17 N=30			CL / CI	Sandy Gravelly CLAY low to medium plasticity, brown, fine to coarse grained sub-angular to angular gravel, fine to coarse grained sand, sandstone and ironstone gravel						
		8 <u>8.00</u> BH207_010 SPT 8.00-8.45 m 5, 10, 18 N=28 U75 8.50-8.67 m End buckled	BH207_010 SPT 8.00-8.45 m 5, 10, 18 N=28 U75 8.50-8.67 m End buckled BH207_011				becoming low plasticity	- w	VSt - H	RESIDUAL SOIL				
			9											

G		G	olde	er ates				REPORT C	)F I	<b>BO</b> Shee	<b>REHOLE: BH207</b> TT: 2 OF 2	
CLIEN PROJ LOCA JOB N	NT: JECT: ATION: NO:	Wollor Whyte New C 11762	ngong C es Gully Cell Flooi 5003	ity Council			PO: SUI INC	SITION: Refer to Figure 4 RFACE RL: DATUM: AHD LINATION: -90° LE DEPTH: 13.30 m	1	DRILL CONT LOGO CHEC	. RIG: Drill Cat "RACTOR: Terratest SED: RMP/CJW DATE: 14/12/11 CKED: BJF DATE: 5/3/12	
	Dri	illing		Sampling				Eiold Material Des	orintia			_
METHOD	WATER	DEPTH (metres)	DEPTH	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION			STRUCTURE AND ADDITIONAL OBSERVATIONS	
ADT			11.50	BH207_012 SPT 10.00-10.45 m 7, 17, 17 N=34 BH207_013 SPT 11.50-11.95 m 9, 11, 13 N=24 BH207_014 SPT 13.00-13.30 m 8, 30/150mm N>38			CL / CI	Sandy Gravelly CLAY low to medium plasticity, brown, fine to coarse grained sub-angular to angular gravel, fine to coarse grained sand, sandstone and ironstone gravel Clayey Sandy GRAVEL fine to medium grained, sub-angular to angular, orange mottled dark brown and white, fine to coarse grained sand, medium plasticity clay SANDSTONE medium to coarse grained, orange mottled blue and white, extremely weathered, very low strength	- w	WSt - H	RESIDUAL SOIL	
GAP NON-CORED FULL PAGE 117625003 NEW CELL FLOOR LOGS GFU < <drawingfile>&gt; 05/03/2012 14:18 8.2.856</drawingfile>								END OF BOREHOLE (2) 13.30 m REACHED TARGET DEPTH STANDPIPE PIEZOMETER INSTALLED				
GAP 8_05J.1 LIB.GLB L		20-	T geot	his report of borehol echnical purposes or information only	e mu nly, w and o	st be r ithout do not	ead i atten nece	n conjunction with accompanying notes and abbreviations. npt to assess possible contamination. Any references to pr issarily indicate the presence or absence of soil or groundy	It has otentia	s beer al cont	n prepared for amination are for nination. GAP gINT FN. Fi	

C F L J	CLIEN ROJE OCAT OB NO	T: W CT: W TON: N D: 1	Gol SSO /ollongo /hytes G ew Cell 1762500	der ciates ng City Council sully Floor 13			REPORT C POSITION: Refer to Figure 4 SURFACE RL: DATUM: AHD INCLINATION: -90° HOLE DEPTH: 7.90 m	DF E	FBOREHOLE: MWBH205 SHEET: 1 OF 1 DRILL RIG: Drill Cat CONTRACTOR: Terratest LOGGED: CJW DATE: 16/12/11 CHECKED: BJF DATE: 5/3/12						
doh-	IER	Ling (sa:		SAMPLE OR FIELD TEST	OVERED	APHIC	SOIL/ROCK MATERIAL DESCRIPTION	LD (L/S)	CONSTRUCTION						
7625003 NEW CELL FLOOR LOGS.GPJ < <drawingfile>&gt; 05/03/2012 14:20 8.2856 ADT ADT ADT</drawingfile>	16/12/2011 12:00 16/12/11 14:00 K		DEPTH RL 2.00 6.00 7.50 7.90	U75 1.00-1.40 m BH205_001 SPT 2.00-2.45 m 4, 11, 16 N=27 BH205_002 U75 3.00-3.40 m BH205_003 SPT 4.00-4.45 m 5, 10, 14 N=24 BH205_004 U75 5.00-5.40 m BH205_005 SPT 6.00-6.45 m 14, 18, 21 N=39 BH205_006 SPT 7.50-7.91 m 25, 27, 30/110mm N>57 BH205_007			Silty Sandy CLAY         medium plasticity, dark brown, fine to medium grained sand, trace organics (roots)         Silty Sandy CLAY         medium plasticity, orange mottled grey and white, fine to coarse grained sand, with fine to medium grained sub-angular to angular gravel         Sandy Clayey GRAVEL         fine to coarse grained, sub-angular to angular, orange mottled brown and white, medium plasticity clay, fine to coarse grained sand         SANDSTONE         fine to medium grained, orange mottled white and dark orange, inferred extremely weathered, inferred very low strength         END OF BOREHOLE @ 7.90 m         REACHED TARGET DEPTH         STANDPIPE PIEZOMETER INSTALLED		Top of Collar +0.7magl						
GAP 8_05J.1 LIB.GLB Log GAP WELL 1				This report of bor geotechnical purpos information	ehol es or only	e must nly, with and do	be read in conjunction with accompanying notes and abbroout attempt to assess possible contamination. Any reference on the presence or absence of soil o	eviation nces to r ground	s. It has been prepared for potential contamination are for dwater contamination. GAP gINT FN. F05 RL3						



05/03/2012 14:20 <<DrawingFile>> LOGS.GPJ NEW CELL FLOOR 117625003 GAP WELL Log 05J.1 LIB.GLB

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# **APPENDIX K**

**Baseline Data Assessment Report** 





**DATE** 20 June 2013

TO Wollongong City Council

CC

FROM Lange Jorstad

**EMAIL** LJorstad@Golder.com.au

PROJECT No. 117625003_267_M_Rev0

#### WHYTES GULLY NEW LANDFILL CELL – BASELINE DATA ASSESSMENT REPORT

#### 1.0 INTRODUCTION

A Report titled "*Whytes Gully Hydrogeological Investigation*" has been prepared by Golder Associates Pty Ltd (Golder) (March 2012) on behalf of Wollongong City Council (Council) following completion of a combined hydrogeological and geotechnical investigation at the Whytes Gully Resource Recovery Park (WGRRP) in July and August 2011. In the Report, groundwater monitoring of 21 existing monitoring wells (GMW01, GMW103–GMW106, GMW108S/D, GMW109S/D, GMW110–GMW111, GABH01-03, GABH06S/D and BH6) has been proposed to provide a baseline dataset of local groundwater quality.

The objective of this data review is to optimise the current monitoring program for the site following the completion of an annual quarterly monitoring cycle.

In addition to evaluating the baseline monitoring data as a whole, the following specific issues were addressed, which were raised by Council during review of the hydrogeological investigation report:

- A low reported ammonia concentration (0.69 mg/L) in a leachate sample, December 2011.
- A low reported value of electrical conductivity (EC; 0.1 µS/cm) in surface water samples from on-site ponds in a flora and fauna assessment by Biosis (Report Reference No. 12379, March, 2012). The reported value was based on values recorded on-site by Golder on 18 July 2011.
- Elevated concentrations of nutrients (ammonia, TKN, TOC) and manganese in monitoring well GMW109S.

These items are addressed in the recommendations section of this technical memorandum.

#### 2.0 HISTORICAL MONITORING EVENTS

A total of five baseline monitoring events (i.e. August 2011, December 2011, January 2012, May 2012 and August 2012) were performed at all proposed sampling locations, except the following:

 GMW101, GMW106, GMW107, GABH04 and GABH05 were only sampled during the August 2011 monitoring event.

All wells on-site were sampled in August 2011 by Golder following installation. Since then ALS Laboratory has collected groundwater samples. The programme excludes wells that have been dry since installation (GMW101 and GMW107) and others that were considered to be adequately covered by other wells for the purposes of routine monitoring (GMW106, GABH04 and GABH05);

GMW102 has been dry since December 2011, therefore, no groundwater sample was collected; and



GABH01 was unable to be sampled during the August 2012 monitoring event due to access issues.

In addition, surface water samples were collected along the Dapto Creek and and leachate samples were collected from the influent sump adjacent to the leachate ponds, in conjunction with the groundwater monitoring events since December 2011.

Historical groundwater, surface water and leachate results are presented in the attached **Tables 1 & 2**, respectively.

#### 2.1 Summary of Historical Groundwater Analytical Results

The historical groundwater sampling results (attached **Table 1**) have indicated that:

- In general, nitrate (only analysed in the August 2011 monitoring event) and nitrite concentrations were either low or below the laboratory limits of reporting (LORs) across the site.
- Ammonia, total Kjeldahl nitrogen (TKN), total organic carbon (TOC) and biochemical oxygen demand (BOD) concentrations were generally low or below the laboratory LOR across the site, with the following exceptions:
  - Elevated ammonia, TKN, and TOC concentrations were consistently reported for well GMW109S, with the reported ammonia concentrations exceeding the adopted assessment criterion; and
  - Elevated TKN and TOC concentrations were reported for GMW101 in the August 2011 monitoring round. This well was not sampled in the subsequent monitoring events as it was typically dry, therefore, the result could not be re-evaluated.
  - Elevated TKN concentrations were reported for GMW108D, GMW111, GABH02, GABH03 and BH6 during the January 2012 monitoring round, TKN concentrations were below or close to the laboratory LOR at these locations for the rest of the baseline monitoring events, and thus far represent an one-off spike in the reported TKN concentrations.
- Metals including aluminium (AI), copper (Cu), lead (Pb), and zinc (Zn) were reported at concentrations greater than the adopted assessment criteria at most locations in one or more monitoring events. In addition, the reported manganese (Mn) concentrations at location GMW109S were above the assessment criterion during all sampling events. Of note, samples for metal analysis were filtered during the August 2011 monitoring event and were unfiltered in the subsequent monitoring rounds. The adopted assessment criteria are based on dissolved (i.e. filtered) metal concentrations, and as such the unfiltered sample results may include a non-dissolved bias that is not directly applicable to the assessment criteria.
- The reported concentrations of the organic analytes were generally below the laboratory LORs across the site. However, total petroleum hydrocarbons (TPH) were reported at the following locations:
  - GMW110: C₁₅-C₂₈ fraction (430 μg/L) was reported during the August 2011 monitoring event. TPH was not reported at this location in any other baseline monitoring events.
  - GMW111: C₁₅-C₂₈ fraction (1,090 μg/L) and C₂₉ C₃₆ fraction (770 μg/L) were reported during the August 2011 monitoring event. TPH was not reported at this location in any other baseline monitoring events.
  - GMW105: C₁₅-C₂₈ fraction (170 µg/L) and C₂₉ C₃₆ fraction (80 µg/L) were reported during the January 2012 monitoring event. TPH was not reported at this location in any other baseline monitoring events.
  - GMW109S: C₁₅-C₂₈ fraction (360 and 210 µg/L) was reported during the January and August 2012 monitoring events, respectively. TPH was not reported at this location in any other baseline monitoring events.


GABH01: C₁₀-C₁₄ fraction (60 µg/L), C₁₅-C₂₈ fraction (560 µg/L) and C₂₉-C₃₆ fraction (260 µg/L) were reported during the January 2012 monitoring event. TPH was not reported at this location in any other baseline monitoring events.

Low reliability interim indicative working levels (IIWLs) provided in the ANZECC (2000) guidelines refer to a Trigger Value of 7  $\mu$ g/L. This is based on US EPA methodology, which is generally not used in deriving guideline values for Australian conditions. More importantly, the values are based on the toxicity to crustaceans from North-West Shelf crude oils. As such, the IIWL for TPH is not an appropriate guideline for assessing the effects of refined petroleum products in an urban environment freshwater ecosystem.

More recently, health screening levels (HSLs) for petroleum hydrocarbon compounds were introduced in the recently amended National Environment Protection (Assessment of Site Contamination) Measure (NEPM, 1999). The HSLs provide soil, groundwater and soil vapour guidelines to be used for the assessment of vapour intrusion potential from volatile components of petroleum hydrocarbon compounds, including benzene, toluene, ethylbenzene and xylenes (BTEX) and for two TPH fractions ( $C_6-C_{10}$ , and  $>C_{10}-C_{16}$ ). Only one TPH detection was in a carbon range approximating the HSL fractions (GABH01:  $C_{10}-C_{14}$  fraction (60 µg/L)), for which the most conservative appropriate criterion is "non-limiting" (i.e. the derived assessment criterion was higher than the solubility limit of the carbon fraction). Hence, the TPH detections are not considered to represent a vapour intrusion risk.

#### 2.2 Summary of Historical Surface Water and Leachate Analytical Results

The historical sampling results (attached Table 2) have indicated that:

- Significantly higher ammonia, TKN, TOC and BOD concentrations were reported in leachate samples than those reported in the surface water samples.
- Nitrite concentrations were either low (surface water sampling locations 1 and 2) or below the laboratory LOR (remaining surface water sampling locations and leachate).
- Of all the surface water samples, higher ammonia, TKN, TOC, BOD and metal concentrations were generally reported at sampling locations 1 and 2 than the remaining sampling locations.
- Metals including arsenic (As), cadmium (Cd), chromium (Cr), Pb, and mercury (Hg) were either low or below the LORs at all surface water sampling locations. The reported AI and Cu concentrations have been consistently greater than the adopted assessment criteria at sampling locations 1 and 2. Of note, samples for metal analysis were unfiltered in all sampling events.
- Metal concentrations reported in leachate samples were generally higher than those reported in the surface water samples and the reported Al, Cd, Cu, Pb, Ni and Zn concentrations have been consistently greater than the adopted assessment criteria.
- The reported concentrations of the organic analytes were generally below the laboratory LORs in all surface water samples.
- The majority of organic analytes were below the laboratory LORs, and detect concentrations above the LOR were below the assessment criteria where available in the leachate samples. The organic analytes detected above the LORs in leachate included 1,2,4 trimethylbenzene (ranging from 7-10 µg/L), p-isopropyltoluene (9-13 µg/L), 2-butanone (MEK) (1530-4250 µg/L), 4-methyl-2-pentanone (MIBK)(<50-80 µg/L), total phonels (2070-3750 µg/L), naphthalene (<9.4-11.1 µg/L), benzene (2-4 µg/L), toluene (16-53 µg/L), ethylbenzene (6-12 µg/L), m-&p-xylene (13-26 µg/L), o-xylene (9-17 µg/L), TPH C₆-C₉ fraction (220-540 µg/L) and C₁₀-C₃₆ fractions (43200-80700 µg/L).

In addition, major cations and anions have been tested for the collected groundwater, surface water and leachate samples. The results will be used to characterise the general water chemistry across the site and to assess whether leachate impact to groundwater / surface water is occurring.



#### 3.0 OBSERVATIONS AND RECOMMENDATIONS FROM BASELINE MONITORING

### 3.1 RESPONSE TO COUNCIL COMMENTS

Three items of concern were noted by Council during the review of the hydrogeological investigation report. Golder addresses these below and recommends the following:

- A low reported ammonia concentration (0.69 mg/L) in a leachate sample in December 2011. It was apparent this value was lower than expected; however, review of the sampling documentation and laboratory report did not identify an obvious source of error. This was the first sample collected under the current programme, and was the only result available when the hydrogeological assessment was prepared. Since the December 2011 monitoring round, three samples were collected with ammonia concentrations ranging from 1440 to 2160 mg/L. It is recommended this range is considered as a representative range of ammonia concentrations in leachate.
- A low value of EC (0.1 µS/cm) was reported for the surface water pond samples in the Biosis Report (March, 2012). The recorded EC values for the six surface water monitoring locations supplied to Biosis included two ranges: 1,290 to 1,560 µS/cm in the western ponds; and 620 to 13,990 µS/cm in the leachate ponds at the base of the Eastern Gully Landfill. It is recommended these ranges are taken as the representative conductivities across the site's surface water ponds.
- Elevated concentrations of nutrients (ammonia, TKN, TOC) and manganese in monitoring well GMW109S. This location is on the south-eastern (downgradient) site boundary, and shows anomalously high concentrations in comparison to all other groundwater sampling locations. The source of impact is uncertain, as the upgradient monitoring wells and adjacent stormwater ponds do not reflect these concentrations. As the elevated concentrations have been consistent at this location throughout the baseline monitoring program, it is recommended that further targeted assessment of the potential source and associated risks is undertaken.



#### 3.2 PROPOSED REVISIONS TO THE BASELINE MONITORING PROGRAM

Based on a review of the available monitoring results, revisions to the monitoring analytical suite are proposed, as presented in Table 1.

Analyte	Quarterly	Annual	Comment
Temperature	Х	Х	Field measurement
рН	Х	Х	Field measurement
Electrical Conductivity	Х	Х	Field measurement
Dissolved Oxygen	Х	Х	Field measurement
Oxidation Reduction Potential	Х	Х	Field measurement
Total Suspended Solids	Х	Х	Surface water only
Calcium		Х	
Magnesium		Х	
Sodium		Х	
Potassium		Х	
Chloride	Х	Х	
Sulphate		Х	
Alkalinity	X (total)	X (spec.)	
Aluminium		Х	
Arsenic		Х	
Cadmium		Х	
Chromium (total)		Х	
Copper		Х	
Iron	Х	Х	
Manganese	Х	Х	
Mercury		Х	
Nickel		Х	
Lead		Х	
Zinc		Х	
Ammonia	Х	Х	
Total Kjeldahl Nitrogen	Х	Х	
Total Petroleum Hydrocarbons		Х	
Volatile Organic Compounds		Х	BTEX and naphthalene only
Total Organic Carbon	Х	Х	

#### Table 1: Proposed Revisions to Monitoring Analytical Suite



From review of the baseline data, the analytes (or groups of analytes) in Table 2 are proposed to be excluded from future monitoring as they were either not detected in leachate, or alternative analytes provide equivalent information:

Analyte	Comment
TDS	EC provides equivalent information
Nitrate and nitrite	Below LOR or only present at low concentrations
Fluoride	No value to monitoring objectives
VOCs	Limit to BTEX and naphthalene
PAHs	Not detected in leachate, surface water or groundwater (with the exception of naphthalene, addressed in Table 1)
Phenolics	Proposed only as a contingency if significant leachate impact is suspected.
BOD	TOC provides equivalent information

Table 2: Analyte	es proposed fo	or exclusion from	further monitoring
1			

The results of monitoring should be reviewed on an annual basis to assess whether further revisions to the monitoring program are warranted, including monitoring locations, frequency and analytical suite. Where potential indications of leachate impact are identified in surface water or groundwater, further targeted assessment may be warranted with regard to the source of the leachate release, and potential risks to human health and the environment.

#### 4.0 CONCLUSIONS

A review of the baseline surface water, groundwater and leachate monitoring program for the WGRRP has identified an opportunity to optimise the ongoing compliance monitoring program to focus on key water quality and leachate indicator parameters.

The baseline data for monitoring well GMW109S suggest a potential source of groundwater quality impact is affecting this location. It is proposed that a targeted assessment program is developed to evaluate potential sources of impact, and to consider the associated risks to human health and potential receiving environments.



#### 5.0 CLOSURE

We trust that this technical memorandum is adequate for your requirements. Please contact the undersigned if you wish to discuss the review provided or if we can be of further assistance.

#### **GOLDER ASSOCIATES PTY LTD**

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https://aupws.golder.com/117625003wollongongcitycouncilnewcellwhytesgully/project doc/201 b hydrogeology (groundwater)/baseline data review 2013/117625003_267_m_rev0_baseline data review.docx



# Table 1: Historical Groundwater Quality Results Summary Table Whytes Gully New Landfill Cell Project No. 117625003

			Field Par	ameters						Major Ion	s													Nutrients							Metals and	Metalloids							
			Static	Static	Static Field-pH	Field- Fi	ield-	Field-EC Fie	eld	Total	Hydroxide 0	Carbonate	Bicarbonate	Total S	ulfate as Ch	loride Ca	cium Ma	gnesium Soc	lium Pota	assium F	luoride Tota	al Total	Ionic	Ammonia as	Nitrite as N	Nitrate as N	Nitrite + Nitrate	Total Kjeldahl Nitrogen a	s Total E	Biochemical	Aluminium	Arsenic Cad	lmium Cl	hromium 0	Copper Lead	Manganese	Nickel Zi	nc Iron	Mercury
			Water	Water	Water	temp re	edox	Di	issolved	Hardness	Alkalinity as A	Alkalinity as	Alkalinity as	Alkalinity S	04 -						Anic	ons Cations	Balance	N			as N	N	Organic	Dxygen						-			
		Analytes	Level	Level	Level			02	kygen	as CaCO3	CaCO3 0	CaCO3	CaCO3	as CaCO3 T	urbidim														Carbon	Demand									
														e	tric																								
		l la la	DTOC			00		Class						(h	(h				/								h	h	me h	h						h			1
			MBIOC	MBGL	MAHD PH UNITS	L	mv	µs/cm	ppm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L i	ng/L	mg/L n	ng/L r	mg/L	mg/L m	eq/L meq/L	%	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L n	ng/L	mg/L	mg/L mg/L	mg/L	mg/L	mg/L mg/	L mg/L
Wall ID	comple Data									1	1	1	1	1	1	1	1	1	1	1	0.1 0	0.01	0.01	0.01	0.01	0.01	0.01	0.1	1	2	0.01	0.001 0.	0001	0.001	0.001 0.001	1.0	0.001	0.005 0.03	0.0001
Well ID 3		ANZECC	-	-		-	-	-	-	-	-	-	-	-		-	-	-	-	-	-		-	0.9	-	-		-	-	-	0.055	- 0.	.0002	-	0.0014 0.0034	1.9	0.011	0.008 -	0.0006
GIVIW101	17/08/2011		10.09	9.57	80.582 7.79	1/	19	2850	2.37	869	-	-	-	-	154	484	183	100 .	247	12	-		-	0.07	-	-	-	12.3 +	23 *		0.01	<0.001 <0	10001	0.002	0.023 <0.001	0.096	0.03	0.018 <0.0	5 <0.0001
GIVIW102	1//08/2011		9.28	8.75	79.489 8.22	16.8	42	301	0.97	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-			-	-	-		-	-		-			
· · · · · · · ·	13/12/2011		-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-		-	-		
· · · · · · · · · · · · · · · · · · ·	24/01/2012		-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-		-	-	-	-	-		-	-		-
	2/05/2012		-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-		-	-	-	-	-	-		-	-		-
GMW103	18/08/2011		7.65	7.12	73.655 0.59 *	18.7	90	1554	2.73	510	<1	<1	290	290	86	326	130	45	133	1	0.6 1	.6.8 16	2.36	0.02	<0.01	1.03	1.03	0.2	2		0.01	<0.001 <0	0.0001	0.001	0.002 <0.001	0.061	0.002	<b>0.01</b> <0.0	5 <0.0001
	13/12/2011		-	8.48	- 7.3	19	252	1650	8.49	-	<1	<1	339	339	104	306	143	51	160	2	0.4		-	< 0.01	<0.01	-	-	1	<1	<2	5.64	0.001 <0	0.0001	0.006	0.04 0.009	0.291	0.006	0.052 7.95	< 0.0001
· · · · · · · · · · · · · · · · · · ·	24/01/2012		-	7.6	- 1.2	19.4	/4.8	1610	6.21	-	<1	<1	366	366	114	292	131	50	158	1	0.5		-	<0.01	<0.01	-	-	<0.1	<1	<2	0.29	0.002 <0	0.0001	<0.001	0.004 <0.001	0.018	<0.001	0.012 0.55	< 0.0001
	2/05/2012		-	7.252	- 7	19.6	143	1540	4.82	-	<1	<1	411	411	111	328	159	57	169	1	0.6		-	<0.01	<0.01			0.4	<1	<2	8.36	0.001 <0	0.0001	0.009	0.021 0.013	0.35	0.006	0.056 10.8	< 0.0001
	17/08/2012	-	-	7.68	- 6.9	18.6	80	1840	1.3	-	<1	<1	415	415	138	465	179	63	202	1	0.4		-	0.03		-	-	<0.1	<1	-	-	<0.001 <0	0.0001	0.001	0.009 0.001	0.054	0.002	0.012 1.14	+ <0.0001
GMW104	17/08/2011		6.335	5.825	27.609 7.33	17.1	87	787	5.03	235	<1	<1	349	349	50	58	48	28	118	1	0.9 9	9.86	1.04	0.02	<0.01	0.02	0.02	0.2	1	<2	0.02	<0.001 <0	0.0001	< 0.001	<0.001 <0.001	0.389	0.001	0.008 <0.0	5 <0.0001
	13/12/2011		-	6.15	- 6.9	18.5	184	474	6.26	-	<1	<1	154	154	32	33	28	16	56	<1	0.7		-	< 0.01	<0.01			<0.1	<1	<2	0.43	<0.001 <0	0.0001	< 0.001	0.002 <0.001	0.105	<0.001	0.008 0.49	/ <0.0001
	24/01/2012		-	6.51	- 7.1	18	69.2	551	4.27	-	<1	<1	211	211	34	47	38	26	55	3	0.8		-	0.01	< 0.01	-	-	0.2	<1	<2	24	0.002 0.	.0002	0.013	0.039 0.01	0.657	0.009	0.07 36.5	0.0001 د
	2/05/2012		-	6.432	- 6.7	18.3	27.4	720	3.9	-	<1	<1	294	294	36	50	51	29	112	1	0.8		-	0.04	< 0.01	-	-	0.5	2	<2	15	<0.001 <0	0.0001	0.006	0.016 0.009	0.468	0.004	0.042 12.2	2 <0.0001
	17/08/2012		-	6.91	- 7.1	16.8	57.5	640	3.3	-	<1	<1	292	292	41	50	40	24	112	<1	0.7		-	0.02	-	-	-	<0.1	<1	-	-	<0.001 <0	0.0001	< 0.001	<b>0.009</b> <0.001	0.07	<0.001 <	<0.005 0.28	s <0.0001 ک
GMW105	17/08/2011		10.655	10.095	77.043 5.78	17	157	231	3.1	39	<1	<1	58	58	11	30	9	4	33	<1	0.4 2	2.23 2.21	-	0.01	<0.01	0.48	0.48	<0.1	<1	<2	0.06	<0.001 <0	0.0001	< 0.001	<0.001 <0.001	0.041	< 0.001	<b>0.01</b> <0.0	5 <0.0001
	13/12/2011		-	10	- 5.6	18.3	227	216	2.02	-	<1	<1	33	33	10	19	14	6	26	3	0.2		-	0.01	< 0.01	-	-	0.7	<1	<2	25.2	<0.001 <0	0.0001	0.015	0.05 0.013	0.33	0.006	0.059 22	<0.0001
	24/01/2012		-	10.8	- 5.8	18.5	135	188	2.64	-	<1	<1	42	42	12	28	28	14	31	6	0.3		-	0.03	< 0.01	-	-	0.2	<1	<2	62.1	0.003 0.	.0001	0.039	0.088 0.034	0.923	0.012	<b>0.13</b> 66	<0.0001
	2/05/2012		-	9.562	- 5.5	19.1	144	191	1.39	-	<1	<1	48	48	12	28	14	7	33	2	0.2		-	< 0.01	< 0.01	-	-	0.3	<1	<2	19.7	0.001 <0	0.0001	0.011	0.027 0.012	0.321	0.004	0.046 17.1	40.0001
	17/08/2012		-	10.79	- 5.2	17.9	130	197	1.3	-	<1	<1	52	52	13	25	9	4	37	2	0.2		-	0.03			-	0.1	<1	-	-	<0.001 0.	.0001	0.012	0.04 0.005	0.114	0.004	0.034 4.88	3 <0.0001
GMW106	17/08/2011		9.33	8.68	69.262 5.13	16.8	95	-	4.26	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	~	-	-	-	-	-	-	-		-	-		-
GMW107	17/08/2011		-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-		-	-		-
GMW108S	22/08/2011		2.48	1.9	16.993 7.10	17.9	53	4020	1.23	988	<1	<1	520	520	271	1010	168	138	531	<1	0.7 4	4.5 42.8	1.94	<0.01	<0.01	<0.01	<0.01	<0.1	2	<2	<0.01	<0.001 <0	0.0001	<0.001	<0.001 <0.001	0.726	0.002	0.012 0.0	/ <0.0001
	13/12/2011			2.66	- 7	18.7	23.8	1480	6.07	-	<1	<1	364	364	206	871	104	96	533	2	0.6			0.02	<0.01	-	-	0.5	<1	<2	12.2	0.001 <0	0.0001	0.008	0.015 0.008	1.34	0.006	0.037 21	<0.0001
	24/01/2012			2.33	- 6.6	18.1	51.2	3540	3.51	-	<1	<1	482	482	244	871	66	78	585	1	0.7			0.03	<0.01	-	-	0.2	<1	<2	3.07	0.005 <0	0.0001	0.003	0.008 0.002	0.675	0.006	0.018 7.28	3 <0.0001
	2/05/2012		1	2.267	- 6.5	18.2	44.1	3340	3.07	-	<1	<1	296	296	249	990	152	135	524	2	0.4			<0.01	<0.01			<0.1	1	<2	13.4	0.002 <0	0.0001	0.007	0.013 0.006	0.344	0.003	0.032 18.3	3 <0.0001
	17/08/2012		-	2.42	- 6.6	16.6	121	3160	1.6	-	<1	<1	522	522	255	916	144	120	616	<1	0.6		-	0.03	-	-	-	<0.1	2	-	-	<0.001 <0	0.0001	< 0.001	0.002 <0.001	0.275	0.002	0.005 0.93	i <0.0001
GMW108D	22/08/2011		1.92	1.335	17.642 6.71	17.0	4131	3120	1.20	669	<1	<1	459	459	214	717	126	86	436	<1	0.8 3	3.8 32.3	2.31	< 0.01	< 0.01	< 0.01	< 0.01	<0.1	1	<2	0.02	<0.001 <0	0.0001	< 0.001	<0.001 <0.001	0.026	<0.001	0.008 <0.0	5 <0.0001
	13/12/2011		-	2.22	- 6.5	17.8	305	3080	6.96	-	<1	<1	422	422	210	748	145	100	478	<1	0.7		-	0.03	0.02	-	-	0.3	<1	<2	0.36	0.002 <0	0.0001	< 0.001	0.004 <0.001	0.02	0.002	0.009 0.40	0.0001> ذ
	24/01/2012		-	1.8	- 6.7	19.1	84.3	2950	3.29	-	<1	<1	462	462	224	710	118	90	473	1	0.9		-	0.02	< 0.01	-	-	9.8	<1	<2	0.82	0.003 0.	.0001	0.001	0.013 0.002	0.022	0.003	0.025 0.82	2 <0.0001
	2/05/2012		-	1.678	- 6.7	18.4	105	2660	2.58	-	<1	<1	472	472	201	735	123	89	439	<1	0.7		-	< 0.01	< 0.01	-	-	<0.1	<1	<2	0.32	<0.001 <0	0.0001	< 0.001	0.001 <0.001	0.005	<0.001 <	< 0.005 0.38	3 <0.0001
	17/08/2012		-	1.9	- 6.7	15.8	123	2580	1.6	-	<1	<1	486	486	222	731	126	90	512	<1	0.7		-	0.03	-	-	-	<0.1	<1	-	-	<0.001 <0	0.0001	< 0.001	<0.001 <0.001	0.002	<0.001 <	<0.005 <0.0	5 <0.0001
GMW109S	18/08/2011		3.31	2.775	14.532 6.40	18.1	-23	1432	5.3	474	<1	<1	407	407	83	297	119	43	181	6	0.2 1	8.2 17.5	2.05	3.22	-	-	-	2.4	16	-	0.01	0.002 <0	0.0001	< 0.001	<0.001 <0.001	4.17	0.01	0.02 10.1	1 <0.0001
	13/12/2011		-	2.9	- 6.3	18.8	-15	1570	1.67	-	<1	<1	359	359	89	275	108	39	182	6	0.2		-	2.87	< 0.01	-	-	3.4	<1	<2	0.32	0.003 <0	0.0001	< 0.001	0.002 <0.001	3.93	0.006	0.008 18.	i <0.0001 خ
	24/01/2012		-	3.19	- 7	19.5	-107	1860	2.12	-	<1	<1	817	817	34	175	201	49	161	13	0.4		-	7.06	<0.01	-	-	10.3	<1	12	5.04	0.005 <0	0.0001	0.008	0.016 0.009	3.6	0.007	0.058 26.	0.0001> د
	2/05/2012		-	3.172	- 6.8	19.2	-108	1520	2.05	-	<1	<1	813	813	51	162	205	53	153	15	0.4		-	6.68	< 0.01	-	-	7.6	29	<2	30.1	0.006 0.	.0005	0.042	0.112 0.053	4.52	0.055	0.246 62.0	i <0.0001 د
	17/08/2012		-	3.33	- 6.9	16.5	-130	1600	1	-	<1	<1	814	814	12	174	215	51	179	13	0.3		-	7.38	-	-	-	7.4	45	-	-	0.005 0.	.0001	0.003	0.006 0.011	4.3	0.009	0.062 23.2	2 <0.0001
GMW109D	22/08/2011		2.93	2.36	14.93 -	-	-	-	-	343	<1	<1	232	232	27	361	73	39	173	1	0.4 1	.5.4 14.4	3.28	0.09	<0.01	< 0.01	<0.01	0.1	<1	<2	0.01	<0.001 <0	0.0001	< 0.001	<0.001 <0.001	0.656	< 0.001	<b>0.01</b> <0.0	5 <0.0001
	13/12/2011		-	1.71	- 6.7	18.7	270	3040	3.16	-	<1	<1	225	225	26	377	74	40	181	1	0.4		-	0.01	<0.01	-	-	0.2	<1	<2	0.12	<0.001 <0	0.0001	< 0.001	0.005 <0.001	0.638	0.003	0.013 0.18	\$ <0.0001
	24/01/2012		-	2.83	- 7.1	18.8	55.5	1380	4.22	-	<1	<1	252	252	27	380	70	40	180	1	0.4		-	0.02	0.02		-	0.2	<1	<2	0.07	0.001 <0	0.0001	< 0.001	0.005 <0.001	0.605	0.001	0.016 0.18	\$ <0.0001
	2/05/2012		-	2.784	- 7.1	18.6	113	1300	2.19	-	<1	<1	246	246	26	401	75	42	179	1	0.7		-	0.07	<0.01	-	-	<0.1	<1	<2	0.05	<0.001 <0	0.0001	< 0.001	0.001 <0.001	0.724	<0.001 <	<0.005 <0.0	5 <0.0001
	17/08/2012		-	3.03	- 7.4	16.5	-16	1300	4.3	-	<1	<1	243	243	28	404	72	40	204	1	0.4		-	0.03	-	-	-	<0.1	<1		-	<0.001 <0	0.0001	< 0.001	<0.001 <0.001	0.01	<0.001 <	<0.005 <0.0	5 <0.0001
GMW110	25/07/2011		3.93	3.44	16.1/1 6./3	18.1	134.6	3562	3.08	1040	<1	<1	560	560	284	911	1/0	150	534	2	0.6 4	2.8 44.1	1.49	0.03	<0.01	0.01	0.01	1.9	2	5	<0.01	<0.001 <0	00001	<0.001	<0.001 <0.001	<0.001	0.012	0.159 <0.0	5 <0.0001
	24/01/2012		-	3.75	- 0.0	18.3	199	3730	2.91	-	<1	<1	505	505	282	961	1097	151 4	491	3	0.4			0.01	<0.01			0.4	<1	<2	2 5 6	0.002 0.	0002	0.008	0.03 0.009	0.419	0.008	0.053 23.5	1 <0.0001
· · · · · · · · · · · · · · · · · · ·	2/05/2012			3.04	- 6.6	18.6	117	3710	2.07	-	<1	<1	564	564	250	997	196	155	186	2	0.4			0.02	<0.01			0.3	<1	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	11.9	0.003 <0	0001	0.002	0.000 0.002	0.124	0.002	0.010 3.5	1 <0.0001
· · · · · ·	17/08/2012			3.20	- 6.8	16.3	106	3170	2.51		<1	<1	583	583	304	917	176	130	520	2	0.5	_		0.10	<0.01		-	<0.5	2	~2	11.5	<0.001 <0	0001	<0.000	0.003 <0.001	0.068	0.003	0.006 2.4	1 <0.0001
GMW111	25/07/2011		6.19	5.63	16.403 7.07	18.4	123.9	3016	3.72	875	<1	<1	593	593	218	828	141	127	564	3	0.6 3	9.7 42.1	2.86	0.02	<0.01	0.02	0.02	0.3	<1	5	<0.01	<0.001 <0	0.0001	<0.001	<0.001 0.003	<0.001	0.01	0.752 <0.0	15 < 0.0001
	13/12/2011		-	6.06	- 6.8	19.1	93.3	3680	2.98	-	<1	<1	577	577	248	825	127	117	547	3	0.6		-	0.04	< 0.01	-	-	<0.1	<1	<2	8.05	0.002 0.	.0002	0.003	0.022 0.004	0.539	0.007	0.043 11.0	ó <0.0001
	24/01/2012		-	6.09	- 6.9	18.8	79.5	3130	2.83	-	<1	<1	542	542	215	728	114	106	523	3	0.5		-	< 0.01	< 0.01	-	-	27	<1	<2	7.82	0.005 <0	0.0001	0.004	0.015 0.004	0.752	0.004	0.033 14.4	4 < 0.0001
	2/05/2012		-	5.9	- 6.8	18.7	14	2480	2.78	-	<1	<1	536	536	175	734	126	103	480	4	0.6		-	0.09	< 0.01	-	-	0.5	2	<2	22.5	0.006 0.	.0002	0.008	0.04 0.012	1.03	0.012	0.105 35.8	3 <0.0001
	17/08/2012		-	6.06	- 6.9	18.6	114	2520	1.3	-	<1	<1	507	507	173	653	91	77	496	1	0.5		-	< 0.01	-	-	-	<0.1	<1	-	-	0.002 <0	0.0001	< 0.001	0.003 <0.001	0.391	0.001	0.007 4.74	4 < 0.0001
GABH01	18/08/2011		2.905	2.33	28.011 6.69	17.4	28	2660	5.92	830	<1	<1	604	604	208	596	161	104	364	2	0.5 3	3.2 32.5	1.12	0.04	< 0.01	0.02	0.02	0.1	3	<2	< 0.01	<0.001 <0	0.0001	< 0.005	<0.001 <0.001	0.437	0.002	0.016 0.93	/ <0.0001
	13/12/2011		-	2.67	- 6.7	18.7	275	2680	5.93	-	<1	<1	570	570	208	587	152	96	370	2	0.4		-	0.06	< 0.01	-	-	0.8	<1	<2	0.65	<0.001 <0	0.0001	<0.001	0.004 <0.001	0.39	0.004	0.006 1.9	< 0.0001
	24/01/2012			2.81	- 6.9	19.5	-14.8	2410	2.63	-	<1	<1	592	592	196	481	154	89	363	5	0.6			0.04	<0.01			1	<1	<2	17.8	0.004 <b>0</b> .	.0003	0.034	0.092 0.016	1.64	0.026	<b>0.122</b> 60.5	0.0001> د
	2/05/2012	· · · · · ·		2.522	- 6.6	19.2	31	2430	3.41	-	<1	<1	628	628	207	550	174	108	348	5	0.5			0.13	<0.01		-	0.5	1	<2	15.5	0.004 0.	.0002	0.02	0.073 0.012	1.06	0.016	<b>0.091</b> 42.0	s <0.0001
CARLING	1//08/2012		-	-		- 17.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-		-	-		-	-		-
GABH02	19/08/2011		4.725	4.195	10.708 0.68	17.2	131	4940	1.95	1260	<1	<1	834	834	15/	1210	242	190	590	5	0.6 5	51.2	0.36	<0.01	<0.01	0.05	0.05	0.2	5	<2	<0.01	<0.001 <0	0001	<0.005	0.001 <0.001	0.43/	0.004	0.00 0.00	· <0.0001
	24/01/2012			4.43	- 0.4	17.3	200	4670	2.45	-	<1	<1	045	045	18/	1100	284	100	646	3	0.0		+	0.01	<0.01		1	U.4 E D	<1	~2	0.18	0.001 0.	0001	<0.001	0.002 <0.001	0.1/0	<0.003	0.006 0.1	7 <0.0001
<b>├</b>	2/05/2012		+	3.67	- 6.0	17.2	12.4	4000	3 32		<1	<1	961	961	174	1290	297	202	655	4	0.0		+	0.05	<0.01	+	<u> </u>	2.2	5	<2	6.26	<0.003 <0	0001	0.001	0.002 0.001	0.134	0.001	0.018 7.24	<0.0001 6 <0.0001
<b>├</b>	17/08/2012	l	1 -	4 /10	- 66	16.1	136	4380	0.8		<1	<1	1000	1000	183	1320	281	180	704	3	0.5		+ -	0.05	-0.01	+		<0.1	2	~4	0.20	<0.001 <0	0001	<0.004	<0.001 <0.001	0.072	0.004	(0.005 0.14	6 <0.0001
GABH03	19/08/2012		0.19	-0 375	19.033 6.82	17.0	110	5020	1.42	1560	<1	<1	607	607	214	1300	325	183	512	2	0.5	32 524	032	0.02	<0.01	0.01	0.01	<0.1	2	<2	<0.01	<0.001 <0	0001	<0.001	<0.001 <0.001	0.327	<0.002	0.011 -0.0	15 <0.0001
GADIIOS	13/12/2011		-	0.05	- 65	17.8	256	4830	4 32		<1	<1	569	569	312	1390	342	194	525	2	0.0 5			0.04	<0.01	-	-	0.6	<1	<2	0.58	0.002 <0	0001	<0.003	0.006 0.001	0.327	0.002	0.013 0.93	3 <0.0001
	24/01/2012		-	0.05	- 67	18.6	42.1	4920	3.5	-	<1	<1	625	625	220	1290	324	203	525	2	0.5			0.05	<0.01	-		26.5	<1	6	0.19	0.005 0	0002	<0.001	0.003 <0.001	0.318	<0.001	0.011 0.5	6 <0.0001
	2/05/2012		-	0	- 6.5	17.6	83.7	4210	4	-	<1	<1	680	680	203	1440	340	204	510	2	0.6		-	0.03	< 0.01	-	-	<0.1	1	<2	0.29	<0.001 <0	0.0001	<0.001	0.001 <0.001	0.308	0.001	<0.005 0.5	2 <0.0001
	17/08/2012		-	0.17	- 6.4	13.2	162	4090	1.3	-	<1	<1	697	697	235	1430	323	192	588	2	0.5		-	0.03	-	-	-	<0.1	4		-	<0.001 <0	0.0001	< 0.001	0.072 0.005	0.324	0.002	0.008 0.1	2 <0.0001
GABH04	19/08/2011		0.94	0.44	17.794 6.48	17.3	138	4990	1.14	1500	<1	<1	458	458	287	1320	293	188	520	1	0.6 5	2.4 52.7	0.36	0.01	-	-	-	0.2	2	-	<0.01	<0.001 <0	0.0001	< 0.001	<0.001 <0.001	0.18	< 0.001	0.018 <0.0	5 <0.0001
GABH05	22/08/2011		5.72	5.25	15.079 6.68	17.9	85	4410	1.54	1260	<1	<1	574	574	242	1080	245	158	495	<1	0.6	47 46.8	0.22	0.02	< 0.01	0.05	0.05	0.1	2	<2	< 0.01	<0.001 <0	0.0001	0.002	<0.001 <0.001	0.224	0.001	0.012 0.48	3 <0.0001
GABH06S	17/08/2011		1.89	1.3	- 6.52	17.8	99	2870	2.62	411	<1	<1	376	376	220	605	64	61	475	<1	1 2	9.2 28.9	0.51	< 0.01	< 0.01	0.03	0.03	0.3	<1	<2	< 0.01	<0.001 <0	0.0001	< 0.001	<0.001 <0.001	0.016	< 0.001	0.009 <0.0	5 <0.0001
	13/12/2011		-	1.8	- 6.9	18	246	2880	6	-	<1	<1	376	376	231	711	74	68	483	<1	0.9		-	< 0.01	<0.01	-	-	0.2	<1	<2	1.22	<0.001 <0	0.0001	< 0.001	0.003 <0.001	0.089	0.002	0.008 1.44	4 <0.0001
	24/01/2012		-	1.86	- 7	18.5	91.5	2980	2.47	-	<1	20	406	426	241	690	78	76	509	<1	1		-	0.02	<0.01	-	-	0.4	<1	4	0.63	0.004 <0	0.0001	0.001	0.006 0.001	0.088	0.001	0.017 1.34	4 <0.0001
	2/05/2012		-	1.638	- 6.6	18.8	99.6	2690	3.45	-	<1	<1	410	410	220	709	78	78	493	2	1		-	0.04	<0.01	-	-	<0.1	<1	<2	12.5	0.002 <0	0.0001	0.005	0.015 0.007	0.414	0.004	0.041 15	<0.0001
	17/08/2012		-	1.87	- 7.1	17.4	98	2720	3	-	<1	<1	436	436	246	738	88	79	594	<1	1		-	0.04	-	-	-	<0.1	<1	-	-	<0.001 <0	0.0001	< 0.001	0.006 <0.001	0.06	0.002	0.011 0.53	2 <0.0001
GABH06D	18/08/2011		1.37	0.8	21.249 6.83	18.7	139	3030	1.42	575	<1	<1	319	319	220	745	115	70	453	<1	0.5	32 31.2	1.22	0.01	< 0.01	< 0.01	<0.01	<0.1	2	<2	< 0.01	<0.001 <0	0.0001	< 0.001	<0.001 <0.001	0.012	<0.001	<b>0.013</b> <0.0	5 <0.0001
	13/12/2011		-	1.24	- 6.6	17.9	296	2920	3.7	-	<1	<1	296	296	215	790	114	69	469	<1	0.5		-	0.01	<0.01	-	-	0.8	<1	<2	0.12	<0.001 <0	0.0001	<0.001	0.015 <0.001	0.009	0.002	0.012 0.1	ذ <0.0001
	24/01/2012			1.29	- 6.7	19.1	91.5	2950	2.5	-	<1	<1	343	343	231	767	108	71	472	1	0.5			0.02	<0.01			0.4	<1	3	0.5	0.004 0.	.0003	0.002	<b>0.013</b> 0.002	0.022	0.002	0.045 0.9	< 0.0001
	2/05/2012			1.06	- 6.7	18.8	129	2750	3.4	-	<1	<1	345	345	212	781	117	73	461	<1	0.5			0.02	<0.01			<0.1	<1	<2	0.06	<0.001 <0	0.0001	<0.001	<0.001 <0.001	0.006	<0.001 <	<0.005 0.00	0.0001> د
	17/08/2012		-	1.32	- 6.7	17	118	2660	2.1	-	<1	<1	346	346	238	782	112	69	535	<1	0.5		-	0.01	-	-	-	<0.1	<1	-	-	<0.001 <0	0.0001	< 0.001	0.003 <0.001	0.007	<0.001 <	<0.005 <0.0	5 <0.0001
BH6	18/08/2011		1.34	1.4	14.902 6.65	18.8	-6	4570	2.28	808	<1	<1	656	656	293	1060	124	121	/47	<1	1 4	9.1 48.6	0.5	0.04	<0.01	0.08	0.08	0.4	<1	<2	<0.01	<0.001 0.	.0002	< 0.005	0.001 0.003	0.405	0.002	<b>U.014</b> <0.0	5 <0.0001
	13/12/2011		-	1.09	- 6.9	21.2	61.1	4830	3.49	-	<1	<1	615	615	266	1130	113	116	/60	1	0.8		-	0.08	<0.01			0.8	<1	<2	0.41	0.002 <0	0.0001	<0.001	0.007 0.006	1.02	0.003	0.018 0.7	<0.0001
<b>├</b>	24/01/2012		1	1.18	- /	21./	-210	4940	1.78	-	<1	<1	/43	/43	2/4	1150	110	124	770	<1	1		+	0.17	0.03			15.7	<1	8	0.6	0.007 <0	0001	0.002	0.003 0.007	0.932	0.004	0.015 2.2	<0.0001
	2/03/2012		1	1.1/4	- 0.0	46.4	-0.1	4550	2.03	-	~1	~1	054	054	212	1130	123	130	//0	4	1			0.19	~U.UI	+	+	0.2	1	~2	7.2	0.002 0.	10001	0.000	0.014 0.016	0.040	0.008	9.8	. \0.0001

Legend: GMW102 were chyoted as total metals in Dec.11, Jan.12, and May 12 sampling rounds No Access in the Aug. 12 sampling round * Values suspected of being anomalous or due to transcription error - to be reasse Concentration acceed the AMECEC Guidelines -: not anlyzed or values not available

# Table 1: Historical Groundwater Quality Resul Whytes Gully New Landfill Cell Project No. 117625003

			Monoc	yclic Aroma	tic Hydrocarbo	ns						Oxygenated Com	pounds		Sulfonated Compounds	Fumigants			Halo	ogenated A	Aliphatic Con	npounds																		
			Styrene	Isopropylb	n-Propylbenzene	1.3.5-	sec-	1.2.4- tert-	p∙	o- n-	-Butylbenzene	Vinyl 2-Butano	ne 4-Methyl-2-	2-Hexanone	Carbon disulfide	2.2- 1.2-	cis-1.3-	trans-1.3-1.2	- Dichlo	loro Chloro	m Vinyl	Bromom C	Chloroet Trichlo	oro 1.1- lo	domet trans	-1.2- 1.1-	cis-1.2- 1.	1- 1.1-	Carbon 1.	2- Trichlor	o Dibromo	1.1.2- 1.3	- Tetra	chlo 1.1.1.2	.2- trans-1.4	- cis-1.4- 1	1.1.2.2- 1.2	.3- Pent	tachl 1.2-	Hexachlo
		Analyter		enzene		Trimethylb I	Butylbenzene	Trimethy Buty	Ibenzene Is	sopropylt		Acetate (MEK)	pentanone (MIRK)	(MBK)		Dichloro Dichlo	ro Dichloropro	Dichloro Dit	promo difluo	oro ethane	e chloride	ethane h	ane fluoroi thane	me Dichloro ha	ane Dich	oro Dichloro	Dichloro Tr	chloro Dichloro	Tetrachlo Di rido	ichloro ethene	methane	Trichloro Dic	hloro roeth	ene Tetrac	chlo Dichloro-	Dichloro- Tr	etrachlo Tric	chloro oroe	ethan Dibron	no- robutadi
		Analytes				enzene		ibenzene	01	Juene			(IVIIDK)			propane propa	ie pylelle	e (EE	B)	Idile			thane	ethelle	ette	le ethane	ethene et	e propylen	iue ei	Indile		ethane pro	phane	roetha	ane 2-butene	2-buterie itu	Jethane pro	pane e	chlorop	pr
																																							opane	/
		Unit	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L μg/L	μg/L	μg/L	μg/L	μg/L μg/	L μg/L	μg/L μ	ug/L μg/	g/L μg/	L μg/L	μg/L	μg/L μg/	L μg/L	μg/L με	/L µg/L	μg/L	ug/L μg/L	μg/L	μg/L μg/L	μg/L	μg/L μ	ug/L μg	/L μg/	/L μg/L	μg/L	μg/L ι	ıg/L μį	g/L μg/l	L μg/L
		LOR	5	5	5	5	5	5	5	5	5	50 50	50	50	5	5 5	5	5	5 50	0 50	50	50	50 50	5	5	5	5	5 5	5	5 5	5	5	5 5	5	, 5	5	5	5	5 5	5
Well ID	Sample Date	ANZECC	-	-	-	-		-	-	-	•		-	-	-		-	-			-	-		-	-		-		-		-	6500		-	-	-	-	-		-
GMW101	17/08/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	i <5	<5	<5	<5 <	<5 <5	<5
GMW102	17/08/2011		-	-	-	-	-	-	-	-	-		-	-	-		-	-			-	-		-		-	-		-		-	-		-	-	-	-	-		-
	13/12/2011		-	-	-	-	-	-	-	-	-		-	-	-		-	-			-	-		-		-	-		-		-	-		-	-	-	-	-		-
	24/01/2012		-	-	-	-	-	-	-	-	-		-	-	-		-	-			-	-		-		-	-		-		-	-		-	-	-	-	-		-
	2/05/2012		-	-	-	-		-	-	-	-		-		-		-	-			-	-		-			-		-		-	-			-	-	-	-		-
GMW103	18/08/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	5> ز	<5	<5	<5 <	<5 <5	<5
	13/12/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	5> ز	<5	<5	<5 <	<5 <5	<5
	24/01/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	5> ز	<5	<5	<5 <	<5 <5	<5
	2/05/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	5> ز	<5	<5	<5 <	<5 <5	<5
	17/08/2012		-	-	-	-	-	-	-	-	-		-	-	-		-	-			-	-		-	-	-	-		-		-	-		-	-	-	-	-		-
GMW104	17/08/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	5> ز	<5	<5	<5 <	<5 <5	<5
	13/12/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	5> ز	<5	<5	<5 <	<5 <5	<5
	24/01/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	5> ز	<5	<5	<5 <	<5 <5	<5
	2/05/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	5> ز	<5	<5	<5 <	<5 <5	<5
	17/08/2012		-	-	-	-		-	-	-	-		-	-	-		-	-			-	-		-	-		-		-		-	-		-	-	-	-	-		-
GMW105	17/08/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	5> ز	<5	<5	<5 <	<5 <5	<5
	13/12/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	5> ز	<5	<5	<5 <	<5 <5	<5
	24/01/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	5> ز	<5	<5	<5 <	<5 <5	<5
	2/05/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	5> ز	<5	<5	<5 <	<5 <5	<5
	17/08/2012		-	-	-	-	-	-	-	-	-		-	-	-		-	-			-	-		-	-	-	-		-		-	-		-	-	-	-	-		-
GMW106	17/08/2011		-	-	-	-	-	-	-	-	-		-	-	-		-	-			-	-		-	-	-	-		-		-	-		-			-	-		
GMW107	17/08/2011		-	-	-	-	-	-	-	-	-		-	-	-		-	-			-	-		-		-	-		-		-	-		-		-	-	-		
GMW1085	22/08/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	, <5	<5	<5	<5 <	<5 <5	<5
· · · · · · · · · · · · · · · · · · ·	13/12/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	, <5	<5	<5	<5 <	<5 <5	<5
· · · · · · · · · · · · · · · · · · ·	24/01/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	, <5	<5	<5	<5 <	<5 <5	<5
	2/05/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	, <5	<5	<5	<5 <	<5 <5	<5
C1 11/1 000	1//08/2012		-	-	-	-		-	-	-			-	-				-			-	-		-	-		-		-		-	-		-			-	-		
GIVIW108D	22/08/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	> <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	, <5	<5	<5	<5 <	<5 <5	<5
	13/12/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	> <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	, <5	<5	<5	<5 <	<5 <5	<5
	24/01/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	> <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	, <5	<5	<5	<5 <	<5 <5	<5
	2/05/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	, <5	<5	<5	<5 <	<5 <5	<5
CM04/1005	17/08/2012		-	-	-	-	-	-	-	-	-		-	-	-		-	-			-	-		-			-		-		-	-		-		-	-	-		
GIVIW1095	18/08/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	> <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	) <5 5	<5	<5	<5 <	<5 <5	<5
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	2/05/2012			<5		<5		<5	<5		<5	<50 <50	<50	<50	5	() ()		<5	<5 <5	50 <50	) <50	<50	<50 <50	) (5		5 75	<5	<5 <5		(5 (5		<5	<5 <	5 <5	5 75			-5	5 75	
	17/08/2012								-																										<u></u>	1		-		
GMW109D	22/08/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	5 <5	<5	<5	<5 <	<5 <5	<5
	13/12/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	5 <5	<5	<5	<5 <	<5 <5	<5
	24/01/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	ŝ <5	<5	<5	<5 <	<5 <5	<5
	2/05/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	i <5	<5	<5	<5 <	<5 <5	<5
	17/08/2012		-	-	-	-	-	-	-	-	-	- <50	<50	-	-		-	-			-	-		-	-		-		-			-		-	-	-	-	-		-
GMW110	25/07/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	5> ز	<5	<5	<5 <	<5 <5	<5
	13/12/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	5> ز	<5	<5	<5 <	<5 <5	<5
	24/01/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	, <5	<5	<5	<5 <	<5 <5	<5
	2/05/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	, <5	<5	<5	<5 <	<5 <5	<5
Chantana	25/07/2012		-	-	-	-	-	-	-	-	-		-	-	-		-	-			-	-		-		-	-		-		-5	-		-	-	-	-	-		
GIVIVIII	13/12/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	5 6	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	5 65		<5	<5 <	5 5	
	24/01/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	5 <5	<5	<5	<5 <	(5 <5	< <5
	2/05/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	5 <5	<5	<5	<5 <	<5 <5	<5
	17/08/2012		-	-	-	-	-	-	-	-	-	- <50	<50	-	-		-	-			-	-		-	-	-	-		-		-	-		-		-	-	-		-
GABH01	18/08/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <5	5 <5	s <5	<5	<5	<5 <	<5 <5	<5
	13/12/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	5> ذ	<5	<5	<5 <	<5 <5	<5
	24/01/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	5> ز	<5	<5	<5 <	<5 <5	<5
	2/05/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	5> ز	<5	<5	<5 <	<5 <5	<5
	17/08/2012		-	-		-		-	-	-	-		-		-		-	-			-	-		-			-		-		-	-		-		· ·	-	-		
GABH02	19/08/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	> <5	<5	<5	<5 <	<5 <5	<5
	13/12/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	, <5	<5	<5	<5 <	<5 <5	<5
· · · · · · · · ·	24/01/2012	· · · · · · · · · · · · · · · · · · ·	<5	<5	<5	<5	~ ~ ~	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	C)		<5	<5 <5	<5	<5 <5	<5	<5	<>			~	<5	<>	· · · · · · · · · · · · · · · · · · ·	<
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GABH03	19/08/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	< 50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <1	5 <5	5 <5	<5	<5	<5 <	(5 <5	<5
0,10,100	13/12/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	5 <5	<5	<5	<5 <	(5 <5	<5
	24/01/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	ś <5	<5	<5	<5 <	<5 <5	<5
	2/05/2012	1	<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	i <5	<5	<5	<5 <	<5 <5	<5
	17/08/2012		-	-	-	-	-	-	-	-	-	- <50	<50	-	-		-	-				-		-	-	-	-		-		-	-		-	-	-	-	-		
GABH04	19/08/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	5> ز	<5	<5	<5 <	<5 <5	<5
GABH05	22/08/2011	1	<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	5> ز	<5	<5	<5 <	<5 <5	<5
GABH06S	17/08/2011	<b> </b>	<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	, <5	<5	<5	<5 <	<5 <5	<5
	13/12/2011	ł	<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	, <5	<5	<5	<5 <	<5 <5	<5
<b>├</b>	24/01/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	/ <50	<50	<50 <50	J <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	< <5	> <5	<5	<5	<5 <	<5 <5	<5
	2/05/2012	+	<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<>	<> <5	ov <50	v <50	<50	<50 <50	, <5	<5 <	> <5	<5	<> <5	<5	<5 <5	<5	<5	<5 <	> <5	, <5	<5	<5	<5 <	-> <5	<5
CARLINCO	18/08/2012	<u> </u>	- /0	-	-	-	-				-	- <50	<50				- /5	-		50 /5/	-			-		5 /C					-			5 /5	5 /5					- /5
GADHUGU	13/12/2011	ł	~5	<5	~5	<5	~5		<5	~5	<5	<50 <50	<50	<50	~5	\	~5		<5 <5	50 <50	, <50	<50	<50 <50	, , , , , , , , , , , , , , , , , , , ,	5 5	5 75	~5	-5 -5	~5	<5 <5	~5	<5	<5 /	5 /5	5 75		~5	5	5 15	5
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<b>├</b>	2/05/2012	1	<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	5 <5	<5	<5	<5 <	<5 <5	<5
· · · · · · · · · · · · · · · · · · ·	17/08/2012	1	1-	-	-	- 1	-	1 - 1	-	-		- <50	<50	-	-			1 - 1			-								-			-	-   -			1 - 1		-		1
BH6	18/08/2011	1	<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	s <5	<5	<5	<5 <	<5 <5	<5
	13/12/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	5> ز	<5	<5	<5 <	<5 <5	<5
	24/01/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	5> ز	<5	<5	<5 <	<5 <5	<5
	2/05/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50 <50	<50	<50	<5	<5 <5	<5	<5	<5 <5	50 <50	) <50	<50	<50 <50	) <5	<5 <	5 <5	<5	<5 <5	<5	<5 <5	<5	<5	<5 <	5 <5	5> ز	<5	<5	<5 <	<5 <5	<5
	17/08/2012	1		- 1	-	1 - T	-	1 - 1	-	-		- <50	<50		-		- 1	1 - 1		.   -		- 1		- T			I - [		-		1 - T	-	-   -			1 - E	-	- 1		

Legend: GMW102 were chyoten as total metals in Dec.11, Jan.12, and Mo Access in the Aug. 12 sampling round * Values suspected of being anomalous or due to transcript Concentration acceed the AMZEC Guidelines -: not anlyzed or values not available

# Table 1: Historical Groundwater Quality Resul Whytes Gully New Landfill Cell Project No. 117625003

Normal         Normal        Normal </th <th></th> <th></th> <th></th> <th>Monocyclic Aron</th> <th>natic Hydrocarbon</th> <th>ns</th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th> <th>Trihalomet</th> <th>thanes</th> <th></th> <th></th> <th>Phenolic</th> <th>Compou</th> <th>nds</th> <th></th>				Monocyclic Aron	natic Hydrocarbon	ns							Trihalomet	thanes			Phenolic	Compou	nds										
				Chlorobenzene	Bromobenzene 2-	-Chlorotoluene	4-Chlorotoluene	1.3-	1.4-	1.2-	1.2.4-	1.2.3-	Chloroform	Bromodichloro	Dibromochloro	Bromoform	Phenol	2-	2-	3- & 4-	2-	2.4-	2.4-	2.6-	4-Chloro-3-	2.4.6-	2.4.5-	Pentachl	Total
								Dichlorobe	Dichlorobe	Dichlorobe	Trichlorobe	Trichlorob		methane	methane			Chloroph	Methylph	Methylp	Nitrophe	Dimethyl	Dichlorop	Dichloro	Methylphenol	Trichloro	Trichloro	orophen	Phenols
No.         No. <th></th> <th></th> <th>Analytes</th> <th></th> <th></th> <th></th> <th></th> <th>nzene</th> <th>nzene</th> <th>nzene</th> <th>nzene</th> <th>enzene</th> <th></th> <th></th> <th></th> <th></th> <th></th> <th>enol</th> <th>enol</th> <th>henol</th> <th>nol</th> <th>phenol</th> <th>henol</th> <th>phenol</th> <th></th> <th>phenol</th> <th>phenol</th> <th>ol</th> <th></th>			Analytes					nzene	nzene	nzene	nzene	enzene						enol	enol	henol	nol	phenol	henol	phenol		phenol	phenol	ol	
Image         Image <th< th=""><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th></th<>																													
Des         Des        Des         Des         Des																													
Number         Display         Display <th< th=""><th></th><th></th><th>Unit</th><th>μg/L</th><th>μg/L</th><th>μg/L</th><th>μg/L</th><th>μg/L</th><th>μg/L</th><th>μg/L</th><th>μg/L</th><th>μg/L</th><th>μg/L</th><th>μg/L</th><th>μg/L</th><th>μg/L</th><th>μg/L</th><th>μg/L</th><th>μg/L</th><th>μg/L</th><th>μg/L</th><th>μg/L</th><th>μg/L</th><th>μg/L</th><th>μg/L</th><th>μg/L</th><th>μg/L</th><th>μg/L</th><th>μg/L</th></th<>			Unit	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L
Name         Name <th< th=""><th>·····</th><th></th><th>LOR</th><th>5</th><th>5</th><th>5</th><th>5</th><th>5</th><th>5</th><th>5</th><th>5</th><th>5</th><th>5</th><th>5</th><th>5</th><th>5</th><th>0.2</th><th>0.2</th><th>0.2</th><th>0.4</th><th>0.2</th><th>0.2</th><th>0.2</th><th>0.2</th><th>0.2</th><th>0.2</th><th>0.2</th><th>0.4</th><th>50</th></th<>	·····		LOR	5	5	5	5	5	5	5	5	5	5	5	5	5	0.2	0.2	0.2	0.4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.4	50
Serie         Cond         Cond <t< th=""><th>Well ID</th><th>Sample Date</th><th>ANZECC</th><th>-</th><th>-</th><th>-</th><th>-</th><th>260</th><th>60</th><th>160</th><th>170</th><th>10</th><th>-</th><th>-</th><th>-</th><th>-</th><th>320</th><th>490</th><th>-</th><th>-</th><th>-</th><th>-</th><th>160</th><th>-</th><th>10</th><th>20</th><th>-</th><th>-</th><th>-</th></t<>	Well ID	Sample Date	ANZECC	-	-	-	-	260	60	160	170	10	-	-	-	-	320	490	-	-	-	-	160	-	10	20	-	-	-
Control         Contro <thcontrol< th=""> <thcontrol< th=""> <thco< th=""><td>GMW101</td><td>17/08/2011</td><td></td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;0.5</td><td>&lt;0.5</td><td>&lt;0.5</td><td>&lt;1.0</td><td>&lt;0.5</td><td>&lt;0.5</td><td>&lt;0.5</td><td>&lt;0.5</td><td>&lt;0.5</td><td>&lt;0.5</td><td>&lt;0.5</td><td>&lt;1.0</td><td>-</td></thco<></thcontrol<></thcontrol<>	GMW101	17/08/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<0.5	<0.5	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	-
Number         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·        ·         ·         · <td>GMW102</td> <td>17/08/2011</td> <td></td> <td>-</td> <td></td> <td>-</td>	GMW102	17/08/2011		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Norm         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·        ·         ·         ·		13/12/2011		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NUMBO         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I        I         I         I		24/01/2012		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ome         District         dia         di		2/05/2012		-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-
NAME         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A        A         A         A	GMW103	18/08/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<0.5	<0.5	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	-
Notani         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A        A         A         A <td></td> <td>13/12/2011</td> <td></td> <td>&lt;5</td> <td>-</td> <td>&lt;50</td>		13/12/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	-	-	-	-	-	-	-	-	-	-	-	-	<50
Normal         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A        A         A         A <td></td> <td>24/01/2012</td> <td></td> <td>&lt;5</td> <td>-</td> <td>&lt;50</td>		24/01/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	-	-	-	-	-	-	-	-	-	-	-	-	<50
NUMBE         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I <td></td> <td>2/05/2012</td> <td></td> <td>&lt;5</td> <td>-</td> <td>&lt;50</td>		2/05/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	-	-	-	-	-	-	-	-	-	-	-	-	<50
Dome         Display         D		17/08/2012		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<50
HOUSE         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G        G         G         G	GMW104	17/08/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<0.5	<0.5	0.5	<0.9	<0.5	0.7	<0.5	<0.5	<0.5	<0.5	<0.5	<0.9	-
NAMP         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A         A        A        A        A        A		13/12/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	-	-	-	-	-	-	-	-	-	-	-	-	<50
JADOM         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O         O        O         O         O		24/01/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	-	-	-	-	-	-	-	-	-	-	-	-	<50
NUMBE         NUMBE <th< th=""><td></td><td>2/05/2012</td><td></td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>&lt;50</td></th<>		2/05/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	-	-	-	-	-	-	-	-	-	-	-	-	<50
OMMONE         Dial Dial Dial         Dial Dial Dial         Dial Dial Dial Dial Dial Dial Dial Dial		17/08/2012		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<50
MULADIO         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G        G         G         G <td>GMW105</td> <td>17/08/2011</td> <td>ł</td> <td>&lt;5</td> <td>&lt;0.5</td> <td>&lt;0.5</td> <td>&lt; 0.5</td> <td>&lt;1.0</td> <td>&lt;0.5</td> <td>&lt;0.5</td> <td>&lt;0.5</td> <td>&lt;0.5</td> <td>&lt;0.5</td> <td>&lt;0.5</td> <td>&lt;0.5</td> <td>&lt;1.0</td> <td>-</td>	GMW105	17/08/2011	ł	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<0.5	<0.5	< 0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	-
Additional         Additio		13/12/2011	ł	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	-			-	-					-	-	-	<50
Observe         Observe <t< th=""><td> </td><td>24/01/2012</td><td>ł</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>-</td><td></td><td></td><td>-</td><td>-</td><td></td><td></td><td></td><td></td><td>-</td><td>-</td><td>-</td><td>&lt;50</td></t<>		24/01/2012	ł	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	-			-	-					-	-	-	<50
Number         Number<		2/05/2012	ł	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	-			-	-					-	-	-	<50
Number         Display         Display <th< th=""><td></td><td>17/08/2012</td><td></td><td>-</td><td></td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td> </td><td></td><td> </td><td> </td><td> </td><td>I</td><td> </td><td>I</td><td> </td><td>   </td><td></td><td></td><td>&lt;50</td></th<>		17/08/2012		-		-	-	-	-	-	-	-	-	-	-	-						I		I					<50
Summe         Summe <th< th=""><td>GMW106</td><td>1//08/2011</td><td></td><td>-</td><td></td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td></td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></th<>	GMW106	1//08/2011		-		-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
unexa         unexa <th< th=""><td>GMW107</td><td>1//08/2011</td><td> </td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td></td><td>-</td><td>-</td><td></td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></th<>	GMW107	1//08/2011		-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-		-	-	-	-	-	-	-	-
Material         So         <	GIVIW108S	22/08/2011	ł	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<0.5	<0.5	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	-
Subsciss		13/12/2011		<5	<5	<>	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	-	-						+	+		-	-	<50
absorbed		24/01/2012		<5	<5	<>	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	-	-						+	+		-	-	<50
NUMBER         NUMBER         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I <thi< th="">         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I        I         I         I</thi<>		2/05/2012	<u> </u>	<5	<>	<>	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5						<u> </u>		<u> </u>	+		-	-	<50
ymme         image	GMW/108D	17/06/2012	<u> </u>	-	-	-	-	-	-	-	~	-		-	-	~	-0.5		-0.5	-0.0		-0.5		-0.5	-0.5	-0.5			<5U
MARCEN         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G        G         G         G <td>GIVIN 100D</td> <td>12/12/2011</td> <td>ł</td> <td>&lt;5</td> <td>&lt;5</td> <td>&lt;5</td> <td>&lt;5</td> <td>&lt;5</td> <td>&lt;5</td> <td>&lt;5</td> <td>~</td> <td>&lt;5</td> <td>&lt;5</td> <td>&lt;5</td> <td>&lt;5</td> <td>&lt;5</td> <td>&lt;0.5</td> <td>&lt;0.5</td> <td>&lt;0.5</td> <td>&lt;0.9</td> <td>&lt;0.5</td> <td>&lt;0.5</td> <td>&lt;0.5</td> <td>&lt;0.5</td> <td><u.5< td=""><td>&lt;0.5</td><td><u.5< td=""><td>&lt;0.9</td><td></td></u.5<></td></u.5<></td>	GIVIN 100D	12/12/2011	ł	<5	<5	<5	<5	<5	<5	<5	~	<5	<5	<5	<5	<5	<0.5	<0.5	<0.5	<0.9	<0.5	<0.5	<0.5	<0.5	<u.5< td=""><td>&lt;0.5</td><td><u.5< td=""><td>&lt;0.9</td><td></td></u.5<></td></u.5<>	<0.5	<u.5< td=""><td>&lt;0.9</td><td></td></u.5<>	<0.9	
Number         3         3         3         3         3         3         3         3         3         3         4         5         5         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1 <td>·</td> <td>24/01/2012</td> <td>ł</td> <td>&lt;5</td> <td>&lt;5</td> <td>&lt;5</td> <td>&lt;5</td> <td>&lt;5</td> <td>&lt;5</td> <td>&lt;5</td> <td>~</td> <td>&lt;5</td> <td>&lt;5</td> <td>&lt;5</td> <td>&lt;5</td> <td>&lt;5</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td><u> </u></td> <td><u> </u></td> <td><u> </u></td> <td>+</td> <td></td> <td></td> <td></td> <td>&lt;50</td>	·	24/01/2012	ł	<5	<5	<5	<5	<5	<5	<5	~	<5	<5	<5	<5	<5						<u> </u>	<u> </u>	<u> </u>	+				<50
1773         178         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18         18		24/01/2012		<5	<5	<5	<5	<5	<5	<5	0	<5	< 5	<5	<5	< 5							-	-			-	-	<50
NUMBER         NUMBER        NUMBER </th <td></td> <td>2/05/2012</td> <td></td> <td>&lt;5</td> <td>-</td> <td></td> <td>-</td> <td>-</td> <td>-</td> <td></td> <td>-</td> <td>-</td> <td></td> <td>-</td> <td>-</td> <td>-</td> <td>&lt;50</td>		2/05/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	-		-	-	-		-	-		-	-	-	<50
UNITABLE         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1<	GMM/1095	17/08/2012		-	-	-	-	-	-	-	-	-	-	-	-	-				- 10							-	- 10	<50
1400/001         36         36         36         36         36         36         36         36         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1 <th1< th="">         1         1</th1<>	GIVIV/1055	12/12/2011		<5	<5	<5	<5	<5	<5	<5	0	<5	<5	<5	<5	<5	<0.5	<0.5	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	
1200/001         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -        -         -         - </th <td></td> <td>24/01/2012</td> <td></td> <td>&lt;5</td> <td>&lt;5</td> <td>&lt;5</td> <td>&lt;5</td> <td>&lt;5</td> <td>&lt;5</td> <td>&lt;5</td> <td>5</td> <td>&lt;5</td> <td>&lt;5</td> <td>&lt;5</td> <td>&lt;5</td> <td>&lt;5</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>-</td> <td></td> <td></td> <td></td> <td>-</td> <td>&lt;50</td>		24/01/2012		<5	<5	<5	<5	<5	<5	<5	5	<5	<5	<5	<5	<5								-				-	<50
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Conversion         Conversion <thconversion< th="">         Conversion         Conversi</thconversion<>		17/08/2012		-	-	-	-	-	-	-			-	-		-	-	-	-	-	-	-	-	-		-	-	-	<50
H3122011         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G        G         G         G </th <td>GMW109D</td> <td>22/08/2011</td> <td></td> <td>&lt;5</td> <td>&lt;0.5</td> <td>&lt;0.5</td> <td>&lt;0.5</td> <td>&lt; 0.9</td> <td>&lt;0.5</td> <td>&lt; 0.5</td> <td>&lt;0.5</td> <td>&lt;0.5</td> <td>&lt;0.5</td> <td>&lt;0.5</td> <td>&lt;0.5</td> <td>&lt;0.9</td> <td>-</td>	GMW109D	22/08/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<0.5	<0.5	<0.5	< 0.9	<0.5	< 0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.9	-
MUD201         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G        G         G         G <td></td> <td>13/12/2011</td> <td></td> <td>&lt;5</td> <td>-</td> <td>&lt;50</td>		13/12/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	-	-	-	-	-	-	-	-	-	-	-	-	<50
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17.08/2012         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·        ·         ·         ·		2/05/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	-	-	-	-	-	-	-	-	-	-	-	-	<50
GMM:11         2507/2011         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65        65         65        65		17/08/2012		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<50
11/12/001         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65        65        65 <t< th=""><td>GMW110</td><td>25/07/2011</td><td></td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;1.0</td><td>&lt;1.0</td><td>&lt;1.0</td><td>&lt;2.0</td><td>&lt;1.0</td><td>&lt;1.0</td><td>&lt;1.0</td><td>&lt;1.0</td><td>&lt;1.0</td><td>&lt;1.0</td><td>&lt;1.0</td><td>&lt;2.0</td><td>-</td></t<>	GMW110	25/07/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	-
2400/2012         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65         65        65        65 <t< th=""><td></td><td>13/12/2011</td><td></td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>&lt;50</td></t<>		13/12/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	-	-	-	-	-	-	-	-	-	-	-	-	<50
ADD/ADD         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G </th <td></td> <td>24/01/2012</td> <td></td> <td>&lt;5</td> <td>-</td> <td>&lt;50</td>		24/01/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	-	-	-	-	-	-	-	-	-	-	-	-	<50
Import         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I         I <td></td> <td>2/05/2012</td> <td></td> <td>&lt;5</td> <td>-</td> <td>&lt;50</td>		2/05/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	-	-	-	-	-	-	-	-	-	-	-	-	<50
Image: Difference         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G         G	CN414111	25/07/2012		-	-	-	-	-	-		-	-	- /5	-	-	-	<1.0	<1.0	-1.0	-20	<1.0	-10	<1.0	<1.0	<1.0	<1.0	-10	<2.0	<50
AM012012         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         <	GIVIVVIII	13/12/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	~1.0	~1.0	~1.0	~2.0	~1.0	<1.0	~1.0	1.0	1.0	~1.0	<1.0	~2.0	<50
2/05/202         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -        -         -         - </th <td></td> <td>24/01/2012</td> <td></td> <td>&lt;5</td> <td>_</td> <td>-</td> <td>-</td> <td>-</td> <td>-</td> <td>_</td> <td>_</td> <td>-</td> <td>-</td> <td>-</td> <td>-</td> <td>-</td> <td>&lt;50</td>		24/01/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	_	-	-	-	-	_	_	-	-	-	-	-	<50
17/08/002         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .        .         .         .<		2/05/2012	1	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	-	-	-	-	-	-	-	-	-	- 1	-	-	<50
GABHOL         18/08/2011         -5         -5         -5         -5         -5         -5         -5         -5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5         -0.5 <td></td> <td>17/08/2012</td> <td>1</td> <td>-</td> <td></td> <td>-</td> <td>&lt;50</td>		17/08/2012	1	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<50
13/12/011	GABH01	18/08/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<0.5	<0.5	< 0.5	<0.9	<0.5	< 0.5	<0.5	< 0.5	<0.5	< 0.5	<0.5	<0.9	-
24/01/2012         CS		13/12/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	-	-	-	-	-	-	-	-	-	-	-	-	<50
2/05/2012         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -        -         -         -<		24/01/2012	I	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5		-	-	-	-		-	-		- 1	-	- ]	<50
1/08/2012         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·        ·         ·         ·<		2/05/2012	I	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	-	-	-	-	-	-	-	-		-	-	-	<50
usymula         usymula <t< th=""><td>CADURE</td><td>1//08/2012</td><td></td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td></td></t<>	CADURE	1//08/2012		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Largent         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S         S </th <td>GABHUZ</td> <td>13/12/2011</td> <td>+</td> <td>&lt;5</td> <td>&lt;<u>&gt;</u></td> <td>&lt;&gt;</td> <td>&lt;5</td> <td>&lt;0.5</td> <td>&lt;0.5</td> <td>&lt;0.5</td> <td>&lt;0.9</td> <td>&lt;0.5</td> <td>&lt;0.5</td> <td>&lt;0.5</td> <td>&lt;0.5</td> <td><u.5< td=""><td>&lt;0.5</td><td><u.5< td=""><td>&lt;0.9</td><td>-</td></u.5<></td></u.5<></td>	GABHUZ	13/12/2011	+	<5	< <u>&gt;</u>	<>	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<0.5	<0.5	<0.5	<0.9	<0.5	<0.5	<0.5	<0.5	<u.5< td=""><td>&lt;0.5</td><td><u.5< td=""><td>&lt;0.9</td><td>-</td></u.5<></td></u.5<>	<0.5	<u.5< td=""><td>&lt;0.9</td><td>-</td></u.5<>	<0.9	-
		24/01/2012	<u> </u>	<5	<5	<5	<5	~5	<5	~5	<5	~5	<5	<5	<5	<5	-	-					-	1 -			-	-	<50
Image: constraint of the		2/05/2012	ł	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5		-					-		-		-	-	<50
GABH03         19/08/2011		17/08/2012	1	-	<u> </u>	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	<50
13/12/2011         c5	GABH03	19/08/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<0.5	<0.5	<0.5	<0.9	< 0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.9	-
24/01/2012                                                                                                                        <		13/12/2011	1	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	-	-	-	-	-	-	-	-	-	-	-	-	<50
2/05/2012 </th <td></td> <td>24/01/2012</td> <td></td> <td>&lt;5</td> <td>-</td> <td>&lt;50</td>		24/01/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	-	-	-	-	-	-	-	-	-	-	-	-	<50
17/08/2012         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·         ·		2/05/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	-	-	-	-	-	-	-	-	-	-	-	-	<50
GABHO4         19(8)2011         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -5         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55         -55		17/08/2012		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<50
GABHOS       22/08/2011	GABH04	19/08/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<0.5	<0.5	<0.5	<0.9	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.9	-
GABHOGS       17/08/2011 <t< th=""><td>GABH05</td><td>22/08/2011</td><td></td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;5</td><td>&lt;0.5</td><td>&lt;0.5</td><td>&lt;0.5</td><td>&lt;0.9</td><td>&lt;0.5</td><td>&lt;0.5</td><td>&lt;0.5</td><td>&lt;0.5</td><td>&lt;0.5</td><td>&lt;0.5</td><td>&lt;0.5</td><td>&lt;0.9</td><td>-</td></t<>	GABH05	22/08/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<0.5	<0.5	<0.5	<0.9	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.9	-
13/12/2011	GABH06S	17/08/2011	ļ	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<0.5	<0.5	<0.5	<0.9	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.9	-
2401/2012                                                                                                                                   <	L	13/12/2011	Į	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	-	-	-	-	-	-	-	-		-	-	-	<50
ZUDY/DUL         CS         <	·	24/01/2012	l	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	-	-	-	-	-						-	-	<50
Introduction         Image: constraint of the stress o	L	2/05/2012	ł	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5		-			-						-	-	<50
unprove         10/02/011         53         53         53         53         53         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         55         50	CARUSCO	17/08/2012		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-			-	-	<50
1/1/1/1/1         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5         5	GABH06D	13/12/2011	<u> </u>	<5	< <u>&gt;</u>	<>	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<0.5	<0.5	<0.5	<0.9	<0.5	<0.5	<0.5	<0.5	<u.5< td=""><td><u.5< td=""><td><u.5< td=""><td>&lt;0.9</td><td>-</td></u.5<></td></u.5<></td></u.5<>	<u.5< td=""><td><u.5< td=""><td>&lt;0.9</td><td>-</td></u.5<></td></u.5<>	<u.5< td=""><td>&lt;0.9</td><td>-</td></u.5<>	<0.9	-
2/05/2012       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5       -5	<b>├</b> ────	24/01/2012	ł	<5	~ ~ ~	~5	<5	~5	<5	~5	· · ·	<5	~5	<5	~5	<5		-				<u> </u>		+	+			-	<50
17/08/2012         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -		2/05/2012	<u> </u>	<5	<5	<5	<5	~5	<5	~5	<5	~5	<5	<5	<5	<5					-		-	-			-	-	<50
BH6 18/08/2011 <5 <5 <5 <5 <5 <5 <5 <5 <5 <5 <5 <5 <5		17/08/2012	+	-		-			-			-			-	-					-	1	-	1 -	-		- 1	-	<50
	BH6	18/08/2011	1	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<0.5	<0.5	< 0.5	< 0.9	<0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	<0.5	<0.9	-
13/12/2011 <5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5	5110	13/12/2011	1	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	-	-	-	-	-	-	-	-	-	-	-	-	<50
24/01/2012 <5 <5 <5 <5 <5 <5 <5 <5 <5 <5 <5 <5 <5		24/01/2012	1	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5		-	-	-	-	-	-	-	- 1	- 1	-	-	<50
2/05/2012 <5 <5 <5 <5 <5 <5 <5 <5 <5 <5 <5 <5 <5	· · · · · ·	2/05/2012	1	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	-	-	-	-	-	-	-	-	-	-	-	-	<50
17/08/2012		17/08/2012	1	-		-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<50

Legend: GMW102 were dry Metals were reported as total metals in Dec.11, Jan.12, and No Access in the Aug. 12 sampling round * Values suspected of being anomalous or due to transcript Concerntation exceed the AUZCC Guidelines -: not anlyzed or values not available

# Table 1: Historical Groundwater Quality Resul

Whytes Gully New Landfill Cell	
Project No. 117625003	

			Polynuclear A	romatic Hydroca	rbons														BTEX						Total Pe	troleum Hy	drocarbons			Total Reco	verable Hyd	drocarbons			
			Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene B	Benz(a)anthracene	Chrysene	Benzo(b)fluor	Benzo(k)flu	Benzo(a)py	Indeno(1.2.3.co	d Dibenz(a.h)an	Benzo(g. Sum of	Benzene	Toluene E	Ethylbenzene	m-&p- 0	-Xylene T	otal Sum	n of C6 - C9	C10 - C14	C15 - C28	C29 - C36	C10 - C36	C6 - C10 C6	6 - C10	>C10 - C16	>C16 - C34	>C34 - C40	>C10 - C40
													anthene	oranthene	rene	)pyrene	thracene	h.i)peryle PAHs				Xylene	Þ	ylenes BTE	X Fraction	Fraction	Fraction	Fraction	Fraction	Fraction Fr	raction	Fraction	Fraction	Fraction	Fraction
		Analytes																ne											(sum)	m /r	ninus BTEX				(sum)
																														(F	1)				1
		Unit	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/I	ug/L	ug/L ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L u	g/L ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
		LOR	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2 0.5	1	2	2	2	2	2	1 20	50	100	50	50	20	20	100	100	100	100
Well ID	Sample Date	ANZECC	16	-	-	-	-	-	-	-	-	-	-	-	-		-		950	-	-	200	350	-		-	-	-	-	-	-	-	-	-	-
GMW101	17/08/2011		< 0.5	<0.5	< 0.5	< 0.5	<0.5	< 0.5	< 0.5	< 0.5	<0.5	< 0.5	<0.5	< 0.5	< 0.5	< 0.5	<0.5	<0.5 -	<1	<5	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
GMW102	17/08/2011		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-		-	-	-	-	-	-	-	-	-	-
	13/12/2011		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-
	24/01/2012		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-
	2/05/2012		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-
GMW103	18/08/2011		< 0.5	< 0.5	< 0.5	< 0.5	<0.5	< 0.5	< 0.5	< 0.5	<0.5	<0.5	< 0.5	< 0.5	< 0.5	<0.5	< 0.5	<0.5 -	<1	<5	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	13/12/2011		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<5	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	24/01/2012		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	< 0.5	<1.0	<1.0	<1.0 <0.5	<1	<5	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	2/05/2012		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<2	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	17/08/2012		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<2	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
GMW104	17/08/2011		< 0.5	< 0.5	<0.5	< 0.5	<0.5	<0.5	< 0.5	< 0.5	<0.5	< 0.5	<0.5	< 0.5	< 0.5	< 0.5	< 0.5	<0.5 -	<1	<5	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	13/12/2011		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<5	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	24/01/2012		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	< 0.5	<1.0	<1.0	<1.0 <0.5	<1	<5	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	2/05/2012		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<2	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	17/08/2012		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	< 0.5	<1.0	<1.0	<1.0 <0.5	<1	<2	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
GMW105	17/08/2011		<0.5	<0.5	< 0.5	<0.5	<0.5	<0.5	<0.5	< 0.5	<0.5	<0.5	<0.5	<0.5	< 0.5	<0.5	< 0.5	<0.5 -	<1	<5	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	13/12/2011		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<5	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	24/01/2012		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<5	<2	<2	<2	<2	<1 <20	<50	170	80	250	<20	<20	<100	220	<100	220
	2/05/2012		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<2	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	17/08/2012	_	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<2	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
GMW106	17/08/2011			-	-	-		-	-	-	-	-	-	-	-		-			<u> </u>	-	-	-	-		-	-	-	-	- T	-	-	-	-	
GMW107	17/08/2011			-	-	-		-	-	-	-	-	-	-	-		-			<u> </u>	-	-	-	-		-	-	-	-	- T	-	-	-	-	
GMW1085	22/08/2011		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 -	<1	<5	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	13/12/2011		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<5	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	24/01/2012		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	< 0.5	<1.0	<1.0	<1.0 <0.5	<1	<5	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	2/05/2012		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<2	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
<b>CHR····</b>	17/08/2012	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<2	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
GMW108D	22/08/2011		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 -	<1	<5	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	13/12/2011		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<5	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	24/01/2012	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<5	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	2/05/2012		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<2	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
C	17/08/2012		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<2	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
GMW1095	18/08/2011		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 -	<1	<5	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
· · · · ·	13/12/2011	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<5	<2	<2	<2	<2	<1 <20	<50	260	<50	<50	<20	<20	<100	260	<100	260
	24/01/2012		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	()	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	(2)	<2	~ ~ ~	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
· · · · · · · · · · · · · · · · · · ·	17/08/2012		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<2	<2	<2	<2	<2	<1 <20	<50	210	<50	210	<20	<20	<100	200	<100	200
GMW109D	22/08/2011		< 0.5	<0.5	<0.5	<0.5	< 0.5	< 0.5	< 0.5	<0.5	<0.5	<0.5	<0.5	< 0.5	< 0.5	< 0.5	<0.5	<0.5 -	<1	<5	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	13/12/2011		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<5	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	24/01/2012		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<5	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	2/05/2012		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	< 0.5	<1.0	<1.0	<1.0 <0.5	<1	<2	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	17/08/2012		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	< 0.5	<1.0	<1.0	<1.0 <0.5	<1	<2	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
GMW110	25/07/2011		<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2 -	<1	<5	<2	<2	<2	<2	<1 <20	<50	430	<50	430	<20	<20	<100	500	<100	500
	13/12/2011		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<5	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	24/01/2012	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<5	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	2/05/2012		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<2	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
GMW111	25/07/2012		0.4	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.3	<0.2	<0.2	<0.2 0.4	<1	<5	<2	<2	<2	<2	<1 <20	<50	1090	770	1860	<20	<20	<100	1640	370	2010
GIVIVVIII	13/12/2011	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.2	<1.0	<1.0	<1.0 <0.5	<1	<5	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	24/01/2012		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<5	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	2/05/2012	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<2	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	17/08/2012		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<2	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
GABH01	18/08/2011		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	< 0.5	<0.5	<0.5	<0.5 -	<1	<5	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	13/12/2011	ļ	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<5	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	24/01/2012	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<5	<2	<2	<2	<2	<1 <20	60	560	260	880	<20	<20	<100	770	100	870
	2/05/2012	l	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<2	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
GARH02	19/08/2012		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5		<5	-	4	2	6	6 30	<50	<100	<50	<50	40	30	<100	<100	-	- <100
0.0102	13/12/2011	+	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<5	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	24/01/2012	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<5	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	2/05/2012	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<2	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	17/08/2012		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<2	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
GABH03	19/08/2011		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 -	<1	<5	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	13/12/2011		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<5	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	24/01/2012	Į	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<5	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	2/05/2012		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<2	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	17/08/2012		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<2	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
GABH04	19/08/2011		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 -	<1	<5	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
GABHOS	17/08/2011	1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 -	~1	<5	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
3450003	13/12/2011	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<5	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	24/01/2012	†·	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<5	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	2/05/2012	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<2	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	17/08/2012		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<2	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
GABH06D	18/08/2011		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 -	<1	<5	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	13/12/2011		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<5	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	24/01/2012	ļ	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<5	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	2/05/2012		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<2	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	17/08/2012	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<2	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
BH6	18/08/2011	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5 -	<1	<5	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	24/01/2012		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<5	~2	~2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
· · · · · ·	2/05/2012	+	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0 <0.5	<1	<2	<2	<2	<2	<2	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	17/08/2012	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<10 <0.5	~1	-2	-2	~	<2	~	<1 <20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100

Legend: GMW102 were exported as total metals in Dec.11, Jan.12, and Mo Access in the Aug. 12 simpling round * Values suspected of being anomalous or due to transcript Concentration acceed the AM2ECC Guidelines -: not anlyzed or values not available

# Table 1: Historical Groundwater Quality Resul Whytes Gully New Landfill Cell Project No. 117625003

	-		Organoc	hlorine Pes	ticides																									Polychlori	inated B	iphenyls	as Aroclo	rs)	
			Aldrin	alpha-BHC	beta-BHC	delta-BHC	4.4`-DDD	4.4`-DDE	4.4`-DDT	Dieldrin alp	oha-	beta-	Endosulfan	Endrin	Endrin	Endosulfan	Endrin	Heptachlor	Heptachlor	Hexachloro	gamma-	Methoxychlor	cis-	trans-	Total	Oxychlor	Sum of	Total	Aroclor	Aroclor A	Aroclor	Aroclor	Aroclor A	roclor Ar	oclor 1260
		Analutas								En	dosulfan	Endosulfan	sulfate		aldehyde	(sum)	ketone		epoxide	benzene	BHC		Chlordane	Chlordane	Chlordane	dane	DDD +	PCBs	1016	1221 1	.232	1242	248 1	254	
	ŕ	Andiytes																1		(100)					(sum)		DDE +								
																											551								
		Unit	μg/L	μg/L	µg/L	μg/L	µg/L	µg/L	μg/L	µg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	µg/L	μg/L	µg/L	μg/L	µg/L	µg/L	µg/L	µg/L	μg/L	µg/L	µg/L	µg/L
	The second se	LOR	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.005	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Well ID	Sample Date	ANZECC	-	-	-	-	-	-	0.01	-	-		-	0.02		0.2	-	0.09	-	-	0.2	-	-	-		-	-	-	-	-	-	0.6	-	-	-
GMW101	17/08/2011		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.005	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	<0.10	< 0.10
GMW102	17/08/2011		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	13/12/2011		-	-	-	-	-	-	-	-	-		-	-			-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	24/01/2012		-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-		-	-	-	-		-	-	-	-	-	-	-	-	-	-
	2/05/2012																													_	_		_		
GMW103	19/09/2012		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.005	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
01111105	12/12/2011		<0.010	(0.010	<0.010	(0.010	<0.010	<0.010	<0.010	<0.010	<0.010	(0.010	N0.010	<0.010	<0.010	(0.010	<0.010	<0.00J	<0.010	<0.010	<0.010	<0.010	(0.010	<0.010	<0.010	<0.010	<0.010	<0.10	NU.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
	24/01/2012		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	24/01/2012				-						-	-								-											-	-	-		-
	17/09/2012										-	-				-																-			
C1411404	17/08/2012		.0.010	.0.010	-0.010	-0.040	-0.040	.0.010	.0.010	.0.010	.0.010	-0.010	-0.010	-0.010	-0.010	10.010	-0.010	-0.005	.0.040	-0.010	-0.010	-0.040	.0.010	.0.010	.0.010	-0.010	.0.010	-	-	-	-	-0.40	-	-	-
GIVIV/104	17/08/2011		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.005	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
	13/12/2011		-	-	-	-	-	-	-	-	-		-	-		-		-	-	-	-	-	-	-		-	-	-	-	-	-	-	-		-
	24/01/2012		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2/05/2012		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C1 11/1 05	17/08/2012															0.010		0.005	0.040			0.010	0.010	0.010	0.010			-	-	-	-	-	-	-	-
GMW105	17/08/2011		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	<0.010	<0.010	< 0.010	< 0.010	< 0.010	<0.010	<0.010	<0.010	<0.010	<0.005	<0.010	< 0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	< 0.010	<0.10	< 0.10	< 0.10	<0.10	<0.10	<0.10	<0.10	<0.10
·	13/12/2011			-				-	-		-					-	-		-		-		-				-		-	-	-	-	-		-
·	24/01/2012		-	-				-	-		-					-	-		-		-		-	-			-		-	-	-	-	-		-
·	2/05/2012		-	-	-	-	-	-	-		-	-	-		-	-	-		-	-	-		-	-	-	-	-		-	-	-	-	-	-	-
<b>C 1 1 1 1 1 1 1 1 1 1</b>	17/08/2012					<u> </u>				-																									
GMW106	1//08/2011		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GMW107	1//08/2011		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GMW108S	22/08/2011		< 0.010	<0.010	< 0.010	< 0.010	<0.010	< 0.010	<0.010	<0.010	<0.010	<0.010	< 0.010	<0.010	<0.010	<0.010	<0.010	<0.005	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
	13/12/2011		-	-	-			-	-		-	-			-	-	-		-	-	-		-	-	-	-	-	-		-	-	-	-		-
	24/01/2012		-	-	-			-	-		-	-			-	-	-			-	-		-	-	-	-	-		-	-	-	-	-	-  -	-
	2/05/2012		-	-	-	-		-	-		-	-	-		-	-	-		-	-	-		-	-	-	-	-		-	-	-	-	-	-  .	-
	17/08/2012																											-	-	-	-	-	-	-	-
GMW108D	22/08/2011		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	<0.010	< 0.010	< 0.010	< 0.010	<0.010	< 0.010	< 0.010	< 0.005	< 0.010	< 0.010	< 0.010	<0.010	< 0.010	< 0.010	<0.010	< 0.010	< 0.010	<0.10	< 0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
	13/12/2011		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-
	24/01/2012		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2/05/2012		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	17/08/2012		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GMW109S	18/08/2011		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	<0.010	< 0.010	< 0.010	< 0.010	< 0.010	<0.010	< 0.010	< 0.010	< 0.005	< 0.010	< 0.010	< 0.010	<0.010	< 0.010	< 0.010	<0.010	< 0.010	< 0.010	<0.10	< 0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
	13/12/2011		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	24/01/2012		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-		-	-	-	-		-	-	-	-	-	-	-	-
	2/05/2012		-	-	-	-	-		-	-	-	-	-	-	-		-			-	-	-	-	-	-	-		-		-	-	-	-	-	-
CM44/100D	17/08/2012		-		-			-	-		-						-					-	-	-	-	-	-			- 10	- 10	- 10	- 10	-	
GIVIW109D	12/12/2011		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.005	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
	24/01/2012										-																				-	-		-	
	2/05/2012		-	-	-	-		-	-	-	-										-	-				-				-	-	-	-	-	
	17/08/2012		-	-	-	-		-	-	-	-			-				-			-	-				-		-	-	-	-	-	-	-	-
GMW110	25/07/2011		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.005	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	<0.10	< 0.10
	13/12/2011		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	24/01/2012		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2/05/2012		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	17/08/2012																											-	-	-	-	-	-	-	-
GMW111	25/07/2011		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	<0.010	<0.010	<0.010	< 0.010	< 0.010	<0.010	< 0.010	< 0.010	< 0.005	<0.010	<0.010	< 0.010	<0.010	< 0.010	<0.010	<0.010	< 0.010	< 0.010	<0.10	< 0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
	13/12/2011		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	24/01/2012		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2/05/2012		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1//08/2012		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GABH01	18/08/2011		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.005	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
	15/12/2011			-					-		-	-			-		-	··· -		-	-	+	-	-	-		-		-	-	-	-	-	-  -	-
	24/01/2012			-		<u> </u>				<u> </u>				<u>                                      </u>			-					+	-												
	17/08/2012			-	-	<u> </u>			-		_	-		-			-	1		-	-	+	_				_	-		_	-	_	- 1		
GABH02	19/08/2011		<0.010	<0,010	<0,010	<0.010	<0,010	<0.010	<0,010	<0.010	<0.010	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010	<0.005	<0,010	<0.010	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010	<0.10	<0.10	<0.10	<0.10	<0,10	<0.10	<0.10	<0.10
	13/12/2011		-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-
	24/01/2012		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	2/05/2012		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	17/08/2012																											-	-	-	-	-	-	-	-
GABH03	19/08/2011		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	<0.010	<0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	<0.010	< 0.010	< 0.005	<0.010	<0.010	<0.010	<0.010	< 0.010	< 0.010	<0.010	<0.010	< 0.010	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
	13/12/2011		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	24/01/2012		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2/05/2012		-	-			<u> </u>				-	-			-		-	ļ		-			-	-	-		-			-	-	-	- [	-	- ]
	17/08/2012		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-		-	-	-	-	-	-	-	-	-	-
GABH04	19/08/2011		< 0.010	< 0.010	< 0.010	< 0.010	<0.010	< 0.010	<0.010	< 0.010	< 0.010	<0.010	< 0.010	< 0.010	<0.010	<0.010	<0.010	< 0.005	< 0.010	< 0.010	< 0.010	<0.010	<0.010	<0.010	<0.010	< 0.010	< 0.010	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
GABH05	22/08/2011		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	< 0.010	<0.010	<0.010	<0.010	< 0.005	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.10	<0.10	<0.10	<0.10	<0.10	< 0.10	<0.10	<0.10
GABH06S	17/08/2011		< 0.010	<0.010	< 0.010	< 0.010	<0.010	< 0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.005	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
L	13/12/2011		-	-		<u> </u>	····				-	-			-		-	··· ·		-			-	-	-					-	-	-	-		-
	24/01/2012			-	-	-			-		-	-			-	-	-			-			-	-	-		-				-	-	-		-
	2/05/2012		-	-	-	-	-	-	-		-	-		-	-	-	-			-	-		-	-	-	-	-	-	-	-	-	-	-		-
CARUSCE	1//08/2012		-	-	-		-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-				- 10	-		-	
GABH06D	13/13/2011		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.005	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.10	<0.10	<0.10	~U.1U	<0.10	~0.10	~0.10	<0.10
<b> </b>	24/01/2012									<u>⊢ -</u> -  -	-	-		<u> </u>			-	+		-		+						<u> </u>			-	-		<u> </u>	-
	2/05/2012			-	-	1			-		-	-		1				1			-	+	-	-	-			1		-					
	17/08/2012			-		+					-			1				1				+	-							-					
BHG	18/08/2011		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	< 0.010	<0.010	<0.010	<0.010	<0.005	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
500	13/12/2011		-0.010	-0.010	-0.010	-0.010	-0.010	-0.010	-0.010		-	-0.010	-0.010		-0.010	-0.010			-0.010	-0.010	-0.010		-0.010	-0.010	-0.010	-0.010	-0.010		-0.10	-0.10	-0.10			-	
	24/01/2012			-					-		-							1			-							-	-	-	-		-		
	2/05/2012			-	-			-	-		-	-								-	-	-	-	-	-	-		-	-	-	-		-		-
<b> </b>	17/08/2012		-	-	-	-		-	-		-	-	-	-	· ·	-	-		-	-	-		-	-		-	-	-	-	-	-		-		-
						1	1															1													

Legend: GMW102 were chyoted as total metals in Dec.11, Jan.12, and Mo Access in the Aug. 12 sampling round * Values suspected of being anomalous or due to transcript Concentration acceed the AMZEC Guidelines -: not anlyzed or values not available

#### Table 2: Historical Surface Water Quality and Leachate Results Summary Table Whytes Gully New Landfill Cell Project No. 117625003

			Field Parar	meters				Major lons										
		Analytes	Field-pH	S Field-temp	Field-redox	Field-EC	Field Dissolved oxygen	Hydroxide Alkalinity as CaCO3	Carbonate Alkalinity as CaCO3	bicarbonate Alkalinity as caCO3	Total Alkalinity as CaCO3	Sulfate as SO4 - Turbidimetric	Chloride	Calcium	Magnesium	Sodium	Potassium	Fluoride
		LOR	pH units	L	mv	µs/cm	ppm	1 nig/L	nng/L	1 mg/L	mg/∟ 1	nig/L	1 mg/L	nig/L	nng/∟ 1	1 mg/L	1 nig/L	0.1
Sample ID	Sample Date	ANZECC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface Water 1	13/12/2011		8	19.3	187	840	6.03	<1	6	245	251	12	102	32	22	95	26	0.4
	24/01/2012		7.8	22.8	195	1050	4.94	<1	32	275	307	18	165	29	28	134	29	0.5
	2/05/2012		7.7	15.9	-65.6	925	5.03	<1	<1	342	342	20	178	44	32	136	32	0.5
	17/08/2012		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface Water 2	13/12/2011		7.7	18.9	213	709	6.11	<1	<1	218	218	12	84	32	20	79	20	0.3
	24/01/2012		7.5	23.3	180	1010	7.27	<1	26	281	307	12	157	30	26	128	27	0.4
	2/05/2012		7.3	12.9	161	751	5.64	<1	<1	335	335	20	170	40	30	132	33	0.4
	17/08/2012		7.2	10.5	83.5	909	2.1	<1	<1	331	331	19	239	44	35	189	23	0.4
Surface Water 3	13/12/2011		6.8	18.4	196	185	5.4	<1	<1	45	45	19	19	14	4	13	5	<0.1
	24/01/2012		7.4	20.8	159	431	5.99	<1	<1	137	138	20	53	29	16	31	3	0.1
	2/05/2012		7.2	13.8	172	292	9.11	<1	<1	118	118	24	51	31	15	31	3	0.1
	17/08/2012		7.1	10.9	88.5	417	5.8	<1	<1	163	163	31	66	39	20	42	3	0.1
Surface Water 4	13/12/2011		7.3	18.9	216	347	8.74	<1	<1	96	96	16	39	22	11	30	5	0.1
	24/01/2012		7.4	21.2	108	566	5.68	<1	2	178	181	13	79	29	18	53	8	0.2
	2/05/2012		7.8	14.7	50.4	383	7.99	<1	<1	128	128	21	58	31	16	37	5	0.2
	17/08/2012		7.1	10.9	-10.5	401	3.9	<1	<1	166	166	23	68	35	19	46	4	0.2
Surface Water 5	13/12/2011		7.4	19.2	208	348	8.32	<1	<1	97	97	16	38	23	11	30	5	0.2
	24/01/2012		7.6	20.4	88.5	591	6.77	<1	4	179	183	11	79	29	17	53	8	0.2
	2/05/2012		7.8	14.7	43.3	362	7.61	<1	<1	130	130	20	58	30	16	38	5	0.1
	17/08/2012		7.2	11	-4	408	3.8	<1	<1	171	171	22	67	35	18	46	4	0.2
Surface Water 6	13/12/2011		7.5	17.7	231	348	10.6	<1	4	98	102	22	36	25	12	25	3	0.1
	24/01/2012		7.6	19.9	164	510	7.44	<1	20	160	180	31	58	39	20	33	3	0.2
	2/05/2012		7.7	14.2	124	374	7.7	<1	<1	147	147	31	60	38	18	35	3	0.1
	17/08/2012		7.3	11	104	464	5.2	<1	7	187	194	42	70	46	22	43	3	0.1
Leachate	13/12/2011		8.3	32	-32.7	22700	2.36	<1	654	6400	7060	<1	1710	38	56	1590	627	1.7
	24/01/2012		8.3	36	-133	29500	0.27	<1	681	9920	10600	<10	2030	34	58	2120	848	2.2
	2/05/2012		8	30.6	-46.6	20300	1.26	<1	193	7110	7300	<10	2150	55	73	1760	678	1.7
	17/08/2012		8.2	28.8	-47.5	25700	0.3	<1	<1	10600	10600	<10	2740	31	53	2500	1040	1.7

Legend:

Metals were reported as total metals in Dec.11, Jan.12, and May 12 sampling rounds

No Access in the Aug. 12 sampling round

Concentration exceed the ANZECC Guidelines

		-	Nutrients					Metals and N	letalloids				-					
		Analytes	Ammonia as N	Nitrite as N	Total Kjeldahl Nitrogen as N	Total Organic Carbon	Biochemical Oxygen Demand	Aluminium	Arsenic	Cadmium	Chromium	Copper	Lead	Manganese	Nickel	Zinc	Iron	Mercury
		Unit	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
		LOR	0.01	0.01	0.1	1	2	0.01	0.001	0.0001	0.001	0.001	0.001	0.001	0.001	0.005	0.05	0.0001
Sample ID	Sample Date	ANZECC	0.9		<u> </u>		-	0.055		0.0002	-	0.0014	0.0034	1.9	0.011	0.008	-	0.0006
Surface Water 1	13/12/2011		0.68	0.26	5.2	18	11	0.49	0.003	< 0.0001	0.003	0.005	0.001	0.584	0.007	0.017	1.15	< 0.0001
	24/01/2012	'	0.41	0.06	1.1	8	6	0.54	0.003	<0.0001	0.002	0.003	<0.001	0.479	0.005	0.005	1.48	< 0.0001
	2/05/2012		4.57	0.11	9.1	48	20	0.4	0.003	<0.0001	0.003	0.006	<0.001	1.02	0.007	0.018	1.34	<0.0001
	17/08/2012	<b> </b> '	-	-	<u> </u>	-	-	-	-		-		<u> </u>	-		-	-	-
Surface Water 2	13/12/2011		0.52	0.15	3.3	24	5	1.05	0.003	<0.0001	0.002	0.004	0.001	0.446	0.006	0.012	1.63	< 0.0001
	24/01/2012		0.11	<0.01	0.4	21	4	0.31	0.003	<0.0001	0.001	0.002	<0.001	0.848	0.006	<0.005	1.52	< 0.0001
	2/05/2012		4.9	0.14	9.2	26	7	1.6	0.003	<0.0001	0.003	0.005	0.002	1.9	0.007	0.016	3.11	< 0.0001
	17/08/2012	<b> </b> '	0.56	-	2.4	21	- 1	-	0.002	<0.0001	0.001	0.001	0.001	2.01	0.006	0.006	1.41	< 0.0001
Surface Water 3	13/12/2011	L	0.1	<0.01	1	14	3	1.09	0.002	<0.0001	0.002	0.005	<0.001	0.291	0.004	0.021	2.03	< 0.0001
	24/01/2012	L	0.01	<0.01	<0.1	<1	<2	0.02	<0.001	<0.0001	<0.001	<0.001	<0.001	0.247	< 0.001	<0.005	0.99	< 0.0001
	2/05/2012		0.07	<0.01	0.4	2	<2	0.06	<0.001	<0.0001	<0.001	<0.001	<0.001	0.204	< 0.001	<0.005	0.69	< 0.0001
	17/08/2012		0.07	-	0.1	2	-	-	<0.001	<0.0001	<0.001	<0.001	<0.001	0.318	< 0.001	<0.005	1.21	< 0.0001
Surface Water 4	13/12/2011		0.18	0.01	0.8	7	<2	0.65	0.002	<0.0001	<0.001	0.002	<0.001	0.132	0.002	<0.005	1.38	< 0.0001
	24/01/2012		0.02	<0.01	0.3	7	<2	0.02	0.001	<0.0001	<0.001	<0.001	<0.001	0.343	0.002	<0.005	1.79	< 0.0001
	2/05/2012		0.14	0.02	0.8	3	<2	0.04	<0.001	<0.0001	<0.001	<0.001	<0.001	0.252	0.001	<0.005	0.87	< 0.0001
	17/08/2012		0.04	-	0.2	2	-	-	<0.001	<0.0001	<0.001	<0.001	<0.001	0.54	<0.001	<0.005	1.19	< 0.0001
Surface Water 5	13/12/2011		0.16	<0.01	1.3	7	<2	0.76	0.001	<0.0001	<0.001	0.003	<0.001	0.114	0.002	0.007	1.62	< 0.0001
	24/01/2012		0.02	<0.01	17.3	7	<2	<0.01	0.001	<0.0001	<0.001	<0.001	<0.001	0.301	0.002	<0.005	1.86	< 0.0001
	2/05/2012		0.1	0.02	1.8	3	<2	0.03	<0.001	<0.0001	<0.001	<0.001	<0.001	0.252	0.001	<0.005	1.08	< 0.0001
	17/08/2012		0.06	-	0.3	3	-	-	<0.001	<0.0001	<0.001	<0.001	<0.001	0.545	< 0.001	<0.005	0.97	< 0.0001
Surface Water 6	13/12/2011		0.04	<0.01	4.3	2	<2	0.94	0.001	< 0.0001	<0.001	0.002	<0.001	0.093	0.001	0.006	1.09	< 0.0001
	24/01/2012		0.09	<0.01	0.3	2	<2	0.04	< 0.001	< 0.0001	<0.001	0.001	<0.001	0.22	< 0.001	0.006	0.76	< 0.0001
	2/05/2012		0.09	<0.01	0.2	1	<2	0.07	<0.001	<0.0001	<0.001	<0.001	<0.001	0.156	< 0.001	<0.005	0.31	< 0.0001
	17/08/2012		0.06	-	0.6	1	-	-	<0.001	<0.0001	<0.001	<0.001	<0.001	0.35	< 0.001	<0.005	0.68	< 0.0001
Leachate	13/12/2011		0.69	<0.01	17.7	1780	1430	0.22	0.167	0.0006	0.24	0.011	0.005	0.258	0.088	0.093	3.49	<0.0010
	24/01/2012		1440	<0.10	2400	1810	1220	0.13	0.169	0.0002	0.312	0.006	0.004	0.126	0.103	0.08	4	< 0.0001
	2/05/2012		1500	<0.10	1510	949	885	0.23	0.128	0.0004	0.196	0.035	0.004	0.583	0.091	0.072	3.33	< 0.0001
	17/08/2012		2160	-	1970	1800			0.17	0.0003	0.265	0.008	0.004	0.11	0.11	0.064	2.93	< 0.0001

Legend:

Metals were reported as total metals in Dec.11, Jan.12, and May 12 s

No Access in the Aug. 12 sampling round

			Monocycli	ic Aromatic	Hydrocarb	ons						Oxygenate	ed Compou	nds		Sulfonated	Fumigants				
		Analytes	Styrene	, Isopropylbenzene	, n-Propylbenzene	1.3.5-Trimethylbenzene	, sec-Butylbenzene	1.2.4-Trimethylbenzene	tert-Butylbenzene	, p-lsopropyltoluene	, n-Butylbenzene	, Vinyl Acetate	, 2-Butanone (MEK)	4-Methyl-2-pentanone (MIBK)	, 2-Hexanone (MBK)	, Carbon disulfide	2.2-Dichloropropane	1.2-Dichloropropane	, cis-1.3-Dichloropropylene	, trans-1.3-Dichloropropylene	1.2-Dibromoethane (EDB)
		Unit	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L F	µg/L
Sample ID	Sample Date		5	5	5	5	5	5	5	5	5	50	50	50	50	5	5	5	5	5	-
Surface Water 1	13/12/2011	ANZLEC		5	5	5	- <5	5	- <5	- <5	5	<50	- <50	- <50	-	5	- <5	- <5	- <5	5	- <5
Surface Water 1	24/01/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50	<50	<50	<50	<5	<5	<5	<5	<5	<5
	2/05/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50	<50	<50	<50	<5	<5	<5	<5	<5	<5
	17/08/2012		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface Water 2	13/12/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50	<50	<50	<50	<5	<5	<5	<5	<5	<5
	24/01/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50	<50	<50	<50	<5	<5	<5	<5	<5	<5
	2/05/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50	<50	<50	<50	<5	<5	<5	<5	<5	<5
	17/08/2012												<50	<50		-	-	-	-	-	-
Surface Water 3	13/12/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50	<50	<50	<50	<5	<5	<5	<5	<5	<5
	24/01/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50	<50	<50	<50	<5	<5	<5	<5	<5	<5
	2/05/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50	<50	<50	<50	<5	<5	<5	<5	<5	<5
	17/08/2012												<50	<50	-	-	-	-	-	-	-
Surface Water 4	13/12/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50	<50	<50	<50	<5	<5	<5	<5	<5	<5
	24/01/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50	<50	<50	<50	<5	<5	<5	<5	<5	<5
	2/05/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50	<50	<50	<50	<5	<5	<5	<5	<5	<5
	17/08/2012												<50	<50	-	-	-	-	-	-	-
Surface Water 5	13/12/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50	<50	<50	<50	<5	<5	<5	<5	<5	<5
	24/01/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50	<50	<50	<50	<5	<5	<5	<5	<5	<5
	2/05/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50	<50	<50	<50	<5	<5	<5	<5	<5	<5
	17/08/2012												<50	<50	-	-	-	-	-	-	-
Surface Water 6	13/12/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50	<50	<50	<50	<5	<5	<5	<5	<5	<5
	24/01/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50	<50	<50	<50	<5	<5	<5	<5	<5	<5
	2/05/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<50	<50	<50	<50	<5	<5	<5	<5	<5	<5
	17/08/2012		<u> </u>										<50	<50	-	-	-	-	-	-	-
Leachate	13/12/2011		<5	<5	<5	<5	<5	10	<5	13	<5	<50	3100	80	<50	<5	<5	<5	<5	<5	<5
	24/01/2012		<5	<5	<5	<5	<5	7	<5	9	<5	<50	4250	70	<50	<5	<5	<5	<5	<5	<5
	2/05/2012		<5	<5	<5	<5	<5	8	<5	13	<5	<50	1530	<50	<50	<5	<5	<5	<5	<5	<5
	17/08/2012												2220	70	-	-	-	-	-	-	-

Legend:

Metals were reported as total metals in Dec.11, Jan.12, and May 12 :

No Access in the Aug. 12 sampling round

			Halogenat	ed Aliphati	c Compour	nds												
		Analytes	Dichlorodifluoromethane	Chloromethane	vinyl chloride	Bromomethane	Chloroethane	Trichlorofluoromethane	1.1-Dichloroethene	odomethane	trans-1.2-Dichloroethene	1.1-Dichloroethane	cis-1.2-Dichloroethene	1.1.1-Trichloroethane	1.1-Dichloropropylene	Carbon Tetrachloride	1.2-Dichloroethane	Trichloroethene
		Unit	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L
-		LOR	50	50	50	50	50	50	5	5	5	5	5	5	5	5	5	5
Sample ID	Sample Date	ANZECC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface Water 1	13/12/2011		<50	<50	<50	<50	<50	<50	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	24/01/2012		<50	<50	<50	<50	<50	<50	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	2/05/2012		<50	<50	<50	<50	<50	<50	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	17/08/2012		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface Water 2	13/12/2011		<50	<50	<50	<50	<50	<50	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	24/01/2012		<50	<50	<50	<50	<50	<50	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	2/05/2012		<50	<50	<50	<50	<50	<50	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	17/08/2012		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface Water 3	13/12/2011		<50	<50	<50	<50	<50	<50	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	24/01/2012		<50	<50	<50	<50	<50	<50	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	2/05/2012		<50	<50	<50	<50	<50	<50	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	17/08/2012		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface Water 4	13/12/2011		<50	<50	<50	<50	<50	<50	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	24/01/2012		<50	<50	<50	<50	<50	<50	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	2/05/2012		<50	<50	<50	<50	<50	<50	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	17/08/2012		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface Water 5	13/12/2011		<50	<50	<50	<50	<50	<50	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	24/01/2012		<50	<50	<50	<50	<50	<50	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	2/05/2012		<50	<50	<50	<50	<50	<50	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	17/08/2012		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface Water 6	13/12/2011		<50	<50	<50	<50	<50	<50	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	24/01/2012		<50	<50	<50	<50	<50	<50	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	2/05/2012		<50	<50	<50	<50	<50	<50	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	17/08/2012		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Leachate	13/12/2011		<50	<50	<50	<50	<50	<50	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	24/01/2012		<50	<50	<50	<50	<50	<50	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	2/05/2012		<50	<50	<50	<50	<50	<50	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	17/08/2012		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Legend:

Metals were reported as total metals in Dec.11, Jan.12, and May 12 :

No Access in the Aug. 12 sampling round

		_												
		Analytes	Dibromomethane	1.1.2-Trichloroethane	- 1.3-Dichloropropane	Tetrachloroethene	1.1.1.2-Tetrachloroethane	trans-1.4-Dichloro-2-butene	cis-1.4-Dichloro-2-butene	1.1.2.2-Tetrachloroethane	1.2.3-Trichloropropane	E Pentachloroethane	1.2-Dibromo-3-chloropropane	Hexachlorobutadiene
		LOR	5	5	5	5	5	5	5	5	5	5	5	5
Sample ID	Sample Date	ANZECC	-	6500	-	-	-	-	-	-	-	-	-	-
Surface Water 1	13/12/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	24/01/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	2/05/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	17/08/2012		-	-	-	-	-	-	-	-	-	-	-	-
Surface Water 2	13/12/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	24/01/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	2/05/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	17/08/2012		-	-	-	-	-	-	-	-	-	-	-	-
Surface Water 3	13/12/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	24/01/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	2/05/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	17/08/2012		-	-	-	-	-	-	-	-	-	-	-	-
Surface Water 4	13/12/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	24/01/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	2/05/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	17/08/2012		-	-	-	-	-	-	-	-	-	-	-	-
Surface Water 5	13/12/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	24/01/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	2/05/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	17/08/2012		-	-	-	-	-	-	-	-	-	-	-	-
Surface Water 6	13/12/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	24/01/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	2/05/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	17/08/2012		-	-	-	-	-	-	-	-	-	-	-	-
Leachate	13/12/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	24/01/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	2/05/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	17/08/2012		-	-	-	-	-	-	-	-	-	-	-	-

Legend:

Metals were reported as total metals in Dec.11, Jan.12, and May 12 :

No Access in the Aug. 12 sampling round

			Monocyclic Aromatic Hydrocarbons							Trihalomethanes					
		Analytes	Chlorobenzene	3r om obenzene	2-Chlorotoluene	4-Chlorotoluene	L.3-Dichlorobenzene	1.4-Dichlorobenzene	L.2-Dichlorobenzene	I.2.4-Trichlorobenzene	I.2.3-Trichlorobenzene	Chloroform	3 romodichlor omethane	Dibromochloromethane	sromoform
		Unit	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L
	-	LOR	5	5	5	5	5	5	5	5	5	5	5	5	5
Sample ID	Sample Date	ANZECC	-	-	-	-	260	60	160	170	10	-	-	-	-
Surface Water 1	13/12/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	24/01/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	2/05/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	17/08/2012		-	-	-	-	-	-	-	-	-	-	-	-	-
Surface Water 2	13/12/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	24/01/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	2/05/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	17/08/2012		-	-	-	-	-	-	-	-	-	-	-	-	-
Surface Water 3	13/12/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	24/01/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	2/05/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	17/08/2012		-	-	-	-	-	-	-	-	-	-	-	-	-
Surface Water 4	13/12/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	24/01/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	2/05/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	17/08/2012		-	-	-	-	-	-	-	-	-	-	-	-	-
Surface Water 5	13/12/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	24/01/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	2/05/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	17/08/2012		-	-	-	-	-	-	-	-	-	-	-	-	-
Surface Water 6	13/12/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	24/01/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	2/05/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	17/08/2012		-	-	-	-	-	-	-	-	-	-	-	-	-
Leachate	13/12/2011		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	24/01/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	2/05/2012		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	17/08/2012		-	-	-	-	-	-	-	-	-	-	-	-	-

Legend:

Metals were reported as total metals in Dec.11, Jan.12, and May 12 s

No Access in the Aug. 12 sampling round

Concentration exceed the ANZECC Guidelines

		-	Total Phenolics	Polynuclea	r Aromatic	Hydrocarb	ons													-
		Analytes	Total Phenols	Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benz(a)anthracene	Chrysene	Benzo(b)fluoranthene	Benzo(k)fluoranthene	Benzo(a)pyrene	Indeno(1.2.3.cd)pyrene	Dibenz(a.h)anthracene	Benzo(g.h.i)perylene	Sum of PAHs
		Unit	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	µg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L
Sample ID	Sample Date		50	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.5
Surface Water 1	13/12/2011	ANZECC	50	<1.0	-10	-10	-	- 10	- 10	-	-10	- 10	-	-10	-10	-	-	-10	-	-
Surface Water 1	24/01/2012		<50	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0	<0.5
	2/05/2012		<50	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0	<0.5
	17/08/2012		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface Water 2	13/12/2011		<50	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0	<0.5
	24/01/2012		<50	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0	<0.5
	2/05/2012		<50	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0	<0.5
	17/08/2012		<50	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0	<0.5
Surface Water 3	13/12/2011		<50	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0	<0.5
	24/01/2012		<50	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0	<0.5
	2/05/2012		<50	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0	<0.5
	17/08/2012		<50	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0	<0.5
Surface Water 4	13/12/2011		<50	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0	<0.5
	24/01/2012		<50	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0	<0.5
	2/05/2012		<50	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0	<0.5
	17/08/2012		<50	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0	<0.5
Surface Water 5	13/12/2011		<50	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0	<0.5
	24/01/2012		<50	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0	<0.5
	2/05/2012		<50	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0	<0.5
	17/08/2012		<50	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0	<0.5
Surface Water 6	13/12/2011		<50	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0	<0.5
	24/01/2012		<50	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0	< 0.5
	2/05/2012		<50	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0	< 0.5
1	17/08/2012		<50	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0	< 0.5
Leachate	13/12/2011		2830	6.2	<4.7	<4.7	<4.7	<4.7	<4.7	<4.7	<4.7	<4.7	<4.7	<4.7	<4.7	<4.7	<4.7	<4.7	<4.7	6.2
	24/01/2012		3750	<9.6	< 9.6	<9.6	<9.6	<9.6	<9.6	<9.6	<9.6	<9.6	<9.6	<9.6	<9.6	<9.6	<9.6	<9.6	<9.6	<9.6
	2/05/2012		2280	11.1	<9.4	<9.4	<9.4	<9.4	<9.4	<9.4	<9.4	<9.4	<9.4	<9.4	<9.4	<9.4	<9.4	<9.4	<9.4	11.1
	1//08/2012		2070	<9.4	<9.4	<9.4	<9.4	<9.4	<9.4	<9.4	<9.4	<9.4	<9.4	<9.4	<9.4	<9.4	<9.4	<9.4	<9.4	<9.4

Legend:

Metals were reported as total metals in Dec.11, Jan.12, and May 12 s

No Access in the Aug. 12 sampling round

Concentration exceed the ANZECC Guidelines

		<b>-</b>	BTEX							Total Petroleum Hydrocarbons					Fotal Recoverable Hydrocarbons					
		Analytes	Benzene	Toluene	Ethylbenzene	m- & p-Xylene	o-Xylene	Total Xylenes	Sum of BTEX	C6 - C9 Fraction	C10 - C14 Fraction	C15 - C28 Fraction	C29 - C36 Fraction	C10 - C36 Fraction (sum)	C6 - C10 Fraction	C6 - C10 Fraction minus BTEX (F1)	>C10 - C16 Fraction	>C16 - C34 Fraction	>C34 - C40 Fraction	>C10 - C40 Fraction (sum)
		Unit	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L
Sample ID	Sample Date		1	2	2	2	2	2	1	20	50	100	50	50	20	20	100	100	100	100
Surface Water 1	12/12/2011	ANZELL	950	-	-	200	<b>350</b>	-	-		-	-	-	-	- 20	-	-	-	-	-100
Surface Water 1	24/01/2012		<1	<5	<2	<2	<2	<2	<1	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	2/05/2012		<1	<2	<2	<2	<2	<2	<1	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	17/08/2012		-	-	-	-	-	-	-	-	-		-	-	-	-				-
Surface Water 2	13/12/2011		<1	<5	<2	<2	<2	<2	<1	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	24/01/2012		<1	<5	<2	<2	<2	<2	<1	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	2/05/2012		<1	<2	<2	<2	<2	<2	<1	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	17/08/2012		<1	<2	<2	<2	<2	<2	<1	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
Surface Water 3	13/12/2011		<1	<5	<2	<2	<2	<2	<1	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	24/01/2012		<1	<5	<2	<2	<2	<2	<1	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	2/05/2012		<1	<2	<2	<2	<2	<2	<1	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	17/08/2012		<1	<2	<2	<2	<2	<2	<1	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
Surface Water 4	13/12/2011		<1	<5	<2	<2	<2	<2	<1	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	24/01/2012		<1	<5	<2	<2	<2	<2	<1	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	2/05/2012		<1	<2	<2	<2	<2	<2	<1	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	17/08/2012		<1	<2	<2	<2	<2	<2	<1	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
Surface Water 5	13/12/2011		<1	<5	<2	<2	<2	<2	<1	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	24/01/2012		<1	<5	<2	<2	<2	<2	<1	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	2/05/2012		<1	<2	<2	<2	<2	<2	<1	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	17/08/2012		<1	<2	<2	<2	<2	<2	<1	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
Surface Water 6	13/12/2011		<1	<5	<2	<2	<2	<2	<1	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	24/01/2012		<1	<5	<2	<2	<2	<2	<1	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
	2/05/2012		<1	<2	<2	<2	<2	<2	<1	<20	<50	<100	200	200	<20	<20	<100	300	<100	300
	17/08/2012		<1	<2	<2	<2	<2	<2	<1	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100
Leachate	13/12/2011		3	28	10	21	13	34	75	270	36200	37100	490	73800	240	160	35100	28800	<100	63900
	24/01/2012		2	16	6	13	9	22	46	220	27000	24200	510	51700	140	90	30200	18900	<100	49100
	2/05/2012		3	53	9	20	12	32	97	540	39500	40600	610	80700	590	490	36600	33600	110	70300
	17/08/2012	1	4	33	12	26	17	43	92	370	23800	19200	220	43200	410	320	22100	14100	<100	36200

Legend:

Metals were reported as total metals in Dec.11, Jan.12, and May 12 s

No Access in the Aug. 12 sampling round

Concentration exceed the ANZECC Guidelines







## WHYTES GULLY RESOUCE RECOVERY PARK

# LANDSCAPE STRATEGY

## SUMMARY REPORT

7 March 2012

prepared for

# **Golder Associates Pty Ltd**

by



Landscape Architecture • Urban Design Suite 3, 38 Albany Street • St Leonards • NSW 2065 T (02) 9906 6636 • F (02) 9906 6634 E office@corkeryconsulting.com.au • www.corkeryconsulting.com Whytes Gully Resource Recovery Park - Landscape Strategy

Date	Issue	Status	Signed
23.01.12	Issue A	Preliminary Draft	Mit lookeng
28.02.12	Issue B	Final Draft	Mit lookeng
07.03.12	Issue C	Final	Mile Contrang

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Whytes Gully Resource Recovery Park - Landscape Strategy

#### **1.0 OBJECTIVES AND PRINCIPLES**

The Landscape Strategy presented in this Report provides the basis for planning and design of the post-completion landscape at the Whytes Gully Resource Recovery Park (WGRRP). The Landscape Strategy will guide the transition from the operational stage of the new landfill to the post completion stage by addressing the recommendations of the Visual Impact Assessment carried out as part of the Environmental Assessment prepared by Golder Associates.

The Strategy aims to create a landscape that is both robust and visually compatible with the character of surrounding areas while requiring minimum maintenance once it is established. The Strategy takes account of the operational requirements of the Landfill, which includes staging of the landfill operations, slope stability, stormwater management, maintenance access and bushfire management.

The proposed plant species and planting structure will establish vegetation that forms a sustainable ecosystem similar to the adjoining areas of remnant vegetation providing wildlife habitat and contributing to the ecological values of the region.

The proposed landscape works will also add value to the site by creating potential public open space recreation opportunities following completion of the landfill operations and closure of the site.

#### 2.0 KEY COMPONENTS

The Landscape Strategy incorporates the following Key Components:

- staging of the revegetation will aim to ensure the area of un-vegetated landfill slope is minimised by progressively establishing a vegetation cover on each section of slope as it is completed;
- existing vegetation on the portions of site not required for landfill, particularly mature remnant trees, will be retained wherever possible to provide visual screening and contribute to the landscape character of the site;
- vegetation to be established on the landfill slopes will include a mix of shrubs and small trees with areas of grass that will create a landscape character similar to adjoining rural areas;
- the top of the new landform will be visually modified to ensure it is visually compatible with the surrounding topography;
- views to the coast will be maintained from the potential lookout area on the landfill ridgeline and from properties upslope of the site;
- screen planting with dense tall tree planting on natural ground will be used to block views to the site, particularly from adjoining residences;
- biodiversity and habitat values will be maintained and increased where possible by planting a range of indigenous species;
- the potential will be created for future public open space facilities such as a lookout and passive recreation areas with access provided by upgrading the maintenance track to the top of landfill landform;
- the visibility of drainage channels on the slopes will be minimised by design options that could include the use of dark coloured stone and native grasses;
- provision of a maintenance program that includes regular removal of identified weed species;
- coordination of vegetation planting with bushfire management requirements that include access tracks and fuel management zones.

### 3.0 PLANT SELECTION

The selection of plant species to be used in implementing the Landscape Strategy has taken account of various considerations that include:

- visual and landscape character of surrounding areas;
- growing conditions including soils, aspect and drainage;
- functional requirements that include visual screening, erosion control, weed management and minimising maintenance;
- ecological and biodiversity values of the site and adjoining areas;

In selecting the plant species to be used in the various locations the following planting types have been identified and are referred to on the Landscape Strategy Plan:

Type 1 - Screen planting along site boundary

Type 2 - Tree planting on natural ground

Type 3 - Shrub and small tree planting on landfill

Type 4 - Grass planting, native and exotic on landfill including drainage channels

In identifying the mix of species to be used in each Planting Type reference has been made to the Whytes Gully New Landfill Cell Development Flora & Fauna Assessment Report, 2011 by Biosis Research for Golder Associates. Particular reference was made to Section 3.1 Vegetation Communities and Appendix 1, Flora Studies Inventory.

Existing remnant plant communities include Lowland Dry Subtropical Rainforest and Moist Box Redgum Foothills Forest occurring on the WGRRP site are to be retained and protected.

Planted vegetation is to be retained wherever possible subject to the bushfire mitigation measures described in the Bushfire Report Section 5.0, which include:

- the canopies of retained trees are to be a minimum of 10m from any building;
- planted trees are to have lower branches trimmed to a height of 2m above the ground.

The Bushfire Report recommends that fuel load formed by vegetation should not exceed 2t/ha.

#### 4.0 PLANTING TYPES

The Landscape Strategy includes four recommended Planting Types that respond to different growing conditions and aim to achieve specific landscape objectives. Each of these Planting Types are described in terms of their objective and implementation requirements.

#### Type 1 - Screen planting along boundaries

The proposed planting along sections of the site boundary is intended to provide visual screening of the landfill operations from adjoining properties. In order to fulfil this function the planting will need to be carried out in advance of the landfill operations. A minimum of 5 years growth will be required to provide the intended visual screening.

Mixture of tall and small canopy trees combined with shrub understorey along the edges is proposed to provide visual screening and to form a closed canopy that will minimise the growth of weeds.

Detailed design of the planting will need to take account of access tracks and fuel load levels required for bushfire management.



Site preparation is to include ripping to a minimum depth of 300mm to create suitable soil profile for tree root growth. Coarse wood chip mulch is to be applied to maintain soil moisture and reduce weed growth. Tree guards are to be installed to protect the plants from rabbits and other animals while providing an improved microclimate for the plant and protection from wind.

#### Type 2 - Tree planting on natural ground

The objective of this Planting Type is to provide additional visual screening to views of the landfill operations from public roads and areas adjoining the site. Trees are to be planted in informal clumps to create an appearance similar to the remnant clumps of trees occurring on the site and adjoining areas. Spacing between 1.5 and 3m centres is recommended, depending on species.



TYPE Z

The locations identified for this Planting Type have natural soil profiles that generally provide good growing conditions. Ground preparation should include deep ripping to a minimum of 300mm and removal of existing grass and weeds using a non-residual herbicide such as Roundup.

Trees to be planted should be supplied in 5 litre container sizes.

Tree guards are to be installed to protect the plants from rabbits and other animals while providing an improved microclimate for the plant and protection from wind.

Coarse wood chip mulch is to be placed over the soil surface to maintain soil moisture and reduce weed growth.

#### Type 3 – Shrubs and small trees on landfill

The objective of this Planting Type is to establish areas of vegetation consisting of shrubs and small tree to reduce the visual prominence of the landfill landform by creating a landscape character similar to adjoining rural land use areas. It will also create visual variation in the apparent height of the ridgeline to be created by the proposed landfill operations.



Requirements for ongoing maintenance will be reduced by creating a continuous canopy cover that will suppress weed growth.

The dense layered vegetation structure will resemble the ecosystems within the remnant vegetation adjoining the landfill, enhancing wildlife habitat and biodiversity.

The recommended species are suitable for the limited soil depth that will be provided on top of the impermeable membrane over the landfill cells. Planting of tubestock is recommended to allow plants to adapt to these growing conditions. Plant roots should be pruned in the nursery to encourage lateral root development prior to planting.

Dense planting in an informal layout will create a closed canopy relatively quickly to minimise weed growth and visually relate the new vegetation to existing vegetation adjoining the landfill.

A minimum depth of 1 metre will be required to allow adequate root growth to ensure plant survival during periods of low rainfall. If shallower soil depths are adopted the final vegetation height may be reduced and some of the trees and shrubs may die during prolonged dry periods unless irrigation is adopted.

The growing medium will need to contain adequate nutrients and organic matter for adequate plant growth. As soil to be used as the growing medium is likely to come from various sources there is likely to be significant variation from one area to another. Regular Soil Testing will therefore need to be carried out in a testing laboratory and recommended treatments implemented.

Site preparation is to include removal of existing grass and weeds using a non-residual herbicide such as Roundup and ripping to a minimum depth of 300mm

Coarse wood chip mulch is to be applied to the soil surface to minimise weed growth and associated maintenance requirements.

If areas of slope are steeper than 1:3 or greater occur then 'Jute mesh' or similar should be applied to provide erosion control.

#### Type 4 - Grass planting on landfill

The objective of this Planting Type is to establish a grass cover on the final landfill slopes that is visually compatible with the landscape character of adjoining rural land use areas and requires minimum maintenance.

A combination of native grasses and pasture species is recommended. The pasture species are to be established on the side slopes of the landfill which are generally 1:4 gradients. Areas of native grass are proposed on the gentler slopes on top of the final landform of the landfill. Native grass species are also recommended for use along the drainage ways where moist growing conditions occur and soil-binding grasses are required.



The grass cover is to be established progressively as each section of landfill is completed to protect the slope from possible soil erosion.

Soil depth of 800mm is recommended to allow the development of deep roots that will assist survival during periods of low rainfall. Soil depth of 500mm may be adequate but the vigour of grasses is likely to be reduced in drought periods due to the reduced available soil moisture provided by 500mm unless irrigation is adopted.

The quality of soil used will need to be monitored to ensure adequate nutrients and organic matter content for healthy growth of the grass. Soil preparation should include cultivation to minimum depth of 150mm and removal of existing weeds using a non-residual herbicide such as Roundup.

Maintenance will include periodic slashing as required for bushfire management and spot spraying of weeds with a non-residual herbicide.

#### **Planting Plans**

The Indicative Plant Schedule presented on the following page lists recommended species to be used in each Planting Type. These species are to be used in preparing detailed Planting Plans that will be required for implementation of the Landscape Strategy. The Planting Plans will need to be coordinated with detailed layout of infrastructure elements including roads, tracks, surface drainage and gas well heads. A Landscape Maintenance Schedule will also need to be prepared that is coordinated with the landfilling operations and landfill closure plan.

### INDICATIVE PLANT SCHEDULE - Whytes Gully Recovery Park

BOTANICAL NAME	COMMON NAME	Type 1 Screen Planting along Boundary	Type 2 Tree Planting on Natural Ground	Type 3 Shrub & Small Tree Planting on Landfill	Type 4 - Grass planting on landfill
Tall Canopy Trees					
Acacia melanoxylon	Black Wattle				
Angophora floribunda	Rough-barked Apple				
Casuarina glauca	Swamp Oak				
Diploglottis australis	Native Tamarind				
Cryptocarya glaucescens	Jackwood				
Eucalyptus botryoides x saligna	Blue x botryoides Gum				
Eucalyptus crebra	Narrow-leaved				
Eucalyptus guadrangulata	White-topped Box				
Eucalyptus tereticornis	Forest Red Gum				
Ficus rubiginosa	Port Jackson Fig				
Syzygium australe	Brush Cherry				
Toona australis	Red Cedar				
Small Trees					1
Acacia mearnsii	Black Wattle				
Acacia implexa	Hickory Wattle				
Acmena smithii	Lilly Pilly				
Alphitonia excelsa	Red Ash				
Backhousia myrtifolia	Grey Myrtle				
Brachychiton populneus	Kurrajong				
Diospyros australis	Black Plum				
Glochidion ferdinandi	Cheese Tree				
Melaleuca linariifolia	Snow in Summer				
Melaleuca stypheliodes	Prickly-leafed Tea Tree				
Notelaea longifolia	Large mock-Olive				
Streblus brunonianus	Whalebone Tree				
Shrubs	Two Vicined Hickory	1	1		
Acacia binervata	Two Veined Hickory				
Acacia falcata	Sickle Wallie				
Acacia longifolia	Wattle				
Breynia oblongifolia	Coffee Bush				
Clerodendrum tomentosum	Hairy Clerodendrum				
Dodonaea viscosa	Common Hop Bush				
Bursaria spinosa	Blackthorn				
Hakea salicifolia	Willow-leafed Hakea				
Kunzea ambigua	Tick Bush				
Grasses Native (Dry Zones)					
Astrodanthonia monticola	Small-flower Wallaby Grass				
Imperata cylindrica	Blady Grass				
Lomandra longifolia	Spiny-headed Mat Rush				
Microlaena stipoides	Weeping grass				

BOTANICAL NAME	COMMON NAME	Type 1 Screen Planting along Boundary	Type 2 Tree Planting on Natural Ground	Type 3 Shrub & Small Tree Planting on Landfill	Type 4 - Grass planting on landfill
Poa labillardieri	Tussock Grass				
Themeda australis	Kangaroo Grass				
Fimbristylis dichotoma	Common Finge- sedge				
Grasses Native (Wet Zones)					
Carex appressa	Tall Sedge				
Gahnia sieberiana	Red Fruited Saw Sedge				
Juncus continuus	Rush				
Lepidosperma laterale	Variable Sword Sedge				
Oplismenus imbecillis	Basket Grass				
Pasture Grasses					
Austrodanthonia richardsonii	Wallaby Grass				
Cynodon dactylon	Unhulled Couch				
Microlaena stipoides	Weeping grass				
Themeda australis	Kangaroo Grass				
Cover Crop		•	•	•	
Echinocloa itilis (Sept-Mch) or Secale cereale (Apr-Aug)	Japanese Millet or Rye Corn				
Lolium multiflorum	Eclipse Rye				
Trifolium pratense	Red clover				

#### 5.0 LANDSCAPE MAINTENANCE

The Landscape Strategy incorporates measures to minimise maintenance requirements which will decline as the new vegetation is established in particular areas. However, there will be a need for some ongoing landscape maintenance to ensure it achieves the objectives of the Landscape Strategy and fire management requirements.

The main ongoing maintenance will involve weed management. The primary objective will be to minimise the introduction of weeds to the site and control those that currently occur.

The following general recommended measures should be incorporated into Maintenance Schedules as part of Detailed Planting Plans:

- ensure plant stock as well as wood chip mulch are free of weeds;
- carry out regular inspections of the site to identify the presence of weeds and implement appropriate control measures;
- remove dead vegetation and replace failed plantings;
- replace areas of failed grass sowing to ensure continual cover of vegetation over the landfill ground surface;
- check and repair or replace tree guards if damaged or missing;
- fertilise plants during the growing season;
- prune trees and shrubs to meet bushfire mitigation requirements;
- check for pests and diseases and implement control measures;
- maintain an adequate depth of mulch;
- slash and / or mow grasses to maintain a fuel load that does not exceed 2t/ha.

### 6.0 LANDSCAPE STRATEGY PLAN AND CROSS SECTIONS



#### LEGEND

-	Site boundary
_	New landfill boundary
	Proposed contours (5m intervals)
	Existing trees to be retained
<b>***</b>	Proposed screen planting along boundary
	Proposed small tree & shrub planting on landfill
	Proposed tree planting on natural ground
	Proposed grass on landfill slopes
	Existing ponds retained
A	Potential lookout area
B	Potential passive open space recreation area
	Existing industrial buildings on site
	Existing residential buildings adjoining site



#### 1:4000 @ A3

Project

Whytes Gully Resource Recovery Park

Client

Golder Associates Pty Ltd

#### Drawing Title

## Landscape Strategy Plan

Drawing No	
LS-001	

Rev C

Date

7 March 2012

FINAL

Landscape Architect



Landscape Architecture Urban Design

Suite 3, 38 Albany Street St Leonards NSW 2065 T (02) 9906 6636 F (02) 9906 6634 E office@corkeryconsulting.com www.corkeryconsulting.com



Section 1-1 Through Potential Lookout 1:1000 @ A3

1





# ON LANDFILL SLOPE (TYPE 3 PLANTING)

#### Project Whytes Gully Resource Recovery Park

Client

Golder Associates Pty Ltd

Drawing Title

#### Landscape Cross Sections

Drawing No	Rev
LS-002	С
Date 7 March 2012	FINAL

Landscape Architect



Landscape Architecture Urban Design

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**Noise Management Plan** 





### 3.0 ENVIRONMENTAL MANAGEMENT PLANS

CEMP

### 3.1 Air Quality

#### 3.1.1 Environmental Aspects and Impacts

The most likely contributors to affect air quality at the site include but are not limited to:

- Vegetation removal during construction
- Haul Roads
- Equipment and Plant Emissions
- Dust generation during earthworks construction and stockpiling of materials
- Waste material odour generation

#### 3.1.2 Requirements

The CEMP will include procedures for air quality management, including dust and odour, to meet the following objectives:

- To conform with WorkCover, NSW, OEH, NSW and Council requirements for the management of odour, dust, landfill gas and asbestos containing material (if encountered); and
- To minimise odour and dust emissions from the site which could adversely affect air quality or the amenity of the local area.

Works would be conducted with reference to the following relevant guidance documents:

- National Environmental Protection Council (1998); National Environment Protection Measure (NEPM) on Ambient Air Quality.
- DEC, NSW (2005); Approved Methods for the Modelling and Assessment of Air Pollutants in NSW.
- DEC, NSW (2007); Approved methods for the Sampling and Analysis of Air Pollutants in NSW.
- NSW Solid Waste Landfill Guidelines, NSW EPA 1996
- National Occupational Health and Safety Commission, 2nd Edition (NOHSC; 2002(2005)) Code of Practice for the Safe Removal of Asbestos.

#### 3.1.3 Management Strategy / Control Measures

The Contractor, in order to limit air quality impacts shall as a minimum:

- Minimise the dust, odours and emissions generated onsite due to construction activities.
- Consider weather conditions prior to commencing work.
- Not burn any materials onsite.

#### Plant and Equipment

The Contractor will develop a plan that includes the following requirements for machines:

- All plant used on site shall comply with OEH licence conditions.
- Operators of machinery will make a concerted effort to minimise unnecessary movements onsite.





- Operators of machinery must comply with speed limits established onsite by the Wollongong Council.
- Trucks carrying materials or travelling on public roads should be covered to prevent spills or dust emissions.
- Trucks travelling offsite must have their tires cleaned to prevent spillage of soils offsite.

#### **Dust Suppression**

Dust generation and transport off-site will be controlled by:

- Provision of shade cloth along the site boundary fences. This can be limited as required to the current areas of work.
- Use of water sprays to suppress dust generation.
- Watering of active work areas including haul roads and stockpiles by water cart and/or sprinklers to suppress dust in dry conditions when necessary (the water will be applied across ground surfaces to prevent the surface drying out and generating visible levels of dust, either by the operation of equipment over the surface or by wind).

#### **Odour Control**

The Contractor should manage the amount of odour, landfill gas or vapour generated from the proposed works, and ensures minimal impact on the air quality of the local area and health of onsite workers and the general community.

The Contractor should implement the following measures:

- The area of waste exposed at any one time would be minimised wherever possible by a localised staged program.
- Cover material should be applied of an increasing thickness to control odour whenever necessary.

#### Landfill Gas

 Landfill gas emissions will be monitored during the works in the waste excavation areas. If elevated readings are obtained work methods will be reviewed and changed as necessary.

#### 3.1.4 Monitoring

The ambient air quality monitoring program shall be conducted by the Contractor throughout the contract period. The purpose of the monitoring program shall be to monitor the Contractor's compliance with ambient air quality standards at the boundaries of the site, and to demonstrate that site works undertaken by the Contractor have not adversely impacted surrounding areas.

- The monitoring program shall involve dust monitoring, odour assessments and explosive gases (methane).
- Dust control measures will be monitored by qualitative assessment (i.e. visual inspection) and air quality monitoring. Visual assessments will be conducted at the start of each new construction activity. Quantitative air quality monitoring will be conducted on a monthly basis.
- Odour assessment should be performed prior to, during and following the proposed waste relocation works. Explosive gas monitoring will be conducted over areas where waste or leachate has been exposed at the commencement of an activity.




# 3.1.5 Corrective Action

The ambient air quality shall be considered to be unacceptable should any one result fail to meet the air quality standards.

In the event that the ambient air quality is found to be unacceptable, the Contractor shall immediately instigate works to rectify the ambient air quality in order that it reaches an acceptable quality within the shortest time period. Rectification of the ambient air quality shall initially involve the suspension by the Contractor of any activity that is contributing to the generation of unacceptable dust, odours, explosive gases.

# 3.2 Water Quality

# 3.2.1 Environmental Aspects and Impacts

Water quality impacts are most likely to be caused by:

- Haul Road Erosion
- Erosion of stockpiles
- Erosion due to vegetation removal during construction
- Off site impact by contaminated runoff

### 3.2.2 Requirements

The CEMP will include procedures for management of water to meet the following objectives:

- To prevent surface run off from becoming contaminated as a result of soil disturbance or contact with waste.
- To control erosion and sediment transport from the site, and thereby minimise the potential for off-site contamination of surface water by sediment.
- To control and manage run off in sediment control ponds prior to discharge from the site.
- To minimise potentially contaminated groundwater entering excavations.

# 3.2.3 Management Strategy / Control Measures

Surface water on this project falls into 2 categories as follows:

- Clean' stormwater all water which falls on undisturbed areas of the site
- 'Dirty; stormwater all water which falls over disturbed areas. (i.e. cleared for construction or stockpiles of uncontaminated material) areas and is potentially contaminated with gross pollutants, sediments, etc.
- 'Leachate' all water which falls over areas of exposed waste

The Contractor shall develop detailed Soil and Water Management Plans including schematics of planned control measures. The Contractor may be allowed to use existing stormwater management infrastructure following negotiation with council.

#### 3.2.3.1 Control and Management of "Clean" Stormwater

All "clean" stormwater shall be managed in accordance with the requirements of DECC, 2008, Managing Urban Stormwater, Soils and Construction, Volume 2B Waste Landfills, June 2008





"Clean" stormwater within the site shall be allowed to discharge directly into the existing natural drainage system with no treatment and/or containment required. "Clean" stormwater runoff will be diverted around disturbed areas to minimise the volume of "dirty" water generated.

The Contractor shall intercept and redirect runoff in a controlled manner by any appropriate means including but not limited to, use the existing drainage, construct new drains and temporary bunds to direct stormwater runoff from up-gradient around any construction onsite.

# 3.2.3.2 Control and Management of "Dirty" Stormwater

All "dirty" stormwater shall be managed in accordance with the requirements of DECC, 2008, Managing Urban Stormwater, Soils and Construction, Volume 2B Waste Landfills, June 2008

The Contractor shall implement the following control measures to mange "Dirty" Stormwater impacted by sediment as a minimum:

- Construction of temporary sediment ponds with disposal by:
  - Evaporation from the pond surface
  - Use for dust suppression
  - Use for irrigation of revegetated areas
  - Treated to remove the suspended solids and minor gross pollutants and disposal to the natural drainage system
- Erosion and sediment control must be installed prior to any earthworks or site disturbance.
- Construct upslope diversion drains to collect and divert clean water around the active construction areas. Diversions must be installed and maintained to prevent off-site surface water run-off from entering disturbed areas of the site.
- Keep working face and areas of open excavation to a minimum.
- Do not place stockpiles within 30 metres of any watercourse.
- Place an effective combination of sediment filters, barriers and/or basins at the down slope boundary of all disturbed areas. Place silt fence/erosion controls around stockpiles.
- Stabilise all disturbed areas as soon as practicable. Temporary vegetative destabilisation techniques must be applied to any disturbed soil to prevent areas remaining bare for more than 28 days.
- Stabilise all temporary and permanent drainage immediately.
- Maintain all sediments and erosion control measures in effective condition until the works are completed and the site is stabilised.
- Clean sediment traps when their capacity is reduced by 30 percent.
- Bund fuels, oils, paints, and other chemicals onsite to comply with the requirements of;
  - AS1940B 1993: The Storage and handling of Flammable and Combustible Liquids
  - AS4452B 1997; The Storage and Handling of Toxic Substances
  - Dangerous Goods (Roads and Rail Transport) Act 2008
- Bunds must be fitted with an impervious floor and must not be fitted with a drain valve.





- Construct vehicular crossings in a manner that prevents sediment from washing into the water course or stream.
- Remove accidental spills of soil or other materials.
- Release "Dirty" Stormwater, captured and stored by sediment and erosion control measures or site works, after treatment and testing to confirm compliance with relevant criteria.
- Rapid re-vegetation of exposed areas where possible.

#### 3.2.3.3 Control and Management of Leachate

All leachate shall be managed in accordance with the requirements of DECC, (2008) Managing Urban Stormwater, Soils and Construction, Volume 2B Waste Landfills, June 2008 and NSW EPA (1996) Environmental Guidelines, Solid Waste Landfills, January 1996.

The general requirements for managing leachate are outlined in the following points:

- All leachate will be diverted to the leachate management system on site.
- Progressive construction of bunds around areas which can give rise to leachate to direct control and direct surface waters away from any exposed waste areas.
- Progressive covering of waste to minimise the available catchment area for the generation of leachate.
- Diversion of upgradient surface waters prior to coming in contact with areas which can give rise to leachate.

#### 3.2.4 Monitoring

The objective of the surface water monitoring plan is to effectively monitor and report surface water character and ensure early detection and reporting of possible pollution to surface water.

The water quality shall be considered to be unacceptable should any one result fail to meet the water quality standards. In the event that the water quality is found to be unacceptable, the Contractor shall immediately instigate works to rectify the water quality in order that it reaches an acceptable quality within the shortest time period.

The Contractor shall regularly inspect the conditions and integrity of protection works at a frequency not less than:

- Prior to the commencement of each working day
- At hourly intervals throughout major storm events
- Prior to the re-commencement of work following rainfall of more than 1 mm

At each inspection the Contractor shall record the condition of the protective works, their performance, the extent of any maintenance, and the need for any additional works.

# 3.2.5 Corrective Actions

The Stormwater Management Plan shall identify mechanisms to identify and address the cause of any sediment dispersion or leachate runoff.





# 3.3 Erosion and Sediment

# 3.3.1 Environmental Aspects and Impacts

Impacts on erosion and sediment are most likely to occur during major rainfall events and heavy wind. The Contractor may combine the erosion and sediment control plan with the stormwater management plan as these two issues are strongly correlated.

## 3.3.2 Requirements

The CEMP will include procedures for management of soil and erosion to meet the objectives of DECC, 2008, Managing Urban Stormwater, Soils and Construction, Volume 2B Waste Landfills, June 2008.

The CEMP will include procedures for management of erosion and sediment to meet the following objectives:

- To control soils released as a result of site excavations and the handling, including stockpiling, loading and/or placement of site and imported materials.
- To control erosion and potential sediment transport from the site.
- To minimise the extent of soil transport and erosion by heavy machinery.

# 3.3.3 Management Strategy / Control Measures

Soil and erosion management during the construction activities may be controlled by:

- Construction of earth bunds and similar diversion drains around the perimeter of construction areas where surface disturbance occurs, to prevent surface water entering these areas.
- Erection of silt fences or straw bales at strategic locations (i.e. around stockpiles) to prevent the migration of fines.
- Construction of temporary sediment retention ponds.
- Installation of water recycling equipment for dust suppression as needed.
- Minimising the surface area disturbed by construction activities at any one time.
- Regular inspection and maintenance of erosion control structures.
- Protecting and retaining surface cover where possible.
- Placement of an erosion protection barrier (e.g. grassing) at the completion of works.
- Restricting vehicles to designated access roads and paths where possible.
- Washing trucks and plant (bodies, wheels and undercarriage) moving from asbestos impacted areas to other areas of the site or off site (if asbestos is found).
- Removing soil adhering to the wheels and undercarriage of trucks (e.g. by wheel wash) prior to departure from the site.

In addition, every effort will be made to limit both the site of any stockpile footprints and the time between excavation and removal off-site of materials.





# 3.3.4 Monitoring

An erosion monitoring program shall be conducted by the Contractors at the site throughout the construction period to monitor compliance with the erosion and sediment plan. Monitoring frequency for erosion and sediment control should be undertaken concurrently with stormwater management monitoring.

# 3.3.5 Corrective Actions

The Erosion and Sediment Control Plan shall identify mechanisms to identify and address the cause of any sediment dispersion or leachate runoff.

# 3.4 Noise

### 3.4.1 Environmental Aspects and Impacts

Noise pollution will most likely be caused by plant and equipment during construction or traffic to and from the site.

## 3.4.1.1 Sensitive Receivers

The nearest residential receivers to Whytes Gully RRP have been identified based upon aerial photos and site visits and are considered to be the most likely noise sensitive receivers to be impacted by the Project based on the attenuation of noise at this location. The noise sensitive receivers are shown in Figure 10.1 and are identified as follows:

- N1 Residence NW of Whytes Gully RRP;
- N2 Residence NE of Whytes Gully RRP;
- N3 Residence SW of Whytes Gully RRP;
- N4 Residence NE of Whytes Gully RRP; and
- N5 Closest Resident at Farmborough Heights.

# 3.4.2 Requirements

The noise management plan will:

- Identify best management practice techniques to minimise noise from the construction and operation of the project; and
- adhere to regulatory limits for noise emissions.

Measures shall be undertaken by the Contractor to minimise the generation of noise from within the site. The Contractor shall use the best available technology and the best practicable means to prevent or mitigate the effects of noise emission from the works, and shall be prepared to demonstrate that plant, equipment and methods comply with these requirements at all times.

# 3.4.3 Project Noise Limits

The noise limits for the project set out by Condition 31 of the CoA are as follows:

Residential Receiver Location	Day L _{Aeq (day)}
N1	47
N2	45
N3	38

#### Table 2: Noise impact assessment criteria dB(A)





Residential Receiver Location	Day L _{Aeq (day)}
N4	35
N5	35

# 3.4.4 Management Strategy/Control Measures

The Contractor is responsible for implementing all noise migration measures required by the CEMP from the start of construction. The Contractor will be responsible or limiting all noise produced on site.

The Contactor shall use the best practical means to minimise noise levels in all sections of work.

The Contractor will include construction noise issues in site induction of staff and sub-contractors. This will include communication of the restrictions on hours of construction, the number and types of known sensitive receivers and their location relative to the project site, and the requirements for implementing noise management set out below.

The Contractor shall implement the following control measures throughout the works:

- Neighbouring premises will be informed of the work programme, potential impacts, and measures taken to minimise the impacts.
- A minimum of 48 hours notice will be given to directly affect premises prior to construction works commencing.
- Advising neighbouring premises of any variation to work hours prior to work commencing.
- Standard construction working hours 7:30 am to 4:30 pm Mondays to Fridays and 8:00 am to 4:00 pm Saturdays. No construction works shall take place on Sundays or Public Holidays. These hours may be varied only with prior written consent of the OEH.
- All vehicles shall enter and leave the site in accordance with the site entry controls.
- Equipment will be selected on the basis of its noise performance and will comply with regulatory standards for noise generation.
- All equipment on site shall be fitted with OEH approved residential silencers
- All items of mobile plant and equipment used are required to be fitted with broadband audible reversing alarms.
- Vibrations generated on the site shall be within relevant noise control guidelines
- Maintenance and/or repairs of plant and equipment may be carried out by the Contractor outside the above hours provided that:
  - Plant and equipment subject to maintenance and/or repairs, and compounds for overnight onsite parking of vehicles and mobile plant, shall be located as far away as possible from noise sensitive premises.
  - The Contractor can demonstrate that noise levels at the site boundaries are not adversely impacted.
  - No heavy machinery shall be operated during this period.





- Noise to be generated by these maintenance and/or repair works during the extended operational hours shall be inaudible at any noise sensitive premises.
- The Contractor will be directed to cease maintenance and/or repair work during the extended operational hours if noise emission becomes audible at any noise sensitive premise.
- Emergency work may be carried out by the Contractor which is required outside the specified hours provided;
  - The site superintendent is satisfied that the proposed work is of an essential nature and cannot be carried out during specific hours.
  - The Contractor submits a report summarising the event to the Site Superintendent within 48 hours after the event commenced.

In order to meet the noise standards, the Contractor shall provide appropriate measures such as the adoption of suitable methodologies, selection of quieter equipment, use of acoustical enclosures, construction of suitable placed acoustic barriers or earth mounds, and the fitting of "residential" class mufflers and noise reduction kits to heavy equipment, controls on the hours of operation or controls on the programming of works shall be implemented.

# 3.4.5 Monitoring

A noise monitoring program shall be conducted by the Contractors at the site throughout the construction period to monitor compliance with the noise emissions limits.

The following noise monitoring will be undertaken:

- Periodic noise monitoring at nominated sensitive receiver locations (refer Section 3.4.3 of this plan) to determine effectiveness of mitigation measures against predicted impacts. Monitoring will include:
  - Compliance noise monitoring at the start of construction activities and subsequently on a monthly basis while significant noise generating activities are being undertaken
  - Where required and in response to a complaint, noise monitoring will be undertaken at the complainant's residence.
- Ongoing spot checks of noise intensive plant and equipment will be undertaken at project commencement and throughout construction to ensure compliance with the manufacturers specifications.
- Details of site activity and equipment usage will be noted during construction noise monitoring including the locations of mobile plant.
- Acoustic instrumentation employed in the use of noise monitoring surveys will comply with the requirements of AS1259.2-1990 Acoustics – Sound Level Meters, Part 2: Integrating – Averaging and carry appropriate NATA (or manufacturer) calibration certificates.

Noise monitoring reports will be prepared which will include the following information:

- Iocations and description of monitoring undertaken
- a tabulation of results and notes identifying the principle noise sources and operations
- summary of any measurements exceeding the noise limits, and descriptions of the plant or operations causing these exceedences
- details of any corrective actions and confirmation of their successful implementation.





# 3.4.6 Corrective Actions

Rectification of unacceptable noise levels shall initially involve the suspension by the Contractor of any activity that is contributing to the generation of unacceptable noise at the site. The rectification measures shall continue to be undertaken by the Contractor until the noise levels comply with the required limit.

# 3.4.7 Negotiated Agreements

In accordance with Chapter 8 of the EPA "NSW Industrial Noise Policy" (2000) negotiated agreements would be commenced prior to construction of the appropriate stage of the Project with the affected community (i.e. Receiver N1 – Stage 3, Receiver N2 – Stage 2).

# 3.5 **Public Roads Aspects and Impacts**

### 3.5.1 Environmental Aspects and Impacts

The condition of public roads adjacent to the Whytes Gully RRP will potentially be impacted by traffic travelling offsite.

# 3.5.2 Requirements

The objective of the Public Roads and Traffic Management within the CEMP will be to undertake the works with regard to the safety and welfare of the general public and to alleviate the impact of additional traffic volumes of site access and traffic flow in the surrounding area.

### 3.5.3 Management Strategy/Control Measures

The Contractor is required to develop a Public Roads and Traffic Management Plan for the works. This would as a minimum include the following control measures:

- Compliance with the requirements of the Construction Traffic Management Plan prepared by GTA Consultants, provided in APPENDIX A.
- Establishment of designated haul routes.
- Utilisation of a transport routes approved in the development consent conditions (if any) when travelling to and from the site as required.
- Access to neighbouring premises will be maintained at all times.
- Require all trucks travelling offsite to clean their tires and undercarriage of any loose soils.
- Ensure all trucks carrying loads offsite have adequately fastened and covered any materials they are carrying.
- If necessary, stockpile materials on-site temporarily to regulate and control the truck movements.
- Selection of roads which are to be used for transport of excavated materials on the basis that they have adequate capacity to accommodate the increased traffic volumes.
- Retention of heavy equipment on-site where practicable.
- Provision for a staging area for vehicles on site to prevent queuing on public roads outside of the site.

All truck drivers carting materials from the site will be given a safety instruction brief. The brief will be concise and shall detail the procedures to be followed by the truck driver should spillage of loads occur. These will include, but not limited to:

Vehicle Accident





# **APPENDIX N**

**Flood Emergency and Evacuation Plan** 



# 14 August 2013

# WHYTES GULLY RESOURCE RECOVERY PARK

# Flood Emergency and Evacuation Plan

Submitted to: Department of Planning and Infrastructure

REPORT



Report Number. Distribution: 117625003_287_R_RevA

Department of Planning and Infrastructure Wollongong City Council Golder Associates





# FLOOD EMERGENCY AND EVACUATION PLAN

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# 1.0 INTRODUCTION

# 1.1 Background

The Whytes Gully Resource Recovery Park (RRP) is located on Reddalls Road, Kembla Grange NSW. The site is generally bounded by Reddalls Road to the south and west, rural residential lands to the north, northeast and north-west, and a water treatment plant to the south east. An industrial area lies to the south of Reddalls Road and Dapto Creek lies to the west.

# 1.2 Purpose

This document forms a practical guide to managing the requirements of the Project Approval in relation to flooding and emergency evacuation. The requirements are presented in Table 1.

Table 1: Con	ditions of Approva	I relevant to Flo	bod Emergency a	and Evacuation Plan

СоА	Condition Requirements	Document Reference
Schedule 4, Condition 16	Flooding Management 16. The Proponent must prepare and implement a Flood Emergency and Evacuation Plan to the satisfaction of the Director-General. The Plan must: a) be prepared by a suitably qualified and experienced expert in	
	<ul> <li>consultation with Council;</li> <li>b) be approved by the Director-General prior to the commencement of construction;</li> <li>c) ensure the project is designed in accordance with Chapter E13 of <i>Wollongong DCP 2009</i>, Council's Mullet and Brooks Creeks Floodplain Risk Management Study and Plan and the NSW Floodplain Development Manual, taking into account Council's conduit blockage criteria;</li> <li>d) identify contingency actions to be implemented in the event that the site is injundated during a major flood event to protect.</li> </ul>	Section 2
	<ul> <li>the integrity of stormwater/leachate ponds and prevent release of stormwater/leachate into the local environment including water quality control measures; and</li> <li>human safety.</li> <li>e) identify emergency evacuation routes, flood warning alarms, and evacuation procedures.</li> <li>This plan must be documented in the Landfill EMP (see Condition 3 in Schedule 5).</li> </ul>	Section 3 and Appendix A

# 1.3 **Design Requirements**

Design of surface water features for the Project relevant to flooding will be conducted in accordance with the requirements of:

- Chapter E13 of Wollongong DCP 2009
- Council's Mullet and Brooks Creeks Floodplain Risk Management Study and Plan
- NSW Floodplain Development Manual
- taking into account Council's conduit blockage criteria.

Design of the surface water features will be documented in design drawings and a design report for each stage of the project.

# 2.0 FLOOD

# 2.1 Existing Environment

The site is located to the north of the Mullet Creek floodplain. To the southwest of the site lies Dapto Creek.

The Whytes Gully site lies upstream of the Mullet Creek floodplain and the majority of the site exists above the flood planning area, as defined in the LEP.

The Mullet Creek floodplain is broad and flat and is hydrodynamically influenced by the Illawarra Railway and Lake Illawarra. Dapto Creek is a minor tributary of the Mullet Creek floodplain of moderate slope, 10 percent below the escarpment, with a contributing catchment of only 280 ha.

The current flood study for Mullet Creek is presented in the Bewsher (2011) "Mullet Creek, West Dapto Extension of Flood Model".

# 2.2 Impact Assessment

The Project would include reconfiguration of the leachate ponds in Lot 50, DP 1022266 as well as reconfiguration of the surface water treatment ponds in the south of Lot 50. The proposed leachate treatment pond lies above the FPL, therefore reconfiguration would not affect flood level or flood behaviour. The footprint of the surface water treatment ponds lie within the FPA (or the interpreted extent including freeboard). However, the proposed configuration would be such so as to maintain existing floodplain storage at this location. Accordingly the Project would not affect flood levels or flood behaviour.

The Project does not include alteration to existing land-use with respect to Lot 51, DP 1022266 and therefore would not affect flood levels or flood behaviour with respect to Lot 51.

A report on surface water routing and flood analysis was prepared by Golder Associates (2012) and is included in APPENDIX B.

# 2.3 Mitigation Measures

The project does not alter the existing flood storage. Accordingly the Project would not affect flood levels or flood behaviour.

# 2.4 Contingency Measures

Possible contingency measures to be implemented in the event that the site is impacted by a major flood event include:

- Temporarily shut down leachate transfer pumps and the leachate treatment system in case of impact of flood waters to leachate treatment system and transfer pumps.
- Sampling of waters discharged from site for leachate indicators in the event that leachate contamination of surface waters is suspected.

# 3.0 EVACUATION

The Wollongong City Council Emergency Response Procedures and Plans & Pollution Incident Response Plan is provided in APPENDIX A. The Plan includes procedures for evacuation, for flooding of entry and exit roads at the site (section 30.5), and for management of escape of leachate from the site (section 29.3).







# **Report Signature Page**

**GOLDER ASSOCIATES PTY LTD** 

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KAD/GRS/kad

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# **APPENDIX A**

**Emergency Response Procedures and Plans** 





**Attachment 9** 



# Wollongong City Council

# **Emergency Response**

# **Procedures and Plans**

&

# **Pollution Incident Response Plan**

For

# Whytes Gully Waste & Resource Recovery Park

Reddalls Road, Kembla Grange (Nearest Cross Street – West Dapto Road)

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ATTACHMENT TO OHS CORPORATE PROCEDURE DEVELOPING EMERGENCY PROCEDURES PROCEDURE

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# 1. Purpose/Scope

The Whytes Gully Waste Facility is a multipurpose facility that has a number of workers, Contractors and members of the public that will need to be managed should an emergency event occur.

The purpose of this emergency plan is to provide a framework which workers and occupants of this facility must utilise in the event of an emergency. The primary function of this plan is to preserve the safety and well being of all occupants. The secondary purpose of this plan is to minimise the possible damage to Council property as well as disruption to Council services. This plan forms part of the **Site Safety Management Plan for Whytes Gully Waste Facility.** 

The outlined response procedures within this document are to be implemented by all Council workers until the appropriate Emergency Services arrive or until such time as the emergency event has been controlled or threat has been removed.

Given the nature of this facility it will require more than one person to effectively evacuate the entire complex during an emergency. It is for this reason that this facility has a number of nominated emergency personnel who will be required to initiate specific responses in the event of an emergency. These nominated emergency personnel (workers) form the basis of the Local Emergency Control Organisation (LECO). See section 4 for names and contact details.

It will be necessary for Council workers of this facility to direct members of the public and any sub Contractors or visitors when a full evacuation of the facility is required.

The Whytes Gully Waste Facility consists of:

- Weighbridge & office;
- o Tip Face
- o Transfer Station
- o Staff Amenities
- Recycle collection area
- o Revolve Centre
- o Green Waste; Scrap Steel & e-waste collection area
- o Leachate Ponds
- Stormwater Ponds

Whytes Gully standard hours of operation are 07.30 – 16.30, 7 days per week

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# 2. What is an Emergency

An emergency is defined as any event that arises internally, or from external sources, which may adversely affect the occupants, visitors or the environment in a facility, and which requires an immediate response.

# 2A Types of Emergencies

The following is a list of all the emergencies that could potential occur at Whytes Gully Waste Facility. Each identified emergency event has been allocated a colour code. This colour code is to be utilised when communicating to fellow workers the emergency event and/or when announcing the emergency. All occupants of Whytes Gully Waste Facility and any other council workers at this facility must be familiar with these codes and what they represent. This is to avoid any confusion, unnecessary panic and to act as a trigger for the initiating of the required response.

.This document outlines the response procedures for Whytes Gully Waste Facility for the listed emergency types:

- Evacuation Code ORANGE
- Fire/Smoke Code **RED**
- Bomb Threat Code **PURPLE**
- Medical Emergency Code **BLUE**
- Personal Threat Code **BLACK**
- Internal Emergency Code YELLOW
  - Loss of Power to Facility (Lighting and Air Conditioning)
  - Loss of Power to Facility (Phones)
  - Loss of Communication (mobiles/landline/PC's)
  - Loss of Water to Facility
  - Sewage Blockage/Flooding (septic)
  - Vehicular Accidents
  - Illegal Occupation
- Pollution/Environmental Emergency Code GREEN
  - Fires in Waste
  - Spill of Hazardous Material
  - Escape of Leachate from site
  - Emission of Gas from the Landfill
- External Emergency Code **BROWN** 
  - Bushfire
  - Earthquake
  - Explosion or industrial accident (adjoining industries)
  - Toxic Emissions or Substance Spills (adjoining industries)
  - Flooding (including entry and exit roads)
  - Severe Weather Conditions ie Winds, Storm Surges, Lightning Storm, Cyclone
  - Transport Incident on road or railway track

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#### **3.** Local Emergency Control Organisation (LECO)

The following table identifies personnel that shall be contacted in the event of an emergency. The listed persons form the Local Emergency Control Organisation (LECO) for this facility.

The LECO is responsible for the development, documentation, implementation and maintenance of this emergency plan and the associated response procedures.

Position	Name	Speed	Mobile No:	Ext	Location
		Dial		No:	
Chief Warden	David Storm		0419-495633		
Deputy Chief Warden	Guy Menagh		0407213744		
Deputy Chief Warden					
Emergency Warden	Col Ketteringham		42609857		
Emergency Warden	Frank Hughes		0423675333		
Emergency Warden					
First Aid Officer/s	Frank Hughes		0423675333		
	Mick Murphy				
Controller of Premises	Wayde Peterson		0408-751-199		
After Hours Emergency					
Council's After Hours	Ask for Waste				
Service Company – Well	After Hours Duty		1300 557 980	4227 7111 Option 1	
Done	Officer				

All of the above listed positions have a key role to play in the event of an emergency. The key functions of the LECO in the event of an emergency include:

- Conduct an orderly evacuation of all occupants to the nominated assembly area and
- Assist Emergency Services personnel upon their arrival to the facility

Council workers, other occupants, official visitors, volunteers, contractors and members of the public shall obey all instructions/directions given to them by any of the above listed personnel in the event of an emergency.

#### The Chief Warden has overriding authority of the facility until the arrival of Emergency Services and all occupants in the event of an emergency. This authority is also extended to the Deputy Chief and the Emergency Wardens.

The LECO have been allocated coloured tabard/s that they must wear in the event of an emergency or a simulated exercise. The tabards will assist in the quick identification of these workers by members of the public and Emergency Services. The identification tabards are:

Chief Warden – white tabard with red lettering Deputy Chief Warden – white tabard with red lettering Emergency Warden – red tabard with white lettering First Aid Officer – green tabard with white cross and white lettering

The facilities LECO will meet **yearly**. All meeting minutes will documented (in line with corporate template).

Meeting minutes to be forwarded to the Corporate Emergency Control Organisation (CECO).

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All LECO members will be trained to develop the skills and knowledge necessary to competently undertake the duties as set out within this plan. Refresher and/or retraining shall occur at intervals no greater than 6 months.

Review dates, staff training schedules to be included on the Inspection and Testing Register & Matrix.

Evacuation Emergency plan to be tested annually and within 1 (one) month of any incident occurring where the plan has been activated.

If an after hours emergency occurs, the following After Hours Company/s that carries out security patrols and alarm monitoring should also be notified.

Southern Cross Protection	-	Security Company Patrols	-	1300 136 102
Active Security	-	Alarm Monitoring	-	4260 7211

Site Controller

**Communication Officer** 

#### Whytes Gully Staff

David Storm (Leading Hand) Guy Menagh Mick Murphy Frank Hughes Col Ketteringham Matt Dowse Harry Finch Ray Mitchell Steven Phillips James Haines

#### Whytes Gully Contractor(s)

Revolve Centre Scrap Steel	-	One Steel (sub contract to One Steel (contact Steve Martin)
Green Waste	-	Thiess
Ammonia Plant	-	URS

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# 4. Evacuation – Code Orange

Evacuation is the orderly movement of people from a place of danger.

The evacuation of Whytes Gully Waste Facility is to occur once an emergency has been identified and there is a potential risk to the heath and safety of any persons.

Within this facility the stages of evacuation are:

**Stage 1:** Remove any person/s away from the immediate vicinity of the danger, if safe to do so. This movement can be to another room, into a hallway or corridor.

**Stage 2:** Move all persons to a safe compartment. This can include beyond a smoke or fire rated door which is located on the same floor/level or the floor/level below.

Full evacuation of all persons from Whytes Gully Waste Facility.

This requires all persons to follow the directions of the Chief Warden or the Deputy Chief Warden or the Emergency Warden. Persons are to attend the nominated assembly area which is the main entrance to the facility - front gates at Whytes Gully or to the alternate assembly area - gate entry to Glengarry eastern carpark (south side of transfer station).

In some instances the Chief Warden will be required to select an alternate assembly area to that which is previously nominated. Should such set of circumstances occur, the Chief Warden will inform all persons at the time of the evacuation or, if possible, prior to the evacuation.

The Chief Warden will contact Council staff (Weighbridge, Transfer Station, Tip Face & Amenities) and contractors (Revolve Centre, Scrap Steel, Green Waste area, Ammonia Plant) via two way radio and/or 'drive through' the waste site and instruct staff to gather in the meeting room. An explanation of the emergency will be given to the staff and instructions given to evacuate to the assembly area. Staff to take their personal belongings and keys only if safe to do so. Staff and Visitors to follow the direction of the Chief Warden who will direct them to one of the 2 designated exits.

The Emergency Warden/s to act as a directional monitor to guide visitors, staff and contractors to the correct exit. The Wardens to carry out sweep of entire site if safe to do so.

The Deputy Chief Warden shall ensure that all occupants have been evacuated. The Emergency Warden/s should be the last to evacuate their designated area. Prior to evacuating the Emergency Warden is to contact the Chief Warden and state that their area is "clear" or outline why the area is not clear. Stating that the area is clear means that there are no persons left.

No person, worker or otherwise, is permitted to re-enter the facility once they have exited. Persons can only re-enter the facility once the direction has been given to do so by the Chief Warden or by the officer-in-charge of the Emergency Service in attendance.

Council workers shall remain in the nominated assembly area until otherwise advised that they can leave the assembly area or have been directed to return to the facility.

Where possible Emergency Warden/s shall conduct a roll call/head count and report the results of this roll call to the Chief Warden verbally or via mobile phone.

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First Aid Officer/s are to make available first aid provisions and provide first aid treatment where required by way of a mobile first aid kit.

Chief Warden to meet emergency authority or combat agency to advise of situation.

The Chief Warden shall undertake a documented debrief following all emergency events. The debrief shall occur as soon as practically possible after the *all clear* has been given and the emergency has been controlled.

NOTE: In an emergency event the intent is to evacuate occupants as *quickly* as you can via any available exits. Once evacuated the occupants are to proceed to the facilities nominated assembly area.

In the event of evacuating due to a bomb threat, occupants shall proceed to the announced assembly area (this may vary from the primary and secondary assembly area) via a specified path of egress.

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# 5. Other Emergency Contact Numbers

When dialling from a landline within Whytes Gully – Amenities you dial [0] then the below listed number.

In all other circumstance dial the number directly.

Name of Service	Contact Number
NSW Police	000
NSW Ambulance	000
NSW Fire Brigade	000
Local Police Station – Dapto	4262 9499
72 Byamee Street	
DAPTO 2530	
Local Area Command	4232 5599
6 Pioneer Drive	
OAK FLATS 2529	40.40.00
Local Ambulance Station – Dapto	13 12 33
Beltana Avenue	
DAPTO 2530	4070 1105
Local Fire Brigade Station – Unanderra	4272 1125
UNANDERRA 2526	
UNANDERIKA 2320	
State Emergency Services (SES – 24hour)	13 25 00 (flood/storm)
	4251 6111 (other)
Office of Environment 8 Heritage (24beur)	
Office of Environment & Heritage (24hour)	13 15 55
Endeavour Energy (24hour)	13 10 03
Boisons Information Contro (24hour)	
Sudpov Water (24 hour)	13 11 20
Sydney Water (24 hour)	13 20 90
WorkCover (24 Hour)	13 10 50
WORCOVER (24 Hours)	13 10 50
WCC Alter Hours Duty Officer	
	1300 557 980 (secondary)
WCC Media Liaison Officer	4227 7100 (business hours)
	. , , , , , , , , , , , , , , , , , , ,
	0419 251 607 (after hours)

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# 6. Nominated Assembly Area (refer to Map below)

Primary Assembly Area: Whytes Gully main entry gates (Reddalls Road entry)

Secondary Assembly Area: Glengarry north -east carpark (entry via gate south of transfer station.

Emergency Control Point – Whytes Gully weighbridge

(NB: No protections from the elements is provided at either Assembly Area)



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# 7. Facility Site Map





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## 8. Authority to Evacuate

The initial decision for full evacuation of this facility is to be made by the Chief Warden or the Deputy Chief Warden. In their absence, the nominated Emergency Warden can make this determination.

In the absence of any nominated emergency wardens and no automated emergency warning systems the decision for a total evacuation (stage 2) of **Whytes Gully** can be made by the attending Emergency Services.

The Chief Warden, Deputy Chief Warden and Emergency Wardens will act upon any directions issued to them by the attending Emergency Service.

The Deputy Warden to ensure that a roll call is undertaken at the Assembly Area.

The Chief Warden to nominate where the control point is going to be, if it is not going to be the Whytes Gully weighbridge.

If unable to return to Whytes Gully after the Evacuation, staff and visitors to be instructed to leave the assembly area and if possible take their cars out of the carpark and go home.

The Deputy Chief Warden to record time staff and visitors left the premises and their contact details for further notification or update on the emergency if required, and to advise when they can return to the premises.

# 9. All Clear

Under no circumstances are evacuated persons allowed to re-enter the facility until given the "All Clear".

The "All Clear" can only be given by the Officer in Charge of the attending Emergency Service.

The "All Clear" will then be given to the Chief Warden who will then advise the Emergency Wardens to direct workers (and any other persons) back into Whytes Gully.

The Chief Warden must directly advise each individual Emergency Warden of the "All Clear".

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# **10. Responsibilities of the Chief Warden -** (white tabard)

The Chief Warden at Whytes Gully will be the Council nominated Officer in Charge in the event of an emergency. The primary duty of the Chief Warden is to ensure the safety of the occupants and the orderly evacuation of the facility.

The **Chief Warden** is responsible for:

- The facility and all its occupants in the event of an emergency.
- The overall development, implementation and maintenance of all emergency response procedures, plans and diagrams.
- The overall implementation and maintenance of all emergency protection systems and emergency control equipment.
- The implementation and coordination of emergency response procedures, plans and systems in the event of an emergency.
- The establishment of a primary assembly area and an alternate assembly (including secret assembly area).
- The preparedness and training of the responsible emergency personnel. This includes ensuring that all members of the LECO are suitably trained and qualified.
- Providing every occupant, at the facility, with the relevant instructions relating to all emergency procedures and the role the occupant will have in the event of an emergency.
- Ensuring that all occupants of the facility have read this document and know where it is located and how to access it.
- Ensuring that all occupants have access to Council's Emergency Procedures Guide (flipchart).
- Ensuring that all Hazardous Substances/materials or Dangerous Goods are stored safely and in line with best practice principles and legislation.
- Maintaining a current Substance Register and/or Dangerous Goods manifest.
- Ensuring that the substance register/ DG manifest is made available to the attending emergency service upon request.
- Liaising with the Emergency Services and other WCC personnel in the event of an emergency.
- Ordering the full evacuation (stage 2) of the facility.
- Provide "all clear" notification to Emergency Wardens or in their absence directly to employees and occupants for the safe return to the facility.
- Conducting a simulated emergency exercise at least once in any given 12 month period.
- Conducting a documented debrief session following every emergency event whether that emergency event is real or simulated.
- Identify corrective action following emergency event debrief.
- Implementing corrective action as soon as practically possible following the emergency event.
- Communicating the implemented corrective action to LECO members and occupants of the facility.
- Completion of Personal Emergency Evacuation Plans (PEEP)
- Document all relevant details during the emergency event.

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# 11. **Responsibilities of the Deputy Chief Warden -** (white tabard)

The **Deputy Chief Warden** is responsible for:

- Assuming the role of Chief Warden and the position's responsibilities in the absence of the Chief Warden plus:
  - Assisting the Chief Warden in the event of an emergency.
  - Notifying the Chief Warden in the event of an emergency at the facility.
  - Coordinating the directions of the Chief Warden to the Emergency Warden/s and First Aid Officer/s.
  - o Assisting in the overall development, implementation and maintenance of:
    - Emergency response procedures
    - Emergency protection systems and
    - Emergency control equipment.
- Participate in all emergency event debriefing sessions.

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# 12. Responsibilities of the Emergency Warden - (red tabard)

The Emergency Warden is responsible for:

- Initiating established emergency response procedures relevant to their area of responsibility.
- Conducting regular checks of their area for any potential hazardous situations.
- Notify the Chief Warden and/or Deputy Chief Warden in the event of an emergency at the facility, detailing what the emergency is and what actions, if any, have been taken.
- Following the directions given to them by the Chief Warden and/or the Deputy Chief Warden eg commence search for suspicious object/s, stop person from using lifts etc.
- Having a sound knowledge of:
  - The layout of their area of responsibility
  - The location of all designated emergency exits, safe compartments and all designated emergency paths of egress.
  - The location and how to use all emergency protection systems and emergency control equipment.
- Calmly and effectively removing all persons from the immediate danger area.
- Calmly and effectively directing all persons from the immediate danger area to a safe compartment.
- Calmly and effectively direct all persons from the facility to the nominated assembly areals to ensure that occupants **do not** carry any bulky items, food or drink during an evacuation.
- Knowing the location of all person/s with a disability in their area of responsibility.
- Assisting occupants with disabilities in the event of an emergency.
- Ensure that their designated area has completely evacuated. They are required to carry out a final inspection prior to them evacuating. **Note:** The Emergency Warden must be the last to leave their designated area of responsibility.
- Informing the Chief Warden and /or Emergency Services of anyone who has refused to evacuate the facility
- Inform Chief Warden and/ or Emergency Services of any person/s with disabilities, that are unable to evacuate and their exact location within the facility.
- Ensuring that emergency exits, fire/smoke doors and windows are properly closed behind them as they evacuate their designated area.
- Accompanying evacuees to the nominated assembly area and awaiting further instructions.
- Conducting an accurate role call at the assembly area and report any abnormalities to the Chief Warden or Emergency Services.
- Ensuring that no one re-enters the facility.
- Reporting the status of their area and the action taken to the Chief Warden or the Emergency Services.
- Assisting the Chief Warden and Deputy Chief Warden/s in carrying out their duties.
- Assisting in the overall development, implementation and maintenance of:
  - Emergency response procedures
  - Emergency protection systems and
  - Emergency control equipment.
- Participating in all emergency debriefing sessions.

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# **13. Responsibilities of the First Aid Officer -** (green tabard)

First Aid Officer/s are to ensure that they:

- Initiate established emergency response procedures in the event of an emergency.
- Maintain their qualifications in order to perform their role as a First Aid Officer.
- Provide First Aid treatment to any persons requiring assistance.
- Recommend and initiate the assistance of advanced medical service providers as required ie call an ambulance or arrange transport for an injured or ill person to a hospital or other medical facility.
- Maintain first aid provisions ie ensure allocated First Aid Kits are re-stocked after use.
- Record details of each person that receives treatment. In instances where the casualty is referred for further treatment, the First Aid Officer is to provide information relating to treatment the casualty has already received to the advanced medical carer.
- Are familiar with Council's First Aid procedure.
- Take an active role in the development, implementation, maintenance and review of Emergency Procedures at the facility.

### 14. Responsibilities of Security Staff - After Hours Only (When responding to an alarm or when on regular patrol after hours)

- Inform all persons (if any) in the immediate area verbally (calmly **do not shout**) to evacuate building and to wait at Assembly Area at Eastern end of Carpark.
- Security staff to contact relevant Emergency Service from his mobile or by landline by dialling 000.
- Security staff to contact Council's after hours service, Well Done 4227 7111, option 1, or 1300 557 980 who will contact relevant after hours waste staff on duty who will in turn contact the Chief Warden/Controller of Premises.
- Security staff to notify their Manager or staff at Southern Cross Protection 1300 136 102, Branch Manager, Hugo Marais, 0478 313 825 of situation.
- Meet Emergency personnel and Council staff on site.
- Take instructions from the relevant Emergency Services personnel and Emergency Warden or Council officer.
- Liaise with persons (if any) in Assembly Area to keep them up to date and for reassurance.

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# 15. Responsibilities of all Workers / Occupants

Council workers and/or occupants that do not have a specific role to play in the event of an emergency are to:

- Follow the directions given to them by the Chief Warden, Deputy Chief Warden and/or the Emergency Warden/s
- Assist any of the LECO in the execution of their duties
- Leave the facility in an orderly manner
- Go to the nominated assembly area
- Remain in the nominated assembly area until advised by the Chief Warden or by the attending Emergency Service personnel
- Ensure they have access to Council's Emergency Procedures Guide ie flip chart
- Provide guidance and assistance to members of the public and any other persons, which might be at the facility at time of the emergency.
- Attend regular training and information sessions relating to the emergency response procedures for Whytes Gully.
- Participate in the undertaking of emergency exercise/s
- Know the location and types of fire fighting equipment, fire alarms and/or warning system for this facility.

# Any worker who fails to comply with their workplace health and safety obligations and responsibilities, as outlined above, could face disciplinary action and/or prosecution.

Fire prevention is the responsibility of all workers and occupants of this facility. Any potentially hazardous situation must be reported to your immediate supervisor/manager, the facility's Chief Emergency Warden and, in their absence, the Deputy Chief Warden as a matter of urgency.

Typical hazardous situations for workers and occupants to look out for are:

- Accumulation of disused paper, furniture, litter/waste, dust or other items
- Faulty electrical wiring or appliances
- Overloading of power outlets
- Obstructions in designated paths of egress, exits and access areas
- Obstruction of fire fighting equipment and emergency signage
- Missing or untested fire fighting equipment
- The propping open or obstruction of fire or smoke doors
- The misuse of emergency equipment
- The storage of any items in emergency evacuation stairwells and designated emergency store points.
- Ongoing leaks or spills of substances
- Damaged or defective emergency equipment

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### 16. Persons who refuse direction

During an emergency event, whether that emergency is real or simulated, should any worker refuse to evacuate the facility or refuse to comply with a direction given to them by the designated Emergency Warden, they shall be reported to the Chief Warden. The report being provided shall contain information such as:

- Who the worker is
- Where the incident occurred
- What time the incident occurred
- Acknowledgement that the worker understood the direction
- The reason (if any) that the worker has given for refusing the direction
- Confirmation that the worker was given the direction to evacuate twice by the Emergency Warden

Upon receipt of the Emergency Warden's verbal report, the Chief Warden shall provide the exact same information to the Officer in Charge of the attending emergency services.

Once the emergency event has been controlled and the **all clear** has been provided, the refusal is to be tabled at the debrief. Following this debrief, the refusal is to be reported to the General Manager. Disciplinary action may be taken against the worker in accordance with Council's Disciplinary Procedure.

Where a member of the public or visitor to the facility refuses to evacuate or follow the direction given to them by the emergency warden, the following steps are to be initiated:

- The Emergency Warden is to repeat the direction to evacuate twice
- Ascertain the name of the individual
- Note where the incident occurred
- What time the incident occurred
- Provide all information to the Chief Warden

Upon receipt of the Emergency Warden's verbal report, the Chief Warden shall provide the exact same information to the officer in charge of the attending emergency services.

Once the emergency event has been controlled and the **all clear** has been provided, the refusal is to be tabled at the subsequent debrief.

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# 17. Raising the Alarm

When an emergency event is occurring at this facility during normal hours of operation, the alarm can be raised by following these steps.

- 1. Informing all persons in the immediate area verbally (calmly and **do not** shout).
- 2. Contact the relevant emergency services by **000** on a land line or from a mobile by dialling the primary emergency number **000** or the secondary emergency number **112**.
- 3. Text emergency message to **106** from a mobile phone
- Notifying the Chief Warden David Storm mobile 0419-495633 or, in their absence, the Deputy Chief Warden Guy Menagh – mobile 0407-213744 Informing your immediate supervisor/manager Wayde Peterson – mobile 0419-495633
- 5. Contact security Company Southern Cross Protection 1300 136 102, or Branch Manager, Hugo Marais, 0478 313 825.

In the event that an emergency is occurring at this facility outside of the normal hours of operation, the alarm can be raised by following the above stated steps.

It is important to note that dialling **000** is the primary emergency number whether using a landline or a mobile phone. The option of using **112** on a mobile phone is possible when a person finds themselves in a situation where they are unable to use a landline and that they are using a mobile that is not their own or is out of the normal service provider's range or has no credit available or has a password block.

In circumstances where a person is unable to communicate the emergency event verbally to the relevant emergency service, the event can be notified to emergency services by texting a message to **106**.

In the event an emergency occurs outside of normal business hours the following steps are to be implemented.

- 1. Informing all persons in the immediate area verbally (calmly and **do not** shout).
- Contact the relevant emergency services by dialling [0 000] on a land line or from a mobile by dialling the primary emergency number 000 or the secondary emergency number 112.
- 3. Text emergency message to **106** from a mobile phone.
- Notifying Council's After Hours Service Company Well Done 4227 7111 Option 1 (primary) or 1300 557 980 (secondary) to notify Waste staff on after hours duty.
- 5. Informing your immediate supervisor/ or facility manager **Wayde Peterson 0408-751-199**
- 6. Contact security Company Southern Cross Protection 1300 136 102, or Branch Manager, Hugo Marais, 0478 313 825

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### 18. Persons with Special Needs

The person with a disability is to alert waste depot operative who must notify the Chief Warden via two way radio/ phone of the situation. The person with a disability is to wait at the site if safe to do so until the person nominated by the Chief Warden or Deputy Chief Warden arrives to assist the person with special needs to exit the site. The person with special needs will be assisted from the premises by a person nominated by the Chief Warden or Deputy Chief Warden or Deputy Chief Warden. This staff member to stay with the person with special needs at all times

#### For future Reference

If there is an employee that has special needs a <u>Personal Emergency Evacuation Plan</u> (PEEP)- see form in Section 33 shall be developed for each of the identified workers with a disability. Guidelines for such a plan are included in Councils Developing Emergency Procedures procedure. The completed PEEP should be included in a readily identifiable section of the facilities documented procedures plan allowing easy access for the Chief Warden

The Chief Warden to have at hand a list of all workers names and their locations. Updated information can be obtained from the daily Location Board in the Hall.

Key points:

- Workers with a disability are **not** to be left alone during an emergency. An Emergency Warden (or another worker) is to be given the responsibility to stay with the person to provide comfort and reassurance until such time as the emergency event is over or until emergency services personnel arrive.
- Person/s with a disability are to be placed in an area that has a fire/smoke rating. Safe area or holding area is to be identified and stated in the plan for the facility.
- During an incident requiring a site evacuation, an "<u>evacuation check-list</u>" could include provision to record details of any PEEP occupant (for assisting in occupant accounting procedures.)
- Consideration is to be given to the type of occupants and visitors who, for one reason or another may need assistance in an emergency.
- A list of worker/s names and their location is to be developed and kept where the Chief Warden exercises control during an emergency ie control room.

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### **19.** Management of Contractors and Official Visitors

All contractors, official visitors and meeting participants vehicles are electronically logged into the site and must sign in and out of the site via the log kept at weighbridge

Outline in detail what steps are to be taken with Contractors and Official Visitors that are at your site in the event of an emergency.

All visitors are to be inducted as per the Site Safety Management Plan. This induction to include location of emergency exits, general site layout, location of emergency control point and assembly area.

The Chief Warden to instruct occupants/staff and contractors and Visitors to proceed to the Assembly Area

The Emergency Warden to bring with him the Visitor's Book to use for a roll call and a list of all staff that are stationed at Whytes Gully. List of staff on site for the day is located on daily toolbox meeting register and staff vehicles are logged into/out of the site.

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### 20. Fire and/or Smoke – Code RED

In an emergency that involves fire or the identification of smoke, all workers are to remain calm and apply **RACE**.

**R** – **Remove** any person/s from immediate danger

- A Announce the presence of danger by:
  - Where available, activate automated system ie break glass alarm (BGA). In instances where the emergency has been notified to the Fire Brigade via the activation of an automated system, a telephone call to the Fire Brigade is to be made so as to confirm their receipt of the alarm and to allow for further information to be provided to the Emergency Services
  - Dialling 0 000 from a landline or from a mobile by dialling the primary emergency number 000 or secondary emergency number 112 (or text message to 106) and request the Fire Brigade. In a clear and calm voice state:
    - Type of emergency Fire/Smoke
    - Your name
    - Location of emergency Whytes Gully Waste Resource Recovery Park
    - -Nearest cross street West Dapto Road, Kembla Grange
    - Details of any action undertaken
    - Number of casualties and any information about the casualties
    - Any other hazards in the area
    - Be prepared to answer any questions the emergency operator asks you
    - Wait on line until the emergency operator tells you to hang up
    - Follow evacuation process
    - Notify all persons in the immediate area
- **C Contain** the fire/smoke by closing all windows and doors as you exit the immediate area
- **E Evacuate** the facility/workplace **or**
- **E Extinguish** the fire if you are trained and if it is safe to do so.

#### NOTE:

Where a full evacuation has been undertaken you must go to your nominated assembly area and await further instructions.

Attend debrief session if you have been directed to do so.

The **RACE** procedure can be used in any order taking into consideration the progression of the emergency.

You must **NOT** turn off internal lights as you exit the building You must **NOT** lock doors as you exit the building You must **NOT** take unnecessary risks

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### 21. Bomb Threat – Code Purple

In an emergency that involves a bomb threat (whether that be substance bomb or any other type), all workers are to remain calm and apply the below steps that are relevant to the threat type. All bomb threats are to be treated as a real threat until such time as the threat has been assessed and a different determination is made.

When any type of bomb threat emergency occurs, Emergency Warden/s will be required to carry out a search of their designated area. In some circumstances it may be deemed necessary to recruit the assistance of other workers/occupants of the area in order for a more thorough search to occur. The reason for using workers/occupants is that they are more likely to identify an item that is out of place or unusual for that area.

During the actual search, workers/occupants are **not** to touch anything. They are only required to visually inspect their area. Areas, rooms and/or cubicles that have been checked are to be clearly marked by using chalk and writing "**area clear**" on the floor at the point of entry.

The search will be conducted in the following manner:

- 1. Carry out the search whilst exercising the utmost care
- 2. Remove any hand held radio transceivers and mobile phones from your person whilst carrying out the search
- 3. Enter the area and listen for any unusual sounds
- 4. Enter the area to the left side and search in a clockwise direction
- 5. Check the area systematically by looking from
  - a. floor to waist level
  - b. waist to head level
  - c. head to ceiling
- 6. Look for anything that :
  - a. Matches the item described in the threat
  - b. Appears out of place or unusual
  - c. Has no identifiable owner or markings
  - d. Is of an unusual size or shape
  - e. Has a sound emanating from it
- 7. Mark on the floor that the area is clear or mark that the area has been identified as having a suspicious item

A sticker or paper with the words "room checked" is to be placed in all rooms that have been checked, preferably on the doorway. The suspicious item is to be marked with make- shift signage using arrows and appropriate wording and hung in the vicinity of the suspicious item and a paper trail laid to provide easy guidance to that location from the entry point.

# The process of marking should only be undertaken if time frames relating to the incident threat are deemed adequate.

#### NOTE:

Areas within this facility that are accessed by the public are **not** to be searched while the members of the public are present.

### NOTE:

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Upon receipt of a Bomb Threat the Chief Warden in consultation with relevant persons shall determine what action is to be taken. The options available are:

- 1. Do nothing and dismiss the threat
- 2. Undertake and immediate search and if a suspicious item is found evacuate the facility
- 3. Immediately initiate a stage 3 full evacuation of the facility

### NOTE:

When evacuating due to Bomb Threat, occupants are to take personal items with them but only where it has been deemed safe to do so. Occupants are then required to exit safely via the predetermined path of egress.

### 22 Telephone Threat

Should you receive a telephone threat the following actions shall be initiated.

- 1. Remain Calm
- 2. **DO NOT** hang-up the phone, from which the threat was received, at anytime until directed to do so by the Chief Warden.
- 3. Access the "telephone threat checklist" and complete as much of the document as you can. This checklist is located at the end of this document as well as being on the back of every WCC Emergency Procedures "flipchart" Guide. Every worker and/or occupant of this facility is to have easy access to the "flipchart" guide.
- 4. Try and keep the caller on the line for as long as you can and ask as many of the listed questions as possible.
- 5. Try and get the attention of the nearest worker so that they can contact the Chief Warden.
- 6. If you are unable to obtain assistance from an worker you must contact the Chief Warden immediately after the caller has cut off communications with you.
- 7. Contact your immediate Supervisor/Manager and inform them of what has happened.
- 8. Finish completing the telephone threat checklist
- 9. Hand the completed checklist to the Chief Warden or, in their absence, your Supervisor/Manager
- 10. Attend debrief session if required.

If you are the only worker/occupant of the facility at the time of receiving the call you must notify the emergency services by dialling **0-000** from a landline or from a mobile by dialling the primary emergency number **000** or secondary emergency number **112** (or text message to **106**). In a clear and calm voice state:

- Emergency service required Police(and where deemed appropriate the NSW Fire Brigade)
- Type of emergency Bomb Threat
- Your name
- Location of emergency Whytes Gully Waste Recovery Resource Park
- Nearest cross street West Dapto Road, Kembla Grange
- Details of any action undertaken
- Number of casualties and any information about the casualties (if applicable)
- Any other hazards that the emergency services could encounter when they attend the facility

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- Be prepared to answer any questions the emergency operator asks you
- Wait on line until the emergency operator tells you to hang up
- Follow evacuation process

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### 23 Written Threat

Should you receive a written threat the following actions are to be initiated.

- 1. Remain Calm
- 2. Avoid any unnecessary direct handling of the document.
- 3. If you are able to, place the document in a clear plastic container.
- 4. Contact the Chief Warden.
- 5. Contact your immediate Supervisor/Manager and inform them of what has happened.
- 6. Attend debrief session if required.

If you are the only worker/occupant of the facility at the time of receiving the written threat you must notify the emergency services by dialling 0 - 000 from a mobile by dialling the primary emergency number 000 or secondary emergency number 112. In a clear and calm voice state:

- Emergency service required Police
- Type of emergency Bomb Threat
- Your name
- Location of emergency Whytes Gully Waste Recovery Resource Park Nearest cross street West Dapto Road, Kembla Grange
- Details of any action undertaken
- Number of casualties and any information about the casualties (if applicable)
- Any other hazards that the emergency services could encounter when the attend the facility
- Be prepared to answer any questions the emergency operator asks you
- Wait on line until the emergency operator tells you to hang up
- Follow evacuation process

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### 24 Identification of suspicious item or receiving suspicious mail

There are many varying types of objects or methods that can be used in order for a bomb threat to be carried out. Emergency Warden/s, workers or occupants of the facility that carry out a search for a suspicious object or if they receive a suspicious object, should be looking for these key identifiers:

- The item seems out of place for the area or doesn't appear to belong there
- The item can not be accounted for
- The item appears excessive in weight for its size
- The item appears lopsided or uneven
- The item contains loose or powdery materials
- The item is covered with, or secured with, excessive amounts of tape or any other binding material
- The item being received is from an unknown or unusual source
- The item has wires or any other metallic objects protruding from it
- The item is covered with excessive postage
- The item was not expected
- The item can not be identified from the packaging
- The sender's details are not on the packaging
- The details on the packaging are hand written and/or poorly written
- The information on the packaging is misspelt
- There is no return address

Should you identify a suspicious object, the following actions are to be initiated.

- 1. Remain Calm.
- 2. Do not touch, handle or move the suspicious item.
- 3. If you are able to do so, place a marker near the suspicious item. This marker will assist the Emergency Services in locating the item once the building has been evacuated.
- 4. Clear/evacuate all persons from the immediate area.
- 5. Secure the area.
- 6. Contact the Chief Warden by way of landline or if possible in person and inform them of what you have identified and what marker you used.
- 7. Contact your immediate Supervisor/Manager and inform them of what has happened.
- 8. Await further direction.
- 9. Attend debrief session if required.

**NOTE:** If you receive suspicious mail and you have doubts as to the stability of the package, you should contact the addressee and seek clarification as to the package and its contents.

If the contents of the package appear to be a powder or some other type of substance and the addressee and/or the contents can not be confirmed, the recipient is to follow the below steps.

- Remain calm.
- Stay in the immediate area.

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- Place another container over the mail or place the mail in another package (but only if safe to do so).
- Stop others from entering the area.
- Immediately contact Chief Warden and your supervisor/manager.
- Await further instructions.
- **Do Not** disturb the item.
- **Do Not** pass the item around.
- **Do Not** attempt to clean up any of the substance that has exited the package.
- **Do Not** attempt to brush the substance off your clothing.
- Do Not touch your eyes, mouth or nose (even if you have washed your hands).

If you are the only worker/occupant of the facility at the time of identifying or receiving the suspicious object/mail, you must notify the emergency services by dialling 0 - 000 from a mobile by dialling the primary emergency number 000 or secondary emergency number 112 (or text message to **106**).

In a clear and calm voice state:

- Emergency service required Police
- Type of emergency Bomb Threat
- Your name
- Location of emergency Whytes Gully Waste Recovery Resource Park Nearest cross street West Dapto Road, Kembla Grange
- Details of any action undertaken
- Number of casualties and any information about the casualties (if applicable) _
- Any other hazards that the emergency services could encounter when they attend the facility
- Be prepared to answer any questions the emergency operator asks you
- Wait on line until the emergency operator tells you to hang up
- Follow evacuation process

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### 25 Medical Emergency – Code Blue

Where possible and depending upon the medical emergency the workers are to always use personal protective equipment when performing first aid.

The steps that are to be initiated in a medical emergency are:

- The employee who identifies the medical emergency is to check for danger to themselves, the casualty and anyone else who is in the immediate area
- The rescuer must maintain his/her personal safety at all times.
- Ascertain whether casualty is in any immediate or further danger
- Do not remove casualty if no danger exists
- Remove casualty from immediate danger only if safe to do so.
- Check for response by talking to the casualty
- If no response provide first aid by treating the casualty's condition (to your level of knowledge and ability). Follow Basic Life Support Flow Chart.

## **BASIC LIFE SUPPORT FLOW CHART**

- **D** = Check for **DANGER** / Safety to yourself and the casualty If it is safe to do so, remove the casualty from immediate danger
- **R** = Check **RESPONSE**.

Check for a response by talking to the casualty in a loud and clear voice

No signs of life = no response (unconscious), not breathing normally, not moving

- **S** = **Send** for help. Call or ask a bystander to phone 000 for emergency services
- **A** = Clear and open **AIRWAY** and check for signs of life.
- **B** = **BREATHING** normally if yes place in recovery position. If no, commence compressions
- **C** = Give 30 chest **COMPRESSIONS** at 100 per minute, followed by 2 breaths. Continue by repeating CPR until advance medical assistance arrives or casualty becomes responsive (breathing normally).
- **D** = **DEFIBRILLATE** attach AED (Automated External Defibrillator) as soon as it is available and follow the audible prompts of the AED
- Notify First Aid Officer
- Contact advanced medical (ambulance) emergency services by dialling 000 or 112 from a mobile and in a clear and calm voice state:
  - Emergency service required Ambulance
    - Type of emergency Medical
    - Your name
    - Location of emergency Whytes Gully Waste Recovery Resource Park
    - Nearest cross street West Dapto Road, Kembla Grange

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- Details of any action undertaken
- Number of casualties and any information about the casualties (if applicable)
- Any other hazards that the emergency services could encounter when the attend the facility
- Be prepared to answer any questions the emergency operator asks you
- Wait on line until the emergency operator tells you to hang up
- Remain with casualty until such time as advanced medical assistance arrives.
- Notify person/s in the immediate area
- Report the emergency to your Chief Warden and your immediate supervisor/manager
- First Aid officer to nominate a staff member to meet ambulance at entrance Gate.
- If required First Aid Officer to request assistant from other staff who have their First Aid experience or from staff at Glengarry Cottage who are First Aiders.
- The First Aid Kit Kit Type 'B', is located in the amenities area & weighbridge, it can easily be transported to another location, it is not attached to the wall. The kit is equipped with basic supplies like various dressings and bandages, eye pads, eyewash, antiseptic swabs, rescue blanket, scissors and forceps.

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### 26 Personal Threat – Code Black

Procedure on the management of a personal threat needs to focus on the preservation of life in the first instance and property in the second.

It is recognised that it is not always possible to eliminate all forms of personal threats. The intent is to reduce the opportunities for the situation to arise and reduce potential for loss to workers and the organisation.

A personal threat can be in the form of a verbal and/or physical assault and can manifest into a psychological illness.

If armed confrontation or any similar type of personal threat occurs remember to be calm and think **SAFE**.

- **S** = **Safety**, which is your safety and those around you is a priority
- **A** = **Actions**, be open honest and compliant at all times
- **F** = **Focus**, on demands of the offender and your responses
- **E** = **Emotions**, stay calm and manage your emotions

All workers and/or occupants of this facility are required to:

- Remain observant at all times during the threat
- Keep a safe distance from the offender/s
- Obey offender/s instructions. Do exactly what they say (no more no less) and ensure that you advise the offender of what you are doing before you do it
- Put your hands up (shoulder level) to show that you are submitting to their requests
- Look down and away from the offender/s
- Avoid direct eye contact with the offender/s
- Stay calm and quiet
- If you cannot retreat or you are unable to leave the immediate threat area remain where you are until help arrives

If you are able to leave the facility or the immediate threat area, then do so. Once you have managed to leave the threat area you must raise the alarm by notifying the Police and if there are any casualties contact the Ambulance service. You can contact Emergency Services by dialling **0** -000 from a landline or from a mobile by dialling the primary emergency number **000** or secondary emergency number **112** (or text message to **106**). In a clear and calm voice state:

- Emergency service required Police
- Type of emergency Personal threat / Armed hold-up
- Your name
- Location of emergency Whytes Gully Waste Recovery Resource Park
- Nearest cross street West Dapto Road, Kembla Grange
- Details of any action already undertaken
- Number of casualties and any information about the casualties (if applicable)
- Physical description of the offender/s
- The direction of the offender's on exit

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- Mode of escape
- Wait on line until the emergency operator tells you to hang up
- Remain in a safe area until such time as Police arrive.
- Report the emergency to your Chief Warden and your immediate supervisor/manager

Immediately after the offender/s have left the facility close off the area where the threat occurred. This can be done by locking internal doors. The need to isolate the area is to avoid contamination of the crime scene.

A sign "Closed Due To Emergency" is to be placed on the main entry gates once it has been locked.

Workers must:

- **Not** follow the offender/s as they leave the facility.
- Not allow unnecessary access to the area where the incident occurred.
- Ask all witnesses to remain until responding Police arrive.
- Advise witnesses **not** to discuss what they have experienced with each other or anybody else until the police have interviewed them.
- Not speak to the media.

All witnesses are to write down their observations, taking into consideration:

- Description of offender ie height, hair colour, eye colour, physical condition, obvious scars or any other distinguishing features.
- Sex
- Colour and type of clothing
- Speech
- Mannerisms
- Distinguishing or noticeable features, such as tattoos, facial hair
- Weapons used (if any)
- The mode of escape ie vehicle (type, make, colour)
- Direction of escape
- And anything else that could assist identifying the offender/s
- All witnesses to remain in the area
- Maintain integrity of the crime scene
- If necessary secure the area by closing access doors to the area and/or gate to the property.
- Provide medical assistance, if required. Use First aid provisions located in the kitchen.
- The most senior officer present is to initiate Emergency Response Procedure as soon as practicable.

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# 27. "Lock Down" Procedure Relating to a Personal Threat

The intent of the "lock down" is to isolate the facility occupant/s from the threat in particular when an occupant in alone in the building. It I important that if an occupant is alone in the building, the back and front screen doors are to be 'clicked' into the lock position.

In the event of an intruder or of a hostile visitor who is threatening or who is trying to enter weighbridge office

Ensure all entry/exit doors are locked.

Contact Emergency Services by dialling **[0-000]** from a landline or from a mobile by dialling the primary emergency number **000** or secondary emergency number **112** (or text message to **106**). In a clear and calm voice state:

- Emergency service required Police
- Type of emergency **Personal threat / Break-in**
- Your name
- Location of emergency Reddalls Road, Kembla Grange
- Nearest cross street West Dapto Road, Kembla Grange
- Details of any action already undertaken
- Number of casualties and any information about the casualties (if applicable)
- Physical description of the offender/s
- The direction of the offender's on exit
- Mode of escape
- Wait on line until the emergency operator tells you to hang up
- Remain inside until such time as Police arrive.
- Report the emergency to your Chief Warden 0419-495633 or after hours 42277111 Option 1 or 1300557980 (as per the emergency procedures Guide)
- Report the emergency to your immediate supervisor/manager
- Stay in the building in lock down mode and await instructions from Police when they arrive.

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### 28. Internal Emergencies – Code Yellow

Below are some examples of the types of internal emergencies that could be relevant for Whytes Gully Waste Resource & Recovery Park together with the planned response. It may be necessary to add additional scenarios in the future with changing circumstances.

- Structural Instability
- Loss of power (electricity)
- Communications failure (no phones, mobiles or PC's)
- Loss of water supply
- Flooding
  - o Water leak
    - Sewerage (septic system)
- Vehicular Accidents

### 28.1 Structural Instability

Structural instability damage to the Whytes Gully could include major structural damage to the building(s), which may include movement, or minor damage to walls, roof, windows or even collapse.

Basic outline of internal emergency response plan -

- Maintain your personal safety and of those around you at all times during the emergency event.
- Remove persons from the immediate threat if safe to do so.
- Isolate the immediate area.
- Prevent access to the affected area.
- Proceed with evacuation if deemed appropriate.
- Report the emergency to the Chief Warden and your immediate supervisor/manager and await their instruction.
- Contact Incident Report Hotline on 4227 7700 if calling after hours leave a message.
- Undertake a debrief session and ensure that the debrief is documented.

If required contact emergency services by dialling **[0-000]** or from a mobile by dialling the primary emergency number **000** or secondary emergency number **112** (or text message to **106**). In a clear and calm voice state:

- Emergency service required Fire Brigade/Ambulance
- Type of emergency –
- Your name
- Location of emergency Whytes Gully Waste Resource Recovery Park -Reddalls Road, Kembla Grange
- Nearest cross street West Dapto Road, Kembla Grange
- Details of any action undertaken
- Number of casualties and any information about the casualties (if applicable)
- Any other hazards that the emergency services could encounter when they attend the facility
- Be prepared to answer any questions the emergency operator asks you Page 35 of 65

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- Wait on line until the emergency operator tells you to hang up

# 28.2 Loss of Power (Electricity) lighting and communications

### a) Lighting

- Maintain your personal safety and of those around you at all times during the emergency event.
- Contact Operations manager & /or systems support to arrange generator to site for weighbridge
- Open all windows, doors to ensure maximum natural lighting.
- Prevent access to the affected area, if necessary.
- Contact Electricity Company to confirm if power is localised.
- Report the emergency to the Chief Warden and your immediate supervisor/manager and for their instruction.
- Proceed with evacuation if deemed appropriate.
- Advise Security Company of situation
- Undertake a debrief session and ensure that the debrief is documented

**Only if required**, contact emergency services by dialling **[0-000]** or from a mobile by dialling the primary emergency number **000** or secondary emergency number **112** (or text message to **106**). In a clear and calm voice state:

- Emergency service required Fire Brigade/Ambulance
- Type of emergency -
- Your name
- Location of emergency Whytes Gully Waste Resource Recovery Park -Reddalls Road, Kembla Grange
- Nearest cross street West Dapto Road, Kembla Grange
- Details of any action undertaken
- Number of casualties and any information about the casualties (if applicable)

### b) Communications Failure (no IP phones or PC's)

- Maintain your personal safety and of those around you at all times during the emergency event.
- Use mobile phones if available to contact Council's Information Management section to determine extend of communications failure.
- Use mobile phones if available to Report the emergency to the Chief Warden and your immediate supervisor/manager for their instruction.
- Proceed with evacuation if deemed appropriate.
- Contact Incident Report Hotline on 4227 7700 if calling after hours leave a message
- Undertake a debrief session and ensure that the debrief is documented

**Only if required** contact emergency services by dialling **[0-000]** or from a mobile by dialling the primary emergency number **000** or secondary emergency number **112** (or text message to **106**). In a clear and calm voice state:

- Emergency service required Fire Brigade/Ambulance
- Type of emergency –
- Your name

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- Location of emergency Whytes Gully Waste Resource Recovery Park -Reddalls Road, Kembla Grange
- Nearest cross street West Dapto Road, Kembla Grange
- Details of any action undertaken
- Number of casualties and any information about the casualties (if applicable)

### 28.3 Loss of Water Supply

- Maintain your personal safety and of those around you at all times during the emergency event.
- Isolate the immediate area
- Prevent access to the affected area
- Contact the Local Authority to determine cause and duration of loss of water.
- Proceed with evacuation if deemed appropriate.
- Report the emergency to the Chief Warden and your immediate supervisor/manager for their direction.
- Contact After Hours Services
- Contact Incident Report Hotline on 4227 7700 if calling after hours leave a message
- Undertake a debrief session and ensure that the debrief is documented

**Only if required**, contact emergency services by dialling **[0-000]** or from a mobile by dialling the primary emergency number **000** or secondary emergency number **112** (or text message to **106**). In a clear and calm voice state:

- Emergency service required Fire Brigade/Ambulance
- Type of emergency -
- Your name
- Location of emergency Whytes Gully Waste Resource Recovery Park -Reddalls Road, Kembla Grange
- Nearest cross street West Dapto Road, Kembla Grange
- Details of any action undertaken
- Number of casualties and any information about the casualties (if applicable)

### 28.4 Flooding (water & sewerage)

### a) Water Leak

- Maintain your personal safety and of those around you at all times during the emergency event.
- Remove persons from the immediate threat if safe to do so.
- Isolate the immediate area.
- Prevent access to the affected area.
- Proceed with evacuation if deemed appropriate.
- Contact Council's Building Maintenance to arrange for a plumber to attend.
- Report the emergency to the Chief Warden and your immediate supervisor/manager and await their direction.
- Contact Incident Report Hotline on 4227 7700 if calling after hours leave a message
- Undertake a debrief session and ensure that the debrief is documented

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**Only if required**, contact emergency services by dialling **[0-000]** or from a mobile by dialling the primary emergency number **000** or secondary emergency number **112** (or text message to **106**). In a clear and calm voice state:

- Emergency service required Fire Brigade/Ambulance
- Type of emergency -
- Your name
- Location of emergency Whytes Gully Waste Resource Recovery Park -Reddalls Road, Kembla Grange
- Nearest cross street West Dapto Road, Kembla Grange
- Details of any action undertaken
- Number of casualties and any information about the casualties (if applicable)

### b) Sewerage (septic system)

- Maintain your personal safety and of those around you at all times during the emergency event.
- Remove persons from the immediate threat if safe to do so
- Isolate the immediate area
- Prevent access to the affected area
- Isolate the area using tape
- Proceed with evacuation if deemed appropriate.
- Contact Council's Contractor to arrange for emptying of the tank.
- Report the emergency to the Chief Warden and your immediate supervisor/manager for direction.
- Contact Incident Report Hotline on 4227 7700 if calling after hours leave a message
- Undertake a debrief session and ensure that the debrief is documented

**Only if required**, contact emergency services by dialling **[0-000]** or from a mobile by dialling the primary emergency number **000** or secondary emergency number **112** (or text message to **106**). In a clear and calm voice state:

- Emergency service required Fire Brigade/Ambulance
- Type of emergency -
- Your name
- Location of emergency Whytes Gully Waste Resource Recovery Park -Reddalls Road, Kembla Grange
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- Details of any action undertaken
- Number of casualties and any information about the casualties (if applicable)

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### 28.5 Vehicular Accidents

Staff witnessing a motor vehicle accident on site must notify the Chief Warden

- see if anyone is injured and arrange for first aid assistance or ambulance as appropriate
- contact the police if deemed appropriate
- make written records of witness's statements
- note accident in the site diary.

**Only if required**, contact emergency services by dialling **[0-000]** or from a mobile by dialling the primary emergency number **000** or secondary emergency number **112** (or text message to **106**). In a clear and calm voice state:

- Emergency service required Fire Brigade/Ambulance
- Type of emergency -
- Your name
- Location of emergency Whytes Gully Waste Resource Recovery Park -Reddalls Road, Kembla Grange
- Nearest cross street West Dapto Road, Kembla Grange
- Details of any action undertaken
- Number of casualties and any information about the casualties (if applicable)

### 28.6 Illegal Occupation

If intruders occupy the premises, the following steps should be followed:

- Inform personnel of the emergency.
- Assist and obey the intruders. Do not resist or provoke them.
- As soon as it is safe, dial 000 and call the police.
- Where phone lines may have been cut and an alarm system/guard is available, activate it.
- Write down as much information as possible in regard to physical appearance, outstanding characteristics, dress, voice, behaviour and actions of intruder. What did they do, say and touch?
- Write down the escape direction, vehicle description and registration and follow up with the Chief Warden.

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### 29 Environmental Emergency - Code Green (& Pollution Response Plan)

### 29.1 Fires in Waste (Tip Face)

The person identifying the fire should, if feasible and safe, attempt to extinguish it immediately. If it is not feasible or not successful, the Chief Warden must immediately be notified.

The Chief Warden notifies the fire brigade and the takes control of the fire fighting effort until the fire brigade arrives. Measures taken may include the following:

- extinguishes all flames with the water cart or fire fighting equipment
- isolating the source of fuel using mobile plant if it is safe to do so.
- shutting off power supply to affected areas as appropriate
- using portable fire extinguishers and cover material as appropriate.

If the fire is serious enough that emergency services has to be called (police, rescue, ambulance or SES) the Chief Warden hands control over to the officer in charge and briefs him as to the following:

- injured or trapped persons needing their help
- highly flammable materials in close proximity to the fire

All fire affected waste will remain isolated until inspected by the Site Manager and approved for reburial.

Waste Operations Administrator - Wayde Peterson 0408-751-199 to report incident to the EPA immediately as per the requirements of the site Environmental Protection License.

### 29.2 Spill of Hazardous Material

For spills of materials that are clearly identified as a low hazard material and where it is clearly within the capability of the person discovering it, immediate action will be taken by this person to ensure that the following steps are taken;

- 1. In a safe manner, isolate the source of the spill.
- 2. Contain the (spills kits provided) from spreading or reaching drainage systems.
- 3. Identify the spilled material and contact the Site Manager for instructions regarding handling of the spill and cleanup procedures

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After this initial containment the Site Manager will immediately be contacted to review containment and clean up procedures or where it is beyond the capacity of the person discovering the spill to contain it so that the responsible person can allocate appropriate resources or obtain expert technical advice on how to appropriately contain and cleanup the material so that there is no risk to health, safety or the environment.

**Waste Operations Administrator - Wayde Peterson 0408-751-199** to report incident to the EPA immediately as per the requirements of the site Environmental Protection License.

### 29.3 Escape of Leachate from site

Provide effective response to emergency situations involving the discharge of waste or Leachate. As with any emergency response, these procedures must be implemented in a timely fashion to minimize the impact of the incident. This response must be undertaken by qualified individuals, experienced in emergency response for spills to flowing water

Although unlikely, it is possible through human error, an accident or force of nature, that leachate or waste could enter the stormwater system. This may include situations involving:

- damage to the leachate collector;
- a large storm event

The following procedures should be followed when an accident occurs that has caused, or is likely to cause, leachate or waste to enter the stormwater. As with any emergency response, these procedures must be implemented in a timely fashion to minimize the impact of the incident. This response must be undertaken by qualified individuals, experienced in emergency response for spills to flowing water.

### Containment

When safe to do so, stop or contain the source of the discharge. This may involve the construction of temporary berms and trenches.

- The groundwater monitoring program is designed to detect changes in the groundwater regime which could be attributed to the operations of the depot. Given the nature of the groundwater movement, it is unlikely that such a situation would develop without considerable forewarning.
- In the event that the monitoring results indicate that there is leakage of material from the depot, experts will be engaged to devise appropriate response strategies which will be implemented after approval by the Waste Operations Administrator – Wayde Peterson 0408-751-199, Details of staff responsibilities and responses will be determined at that time.

Waste Operations Administrator - Wayde Peterson 0408-751-199 to report incident to the EPA immediately as per the requirements of the site Environmental Protection License.

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### 29.4 Emission of Gas from the Landfill

There is a risk of the build-up of hazardous

landfill gas which contains methane and which may ignite and explode under certain circumstances. A response will be required in the event of:

- · ~ Elevated levels of gas being detected by presence of gas odour;
- ~ Elevated levels of gas being detected by the Automatic Monitoring System;
- ~ Fire or explosion.
  - Gas emissions from the landfill would most likely be gradual and unlikely to reach dangerous levels. However, if a gas leak from the landfill is detected, the Chief Warden will ensure that personnel are kept clear until expert advice is obtained.
  - Where there is a need to work in proximity to the leaking area, air fed respiratory equipment shall be used - if there is a gas build-up, it may cause oxygen depletion.
  - In the event that gas is detected being emitted from the landfill, the Chief Warden shall:
    - evacuate all personnel not directly involved in the operation
    - prepare to control any fire that may result
    - ensure that any person needing to enter the proximity of the leak is wearing air-fed respiratory equipment.

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### 30. External Emergencies – Code Brown

Below are some examples of the types of external emergencies that could be relevant for Glengarry Cottage together with the planned response. It may be necessary to add additional scenarios in the future in accordance with changing circumstances.

- Bushfire, Shrub or Grass Fire
- Earthquake
- Explosion Emissions (from adjoining industries)
- Toxic Emissions or substance spill (from adjoining industries)
- Flooding (entry and exit roads)
- Transport Incident on Road or Railway Track
- o Adverse weather conditions eg
  - Severe winds
  - Storm surges
  - Lightning
  - Cyclone
  - Tsunami
- Substance spill from industry or traffic accident eg
  - Gas or other Dangerous Good
  - Hazardous Substance
  - Biological
  - Radiological
  - Nuclear
  - Toxic Emissions

### 30.1 BUSHFIRE, SHRUB OR GRASS FIRE

In the event of a bushfire or shrub or grass fire -

- Maintain your personal safety and of those persons around you at all times during the emergency event.
- DO NOT evacuate the building unless directed to do so by the Chief Warden or in their absence, the attending Emergency Services.
- Close all windows and doors and shutters.
- Report the emergency to the Chief Warden and your immediate supervisor/manager and await instruction.
- If possible contact any workers who are expected to arrive at the facility and inform them to stay away from the facility until advised that it is safe.
- Be aware that there may be wildlife in your path or in the area eg snakes, deer that may be trying to get away from the fire.

Contact emergency services by dialling **[0-000]** or from a mobile by dialling the primary emergency number **000** or secondary emergency number **112** from a mobile (or text message to **106**). In a clear and calm voice state:

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- Emergency service required Fire Brigade/Ambulance/Police
- Type of emergency –
- Your name
- Location of emergency Whytes Gully Waste Resource Recovery Park
  Reddalls Road, Kembla Grange
- Nearest cross street West Dapto Road, Kembla Grange
- Details of any action undertaken
- Number of casualties and any information about the casualties (if applicable)
- Any other hazards that the emergency services could encounter when they attend the facility
- Be prepared to answer any questions the emergency operator asks you
- Wait on line until the emergency operator tells you to hang up

### **30.2 EARTHQUAKE**

In the event of an earthquake occupants should not attempt to run from the facility. Occupants are advised to remain where they are until such time as the earthquake subsides. Basic guidelines to remember in the event of an earthquake are:

- Try to remain calm.
- Move away from windows and exterior walls.
- Try to keep away from mirrors, light fittings, shelves, bookcases and any other furniture that may fall or slide during the quake.
- If possible take cover under a desk or move to an internal corner of a room, sit down and protect your face and head by placing your hands over them.
- Once the tremor has stopped, look around for injured persons and provide assistance if it is safe to do so.
- In a minor event/ tremor the occupants should remain in the building until further instructed by the Chief Warden.
- In a major event/ tremor where substantial building movement occurs evacuate the cottage in accordance with stage (3) Evacuation Procedures. All occupants of the facility are to leave the building once instructed to do so by the Chief Warden or his representative. Persons are to attend the nominated assembly area which is the main entry front gates or to the alternate assembly area gate entry to Glengarry Cottage (south side of Transfer station) for roll call.

Contact emergency services by dialling **[0-000]** or from a mobile by dialling the primary emergency number **000** or secondary emergency number **112** from a mobile (or text message to **106**). In a clear and calm voice state:

- Emergency service required Fire Brigade/Ambulance/Police
- Type of emergency –
- Your name
- Location of emergency Whytes Gully Waste Resource Recovery Park
  Reddalls Road, Kembla Grange
- Nearest cross street West Dapto Road, Kembla Grange
- Details of any action undertaken
- Number of casualties and any information about the casualties (if applicable)
- Any other hazards that the emergency services could encounter when they attend the facility

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- Be prepared to answer any questions the emergency operator asks you
- Wait on line until the emergency operator tells you to hang up

### **30.3** EXPLOSION OR INDUSTRIAL INCIDENT

In the event of an external explosion ie at Glengarry Cottage or nearby industrial sites, occupants are to:

- Remain calm.
- Stay in the building.
- Close all windows and doors and if necessary shutters.
- Remove persons from the immediate threat if safe to do so
- If safe Isolate the immediate area
- If safe, prevent access to the affected area
- If safe, Isolate the area using tape
- Notifying your immediate supervisor and the Chief Warden and await their instructions.
- If required contact emergency services by dialling **0-000** or from a mobile by dialling the primary emergency number **000** or secondary emergency number **112** from a mobile (or text message to **106**). In a clear and calm voice state:
  - Emergency service required Fire Brigade/Ambulance/Police
  - Type of emergency –
  - Your name
  - Location of emergency Whytes Gully Waste Resource Recovery Park – Reddalls Road, Kembla Grange
  - Nearest cross street West Dapto Road, Kembla Grange
  - Number of casualties and any information about the casualties (if applicable)
  - Any other hazards that the emergency services could encounter when they attend the facility
  - Be prepared to answer any questions the emergency operator asks you
  - Wait on line until the emergency operator tells you to hang up

### **30.4** TOXIC EMISSIONS OR SUBSTANCE SPILL (FROM ADJOINING INDUSTRIES)

In the event of toxic emissions from adjoining industries affecting occupants at Whytes Gully Waste Resource Recovery Park occupants to -

- Stay in the building.
- Close all windows and doors and if necessary shutters.
- Notifying your immediate supervisor and the Chief Warden and await their instructions.
- Notify any one that you know that is expected at the building.
- If required contact emergency services by dialling **0-000** or from a mobile by dialling the primary emergency number **000** or secondary emergency number **112** from a mobile (or text message to **106**). In a clear and calm voice state:

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- Emergency service required Fire Brigade/Ambulance/Police
- Type of emergency –
- Your name
- Location of emergency Whytes Gully Waste Resource Recovery Park – Reddalls Road, Kembla Grange
- Nearest cross street West Dapto Road, Kembla Grange
- Number of casualties and any information about the casualties (if applicable)
- Any other hazards that the emergency services could encounter when they attend the facility
- Be prepared to answer any questions the emergency operator asks you
- Wait on line until the emergency operator tells you to hang up

### **30.5** FLOODING – ENTRY AND EXIT ROADS ONLY

In the Event of road flooding of the entry and exit roads to Whytes Gully ie **West Dapto Road or Reddalls Road**, occupants to -

- Do not leave the property.
- Notifying your immediate supervisor and the Chief Warden and await their instructions.
- Listen to ABC Radio Reports for weather forecasts and update on situation.
- Contact the relevant section of Council (South Depot) re road closures and of alternate exit and entry routes advice.
- If required contact emergency services by dialling **0-000**, or **132500** (SES) or from a mobile by dialling the primary emergency number **000** or secondary emergency number **112** from a mobile (or text message to **106**). In a clear and calm voice state:
  - Emergency service required SES 132500
  - Type of emergency –
  - Your name
  - Location of emergency Whytes Gully Waste Resource Recovery Park – Reddalls Road, Kembla Grange
  - Nearest cross street West Dapto Road, Kembla Grange
  - Number of casualties and any information about the casualties (if applicable)
  - Any other hazards that the emergency services could encounter when they attend the facility
  - Be prepared to answer any questions the emergency operator asks you
  - Wait on line until the emergency operator tells you to hang up

### **30.6** TRANSPORT INCIDENT – ON ROAD OR RAILWAY TRACK

In the Event of road closure of the entry and exit roads to Whytes Gully ie West Dapto Road or Reddalls Road, due to a transport incident on the road or railway track do not leave the property.

• No leave the property.

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- Notifying your immediate supervisor and the Chief Warden and await their instructions.
- Listen to ABC Radio Reports and weather forecasts
- Contact the relevant section of Council (South Depot) re road closures and of alternate exit and entry routes advice.
- If required contact emergency services by dialling **0-000** or from a mobile by dialling the primary emergency number **000** or secondary emergency number **112** from a mobile (or text message to **106**). In a clear and calm voice state:
- If required contact emergency services by dialling **0-000** or from a mobile by dialling the primary emergency number **000** or secondary emergency number **112** from a mobile (or text message to **106**). In a clear and calm voice state:
  - Emergency service required Fire Brigade/Ambulance/Police
  - Type of emergency –
  - Your name
  - Location of emergency Whytes Gully Waste Resource Recovery Park – Reddalls Road, Kembla Grange
  - Nearest cross street West Dapto Road, Kembla Grange
  - Number of casualties and any information about the casualties (if applicable)
  - Any other hazards that the emergency services could encounter when they attend the facility
  - Be prepared to answer any questions the emergency operator asks you
  - Wait on line until the emergency operator tells you to hang up

# **30.7** ADVERSE WEATHER CONDITIONS (SEVERE WINDS, CYCLONIC CONDITIONS, LIGHTNING, STORM SURGES, TSUNAMI)

External emergencies that include severe storms, extreme winds, cyclonic conditions, lightning, storm surges and tsunami are all considered as adverse weather conditions. In the event of such conditions occurring, occupants are advised to -

- Try to remain calm.
- Notifying your immediate supervisor and the Chief Warden and await their instructions.
- Close all windows and doors, and if necessary shutters.
- Move away from windows and exterior walls.
- Try to keep away from mirrors, light fittings, shelves, bookcases and any other furniture that may fall or slide during adverse conditions.
- If necessary, take cover under a desk or move to an internal corner of a room, sit down and protect your face and head by placing your hands over them.
- In a minor event the occupants should remain in the building until further instructed by the Chief Warden.
- In a major event where substantial building damage, evacuate the building.
- If required contact emergency services by dialling 0-000 or 132500 (SES) or from a mobile by dialling the primary emergency number 000 or secondary emergency number 112 from a mobile (or text message to 106). In a clear and calm voice state:
  - Emergency service required SES

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- Type of emergency –
- Your name
- Location of emergency Whytes Gully Waste Resource Recovery Park – Reddalls Road, Kembla Grange
- Nearest cross street West Dapto Road, Kembla Grange
- Number of casualties and any information about the casualties (if applicable)
- Any other hazards that the emergency services could encounter when they attend the facility
- Be prepared to answer any questions the emergency operator asks you
- Wait on line until the emergency operator tells you to hang up

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### 31. Facility Emergency Safety Rules

The following safety rules must be adhered to in the event of an emergency by all workers and/or occupants of this facility

- Remain calm and not shout out.
- No person is to re-enter the facility once they have exited.
- Re-entry to the facility can only occur once the **all clear** has been given by the Chief Warden or the Officer in Charge of the attending Emergency Service.
- In the event of a fire evacuation workers must NOT:
  - Lock doors as they exit and/or
  - o Turn off lights
- Workers must not take unnecessary risks
- All facility workers must have easy access to the Council's Emergency Procedure Guide "flip chart"
- Fire fighting equipment must not be obstructed at any time for any reason
- Designated paths of egress must be free from obstructions at all times
- Emergency exit doors must be free from obstructions at all times
- Designated Fire and/or Smoke doors must not be chocked open or obstructed at anytime
- Assist LECO where assistance has been requested
- No bulky items or things such as food and drink are to be carried in an evacuation

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### 32. Fire Fighting Equipment and Emergency Safety equipment

Whytes Gully has emergency equipment that can be utilised in the event of an emergency.

The following is a list of the types of fire fighting equipment (FFE) that are located throughout the facility:

- Water (red) for use on ordinary combustibles or free burning materials such as paper, clothing wood textiles
- Carbon Dioxide CO2 (red with black band) Flammable liquids electrically energised fires and for use on burning materials such as paper, clothing, wood, textiles, liquids, petrol, oils, greases etc
- Dry Chemical (red with white band) for general use including ordinary combustibles flammable gases and liquids and electrically energised fires
- Wet Chemical (red with oatmeal band) for use on cooking oils and fats
- Foam (red with blue band) to be used on ordinary combustibles and flammable liquids
- Hose Reels DO NOT use on electrical fires
- **Fire Blankets** for use on fires involving flammable liquids in cooking containers

The following is a list of the types of emergency safety and equipment that are located throughout the facility:

- Smoke detectors
- Emergency lighting
- Exit signs
- Fire hydrants
- Fire isolated compartments i.e. Fire doors
- Smoke isolated compartments ie Smoke doors
- Emergency exits
- First Aid provisions ie kits, rooms etc

### NOTE:

- All occupants of this facility must be able to identify and locate Fire Fighting Equipment and where necessary occupants will be required to identify and locate emergency safety equipment.
- Never use water on an electrical fire, if in doubt always use the CO2 as the first choice of FFE
- Where possible, turn off the energy source or the fire's fuel source prior to attempting to attack the fire. Only do this if it is safe to do so.
- Only use FFE when it is safe to do. The five safety rules when dealing with a fire are:
  - 1. Is the fire small enough for me to manage it?
  - 2. Make sue that I tell someone about the fire ie person/s within the immediate area, an emergency warden and/or the Emergency Services
  - 3. Do not fight fire on your own have someone with you to watch your back.
  - 4. Check the FFE before using it. Consider:
    - Is the right FFE for the type of fire?

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### • Does it work?

- 5. Am I trained and confident enough to use the FFEIf in doubt get out and close the door/s behind you as you leave.

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### 33. Evacuation Diagrams

Evacuation diagrams are located throughout the facility. The plan to be orientated to show nearest exit direction when viewing the plan. A **sample** plan follows -

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# PERSONAL EMERGENCY EVACUATION PLAN

Person Assessed Name	
Building Facility Name	
Building Facility Location	
Floor	
Location on floor (be specific)	
Name of assessment team	
(Include occupant, Chief Warden, Controller of Premises, Manager and any other persons involved)	
Date of Assessment	
Is an assistance animal involved?	
If yes describe animal type and de	etail any specific requirements/needs for the animal
Is the person assessed trained in (Training must include evacuation steps)	the emergency response procedures for this site?
Date emergency training was und	ertaken:
Person assessed's preferred metl (Detail method of notification eg visual alarm, p	nod for notification of emergency event: personal vibrating device SMS etc)
List method and type of assistanc	e required for person assessed:
(Provide detailed steps on how evacuation is t	o occur. Include the use of any equipment and path of egress that will be implemented)
1	
2	
3	
4	
5	
6	
7	
8	
9	

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# PERSONAL EMERGENCY EVACUATION PLAN

Designated assistants and their contact details:

Name	Location	Landline	Mobile		Email
Are all the above lis must include evacuation s	sted assistants trained	I in the emerg	gency response proc	edures for	this site? (Training
Are all the above lis person assessed? If no, state date wh	sted assistants trained en training is to occur	I in the metho	od and type of assista <b>YES   N</b> O ninated person:	ance requi	red for the
Diagram (attachme	nt) of the preferred ro	ute for assist	ed evacuation is pro	vided:	
If no, provide detail	s explaining why:				
<u> </u>					
Issue Date:	/ /	Review	v Date: /	/	
Person Assessed A	Approved (Signature):		Da	ate: /	/
Chief Warden Appr	oved (Signature):		Da	ate: /	/
Manager Approved	(Signature):		Da	ate: /	/

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## 35 Critical Incident Response Flow Chart



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# 36 Emergency Response Plan – Whytes Gully EMERGENCY RESPONSE PLAN – WHYTES GULLY WASTE DEPOT

# IF YOU HEAR AN ALARM OR ARE IN IMMEDIATE DANGER

- Evacuate immediate work area via nearest exit and proceed to the nominated Assembly Area
- NOMINATED ASSEMBLY AREA:
  - 1. Front Entry Gates
  - 2. Entry to Glengarry (south side of transfer station)

### THEN YOU MUST

- Telephone emergency services by dialling the primary emergency contact number (using a landline dial '0' 000 (or secondary contact by dialling 112 mobile only or text a message from a mobile to 106. 000 (or mobile 112)
- In a clear and calm voice state:
  - Type of emergency
  - Your name
  - Location of emergency Whytes Gully Waste Resource Recovery Park, Reddalls Road, Kembla Grange
  - Nearest cross street West Dapto Road, Kembla Grange
  - o Details of any action already taken at site
  - Number of casualties (if any)
  - Any information about the casualties
  - Any other hazards in the area
  - Be prepared to answer any questions the emergency operator asks you
  - Wait on line until the emergency operator tells you to hang up
- In all cases advise Wayde Peterson 0418 713 531

If after hours ring the WCC After Hours Duty Officer

# 4227 7111 (Primary)

# 1300 557 980 (Secondary)

# FOR YOUR OWN SAFETY, IN THE EVENT OF AN EMERGENCY :

- Do not re-enter site until advised to do so by the Officer In Charge of the attending emergency services.
- Make sure you know the location of your nearest exits
- Do not take any unnecessary risks
- Do not talk to the media
- Await further instructions from Site/Project Manager/Supervisor.

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# **EMERGENCY COMMUNICATION FLOWCHART**





# 37. Emergency Debrief

# **EMERGENCY DEBRIEF**

Type of emergency (please tick):  $\Box$  Simulated exer

 $\Box$  Simulated exercise  $\Box$  False Alarm  $\Box$  Real Event

### Type of emergency:

Time:	Date:	Workplace/Facility:
How was alarm initia	ted:	
Chief Warden at time	of event:	

### Section/Division(s) participated:

Name of Division:	Section/Location/Area:

# Emergency Warden/s at time of event:

Name:	Name:

#### Security Personnel:

Name:	Name:

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<b>Observers:</b>
-------------------

Name:	Organisation:

Pre Evacuation Checklist	Comment
(for simulated exercise)	
Name of Wardens in attendance at pre-	
evacuation briefing	
All wardens & First Aid Officers wearing	□Yes
tabard	□No

Evacuation Sequence	Time
Alarm raised	
Warden(s) response	
Warden check of floor or area of responsibility	
Visitors sign in book retrieved	
Evacuation commenced	
Wardens report floor or area has been fully evacuated	
Persons with disabilities accounted for	
Arrive at nominated assembly area	
Wardens check personnel present	
All Visitors accounted for	
Evacuation completed	
Exercise terminated	

# Emergency Service/s in attendance (please tick)

□ NSW Fire Brigade	□ NSW Rural Fire Service	□ Ambulance Service
□ Police	□ State Emergency Service	□ Other (nominate):

#### **Observations and comments:**

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#### **Corrective Actions Requests generated:**

CAR detail	CAR No	Responsible Person	

Chief Warden (signature): Dat	
-------------------------------	--

Debrief – to be completed by Chief Warden to address issues arising from the emergency event. Any CARS arising from the emergency event must be reported to the Incident Report Hotline 4227 7700.

Completed form is to be forwarded to your Local Emergency Planning Committee (LEPC) and Divisional Document Controller.

Local Document Controller is to place all records of the event in the relevant Trim file.

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40. Telephone Threat Checklist (see next page)

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TELEPHONE THREAT CHECKLIST Receiver of call to complete			
KERCALM       DO NOT HANG UP       ATTACHMENTATO ACHSUCORPORTATION AS POSSIBLE         WHAD TOOPE OF TI       DEVELOPING EMERGENCY PROCEDURES PROCEDURES         City of innovation       PROCEDURE			
	osia 🔄 Biologicai 🔄 Raulologicai 🔄 Personai		
NOTE       EXACT       WORDING       OF         THREAT	LER:       THREAT LANGUAGE         explode? Or       Well spoken       Taped         Incoherent       Message read by caller         Incoherent       Abusive         Other:       Other:		
<ul> <li>6. Did you put it there?</li> <li>7. Why did you put it there?</li> </ul>	BACK GROUND NOISES  Street noises  Aircraft  Voices  Local call  Music  STD call		
BOMB THREAT QUESTIONS:         What type of bomb is it?         What is in the bomb?         What will make the bomb         explode?	Machinery       Other:         OTHER       Sex of caller:       Male       Female         Estimated       age       of caller:       Male       Female		
CHEINICAL/BIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOLOGICAL/RADIOL	Date call taken: Time of call: Duration of call: <i>(estimation)</i> Name/ext of person received call: Caller's number displayed: Page 64 of 65 Answers My Version Voice olevel My Version Voice olevel My Review Date Manner Diction (call taken: Page 64 of 65 Caller's number Caller's number Diction (call taken: Page 64 of 65 Caller's number Caller's		



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