September 2017

GREAT SOUTHERN LANDFILL

Technical Specification for Construction of Cell 1 and Ancillary Works

Submitted to:
Alkina Holdings Pty Ltd
45 Clune Street
BAYSWATER WA 6053

REPORT

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Distribution:

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1.0 GENERAL

1.1 Introduction

Alkina Holdings Pty Ltd (AH) has appointed Golder Associates Pty Ltd (Golder) to provide supporting technical advice and detailed civil design documentation for a new Class II landfill site known as the Great Southern Landfill. This includes a technical specification, engineering drawings and other supporting documentation associated with the design and construction of Cell 1 of the landfill. The proposed landfill is located south of the Great Southern Highway, approximately 20 km west of the town of York (Drawing D101).

This Technical Specification shall be read in conjunction with the drawings as listed in Section 1.5 and all other parts of this document. This specification has generally been prepared in accordance with the *Best Practice Environmental Management* (BPEM) EPA Victoria guidelines, "*Siting, Design, Operation and Rehabilitation of Landfills"*, and any relevant standards (refer to Section 1.4).

1.2 Extent of Works

The Works for the construction of Cell 1 at the Great Southern Landfill site will comprise of the construction of the:

- Engineered clay subgrade and general fill embankments
- Subsurface drain system
- Geosynthetic lining system
- Leachate collection system.

The Works will also include the construction of the landfill's ancillary structures:

- Stormwater Dam
- Leachate and Retention Ponds
- Sediment management structure
- Stormwater diversion works.

1.3 Abbreviations and Definitions

The acronyms and abbreviations used in this Technical Specification are defined in Table 1.

Table 1: Acronyms, Abbreviations and their Meaning

Name/Acronym	Definition
Contractor(s)	Party awarded the Contract to complete the Works described in this Document.
CQA	Construction Quality Assurance
Designer	Golder Associates Pty Ltd (Golder)
FSL	Finished Subgrade Level (Top of 500 mm thick compacted Unit 3 – Engineered Clayey Fill).
GCL	Geosynthetic Clay Liner
Hold Point	An identified point in the landfill construction sequence where the Contractor(s) must halt work and provide required information to the Superintendent. The Contractor(s) must not resume work until the Hold Point is released, in writing, by the Superintendent.
HDPE	High Density Polyethylene

Name/Acronym	Definition
Inspection Point	An identified point in the landfill construction sequence where the Contractor(s) 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.
Installer	Specialist geosynthetics or pipe installer who will be nominated by the Contractor(s)
LCP	Leachate Collection Pond
MARV	Minimum Average Roll Value
OMC	Optimum Moisture Content
Principal	Alkina Holdings Pty Ltd (AH)
PSD	Particle Size Distribution
QA	Quality Assurance
GITA (QAI)	Geotechnical Inspection and Testing Authority (GITA) shall be an independent third party engineer with experience in construction of earthen embankments and geosynthetics. The GITA will have the following responsibilities: ■ Undertaking Level 1 independent quality assurance inspection and testing of landfill earthworks in accordance with AS3798-2007. ■ Independent inspection and testing of the geosynthetic lining system. ■ Compiling the Quality Assurance Completion Report. ■ Report directly to the Superintendent. The GITA shall be engaged by the Principal and maintain a fulltime presence on site for the duration of the Works and shall be independent of the Contractor. The GITA may also be referred to as the Quality Assurance Inspector (QAI) in some documentation.
QC	Quality Control

1.4 Codes and Standards

All Works performed and all materials supplied under this Technical Specification shall comply with the latest revision of the Codes, Standards and Regulations applicable in Western Australia. Notwithstanding this, the Works shall, as a minimum, conform to the standards referenced in this Specification. In the case of a dispute between codes, the Western Australian regulations shall take precedence.

1.4.1 Australian Standards

AS 1181 Method of Measure of Civil Engineering Works and Associated Building Works

AS 1289 Methods of Testing Soils for Engineering Purposes

AS 1470 Health and Safety at Work – Principles and Practices

AS 1726 Geotechnical Site Investigations

AS 2001 Methods of Test for Textiles

AS 3706 Geotextiles – Methods of Test

AS 3798 Guidelines on Earthworks for Commercial and Residential Developments

1.4.2 American Standards

ASTM D 792 Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement

ASTM D 1004 Standard Test Method for Tear Resistance (Graves Teat) of Plastic Film and Sheeting

ASTM D 1505 Standard Test Method for Density of Plastic by the Density – Gradient Technique

ASTM D 1777 Standard Test Method for Thickness of Textile Material

ASTM D 3895 Standard Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry

ASTM D 4355 Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus

ASTM D 4595 Standard Test Method for Tensile Properties of Geotextiles by the Wide Width Strip Method

ASTM D 4632 Standard Test Method for Grab Breaking Load and Elongation of Geotextiles

ASTM D 4643 Standard Test Method for Determination of Water (Moisture) Content of Soil by Microwave Oven Heating

ASTM D 4833 Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products

ASTM D 5199 Standard Test Method for Measuring the Nominal Thickness of Geosynthetics

ASTM D 5261 Standard Test Method for Measuring Mass per Unit Area of Geotextiles

ASTM D 5321 Standard Test Method for Determining the Shear Strength of Soil-Geosynthetic and Geosynthetic-Geosynthetic Interfaces by Direct Shear

ASTM D 5323 Standard Practice for Determination of 2 % Secant Modulus for Polyethylene Geomembranes

ASTM D 5596 Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics

ASTM D 5617 Standard Test Method for Multi-Axial Tension Test for Geosynthetics

ASTM D 5721 Standard Practice for Air-Oven Aging of Polyolefin Geomembranes

ASTM D 5885 Standard Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by High-Pressure Differential Scanning Calorimetry

ASTM D 5887 Standard Test Method for Measurement of Index Flux Through Saturated Geosynthetic Clay Liner Specimens Using a Flexible Wall Permeameter

ASTM D 5890 Standard Test Method for Swell Index of Clay Mineral Component of Geosynthetic Clay Liners

ASTM D 5891 Standard Test Method for Fluid Loss of Clay Component of Geosynthetic Clay Liners

ASTM D 5993 Standard Test Method for Measuring Mass Per Unit of Geosynthetic Clay Liners

ASTM D 5994 Standard Test Method for Measuring Core Thickness of Textured Geomembrane

ASTM D 6241 Standard Test Method for Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe

ASTM D 6243 Standard Test Method for Determining the Internal and Interface Shear Resistance of Geosynthetic Clay Liner by the Direct Shear Method

ASTM D 6639 Standard Guide for Using the Frequency Domain Electromagnetic Method for Subsurface Investigations

ASTM D 6768 Standard Test Method for Tensile Strength of Geosynthetic Clay Liners

AASHTO 96 Standard test method for determining resistance to degradation of small-size coarse aggregate by abrasion and impact in the Los Angeles Machine.

1.4.3 European Standards

EN ISO 12236 Geosynthetics – Static puncture test (CBR test) (ISO 12236:2006)

DIN EN ISO 10319 Geosynthetics – Wide-width tensile test (ISO 10319:2008)

DIN EN ISO 13433 Geosynthetics – Dynamic perforation test (cone drop test) (ISO 13433:2006)

1.5 Drawings

The drawings relevant to the construction of Cell 1, the Stormwater Dam, the Leachate and Retention Ponds, sediment management structure and stormwater diversion measures are listed in Table 2.

Table 2: Drawing List

Drawing Number	Description	Revision
D101	Cover Sheet	C
D102	Works Approval Area	C
D103	General Arrangement	C
D104	Cell 1 Top of Prepared Subgrade and Setout Plan and Subsurface Drainage System	C
D105	Cell 2 Top of Prepared Subgrade and Setout Plan	C
D106	Cell 1A & 1B Earthworks Plan (Isopachytes)	C
D107	Cell 2A & 2B Earthworks Plan (Isopachytes)	C
D108	Cell 1A & 1B Sections	C
D109	Cell 2A & 2B Sections	C
D110	Typical Details Sheet 1 of 3	C
D111	Typical Details Sheet 2 of 3	C
D112	Typical Details Sheet 3 of 3	C
D113	Subsurface Drainage Details	C
D114	Cell 1 Leachate Collection Pipes and Setout Plan	C
D115	Cell 2 Leachate Collection Pipes and Setout Plan	C
D116	Cell 1 Sump Layout Plan and Setout	C
D117	Cell 2 Sump Layout Plan and Setout	C
D118	Sump Outlet Pipes	C
D119	Leachate Collection Pipe Details	C
D120	Leachate Pond Plan and Sections	C
D121	Leachate Pond Details	C
D122	Retention Pond Plan and Sections	C
D123	Retention Pond Details	C
D124	Stormwater Dam Plan and Sections	C

Drawing Number	Description	Revision
D125	Stormwater Dam Spillway Plan and Sections	C
D126	Stormwater Dam Discharge Channel Plan and Details	C
D127	Sediment Management Structure Plan and Sections	C

1.6 List of Materials

The materials that are referred to in this Technical Specification are listed below. These materials are referred to in this Specification by unit number.

- Unit 1 – Topsoil
- Unit 2 – Unsuitable Material
- Unit 3 – Engineered Clayey Material
- Unit 4 – General Fill
- Unit 5 – Subsurface Drain Pipes
- Unit 6 – Subsurface Drainage Material
  - Unit 6.1 – Subsurface Drainage Aggregate
  - Unit 6.2 – Subsurface Drainage Sand
- Unit 7 – Subsurface Drain Sump
- Unit 8 – Leachate Drainage Aggregate
- Unit 9 – Geosynthetic Clay Liner
- Unit 10 – 2 mm HDPE Geomembrane
  - Unit 10.1 –Textured HDPE geomembrane
  - Unit 10.2 – Smooth HDPE geomembrane
- Unit 11 – Cushion Geotextile
- Unit 12 – Separation Geotextile
- Unit 13 – Leachate Collection Pipes
  - Unit 13.1 – Perforated Leachate Header Pipe
  - Unit 13.2 – Perforated Leachate Collection Pipe
  - Unit 13.3 – Solid Leachate Header Pipe
- Unit 14 – Leachate Sump
  - Unit 14.1 – Reinforced Concrete
  - Unit 14.2 – Leachate Sump Outlet Sleeves
  - Unit 14.3 – Transducer Riser Pipe

- Unit 15 – Sacrificial Liner Protection Layer
- Unit 16 – Permanent Ballast
- Unit 17 – Protection Layer
- Unit 18 – Wearing Course
- Unit 19 – Spillway and stormwater channel
  - Unit 19.1 – Concrete Spillway and Dissipater blocks
  - Unit 19.2 – Loosely placed rock
  - Unit 19.3 – Erosion protection mat
- Unit 20 – Sediment Management Structure
  - Unit 20.1 – Separation Geotextile
  - Unit 20.2 – Embankment Aggregate.

1.7 Contractor(s) Responsibilities

1.7.1 General

The Contractor(s) obligations under the Contract shall comprise supply, taking delivery, the construction, completion and maintenance of the Works, and the provision of all labour, materials, temporary Works, and everything, whether of a temporary or permanent nature, required in and for such construction, completion and maintenance, so far as the necessity for providing the same is specified in or reasonably to be inferred from the contract.

For any materials supplied by the Principal for the provision of the Works, the Contractor(s) shall be responsible for unloading, storing and protecting the materials until they are incorporated into the Works. If the materials are damaged while under the Contractor(s)'s care the Contractor(s) shall replace the materials to the same specification as supplied by the Principal.

The Contractor(s) shall inform the Superintendent of any **Hold Point** or **Inspection Point**, allowing a minimum of 24 hours for the inspection, unless otherwise approved by the Superintendent. The Contractor(s) shall make all equipment available as required for the inspection.

1.7.2 Construction Quality Assurance Plan

Construction Quality Assurance (CQA) shall be carried out in accordance with the requirements of the CQA Plan.

1.7.3 Submissions

The Contractor(s) is required to submit works methodologies or procedures to the Superintendent for approval. Details of required submissions are found within this document and include:

- Health, Safety and Environmental Management Plan.
- Surface Water Management Plan
- Work Method Statement for Subgrade Construction
- Work Method Statement for Subsoil Drain Construction
- Work Method Statement for Embankment Construction
- Work Method Statement for 500 mm thick Engineered Clayey Material
- Proposed Unit 9 – Geosynthetic Clay Liner placement methodology

- Quality Control Procedures Documentation for Unit 10 – HDPE Geomembrane
- Proposed Panel Layout Plan for Unit 9 – Geosynthetic Clay Liner and Unit 10 – HDPE Geomembrane
- Current calibration certificates for Unit 10 – HDPE Geomembrane test equipment
- Proposed Unit 11 – Cushion Geotextile and Unit 12 – Separation Geotextile placement methodologies
- Work Method Statement for placement of Leachate Collection Pipes onto the cushion geotextile, including placement of Unit 8 – Leachate Drainage Aggregate.
- Work Method Statement for the construction of Leachate Sump
- Work Method Statement for placement of the Unit 20.2 – Embankment Aggregate.

1.8 Material Quality Assurance and Quality Control General

1.8.1 General

The Contractor(s) shall be responsible for supply, delivery, storage, placement and installation of all materials required to carry out the works in this Technical Specification.

The Contractor(s) shall present documentation to the Superintendent for each of the materials prior to delivery to site that demonstrates that the supplied materials meet the specifications in Section 2.0. Subsequent testing of materials to confirm conformance shall be organised and carried out by the GITA, except if agreed otherwise with the Superintendent and the Contractor.

1.8.2 Manufacturer and Supplier Certificates

Manufacturer and supplier certificates and material specification data sheets for the following items shall be submitted to the Superintendent two weeks prior to commencement of construction (**Hold Point**):

- Unit 5 – Subsurface Drain Pipes
- Unit 6 – Subsurface Drainage Material
  - Unit 6.1 – Subsurface Drainage Aggregate
  - Unit 6.2 – Subsurface Drainage Sand
- Unit 8 – Leachate Drainage Aggregate
- Unit 9 – Geosynthetic Clay Liner
- Unit 10 – HDPE Geomembrane
  - Unit 10.1 –Textured HDPE geomembrane
  - Unit 10.2 – Smooth HDPE geomembrane
- Unit 11 – Cushion Geotextile
- Unit 12 – Separation Geotextile
- Unit 13 – Leachate Collection Pipes
- Unit 18 – Wearing Course
- Unit 19.3 – Erosion protection mat
- Unit 20.1 – Separation Geotextile
- Unit 20.2 – Embankment Aggregate.

Certificates and material specification data sheets shall be provided in accordance with the CQA plan, and confirmed in the Contractor(s) Inspection and Testing Plan (ITP). The Superintendent shall assess whether the materials selected meet the requirements of the specifications and may decide on independent laboratory testing if required.

1.9 Schedule of Works

The Stormwater Dam and Sediment Management Structure shall be constructed first to provide water for use in construction and dust suppression and to manage sediment from the Works area. Other identified sources shall be made available to the Contractor for construction purposes[1]. The following general sequence of works shall be applicable:

1.9.1 Stormwater Dam

a) Strip and remove vegetation from the footprint of the Stormwater Dam and place material in stockpiles as instructed by the Superintendent.

b) Excavate and stockpile Unit 1 – Topsoil, for later use, from within the Works area.

c) Excavate key trench and stockpile as instructed by the Superintendent.

d) Proof roll entire dam footprint, including embankment footprint.

e) Excavate Unit 2 – Unsuitable Material, identified by the GITA, to a depth of 500 mm and stockpile within the Works area or as instructed by the Superintendent.

f) Excavate Unit 3 – Engineered Clayey Material from designated borrow area or stockpile, moisture condition, place and compact in areas where unsuitable material has been removed.

g) Excavate Unit 3 – Engineered Clayey Material from designated borrow area or stockpile, moisture condition, place and compact in key-in trench and Stormwater Dam embankment.

h) Load, haul and place Unit 1 – Topsoil to a depth of 150 mm on downstream face of Stormwater Dam.

i) Supply and place Unit 18 – Wearing Course on dam crest.

j) Construct Unit 19 – Spillway and stormwater channel as specified and shown on the Drawings.

1.9.2 Cell 1

a) Strip and remove vegetation, from the footprint of Cell 1, and place material in stockpiles as instructed by the Superintendent.

b) Excavate and stockpile Unit 1 – Topsoil, for later use, from within the Works area.

c) Excavate Unit 2 – Unsuitable Material to a depth of 800 mm over the basin footprint of Cell 1, excluding the outer landfill perimeter embankment footprint and stockpile as instructed by the Superintendent.

d) Excavate from within footprint of Cell 1 to a depth of -250 mm of the finished subgrade level (FSL) and stockpile as instructed by the Superintendent, in consultation with the GITA, for use as Unit 3 – Engineered Clayey Material, Unit 4 – General Fill or Unit 2 – Unsuitable Material.

e) Proof roll cell base.

f) Excavate Unit 2 – Unsuitable Material to a depth of at least -1250 mm below FSL, where deemed necessary by the GITA. Backfill with Unit 3 – Engineered Clayey Material up to -250 mm below finished subgrade level.

g) Excavate and install subsurface drainage system along the southern flank of Cell 1.

[1] Note that the sources of water for construction will still be identified in a separate study that will take place prior to construction commencing.

h) Excavate and compact Leachate Collection Sump.

i) Fill areas and embankment construction:

   i) Load, haul, moisture condition, place and compact Unit 4 – General Fill, for embankment construction of perimeter and division embankments

   ii) Load, haul, moisture condition, place and compact Unit 3 – Engineered Clay material to a thickness of 500 mm on the slopes and crest of the embankments.

   iii) Load, haul, moisture condition and place Unit 3 – Engineered Clayey Material up to -250 mm below finished subgrade level to match *in situ* -250 mm FSL within footprint of Cell 1 and. 2, excluding the perimeter embankment footprint.

j) Rip, moisture condition and re-compact *in situ* or placed fill Unit 3 – Engineered Clayey Material (RL -250 mm of FSL), to a depth of 250 mm.

k) Excavate from designated borrow or stockpile, moisture condition, place and compact 250 mm thick layer Unit 3 – Engineered Clayey Material, to achieve top of FSL.

l) Excavate anchor trenches.

m) Finish the surface of the subgrade to create a smooth surface suitable for placement of Unit 9 – Geosynthetic Clay Liner.

n) Place Unit 9 – Geosynthetic Clay Liner over the prepared subgrade and embankments and into the anchor trenches in accordance with the Drawings.

o) Install Unit 10 – HDPE Geomembrane over the surface of Unit 9 – Geosynthetic Clay Liner and into the anchor trenches in accordance with the approved panel layout and Drawings as appropriate. Unit 9 – Geosynthetic Clay Liner and Unit 10 – HDPE Geomembrane is to be placed concurrently.

p) Place Unit 11 – Cushion Geotextile above Unit 10 – HDPE Geomembrane and into the anchor trenches in accordance with the Drawings.

q) Progressively backfill and compact the anchor trenches with Unit 3 – Engineered Clayey Material.

r) Construct Unit 14.1 – Reinforced Concrete Slab in the Leachate Collection Sump, over the Geosynthetic lining system.

s) Place and install Unit 14.2 – Leachate Sump Outlet Sleeves and Unit 14.3 – Transducer Riser Pipe in the Leachate Sump.

t) Sequentially place and install Unit 13 – Leachate Collection Pipes over Unit 11 – Cushion Geotextile in the base of the cells as per the Drawings.

u) Place Unit 8 – Leachate Drainage Aggregate surrounding and above Unit 13 – Leachate Collection Pipes, in the leachate sump, over the base of Cell 1 and extending up the side slopes, as per the Drawings.

v) Liner Integrity Survey (electrical leak location testing).

w) Place Unit 12 – Separation Geotextile over Unit 8 – Leachate Drainage Aggregate and secure with mounds of gravel or other approved system.

x) Place Unit 15 – Liner Protection[2] on the side slopes of the cells as indicated on the Drawings.

y) Load, haul, place and nominally compact Unit 18 – Wearing Course on the crest of the embankments.

[2] This layer will be placed by the Operator and not by the Contractor, but has been included in the specification for completeness

z) Load, haul and place Unit 1 – Topsoil to a depth of 150 mm on the outer slopes of the perimeter embankments.

1.9.3 Leachate Pond

a) Strip and remove vegetation from the footprint of the Leachate Pond and place material in stockpiles as instructed by the Superintendent.

b) Excavate and stockpile Unit 1 – Topsoil, for later use, from within the Works area.

c) Excavate from within footprint of Leachate Pond to a depth of -250 mm of FSL and stockpile as instructed by the Superintendent for use as Unit 3 – Engineered Clayey Material, Unit 4 – General Fill or Unit 2 – Unsuitable Material.

d) Remove Unit 2 – Unsuitable Material to the extent and depth as directed by the GITA and replace with Unit 3 – Engineered Clayey Material up to -250 mm below FSL.

e) Fill areas and embankment construction:

   i) Load, haul, moisture condition, place and compact Unit 4 – General Fill for the embankment construction.

   ii) Load, haul, moisture condition, place and compact Unit 3 – Engineered Clay material to a thickness of 500 mm on the upstream slopes of the embankment to the alignment and final elevation of the anchor trench.

   iii) Load, haul, moisture condition and place Unit 3 – Engineered Clayey Material up to -250 mm below FSL to match *in situ* -250 mm level in rest of pond.

f) Proof roll pond base.

g) Rip, moisture condition and re-compact *in situ* or placed Unit 3 – Engineered Clayey Material (RL -250 mm of FSL), to a depth of 250 mm.

h) Excavate from designated borrow or stockpile, moisture condition, place and compact 250 mm thick layer Unit 3 – Engineered Clayey Material, to achieve top of FSL.

i) Excavate anchor trenches.

j) Finish the surface of the subgrade to create a smooth surface suitable for placement of Unit 9 – Geosynthetic Clay Liner.

k) Place Unit 9 – Geosynthetic Clay Liner over the prepared subgrade and embankments and into the anchor trenches in accordance with the Drawings.

l) Install Unit 10 – HDPE Geomembrane over the surface of Unit 9 – Geosynthetic Clay Liner and into the anchor trenches in accordance with the approved panel layout and Drawings as appropriate. Unit 9 – Geosynthetic Clay Liner and Unit 10 – HDPE Geomembrane is to be placed concurrently.

m) Progressively backfill and compact the anchor trenches with Unit 3 – Engineered Clayey Material.

n) Construct and install Unit 16 – Permanent Ballast at 10 m centres along the upstream slopes of the embankments and over the basin floor in accordance with the Drawings or as instructed by the Superintendent.

o) Liner Integrity Survey (electrical leak location testing)

p) Load, haul, place and nominally compact Unit 18 – Wearing Course on the crest of the embankments.

q) Load, haul and place Unit 1 – Topsoil to a depth of 150 mm on the outer slopes of the embankments.

r) Construct and install Unit 15 – Sacrificial Liner Protection Layer along the south-east flank of the Leachate pond, to protect Unit 10 – HDPE Geomembrane during periodic pump extraction of the leachate from the pond.

1.9.4 Retention Pond

a) Strip and remove vegetation from the footprint of the Retention Pond and place material in stockpiles as instructed by the Superintendent.

b) Excavate and stockpile Unit 1 – Topsoil, for later use, from within the Works area.

c) Excavate from within footprint of Leachate Pond to a depth of -250 mm of FSL and stockpile a instructed by the Superintendent for use as Unit 3 – Engineered Clayey Material, Unit 4 – General Fill or Unit 2 – Unsuitable Material.

d) Proof roll pond base.

e) Remove Unit 2 – Unsuitable Material to the extent and depth as directed by the GITA and replace with Unit 3 – Engineered Clayey Material up to -250 mm below FSL.

f) Fill areas and embankment construction:

   i) Load, haul, moisture condition, place and compact Unit 4 – General Fill, for the embankment construction.

   ii) Load, haul, moisture condition, place and compact Unit 3 – Engineered Clay material to a thickness of 500 mm on the upstream slopes of the embankment to the alignment and final elevation of the anchor trench.

   iii) Load, haul, moisture condition and place Unit 3 – Engineered Clayey Material up to -250 mm below FSL to match *in situ* -250 mm level in rest of pond.

g) Rip, moisture condition and re-compact in situ or placed Unit 3 – Engineered Clayey Material (RL -250 mm of FSL), to a depth of 250 mm.

h) Excavate from designated borrow or stockpile, moisture condition, place and compact 250 mm thick layer Unit 3 – Engineered Clayey Material, to achieve top of FSL.

i) Excavate anchor trenches.

j) Finish the surface of the subgrade to create a smooth surface suitable for placement of Unit 10 – HDPE Geomembrane.

k) Install Unit 10 – HDPE Geomembrane over the compacted surface and into the anchor trenches in accordance with the approved panel layout and Drawings as appropriate.

l) Progressively backfill and compact the anchor trenches with Unit 3 – Engineered Clayey Material.

m) Construct and install Unit 16 – Permanent Ballast at 10 m centres along the upstream slopes of the embankments and over the basin floor in accordance with the Drawings or as instructed by the Superintendent.

n) Construct and install Unit 15 – Sacrificial Liner Protection Layer along the north-east flank of the Retention pond, to protect Unit 10 – HDPE Geomembrane during periodic pump extraction of the leachate from the pond

o) Load, haul, place and nominally compact Unit 18 – Wearing Course on the crest of the embankments.

p) Load, haul and place Unit 1 – Topsoil to a depth of 150 mm on the outer slopes of the embankments.

1.9.5 Stormwater and Sediment Management Structures

a) Strip and remove vegetation from the footprint of the Sediment Control Structure and Stormwater Diversion bunds and channels, and place material in stockpiles as instructed by the Superintendent.

b) Excavate and stockpile Unit 1 – Topsoil, for later use, from within the Works area.

c) Stormwater Diversion Drains and Bunds

   i) Cut to fill to form Stormwater diversion channels and bunds as detailed on the Drawings.

   ii) Excavate from designated borrow or stockpile, moisture condition, place and compact Unit 4 – General Fill, to form stormwater diversion bunds around Leachate and Retention Ponds or where required.

   iii) Remove Unit 2 – Unsuitable Material to the extent and depth as directed by the GITA and replace with Unit 4 – General Fill up to finished subgrade level.

   iv) Proof roll cut areas

d) Sediment Management Structure.

   i) Excavate for shallow Sediment Management Structure embankment key and place material in stockpiles as instructed by the Superintendent

   ii) Proof roll cut areas

   iii) Supply and place Unit 20.1 – Separation Geotextile to the extent shown on the Drawings.

   iv) Supply and place Unit 20.2 – Embankment Aggregate to the lines and grades shown on the Drawings to form a self-draining embankment.

2.0 MATERIAL PROPERTIES

2.1 General

The Contractor(s) 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(s) 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.

2.2 Unit 1 – Topsoil

Unit 1 – Topsoil, shall comprise soil of any gradation or degree of plasticity that contains significant quantities of visually identifiable vegetable matter, sod, roots or humus, to a nominal depth of 300 mm below the existing surface, or as instructed by the Superintendent or the GITA.

2.3 Unit 2 – Unsuitable Material

The Superintendent or GITA may instruct the Contractor(s) to remove unsuitable material from the Works. Unsuitable material includes but is not limited to:

- Vegetation and materials resulting from clearing, grubbing and stripping activities and all perishable matter.
- Organic soils.
- Soft ground.
- Hard ground/rock.

- Inappropriate material gradation or type, including sandy or gravelly material, up to a maximum depth of 1.5 m below finished subgrade level.
- Zones of higher permeability, including upper 800 mm of the profile below the topsoil layer.
- Materials not suitable for re-use as Unit 3 – Engineered Clayey Material.
- Soils and materials subject to chemical change, due to oxidation or due to attack by any potential aggressive fluids and gases or which, by virtue of their chemical composition, may have a deleterious effect on structures or components forming part of the permanent work.
- Soils containing debris or other contaminants deemed unsuitable by the Superintendent or GITA.

2.4 Unit 3 – Engineered Clayey Material

Unit 3 – Engineered Clayey Material will be excavated from the footprint of Cell 1 or from on-site stockpiles identified by the Superintendent and shall satisfy the following criteria:

- Comprise soil free of organic matter.
- Maximum Particle Size of 19 mm.
- At least 60% passing through the 4.75 mm sieve.
- At least 40% passing through the 75 µm sieve.
- Plasticity Index >20% (in accordance with AS1289).

Prior to construction, the Unit 3 – Engineered Clayey Material shall be tested to confirm that it meets the specified property values listed in this Specification. Specifically, the Contractor shall conduct the following testing on the proposed clay liner material:

- **Atterberg Limits Test** to measure Plasticity Index and Liquid Limit.
- **Standard Compaction Test** to measure compaction characteristics.
- **Particle Size Distribution Test** to measure the percentage by mass of the soil passing the 4.75 mm sieve.
- **Percent Fines Test** to measure the percentage by mass of the soil passing the 75 µm sieve.

The frequency of initial compliance testing during placement of the Unit 3 – Engineered Clayey Material shall as a minimum conform to 1 test per 3 000 m^3 of Unit 3 – Engineered Clayey Material evenly distributed through the clay source.

The GITA may vary the requirements of Unit 3 – Engineered Clayey Material, in consultation with the Designer and the Superintendent, providing that any changes in the material properties do not adversely impact on the design intent. The Contractor shall submit the results of the compliance testing to the GITA and Superintendent.

2.5 Unit 4 – General Fill

Unit 4 – General Fill will be excavated from the footprint of Cell 1 or from on-site stockpiles identified by the Superintendent and shall comprise clay, silt, sand, gravel or any combination thereof or other approved materials. Unit 4 – General Fill have properties in accordance with the following:

- Free of organic matter, topsoil and rubble.
- Well graded.
- Maximum particle size of 37.5 mm.

- Percentage Fines (percent passing 75 µm sieve) >15%.
- Plasticity Index >10%.

Confirmation of the properties of Unit 4 – General Fill shall be by Contractor inspection, documentation, sampling and testing at a frequency of at least one testing event per 3000 m^3 of material placed, with a minimum of one testing event per source.

The GITA may vary the requirements of Unit 4 – General Fill, in consultation with the Designer and the Superintendent, providing that any changes in the material properties do not adversely impact on the design intent. The Contractor shall submit the results of the compliance testing to the GITA and Superintendent.

2.6 Unit 5 – Subsurface Drain Pipes

Unit 5 – Subsurface Drain Pipes shall be supplied by the Contractor and be 110 mm diameter, PN 8 PE100 HDPE or equivalent strength pipe. Slots shall be cut into the drainage pipe as shown in the Drawings and all swarf removed prior to installation.

The fittings for the pipes shall be supplied by the Contractor(s). 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.

2.7 Unit 6 – Subsurface Drainage Materials

2.7.1 Unit 6.1 – Subsurface Drainage Aggregate

Unit 6.1 – Subsurface Drainage Aggregate shall be supplied by the Contractor(s) and shall conform to the following properties:

- Maximum particle size of 53 mm.
- At least 80% of particles passing the 40 mm sieve.
- At least 60% of particles passing the 35.5 mm sieve.
- At least 10% of particles passing the 8 mm in size.
- Maximum of 5% by weight of particles to be less than 1.3 mm.
- Minimum particle size of 1.3 mm.

2.7.2 Unit 6.2 – Subsurface Drainage Sand

Unit 6.2 – Subsurface Drainage Sand shall be supplied by the Contractor(s) and shall conform to the following properties:

- Maximum particle size of 35.5 mm.
- At least 80% of particles passing the 10 mm sieve.
- At least 60% of particles passing the 2.5 mm sieve.
- At least 10% of particles passing the 0.40 mm sieve.
- Maximum of 5% by weight of particles to be less than 0.3 mm.
- Minimum particle size of 0.075 mm.

2.8 Unit 7 – Subsurface Drain Sump

Unit 7 – Subsurface Drain Sump shall consist of 1200 mm ID (internal diameter) precast concrete rings with step irons and frame/cover (Class M), supplied by the Contractor(s). The sump shall be manufactured in accordance with AS 4198:1994. The manhole lid shall be cast iron or similar with a 150 mm diameter hole to facilitate installation of a pump line.

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

The Contractor(s) shall provide the Superintendent with manufacturer's documentation certifying the properties of the material for each component or section of Unit 7 – Subsurface Drain Sump.

2.9 Unit 8 – Leachate Drainage Aggregate

Unit 8 – Leachate Drainage Aggregate shall be supplied by the Contractor(s) and shall conform to the following properties:

- Maximum particle size of 53 mm.
- At least 85% of particles passing the 37.5 mm sieve).
- Particles less than 20 mm in size to be less than 20% by weight.
- Particles less than 2.36 mm size to be less than 3% by weight.
- Hydraulic conductivity of not less than 1×10^{-3} m/s.
- Aspect ratio of particles shall be less than 2.

If the aggregate shape is different to the above requirements a review of the cushion geotextile required properties should be conducted.

The Contractor shall arrange for 4 samples from Unit 8 – Leachate Drainage Aggregate and test the particle size distribution in accordance with AS 1289.3.6.1 of each of the samples. The Contractor shall be responsible for collecting test samples that are representative of the sample to be used during construction and submitting the results to the GITA and the Superintendent.

2.10 Unit 9 – Geosynthetic Clay Liner

The Contractor shall supply Unit 9 – Geosynthetic Clay Liner (GCL) conforming to the following requirements:

The GCL shall be a reinforced multi-layered system comprising at least two layers of geotextile encapsulating a layer of dry, sodium bentonite. A statement from the Manufacturer on the origin and material properties of the bentonite shall be provided. The material properties information shall comprise at least:

- Montmorillonite content.
- Carbonate content (less than 2% by weight).
- Percentage of Sodium Bentonite.
- Cation Exchange Capacity.
- Fluid Loss
- Whether the bentonite has been modified and if so what modification agent was used and in what percentage.

The lower geotextile shall be of woven composition and the top geotextile shall be of non-woven composition, and shall be needle punched across the bentonite layer, and be thermally locked. A statement from the Manufacturer on the origin and material properties of the geotextile component shall be provided.

Unit 9 – Geosynthetic Clay Liner shall have the following minimum properties in Table 3 and the Manufacturer shall conduct Quality Control (MQC) testing on rolls to be delivered to site. The Manufacturer shall provide test results to the Contractor(s) of the testing conducted on rolls delivered to site. The Contractor(s) shall submit these MQC results to the GITA for review.

The tests listed in Table 3 shall be conducted by the GITA on different rolls, delivered to site. Samples recovered by the GITA shall be from different rolls evenly distributed through the batch delivered to site.

Table 3: Unit 9 – Geosynthetic Clay Liner Material Properties

Property	Units	Value (MARV[1])	Test	GITA Testing Frequency
Mass per unit area of GCL including bentonite moisture content	g/m^2	≥4440	ASTM D 5993	1 test per 600 m^2
Bentonite Mass (measure at 0% moisture content)	g/m^2	≥4000	ASTM D 5993	1 test per 2500 m^2
Mass per unit area of bentonite in overlaps (measure at 0% moisture content) [2]	g/m^2	≥4300	ASTM D 5993	1 test per 60 m overlap
Cation exchange capacity of Bentonite	Meq/100 g (or cmol/kg)	≥70	X-Ray diffraction	1 test per 500 m^2
Montmorillonite Content	% by weight	>70	X-Ray diffraction	1 test per 10 000 m^2
Carbonate Content	% by weight	≤2	X-Ray diffraction or ASTM D 4373	1 test per 10 000 m^2
Mass per unit area of carrier geotextile	g/m^2	≥240	AS 2001.2.13	Review MQC data
Mass per unit area of cover geotextile	g/m^2	≥200	AS 2001.2.13	Review MQC data
Tensile Strength	kN/m	≥8	ASTM D 6768	1 test per 10 000 m^2
Tensile Elongation	%	≥10	Modified ASTM D 6768	
CBR Strength	N	≥1500	AS 3706.4	1 test per 5000 m^2
Peel Strength (min avg.)	N/m	≥360	ASTM D 6496	1 test per 500 m^2
Fluid Loss	mL	≤18	ASTM D 5891	1 test per 300 m^2
Permeability	m/s	$\leq 5\times10^{-11}$	ASTM D 5887	1 test per 10 000 m^2

Notes: [1] MARV = Minimum or Maximum Average Roll Value representing a confidence level of 97.5% of test results meets the required value.

[2] The overlap treatment of the GCL rolls may be varied by the GITA in consultation with the Superintendent, depending on the type of GCL, the composition of the geotextile type and edge treatment of the GCL supplied.

The manufacturer shall certify that the bentonite used for the manufacture of the GCL rolls delivered to site is at least 80% by weight of sodium activated powdered bentonite.

The rolls shall also include edge markings to indicate the required 300 mm overlap for panels. The overlap of the GCL rolls may be varied by Superintendent in consultation with the Designer, depending on the type of GCL, the composition of the geotextile type and edge treatment of the GCL supplied.

The Contractor(s) shall also supply buckets of bentonite paste of two different viscosities, for the preparation and pasting of overlaps, where required. The bentonite paste shall be sourced from the GCL Manufacturer and shall be prepared using bentonite similar to the bentonite of the GCL. Alternatives for the overlap seal systems suggested or supplied by the Manufacturer is to be submitted to the GITA for approval prior to use.

Each roll of Unit 9 – Geosynthetic Clay Liner shall be clearly labelled with the following information:

- Weatherproof product identification including product name, grade and date of manufacture.
- Unrolling direction.
- Manufacturer's name.
- Batch number.
- Roll number, length, width and weight.

2.11 Unit 10 – HDPE Geomembrane

Geomembrane liners shall be supplied and delivered to site by the Contractor(s) and shall comprise 2 mm thick:

- Unit 10.1 – Textured (both sides) HDPE geomembrane
- Unit 10.2 – Smooth (both sides) HDPE geomembrane.

The geomembranes shall be manufactured from a virgin first-quality polythene resin, shall not be mixed with other resin, shall not contain more than 2% clean recycled polymer by weight of the HDPE resin and shall be designed and manufactured specifically for use in geomembranes. A statement from the Manufacturer on the origin of the resin and supporting base resin density and OIT test results shall be provided.

The base resin for the geomembranes shall have a density of at least 0.932 g/cm^3.

The Contractor(s) shall also supply extrudate for extrusion welding of seams. The extrudate shall be supplied from the same supplier as the geomembranes and shall be in the form HDPE rod supplied in rolls. The Contractor(s) shall obtain documents from the supplier to certify that the weld rod is from the same resin as the geomembrane sheet for this project.

The Manufacturer shall submit to the Contractor(s) manufacture quality control (MQC) test results conducted on samples from the rolls delivered to site. MQC tests shall be conducted on samples to demonstrate the delivered materials meet the material requirements in Table 4. The Contractor(s) shall submit these MQC results to the GITA for review.

The geomembranes shall be free from holes, blisters, blemishes, striations, bubbles, roughness, undispersed raw materials, and contamination by foreign matter to the satisfaction of the GITA. The geomembranes shall have the minimum properties listed in Table 4 and the independent testing frequency shall be carried out by the GITA on rolls delivered to site. The samples to be tested shall be taken by the Contractor(s) under the supervision of the GITA. The results of the independent testing shall take precedence over the MQC results.

Both the Unit 10.1 –Textured HDPE geomembrane and the Unit 10.2 – Smooth HDPE geomembrane shall satisfy the following properties:

Table 4: Unit 10 – HDPE Geomembrane Material Properties

Property	Units	Value (Unit 10.2 Smooth)	Value (Unit 10.1 Textured)	Test	GITA Testing Frequency
Thickness (ave)	mm	2.0	2.0	ASTM D 5199 (smooth) ASTM D 5994 (textured)	One test per two rolls
Minimum Thickness	mm	>1.85	>1.80	ASTM D 5199 ASTM D 5994	
Density (min)	g/cm^3	≥0.94	≥0.94	ASTM D 1505 or ASTM D 792	One test per five rolls
Asperity Height	mm	NA	>0.40	ASTM D 7466	Two samples from Unit 10.1 (textured)
Melt Flow Index	g/10 min	<1.0	<1.0	ASTM D 1238	Review MQC data
Tensile Properties (each direction) Strength at break Elongation at break Strength at yield Elongation at yield	 N/mm % N/mm %	 >53 >700 >29 >12	 ≥21 >100 >29 >12	 ASTM D 6693 ASTM D 6693 ASTM D 6693 ASTM D 6693	One test per five rolls
Tear Resistance	N	>250	>250	ASTM D 1004	
Puncture Resistance	N	>640	≥535	ASTM D 4833	
Carbon Black Content	%	2 to 3	2 to 3	ASTM D 1603	
Carbon Black Dispersion	Rating	100% Cat 1	100% Cat 1	ASTM D 5596	
Oxidative Induction Time (OIT) Standard OIT (**AND**) High Pressure OIT	Min Min	≥100 ≥400	≥100 ≥400	ASTM D 3895 ASTM D 5885	One test per resin type or per 10 000 m^2, or manufacturing run per geomembrane type
Oven Aging at 85°C High Pressure OIT	% retained after 90 days	≥80	≥80	ASTM D 5721 ASTM D 5885	Review MQC data for batch.
Oven Aging at 85°C Standard OIT	% retained after 90 days	≥55	≥55	ASTM D 5721 ASTM D 5885	Review MQC data for batch.
Environmental Tensile Load Crack Resistance	Hr	>500	>500	ASTM D 5397	One test per resin type or per 10 000 m^2, or manufacturing run per geomembrane type

Notes: Depending on results from the GITA may consider performing OIT testing on both core and surface samples of the geomembrane.

The Contractor(s) shall provide Manufacture Quality Control data for all rolls delivered to site for all parameters listed in Table 4. The test results for Oven Aging and Melt Flow Index tests shall be no older than **12 months** from the manufacture data of the rolls and the manufacturer shall certify whether the material used in the delivered rolls is the same as the material of the oven aging and Melt Flow Index tests.

The GITA test results take precedence over any MQC data.

A sample of each geomembrane type shall also be tested for separation-in-plane phenomenon, for review by the GITA.

In addition, the geomembrane may contain up to a maximum of 1% by weight of additives, fillers or extenders (not including carbon black).

Materials manufacturing quality assurance test certificates shall be submitted to the GITA verifying all tests and test methods required by the Table 4 have been performed on the materials proposed for this project. Each geomembrane roll shall be clearly labelled with the following information:

- Manufacturer's Name and type of material.
- Thickness of the material and type (smooth or textured).
- Roll Number.
- Length and width of the roll.
- References to raw material batch (Batch Number) and laboratory certified reports.
- Manufacturer's approved QA stamp and technician's signature.

2.12 Unit 11 – Cushion Geotextile

Tests shall be conducted by the GITA on samples from different rolls at the frequency listed in Table 5. The GITA will perform sampling and tests listed in Table 5, on the basis that the rolls delivered to site are from one continuous manufacturing batch. The Contractor(s) shall arrange for any independent tests.

Unit 11 – Cushion Geotextile shall be supplied and delivered to site by the Contractor(s) and shall satisfy the property values specified in Table 5. The manufacturer shall provide documentation to demonstrate what process is adopted in the manufacture of the geotextile to ensure that any broken needles or other sharp objects from the manufacturing process are identified and removed from the geotextile prior to dispatch of the materials to site. The GITA shall review the provided documentation and shall recommend to the Superintendent to whether field sensing should be carried out verifying the absence of sharp items in the geotextile that may pose a puncture risk to the geomembrane liner.

Table 5: Unit 11 – Cushion Geotextile Material Properties

Property	Units	Value (MARV)[1]	Test	GITA Testing Frequency
Mass	g/m^2	≥1100	AS 3706.1	1 test per 2500 m^2
Wide Strip Tensile Strength	kN/m	≥50	ASTM D 4595 AS 3706.2	1 test per 5000 m^2
Trapezoidal Tear	N	≥1100	AS 3706.3	
CBR Burst	N	≥9000	AS 3706.4	
Grab Strength	N	≥3500	AS 2001.1.2.3	
Grab Elongation	%	50		
UV Resistance	%	45	ASTM D 4355	Review MQC data

Notes: [1]MARV = Minimum Average Roll Value representing a confidence level of 97.5% of the test results meet the required value.

Samples shall be recovered by the GITA, with assistance and equipment as required provided by the Contractor(s), from site delivered rolls and independent testing arranged by the GITA.

UV resistance test results for the geotextile shall be based on manufacturer quality control test results not less than 12 months old.

Geotextiles shall comprise new (i.e. no recycled materials) polymeric yarns or fibres, seamed or drawn strands oriented into a stable network that retains its structure during handling, placement. Geotextiles shall be non-woven, continuous fibre, polyester needle punched and resin or heat bonded. Compression testing of the proposed cushion geotextile shall be undertaken by the GITA. Compression testing shall be undertaken in accordance with a Modified Hydrostatic Puncture Test (ASTM D5514) to assess the geotextiles capacity to limit potential deformations and strain in the geomembrane liner. The parameters must be agreed with the Designer prior to undertaking the test to simulate the expected future depth of waste. The compression test must simulate a pressure of 350 kPa. In an effort to reduce the risk of unsuitable materials being delivered to site, AH may require that samples of proposed materials are provided for this testing prior to ordering. Alternative types of geotextile with different properties may be considered subject to compression testing with the liner materials.

Unit 11 – Cushion Geotextile shall be capable of withstanding direct exposure to sunlight for **six months** with no visible deterioration. Unit 11 – Cushion Geotextile shall retain at least 70% of the original strength when exposed to the test requirements of ASTM D 7238, or Australian Standard AS 3706.11.

Unit 11 – Cushion Geotextile shall be supplied by the Contractor(s) in rolls wrapped in protective dust-proof covers and marked or tagged with all of the following information:

- Manufacturer's name.
- Product identification including name, grade and polymer type.
- Lot or Batch number.
- Roll number.
- Roll length, width and weight.

The Contractor(s) shall be responsible for all quality assurance and quality control of Unit 11 – Cushion Geotextile delivered to site.

The Contractor(s) shall supply documentation to the Superintendent from the geotextile manufacturer to certify the materials used in the manufacture of the rolls delivered to site meet the requirements of this Section.

2.13 Unit 12 – Separation Geotextile

Tests shall be conducted by the GITA on samples from different rolls at the frequency listed in Table 6. The GITA will supervise sampling of the rolls at frequencies listed in Table 6. The Contractor(s) shall arrange for any independent tests. Unit 12 – Separation Geotextile shall be supplied and delivered to site by the Contractor(s) and shall satisfy the property values specified in Table 6.

Table 6: Unit 12 – Separation Geotextile Material Properties

Property	Units	Value	Test	GITA Testing Frequency
Mass	g/m^2	>160	AS 3706.1	2 tests
Trapezoidal Tear	N	>350	AS 3706.3	4 tests
Thickness	mm	>1.2	AS 3706.1	2 tests
CBR Burst	N	>2650	AS 3706.4	2 tests
Grab Tensile Strength	N	>1000	AS 2001.2.3	2 tests

Property	Units	Value	Test	GITA Testing Frequency
Pore Size	Microns	>90	AS 3706.7	Review MQC data
Coefficient of Permeability	$x10^{-4}$ m/s	>33	AS 3706.9	Review MQC data
UV Resistance	%	>45	ASTM D 4355	Review MQC data

Samples shall be recovered by the GITA, with assistance and equipment as required provided by the Contractor(s), from rolls that will be delivered to site and independent testing arranged by the GITA.

UV Resistance test results for the geotextile shall be based on manufacturer batch results, not less than 12 months old.

Geotextiles shall comprise polymeric yarns or fibres, seamed or drawn strands oriented into a stable network which retains its structure during handling, placement, and long-term service. Geotextiles shall be nonwoven, needle punched and resin or heat bonded polyester, polypropylene or polyethylene material.

Unit 12 – Separation Geotextile shall be capable of withstanding direct exposure to sunlight for **6 months** with no visible deterioration.

The geotextile to be placed in the “b” sub-cells (i.e. 1b and 2b) shall retain the indicated material values in Table 6 after the samples have been exposed to the simulated UV radiation requirements of ASTM D 7238 for 250 hours or equivalent AS 3706.11 period.

Unit 12 – Separation Geotextile shall be supplied by the Contractor(s) in rolls wrapped in protective dustproof covers and marked or tagged with all of the following information:

- Manufacturer’s name.
- Product identification including name, grade and polymer type.
- Lot or Batch number.
- Roll number.
- Roll length, width and weight.

The Contractor shall be responsible for all quality assurance and quality control of Unit 12 – Separation Geotextile delivered to site.

2.14 Unit 13 – Leachate Collection Pipes

Leachate Collection Pipes shall have the diameter indicated below:

- Unit 13.1 – Perforated Header Pipe – 250 mm diameter.
- Unit 13.2 – Perforated Collection Pipe – 150 mm diameter
- Unit 13.3 – Solid Header Pipe – 250 mm diameter.

The pipes shall be supplied by the Contractor(s) and comprise of PN12 SDR13.6 PE100 material class HDPE. Where the pipes are required to be perforated, the pipes shall be drilled in accordance with the detail shown on the Drawings in the Pipe Installer’s factory and all waste material removed from inside the pipe before installation. The pipes shall have perforations of 15 mm diameter as shown on the Drawings.

The fittings for the pipes shall be supplied by the Contractor. 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. The Contractor(s) shall obtain and present documentation related to these materials to the Superintendent that demonstrates that the materials meet the property requirements of this Specification. Specifically, the documents shall include Manufacturer's documentation certifying the properties of the materials for each manufacture batch used on site.

2.15 Unit 14 – Leachate Collection Sump

The Leachate Sump shall consist of:

- Unit 14.1 – Reinforced Concrete Slab
- Unit 14.2 – Leachate Sump Outlet Sleeves
- Unit 14.3 – Transducer Riser Pipe
- Unit 8 – Leachate Drainage Aggregate

2.15.1 Unit 14.1 – Reinforced Concrete

Unit 14.1 – Reinforced Concrete Slab shall have a minimum thickness of 200 mm and minimum characteristic strength at 28 days of 32 MPa as per AS 1379. Concrete Works shall be conducted in accordance with AS 3600 to the lines and levels shown in the drawings.

Reinforcement shall consist of N20 reinforcing mesh at 200 mm centres both ways, 600 mm overlap and a minimum of 75 mm concrete cover to the reinforcement or as otherwise shown on the Drawings.

Formwork shall satisfy the requirements of AS 3610. The concrete shall be maintained in a moist condition and allowed to cure for a minimum of seven days. The concrete shall have a Class 4 surface finish.

2.15.2 Unit 14.2 – Leachate Sump Outlet Sleeves

Unit 14.2 – Leachate Sump Outlet Sleeves shall comprise two (2) 600 mm diameter solid wall PN12 DR13.6 PE 100 HDPE pipes or approved equivalent.

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.

The fittings for Unit 14.2 – Leachate Sump Outlet Sleeves shall be supplied by the Contractor(s) and shall include the anchor block to secure the pipe on the perimeter embankment crest. The Contractor(s) shall obtain and present documentation related to these materials to the Superintendent that demonstrates that the materials meet the property requirements of this Specification. Specifically, the documents shall include Manufacturer's documentation certifying the properties of Unit 14.2 – Leachate Sump Outlet Sleeves.

The lower 1.5 m (measured vertically from the base of the sump) shall be perforated with 20 mm holes as detailed on the Drawings, including the end cap. All waste shall be removed from the inside of the pipe prior to installation.

2.15.3 Unit 14.3 – Transducer Riser Pipe

Unit 14.3 – Transducer Riser Pipe shall comprise 160 mm diameter solid PN 10 PE100 HDPE 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.

The fittings for Unit 14.3 – Transducer Riser Pipe shall be supplied by the Contractor(s). The Contractor(s) shall obtain and present documentation related to these materials to the Superintendent that demonstrates that the materials meet the property requirements of this Specification. Specifically the documents shall include Manufacturer's documentation certifying the properties of Unit 14.3 – Transducer Riser Pipe.

2.16 Unit 15 – Sacrificial Liner Protection Sheet

Unit 15 – Sacrificial Liner Protection Sheet shall be constructed on site and shall consist of Unit 10.2 – Smooth HDPE geomembrane with the outer edges wrapped and extrusion welded around two 110 mm HDPE Class 4 pipes. The pipes shall be filled with sand or other suitable material as approved by the Superintendent and sealed at each end.

2.17 Unit 16 – Permanent Ballast

Unit 16 – Permanent Ballast shall be constructed on site and shall comprise 110 mm diameter solid PN 4 PE100 HDPE pipes, filled with sand and sealed at the ends. The permanent ballast shall be placed across the floor of the Leachate and Retention Ponds at a nominal spacing of 10 m or as shown on the Drawings or as directed by the Superintendent.

2.18 Unit 17 – Protection Layer

Unit 17 – Protection Layer[3] will be obtained from designated borrow areas and from on-site stockpiles identified by the Superintendent and shall comprise clay, silt, sand, gravel or any combination thereof or other approved materials. Materials shall be placed by the Landfill Operator during operations in progressive lifts not exceeding 2 m in vertical height as the landfill progresses.

2.19 Unit 18 – Wearing Course

Unit 18 – Wearing Course shall be supplied and installed by the Contractor and shall have a Plasticity Index (PI) between 6% and 12% and shall be well graded and contain a good distribution of particles from coarse to fine, with the following gradation:

- 100% passing 75 mm
- 80-100% passing 37.5 mm
- 60-100% passing 19 mm
- 50-80% passing 9.5 mm
- 15-30% passing 75 µm.

2.20 Unit 19 – Spillway and Stormwater Channel

The spillway and stormwater channel shall comprise:

- Unit 19.1 – Concrete Spillway and Dissipater blocks
- Unit 19.2 – Loosely placed rock
- Unit 19.3 – Erosion protection mat.

2.20.1 Unit 19.1 – Concrete Spillway and Dissipater Blocks

Unit 19.1 – Concrete Spillway and Dissipater blocks shall be supplied and constructed by the Contractor. The concrete slab shall have a minimum thickness of 200 mm and minimum characteristic strength at 28 days of 32 MPa as per AS 1379. Concrete Works shall be conducted in accordance with AS 3600 to the lines and levels shown in the drawings.

Reinforcement shall consist of N20 reinforcing mesh at 200 mm centres both ways, 600 mm overlap and a minimum of 75 mm concrete cover to the reinforcement or as otherwise shown on the Drawings.

Formwork shall satisfy the requirements of AS 3610. The concrete shall be maintained in a moist condition and allowed to cure for a minimum of seven days. The concrete shall have a Class 4 surface finish.

[3] Unit 17 – Protection layer to be placed during operations by AH. Included in this document for completeness.

2.20.2 Unit 19.2 – Loosely Placed Rock

Unit 19.2 – Loosely placed rock shall be obtained from the farm site (scattered rock mounds created around the farm when clearing land for agriculture use). The rock shall be placed as indicated on the Drawings or as directed by the Superintendent.

2.20.3 Unit 19.3 – Erosion Protection Mat

Unit 19.3 – Erosion protection mat shall be installed after seeding on top of the topsoil/mulch layer. The material shall comply with the requirements as per Table 7 and be approved by the Superintendent.

Table 7: Unit 19.3 – Erosion Protection Mat Specification

Property	Units	Value	Test Method	Frequency
C[(1)] Factor	-	0.02[(2)] or less	ASTM D6460 for Blanket Type 1 and ASTM D6459 for Blanket Type 2	Based on large scale testing
Material		Biodegradable	-	Based on large scale testing
Longevity	Months	18 to 24	Based on-site UV radiation	Based on large scale testing
Required Shear Stress	PA	≥ 50	ASTM D6460	Based on large scale testing
Maximum Gradient		3H:1V	As constructed survey	Hold points

Notes: [1] 'C' The ratio of soil loss from the performance of the Rolled Erosion Control Product (RECP) protected slope/channel (tested at specified or greater gradient, H:V) to ratio of soil loss from unprotected slope/channel.
[2] C factor shall be provided for a slope gradient of 3H:1V and a slope length equal or longer than 15 m

The material shall comply with the following:

- The "C" Factor of the Erosion Protection Mat shall be determined through the large-scale test method ASTM D6459, or other independent testing approved by the Superintendent.
- The blanket material shall be suitable for vegetation.

The material shall be approved by the Superintendent prior to placement.

2.21 Unit 20 – Sediment Management Structure

The sediment management structure shall comprise:

- Unit 20.1 – Separation Geotextile.
- Unit 20.2 – Embankment Aggregate.

2.21.1 Unit 20.1 – Separation Geotextile

Tests shall be conducted by the GITA on samples from different rolls at the frequency listed in Table 8. The GITA will supervise sampling of the rolls at frequencies listed in Table 8. The Contractor(s) shall arrange for any independent tests. Unit 20.1 – Separation Geotextile shall be supplied and delivered to site by the Contractor(s) and shall satisfy the property values specified in Table 8.

Table 8: Unit 20.1 – Separation Geotextile Material Properties

Property	Units	Value	Test	GITA Testing Frequency
Mass	g/m^2	>800	AS 3706.1	2 tests
Trapezoidal Tear	N	>890	AS 3706.3	4 tests
Thickness	Mm	>1.2	AS 3706.1	2 tests
Puncture Resistance	N	>1110	AS 3706.4	2 tests

Samples shall be recovered by the GITA from site delivered rolls and testing arranged.

Geotextiles shall comprise polymeric yarns or fibres, seamed or drawn strands oriented into a stable network which retains its structure during handling, placement, and long-term service. Geotextiles shall be nonwoven, needle punched and resin or heat bonded polyester, polypropylene or polyethylene material.

Unit 20.1 – Separation Geotextile shall be capable of withstanding direct exposure to sunlight for twelve months with no visible deterioration.

2.21.2 Unit 20.2 Embankment Aggregate

Unit 20.2 – Embankment Aggregate shall be supplied by the Contractor(s) and shall comprise rock that is:

- Dense, hard, durable, well graded and angular.
- Resistant to weathering actions of air and water.
- Free from overburden, spoil and any organic matter.
- Meets the PSD requirements specified in Table 9.

Table 9: Unit 20.2 – Embankment Aggregate Properties

Particle Size Distribution	Standard	Test Frequency
$450 \leq D_{100} \leq 500$ mm	AS 1141.11.2	2 tests per 1000 m^3 if supplier materials testing records are not provided
$350 \leq D_{50} \leq 450$ mm		
$250 \leq D_{30} \leq 350$ mm		
Density Requirements		
Density of Stone ≥ 2600 kg/m^3	AS 1141.6.1	1 test per 1000 m^3 if supplier materials testing records are not provided

The sources from which the Unit 20.2 – Embankment Aggregate will be obtained shall be selected at least two weeks prior to commencement of the works. The acceptability of the aggregate shall be based on quarry records and test results. Samples of aggregate shall be taken in the presence of the GITA at least two weeks in advance of placing Unit 20.2 – Embankment Aggregate.

Control of gradation shall be done by visual inspection. The Contractor(s) shall provide two samples of aggregate of at least 5 tonnes each, meeting the gradation specified, one sample stockpile at the site and one at the quarry. These samples shall be used as a frequent reference for judging the gradation of the aggregate supplied.

3.0 QUALITY ASSURANCE AND QUALITY CONTROL

3.1 Unit 3 – Engineered Clayey Material

3.1.1 Initial Compliance Testing

Prior to construction, the Unit 3 – Engineered Clayey Material shall be tested to confirm that it meets the specified property values listed in Section 2.4 of this Specification. Specifically, the GITA shall conduct the following testing on the proposed clay liner material:

- **Atterberg Limits Test** to measure Plasticity Index and Liquid Limit.
- **Standard Compaction Test** to measure compaction characteristics.
- **Particle Size Distribution** Test to measure the percentage by mass of the soil passing the 4.75 mm sieve.
- **Percent Fines Test** to measure the percentage by mass of the soil passing the 0.075 mm sieve.

The frequency of initial compliance testing during placement of the Unit 3 – Engineered Clayey Material shall as a minimum conform to 1 test per 3 000 m^3 of Unit 3 – Engineered Clayey Material evenly distributed through the clay source.

The GITA shall submit the results of the compliance testing to the Superintendent.

3.1.2 Compliance Testing

The GITA shall provide quality assurance testing of Unit 3 – Engineered Clayey Material using a NATA endorsed soils testing laboratory. Testing shall be carried out in accordance with the provisions of AS 3798 – 2007 "*Guidelines on Earthworks for Commercial and Residential Developments*", at Level 1 responsibility. Inspection and testing shall be carried out in accordance with the requirements of AS 1289 "*Methods of Testing Soil for Engineering Purposes*", and this Specification.

The Contractor shall be responsible for informing the Superintendent when testing is required. Works shall be programmed such that an area that has been tested shall not be covered until satisfactory compliance test results are obtained.

Compliance testing shall comprise field density tests (*in situ* dry density and moisture content) measurements on undisturbed samples from Unit 3 – Engineered Clayey Material.

The frequency of field density testing during placement of the Unit 3 – Engineered Clayey Material shall as a minimum conform to the requirements for large scale operations as given in Table 8.1 of the AS3798-2007, by carrying out not less than the following:

- One test per 500 m^3 of material, distributed reasonably evenly throughout the full depth and area,
- One test per layer or 250 mm thickness, per material type per 2 500 m^2, whichever requires the more tests.

The GITA may vary the test frequency depending on the observed general performance of the Works and the variation of material used for the Unit 3 – Engineered Clayey Material.

The GITA shall submit the results of the compliance testing to the Superintendent.

3.2 Units 9, 10, 11 and 12 Geosynthetics Site Testing Frequencies

All tests listed in Table 3 through to Table 6 in Section 2.0 of this Specification must be performed on the actual geosynthetic materials that are delivered to site. The Contractor(s) shall be responsible for obtaining manufacturing quality control results from the geosynthetics suppliers and submitting this information to the GITA. The GITA shall submit all independent testing results to the Superintendent. All quality control testing is to be performed by accredited testing laboratories.

The GITA shall provide the Contractor with a copy of the list of rolls approved for use in construction and will check roll numbers during deployment. The Contractor will be responsible for selecting only approved rolls for use in construction. At the commencement of works the Contractor may request that the GITA mark all rolls approved for use in construction. The Contractor shall be responsible for maintaining any roll markings.

3.2.1 Unit 9 – Geosynthetic Clay Liner

3.2.1.1 General

The Contractor shall be responsible for control of the storage, transportation and installation of Unit 9 – Geosynthetic Clay Liner. This shall include all inspections, repairs, and certification as detailed in this Specification.

A site specific installation procedure shall be prepared by the Contractor. All field installation methods and repairs shall be undertaken in accordance with this Specification.

The Contractor shall also establish and maintain a quality control system for all operations including but not limited to the following:

- Handling, and storage of materials.
- Placement, joining and repair.
- Reference roll numbers to deployed panel numbers.

3.2.1.2 Quality Control Procedures Documentation

The Contractor shall submit the following information, to the Superintendent at least 5 days before planned commencement of lining activities:

a) The Installer's personnel, and the qualifications and experience of the proposed installation personnel.

b) Deployment equipment and procedures (including storage and handling).

c) Safety equipment.

The Superintendent may request additional information specific to the project installation conditions. The Lining Installer will not be permitted to commence work until this information is received and approved by the Designer and the Superintendent.

3.2.1.3 Reporting

The Installer shall submit all quality forms, test results and other documentation required by this Specification to the GITA to demonstrate the compliance of the installed Unit 9 – Geosynthetic Clay Liner with this Specification. The Installer shall also include any non-compliance testing results for all materials with the satisfactory retest. All quality control results shall be referenced to roll numbers. The GITA shall verify all documentation supplied by the Installer

The Installer shall prepare as-built drawings of the panel layout of the Unit 9 – Geosynthetic Clay Liner, with locations and details of all repairs, joins and anchor trenches. The as-built drawings shall be to scale and reference GCL roll numbers to panel numbers, and provide details and locations of the anchor trenches. The as-built drawings shall be prepared on survey drawings of the earthworks provided by the Contractor.

The Contractor(s) shall supply survey data of the as-built location of the anchor trenches.

3.2.2 Unit 10 – HDPE Geomembrane

3.2.2.1 General

The GITA shall be responsible for verifying all quality assurance and quality control documentation, supplied by the Installer, on the installation of Unit 10 – HDPE Geomembrane, and submission of the information to the Superintendent. This shall include the documentation of all inspections, non-destructive and destructive testing and repairs etc., and the assessment as detailed in this Specification.

The GITA shall monitor the installation of the geomembrane. The GITA shall measure the thickness of the Unit 10 – HDPE Geomembrane during installation at a frequency of 5 tests per 100 m, 20 m apart, taken at the edge of the sheet. The Contractor shall accommodate all Quality Assurance activities described in this Section.

3.2.2.2 Quality Control Procedures Documentation

The Contractor shall submit the following information, to the Superintendent at least 5 days before planned commencement of lining activities:

a) The Installer's personnel, and the qualifications and experience of the proposed installation personnel.

b) Management of temperature variations (including those potentially causing wrinkles) during the installation.

c) Welding methods, equipment and testing procedures.

d) Deployment equipment and procedures (including storage and handling).

e) Safety equipment.

The Superintendent may request additional information specific to the project installation conditions. The Lining Installer will not be permitted to commence work until this information is received and approved by the Designer and the Superintendent.

3.2.2.3 Installers, Reports and Certificates

The Installer shall submit any requested documentation by the GITA to demonstrate its compliance with the Quality system for the project and to demonstrate compliance of the installed geomembrane with this Specification. The Installer shall record all results of testing of the geomembrane. The Installer shall ensure that the GITA is present for all testing to facilitate the recording of results and details of any testing. The Installer shall adjust its installation program to facilitate the observation and recording of results by the GITA. The GITA shall make all reasonable endeavours to provide supervision to suit the Installers proposed works methodology.

No work shall be covered with subsequent layers until the GITA is satisfied that all information related to the installed Works has been recorded and meets the requirements of this Specification.

3.2.2.4 Installers Layout Drawings

The Installer shall provide proposed Panel Layout drawings for the Unit 10 – HDPE Geomembrane at least seven days before installation starts. The geomembrane installed over all slopes shall extend onto the cell floor and shall be staggered to eliminate the occurrence of coincident cross-seams. The proposed configuration of the smooth and textured geomembrane shall be shown on the Panel Layout drawing. The Panel Layout drawings shall indicate the panel configuration and the location of seams and vents. The Panel Layout drawings shall be suitable for use as construction drawings and shall include key dimensions and details. The GITA shall approve the Panel Layout drawings before installation commences.

3.2.2.5 Reporting

The Installer shall submit all quality forms, test results and other documentation required by this Specification to the GITA to demonstrate the compliance of the installed Unit 10 – HDPE Geomembrane with this Specification. The Installer shall also include any non-compliance testing results for all materials with the satisfactory retest. All quality control results shall be referenced to roll and panel numbers.

A field panel is the unit area of Unit 10 – HDPE Geomembrane to be welded in the field and shall be bounded by field welds or anchor trenches. Each field panel shall be numbered by the Installer and an as-built layout of the panels of the geomembrane shall be prepared by the Installer showing the panel numbers, the dimensions of each panel and the orientation of seams of panels. The Installer shall adhere to the numbering system adopted by the GITA. The layout shall be schematic and be to scale. The Installer shall also prepare a layout identifying the location of any defects identified on the geomembrane panels in addition to locations and details of all repairs.

The Installer shall reference roll numbers to deployed panel numbers.

3.2.3 Unit 11– Cushion Geotextile and Unit 12 – Separation Geotextile

3.2.3.1 General

The Contractor(s) shall be responsible for the installation of the Unit 11 – Cushion Geotextile and Unit 12 – Separation Geotextile. The Contractor shall establish and maintain a quality control system for all operations including:

a) Handling of materials.

b) Placement equipment and heat bonding.

3.2.3.2 Quality Control Procedures Documentation

The Contractor shall submit the following information, to the Superintendent at least five days before planned commencement of lining activities:

a) The Installer's personnel, and the qualifications and experience of the proposed installation personnel.

b) Deployment equipment and procedures (including storage and handling).

c) Safety equipment.

The Superintendent may request additional information specific to the project installation conditions. The Lining Installer will not be permitted to commence work until this information is received and approved by the Designer and the Superintendent.

3.2.3.3 Reporting

The Installer shall submit all quality forms, test results and other documentation required by this Specification to the GITA to demonstrate the compliance of the installed Unit 11 and Unit 12 Geotextiles with this Specification. The Installer shall also include any non-compliance testing results for all materials with the satisfactory retest.

The Installer shall prepare an as-built layout of the panels of the Unit 11 Cushion Geotextile only to show orientation of seams of panels. The layout shall be schematic and does not need to be to scale.

3.2.4 Geomembrane Leak Detection Testing

The Contractor(s) shall carry out a leak detection test of all geomembrane lined areas where Unit 8 – Leachate Drainage Aggregate has been installed. The testing shall be undertaken by a suitably qualified subcontractor (it could be the main Contractor) approved by the Superintendent.

The leak detection survey shall be undertaken once the Unit 10 – HDPE geomembrane and Unit 11 – Cushion Geotextile has been installed and the Unit 8 – Leachate Drainage Aggregate has been placed on top of the Unit 11 – Cushion Geotextile, but before installation of the Unit 12 – Separation Geotextile has been installed, to assess whether the geomembrane has sustained damaged during its installation and placement of the Unit 8 – Leachate Drainage Aggregate.

The Contractor(s) shall provide adequate notification (minimum **24 hours**) to the Superintendent of when any installation of testing equipment or any testing is being carried.

The results of the leak detection testing shall be provided to the Superintendent for review prior to any repairs being undertaken.

The Contractor(s) shall repair and test all identified leaks in the lining system. If the Superintendent deems that the area of Unit 8 – Leachate Drainage Aggregate removal and replacement is substantial and there is the likelihood that the lining system could have been further damaged by the repair activity, the Superintendent may instruct that the area be retested for any further leaks.

The Unit 12 – Separation Geotextile shall be installed once the Superintendent has approved the completion of leak detection testing and all repairs have been carried out, including any retesting if necessary.

3.2.4.1 Testing Requirements

The GITA shall confirm that the leak detection test has been undertaken and the relevant activities have been carried out, prior to the placement of the Unit 12 – Separation Geotextile. These activities shall include the confirmation of:

- The party undertaking the testing is suitably qualified.
- That the necessary equipment has been installed in the works in the appropriate location (some test methods require a wire grid or lines to be installed under the geomembrane).

- That the test is carried out in accordance with the equipment manufacturer's instructions.
- All leaks that are detected are recorded appropriately.
- During repair, that the Unit 8 – Leachate Drainage Aggregate is removed carefully so as not to further damage the liner.
- That each leak is investigated and repaired appropriately, including the appropriate weld testing.
- That the Unit 8 – Leachate Drainage Aggregate layer is replaced carefully so as not to further damage the liner.
- That if deemed necessary, the area is retested for leaks.
- Subsequent Works shall not commence until approval has been given by the Superintendent (**Hold Point**).

4.0 CONSTRUCTION MANAGEMENT

4.1 General Management

Construction shall be achieved in compliance with the Contractor(s) site management plans prepared in accordance with Contract requirements.

4.2 Stockpile Management

The Contractor(s) will manage stockpiles in accordance with the requirements of the Contract for the Works. 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(s):

- 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 runoff on the site.

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

- Remove all remaining stockpiled material for reuse or placement in accordance with this Technical Specification.

4.3 Surface Water Management

The Contractor(s) shall manage surface water within the construction site in accordance with the approved surface water management plan. The surface water collected from the construction area shall be diverted to the Stormwater Dam, where practical, for use in construction activities and dust suppression.

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

4.4 Tolerances

The Contractor(s) shall be responsible for setting out the Works and maintaining all benchmarks and set out points needed for the construction of the Works. Survey work shall be performed by an appropriately experienced surveyor.

The final surface finish of all earthworks shall be within the following tolerances:

- Subgrade elevations shall have a maximum deviation of 0 mm to +50 mm relative to the design and the final subgrade surface must be free draining.

- Thickness of the 500 mm thick Unit 3 – Engineered Clayey Material below Unit 9 – Geosynthetic Clay Liner shall have a tolerance of 0 mm to +50 mm and the final subgrade surface must be free draining.
- Thicknesses shall have a tolerance of 0 mm and +100 mm (i.e. leachate gravel).
- The specified grade on the base of Cell 1 and the Leachate and Retention Ponds is the minimum average grade. The average grade may not be flatter. The Superintendent may instruct the Contractor(s) to improve the grades where they are considered not appropriate for the Works.

It is a requirement that the Unit 9 – Geosynthetic Clay Liner is not deployed over the subgrade until the level of the subgrade has been checked and approved. The Superintendent will approve the levels of the subgrade within one week of submission. The Contractor(s) may seek approval from the Superintendent to commence placement of the Unit 9 – Geosynthetic Clay Liner at the Contractors own risk prior to checking and approval of the subgrade survey being completed.

4.5 Survey

The Contractor(s) shall be responsible for setting out the Works and maintaining all benchmarks and set out points needed for the construction of the Works. A survey of the existing conditions shall be performed by the Contractor(s) on the surface handed over by the Principal prior to the commencement of the construction Works (**Hold Point**) and during the Works to assess placement of materials.

The Contractor shall undertake a survey of:

- Crown and alignment of subsurface drainage pipes.
- Top of Subgrade (at -250 mm RL of finished subgrade levels and at finished subgrade level, i.e. top of Unit 3 – Engineered Clayey Material).
- Top of Unit 3 – Engineered Clayey Material shall again be surveyed prior to Unit 9 – Geosynthetic Clay Liner installation, if the top of clay liner is to be reworked due to degradation (cracking and erosion).
- Crown and alignment of leachate collection pipes.
- Top of Unit 8 – Leachate Drainage Aggregate
- Embankment bench crest elevations and alignments.
- Alignment of the edges of all anchor trenches.
- An “as-built” 3D survey will be required at the completion of the Works.

The surveys shall pick up the crest and valley lines and all changes in grade. The Contractor shall prepare and issue drawings showing the as-built Works items listed above.

The results of the surveys shall be presented to the Superintendent within one week of completing construction of each of the components listed above.

5.0 SITE PREPARATION

5.1 Decommissioning of Monitoring Bores

a) The Contractor(s) shall decommission Monitoring Bores MB12 and MB13 in Cell 1, and GMB6 in Cell 2, as shown on the Drawings.

b) Boreholes requiring backfill shall be located, surveyed for location and depth and backfilled in accordance with the specification by the Contractor(s), prior to the commencement of site clearing.

c) The Contractor(s) shall ensure that the monitoring bore is cut such that a minimum of 500 mm of material can be placed above it to form the final basin level.

d) The boreholes shall be decommissioned by means of backfilling the remaining depth with a cement/bentonite grout mix. The grout mix should be a pumpable slurry and contain approximately 5% bentonite and 5% cement.

e) The cement mixture shall be injected into the borehole using a trémmie line (19 mm polyline or similar). The trémmie line should be run to a depth approximately 0.1 m from the base of the hole and the cement mixture pumped through the line. The trémmie line should be removed slowly, as the cement level rises, to allow complete filling of the borehole from the bottom up.

f) The volume of grout used for each borehole shall be recorded by the Contractor(s) and provided to the Superintendent.

5.2 Clearing and Grubbing

a) The Contractor(s) shall clear and grub all vegetation from the area shown on the Drawings.

b) All trees, bushes and other vegetable matter shall be chipped and stockpiled in the nominated location, as shown on the Drawings, or placed elsewhere as directed by the Superintendent.

c) The chipped vegetation stockpile shall not exceed 2 m in height or have side slopes steeper than 1:3 (V:H).

d) Prior to any earthworks cutting or filling, grubbing shall be carried out for the full extent of areas specified on the Drawings.

e) Grubbing can be defined as the removal of all stumps and roots, greater than 100 mm in diameter, to a depth of 600 mm below the natural or final finished surface, and all other vegetation and boulders (particles greater than 200 mm in diameter) to a depth of 300 mm below the natural surface.

f) Clearing and grubbing methods shall not result in unnecessary waste of materials required for use elsewhere.

g) The debris, together with all roots, shall be deposited in the stockpile areas as shown on the Drawings.

h) Any clearing and stripping that the Contractor(s) elects to perform for its own purposes, such as for construction of temporary haul roads, equipment yard etc. shall be subject to the approval of the Superintendent and shall be performed at the Contractor(s)'s own expense. At the end of the Contract, all such areas shall be reinstated and rehabilitated by the Contractor(s), at its own expense, to meet the Principal's requirements and environmental obligations and to the satisfaction of the Superintendent.

i) Subsequent Works shall not commence until approval has been given by the Superintendent (**Hold Point**).

5.3 Topsoil Stripping

a) On completion of vegetation clearing the Contractor(s) shall strip and remove the topsoil from the Work area to the approval of the Superintendent.

b) The stripped topsoil shall be placed in stockpiles not exceeding 2 m in height. Side slopes shall not be steeper than 1:3 (V:H).

c) A 250 mm thick layer of chipped vegetation shall be placed on top of completed stockpiles to assist in preventing soil loss due to wind erosion.

d) Topsoil, for the purpose of this Specification, shall be defined as soil of any gradation or degree of plasticity tjat contains significant quantities of visually identifiable vegetable matter, sod, roots or humus. Stripping means the removal of all topsoil to a nominal depth of 200 mm or as directed by the Superintendent. All stripping extents and depth shall be confirmed with the Superintendent prior to commencing stripping.

e) At the completion of the topsoil stripping the Superintendent will inspect the Works and if suitable grant approval to continue with subsequent Works.

6.0 EARTHWORKS

6.1 General

6.1.1 Compaction

6.1.1.1 Density and Moisture Variance

The compaction requirements for materials and subgrade areas, unless otherwise specified, are:

Table 10: Compaction Density and Moisture Content Requirements

Material Type	Compaction Specification	Compaction Water Content Range	Minimum Dry Density Ratio
Unit 3 – Engineered Clayey Material	AS 1289.5.1.1	-0% to +3% of Optimum Moisture Content	95% of Standard Maximum Dry Density
Unit 4 – General Fill	AS 1289.5.1.1	-2% to +2% of Optimum Moisture Content	95% of Standard Maximum Dry Density

a) A detailed compaction method shall be developed for the project during the first week of activities. The required dry time or addition of moisture to Unit 3 – Engineered Clayey Material and Unit 4 – General Fill will be identified and *in situ* density tests performed to identify the required number of passes of the roller to achieve the compaction criteria. This shall be a **Hold Point**.

b) Testing of the Works shall be carried out by the Contractor(s) at no extra cost. It is the Contractor's responsibility to ensure that target minimum density ratios and target moisture contents are achieved and maintained until it is covered by the next layer in the Works.

c) Unit 3 – Engineered Clayey Material and Unit 4 – General Fill shall be placed in 250 mm compacted thickness layers.

d) The Contractor will be allowed to carry out a trial prior to construction to access whether other placement options would achieve the specified result. The alternative placement option shall be approved by the Superintendent prior to implementation.

6.1.1.2 Drying of Wet Material

a) If at any time the GITA considers the material is too wet or testing shows the moisture content is above the specified tolerances, compaction operations may be ordered to cease until the material has dried out sufficiently.

b) Disc plough or deep ripping methods may be an effective measure to reduce the moisture content of wet material.

c) When drying is necessary, it shall be carried out to allow the full depth of the layer to dry uniformly.

d) Drying and re-compaction shall be carried out under favourable weather conditions.

e) Re-compaction is only to be carried out once the specified OMC has been achieved uniformly through the layer. Mixing and blending may be required.

6.1.1.3 Wetting of Dry Material

a) If at any time the GITA considers the material is too dry for efficient compaction, or testing indicates that the moisture content is below the specified tolerances, compaction operations may be ordered to cease.

b) The material shall be moisture conditioned to ensure uniform and controlled distribution of water. After wetting, the material shall be mixed to ensure a uniform distribution of moisture throughout the layer, before being re-compacted.

6.1.1.4 Compliance Testing

a) Compliance testing, to confirm that suitable compaction is achieved, shall be the responsibility of the GITA and shall be carried out in accordance with AS 1289.5.1.1, which outlines but is not limited to such methods as the Sand Replacement method (in accordance with AS 1289.5.3.1) or the Nuclear Densitometer method (in accordance with AS 1289.5.8.1).

b) Initially one moisture-density relationship test (based on Standard Compaction) shall be conducted **for each field density test**. The GITA may reduce the frequency of moisture density relationship tests per lift if sufficient consistency is shown in the moisture-density relationship of the borrow material.

c) At least one field density test shall be carried out for every 600 m^3 of Engineered Clayey Material or General Fill placed, or every horizontal distance of 200 m, whichever is less.

d) Nuclear Densitometer testing shall be conducted to a depth of no less than the fill layer thickness of 250 mm to ensure that sufficient compaction is being achieved throughout the layer.

e) Compaction testing shall be performed by a NATA-registered laboratory, or a suitably qualified technician, as agreed by the Superintendent.

f) Field density testing shall be carried out within 48 hours of completion of compaction of the layer to be tested.

g) In the event that a field density test indicates that a section of the layer has failed to meet the compaction requirements but has met the moisture content requirements, as set out in Section 6.1.1.1, the material represented by the failed test shall be re-compacted as directed by the Superintendent, prior to re-testing.

h) In the event that a field density test indicates that a section of the layer has failed to meet the moisture content requirements as set out in Section 6.1.1.1, the material represented by the failed test shall be ripped to a depth of 250 mm or the layer thickness, moisture conditioned or dried as required and re-compacted, prior to re-testing.

i) If a reworked section fails the re-test for either moisture content or density, the material shall continue to be reworked by the Contractor(s), to the satisfaction of the Superintendent, and re-tested until the section meets the requirements as set out in Section 6.1.1.1.

j) The Contractor(s) shall provide the GITA and Superintendent with a copy of the field density test original results, which will include a test identifier, layer number, and GPS coordinates prior to placement of a subsequent layer. No subsequent layer shall be placed until the preceding layer has met the compaction standards outlined in clause Section 6.1.1.1.

k) Test results shall be provided to the nearest 0.5% for both density and moisture content variation. Results that fall outside the requirements by 0.5% or greater will constitute a non-conformance.

l) At the start of the Contract and at any other time as required by the Superintendent, the GITA and NATA-registered laboratory shall provide the Superintendent with copies of the calibration certificates for all testing equipment in use on the Works.

m) The Contractor(s) shall submit to the GITA all the compaction test logs as the work is completed (**Hold Point**).

6.2 Subgrade Construction

6.2.1 General

The Contractor(s) shall provide a Work Method Statement presenting proposed methods for subgrade construction activities, including cutting, filling, proof rolling, undercutting and replacement and all items described below. Submission of the work method statement constitutes a **Hold Point**. These activities shall not commence until the Hold Point is released.

6.2.2 Stormwater Dam

a) Clear and grub and strip Unit 1 – Topsoil as per Section 5.2 and Section 5.3 of this Specification.

b) Proof roll the entire footprint of the stormwater dam, including the embankment footprint, using at least a fully laden water truck, or roller of equivalent mass. Proof rolling in each local area constitutes an **Inspection Point**. The Contractor(s) is required to provide **24 hour** notice before commencing or recommencing this activity.

c) The GITA shall identify any areas of Unit 2 – Unsuitable Material during the proof rolling. Identified areas shall be excavated to a minimum depth of 500 mm or as specified by the GITA, and backfilled with compacted Unit 3 – Engineered Clayey Material.

d) Any Unit 2 – Unsuitable Material excavated shall be stockpiled within the Works area or as instructed by the Superintendent.

e) The stormwater dam embankment key-in trench shall be constructed as per Section 6.3.5 of this specification.

f) Excavate Unit 3 – Engineered Clayey Material from designated borrow area or stockpile, moisture condition, place and compact, as per Section 6.1.1, in areas where unsuitable material has been removed, in the **full time** presence of the GITA.

g) Over-excavation: The Contractor(s) shall not excavate deeper than the maximum design cut depth. Any excavation deeper than the design cut depth, not including any additional depth required for removal of unsuitable materials, shall be deemed Contractor(s) over-excavation. If over-excavation occurs, the Contractor(s) shall perform, at his cost, all activities required to safely manage any excess dewatering and excess cut materials in accordance with the Contract requirements. The Contractor(s) shall also be responsible for all costs associated with reinstatement of over-excavated areas with Unit 3 – Engineered Clayey Material or Unit 4 – General Fill, as directed by the Superintendent in consultation with the GITA, as per Section 6.1.1.

6.2.3 Cell 1

a) Clear and grub and strip Unit 1 – Topsoil as per Section 5.2 and Section 5.3 of this Specification.

b) Excavate Unit 2 – Unsuitable Material to a depth of 800 mm, from the footprint of Cell 1, excluding the embankment footprint.

c) Excavate the *in situ* material to a depth of -250 mm of the finished subgrade level (FSL), across the footprint of Cell 1, sort and stockpile separately as Unit 2 – Unsuitable Material, Unit 3 – Engineered Clayey Material and Unit 4 – General Fill, as instructed by the Superintendent and GITA.

d) Proof roll the entire footprint of Cell 1 using a fully laden watercart, or suitable alternative. Proof rolling in each local area constitutes an **Inspection Point**. The Contractor(s) is required to provide a **24 hour** notice before commencing or recommencing this activity.

e) The GITA shall identify any additional areas of Unit 2 – Unsuitable Material during the proof rolling. Identified areas shall be excavated to a minimum depth of 1500 mm below FSL or as specified by the GITA, and backfilled to -250 mm below FSL with Unit 3 – Engineered Clayey Material.

f) Load, haul, moisture condition and place Unit 3 – Engineered Clayey Material up to -250 mm below FSL across the cells, excluding the embankment footprint, to achieve the lines and levels presented in the Drawings.

g) Rip, moisture condition and compact, as per Section 6.1.1, *in situ* or placed fill Unit 3 – Engineered Clayey Material (RL -250 mm of FSL), to a depth of 250 mm.

h) Excavate, from designated borrow area or stockpile, moisture condition, place and compact 250 mm thick layer of Unit 3 – Engineered Clayey Material, to achieve top of FSL.

6.2.4 Leachate and Retention Ponds

a) Clear and grub and strip Unit 1 – Topsoil as per Section 5.2 and Section 5.3 of this Specification.

b) Excavate the *in situ* material to a depth of -250 mm of the FS, across the entire footprint of the Leachate and Retention ponds, sort and stockpile separately as Unit 2 – Unsuitable Material, Unit 3 – Engineered Clayey Material and Unit 4 – General Fill, as instructed by the Superintendent and GITA.

c) Proof roll the entire footprint of the Leachate and Retention Ponds using a fully laden watercart, or suitable alternative. Proof rolling in each local area constitutes an **Inspection Point**. The Contractor(s) is required to provide **24 hours'** notice before commencing or recommencing this activity.

d) The GITA shall identify any areas of Unit 2 – Unsuitable Material during the proof rolling. Identified areas shall be excavated to depths specified by the GITA, and backfilled to -250 mm below the FSL with Unit 3 – Engineered Clayey Material.

e) Load, haul, moisture condition and place Unit 3 – Engineered Clayey Material up to -250 mm below to match *in situ* -250 mm level within pond footprint.

f) Rip, moisture condition and compact, as per Section 6.1.1, *in situ* or placed fill Unit 3 – Engineered Clayey Material (RL -250 mm of FSL), to a depth of 250 mm.

g) Excavate, from designated borrow area or stockpile, moisture condition, place and compact 250 mm thick layer of Unit 3 – Engineered Clayey Material, to achieve top of FSL.

6.3 Excavations

6.3.1 General

a) All excavations shall be to the minimum lines and grades shown on the Drawings or to the satisfaction of the Superintendent and GITA.

b) Excavation Works shall not commence in any zone prior to inspection and approval of the Contractor(s)'s survey markers in that zone by the Superintendent and GITA.

c) During the progress of the Work, the Superintendent or GITA may find it necessary or desirable to revise the lines and grades of any part of the excavations due to unfavourable soil conditions exposed by the excavations, or for any other reason. If such revision requires additional excavation to be made after the excavation of such part has already been completed to the lines and grades shown on the Drawings, additional excavation shall be carried out as specified herein. The cost of any revisions shall be deemed as a variation to the contract. This will include removal of rock and filling of resultant voids.

d) All necessary precautions shall be taken to preserve the material below and beyond the lines of all excavations in the soundest possible condition. Any damage done to the Work including the loosening of material or excavation beyond the required lines and grades, which is performed by the Contractor(s), shall be repaired by the Contractor(s). If such excavation should, in the opinion of the Superintendent, require backfilling, such backfilling shall be done to the satisfaction of the Superintendent with material similar to the fill to be placed against the excavated surface in accordance with this Specification, at the Contractor's expense.

e) Excavations shall include all operations necessary to excavate, irrespective of type and subsurface conditions including the selection of material as specified or otherwise directed, to dispose of all surplus excavated materials not required for embankment construction, to shape formation, drains and batters, all as specified herein or as otherwise to the satisfaction of the Superintendent and GITA.

6.3.2 Stability of Excavations

a) The sides of all excavations steeper than the angle of repose of the material and not self-supporting, shall be benched, battered or adequately supported by bracing or shoring, if necessary, to ensure against slides, cave-ins or danger to persons or structures. The cost of all bracing, shoring or treatment to excavations shall be included in the tendered amount for excavation. All slips of unstable masses of materials outside the limits of excavations and specified cut batters shall be rectified by the Contractor(s) at his expense.

b) Shoring and trench protection shall be constructed in accordance with the relevant statutory safety regulations. Where required or directed by the Superintendent, the Contractor(s) shall use benching techniques to ensure the stability of bulk excavations. Benches shall be sloped inwards and the inside edge of the bench shall be adequately drained.

6.3.3 Disposal of Excavated Materials

a) All suitable material from excavations to be used in the Works shall be separated into three stockpiles for later reuse, namely; Unit 2 – Unsuitable Material, Unit 3 – Engineered Clayey Material and Unit 4 – General Fill, or placed in the final position where it will be used, as directed by the Superintendent.

b) The Contractor(s) shall dispose of all material that has to be excavated, but is unsuitable for construction purpose in waste stockpiles at locations around the site or to the satisfaction of the Superintendent. The Contractor(s) shall spread in layers and traffic compact all unsuitable material to the maximum extent practicable using this method by routing the haulage traffic over the area. All such disposal areas shall be kept neat and tidy.

c) Waste stockpiles shall be levelled, trimmed and shaped to regular lines and grades to prevent the occurrence of ponding or concentrations of surface water runoff.

6.3.4 Stormwater Management Drain

a) The stormwater management drain shall be constructed by cut and fill methods of Unit 4 – General Fill to the lines and levels shown on the drawings.

b) The drain and bund will be constructed with Unit 4 – General Fill to a nominal depth of 500 mm, as shown on the Drawings.

c) The side slopes of the drain shall not be steeper than 1:3 (V:H).

6.3.5 Stormwater Dam Embankment Foundation Key-in Trench

a) The Contractor(s) shall excavate the key-in trench to the lines, depths and grades shown on the Drawings.

b) The key-in trench shall be excavated to a minimum depth of 1.5 m, extended in to the bedrock or clayey material to the satisfaction of the Superintendent, with a base width of 1 m and a maximum of 1:2 (V:H) side slopes.

c) The excavated material shall be reused to construct the embankment if it meets the material standards set out in Section 2.4.

d) If necessary the excavated material may be stockpiled in an area nominated by the Contractor(s) and approved by the Superintendent.

e) The Contractor(s) shall excavate and remove, from any part of the key-in trench, any overburden or rock that will interfere with the compaction of the fill or bonding of the fill within the foundations.

f) The excavations shall continue until all overburden has been removed and a suitable subgrade is exposed, and the foundation materials have properties which, in the opinion of the Superintendent, are acceptable for the embankment foundations.

g) The base of the embankment key-in trench shall be ripped, moisture conditioned and compacted to a depth of 250 mm, in accordance with Section 6.1.1.1, if key-in is not located in rock.

h) No abrupt changes of grade or elevation will be permitted in the excavated base of the embankment foundation key-in trench. The maximum grade of the side slopes in the line of the key trench shall not exceed a slope of 1:1 (V:H), unless otherwise approved by the Superintendent in writing.

i) The Superintendent shall inspect and approve the excavation.

6.3.6 Subsurface Drain Trench

a) The Contractor(s) shall excavate the subsurface drain to the lines, depths and grades shown on the Drawings. The side slopes of the excavation shall be vertical or managed in accordance with Section 6.3.2.

b) The Superintendent shall inspect and approve the excavation prior to the installation of the subsurface drains in accordance with this Specification (refer to Section 1.9.2) and Drawings. This constitutes an **Inspection Point**, noticed should be given **24 hours** prior to inspection.

6.3.7 Subsurface Drain Sump

a) The Contractor(s) shall excavate the subsurface drainage sump to the lines, depths and grades shown on the Drawings.

b) The subsurface drainage sump shall be excavated to the elevations shown on the Drawings. The side slopes of the sump shall not exceed 1:1 (V:H).

c) The Superintendent shall inspect and approve the excavation prior to installation of Unit 7 – Subsurface Sump. This constitutes an **Inspection Point**.

6.3.8 Leachate Collection Sump (LCS)

a) The Contractor(s) shall excavate the LCS within the footprint of Cell 1, to the lines, depths and grades shown on the Drawings.

b) The LCS shall be excavated to the elevations shown on the Drawings. The side slopes of the sump shall not exceed 1:3 (V:H).

c) The Superintendent shall inspect and approve the excavation of the LCS and the compaction of the 250 mm thickness Unit 3 subgrade material prior to the installation of Unit 9 – Geosynthetic Clay Liner in accordance with this Specification (refer to Section 1.9.2).

6.3.9 Anchor Trenches

a) Details of nominal perimeter and division embankment anchor trenches are shown on the Drawings.

b) The anchor trench shall be excavated to 0.7 m depth and 0.6 m width, and set back:

- 1.0 m from the upstream embankment crest for the perimeter embankment.
- 2.0 m from the upstream embankment crest for the division embankment.

c) The upstream top corner of the anchor trench shall be rounded to avoid damage to the geosynthetics. No loose soil shall be allowed to underlie the Unit 9 – Geosynthetic Clay Liner in the anchor trench.

d) Anchor trenches shall be constructed and maintained to the dimensions shown on the Drawings.

e) 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.

f) Prior to the placement of the geosynthetic materials into the trenches, the surface of the trenches shall be inspected to ensure all particles larger than 25 mm, sharp or angular particles of any size, roots, water or desiccation cracks, which could jeopardise the integrity of the liner, are removed. Inspection of the prepared anchor trench excavation shall be **Hold Point**.

g) Anchor trenches shall be backfilled with Unit 3 – Engineered Clayey Material as specified or approved by the GITA and Superintendent.

h) The trenches shall be carefully backfilled in layers not exceeding 200 mm thick, or as directed by the Superintendent, to minimise the risk of damage to the HDPE liner. The layers shall be compacted with hand held equipment to achieve a density consistency of at least dense or very stiff, in accordance with AS 1726.

i) Care shall be taken to avoid damage to the liner system when backfilling anchor trenches. The anchor trench shall be backfilled while the Unit 10 – HDPE Geomembrane is at its most contracted state; preferably during the coolest part of the morning or as agreed with the Superintendent. The geomembrane liners shall be installed in the anchor trench in accordance with the details shown on the Drawings and outlined in this Specification.

j) The Superintendent may conduct spot checks on the consistency of the trench backfill. Areas that, in the opinion of the Superintendent, do not meet the density requirements shall be reworked and re-compacted.

k) The backfill of the trench shall be moisture conditioned in accordance with the requirements specified in Section 6.1.1.

l) The finished and compacted anchor trench is to be inspected and approved by the Superintendent, **Hold Point**.

6.4 Stormwater Diversion Bund

a) The Contractor(s) shall construct the Stormwater Diversion bund to the lines and levels shown on drawings.

b) The stormwater diversion bunds shall be constructed:

- Using Unit 4 – General Fill.
- To a nominal height of 500 mm.
- Side slopes not exceeding 1:2 (V:H).
- Bunds compacted to the satisfaction of the Superintendent.
- Bund shall be compacted to the satisfaction of the Superintendent.

6.5 Cell Stormwater Management Bund

a) The Contractor(s) shall construct the Cell Stormwater Management bund to the lines and levels shown on drawings or as specified by the Superintendent.

6.6 Stormwater Dam Spillway Construction

a) The Contractor(s) shall construct the subgrade, as per Section 6.2 of this Specification, to the lines and levels as shown on the Drawings.

b) Unit 12 – Separation Geotextile shall be placed over the prepared subgrade as per the Drawings.

c) Unit 14.1 – Reinforced Concrete Slab shall be constructed over Unit 12 – Separation Geotextile to the lines and levels shown in the Drawings.

d) Unit 19.1 – Concrete Spillway and Dissipater blocks shall be installed at the embankment crest and down the slope as shown on the Drawings, to the satisfaction of the Superintendent.

e) Unit 19.2 – Loosely placed rock shall be placed along the width of Stormwater spillway channel to a depth and length as specified by the Superintendent.

f) Unit 19.3 – Erosion protection mat shall be installed in the stormwater channel as shown on the Drawings.

6.7 Cell 1 and Stormwater Dam Embankment Construction

6.7.1 Embankment Foundation Preparation

a) Work on the Stormwater Dam embankment foundation shall not commence prior to acceptance of the lines, levels and grades of the key-in trench excavation, as per Section 6.3.4 by the Superintendent. This constitutes a **Hold Point**.

b) All embankment foundations, including the:

- Cell 1 perimeter and division embankments.
- Stormwater Dam embankment including the Stormwater Dam Key-in trench.
- Leachate Pond embankment, and
- Retention Pond embankment.

shall be prepared for embankment construction by ripping, moisture conditioning and compacting the *in situ* to a depth of 250 mm in accordance with this Specification (refer to Section 6.1.1).

c) The foundation preparation and compaction results shall be inspected and approved by the Superintendent prior to placement of embankment construction material begins **(Hold Point)**.

6.7.2 Construction Material

a) The embankments shall be constructed from material that meets the specifications for:

- Unit 3 – Engineered Clayey Material for the Stormwater Dam and for a 500 mm thick layer (where in fill) on the upstream slope of the embankments for Cell 1, Retention Pond and Leachate Pond.
- Unit 4 – General Fill for all other embankments (Internal and external embankments of Cell 1, Retention Pond and Leachate Pond embankments).

b) The material will be won from the excavations for the stormwater dam embankment key-in trench, borrow areas and stockpiles designated by the Superintendent.

c) Any material used to construct the embankment that is deemed Unit 2 – Unsuitable Material (Section 2.3) by the Superintendent or GITA shall be removed and stockpiled in a location nominated by the Superintendent.

6.7.3 Placement

The Contractor(s) shall provide a Work Method Statement presenting proposed methods for embankment construction activities, this constitutes a **Hold Point**. The Work Method statement should include the following:

a) The Contractor(s) shall construct the embankments in nominal loose lift layers not exceeding 250 mm in compacted thickness, or as agreed with the Superintendent after construction commences.

b) Compaction of each lift shall be in accordance with Section 6.1.1 of this Specification.

c) If the Contractor(s) is unable to achieve the required compaction, the layer thickness shall be reduced.

d) Prior to placement of each layer of fill, the top of the previously completed lift shall be scarified and if required moisture treated, to the satisfaction of the Superintendent, to key each layer together and to prevent laminations at layer interfaces.

e) The Contractor(s) shall work the embankment fill material during conditioning and placement, and shall ensure that all large lumps or clods are broken down, that no lenses or layers of sand are present and that hard crusts encapsulating soft and wet materials are not allowed to form.

f) In the event there is, in the opinion of the Superintendent or GITA, Unit 2 – Unsuitable Material, the Contractor(s) shall remove the material identified by the Superintendent as unsuitable and replace it at the Contractor's expense.

g) Compaction shall occur over the entire area of each layer of fill with a uniform degree of effort.

h) Filled areas shall be sealed and shaped, by the Contractor(s) using appropriate plant, to be free draining when rain is expected.

i) All earthworks shall be suitably maintained during the construction period to avoid excess drying or wetting up.

j) Where the compacted fill does not meet the specified requirements of Section 6.1.1 it shall be ripped, moisture conditioned and re-compacted.

k) Any fill or cut surface which has deteriorated through excessive drying, cracking, wetting, or has been weakened or rutted as a result of construction traffic, shall be reworked to satisfy the requirements of this Specification and the Superintendent's requirements.

l) The final surface of the compacted filled embankment shall be sealed and shaped to the final lines, levels and grades specified in the Drawings.

m) Survey of the final embankment bench surface and alignments shall be presented to the Superintendent. This constitute a **Hold Point.**

n) The surface of the embankment shall be proof rolled using at least a fully loaded 50 tonne gross vehicle mass off highway truck with 600 mm wide tyres or equivalent as approved by the Superintendent. Proof rolling in each local area constitutes an **Inspection Point**. The Contractor(s) is required to provide **24 hours'** notice before commencing or recommencing this activity.

o) The Contractor shall place a nominal 150 mm thick layer of Unit 18 – Wearing Course material on the finished embankment crest or as agreed with the Superintendent.

p) The Contractor shall place a nominal 150 mm thick layer of Unit 1 – Topsoil on the outer slopes of the finished perimeter embankment or as agreed with the Superintendent.

7.0 SUBSURFACE DRAIN INSTALLATION

7.1 Installation

The Works described in Section 7.0 shall be undertaken by specialist Pipe Installers (Installer) approved at the time of tender award. Any change to the approved Installer shall demonstrate equivalency to the approved Installer and be approved by the Superintendent prior to Works commencing.

The Contractor(s) shall use the Installer and the Installer's key personnel to test and install the pipes. The Contractor(s) is responsible for all aspects of the Installer's work. Any proposed change to the pipe installation shall be subject to written approval from the Superintendent.

7.2 Quality Assurance and Quality Control

The Contractor(s) shall be responsible for all QA and QC of the transportation and installation of the Unit 5 – Subsurface Drain Pipes. The Contractor(s) shall establish and maintain a quality control system for all operations including but not limited to the following:

- Delivery, handling, and storage of materials
- Placement, joining and repair.

7.3 Subsurface Drain Pipes

a) The Subsurface Drain pipe trenches shall be excavated, in accordance with Section 6.3, along the southern flank of Cell 1, as shown on the Drawings.

b) Inspection of the excavated subsurface drain pipe trenches, by the Superintendent, shall constitute an **Inspection Point**.

c) Unit 5 – Subsurface Drain Pipes shall be installed as shown on the Drawings.

d) Unit 6.2 – Subsurface Drainage Sand shall be installed at the base of the trench as bedding for Unit 5 – Subsurface Drain Pipes. Temporary shutters shall be placed next to Unit 5 – Subsurface Drain Pipes at a distance of 0.3 m from the pipe on either side. Unit 6.1 – Subsurface Drainage Aggregate shall be placed around Unit 5 – Subsurface Drain Pipes on the inside of the shutter works. Unit 6.2 – Subsurface Drainage Sand shall be placed on the outside of the shutter works and to the top of the trench.

e) Unit 5 – Subsurface Drain Pipes shall be joined by full face fusion welding, coupling welding techniques or other joining techniques as approved by the Superintendent.

f) Unit 5 – Subsurface Drain Pipes shall be installed at the gradient shown on the Drawings.

g) A mound of 300 mm high Unit 4 – General Fill shall be placed over the Subsurface drain at the point where it is no longer below Cell 1 embankment.

7.4 Subsurface Drain Sump.

a) The Unit 7 – Subsurface Drain Sump excavation shall be excavated in accordance with Section 6.3, to the lines and levels as shown on the Drawings.

b) Inspection of the excavated sump by the Superintendent shall constitute an **Inspection Point**.

c) Construction and installation of Unit 7 – Subsurface Drain Sump shall be performed by the Contractor(s) and monitored and inspected by the Superintendent.

8.0 SEDIMENT MANAGEMENT STRUCTURE CONSTRUCTION

8.1 Quality Assurance and Quality Control

The Contractor(s) shall be responsible for all QA and QC of the transportation and installation of the Unit 20.1 – Separation Geotextile and Unit 20.2 – Embankment Aggregate. The Contractor(s) shall establish and maintain a quality control system for all operations including but not limited to the following:

- Delivery, handling, and storage of materials.
- Placement, joining and repair.

8.2 Sediment Management Embankment

8.2.1 Key-in and anchor trench construction

a) Clear and grub and strip Unit 1 – Topsoil, as per Section 5.2 and Section 5.3 of this Specification, from the footprint of the Sediment management embankment.

b) The Contractor(s) shall excavate the anchor trenches and key-in trench to the lines, depths and grades shown on the Drawings.

c) The key-in trench shall be excavated to a minimum depth of 500 mm.

d) Where possible, proof roll the key-in trench using at least a fully loaded 50 tonne gross vehicle mass off-highway truck with 600 mm wide tyres. Proof rolling in each local area constitutes an **Inspection Point**. The Contractor(s) is required to provide **24 hours'** notice before commencing or recommencing this activity.

e) The GITA shall identify any areas of Unit 2 – Unsuitable Material during the proof rolling. Identified areas shall be excavated to depths specified by the GITA, and backfilled with compacted Unit 4 – General Fill.

f) The internal corner of the anchor trench, adjacent to the embankment toe, shall be rounded to avoid damage to Unit 20.2 – Separation Geotextile.

g) Anchor trenches shall be constructed and maintained to the dimensions shown on the Drawings.

h) 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.

i) The anchor trenches shall be inspected and approved by the Superintendent prior to the placement of Unit 20.2 – Separation Geotextile. This constitutes an Inspection Point.

j) Anchor trenches shall be backfilled with Unit 4 – General Fill as specified or approved by the GITA and Superintendent.

k) The trenches shall be carefully backfilled in layers not exceeding 200 mm thick, or as directed by the Superintendent. The layers shall be compacted with hand held equipment to achieve a density consistency of at least dense or very stiff, in accordance with AS 1726.

l) Care shall be taken to avoid damage to Unit 20.2 – Separation Geotextile when backfilling anchor trenches.

m) The Superintendent may conduct spot checks on the consistency of the trench backfill. Areas that, in the opinion of the Superintendent, do not meet the density requirements shall be reworked and re-compacted.

n) The backfill of the trench shall be moisture conditioned in accordance with the requirements specified in Section 6.1.1.

o) The finished and compacted anchor trench is to be inspected and approved by the Superintendent, **Hold Point**.

p) Unit 12 – Separation Geotextile shall be placed as per the Drawings, in accordance with Section 9.10.2 of this specification.

8.2.2 Placement of Unit 20.2 – Embankment Aggregate

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 prepare a Work Method Statement for handling and placement of Unit 20.2 – Embankment aggregate. The Work Method Statement shall consider installation of and protection of Unit 20.1 – Separation Geotextile as well as fines generation in the Unit 20.2 Embankment Aggregate. This constitutes a **Hold Point**.

No transport or placement of the Unit 20.2 Embankment Aggregate shall be carried out until the **Hold Point** has been released by the Superintendent. The Work method statement must address the following requirements:

a) Protection of the integrity of the underlying Unit 20.1 – Separation Geotextile.

b) 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.

c) 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 separation geotextile.

d) 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 material requirements, as per Section 2.8.

9.0 INSTALLATION OF GEOSYNTHETICS

9.1 Subcontractor(s)

The Works described in Section 9.0 shall be undertaken by the geosynthetic liner installation specialist (Installer) approved at the time of tender award. Any change to the approved Installer shall demonstrate equivalency to the approved Installer and be approved by the Superintendent prior to Works commencing.

The Contractor(s) shall use the Installer and the Installer's key personnel to test and install the geosynthetics. The Contractor(s) is responsible for all aspects of the Installer's work. Any proposed change to the liner installation shall be subject to written approval from the Superintendent and GITA.

9.2 Surface Preparation

The Contractor(s) shall prepare the surface to receive the geosynthetic materials as specified in Section 6.0.

The re-worked surface shall be approved by the Superintendent prior to placing the geosynthetic liner materials (**Hold Point**).

9.3 Quality Assurance and Quality Control

The Contractor(s) shall be responsible for all QA and QC of the transportation and installation of the geosynthetics. The Contractor(s) shall establish and maintain a quality control system for all operations including but not limited to the following:

- Delivery, handling, and storage of materials.
- Placement, joining and repair.

The Superintendent will undertake periodic audits of the Contractor(s)'s Quality Control procedures. The GITA shall be on site full time to inspect all geosynthetic installation works. Should any areas of the Works show any non-conformance with the approved Quality Control Procedures Manual, this non-conformance shall be resolved by corrective action, presentation of the appropriate documentation, undertaking sampling and testing, or another activity approved by the GITA and Superintendent.

The Superintendent may also undertake periodic conformance testing on samples as supplied by the Contractor(s) in accordance with this Specification.

9.4 Submittals

The Contractor(s) shall submit quality forms and test results to demonstrate the compliance of the installed geosynthetics with this Specification.

Copies of these records and tests, as well as records of corrective actions taken when results are unsatisfactory, shall be presented to the Superintendent in writing, within **24 hours** following an inspection, test or action.

9.5 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:

- Unit 9 – Geosynthetic Clay Liner: No vehicle access over deployed GCL, only careful foot traffic, subject to footwear requirements.
- Unit 10 – HDPE Geomembrane: No vehicle access over deployed geomembrane, only careful foot traffic, subject to footwear requirements.
- Unit 11 – Cushion Geotextile: No vehicle access over deployed geotextile, only foot traffic.

The Contractor(s) 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.

9.6 Anchor Trenches

- Anchor trenches shall be constructed and maintained during construction as per Section 6.3.9.
- Prior to the placement of the geosynthetic materials into the trenches, the surface of the trenches shall be inspected and approved by the Superintendent to ensure all particles larger than 25 mm, sharp or angular particles of any size, roots, water or desiccation cracks which could jeopardise the integrity of the trench are removed.
- The following geosynthetic materials shall be permanently secured in the anchor trenches as per the Drawings:
  - Unit 9 – Geosynthetic Clay Liner
  - Unit 10 – HDPE Geomembrane
  - Unit 11 – Cushion Geotextile.
- Once the liner system has been installed, the anchor trench shall be backfilled whilst the liner material is in a relaxed state (i.e. not in a state of tension), in full contact with the subgrade without the presence of wrinkles or folds. Temporary anchorage such as sandbags shall be used to hold the material in place until a relaxed state is achieved.
- The anchor trench shall be inspected by the Contractor(s) and approved by the Superintendent prior to being backfilled. The approval of the anchor trench shall be a **Hold Point**.

9.7 Installation Sequence

The geosynthetic layers shall be installed following the sequence:

- Placement and anchoring of Unit 9 – Geosynthetic Clay Liner
- Placement and anchoring of Unit 10 – HDPE Geomembrane
- Placement and anchoring of Unit 11– Cushion Geotextile.

9.7.1 Placement of Unit 9 – Geosynthetic Clay Liner (GCL)

Unit 9 – Geosynthetic Clay Liner shall be placed on the prepared subgrade and installed in accordance with Section 9.8.2 and permanently secured in the anchor trench.

Prior to placement of Unit 9 – Geosynthetic Clay Liner, the Contractor(s) shall ensure that the subgrade preparation is in accordance with the requirements specified in Section 6.2. The prepared subgrade shall be signed-off and approval given, by the GITA, to place Unit 9 – Geosynthetic Clay Liner. This constitutes a **Hold Point**.

Once Unit 9 – Geosynthetic Clay Liner is placed, if the GITA is satisfied, the GCL shall be signed-off and approval given to place Unit 10 – HDPE Geomembrane. The surface of the GCL after installation shall be an **Inspection Point**. The Contractor(s) shall maintain the surface of the GCL during installation of Unit 9 – HDPE Geomembrane.

9.7.2 Placement of Unit 10 – HDPE Geomembrane

Unit 10 – HDPE Geomembrane shall be placed overlaying the GCL according to this specification, in line with Section 9.9.5 and permanently secured in the anchor trench. Placement of Unit 10 – HDPE Geomembrane over Unit 9 – Geosynthetic Clay Liner shall take place on the same day, except if otherwise approved by the GITA.

Once Unit 10 – HDPE Geomembrane is placed, if the GITA is satisfied, it shall be signed off and approval given to place Unit 11 – Cushion Geotextile. The surface of the geomembrane after installation shall be a **Hold Point**. The Contractor(s) shall maintain the surface of the geomembrane during installation of Unit 11 – Cushion Geotextile.

9.7.3 Placement of Unit 11 – Cushion Geotextile

Unit 11 – Cushion Geotextile shall be placed overlaying the geomembrane according to this specification, in line with Section 9.10.2 and permanently secured in the anchor trench.

Once Unit 11 – Cushion Geotextile is placed, if the Superintendent is satisfied, the Cushion shall be signed off and approval given to install the leachate collection pipes. The surface of the cushion geotextile after installation shall be an **Inspection Point**. The Contractor(s) shall maintain the surface of the Unit 10 – HDPE geomembrane during installation of Unit 11 – Cushion Geotextile.

9.7.4 Placement of Unit 12 – Separation Geotextile

Unit 12 – Separation Geotextile shall be placed overlaying the Unit 8 – Leachate Drainage Aggregate according to this specification, in line with Section 9.10.2 and secured with mounds of gravel or sand bags or as instructed by Superintendents.

Once Unit 12 – Separation Geotextile is placed, if the Superintendent is satisfied, the Separation Geotextile shall be signed off. The surface of Unit 12 – Separation Geotextile after installation shall be an **Inspection Point**.

9.8 Unit 9 – Geosynthetic Clay Liner (GCL)

9.8.1 Transportation and Storage

Special Care is expected when transporting and storing GCL materials to prevent damage to any protective cover materials or components.

GCL shall be wrapped with weather and moisture resistant heavy duty wrapping. Rolls with damaged wrapping shall be pointed out by the Contractor(s) to the Superintendent who will inspect to assess the extent of hydration of the liner. GCL rolls or portions of rolls with moisture content equal or above 40% by weight (ASTM D5993) may be rejected, as instructed by the Superintendent or GITA. GCL rolls with damaged wrapping and moisture content lower than 40% shall be re-wrapped and sealed.

GCL rolls shall be stored in their original, unopened packaging. The designated storage area should be level, dry, well-drained, stable, and should provide protection against precipitation, chemicals, standing water, excessive heat, and ultraviolet radiation. At no time during storage shall the GCL come into contact with precipitation or any standing water. It is expected that humidity will not deleteriously affect the GCL, as long as the material remains in its original unopened and undamaged packaging.

GCL materials which are damaged during storage and transportation shall be rejected by the Superintendent or GITA and are to be removed, disposed of and replaced at the Contractor(s)'s expense.

9.8.2 Installation

9.8.2.1 Handling and Placement

Field panels shall be installed at the location and positions indicated in a panel layout drawing provided by the Contractor(s). The panel layout drawings shall be supplied to the Superintendent two weeks prior to GCL installation commencing. This is a **Hold Point**.

Panel placement shall take into account forecast weather conditions such as light to heavy rain or high winds so as to minimise possible damage from these conditions. All GCL panels shall be covered by Unit 10 – HDPE Geomembrane by the end of each day.

The Contractor(s) shall handle all GCL in a manner that complies with the following:

- On slopes, the GCL shall be secured and then rolled down the slope to continually keep the GCL in tension to preclude folds and wrinkles.
- All GCL shall be weighted with sandbags or equivalent until covered with overlying materials.
- GCL shall be cut using an approved cutting method and approved equipment only. The method of cutting the GCL shall be approved by the Superintendent.
- GCL shall be examined over the entire surface after installation, to ensure that no potentially harmful foreign objects are present. Any foreign objects encountered shall be removed or the liner shall be replaced.
- The GCL shall be covered with Unit 10 – HDPE Geomembrane by the end of each working day, unless otherwise agreed with the GITA.

9.8.2.2 Overlaps

GCL shall be overlapped according to the following requirements:

- Areas to be joined shall be clean and free of foreign matter.
- **No** cross-slope (horizontal) joints shall be allowed on the side slopes or within 1.5 m of the toe of the batter.
- Longitudinal joints shall be overlapped by 500 mm.
- Any damaged area requiring patching shall be patched according to Section 9.9.6.

9.8.2.3 Repairs

Any holes or tears in the GCL shall be repaired as follows:

- Soil or other material that may have penetrated the torn GCL shall first be removed.
- On slopes, a patch made from the same material, shall be placed (with at least 500 mm overlap to any edge) and sealed along the edges with bentonite paste, 500 mm wide.
- Should any tear exceed 10% of the width of the roll, that section of roll shall be removed

9.9 Unit 10 – HDPE Geomembrane

9.9.1 Quality Assurance and Quality Control

The Installer shall be responsible for all quality assurance and quality control of Unit 10 – HDPE Geomembrane. This shall include the preparation of a Quality Control Procedures Manual and the undertaking of all inspections, recording, non-destructive and destructive testing, repairs etc. and the certification as detailed in this Specification or instructed by the Superintendent or GITA.

The Superintendent shall undertake audits of the QA and QC procedures. The GITA shall be on site **full time** to inspect all geosynthetic installation works. Should any areas of the Works show non-conformances with the approved Quality Control Procedures Manual, then the non-conformance shall be resolved by corrective action, presentation of the appropriate documentation, undertaking sampling and testing, or another activity approved by the GITA and Superintendent.

In addition, the Superintendent may undertake conformance tests on samples supplied by the Installer in accordance with this Specification.

9.9.2 Quality Control Procedures Manual

The Installer shall submit a Quality Control Procedures Manual to the Superintendent at least **two weeks** before the commencement of any installation of HDPE on the site. The submission and approval of the Quality Control Procedures Manual shall be a **Hold Point**. The Manual shall comprise:

- The Installer's organizational structure and personnel, and the qualifications and experience of the proposed installation personnel
- Inspection and Test Plans (ITPs).
- 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.
- Procedures to be employed during deployment and welding of geomembrane on slopes.
- Storage and handling procedures.
- Additional information specific to the project conditions requested by the Superintendent or GITA.

9.9.3 Submittals

The Contractor(s) shall submit to the GITA on a **weekly** basis all quality forms, test results and other documentation indicated in the Quality Control Procedures Manual to demonstrate his compliance with the quality system for the project and to demonstrate compliance of the installed Unit 10 – HDPE Geomembrane with this Specification.

Copies of these records and tests, as well as records of corrective actions taken when results are unsatisfactory, shall be presented to the GITA in writing, within one working day following an inspection, test or action.

9.9.4 Transportation and Storage

Unit 10 – HDPE Geomembrane liners shall be protected from mud, dirt, dust, puncture, cutting or any other damaging or deleterious conditions. Rolls shall be stored away from high traffic areas, and supported continuously and uniformly on a smooth, level prepared surface.

Liner rolls shall not be rolled across the ground, nor stacked more than two rolls high if stored in the open. If the rolls are stored in containers, rolls may be stacked up to 4 rolls high.

HDPE materials which are damaged during storage and transportation shall be rejected by the GITA and are to be removed, disposed of and replaced at the Contractor(s)'s expense.

9.9.5 Installation

9.9.5.1 Handling and Placement

Field panels shall be installed at the location and positions indicated in a panel layout drawing provided by the Contractor(s) and using any one of the following schedules:

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

Panel placement shall take into account forecast weather conditions such as heavy rain or high winds so as to minimise any possible damage from these conditions.

The panel layout drawings shall be supplied to the Superintendent **two weeks** prior to geomembrane installation commencing. This is a **Hold Point**.

9.9.5.2 Night Placement

Night placement of the geomembrane may be required if in the opinion of the GITA daytime temperatures could adversely impact the quality of the geomembrane welding. Installation work carried out at night shall be inspected and tested during daylight hours. All joints shall be tested during daylight hours. Night time placement will be subject to approval by the Superintendent.

9.9.6 Damage and Defects

The Installer shall be responsible for recording all defects, labels, locations and preparing Field QC records of their repair.

Inspections shall be carried out in daylight. The responsibility of identification of defects remains with the Installer, but the type of defect is to be decided by the GITA.

Two types of defects may occur in the geomembrane:

- Manufacturing defects that exist in the geomembrane as delivered to the site, and
- Defects related to the installation of the geomembrane.

Repair of manufacturing and installation defects shall be the responsibility of the Installer. The following section clarifies the limits related to different types of defects.

9.9.6.1 Manufacturing Defects

The following manufacturing defects shall apply:

Fisheye

A gel is also referred to as a "fisheye", which 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. "Fisheyes" often occur repetitively down the length of the roll, and at the same location from the roll edge, and is clearly related to a manufacturing problem. A guide for acceptance of a geomembrane roll with fisheyes is one defect per 50 m roll, for a roll where the fisheye defects occur over the majority of the roll length deployed. A majority of roll length deployed is 75% of the roll length. If the end of a roll has a number of defects greater than one per 50 m of roll, then the end of the roll shall be cut off and removed from site. The GITA in consultation with the Superintendent shall make the final decisions on site.

Surface Blemishes

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 normally be uniform and consistent. Where changes occur in the surface texture or colour the Contractor(s) shall request the GITA to inspect the area. If the area is rejected as unacceptable, then the section of the geomembrane roll shall be removed and replaced, and be treated as a manufacturing defect.

Scratches

Straight-line scratches that penetrate the geomembrane (approximately 0.1 mm) shall be pointed out to the GITA for consideration. The GITA shall inspect the deployment equipment and the shape of the defect to decide if it is a manufacture defect. The GITA decision shall be final. The roll length where such a defect occurs shall, if instructed by the GITA, be cut out and removed from site. The removed length of roll shall constitute one defect.

Defects in the geomembrane that result in non-ductile failure of the sheet shall be considered unacceptable. The acceptance of a scratch shall also be decided on this basis, and where considered appropriate the GITA shall instruct coupons to be recovered from the suspect area and be subject to tensile testing, to demonstrate whether the scratch results in ductile or non-ductile behaviour. Defects shall be capped.

Non-uniform Surface Texture

Geomembrane rolls which present a non-uniform pattern or intensity of texturing shall be considered as follows:

- If the texturing on the surfaces varies to the extent that the surface roughness of the surfaces is significantly different, the geomembrane shall be rejected. A difference in surface roughness over 4 m^2 is considered significant. The difference shall be decided by the GITA using a visual assessment, and shall be final.
- Scattered significant agglomeration of texturing on the surface shall be removed if it occurs at a density of less than one significant agglomeration per 300 m^2. A roll with a higher density of significant agglomerations shall be rejected. A significant agglomeration shall be one that can be seen as a discolouration from a distance of 15 m from the surface being inspected, and is larger than 20 mm in diameter.

9.9.6.2 Repair of Defects

The Installer shall mark observed defects on the installed sheet. The Installer shall record the defects on a layout drawing.

All defects shall be patched or capped and subject to QC testing, reporting and documentation by the Installer. The GITA shall assess all such repairs, reporting and documentation. Repair of defects is part of the Installers responsibility.

Inspections shall be carried out in daylight. The responsibility of identification of defects remains with the Installer.

9.9.7 Field Welding

9.9.7.1 Requirements of Personnel

Personnel performing welding operations shall be qualified as indicated below.

- Shall be qualified by experience or by successfully passing welding tests and at least one welder shall have welded a minimum of 100 000 m^2 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, and
- **No field welding** shall take place unless the Weld Foreman is present.

9.9.7.2 Welding Equipment and Methods

9.9.7.2.1 Approved Processes for Field Welding

Only extrusion welding or fusion welding using equipment approved by make and model shall be used.

Fusion Welding Process

The Contractor(s) shall use dual-track fusion welding process. The Contractor(s) shall maintain at least one spare, operable welding unit of each type employed on the project site at all times.

The fusion-welding apparatus must be automated vehicular-mounted devices. The fusion-welding apparatus shall be equipped with gauges giving the applicable temperatures, speed and pressures. 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.

Extrusion Welding Process

Extrusion welding shall be used only for the geomembrane repairs or other areas approved by the GITA. The Contractor(s) shall maintain at least one spare, operable welding unit of each type employed on the project site at all times.

The extrusion apparatus shall be equipped with gauges giving the temperature in the apparatus and at the nozzle. 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.

9.9.7.3 Protection of Geomembrane Liner

The electric generator shall be mounted on a wheeled trolley so that it is not dragged across the geomembrane. A smooth insulating plate or fabric shall be placed beneath the hot welding apparatus after usage to protect the geomembrane. The wheeled trolley shall not be moved onto the geomembrane without inspection of the wheels to ensure no trapped particles pose a puncture risk to the geomembrane. The Contractor(s) shall also take precautions to ensure that when refuelling, hydrocarbons do not spill onto the geomembrane liner.

Fusion welded seams shall be formed using a slip sheet below the weld to reduce the risk of sharp particles being trapped in the underside of the welder, resulting in scoring of the underside of the geomembrane.

9.9.7.4 Seam Layout

In general, seams shall be oriented parallel to the line of maximum slope, i.e. oriented up and down, not across, the slope. In corners and odd-shaped geometric locations, the number of seams shall be minimised. No horizontal seam shall be closer than 1.5 m from the toe of the slope. No seams shall be located in areas of potential stress concentrations as per direction of the GITA.

No cross-joints shall be allowed unless approved by the GITA. All fusion joints between panel ends are to form T-joints, with panel layouts being staggered to achieve this. The minimum spacing between T-joints shall be 500 mm. All T-joints, defects etc. shall be patched and be subject to quality testing. Where cross-joints are unavoidable, they shall also be patched and be subject to quality control testing.

All seams and joints shall be numbered or named by the Installer and verified by the GITA, which shall be cross-referenced to field notes and records of the Installer. Seam names or numbers shall be marked on the seam layout drawing, and altered as required on the As-Built Drawings.

9.9.7.5 Weather Condition for Welding

Geomembrane jointing and welding shall not be started if the geomembrane temperature is below 5°C or above 55°C, unless otherwise authorised by the GITA. Geomembrane jointing shall not be undertaken in the rain, in the presence of excessive moisture (i.e. 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.

9.9.7.6 Weld Preparation

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

If seam overlap abrading is required, the process shall be completed 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 conditions does not cause artificial cooling of the weld.

The edge flap of fusion seams shall not be ripped from the seam to inspect the “squeeze-out” from the weld. Any required removal of geomembrane material shall be carried out by careful cutting.

The Installer 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.

The information shall be recorded in permanent ink to ensure it is legible for the duration of the Works.

9.9.7.7 Overlapping and Temporary Bonding

Panels of Geomembrane shall be overlapped by a minimum of 75 mm for extrusion welding and 125 mm for fusion welding. The Installer shall make appropriate allowance for the effect of shrinkage of panels related to changes in temperature, to ensure the required overlap during 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.

9.9.7.8 General Welding Procedures

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

- Welding shall extend to the outside edge of panels to be placed in the anchor trench
- Ends of the air channel of dual fusion welds extending into anchor trenches shall be welded closed
- If required, a firm substrate shall be provided by using a flat board, piece of geomembrane, a conveyor belt, or similar hard surface directly under the seam overlap to achieve proper support
- Fish-mouths or wrinkles at the seam overlaps shall be cut along the ridge of the wrinkle to achieve a flat overlap. The cut fish-mouths or wrinkles shall be welded and 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, and
- 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.

9.9.8 Testing

9.9.8.1 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 GITA. 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 at mid-day or at an interval of no greater than **five (5) hours**, whichever is less. The GITA 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 shall 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 1.5 m long for fusion welds or 1.0 m long for extrusion welds with 125 mm overlap, with the weld centred length-wise along the long side. 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 from the trial weld sample by the Installer 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 Installer, using an electrically operated tensiometer with the following features:

- Force exerted is displayed, including the units.
- Strain results.
- Calibration units.

The Installer shall supply evidence demonstrating that the tensiometer has been calibrated within the previous 12-month period.

Trial Weld Evaluation Criteria

If any one of the three specimens fails, the entire trial weld is considered failing. The shear test specimen for both fusion and extrusion welds shall, at a minimum, meet a strength of 95% of the tensile yield strength of the parent geomembrane material and shall not fail within the weld. Both tracks of dual-track fusion welds shall be tested for peel adhesion. If either track fails within the weld, the test specimen is considered to have failed. Peel strength of welds to meet at least 65% of the tensile yield strength of the parent geomembrane material. For extrusion welds, the peel strength of the weld must be at least 60% of the tensile yield strength of the parent geomembrane material.

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 have 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.

9.9.8.2 Non-destructive Weld Continuity Testing

9.9.8.2.1 General

The Installer shall non-destructively test all field and factory welds over their full length using a vacuum test unit, spark testing, air pressure test (for double fusion welds only), or other approved method. Vacuum testing and air pressure testing are described below. Spark Testing shall be carried out in accordance with ASTM D 6365. The purpose of the non-destructive test is to check the continuity of welds. Continuity testing shall be done as the welding work progresses. Any welds that fail non-destructive testing shall be repaired in accordance with these Specifications. Welds, that cannot be non-destructively tested because of seam geometry shall be double welded or capped.

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

The Installer shall demonstrate to the GITA at the beginning of the job, and as otherwise directed by the GITA, that the testing equipment is in good working order by testing a test seam with a known defect.

9.9.8.2.2 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 pressure of at least -15 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 be tested with a minimum 75 mm overlap between sections.

9.9.8.2.3 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 415-450 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 450 kPa, with a tolerance of less than 5 kPa.

The following procedures shall be used:

- Seal both ends of the weld to be tested by grinding through the upper panel and sealing the air channel by extrusion welding.
- 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 between 170 to 210 kPa for a 25 mm wide channel or 300 to 350 kPa for a 13 mm wide channel. Close the valve and sustain the pressure for a minimum of 5 minutes. The Installer may propose a greater test pressure with shorter periods of observation for consideration by the GITA. 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.
- If loss of pressure exceeds 15 kPa, or does not stabilise, locate faulty area and repair in accordance with this section. If, in the judgement of the GITA, 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 weld.
- Remove needle or other approved pressure feed device and repair all holes and damage made to the air channel by grinding and extrusion welding over the damage.

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

9.9.8.3 Destructive Weld Continuity Testing

The Installer shall recover field weld samples, at locations selected by the GITA, for destructive testing. The purpose of these tests is to evaluate field weld strength. Field weld strength testing shall be done as the welding work progresses, not at the completion of all field welds.

A portion of the destructive test samples shall also be tested at an independent laboratory. The GITA will arrange for testing of these samples at an independent NATA accredited laboratory.

9.9.8.3.1 Location and Frequency

Destructive test samples shall be collected at an initial average frequency of one test location per 150 m of seam length for wedge welding and every 120 m of seam length for extrusion welding. As welding progresses the frequency of testing may be increased or decreased by the Superintendent in consultation with the GITA based on the performance of:

- Trial Welds.

- Previous destructive testing, and
- Air Pressure testing.

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. The GITA shall choose the test locations. The Installer shall not be informed in advance of the locations where the samples shall be taken.

The Superintendent reserves the right to increase the frequency depending on the test results of samples taken.

9.9.8.3.2 Sampling Procedure

Results of on-site tensiometer testing shall be reviewed before the geomembrane is covered by another material. Each sample shall be numbered and the sample number and location identified on the panel layout drawing. These details shall also be clearly marked on the geomembrane adjacent to where the sample was retrieved (marked such that the subsequent repair does not cover these details).

Random samples shall be sent off site, by the GITA, to a NATA-accredited laboratory for confirmation testing. However, permission to cover installed geomembrane with subsequent layers may not be reliant on this testing depending on site conditions and discussion with the GITA.

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

9.9.8.3.3 Size of Samples

The samples shall be 0.3 m wide by 1 m long with the weld centred length-wise. The sample length may be increased to provide material for additional laboratory testing or archiving as directed by the Superintendent.

9.9.8.3.4 Weld Destructive Tests

Preliminary Field Testing

Four (4) specimens, two from each end of the weld destructive sample, shall be removed and tested for peel adhesion by the Installer in accordance with ASTM D 6392. The results of this testing shall be evaluated in accordance with the criteria as detailed under '*Trial Weld Evaluation Criteria*' in Section 9.9.8.1 of this Specification. If one of the four field specimens fails, the entire destructive test is considered to fail and additional destructive test samples shall be taken in accordance with the procedures of this Specification. Failure constitutes in-plane separation of the weld when testing.

Laboratory Weld Sample Destructive Testing

Tests shall be performed on 10 specimens cut from each destructive weld sample:

- Five specimens shall be tested in shear, and
- Five 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.

Laboratory Testing 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 and ASTM D 6392.

Shear

The weld shear strength for both fusion and extrusion welds shall be, at a minimum, meet a strength of 95% of the tensile yield strength of the parent geomembrane material. 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.

Peel Adhesion

The weld peel strength shall be equal to or greater than 65% for fusion and 60% for extrusion welds of the minimum yield strength of the geomembrane, as specified in the property values in Table 3 of this Specification. The specimen shall fail in 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 weld surface. 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 any specimen fails in peel, the entire weld destructive test sample shall be considered as failing.

Field Destructive Sample Procedure

The Installer 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 Installer shall trace deficient welds by taking specimens for field testing or by obtaining additional weld destructive samples at a nominal of 5 m intervals in both directions along the deficient weld from the failure location. If tracing by taking field specimens is chosen, the Installer shall continue to obtain specimens from the weld at 3 m intervals until it has confidence that a destructive sample, which will pass laboratory testing, can be obtained. A full laboratory sample will then be taken at that location and tested. If one or both of these samples fail the laboratory 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 that requires obtaining more than two specimens in either direction from the location of the initial failed destructive weld sample shall be brought to the attention of the Superintendent and the process approved by the Superintendent prior to continuing. A review of the Installer's procedures and performance may be conducted.

Alternatively, the Installer may elect to cap the full length of the weld if they do not choose to trace the deficient weld.

9.9.8.4 Liner Integrity Survey

The Contractor is to carry out a liner integrity survey (electrical leak location test) of all geomembrane lined areas where leachate drainage aggregate has been installed (Cell 1) and for the Leachate Pond. The testing is to be undertaken by a suitably qualified subcontractor (it could be the main Contractor) that has been approved by the Superintendent.

The liner integrity survey is to be undertaken once the geomembrane has been installed and the drainage aggregate has been placed on top of the geomembrane, but before installation of the separation geotextile has been installed, to assess whether the geomembrane has sustained damaged during its installation and placement of the drainage aggregate.

The Contractor is to provide adequate notification (minimum **24 hours**) to the Superintendent of when any installation of testing equipment or any testing is being carried.

The results of the liner integrity survey shall be provided to the Superintendent for review prior to any repairs being undertaken.

The Contractor is to repair and test all identified leaks in the lining system. If the Superintendent deems that the area of aggregate removal and replacement is substantial and there is the likelihood that the liner could have been further damaged by the repair activity, the Superintendent may instruct that the area be retested for any further leaks.

The separation geotextile is only to be installed once the Superintendent has approved the completion of leak detection testing and all repairs have been carried out, including any retesting if necessary.

9.9.9 Repairs

9.9.9.1 General

All weld and non-weld areas of the geomembrane shall be visually inspected by the Installer for signs of damage, defective welds, blisters, punctures, undispersed raw materials, and any sign of contamination by foreign matter. Any defective or flawed areas observed shall be marked, repaired, tested, or removed from the installation and disposed of. Unless otherwise approved by the GITA, 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 method of sealing shall be agreed between the Installer and the GITA.

All repairs shall be subjected to quality testing either non-destructively or destructively as directed by the GITA.

The repair procedures shall be in accordance with the Quality Control Procedures Manual. The minimum repair methods are described in this Specification.

Any repairs (patches, caps, etc.) may, at the discretion of the GITA, be destructively tested. Where in the opinion of the GITA a liner panel requires an unacceptably high number of patches, the panel shall be removed and replaced. As a guide, a patch density within the panel, excluding patches for joints, and destructive test samples, of more than one per 50 m length of panel is considered the maximum. This may be varied at the discretion of the GITA depending on the layout of panels.

All cuts made in the geomembrane shall be ended in a round eye, and any cut-out shall be formed with rounded corners to prevent stress concentrations in the geomembrane.

9.9.9.2 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.

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 GITA. 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. 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 **one 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.

9.9.9.3 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 GITA 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 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.

Where a length of dual-track fusion weld that is less than 10 m is not holding air when tested, non-destructively by the air pressure testing method, the weld may be repaired by bevelling the edge, 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 and be vacuum box tested. If the length of the weld exceeds 10 m, and 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.

9.9.9.4 Grinding and Welding

Grinding and extrusion welding may be used to repair sections of defective extrusion weld less than 0.3 m in length if approved by the GITA. Areas requiring repair shall be abraded no more than **one hour** prior to the repair being made.

9.9.9.5 Geomembrane Wrinkles and Bridging

Geomembrane wrinkle and bridge size and extent shall be minimised to the satisfaction of the GITA. 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 50 mm high shall be cut and fusion 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.

9.10 Unit 11 – Cushion Geotextile and Unit 12 – Separation Geotextile

9.10.1 Transportation and Storage

Geotextiles shall be supplied in rolls wrapped in protective dust-proof covers and marked or tagged with all of the following information:

- Manufacturer's name.
- Product identification.
- Lot number.
- Roll number.
- Roll dimensions.

Transportation of the geotextile to the site and all handling on site will be the responsibility of the Contractor(s).

Rolls of Geotextile shall be stored off the ground on hard, dry, free-draining surface, with suitable bearers at closely spaced centres, suitably protected from run-off and other factors that may cause damage. Geotextile shall be completely covered at all times with a tarpaulin or other UV stable cover to protect the geotextile from UV exposure. Materials shall not be stored more than two rolls high.

Materials which are damaged during storage and transportation shall be rejected by the Superintendent and are to be removed, disposed of and replaced at the Contractor(s)'s expense.

9.10.2 Installation

9.10.2.1 Handling and Placement

The Contractor(s) shall handle all geotextiles in such a manner as to ensure they are not damaged in any way, and shall comply with the following:

- On slopes, the geotextiles shall be secured and then rolled down the slope in such a manner as to continually keep the uniform tension within the material to preclude folds and wrinkles.
- Geotextiles shall be cut using an approved cutting method and approved equipment only.
- During placement, care shall be taken not to entrap soil, stones, excessive dust, or moisture that could damage the geotextiles, generate clogging of the geotextiles or hamper subsequent seaming or joining.
- 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.
- Seams and overlaps are to be in accordance with these Specifications for each material type.
- If white geotextile is used, precautions shall be taken to avoid "snow-blindness" of personnel.

9.10.2.2 Seams and Overlaps

Geotextile shall be joined according to the following requirements:

- Areas to be joined shall be clean and free of foreign matter.
- No cross-slope (horizontal) joints shall be allowed in the geosynthetics on the slopes. Where cross-slope joints are proposed for other geosynthetics, the Contractor(s) shall indicate to the Superintendent where these are proposed and measures proposed to ensure the integrity of the layer.
- Panels shall be secured together by stitching or heat bonding as per manufacturer requirements. Geosynthetic joints shall be overlapped by 200 mm and be heat bonded with a welder specifically designed for geotextile seaming.
- Overlap in roof tile effect down slopes and in the direction of flow in drains and trenches.
- Any blow holes or damage caused by the heat bonding shall be patched by using the same material (refer to Section 9.10.4).

9.10.3 Repairs

Material damaged during storage and handling may be rejected by the Superintendent, in which case it shall be removed from site and replaced at the Contractor(s)'s expense.

Any holes or tears in the geotextile shall be repaired using the same material as follows:

- Soil or other material that may have penetrated the torn geosynthetic shall first be removed.
- On slopes, a patch made from the same geosynthetic, shall be heat bonded into place (with at least 200 m overlap to any edge). Should any tear exceed 10% of the width of the roll, that portion of the panel on the slope shall be removed from the Works and replaced.

- Elsewhere, a patch made from the same geosynthetic shall be seamed in place with a minimum of 300 mm overlap in all directions.

9.10.4 Materials in Contact with Geotextiles

The Contractor(s) shall place all materials located on top of a geotextile layer in such a manner as to ensure that the following conditions are satisfied:

- No damage to the geotextile.
- No slippage of the geotextile on underlying layers.
- Geotextile shall not be tensioned by the installation procedure.
- When Unit 12 – Separation Geotextile is to be placed over the Unit 8 – Leachate Drainage Aggregate, it shall be installed once the Superintendent has approved the completion of leak detection testing and all repairs have been carried out, including any retesting if necessary.

10.0 PLACEMENT OF PERMANENT BALLAST

The permanent ballast arrangement in the Leachate and Retention Ponds shall be constructed on site and shall comprise:

a) Unit 10.2 – Smooth HDPE geomembrane fusion welded to form a tube to fit around a 110 mm diameter HDPE pipe.

b) The ballast shall be placed at 10 m centres along the pond floor, or as requested by the Superintendent.

11.0 INSTALLATION OF LEACHATE COLLECTION SYSTEM

11.1 General

The Contractor(s) shall construct the leachate collection system (LCS) in accordance with the Drawings and as given below. As the leachate collection system will likely be constructed in sections, the Contractor(s) shall appropriately cap all temporary leachate pipe terminations to allow future connection. The leachate collection system for Cell 1 includes the following materials:

- Leachate Collection Pipes:
  - Unit 13.1 – Perforated Header Pipe.
  - Unit 13.2 – Perforated Collection Pipe.
  - Unit 13.3 – Solid Header Pipe.
  - Unit 8 – Leachate Drainage Aggregate.
- Leachate collection sump:
  - Unit 14.1 – Reinforced Concrete Slab.
  - Unit 14.2 – LCS Outlet Sleeves.
  - Unit 14.3 – Transducer Riser Pipe.
  - Unit 8 – Leachate Drainage Aggregate.

11.2 Installation of Leachate Collection Pipes

a) The Unit 13.1 – Perforated Header Pipe and Unit 13.2 – Perforated Collection Pipe shall be drilled in, at the Pipe Installer's factory and all waste material removed from inside the pipe before installation.

b) The orientation of the holes shall be maintained during installation as far as practical at as shown on the Drawings. Care shall be taken when welding together to maintain the orientation of the holes in the pipeline.

c) All the excess material from drilling and welding the pipes shall be removed prior to welding the pipes together on site.

d) The ends of all pipes shall be capped during the Works to inhibit the ingress of foreign materials.

e) All leachate collection pipes shall be welded next to the cell ready to be rolled or pulled into place by hand and winch. The leachate pipes shall not be welded *in situ*.

f) Pipes shall be joined by full face fusion welding, coupling welding techniques or other joining techniques as approved by the Superintendent. No filter sock shall be used.

g) The leachate collection pipes shall be placed and aligned in accordance with the Drawings. Minor adjustments to the alignment of the pipes are permitted to facilitate the use of standard angled bends and junctions.

h) The Contractor shall propose a Work Method Statement for installing the welded Leachate Collection Pipes onto the Unit 11 – Cushion Geotextile. This constitutes a **Hold Point**.

i) The Work Method Statement shall include a joining method for consideration and approval by the Superintendent for the joins of the cross pipes. The cross pipes shall be welded taking consideration of the likely thermal movement of the leachate pipes in the long direction of the cell.

j) The ends of Unit 13.3 – Solid Header Pipe shall remain capped until construction of Cells 3 and 4.

k) Placement of leachate collection pipes constitutes an **Inspection Point** and the Contractor(s) is required to provide **24 hours**' notice before commencing or recommencing this activity.

l) Following placement of each portion of leachate collection piping, and prior to covering the pipes with Unit 8 – Leachate Drainage Aggregate the Contractor shall survey all pipe alignments

11.3 Placement of Unit 8 – Leachate Drainage Aggregate

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 place Unit 8 – Leachate Drainage Aggregate over Unit 11 – Cushion Geotextile to form a continuous leachate drainage blanket across the floor of Cell 1, extending up the side slopes to a maximum vertical height of 2 m. The blanket is intended to promote drainage of leachate to the leachate collection pipes and sump.

The Contractor shall prepare a Work Method Statement for handling and placement of Unit 8 – Leachate Drainage Aggregate. The Work Method Statement shall consider installation of and protection of the geosynthetic materials as well as fines generation in the Unit 8 – Leachate Drainage Aggregate. This constitutes a **Hold Point**.

No transport or placement of the Unit 8 – Leachate Drainage Aggregate shall be carried out until the **Hold Point** has been released by the Superintendent. The Work method statement must address the following requirements:

a) Protection of the integrity of the underlying materials including the cushion geotextile, HDPE geomembrane, GCL and leachate collection pipes.

b) Considerations and limitations on access over areas underlain by geosynthetic materials and pipes.

c) 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.

d) 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.

e) Potential inclusion of non-conforming materials during the loading of the aggregate at the source or stockpile.

f) Consideration of on-site screening prior to placement to manage the risk of non-conforming particle size distribution.

g) 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.

h) Vehicles are not permitted to traffic on the surface of Unit 11 – Cushion Geotextile or Unit 10 – HDPE Geomembrane. The aggregate shall be placed by trucking the material over previously placed aggregate and unloading on the previously placed material.

i) The aggregate shall be no less than 0.75 m thick where wheeled vehicles are to traverse the aggregate. 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. The installation methodology shall prevent significant rutting and disturbance of the aggregate by vehicles.

j) Spreading of the aggregate to the required 300 mm thick layer shall be carried out with low ground bearing pressure equipment. Unless otherwise agreed, the maximum permitted machinery ground pressure for drainage layer placement shall be 40kPa 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.

k) The drainage aggregate shall also be placed around the leachate collection pipes as shown on the 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 8 – Leachate Drainage Aggregate 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.

l) 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.

m) 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 material requirements, as per Section 2.8.

n) 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.

o) Spreading of gravel shall be carried out to prevent stretching, tearing, distortion or other damage to the cushion geotextile and geomembrane.

p) 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.

q) 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.

r) The GITA 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 and an acceptable liner integrity survey, Unit 12 – Separation Geotextile shall be placed and secured over the drainage layer. Unit 12 – Separation Geotextile shall be installed in the same manner as outlined in Section 9.10.2 of this Specification. Placement of Unit 12 – Separation Geotextile constitutes an **Inspection Point** and the Contractor is required to provide 24 hours' notice before commencing or recommencing this activity.

Following Unit 8 – Leachate Drainage Aggregate and Unit 12 – Separation Geotextile placement, the Contractor shall survey the finished surface level to demonstrate that the drainage layer design thickness has been achieved and that the constructed leachate sump geometry is in accordance with the design. The survey shall be conducted on an approximate 10 m grid with detailed survey of the sump.

11.4 Construction of Leachate Collection Sump (LCS)

a) The Contractor(s) shall provide a Work Method Statement for the installation of the leachate sump to the Superintendent for approval. This constitutes a **Hold Point**.

b) The leachate sump shall be excavated and constructed in accordance with the Drawings and Section 6.3 of this Specification.

c) The geosynthetic lining system shall be installed in the sump, as per the Drawings and in accordance with Section 9.0 of this Specification, prior to the construction of Unit 14.1 – Reinforced Concrete Slab.

d) Construction of Unit 14.1 – Reinforced Concrete Slab constitutes an **Inspection Point** and the Contractor(s) shall give **24 hours** before commencing or recommencing this activity. Inspection of the completed Unit 14.1 – Reinforced Concrete Slab by the Superintendent shall constitute an **Inspection Point**.

e) Unit 14.2 – Leachate Sump Outlet Sleeves and Unit 14.3 – Transducer Riser Pipe shall be connected to the leachate sump at the Unit 14.1 – Reinforced Concrete Slab structure, as shown in the Drawings.

f) Unit 14.2 – Leachate Sump Outlet Sleeves and Unit 14.3 – Transducer Riser Pipe constitutes an **Inspection Point** and the Contractor(s) shall give **24 hours'** notice before commencing or recommencing this activity.

g) The Unit 14.2 – Leachate Sump Outlet Sleeves and Unit 14.3 – Transducer Riser Pipe shall be secured at the embankment crest with an anchor cradle, as per the Drawings.

h) The backfilling of the sump with Unit 8 – Leachate Drainage Aggregate shall be in accordance with the Drawings and Section 11.4.

12.0 PLACEMENT OF UNIT 17 – LINER PROTECTION

The placement of the Unit 17 – Liner Protection on the embankment slopes of Cell 1 to a depth of 300 mm, as per the Drawings shall be performed by the Operator. The placement of Unit 17 – Liner Protection above Unit 11 – Cushion Geotextile shall be performed in a manner that does not cause damage to any of the Works.

The Operator's operational plan must address the following requirements:

a) Protection of the integrity of the underlying cushion geotextile and HDPE geomembrane. The Operator shall manage the risk of creases or wrinkles in the works by limiting the placement of the material to times when wrinkling is limited (i.e. early morning or at night).

b) Considerations and limitations on access over areas underlain by geosynthetic materials.

c) Vehicles are not permitted to traffic on the surface of Unit 10 – HDPE Geomembrane or Unit 11 – Cushion Geotextile. The Unit 17 – Liner Protection shall be placed by trucking the material over previously placed Unit 8 – Leachate Drainage Aggregate or waste.

d) The method of working shall comprise end-tipping and spreading from previously placed Unit 8 – Leachate Drainage Aggregate or emplaced waste, or a method agreed with the Designer prior to work commencing.

e) Spreading of the Unit 17 – Liner Protection 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 protection placement shall be 13 tonnes 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.

f) 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 material requirements, as per Section 2.18.

g) The placement shall be carried out so that trapped air under the geomembrane is directed to vent flaps at the edge of the works to prevent permanent wrinkles in the Works and so that wrinkles in the geomembrane do not form creases or similar.

h) 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.

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

j) The GITA shall assess the thickness of the placed Unit 17 – Liner Protection by visual assessments and spot checks if considered appropriate by the Superintendent.

Report Signature Page

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