



Technical Specification

North Bannister Resource Recovery Park – Cell 7 Lining Works



Prepared for Veolia Recycling and Recovery (Perth) Pty Ltd

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1 Introduction

The work under this Technical Specification consists of minor earthworks, installation of the composite geosynthetic lining system and leachate collection system for Cell 7 at the North Bannister Resource Recovery Park (NBRRP), located 6364 Albany Highway, North Bannister, Western Australia (WA) (the Site) for Veolia Recycling and Recovery (Perth) Pty Ltd (Veolia/the Principal).

Talis Consultants Pty. Ltd. (Talis) has been engaged by Veolia to design Cell 7, produce the associated tender documentation which includes this Specification and Drawings, and assist with seeking the relevant approvals for development from the Department of Water and Environmental Regulation (DWER). The construction works will be split into two phases, the advance Bulk Earthworks (the Works) and the Lining and Leachate Management Works (the Lining Works), the latter commencing following DWER approval.

This document forms part of the Contract Documents with the full list described in Section 1.5.

1.1 Site Description

Currently, the facility comprises six cells (Cell 1 to Cell 6) with a further seven more cells being proposed. The Site is licenced to accept up to 400,000 tonnes of Class III putrescible waste and 100,000 tonnes of organic waste per year (including up to 30,000 tonnes of biosolids). The compost manufacturing and soil blending facility handles solid green waste, food processing waste and biosolids.

1.2 Location

The NBRRP site (the Site) is located approximately 94km south south-east of Perth along Albany Highway. The Site is a Prescribed Premise under Schedule 1 of the Environmental Regulations 1987 and operates in accordance with Licence No. L8871/2014/1 (the Licence) issued under Part V of the Environmental Protection Act 1986 (the Act).

Construction of Cell 7 is required for ongoing operations at NBRRP. Cell 7 is located within the Phase 2 footprint area of NBRRP, upgradient of Cells 1 to 5.

1.3 Geology

The Pinjarra Map indicates the following geology should be present at the site:

- Colluvium, including valley-fill deposits, variably laterized and podsolised;
- Laterite – chiefly massive (averaging 4m thick) with upper portions potentially consisting of locally uncemented pisolitic gravel and lateritized soil; and
- Even-grained granitic rocks, fine to coarse-grained granodiorite, adamellite and granite.

1.4 Scope of Works

This Specification has been developed for the installation of the geosynthetic lining and leachate collection system for the development of Cell 7. The Works comprise the following:

- Earthworks to form the required subgrade levels and geometry on the base and side slopes of the cell comprising;
 - Excavation to 250mm below finished surface level on the base of the cell and proof roll surface;
 - Ripping, moisture conditioning and recompacting, as necessary, the lower 250mm thick layer of in-situ soils on the base of the cell;
 - Placement and compaction of Engineered Fill on the base of the cell up to and including the lower 250mm layer of Engineered Fill; and
 - Placement and compaction of upper 250mm thick layer of Engineered Fill on the base of the cell;
 - Placement and compaction of 500mm thick Engineered Fill on the side slopes of the cell; and
 - Placement and compaction of Engineered Fill to construct the southern side slope of the cell.
 - Preparation of the subgrade surface for installation of the geosynthetic lining system.
- Supply and installation of the composite geosynthetic lining system;
 - Type 1 Geosynthetic Clay Liner (GCL) on the base of the cell;
 - Type 2 Geosynthetic Clay Liner (GCL) on the side slopes of the cell;
 - 2mm High Density Polyethylene (HDPE) Double Textured Geomembrane;
 - Protection Geotextile;
 - Leachate Collection Layer – 300mm highly permeable low calcareous aggregate; and
 - Separation geotextile.
- Supply and installation of leachate collection pipework and fittings comprising:
 - DN 225mm HDPE perforated primary pipework; and
 - DN 160mm HDPE perforated secondary pipework.
- Electrical Leak Detection Survey.

1.5 Tender Documentation

The following Scope of Works, reports and contracts form the Tender Documentation for this Project:

- This Specification;
- Bill of Quantities;
- Drawings;
- Request for Tender;
- Construction Quality Assurance Plan; and
- Conditions of Contract.

1.6 Drawings

The following Drawings form part of the Tender Documentation.

Table 1-1: List of Drawings

Drawing Number	Drawing Title
W-100	Site Layout
W-102	Bulk Earthworks, Road and Drainage Layout
W-104	Lining Subgrade Isopachyte
W-105	Indicative GCL Panel Layout
W-106	Leachate Collection Layout
W-201	Landfill Sections 1 of 2
W-202	Landfill Sections 2 of 2
W-302	Landfill Standard Details

1.7 Interpretation

Whether or not the words ‘provide,’ ‘install’ and/or ‘supply’ appear in the Specification, all equipment for the complete installation shall be provided and installed by the Contractor. Where equipment is to be provided and installed by others, it will be stated.

Terms in use within this Specification are clarified as follows:

- ‘The Principal’ for the Works will be Veolia Recycling and Recovery (Perth) Pty Ltd. (Veolia);
- ‘The Contractor’ shall mean the future company contracted by the Principal to execute and complete the project;
- ‘The Superintendent’ for the Works will be Veolia or their appointed representative;
- ‘Approved’, ‘directed’, ‘required’, ‘rejected’, and similar expressions, shall mean approved, directed, required, rejected, and the like, by the Superintendent;
- ‘Provide’ shall mean the supply and complete installation of the item to the satisfaction of this Specification;
- ‘Supply’ shall mean supply and delivery without installation;
- ‘Install’ shall mean complete installation of the item to the satisfaction of this Specification excluding supply;
- Manufacturer’s Specifications – applied as directed by the Manufacturer by an experienced person with the nominated product; and
- ‘Give notice’, ‘submit’, ‘furnish’, and similar expressions, shall mean given notice, submit, furnish, and the like, to the Superintendent.

2 General

2.1 Compliance with the DWER Licence and Works Approval

Operations at the Site are governed by Licence No. L8871/2014/1 under Part V of the *Environmental Protection Act 1986 (WA)*. A copy of the Licence may be viewed on the Department of Water and Environmental Regulation (DWER) website (www.der.wa.gov.au).

The Contractor shall comply with the relevant conditions of the Licence/Works Approval and any subsequent conditions issued by the DWER as part of the Licencing process during the contract.

2.2 Quality Management

2.2.1 Quality Plan

For all works the Contractor shall plan, develop, document and implement a Quality System based on the principles and practices specified in the AS/NZS ISO 9000 series.

Details of the Contractor's proposed Quality Assurance Plan shall be submitted to the Superintendent for approval within seven (7) days from the Date of Acceptance of Tender. Any delay by the Contractor in obtaining the approval of the Quality Plan by the Superintendent shall be at the Contractor's expense and the Contractor shall not be entitled to any extension of time for the Contract due to such delay unless the Superintendent has taken more than seven (7) days to reply to the Contractor's submission.

Works shall not commence until the Superintendent has approved in writing the Contractor's Quality Plan.

2.2.2 Quality Plan Requirements

The Contractor's Quality Assurance Plan shall incorporate:

- Such measures as are necessary to trace each product or service from receipt through to construction;
- Quality assurance and quality control procedures covering all material supply, manufacture and construction carried out by the Contractor and any of its Sub-Contractors;
- Quality control tests and inspections shall include, but not be limited to, the following:
 - The tests and inspections required in accordance with this Specification. The frequency of such tests and inspections shall not be less than the requirements set out in this Specification; and
 - Such tests as are necessary to demonstrate that materials and equipment comply with the requirements of this Specification.

Whenever practicable, the Contractor shall carry out material testing such that the results are available for review by the Superintendent prior to the materials being incorporated into the works. However, should the Contractor proceed in completing any of the works with materials or services

which do not comply with the Quality Plan, then the Contractor shall bear the cost of remediating or replacing any non-compliant work.

The Contractor's traceability procedures shall include, but not be limited to, a means of identifying in the works, and the location of all materials represented by a sample which has undergone a quality test.

2.2.3 Quality Plan Contents

The Quality Plan shall include, but not be limited to the following:

- Inspection and test plans for all materials and construction work;
- Items that require approval of the Superintendent before proceeding;
- Non-conformance identification and action procedures;
- Details of quality personnel and relationship to the company; and
- Safety procedures and checklists.

2.2.4 Construction Quality Assurance (CQA) Plan

The supply, storage and placement of geosynthetics shall be carried out following the below order of precedence:

- The Technical Specification & Construction Quality Assurance (CQA) Plan; and
- Manufacturer's Instructions.

2.3 Programme of Works

The Contractor shall provide a Programme of Works in accordance with the following requirements:

- The Contractor must submit a detailed Construction Programme to the Superintendent for acceptance within seven (7) days of the Date of Acceptance of Tender.
- The Construction Programme must:
 - Be submitted in accordance with the details outlined below; and
 - Comply with the Date of Practical Completion set out in Annexure A to the General Conditions of Contract.

If the Superintendent considers that the Construction Programme submitted does not show sufficient details or does not conform to the requirements of the Contract, then the Superintendent may direct by written notice, the Contractor to amend the programme. Such amendments shall be provided within seven (7) days of issuing the written notice.

The Construction Programme submitted, and any subsequent amendments thereto submitted by the Contractor shall, when accepted by the Superintendent, be termed the Construction Programme.

Details to be shown on the Construction Programme shall include, but not be limited to:

- Details of the proposed order of work and the planned dates of completion of the various parts of the works;
- Placing of orders by both the Contractor and Sub-Contractors;
- Hold points at listed in Section 2.6;
- Tests and inspections; and
- Dates of site testing and commissioning.

The Contractor must provide an updated Programme whenever directed by the Superintendent. At intervals determined by the Superintendent, but not exceeding 28 days, the Contractor and the Superintendent together, shall review the actual progress of the works in comparison with the Construction Programme. If in the opinion of the Superintendent, this review shows that the Contractor will not complete the works by the Date of Practical Completion, the Contractor shall within seven (7) days, amend the Construction Programme so that it complies with the date of Practical Completion stated in Annexure A to General Conditions of Contract and resubmit it to the Superintendent for acceptance.

The Contractor shall not commence works on-site until the Construction Programme has been agreed by the Superintendent. Failure to provide the programme or sufficient detail contained thereon shall not relieve the Contractor of the responsibility for completing the project by the date stated in the Conditions of Contract.

The rates submitted by the Contractor should allow for completing the project in the timeframe set out above.

As much of the work is weather dependent, the Contractor shall make due allowance when resourcing the works to accommodate bad weather by accelerating output if necessary to achieve the deadline.

2.4 Hours of Operation of the Site

The Site is operational by the Principal between the hours of 7.00am and 4.00pm Monday to Friday, 8.00am and 4.00pm on Saturday, and 10.00am and 4.00pm on Sunday, excluding Good Friday, Christmas Day and New Year's Day when the Site is closed.

The normal working hours for this Contract shall be 7:00am to 5:00pm, unless specified elsewhere in the contract documents. Exceptionally, the Principal's consent for work outside these hours may be given after any necessary application and consultation with the appropriate authorities. Five working days' notice is required from the Contractor when seeking such consent.

Should the Contractor wish to undertake work outside these hours to perform works that are subject to weather conditions e.g. Installation of Basal Liner/tie-in welds, all night work will require portable lighting. All health and safety controls and costs that are incurred by the Contractor, performing work outside of normal hours shall be deemed to be included in tendered rates.

The Contractor shall employ the best practical means to minimise noise produced by the Contractor's operations including plant maintenance and shall comply with the recommendations in AS 2436.

2.5 Time for Completion

With the Tender, a realistic time for completion shall be submitted, in accordance with the practical completion date documented in Item 7 Annexure Part A of the Conditions of Contract. This time shall include for all annual holidays, public holidays and weather constraints. This realistic time will be presented in the programme of works as described in Section 2.3.

2.6 Hold Points

The critical hold points for completed works that require the CQA Consultant to check and sign off before any subsequent works may commence are listed in Table 2-1.

Table 2-1: Project Hold Points

Hold Point No.	Item	Description
1	Approval of pre-commencement survey	Section 2.10.1
2	Approval of Traffic Management Plan*	Section 2.14
3	Approval of Engineered Fill Layer Field Trial	Section 5.1.2.1
4	Approval of Engineered Fill Layer Testing	Section 5.2
5	Approval of Top of Engineered Fill Layer Levels Survey	Section 2.10.3 and 5.4
6	Approval of Engineered Fill (Subgrade) Surface	Section 6.4.1
7	Approval of GCL Conformance Testing	Section 6.5.1
8	Approval of GCL Installation	Section 6.5.2
9	Approval of HDPE Conformance Testing	Section 6.6.1
10	Approval of HDPE Non-destructive Testing	Section 6.6.4.1
11	Approval of HDPE Destructive Testing	Section 6.6.4.2
12	Approval of Geomembrane Ballasting	Section 6.6.5
13	Approval of Protection Geotextile/ Leachate Drainage Stone Performance Testing	Section 6.7
14	Approval of Protection Geotextile Conformance Testing	Section 6.7.1
15	Approval of Protection Geotextile Installation	Section 6.7.2
16	Approval of anchor trench backfilling and compaction	Section 6.9.1.2
17	Approval of the Leachate Drainage Aggregate Laboratory Testing	Section 7.3
17	Approval of Leachate Collection Layer Installation Thickness by Survey	Section 2.10.3 and 7.1

Hold Point No.	Item	Description
19	Approval Of Leachate Collection Pipework Deflection Calculations	Section 8.1.1
20	Approval of Leak Detection Testing	Section 9
21	Approval of Separation Geotextile Conformance Testing	Section 6.8.1
22	Approval of Separation Geotextile installation	Section 6.8.2

Note: * For sign-off by the Superintendent

2.7 Site Meetings

The Contractor and any Sub-Contractors that the Contractor deems necessary shall attend a Preliminary Site meeting with the Superintendent and/or the Principal. The meeting will include, but not be limited to, a walk-over of the Site and an opportunity for the meeting attendees to discuss any outstanding issues relating to the works.

The Contractor shall attend Site Meetings when requested by the Superintendent or Principal for the proper management and supervision of the contract works. The tendered price shall allow for weekly attendance on-site by the Contractor and/or Sub-Contractors (Domestic or Nominated). Regular fortnightly meetings shall be called to discuss, but not be limited to:

- Information flow;
- Occupational Health & Safety;
- Co-ordination;
- Resources;
- Progress;
- Quality;
- Procurement; and
- Costs.

The Superintendent shall minute the meetings and distribute the minutes within two working days of the meeting ending. The minutes will include all items discussed and in particular actionable items discussed and the person responsible for closing out that item with the due date.

2.8 Safe Work Method Statements

Safe Work Method Statements (SWMS) are required for all major works to include, but not be limited to, the Scope of Works outlined in Section 1.4. The Contractor shall submit relevant SWMS to the Superintendent prior to the works commencing that at a minimum shall address the following:

- Describes how the work is carried out;
- Identifies the work activities assessed as having safety or environmental risks;
- States what the safety and environmental risks are;

- Describes the control measures that will be applied to the work activities to minimise risks to the environment and ensure safety of the Contractor personnel and other personnel;
- Describes how measures will be implemented to do the work in a safe and environmentally sound manner;
- Outlines the legislation, standards and codes to be complied with; and
- Includes a description of the equipment used in the work, the qualifications of the personnel doing the work and the training required to do the work in a safe and environmentally sound manner.

The cost of providing the method statements is to be included in the rates associated with the aspects of the work the method statement relates. If the Superintendent considers that the SWMS submitted does not show sufficient details, is impracticable or does not conform to the requirements set out above, the Superintendent may direct the Contractor to amend and resubmit the SWMS.

The Superintendent's acceptance or non-acceptance of the submitted SWMS does not remove the liability for the works from the Contractor.

2.9 Use of Sub-Contractors

Before commencement of the works, the Contractor shall give full particulars of the Sub-Contractors, if any, it proposes to use for items of work under the Contract. Sub-Contractors shall not be used for any portion of the works without the prior written approval of the Superintendent.

Sub-Contractors shall be skilled in their respective trades and shall provide Certificates of Competency for each employee.

The Sub-Contractors are to provide SWMS for their work prior to commencing on-site as outlined in Section 2.8. The main Contractor is to provide a SWMS pertaining to the Contractor's responsibilities for the Sub-Contractor. The Contractor's SWMS shall also highlight where assistance shall be provided to the Sub-Contractor.

2.10 Drawings and Schedules

The Contractor shall be responsible for checking all Drawings prior to the commencement of the works. If the Contractor discovers any discrepancies between the various Contract Documents or if the Contractor considers that additional Drawings or information are required, then in either case the Contractor shall report such inconsistency to the Superintendent for instruction or apply in writing for such detail drawings or information at least 28 days before the work concerned is to be initiated. This four-week time period shall allow the Superintendent to provide any additional information that may be required.

The Contractor shall not be entitled to claim for any additional cost during this four-week period as a result of delays or other increased expenditure which it may incur by not advising the Superintendent in a timely fashion of any discrepancy or query in the information provided.

The Contractor shall be responsible for the preparation of manhole, chamber, ducting, drainage and finishing schedules, from the contract Drawings, as it deems necessary for the satisfactory completion of the works. These may be requested by the Superintendent for approval.

2.10.1 Setting out the Works

The Contractor shall be responsible for setting out the works. The Contractor shall be supplied with electronic information, in the form of digital terrain model (DTM), with which to establish the lines and levels of the works.

The Contractor shall perform a pre-commencement check survey to satisfy itself that the site conditions at the site handover have not changed since the design documentation was produced. This constitutes a Hold Point.

The Map Grid of Australia Zone 50, using GDA94 shall be used for the setting out of the works.

The Contractor shall provide all necessary hardware and software on-site, a drawing package compatible with AutoCAD, electronic surveying equipment and suitably qualified staff, which will enable it to determine setting out co-ordinates at locations deemed necessary.

All control points and reference points shall be clearly marked and where appropriate bedded in concrete. They shall be adequately protected during the construction of the works. Where it is necessary to remove a control point, additional reference points shall be provided to the satisfaction of the Superintendent.

Prior to commencing construction, the Contractor shall check all centre lines, prominent footprints and grid lines in sufficient detail to ensure that the work is fully compatible with existing features.

Where design conflicts are identified or the required levels, grades, alignments, or geometry cannot be achieved for reasons beyond the Contractor's control, the Contractor must bring this to the attention of the Designer prior to commencement of the Works. The Contractor must not modify or adjust the 3D models without prior written consent from the Designer. Check surveys for comparison against the tolerances described in Section 5.4 must be based on the original DTM unless otherwise approved in writing by the Designer.

The setting out of the works shall be perfectly co-ordinated with and shall be continuous with that of any adjacent works. The Contractor shall, when instructed by the Superintendent, make any adjustments necessary to satisfy these requirements. Where appropriate, reference points shall be adjusted to take account of the new locations of the master control points.

Subsequently, the Contractor shall be fully responsible for the setting out of the works and the Superintendent accepts no responsibility for replacing any of the master control points or master levels where given. The Superintendent's acceptance or non-acceptance of the setting-out does not remove the liability for the works from the Contractor.

2.10.2 Working and Fabrication Drawings

Whenever required by the Superintendent, the Contractor shall supply calculations, test reports, data sheets, etc., in support of its detailed working and fabrication drawings. Such documents shall remain the property of the Superintendent.

The Contractor shall submit three copies of all relevant documents to the Superintendent at least four weeks in advance of the date on which the Contractor proposes to commence such works.

Drawings shall be to an appropriate scale and in sufficient detail to enable the Superintendent to assess the Contractor's proposals.

2.10.3 As-Built Drawings

The Contractor shall supply as-built records, Drawings, details and surveys etc. of all completed work. These records are to be submitted in full to the Superintendent within seven days of practical completion of the works in AutoCAD and PDF electronic formats.

Notwithstanding the above timescale, the Contractor shall note that certain as-built drawings are required to accompany the CQA report as specified elsewhere in this document. The Contractor shall note that the main contract works may only be offered for handover to the Principal upon approval of validation report.

The following is a list of minimum criteria to be adhered to when creating the as-built drawings:

- Line types and colours shall be set 'By Layer';
- Layer names should not be abbreviated, and must be self-explanatory;
- All break lines to identify toes and crests of earthwork slopes;
- Units shall be in metres;
- Levels to Australian Height Datum (AHD); and
- Common Site layouts such as surveys, as-built buildings and road layouts shall be externally referenced to all relevant drawings (insert 0, 0, 0 (X, Y, Z) and to Map Grid of Australia Zone 50, using GDA94).

The as-built drawings must detail the following:

- Top of Engineered Fill Layer levels. This constitutes as a **Hold Point**;
- Construction details including levels and slope angles for the basal liner system;
- Location of leachate collection and extraction pipework including connections of primary pipework to secondary pipework;
- Top of Leachate Drainage aggregate collection layer levels including mounding of material over pipework (top of bank and bottom of bank each side of mound). This constitutes a **Hold Point**;
- Location and inverts of leachate collection pipework;
- Locations and identification marks of each geosynthetic panel, including anchor trenches;
- Locations of damaged areas and penetrations; and
- Locations of patch repairs.

2.11 Document Management

In the performance of the Services, the Contractor shall prepare a wide variety of documentation and information ("Records").

- The Contractor shall ensure proper storage, management and maintenance of the information and store these Records;
- The Contractor will maintain a record keeping system that meets the minimum compliance requirements of State Records Commission Standard 1 “Government Record Keeping”, to the satisfaction of the Principal; and
- The Contractor must not dispose of any records created or collected by the Contractor in the performance of the Services/works without authorisation of the Principal.

2.12 Surface Water and Groundwater Management

Where not included in the permanent works, the Contractor shall make allowances in the Contractor’s system of working and pricing for dewatering both surface and subsurface water if required and permitted.

The Contractor shall sequence the works to minimise the build-up of surface water within and outside the Site as a result of its actions and allow for all arrangements for evaporation on-site. Where it is necessary and permitted to discharge water or groundwater, the Contractor shall not cause overtopping and erosion of any part of the downstream surface water network. In any case, measures shall be implemented to prevent silt entering the offsite surface water network.

Where the sequence or method of work is such that there is a build-up of water within or outside the Site Boundary, the Contractor shall be liable for the expense of dewatering, control and, if necessary, remediation to the infrastructure.

Unless permitted, the build-up of any surface water may not be discharged to the groundwater regime.

2.13 Site Boundary

The Site Boundary shall be as identified on the Drawings.

Should other Contractors, Principal’s personnel, and/or members of the public be operating on-site during this contract, all elements of the works shall be arranged such as to minimise contact. This may require adherence to new haulage routes and variations to the proposed phasing of the works as agreed with the Superintendent.

2.14 Traffic Requirements

2.14.1 General

The Contractor shall submit a Traffic Management Plan (TMP) for the works to the Superintendent for review at least 5 days prior to commencement of works. The Contractor shall implement and maintain the endorsed TMP during the works. The acceptance of the TMP constitutes a **Hold Point**.

The Contractor shall provide traffic signs and undertake any temporary works to comply with the requirements of the Contract. All signs and method of traffic control shall be generally in accordance with AS 1742 and to the express approval of The Local Authority Engineer or Main Roads Western

Australia (MRWA) as appropriate. A copy of the relevant standard method of signing will need to be obtained by the successful Contractor.

Should circumstances arise which are not adequately covered in this section, the Contractor shall submit alternative proposals to the Superintendent for review and approval prior to works proceeding.

The Contractor shall be liable for any accident, damage or injury to any person and/or any claim or litigation or other matters arising out of the works of this Contract.

2.14.2 Traffic Safety and Management – Internal Road Network

The Contractor shall acknowledge that the Site as a whole is open to the public, third party companies and the Principal's own staff and vehicles. This flow of traffic has priority over usage of the internal road network. In carrying the works, the Contractor shall not adversely impact the smooth traffic flows for other users. Where the Contractor, its Sub-Contractors and/or suppliers causes congestion or blockages, the Superintendent may require immediate removal of the offending vehicles, plant, equipment and/or supplies regardless of the consequences to the Contractor's operations.

The Superintendent will not entertain any claim for financial compensation or extension of time to the Contract as a result of the removal of the congestion or blockages.

Where the Contractor, Sub-Contractors and/or Suppliers has vehicles which crosses from non-metalled surfaces to asphalt roads, the Contractor shall ensure that no detritus, mud, litter or other contamination is transferred to the road network. Where the road network surrounding the Site becomes dirty or contaminated, the Superintendent shall require the Contractor to clean the surfacing.

The Contractor shall include cleaning the road surfacing in its pricing structure.

2.14.3 Traffic Safety and Management – External Road Network

All necessary traffic safety precautions shall be taken by the Contractor to ensure the safety of all traffic and pedestrians using the existing roads adjacent to the Site and connecting minor roads during the execution and completion of the works, and all precautions shall be taken to minimise disruption to the local residents.

The Contractor shall ensure that no item of plant, goods, vehicles and/or equipment (including stores or offices) shall be temporarily placed or parked on the public roadway or its verges in a manner which may result in danger to the personnel on the Site or members of the public, or which may restrict sight distances on all accesses to the Site or on public roads.

The Contractor shall ensure that no plant, equipment, goods and/or vehicles shall be parked overnight on the public roads adjacent to the Site.

2.14.4 Cleaning and Damage to Roadways

All roads, accesses, drains, ditches and grips shall be kept clear of all dirt, mud and material arising from the execution and completion of the works and suitable clearing equipment and labour shall be provided by the Contractor for this purpose. Where this is likely, the Contractor shall install temporary wheelwash facilities and/or provide road cleaning equipment.

Particular attention shall be paid to the loading of trucks carrying bulk materials into the Site and spoil from the Site to ensure that these shall not be overloaded or loaded in such a way that spillage shall be unavoidable. Any dirt or mud adhering to the tyres or chassis of any vehicles shall be thoroughly cleaned off before the vehicle shall be permitted to leave the Site. In the case of delivery to the Site, vehicles shall be thoroughly cleaned before they leave the point of collection. The Contractor shall be equally responsible for the vehicles of their Sub-Contractors and Suppliers and the like.

Despite any measures and actions undertaken by the Contractor, should it not prove successful in clearing the roads in a timely manner, then the Superintendent will arrange for professional street cleaners to undertake the work. The cost of doing this shall be subtracted from the monthly or final valuations.

The Contractor shall take particular care to avoid damage to roads, footpaths, grass margins and other surfaces outside of the authorised Site and shall be liable for the cost of repairing all such damage caused by the Contractor's operations to the satisfaction of the Superintendent and the Principal. The Contractor shall also take precautions to prevent spillage of diesel fuel or solvents. Should a spillage arise from either the Contractor, its Sub-Contractors or Suppliers then it will promptly clear up the spillage and remediate any damage. Any such spillage shall be reported to the Superintendent immediately.

The Contractor shall have regard to the maximum legal permissible loads for public roads in WA and where requested by the Superintendent, shall provide evidence of compliance with regard to delivery of material to Site. The Contractor shall also prohibit the use of tracked plant on road surfaces outside of the Site unless suitably approved protective measures are taken to safeguard the integrity of the road surfaces. Pumping of water onto a public road or private property shall not be permitted. Heavy discharges to gullies and storm drains shall have silt traps incorporated in the temporary discharge arrangement. Any damage so caused shall be made good by the Contractor at its own expense.

The Contractor must satisfy the requirements of the Chain of Responsibility Legislation with respect to transportation of materials.

<https://www.mainroads.wa.gov.au/UsingRoads/HVS/Pages/chainofresponsibility.aspx>

2.15 Engineering Control

All verbal instructions given by the Superintendent/CQA Consultant shall be accompanied by a Confirmation of Verbal Instruction (CVI) prior to undertaking in writing or by email. Verbal instructions or verbal requests for information alone shall not be considered binding.

Technical Queries (TQs) from the Contractor to the Superintendent/CQA Consultant are to be issued electronically in a format to be agreed with the Superintendent.

2.16 Variations of Work

Where extra works are ordered, they shall be valued in accordance with the Rates in the Bill of Quantities, where they exist or otherwise in accordance with the Conditions of Contract. Where any additional works are not fully covered by the rates in the Bill of Quantities, the Superintendent will request a separate quotation for the work. Where approved, the Superintendent may commission these works using the Day Rates.

Such works shall not be carried out until a written order has been issued by the Superintendent, and if it is authorised to be carried out on a Time and Materials basis, the Contractor shall submit to the Superintendent weekly time and material sheets for checking and approval. Payment will not be made for work carried out in this manner unless previously authorised by the Superintendent.

The Superintendent reserves the right on the Principal's behalf to omit any part or parts of the Contract and claims for any loss of profit due to any omissions will not be entertained by the Superintendent unless further specified in the Conditions Contract.

2.17 Dayworks

The Contractor shall provide the following:

- 48 hours' notice in writing outlining why the existing rates in the documents are not sufficient to cover the works;
- Contractor to submit maximum working hours in a day;
- Dayworks shall be pre-approved by the Superintendent;
- Dayworks shall be signed off by Superintendent at the end of each day; and
- A list of dayworks rates for all personnel and plant that shall be used during the contract.

Should the personnel or plant change during the Contract, revised rates shall be agreed with the Superintendent before commencement of dayworks.

The Contractor shall give notice to the Superintendent of the commencement and completion of any work for which the Contractor intends to submit daywork records in accordance with the Conditions of Contract. The Contractor shall submit to the Superintendent at the end of each month an application for payment for all dayworks done in the preceding month.

The dayworks records to support applications for payment will include at a minimum the following:

- Description of work done;
- Operative's name and trade;
- Plant type, make and model;
- Rates and hours worked segregated into normal time; and
- Types and quantities of materials used.

2.18 Control of Environmental Issues

The Contractor shall, within 14 days of the Date of Acceptance of Tender, provide the Superintendent with an Environmental Management Plan (EMP), detailing how the Contractor will implement and maintain environmental management measures to comply with all requirements set out in Sections 2.18.1 to 2.18.8. This plan shall include the name of the relevant manager/supervisor with the primary responsibility for environmental matters and environment related communications.

The Contractor shall address the above commitments in the EMP, as well as the requirements set out in Sections 2.18.1 to 2.18.8 of this Specification.

2.18.1 Noise

The normal working hours within the Site shall be as detailed in Section 2.4 of this Specification. Exceptionally, the Superintendent's consent for work outside these hours may be given after any necessary consultation. Five working days' notice is required from the Contractor when seeking such consent. If complaints are received and justified, during work outside the normal hours the Principal reserves the right to require all construction works to be undertaken during the approved hours as per the Environmental Protection (Noise) Regulations 1997.

The Contractor shall employ the best practical means to minimise noise produced by the Contractor's operations, including plant maintenance, and shall comply with the recommendations in AS 2436.

2.18.2 Mud/Clay

The Contractor shall prevent any nuisance occurring through the discharge of dirt, water, fumes and the like on to persons or property.

The Contractor shall ensure that waste products of whatever description associated with the execution and completion of the works shall not enter watercourses, whether dry or not, which are adjacent to the Site.

2.18.3 Dust

Fine material encountered on the Site is susceptible to erosion by wind under normal wind conditions when the surface material is dry. The Contractor shall provide, use, maintain and keep available plant and equipment necessary to minimise the formation and accumulation of dust arising from the works, normally in dry weather conditions. The Contractor shall implement all measures necessary to minimise wind erosion and prevent material from the Site being blown over or onto property outside the Site or onto others on the Site. The measures shall include, but not be limited to:

- Frequent watering of areas disturbed by the Contractor;
- Not carrying out operations with dust-creating potential at a time of high winds; and
- Control of dust caused by the works.

The Contractor shall allow for any delay and effect on the Contract Programme caused by diverting manpower and equipment to control dust and windborne material.

The Contractor shall be responsible for the cost of controlling dust and windborne material generated by the immediate activities of plant, equipment and/or personnel.

If, during the actual construction of work, the suggested dust suppression measures are found to be insufficient, the responsibility for carrying out additional measures necessary to achieve the desired level of dust suppression rests totally with the Contractor. If this is not carried out in a timely manner, the Superintendent shall arrange for additional dust suppression, the cost of which shall be taken from the monthly or final account.

2.18.4 Contaminated Water and Sewage

The Contractor must, at its own cost, provide toilet and adequate wash facilities for its personnel and that of its Sub-Contractors. These facilities shall be connected to a storage tank, or other facility approved by the Superintendent, which shall have a minimum of 14 days storage capacity and shall be located in a place approved by the Superintendent.

The Contractor shall arrange for the removal of all sewage from the holding tank to be collected at regular intervals and disposed of at approved and lawful locations outside the work site.

2.18.5 Smoking

Smoking shall only be permitted in authorised areas as agreed with the Superintendent prior to commencement of work. Smoking is prohibited in Site offices, lunchrooms or enclosed toilet facilities.

2.18.6 Fire Prevention

No fires shall be set alight by the Contractor under any circumstance. The Contractor shall provide and maintain adequate fire-fighting equipment on-site and must comply with the Bush Fires Act 1954.

2.18.7 Refuse Disposal

All Site refuse (including foodstuffs) shall be handled and disposed of in accordance with the requirements of relevant statutes and to the approval of the Superintendent.

Litter and general rubbish generated by the Contractor in executing the works shall be temporarily stored in appropriate receptacles prior to being conveyed to a licensed disposal facility. Prior approval for the disposal of litter and general rubbish at suitable facilities on-site, should they exist, shall be obtained from the Superintendent. All debris, spoil, rubbish or materials shall be suitably contained and covered in vehicles during transportation to or from the Site to prevent spillage or contamination of adjoining and other areas or property.

2.18.8 Vehicles

The Contractor shall maintain vehicles, wheels and tracks in a suitable clean condition to prevent transfer of mud onto adjacent roads or other areas. The location of all servicing/maintenance of plant and equipment on-site shall be agreed with the Superintendent. The Contractor shall identify

all the key environmental aspects for the storage, use, and safe disposal of hazardous materials/fluids and mitigation of any fuel/oil/diesel etc. spills during the works.

2.19 Occupational Health and Safety

The Contractor shall comply with the Work Health and Safety Act 2020 ('WHS Act') and the Work Health and Safety (General) Regulations 2022 (the WHS Regulations) and with any amendments that may be made to the WHS Act and WHS Regulations from time to time.

The Contractor shall comply with all relevant safety and security procedures and rules of the Principal. Where there is conflict between the WHS Acts/Regulations and the Principal's safety and security procedures and rules, the more rigorous requirements shall apply.

2.19.1 Contract Safety Risk Assessment

Within 14 days of the Date of Acceptance of Tender, the Contractor shall carry out a Contract Safety Risk Assessment and shall supply the Superintendent with a copy of the potential hazards identified and the proposed control measures to be implemented for consideration.

Throughout the Contract period, the Contractor shall report to the Superintendent any potential hazards identified or notified.

2.19.2 Safety Management Plan

The Contractor shall, throughout the Contract, implement and maintain a "Safety Management Plan". The Contractor shall prepare the Safety Management Plan in conjunction with a person suitably experienced and qualified in safety matters.

Prior to the commencement of the Contract, the Contractor shall supply to the Superintendent, in writing, its Safety Management Plan.

2.19.3 Induction Training

Employees of the Contractor, its Sub-Contractors and employees of Sub-Contractors shall not commence work on the Site until the Contractor has carried out Site induction training. Prior to this, the Contractor's Representative shall receive the scope of the induction from the Principal in order that it may cascade it to the staff, sub-contractors and suppliers. The Contractor is reminded that the Site induction training is separate to any safety training that it is legally required to impart to its staff. The Contractor's staff, Sub-Contractors and Suppliers will not be allowed to access the Site independently without the Site induction training. To this effect all people engaged in the works will be required to sign an Induction Form confirming that they have received the training.

Upon commencement of work on the Site, the Contractor shall further induct each employee with regard to all significant hazards associated with their particular activity and area of employment on the Site and where relevant, shall include the use of powered plant, tools and equipment. If requested by the Superintendent, the Contractor shall provide appropriate documentation detailing the satisfaction training of its employees on the safe use of all plant, vehicles and equipment to be used on the project. Failure to provide appropriate certification may lead to the relevant employees being removed from the working roster.

2.19.4 Safe Working Procedures

Where legislation or codes of practice identify particularly hazardous activities, including but not limited to, work in confined spaces, asbestos removal, demolition work, excavation work, working near power lines and live conductors and working at heights, the Contractor shall supply to the Superintendent a Safe Work Procedure (SWP) document prior to commencing such activity or type of work on the Site.

The Contractor shall induct the Contractor personnel and its Sub-Contractors with regard to SWP and shall prepare "Training Session Attendance" sheets signed by each attendee verifying that such induction has occurred.

2.19.5 Site and Public Security & Safety

Notwithstanding the Contractor's obligations to the Site and public security as stated elsewhere in this Contract, the Contractor shall monitor and control wherever practical, the access of all persons to the Site.

Should the general safety of the public be compromised, the Superintendent may order an immediate stoppage of the works and may order remedial works at the Contractor's expense.

2.19.6 Contractor's Safety Agreement

The Contractor shall liaise with the Principal's Occupational Safety & Health (OS&H) Co-ordinator to complete and sign a Contractor's Safety Agreement.

2.19.7 Safety Notifications, Compliance & Standards

The Contractor shall notify the Department of Mines, Industry Regulation, and Safety (formerly the Department of Labour and Industry) of all Notifiable Works and make payment of all inspection and other fees in connection with such works.

The Contractor shall conduct the construction of the works in accordance with all current statutory requirements, Local Government By-laws and the provisions of AS 1470, together with any other Code relating specifically to type of machine, process, handling procedures or materials. The Contractor shall provide employees with all necessary equipment and protective clothing to allow the safe construction of the works and shall ensure maintenance to all plant and machinery to ensure fitness for purpose.

2.19.8 Unsafe Machinery or Structures

On notification from the Superintendent, in respect to any operation, machine or structure being, in the opinion of the Superintendent, unsafe, the Contractor shall cease use immediately of such operation, machine or structure and shall conduct remedial work to the satisfaction of the Superintendent before continuing to use the operation, machine or structure in the works. Where no remedial action can ensure continued safe use of an operation, machine or structure, the Contractor shall, in the case of an operation, cease such operation, and, in the case of a machine or structure, shall dismantle and remove such machine or structure from the Site.

2.19.9 Fire Prevention

The Contractor shall provide and maintain adequate, approved fire-fighting equipment on-site. The Contractor shall observe the provisions of the WA Bushfires Act, Local Authority regulations, WA Fire Brigades Board regulations and any other regulation in respect to fire prevention.

BURNING ON SITE IS PROHIBITED.

The Contractor shall ensure that all flammable materials are used and stored in accordance with the Explosives and Dangerous Goods Act and any other statute or regulation governing storage and use of such materials and shall obtain such permits and licenses and pay all relevant fees and charges.

2.20 Containment of Leachate and/or Surface Water Run-Off

Should the Contractor in the course of the works cause a leachate or surface water break out, the Contractor shall immediately inform the Superintendent and remedy the situation at the Contractor's own expense.

Should the Contractor notice a leachate or surface water breakout, the Contractor shall immediately inform the Superintendent and await instruction as to what course of action is required.

2.21 Disposal Areas for Contractor

No waste is expected to be encountered in excavations. The area identified on the contract Drawings is the only area available for the Contractor to dispose of waste arising from excavations. The Contractor is to provide reports to the Superintendent on the same day as the tip area is used, detailing the following:

- Location from where the material was extracted;
- Nature of the fill; and
- Number and type of vehicle used for moving the fill.

No material externally sourced from the Site shall be tipped in the tip area unless it is approved by the Superintendent.

Haulage rates internal to the Site must be included in the appropriate rates.

2.22 Materials Delivered to Site

The Contractor is to provide 24 hours' notice of deliveries to Site and provide written documentation on delivery to Site. Materials shall not be accepted on-site without the appropriate documentation, demonstrating compliance with the specifications. Such documentation should indicate the volume/amount of product delivered.

The Contractor is to maintain a diary of material deliveries, which must be accessible by the Superintendent at all times. Should materials be present on-site for more than 24 hours and not have a corresponding entry in the diary, the materials shall require immediate removal from Site.

2.23 Stability of Ground Conditions

The Contractor is to make all personnel aware (particularly those operating heavy plant and those placing earth) of the hazards associated with working on domestic and industrial waste. The Contractor is to demonstrate to the Superintendent that work practices and sequencing of earth movement shall not increase the risks associated with ground subsidence and slope failure.

The Contractor is to immediately inform the Superintendent should the Contractor become aware of signals indicating subsidence and/or slippage.

2.24 Completion of the Work

The Contractor shall leave the whole of the works in a clean and neat state, perfectly free from all rubbish and superfluous material of any kind. The Contractor shall clear up and cart away all surplus materials and rubbish to an approved waste disposal/recycling facility Site and shall remove all temporary markings, coverings and protective wrappings unless otherwise instructed.

Surplus excavation material shall be transported at the Contractor's expense to a location approved by Superintendent.

Where new works tie into existing works and Site boundaries, the existing works shall be reinstated to a standard similar to that which existed prior to the commencement of the works, or as approved by the Superintendent.

2.24.1 Protection of Works

The Contractor shall take all necessary precautions to safeguard all existing structures or infrastructure from ground movement, settlement, and all other activities associated with the execution of the Contract.

The Contractor shall make all necessary records (photographic or otherwise) of existing structures and other properties that could be affected by execution of the works prior to the commencement of construction.

The Contractor shall carefully case and fix boarding, sheeting or devices, to protect, works and materials from damage by weather or any other external element including other contractors, during the contract period until the works have been handed over.

The Contractor shall provide for protection of the works and property, for the protection and convenience of the public, adjacent owners and occupiers including all necessary watching, lighting, barriers, guard rails, warning notices and for all precautions required by the Superintendent.

The Contractor shall take adequate precautions to prevent trespass on adjoining property by Contractor personnel and/or its Sub-Contractors' personnel. The Contractor shall restrict its activities and Site usage to the area of the works as indicated on the Drawings as approved by the Superintendent.

Thorough and appropriate measures shall be taken to prevent damage occurring and hence the necessity to make good damaged work. The Contractor shall be responsible for notifying the

Superintendent of any damage to the temporary or permanent works as soon as it arises. The Contractor shall identify and understand the possible sources of damage to its works and those of others and take active and positive protection measures to the satisfaction of the Superintendent. The Contractor shall provide protection against damage arising from ground and surface water weather conditions, construction, other contractors, warping, distortion, abrasion, sunlight, humidity or other conditions, which could have an adverse effect on its works and could be reasonably anticipated.

The Contractor must allow for the necessary maintenance, alteration and adaptation of protection during construction to allow for its Subcontractors to progress and to allow the possibility of damage to the contract works by others and allow for removal of protection upon completion. It shall be a requirement of this Contract that a statement on the Contractor's proposals for protecting the works before, during, and upon completion, shall be submitted for approval by the Superintendent. The Contractor shall provide all necessary scaffolding, barriers and rails and other protective measures to excavations, floor openings and edges during the period of the contract works.

The Contractor shall protect its materials during loading, transportation, unloading and storage on-site, prior to incorporation in the works.

Protection used within the context of this document means that the Contractor is required to protect the contract works until practical completion. The type and extent of protection must be sufficient to protect finished or partly finished work, or any damage, caused by accident or otherwise, likely to occur within the currency of the contract works and with regard to the nature of operations being concurrently executed by others. The Contractor is to allow in its tender for providing such protection as necessary and will be held fully liable for any and all damage resulting from its failure to protect.

2.25 Site Climatic Conditions

The Contractor shall inform itself fully in regard to the climatic conditions likely to be experienced at the Site and shall make its own assessment of the effect that such conditions may have on the execution of the works and make due allowances for it in the Construction Programme. The rainfall and other weather conditions details can be accessed Bureau of Meteorology website (www.bom.gov.au).

2.26 Control of Quantities On-Site

The method adopted to verify volume/mass relationship shall be determined between the Contractor and the Superintendent prior to works commencing.

The Contractor is responsible for programming such surveying to limit any delays to the programme and to allow completion of the surveying to the satisfaction of the Superintendent.

The Contractor is required to coordinate with the surveyor to ensure that the surveying is completed in accordance with the Superintendent's requirements without adversely affecting the programme of the works. The independent ground surveyor, as provided by the Contractor, shall be required at a minimum to survey at the following stages:

- Location of specified Site investigations (trial pits and boreholes) carried out by the Contractor at the direction of the Superintendent;
- The reinstated formation levels at the landfill and all other construction areas;
- The surfaces of the individually completed layers, such as but not limited to, sub-bases, engineered clay, GCL, geomembrane, leachate collection, etc.;
- Topographical survey of completed construction including finished earthworks, drainage, all other aspects of the infrastructure and affected areas of the borrow source should it be relevant; and
- Any requirements as stipulated in the CQA Plan as mentioned in the Appendices of this Specification.

2.27 Temporary Accommodation

The Contractor is responsible for the transportation, erection, furnishing, maintaining, and removal of all temporary accommodation on completion of the works. The Contractor shall arrange for adequate office, storage, workshop, lock-up, sanitary, washing, drying, and changing/ shelter facilities for use by Contractor personnel and visiting personnel to the Site. These facilities shall be provided before construction work commences and be maintained for the duration of the contract. The minimum facilities shall be those as specified by the WHS Act and the WHS Regulations and with any amendments that may be made to the WHS Act and WHS Regulations from time to time. The Contractor will not be permitted to set-up any residential (donga/demountable) accommodation on-site, for Contractor personnel or its Sub-Contractors' personnel when undertaking the contract works.

2.28 Security

The Contractor shall be responsible for establishing and maintaining a secure Site for the duration of the Contract during and outside of normal working hours. All new structures shall be made secure.

The Contractor shall allow in its tender for security and provision of all necessary accommodation and utilities, including lighting, for the carrying out of these duties.

Security fencing shall be erected where required to delineate working areas/compounds and access to any open excavations at the end of the working day should be cordoned off, with restricted access.

The security measures to be employed by the Contractor must be to the satisfaction of the Superintendent. The Principal is not responsible for any losses due to lapses in security by the Contractor's personnel and/or its Sub-Contractors' personnel.

3 Site Works

3.1 Entry on to the Site

The Contractor shall notify the Superintendent in writing, 7 days in advance, of its intention to start work within each work / borrow area.

The Contractor shall allow the Principal unfettered access to all areas of the Site to inspect works and conduct work as required.

3.2 Site Fencing

Where the type and location of temporary Site fencing are shown in the Specification Drawings, the Contractor shall erect such fencing as soon as it is given possession of the relevant portion of the Site. The Contractor shall regularly inspect and maintain all such fencing with any defects being made good without delay. Temporary fencing shall remain in position until either it is replaced by permanent fencing, or the works are sufficiently completed to enable that portion of the Site to be brought into use.

3.3 Contractor's Site Facilities

The Contractor must supply and maintain all facilities on-site as deemed necessary by the Contractor for Contractor's personnel, and Sub-Contractors. The facilities shall include all necessary offices, stores, toilets, washing facilities and other facilities as required by the WHS Act and the WHS Regulations for such camps, including the cleaning and maintenance of the camp.

The Contractor must provide facilities satisfactory for the storage of such materials as may be described in the various sections of the Specifications.

Prior to erecting any Site facilities, the Contractor will ensure that the proposed location and positioning of the units have been agreed with the Superintendent.

All buildings and facilities established and used by the Contractor must be removed from the Site at no cost to the Principal on completion of the works and the Site must be left in a clean and tidy condition.

3.4 Office Accommodation for the CQA Consultant

The Contractor shall provide office accommodation to the CQA Consultant personnel for the duration of the works. The office accommodation shall have sufficient climate control, light and be maintained in a clean and tidy state, the offices can be shared and can be part of the Contractor's Site office. Offices and other accommodation shall be erected, furnished and ready for occupation within seven days of the date for commencement of the works and fully equipped and serviced for use within seven days of that date. The compound shall be maintained by the Contractor to the satisfaction of the Superintendent, for the duration of the contract works.

3.5 Interference with Land Interests

The Contractor shall confine its constructional operations within the Site, or such other area of land as may be negotiated and shall instruct the Contractor's personnel not to trespass areas outside of the works area.

Subject to any unavoidable disturbance which may be necessitated by the execution of the Contract, the Contractor shall not interfere with any sporting, fishing or other rights which may be enjoyed on or near the Site.

3.6 Interference with Existing Access

If the Contractor's work interferes with access to any property within the Site, then the Contractor shall provide alternative access arrangements. The Contractor shall notify the Superintendent and the relevant occupiers, in writing, 14 days in advance of any such interference and shall confirm to the Superintendent that alternative arrangements have been agreed.

3.7 Protection against Damage

The Contractor shall take all necessary precautions to avoid causing any unwarranted damage to roads, lands, properties, trees, monitoring boreholes and other features during the currency of the Contract and shall deal promptly with any complaints by owners or occupiers.

Where any portion of the works is close to, across or under any existing apparatus of public utilities or other parties, the Contractor shall temporarily support and work around, under or adjacent to all apparatuses in a manner designed to avoid damage, leakage or danger, and to ensure uninterrupted operation.

If any damage occurs, the Contractor shall, at once, notify the Superintendent and the Statutory Authority or owner concerned. Any damaged or affected apparatus shall be repaired or replaced at the expense of the Contractor.

The Contractor shall take all reasonable necessary precautions to avoid damage to its own works, by the Contractor's personnel, domestic and nominated Sub-Contractors, until such time as the works have been handed over and accepted by the Principal.

3.8 Location of Existing Services

The Contractor shall be responsible for the maintenance and protection of existing services which may be affected by the contract works. It is not warranted that the services shown on the Drawings are in the exact position or are to the full extent shown. Prior to commencing any works, the Contractor should make such investigations with all service authorities and Dial Before You Dig (<http://www.1100.com.au/>) that are necessary to locate all services on-site or within the work areas adjacent to the Site.

If services are located which are not shown on the Drawings, the Contractor shall give at least three (3) working days' notice to the Superintendent prior to commencement of any construction activity that may affect the service.

The Contractor shall make good any damage resulting from its operations and shall indemnify the Principal against any claim for damage to drains, sewers, mains, cables, water pipes, fittings, boxes or other property, caused by its operations. The tendered rates are to include for all identification, protection, repair and/or other necessary work to the presence of the services.

Existing private and public statutory services such as water mains, gas mains, cables, house drains, culverts, etc., shall be located insofar as possible before commencement of the works. The Contractor shall proceed with the works in such a manner that the works shall be constructed without interference.

The Contractor shall make its own arrangements for any diversion or removal of services which it may require for its own convenience or because of its proposed method of work and shall, in all cases, inform the Superintendent in advance of its proposals.

Should any service be found to exist which are not indicated, or not as indicated in the Contract, the Contractor shall, at once, give written notice to the Superintendent.

All located services shall be surveyed for size, position and level, by the Contractor and a record of these services given to the Superintendent.

3.9 Advertising and Project Works Signs

Strictly no advertising will be permitted on the Site other than:

- Project signs approved in writing by the Superintendent;
- Names of Manufacturers or names of owner on items of construction plant; and
- Contractor's mail box.

All Project Works signs must be approved by the Superintendent prior to their manufacture.

Project Works signs must be installed by the Contractor no later than one week from the Principal issuing Possession of Site. The Contractor shall be responsible for all costs and charges relating to the manufacture, installation, maintenance and subsequent removal of all Project Works signs from the Site.

The Contractor must remove all project signs from the Site to an authorised disposal site no earlier than 4 weeks and no later than 6 weeks from the date of Practical Completion unless otherwise directed by the Superintendent.

3.10 Fencing, Watching and Lighting

In the case of all excavation locations to which the public may have access, the Contractor shall include for the temporary fencing off of such excavation locations and for temporary watching and lighting of the excavation locations during the hours of darkness. If spoil heaps obtrude on public areas or Contractor's plant is parked on public areas during the hours of darkness, the Contractor shall define the boundary of its operations as part of the approved Traffic Management Plan (TMP).

3.11 Tidiness of Site

The Contractor shall be responsible for the proper upkeep and maintenance of the Site and the works and shall remove, from the Site, rubbish and other waste as it accumulates. Materials and equipment shall be positioned, stored and stacked in an orderly manner.

3.12 Works Affecting Watercourses

The Contractor shall be responsible for maintaining watercourses within and adjacent to the Site in effective working condition at all times and shall take all practicable measures, which shall be to the prior approval of the Superintendent, to prevent the deposition of silt or other materials in existing watercourses. Settling ponds shall be installed prior to all water discharges to watercourses. Settling ponds shall have a minimum 5-day retention capacity.

4 Earthworks

The advance bulk earthworks, by others, will provide a formation surface on the cell's side slopes 500mm below final subgrade level, and a free draining base of the cell formed from Engineered Fill. The Contractor is required to regrade the base of the cell to 250mm below the finished subgrade levels and undertake a proof roll to check the lower 250mm layer of the Engineered Fill provides a competent foundation for the cell. The Contractor shall place and compact Engineered Fill on the base and side slopes to the geometry and falls shown in the Drawings.

All works carried out under this section of the Specification shall comply with the following standards, and those specified therein, which shall be held to be incorporated in the Specification:

- AS 3798: Guidelines on earthworks for commercial and residential developments; and
- AS 1289: Methods for testing of soils.

4.1 Definitions

The following definitions of earthworks material shall apply to this and other clauses of the Specification in which reference is made to the defined materials.

“Topsoil / Growth Medium” shall mean the top layer of soil that can support vegetation.

“Suitable materials” imported or site-won material complying with the requirements for use in the permanent works.

“Un-suitable material” shall mean material other than suitable material and shall include:

- Peat materials from swamps, marshes or bogs;
- Logs, stumps and perishable material;
- Material susceptible to spontaneous combustion;
- Material in a frozen condition;
- Clay of liquid limit exceeding 80% and/or plasticity index <10% or exceeding 55%;
- Material having a moisture content greater than the maximum permitted for such materials in the Contract, unless otherwise permitted by the Superintendent; and/or
- Non-hazardous material other than those permitted in the Contract.

“Unacceptable Hazardous Material” shall be material having hazardous chemical or physical properties requiring special measures for its excavation, handling, storing, transportation, deposition and disposal.

“Rock” shall mean hard rock in mass formation which can only be removed by the use of a rock breaker or explosives. “Rock” shall also be defined as all material which cannot be ripped and excavated with a track dozer in good condition with matching hydraulic single shank ripper of combined mass not less than 52 tonnes at a rate in excess of 90m³ (solid) per hour. Boulders in excess of 0.25 m³ volume in pipe trenches or in excess of 1.0 m³ in mass excavation shall be deemed to be rock excavation.

“Cohesive Soil” shall include clays and marls with up to 20% of gravel or rock and have a moisture content not less than the value of the plastic limit minus 4.

“Well-graded granular and dry cohesive soils” shall include clays and marls containing more than 20% of gravel or rock and/or having a moisture content less than the value of the plastic limit minus 4 and well-graded sands and gravels with the uniformity coefficient exceeding 10.

“Uniformly-graded material” shall include sands and gravels with uniformity coefficient of 10 or less, and all silts. Any soil containing 80% or more of material in the practical size range 0.06-0.002 mm will be regarded as silt for this purpose.

4.2 Products and Materials

4.2.1 Use of Materials

Engineered Fill material shall be excavated from the Cell 7 and 9 footprints or designated stockpile areas at the Site as shown in the Drawings, or as approved by the Superintendent.

The Contractor shall be responsible for any assumptions made by the Contractor in relation to the nature and types of materials encountered in excavations/stockpiles and the bulking and compaction characteristics of materials incorporated in any earthworks. The summary of the estimated quantity for general earthworks provided includes all types of materials that may be encountered in the cuttings.

4.2.2 Unsuitable Material

Some materials are unsuitable for forming structural fill and should be either removed to spoil or used in non-critical areas. In addition to the definition in Section 4.1, unsuitable materials, as detailed in AS 3798 may include:

- Organic soils, such as many topsoils, severely root-affected subsoils and peat;
- Materials contaminated through past Site usage which may contain toxic substances or soluble compounds harmful to water supply or agriculture;
- Materials containing substances that can be dissolved or leached out in the presence of moisture (e.g., gypsum), or which undergo volume change or loss of strength when disturbed and exposed to moisture (e.g., some shales and sandstones), unless these matters are specifically addressed in the design;
- Silts, or materials that have the deleterious engineering properties of silt;
- Other materials with properties that are unsuitable for the forming of structural fill; and
- Fill that contains wood, metal, plastic, boulders or other deleterious material, in sufficient proportions to affect the required performance of the fill.

In some circumstances a design may allow for the use of some of these materials in structural fill. Before allowing for such use, the Contractor must supply specialised advice from a geotechnical professional. The use of any material in structural fill not specified in the Drawings or otherwise must be approved by the Superintendent before using such materials.

4.2.3 Engineered Fill

Engineered Fill will comprise of suitable site-won soil material from the borrow pit, which will be used to form the Bulk Earthworks. The specification of Engineered Fill is detailed in Section 5.

4.2.4 Imported Fill

Engineered Fill may also be comprised of Imported Fill, provided is it a suitable material, and meets the requirements of Table 4-1 when tested in accordance with Main Roads WA Test Method WA 115.1-2019.

Table 4-1: Particle Size Distribution (Imported Fill Material)

AS1152-1993 Sieve Size (mm)	Minimum % Passing by Mass	Maximum % Passing by Mass
37.5	100	100
19	80	100
4.75	45	100
2.36	30	100
0.0075	1	10

4.3 Excavation

The advance bulk earthworks, by others, will provide a formation surface on the cell’s side slopes and a free draining base of the cell formed from Engineered Fill. The Contractor is required to regrade the base of the cell to 250mm below the finished subgrade levels and proof roll the lower 250mm thick layer of the 500mm thick Engineered Fill Layer.

4.3.1 General Excavation Conditions

Following removal of hard rock and highly cemented soils by the advance Bulk Earthworks, the remaining material within the Works (cohesive and weak to moderately cemented soils) may be excavated using a 30 tonne excavator.

4.3.2 Excavated Materials

Excavated material shall be separated by material type and stockpiled separately in accordance with the Contract and Drawings. No excavated materials, suitable for use in the works shall be removed from the Site except on the direction, or with the permission, of the Superintendent.

4.3.3 Protection of Excavations

The Contractor shall provide all the necessary supports to secure the sides of any excavations whether mass excavation or trench excavation. Except where required by or permitted under the Contract, sides of the excavations shall not be battered. The Contractor shall be responsible for all trench boxes, planking and strutting necessary to ensure the stability of the side slopes of excavation. The Contractor will be responsible for the costs associated with such temporary works. Any battering or collapsed excavations shall be backfilled with material approved by the Superintendent.

All excavations shall have adequate warning lights, handrail and guarding to allow safe work within and on top of the excavations.

4.3.4 Water in Excavations

The Contractor shall not allow water to lie in any part of the works unless required to do so under the Contract. Water arising from or draining into the works shall be drained to the temporary sump for pumping to the western swale drain or other approved disposal point.

No excavation shall occur in water without the area first being dewatered in accordance with this Section.

4.3.5 Excavation below Formation Level

If the Contractor encounters ground below formation or finished surface level which is considered unsuitable (including that described in Sections 4.2.2) or if the formation level is damaged and allowed to deteriorate, the Superintendent shall be promptly informed. Any unauthorised excavation to a depth greater than is necessary for the proper execution of the works shall be filled with suitably approved Engineered Fill material to bring it to the correct formation level.

4.3.6 Hand Excavation

Hand excavation shall be used in confined spaces where the use of excavating machinery is unsuitable and for other operations such as trimming the formation to final level whether in open cut or in trench. Hand excavation shall be used around and adjacent to existing services or geosynthetic lining materials to expose and locate them to ensure no damage occurs to the underlying liner system.

4.4 Formation Preparation

Formation preparation shall be completed in all areas where Engineered Fill is to be placed, and where cut has occurred to achieve final levels. The formation surface shall be constructed to the shape and levels as shown in the Drawings and to the specified requirements and tolerances of Section 5. The completed formation shall be in a homogeneous uniformly bonded condition with no evidence of layering or disintegration.

Soft spots shall be excavated and disposed of as directed by the Superintendent and filled with approved Engineered Fill. The acceptance of the formation levels constitutes a **Hold Point**.

The completed formation surface shall be maintained in its conforming condition until construction commences and shall be watered as necessary to prevent shrinkage cracking, dusting or loosening of its surface.

5 Engineered Fill Layer

All filling required at the Site under the Works shall be Engineered Fill. Engineered Fill is required to be constructed on the base and side slopes of the cell in accordance with the Drawings.

The Engineered Fill shall meet the following requirements:

- Comprise predominantly clay material free from organic matter, debris or waste, classified as either low, medium or high plasticity clay, clayey sand, clayey gravel or silty clay;
- Maximum particle size $\leq 50\text{mm}$;
- Percentage passing a 19mm sieve $\geq 70\%$;
- Percentage passing a 0.075mm sieve $\geq 20\%$ (in accordance with AS 1289.3.6.3);
- Liquid limit $\geq 25\%$ (in accordance with AS 1289.3.1.1);
- Plasticity index $\geq 10\%$ (in accordance with AS 1289.3.3.1); and
- Not comprise unsuitable material as defined in Section 4.2.2;

5.1.1 General Filling

Filling shall, wherever practicable, be undertaken immediately after the specified operations preceding it have been completed. Filling shall not, however, be commenced until the works to be covered have achieved a strength sufficient to withstand all loading imposed thereon.

Filling around tanks and other structures shall be undertaken in such a manner as to avoid uneven loading.

No filling shall take place in water.

5.1.2 Compaction

A vibratory steel drum roller (sheepsfoot/padfoot) or other suitable compaction plant approved by the Superintendent should be used for construction of Engineered Fill. The Contractor shall submit with its completed Tender, a method statement detailing the plant, conditioning and compaction techniques it proposes to use. Uncompacted lift thickness must not exceed 300mm.

Engineered Fill shall be compacted to $>95\%$ MMDD with a moisture content, during compaction, within the range of optimum moisture content (OMC) -3% to $+3\%$ as determined by the test methods of AS1289.

5.1.2.1 Field Trial

To assess the Contractor's proposed placement and compaction procedures, a Field Trial of Engineered Fill construction will be carried out. The trial should be carried out in an area not less than 15m x 10m and consist of two lifts of fill placement.

The purpose of the Field Trials shall be to provide field verification of the moisture/density relationships as determined from the characterisation testing. The following aspects of the mineral liner installation shall be evaluated for each layer of the field trial.

- Material handling and placement requirements;
- Compaction equipment and procedures;
- Number of passes of equipment necessary to achieve the required results; and
- Testing of the fill shall be undertaken after each lift has been placed and compacted.

If a Nuclear Density gauge is utilised for field testing the trial shall be used to calibrate the gauge against adjacent sand replacement or core cutter in-situ density test methods, with a minimum of five (5 No.) corresponding samples. One (1 No.) bulk sample shall be submitted to the laboratory for grading and Atterberg testing.

The calibration will only be applicable to the actual nuclear density gauge as verified by serial number, used as part of the field trial. The results of the Field Trial shall be submitted to the CQA Consultant for approval.

If the results of Field Trials are unsatisfactory, the Field Trial area shall be excavated and removed. The Contractor shall then submit the Contractor’s proposals for a revised procedure to the Superintendent/CQA Consultant for approval before continuing with further field trials.

The contractor may also propose to remediate the unsatisfactory trial area through further compactive effort / conditioning, followed by re-testing, until the clay meets the performance specification for all criteria. Once the trial liner has been proven to meet the specification, the trial area may be incorporated into the works. The acceptance of the Engineered Fill field trial constitutes a **Hold Point**.

5.2 Testing

The Contractor shall undertake the following compliance tests:

Table 4-1: Engineered Fill Layer Testing Requirements

Test	Frequency
In-situ dry density/moisture	1 per 500 m ³ or 1 per 2,500 m ² per layer or 3 tests per lot (whichever the highest)
Laboratory permeability tests (water)	1 per 5,000 m ³
Laboratory permeability tests (50,000 ppm NaCl)	1 per 5,000 m ³
Grading Analysis (to clay size / inc hydrometer)	1 per 2,500m ³
Plasticity Index/Atterberg Limits	1 per 2,500 m ³
MMDD Compaction	1 per 2,500 m ³

All laboratory testing shall be undertaken by a NATA accredited laboratory, approved by the Superintendent.

The in-situ field dry density shall be measured using either the sand replacement method, core cutter method, or by a nuclear density gauge.

If a nuclear gauge is used the readings will be verified by core cutter or sand replacement at a minimum of 1 per 10 nuclear gauge readings. All drill rod penetrations from the nuclear density gauge testing must be backfilled with bentonite granules up to 75mm of the clay surface then plugged with clay.

The undisturbed samples for laboratory permeability testing shall be taken by the Contractor from the finished attenuation layer under the supervision of the Superintendent/CQA Consultant. The samples shall be taken by placing a thin walled sample tube, 150 to 300 mm in length, upright on the completed material and jacking the tube down vertically and steadily. Upon excavation, the samples shall be immediately sealed, labelled and sent to a NATA accredited laboratory (approved by the Superintendent/CQA Consultant) for determination of permeability.

All perforations made in the clay liner for testing shall be backfilled in a manner approved by the Superintendent/CQA Consultant.

All test results shall be submitted to the Superintendent/CQA Consultant, detailing sample location, level, depth and date taken, for approval. Approval of all testing by the Superintendent comprises a **Hold Point**.

5.3 Rectification of Works

If the field testing demonstrates that the compaction requirements are not being attained the Contractor must carry out the following at the Contractor's own expense:

- Undertake additional works on the layer as necessary such that subsequent testing of the layer meets the required compaction requirement. This may include such measures as wetting up or drying of placed materials, additional passes of the compacting plant or other measures as deemed suitable by the Superintendent/CQA Consultant.
- Remove the part of the layer demonstrated to have not met the required compaction requirement and replace it to the satisfaction of the Superintendent/CQA Consultant.

5.4 Tolerances

The Contractor should ensure that, within 3 days of undertaking the survey, all survey data is passed to the Superintendent/CQA Consultant for approval, to demonstrate the required installation levels have been met. This constitutes a **Hold Point**.

The tolerances for the final Finished Surface Levels are: -50mm /+50mm.

5.4.1 Finishing of Batters and Ground Surfaces

Except during the construction of benched or stepped batters, batter slopes shall be smoothly shaped to a uniform plane from top to bottom as shown on the Drawings.

The surface of all slopes/batters shall be excavated and filled, shaped and/or graded as necessary to achieve the finished soil levels and contours nominated in the Drawings, prior to any surface preparation and soil improvements.

The toe of mounds shall be graded evenly to meet adjoining surface levels. The ground surface shall be shaped and/or graded evenly to avoid abrupt changes in levels abutting structures and paved surfaces.

6 Geosynthetic Liners

6.1 General

This section outlines the supply and installation of all geosynthetic materials necessary for the completion of the project. This section should be read in conjunction with the CQA Plan as described in the Appendix C of this Specification.

6.2 Codes & Standards

The works shall comply with all current Australian Standards and Statutory regulations where applicable, unless specified otherwise in this Specification. In particular, the following shall apply:

- ASTM D570 Test Method for Water Adsorption of Plastics;
- ASTM D638 Test Method for Tensile Properties of Plastics;
- ASTM D696 Test Method for Coefficient of Linear Thermal Expansion of Plastics;
- ASTM D746 Test Method for Brittleness Temperature of Plastics and Elastomers by Impact;
- ASTM D751 Method of Testing Coated Fabrics;
- ASTM D792 Test Method for Density and Specific Gravity (Relative Density) of Plastics by Displacement;
- ASTM D1004 Test Method for Tear Resistance (Graves Tear) of Plastic Film and Sheeting;
- ASTM D1238 Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer;
- ASTM D1505 Test Method for Density of Plastics by the Density-Gradient Technique;
- ASTM D4218 Test Method for Carbon Black in Olefin Plastics;
- ASTM D1777 Test Method for Thickness of Textile Materials;
- ASTM D1822 Test Method for Tensile-Impact Resistance of Plastics;
- ASTM D3895 Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry;
- ASTM D4218 Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle Furnace Technique;
- ASTM D4437 Non-destructive Testing (NDT) for Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Sheet Geomembranes;
- ASTM D4595 Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method;
- ASTM D4716 Test Method Determining the (In-plane) Flow Rate per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head;
- ASTM D4833 Test Method for Index Puncture Resistance of Geomembranes and Related Products;
- ASTM D5385 Test Method for Hydrostatic Pressure Resistance of Waterproofing Membranes;

- ASTM D5397 Test Method for Evaluation of Stress Crack Resistance of Polyolefin Geomembranes Using Notched Constant Tensile Load Test;
- ASTM D5514 Test Method for Large Scale Hydrostatic Puncture Testing of Geosynthetics;
- ASTM D5596 Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics;
- ASTM D5617 Test Method for Multi- Axial Tension Test for Geosynthetics;
- ASTM D5641 Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber;
- ASTM D5721 Standard Practice for Air-Oven Aging of Polyolefin Geomembranes;
- ASTM D5820 Standard Practice for Pressurized Air Channel Evaluation of Dual-Seamed Geomembranes;
- ASTM D5885 Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by High-Pressure Differential Scanning Calorimetry;
- ASTM D5887 Test Method for Measurement of Index Flux Through Saturated Geosynthetic Clay Liner Specimens Using a Flexible Wall Permeameter;
- ASTM D5890 Test Method for Swell Index of Clay Mineral Component of Geosynthetic Clay Liners;
- ASTM D5891 Test Method for Fluid Loss of Clay Component of Geosynthetic Clay Liners;
- ASTM D5993 Test Method for Measuring the Mass Per Unit Area of Geosynthetic Clay Liners;
- ASTM D5994 Test Method for Measuring Core Thickness of Textured Geomembranes;
- ASTM D6392 Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods;
- ASTM D6496 Test Method for Determining Average Bonding Peel Strength Between Top and Bottom Layers of Needle-Punched Geosynthetic Clay Liners;
- ASTM D6693 Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes;
- ASTM D7238 Test Method for Effect of Exposure of Unreinforced Polyolefin Geomembrane Using Fluorescent UV Condensation Apparatus;
- ASTM D7466 Test Method for Measuring Asperity Height of Textured Geomembranes;
- AS 1289.2.1.1 Methods of Testing Soils for Engineering Purposes: Soil Moisture Content Tests – Determination of the Moisture Content of a Soil – Oven Drying Method;
- AS 3706.1 Geotextiles – Methods of Test: General Requirements, Sampling, Conditioning, Basic Physical Properties and Statistical Analysis;
- AS 3706.2 Geotextiles – Methods of Test: Determination of Tensile Properties – Wide Strip and Grab Method;
- AS 3706.3 Geotextiles – Methods of Test: Determination of Tearing Strength - Trapezoidal Method;
- AS 3706.4 Geotextiles – Methods of Test: Determination of Burst Strength - California Bearing Ratio (CBR) - Plunger Method;

- AS 3706.5 Geotextiles – Methods of Test: Determination of Puncture Resistance – Drop Cone Method
- AS 3706.6 Geotextiles – Methods of Test: Determination of Seam Strength;
- AS 3706.9 Geotextiles – Methods of Test: Determination of Permittivity;
- ISO 9001 Quality Systems - Model for Quality Assurance in Design, Development, Production, Installation and Servicing;
- GCL3 Test Methods, Required Properties, and Testing Frequencies of Geosynthetic Clay Liners (GCLs)
- GRI-GM13 Standard Specification for HDPE Geomembranes;
- GRI-GM19 Seam Strength of Thermally Bonded Geomembranes;
- GT12 Test Methods and Properties for Nonwoven Geotextiles Used as Protection (or Cushioning) Material
- LFE2 Cylinder Testing Geomembranes and their Protective Materials;
- EN 13719 Geotextiles and Geotextile-Related Products – Determination of the Long-Term Protection Efficiency of Geotextiles in Contact with Geosynthetic Barriers;
- EN 14574 Geosynthetics – Determination of the pyramid puncture resistance of supported geosynthetics

6.3 Environmental Conditions

The Contractor is to take whatever measures are necessary to ensure the timely and effective execution of the works without compromising workmanship, safety or seaming quality. The Contractor shall be responsible for provision of all temporary protection and anchorage for the geosynthetic materials.

6.4 Supply, Handling and Storage

All materials supplied shall be manufactured and provided in accordance with a quality system approved by the Superintendent/CQA Consultant.

The Contractor shall be responsible for all freight, transportation to Site, handling and storage, including security. It is the Contractor's responsibility to prevent any damage of the material due to weather. If the materials are damaged due to any of these activities, including the weather, and subsequently rejected for use by the Superintendent/CQA Consultant, then no claims against the Principal can be made.

Lining materials are generally delivered in rolls weighing up to 1,500kg. For handling and deployment it is considered by the Principal to be necessary to support this weight using an appropriate core pipe which must not deflect more than 50mm as measured from end to midpoint when a full roll is lifted.

Lifting chains or straps rated for at least twice the load of the roll should be used in combination with a spreader bar. The spreader bar must be wide enough to ensure that the lifting chains or straps do not chafe against the ends of the roll, which must be able to rotate freely during installation.

All lining components must be handled with care to avoid damage to the material. Any damaged geosynthetic liner material shall be replaced at the Contractor's expense. Delays in shipping geosynthetic materials shall not qualify for claims for Extension of Time.

Each roll of geosynthetics shall bear a label which identifies the following:

- Manufacturer;
- Product identification;
- Roll number;
- Raw material;
- Batch number;
- Roll width; and
- Roll length.

Lining geosynthetics shall be stacked in accordance with the Manufacturer's recommendations. The Superintendent may direct the Contractor to make adjustments to the stored materials if evidence of damage is observed. Any defects or damage detected shall be repaired to acceptable standards or totally replaced. The rolls shall not be stored on ground conditions which are likely to impose damage or affect the integrity of its long-term performance.

6.4.1 Subgrade Acceptance

The geosynthetics shall, except where stated, be deployed on prepared subgrade. The subgrade preparation shall be such that damage will not be caused to the geomembrane either during installation or during operation. The subgrade material shall be placed and compacted such that the geomembrane will be in continuous contact with the layer and the geomembrane shall not be stretched or bridged over any hollows or humps.

The installer shall certify in writing that the surface on which the geosynthetic will be installed is acceptable. The acceptance of the Engineered Fill surface constitutes a **Hold Point**.

After the supporting subgrade has been accepted by the Contractor it will be the Contractor's responsibility to maintain its condition and to indicate to the Superintendent/CQA Consultant any change in the supporting soil condition that may require repair work. The Contractor will ensure that the supporting soil is repaired prior to placement of the relevant panels of geosynthetics.

6.5 Geosynthetic Clay Liner

The Geosynthetic Clay Liner (GCL) shall be a needle punched multi-layered system comprising two layers of geotextiles encapsulating a layer of dry bentonite.

The bentonite shall be powdered or granulated meeting the requirements in Table 6-1.

Table 6-1: Bentonite Minimum Requirements

Property	Range or Value
Montmorillonite Content	> 70% wt

Property	Range or Value
Carbonate Content	<1 - 2% wt
Bentonite Form	Natural Na bentonite or >80% wt sodium as activated bentonite
Particle Size	Powdered (e.g 80% passing 75 micron sieve) or Granulated (e.g <1% passing 75 micron sieve)
Cation Exchange Capacity	≥ 70 meq/100g (or cmol/kg)
Free Swell Index	≥ 24 ml/2g

No additives to the bentonite shall be allowed unless the supplier can demonstrate the nature, suitability and long-term durability of the additive. In all cases the final decision regarding acceptability shall be made by the Superintendent.

The GCL shall meet the requirements of Table 6-2.

Table 6-2: Geosynthetic Clay Liner Minimum Requirements

Property	Unit	Type 1 - Basal Area Range or Value	Type 2 - Side Slope Areas Range or Value
Geotextile Component			
Cover Layer	g/m ² (MARV)	≥ 200	≥ 200
Carrier Layer	g/m ² (MARV)	≥ 100	≥ 300
Bentonite Component			
Mass per unit area	g/m ² (MARV)/(Typical)	≥ 3,600 / ≥ 4,250 @ 0% MC	
Swell Index	ml/2g	≥ 24	
Fluid Loss	ml	≤ 18	
Geosynthetic Clay Liner			
Mass per unit area	g/m ²	≥ 4,000 @ 0% MC	≥ 4,000 @ 0% MC
Thickness	mm	≥ 6	≥ 8
Maximum Tensile Strength (MD)	kN/m (MARV)/(Typical)	≥ 8 / ≥ 10	≥ 12 / ≥ 15
CBR/Puncture Resistance			
Peel Strength	N (MARV)/(Typical) N/m	≥ 1,500 / ≥ 2,000 >360	≥ 3,000 / ≥ 4,000 >360
Hydraulic Conductivity/Permeability	m/s (MaxARV) /(Typical)	≤ 3.0 x 10 ⁻¹¹ / ≤ 2.4 x 10 ⁻¹¹	

No transverse jointing/overlapping of geosynthetic panels will be allowed on side slopes. The Contractors shall ensure that **bespoke roll lengths** are manufactured to ensure that rolls are installed within the anchor trenches and extend down the slopes to a minimum of 2m onto the cell base.

The use of additional reinforcing geotextiles above or below the GCL to provide sufficient angle of internal friction on the side slopes shall be allowed subject to calculations provided and subject to the final decision of the Superintendent.

Prior to using an alternate GCL, the Contractor must furnish independent test results demonstrating that the proposed alternative material meets all requirements of this Specification and must obtain prior approval of the alternative GCL by the Superintendent.

6.5.1 GCL Acceptance

GCL conformance testing shall be undertaken by the Contractor. Materials shall not be incorporated into the works until the Superintendent/CQA Consultant has assessed the laboratory results.

The Contractor shall submit the laboratory test results to the Superintendent/CQA Consultant for approval of the use of the materials in the works, at the earliest opportunity. Any delay by the Contractor in obtaining the test results shall be at the Contractor’s expense and the Contractor shall not be entitled to any extension of time for the Contract due to such delay unless the Superintendent/CQA Consultant has taken more than seven (7) days to reply to the Contractor’s submission. Acceptance of GCL conformance testing constitutes a Hold Point.

Testing will be undertaken at an accredited, independent third-party laboratory as approved by the Superintendent/CQA Consultant. In addition, the CQA Consultant will undertake on-site visual inspection of the GCL roll delivered to the Site. All Conformance Testing and Visual Inspections are detailed within Table 6-3.

Table 6-3: Minimum CQA Testing for GCL

Property	Frequency	Standards
Conformance Testing		
Thickness (dry)	1 sample per 2,500m ²	ASTM D1777
Mass per unit area of bentonite component of GCL	1 sample per 2,500m ²	ASTM D5993
Mass per unit area of GCL	1 sample per 2,500m ²	ASTM D5993
Montmorillonite content (X-ray diffraction method)	1 sample per 10,000m ²	
Cation exchange capacity of bentonite (methylene blue method)	1 sample per 20,000m ²	
Mass/unit length of bentonite in overlaps (visual inspection and weighting)	1 per 2,500m ²	ASTM D5993
Moisture content of bentonite	Daily visual inspections	AS 1289.2.1.1
Swell index/free swell of clay	1 sample per 2,500m ²	ASTM D5890
Fluid Loss	1 sample per 5,000m ²	ASTM D5891
Peel strength (for needle-punched products only)	1 sample per 2,500m ²	ASTM D6496
Permeability	1 sample per 2,500 m ²	ASTM D5887
Tensile strength	1 sample per 25,000m ²	ASTM D4595

Property	Frequency	Standards
CBR of geotextile	1 sample per 10,000m ²	AS 3706.4
Puncture resistance of geotextile	1 sample per 25,000m ²	AS 3706.5
Index Flux	1 sample per 25,000m ²	ASTM D5887
Visual Inspection of GCL (on arrival and during placement at the Site)		
Colour, thickness, needle punching, presence of needles or broken needles, and sewing density or other faults in the material	Every Roll	
Thickness of GCL (i.e. uniformity of bentonite distribution) and apparent variations in the as placed moisture distribution		
Thickness of GCL (i.e. uniformity of bentonite distribution) and apparent variations in the as placed moisture distribution	Each roll during placement. If thickness appears to be variable a check of the variability of the mass per unit area should be conducted	

All conformance tests must be supervised, reviewed, accepted and reported by the CQA Consultant before deployment of the geosynthetic clay liner. All sampling taken from the GCL at the Manufacturer’s premises or Site shall be under the CQA Consultant’s supervision. This is a Hold Point.

The NATA laboratory shall issue all results to the Superintendent/CQA Consultant at the same time as they are issued to the Contractor. The Contractor and the NATA laboratory shall provide a signed disclosure confirming this procedure has been followed.

6.5.2 GCL Installation

The laying and installation of all GCL shall follow the Manufacturer’s details as well as the requirements as specified. There shall be no trafficking directly on the GCL once installed.

The method of installation of the GCL shall ensure that the following are complied with:

- On slopes, the GCL shall be securely anchored and the GCL material then deployed down the slope in such a manner as to keep the GCL panel in tension. The dimensions of the anchor trenches are as shown on the Drawings;
- Seams shall be placed perpendicular to the line of slope. Horizontal seams shall only be permitted on the face of the slope where directed by the contract drawings;
- The Contractors shall ensure that bespoke roll lengths are manufactured to ensure that rolls are installed within the anchor trenches and extend down the slopes to a minimum of 2m onto the cell base. However, where slope lengths are longer than manufactured roll lengths, the GCL is to be secured in intermediate anchor trenches. Upslope panels will rainlap (roof-tile) downslope panels with a minimum overlap of 1.0m;
- The Contractor shall take all necessary precautions to prevent damage to the underlying layers during placement of the GCL;

- During placement of the GCL, care shall be taken not to entrap beneath the GCL, any stones, excessive dust or moisture that could damage the GCL;
- After installation, a visual examination of the GCL shall be carried out to ensure that no potentially harmful foreign objects, contaminated soil or damaged areas are present; and
- Excess loss of bentonite on edges during deployment should be minimised.

The seams shall have a minimum overlap of 300mm and shall be joined by the addition of bentonite paste, applied to a minimum width of 200mm and a nominal thickness of 10mm as per Manufacturer's installation guidelines, or equivalent application of powdered bentonite to a minimum of 0.4kg/m length of seam, unless the GCL has impregnated surfaces along sheet edges and is installed under the Manufacturer's guidelines. The CQA Consultant will visually inspect all seams and shall reserve the right to remove samples for weighing.

No more GCL material will be deployed during one working day than can be covered by the end of that day. GCL deployment shall not be undertaken during precipitation. The Contractor shall ensure full protection is afforded to the GCL so that premature hydration does not occur.

Acceptance of the GCL installation constitutes a **Hold Point**.

6.5.3 GCL Repair Procedures

Any portion of the GCL exhibiting flaws shall be repaired. Prior to the acceptance of the installed GCL, the contractor shall locate and repair all damaged areas of the liner. Defects or damage can be identified by rips, tears, premature hydration of the GCL or delamination of the geotextiles.

Rips or tears in the GCL shall be covered by another piece of material meeting the project specifications. The material shall extend over the entire damaged area with a minimum 300mm overlap in all directions. Addition of bentonite shall be in accordance with Manufacturer's recommendations.

Where the GCL has been exposed to moisture and has prematurely hydrated prior to placement of overlying material, the material shall be removed and replaced with material meeting the specification.

6.5.4 GCL Materials Placement

Construction vehicles shall not be allowed to operate directly on top of the GCL. The Contractor is to submit method statements and Plant details for the approval of the Superintendent prior to placement.

6.6 Geomembrane (HDPE)

The raw material used for High Density Polyethylene (HDPE) geomembrane manufacture shall be first quality virgin resin of the type nominated with no more than 10% factory re-work material and no post-consumer resin. The quality of the HDPE geomembrane shall be in accordance with the requirements of the Geosynthetic Research Institute (GRI) - GM13 as indicated on Table 6-4 and Table 6-5.

The geomembrane liner shall be a new, first-quality product designed specifically for the purpose of hydraulic containment and a thickness of not less than that specified. The membrane shall be uniform and free of pin-holes, blisters, undispersed raw materials and contamination by foreign matter. The membrane liner shall be shop manufactured in rolls to a seamless width of not less than 5 metres, each roll identifiable in thickness, length and Manufacturer’s roll number.

Any defects such as holes, tears, blisters, ‘fish eyes’, delamination, undispersed raw materials or visible non-uniformity or contamination by foreign matter which in the opinion of the Superintendent is detrimental to the long service life required of the membrane liner, shall be grounds for rejection of the geomembrane liner material.

Defects which are considered as minor by the Superintendent shall be repaired in the presence of the Superintendent. Such repair shall be carried out using the extrusion fusion welding technique in accordance with the Manufacturer’s recommendation and tested in a manner agreeable to the Superintendent.

A material warranty of 20 years is required from the geomembrane Manufacturer. The Contractor shall provide the warranty in writing prior to the commencement of geomembrane installation.

Table 6-4: Raw Material (Polymer Resin) – Minimum Test Value Required

Property	Test Method	Standard HDPE
Density	ASTM D1505 or D792	0.935g/cm ³
Melt Flow Index (minimum) At 190°C/21.6kg At 190°C/5kg	ASTM D1238	<10g/10min <1g/10min
Oxidative Induction Time Standard OIT	ASTM D3895	100 mins

The required minimum test values for geomembrane are set out in Table 6-5.

Table 6-5: High Density Polyethylene (HDPE) Geomembrane – Textured

Properties	Test Method	0.75mm		1.00mm		1.25mm		1.50mm		2.00mm		2.50mm		3.00mm		Minimum Testing Frequency	
		nom. -5%	-10% -15%	nom. -5%	-10% -15%	nom. -5%	-10% -15%	nom. -5%	-10% -15%	nom. -5%	-10% -15%	nom. -5%	-10% -15%	nom. -5%	-10% -15%		
Thickness – mils (min. ave.)	D5199	nom. -5%	-10% -15%	nom. -5%	-10% -15%	nom. -5%	-10% -15%	nom. -5%	-10% -15%	nom. -5%	-10% -15%	nom. -5%	-10% -15%	nom. -5%	-10% -15%	Per Roll	
Asperity Height mils (min. ave.) ¹	GM 12	0.40mm		0.40mm		0.40mm		0.40mm		0.40mm		0.40mm		0.40mm		Every Second Roll ²	
Density (min. ave.)	D1505/D792	0.940 g/cc		0.940 g/cc		0.940 g/cc		0.940 g/cc		0.940 g/cc		0.940 g/cc		0.940 g/cc		90,000 kg	
Tensile Properties (min. ave.) ³	D6693 Type IV	Yield Strength	11 kN/m	15 kN/m	10 kN/m	13 kN/m	8 kN/m	12%	100%	93 N	200 N	500 hr.	2.0% - 3.0%	Note 5	100 min.		
		Break Strength	8 kN/m	10 kN/m	8 kN/m	12%	100%	500 hr.	400 min.								
		Yield Elongation	12%	100%	12%	100%	12%	100%	12%	100%	12%	100%	12%	100%	12%	100%	
		Break Elongation	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	
Tear Resistance (min. ave.)	D1004	93 N		125 N		156 N		187 N		249 N		311 N		374 N		20,000 kg	
Puncture Resistance (min. ave.)	D4833	200 N		267 N		333 N		400 N		534 N		667 N		800 N		20,000 kg	
Stress Crack Resistance ³	D5397 (app.)	500 hr.		500 hr.		500 hr.		500 hr.		500 hr.		500 hr.		500 hr.		Per GRI GM 10	
Carbon Black Content (range)	D4218 ⁴	2.0% - 3.0%		2.0% - 3.0%		2.0% - 3.0%		2.0% - 3.0%		2.0% - 3.0%		2.0% - 3.0%		2.0% - 3.0%		9,000 kg	
Carbon Black Dispersion	D5596	Note 5		Note 5		Note 5		Note 5		Note 5		Note 5		Note 5		20,000 kg	
Oxidative Induction Time (min. ave.) ⁶	D8117	100 min.		100 min.		100 min.		100 min.		100 min.		100 min.		100 min.			
High Pressure OIT	D5885	400 min.		400 min.		400 min.		400 min.		400 min.		400 min.		400 min.		90,000 kg	
Oven Aging at 85°C ⁴⁷	D8117	Standard OIT (min. ave.) - % retained after 90 days, or	55%	55%	55%	55%	55%	55%	55%	55%	55%	55%	55%	55%	55%	Per each formulation	
		High Pressure OIT (min. ave.) - % retained after 90 days	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	
UV Resistance ⁸	D8117	Standard OIT (min. ave.) - % retained after 1,600 hrs ¹⁰	Note 9	Note 9	Note 9	Note 9	Note 9	Note 9	Note 9	Note 9	Note 9	Note 9	Note 9	Note 9	Note 9	Per each formulation	
		High Pressure OIT (min. ave.) - % retained after 1,600 hrs ¹⁰	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	

1. Alternate the measurement side for double sided textured sheet.

2. Machine direction (MD) and cross machine direction (CMD) average values should be on the basis of 5 test specimens each direction. Yield elongation is calculated using a gauge length of 30mm.

3. Break elongation is calculated using a gauge length of 50mm.

4. The SP-NCTL test is not appropriate for testing geomembranes with textured or irregular rough surfaces. Test should be conducted on smooth sheets the same formulation as being used for the textured sheet materials. The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value. Via MOC testing.

5. Other methods such as D 4228 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D 1603 (tube furnace) can be established.

6. Carbon black dispersion (only near spherical agglomerates), 10 different views.

7. The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.

8. It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day responses.

9. The condition of the test should be 30 hr. UV cycle at 75°C, followed by 4 hr condensation at 60°C.

10. The condition of the test should be 30 hr. UV cycle at 75°C, followed by 4 hr condensation at 60°C.

9. *Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.*
10. *UV resistance is based on percent retained value regardless of the original HP-OIT value.*

6.6.1 Geomembrane Conformance Testing Requirements

As a minimum, the tests outlined in Table 6-6 should be completed.

Geomembrane conformance testing shall be undertaken by the Contractor. All conformance sampling shall be under the CQA Consultant’s supervision, whether at the Manufacturer’s premises or onsite. Materials shall not be incorporated into the works until the Superintendent/CQA Consultant has assessed the laboratory results, which comprises a Hold Point.

The Contractor shall submit the laboratory test results to the Superintendent/CQA Consultant for approval of the use of the materials in the works, at the earliest opportunity. Any delay by the Contractor in obtaining the test results shall be at the Contractor’s expense and the Contractor shall not be entitled to any extension of time for the Contract due to such delay unless the Superintendent/CQA Consultant has taken more than seven (7) days to reply to the Contractor’s submission. Acceptance of the HDPE conformance testing constitutes a Hold Point.

Testing will be undertaken at an accredited, independent third-party laboratory as approved by the Superintendent/CQA Consultant.

Table 6-6: Minimum CQA Testing for Geomembranes

Item	Property	Standards	Frequency per Geomembrane Type
Conformance Testing	Thickness	ASTM D5994	One sample per 5,000m ² , or every five rolls delivered to Site, whichever is the greatest number of tests
	Asperity Height (textured only)	ASTM D7466	
	Density	ASTM D1505, ASTM D792	
	Tensile properties (yield and break stress, yield and break elongation)	ASTM D6693 type IV	
	Puncture resistance	ASTM D4833	
	Tear resistance	ASTM D1004	
	Carbon black content	ASTM D1603	
	Carbon black dispersion	ASTM D5596	One sample every 10,000m ² , or resin type or manufacturing run (HDPE only)
	Stress crack resistance	ASTM D5397	
	Oxidative induction time	ASTM D8117, ASTM D5885	
	Axi-Symmetric break resistance strain	ASTM D5617	
Oxidative induction time	ASTM D8117, ASTM D5885		

Item	Property	Standards	Frequency per Geomembrane Type
	Oven ageing and oxidative induction Time	ASTM D5721, ASTM D8117, ASTM D5885	One sample every 10,000m ² , or resin type or manufacturing run (LLDPE only MQC)
Start-up test weld	Welding equipment		Checked daily at start of works, and whenever the welding equipment is shut-off for more than one hour. Also after significant changes in weather conditions
	Weld conditions		Test weld strips will be required whenever personnel or equipment are changed and/or wide temperature fluctuations are experienced. Minimum 1.5m continuous seam
Destructive weld testing	Onsite, hand tensiometer in peel mode		1 tab from start and finish of each weld for fusion welds
	Offsite - weld seam strength in peel and shear	ASTM D6392	Every 300m (if fusion weld) Every 150m (if extrusion weld)
Non-destructive weld testing		Air pressure test, ASTM D5820 Vacuum box test, ASTM D5641	All seams over full length
Visual inspection of geomembrane	Tears, punctures, abrasions, cracks, indentations, thin spots, or other faults in the material		Every roll

Note:

- (1) All conformance tests must be reviewed, accepted and reported by a CQA Consultant before deployment of the geomembrane.
- (2) All testing must be performed on samples taken from the geomembrane delivered to Site under the CQA Consultant supervision.
- (3) All laboratory tests must be performed in a third-party independent accredited geosynthetics laboratory.
- (4) The required testing frequencies may be revised by the CQA Consultant to conform to improvements in testing methods and/or in the state of the art practice and/or to account for the criticality of the application (i.e. to account for the importance of the geomembrane for the safety of works). Revisions must be approved by the relevant authorities before application.

The NATA laboratory shall issue all results to the Superintendent/CQA Consultant at the same time as they are issued to the Contractor. The Contractor and the NATA laboratory shall provide a signed disclosure confirming this procedure has been followed.

6.6.2 Geomembrane Deployment

The Contractor shall submit a detailed Geomembrane Panel Layout Plan showing the proposed layout and sequence of geomembrane placement not less than one week prior to commencing installation. Geomembrane panels shall be installed in accordance with the Layout Plan as approved by the Superintendent/CQA Consultant.

The Contractor shall arrange the panels so that seams are aligned parallel to the line of maximum slope (i.e. normal to contours), whenever practicable in accordance with accepted good practice.

There shall be no cross tie-in seams between batter and base panels within 2.5m of toe of batter.

The free edges of each panel shall be adequately weighed down with sandbags, tyres or other means approved by the Superintendent/CQA Consultant in readiness for seaming.

6.6.3 Seaming

All seaming shall conform to the methods detailed in the EPA Technical Guidance Document, “The Fabrication of Polyethylene FML Field Seams” (no. EPA/530/SW-09/069, September 1989).

The Contractor shall submit method statements not less than one week prior to commencing installation, detailing the following as a minimum:

- Proposed seaming technique or techniques and their proposed applications;
- Proposed seaming machinery;
- Overlap widths and overlap preparation prior to seaming;
- Proposed acceptable temperature ranges for extrudate and/or hot wedge; and
- Proposed acceptable maximum seaming speed if automated machinery to be used.

The Contractor should be aware of the possible temperature differential at the Site during the installation works. Typical Bureau of Meteorology (BOM) weather statistics from Wandering, the closest weather station to the Site at approximately 23.8km, are presented in Table 6-7.

Table 6-7: BOM Wandering Monthly Weather Statistics

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Rainfall (mm)	14.2	15.4	22.5	31.7	56.3	81.2	98.1	93.5	56.8	29.2	19.3	15.4
Mean Max Temp (C)	32.3	31.8	28.9	24.4	20.0	16.9	15.8	16.6	18.6	22.4	27.4	30.6
Mean Min Temp (C)	14.2	14.6	12.6	9.5	6.2	4.7	4.1	4.1	4.8	6.3	9.5	12.1

To minimise the propagation of wrinkles and tensions during installation due the expansion/contraction of the geomembrane, the Contractor shall be deemed to have allowed for all precautions as deemed necessary by the specialist lining Contractor including welding at night (if required) for all general seaming and tie-in welds.

All night work will require portable lighting. All health and safety controls and costs that are incurred by the Contractor, performing work outside of normal hours shall be deemed to be included in tendered rates.

6.6.3.1 Trial Seams

The Contractor shall perform trial seams with each seaming machine and operator at least at the start of each shift, after every four hours of operation and also following any period of machine shutdown or change of operator.

The trial seams shall be at least 1.5m long in the case of extrusion and fusion seams. On completion of the trial seam, the Contractor shall cut six 25mm wide field tabs normal to the seam spaced along the seam length. The tabs shall be subjected to field qualitative destructive testing using a tensiometer. Four of the six tabs shall be tested in peel mode with the other samples tested in shear mode.

The trial seam will be deemed to have passed qualitative destructive testing if the failure occurs solely in the parent material and does not enter the seam. The seam will be deemed to have failed qualitative destructive testing if any of the failure enters the seam.

If a trial seam fails field destructive testing as specified above, then the seaming machine and the operator shall not be allowed to perform field seaming until the deficiencies are corrected and both machine and operator have achieved a passing trial seam. Trial seaming and destructive testing will be observed by the Superintendent/CQA Consultant.

6.6.3.2 Field Seams

The Contractor shall perform field seams only after satisfying trial seam conditions as specified in Section 6.6.3.1 of this Specification. The Contractor shall ensure that all pre-treatment measures (e.g. grinding and cleaning), as specified in EPA/530/SW-89/069 are carried out and that extrudate and/or wedge temperatures are maintained within a range approved by the Superintendent.

The Contractor's attention is drawn to the stipulations in EPA/530/SW-89/069 that:

Seaming is not allowed during rain, hail or snow unless proper precautions, are made to allow the seam to be made on dry geomembrane materials:

- Seaming above saturated soil is not acceptable;
- Ponded water on the soil surface beneath the geomembrane is not acceptable;
- Seaming above frozen ground is not acceptable; and
- Ambient temperature for seaming should be above 5°C.

All field seams shall be completed to the back edge of the anchor trench, i.e. the edge furthest away from the slope or toe bund. Any seam defects falling within the anchor trench shall be repaired in accordance with Section 6.6.4.4 of this Specification.

During construction the specified overlap shall be clearly marked on the edge of the underlying sheet seam prior to seaming. Failure to maintain the minimum overlap may be cause for rejection of the seam.

Extrusion Welding

The Contractor shall verify that extrusion-seaming apparatuses are equipped with gauges giving the relevant temperatures of the extrudate, nozzle, and preheat. In addition, the Contractor shall certify in writing to the Superintendent that the extrudate is compatible with the specifications.

A log of apparatus temperatures, extrudate temperatures, and ambient temperatures at appropriate intervals will be made by the Contractor, during the installation works. Ambient temperatures will be measured approximately 50mm above the geomembrane surface.

Fusion Welding

The Contractor shall ensure that fusion-seaming apparatus comply with the requirements of the Specification. Temperature and pressure settings shall be verified by the Contractor prior to each seaming period, and will be logged (ambient temperatures, seaming apparatus temperatures, speeds). Ambient temperatures will be measured approximately 50mm above the geomembrane surface.

Prior to seaming the Contractor shall confirm that:

- the seam area is clean and free of moisture, dust, dirt, debris of any kind, and foreign material;
- if seam overlap grinding is required, the process is completed within one hour of the seaming operation, and in a way that does not damage the geomembrane;
- if seam overlap grinding is required, less than 10% of the nominal thickness shall be removed;
- the grinding does not extend more than 10mm on either side of the extrusion seam; and
- seams are aligned with the fewest possible number of wrinkles and “fishmouths”.

6.6.4 Sampling and Testing

6.6.4.1 Non-Destructive Testing

The Contractor shall perform non-destructive testing along the entire lengths of all field seams including patches and repairs. The Contractor shall submit not less than one week prior to commencing installation a method statement detailing the proposed non-destructive test technique or techniques and the proposed applications.

For air pressure testing of fusion seams the test length should be sealed at both ends and an approved pressure feed divide inserted into the air channel. The channel should then be pumped to

a pressure of between 25 and 30 psi (~2bar) and allowed to stabilise for 1 minute. The test will have deemed to have failed if the loss of pressure exceeds 10% over a 5-minute period following stabilisation.

Air pressure tests shall be released from the opposite end of the seam to the gauge to verify that the entire seam has been tested and there is no blockage part way along the seam. All pressure test perforations shall be repaired by grinding and welding over the perforation (this also includes needle holes).

For vacuum box testing each section of the seam should be tested and observed for a period of not less than 10 seconds. Apply a generous amount of a strong soapy solution and water to the area to be tested to help create a vacuum. Turn on the vacuum pump and set it to produce approximately 0.35bar of vacuum. It is important that an overlap of a minimum of 75mm is maintained every time the vacuum box is moved along the seam.

For spark testing, a length of copper wire shall be placed along the edge of the repair or extrusion welded seam prior to welding. Following welding, a high-tension electrode is passed over the seam, and any faults in the seam are highlighted by a characteristic increased sparking sound and electrical discharge. Any faults shall then be ground to remove any dirt and a further layer of extrudate applied to ensure a seal is formed. The defect shall then be tested again to ensure that the area has been remediated to a suitable manner.

In the event of a field seam failing non-destructive testing the Contractor shall identify and repair the failed area in accordance with Section 6.6.4.4 of this Specification. The Contractor shall then subject the repair to further non-destructive testing until the repair shall pass the test.

The Contractor shall advise the Superintendent/CQA Consultant when the Contractor is ready to commence non-destructive testing and shall not perform non-destructive testing unless the Superintendent/CQA Consultant is in attendance, constituting a **Hold Point**.

6.6.4.2 Qualitative Destructive Testing

The Contractor shall cut a 25mm wide field tab from the beginning and end of each completed field seam and shall subject it to qualitative destructive testing in peel mode using a tensiometer.

The Contractor **shall not** tear overlaps/rip into the seams to check weld quality. Any such damage shall be deemed a defect and repaired in accordance with Section 6.6.4.4.

The seam will be deemed to have passed qualitative destructive testing if the failure occurs solely in the parent material and does not enter the seam. The seam will be deemed to have failed qualitative destructive testing if any of the failure enters the seam.

If a field tab fails qualitative destructive testing, the Contractor shall either:

- reconstruct the seam between two tabs shown to have passed qualitative destructive testing; or
- cut further tabs from 3m to each side of the failed tab and subject these to qualitative destructive testing.

If these tabs pass qualitative destructive testing the Contractor shall reconstruct the seam between the passed locations in accordance with Section 6.6.4.4 of this Specification. If either sample fails, the Contractor shall cut and test further field tabs until an area bounded by two passed locations can be identified. The Contractor shall then reconstruct the failed seam in accordance with Section 6.6.4.4 of this Specification.

The Superintendent/CQA Consultant reserves the right to request the cutting and destructive testing of further field tabs at any locations along the length of a seam. Acceptance of the qualitative HDPE destructive testing constitutes a **Hold Point**.

6.6.4.3 Quantitative Destructive Testing

The Contractor shall cut laboratory samples from the field seams when instructed by the CQA Consultant and in any case at a frequency not exceeding 1 sample per 300m (if fusion weld), 1 sample per 150m (if extrusion weld) or one per day of welding of seam performed by an individual machine whichever is greater.

The Contractor shall divide the sample and release sub-sample A to the Superintendent for archiving. The Contractor shall without delay dispatch sub-sample B to an approved geosynthetic laboratory for destructive testing in accordance with Table 6-8, or testing on-site utilising a calibrated tensiometer. The Contractor should note that five tabs should be cut for peel tests and five tabs for shear tests. The laboratory shall report quantitative results and the mode of failure for the tests carried out. The Contractor shall issue copies of the test results certificates to the Superintendent/CQA Consultant immediately upon receipt, within 48 hours of cutting the sample from the installation.

If the samples are tested on-site the Contractor shall provide the calibration certificate to the Superintendent for the field tensiometer prior to undertaking any testing.

The seam will be deemed to have passed quantitative destructive testing if in four out of five tabs:

- The failure occurs solely in the parent material and does not enter the seam;
- The peel strength exceeds that indicated in Table 6-8; and
- The shear strength exceeds that indicated in Table 6-8.

The seam will be deemed to have failed quantitative destructive testing if in more than one out of five tabs:

- Any of the failure enters the seam;
- The peel strength is less than that indicated in Table 6-8; and
- The shear strength is less than that indicated in Table 6-8.

If a seam fails quantitative destructive testing the Contractor shall investigate the seam to each side of the failed sample as specified in Section 6.6.4.2 of this Specification. The Contractor shall cut further laboratory samples from each side of the failed section and perform laboratory tests upon them at the expense of the Contractor until the failed seam is bounded by two passed locations.

The Contractor shall then reconstruct the failed seam in accordance with Section 6.6.4.4 of this Specification. The Superintendent/CQA Consultant may at the Superintendent/CQA Consultant's

discretion observe laboratory destructive testing in which event the Contractor shall arrange permission for access to the approved laboratory.

The Contractor shall furnish the CQA Consultant/ Superintendent with a copy of the formal report from the destructive testing detailing the procedures used for testing and including a summary of all results, prior to covering of the geosynthetics. This constitutes a **Hold Point**.

Table 6-8: Geomembrane Field Seam Destructive Testing Criteria

Test	Method	2.0 mm HDPE Requirement (minimum)
Fusion Welds		
Fusion Shear	ASTM D4437	28.0 N/mm (~701N/25mm)
Fusion Peel	ASTM D4437	21.2 N/mm (~530N/25mm)
Extrusion Welds		
Extrusion Shear	ASTM D4437	28.0 N/mm (~701N/25mm)
Extrusion Peel	ASTM D4437	18.2 N/mm (~455N/25mm)

Note:

- (1) Peel Test on double fusion welds to be carried out on both welds.
- (2) Peel Separation <25% of seam width.
- (3) Shear Elongation at failure: Smooth >100% x L, Textured >50% x L.
- (4) Both sides of Fusion weld need to pass strength requirements and Film Tear Bond to constitute a pass.
- (5) Seam strengths are in accordance with GRI GM 19.

6.6.4.4 Repairs, Patches and Cap-Strips

All discontinuities in the geomembrane (whether caused by damage, or failure of geomembrane or seams to conform with Specification, or of sampling or testing or other factors), shall be repaired by the Contractor in the following manner, all holes (including pinholes) in the liner will be patched:

Superficial Defects (Dents and Creases)

- The area shall be prepared in accordance with EPA/530/SW-89/069 and an extra layer of extrudate applied as approved by the Superintendent.

Holes, Pinholes, Cuts & Large Faults

- Large faults, and any holes in the faulted area shall be cut back to remove all imperfections and shall be overlain with a single piece of compatible geomembrane to give a minimum overlap of 100mm in all directions. The area shall then be prepared in accordance with EPA/530/SW-89/069 and seamed in accordance with Section 6.6.3 of this Specification.

Seam Faults

- Faulted extrusion seams shall be overlain with a single piece of compatible geomembrane with a minimum overlap of 100mm in all directions to form a cap strip. The repair may then be completed as for large faults.
- Faulted fusion seams shall be cut back to remove the upper flap, prepared in accordance with EPA/530/SW-89/069, and extruded in accordance with Section 6.6.3 of this Specification.

The Contractor shall test all repairs in accordance with Section 6.6.4.1 of this Specification.

6.6.5 Geomembrane Ballasting

Unless specified otherwise, the Contractor shall design, supply and install the geomembrane/geotextile ballasting system to ensure that the liner will not be adversely affected by wind and/or thermal movement during installation of the lining system. The ballasting system shall be submitted to the Superintendent/CQA Consultant in writing for approval prior to its use.

The Contractor is to place permanent sandbag surcharge on permanently exposed HDPE geomembrane/protection geotextile on the sideslopes that will not be covered by another layer at a minimum of 2m spacing along the seams, change of grade between the basal and sideslopes and external perimeter of the geomembrane. The Contractor is to satisfy themselves of surcharging adequacy to prevent uplift and damage of the geomembrane/geotextile. This constitutes a **Hold Point**.

6.7 Cushion/Protection Geotextile

A cushion/protection geotextile is required between the HDPE geomembrane layer and the leachate collection aggregate. The cushion/protection geotextile shall be woven, or non-woven needle punched, constructed from virgin fibres of polypropylene or polyester, incorporating a minimum 1% by weight active carbon black, or another approved UV stabiliser. The geotextile shall be certified needle free.

No transverse jointing/overlapping of geosynthetic panels will be allowed on side slopes. The Contractor shall ensure that bespoke roll lengths are manufactured so that rolls can be installed within the anchor trenches and extend down the slopes to a minimum of 2m onto the cell base without the need for mid-slope seams.

The Contractor should confirm the grade of geotextile proposed to be of sufficient mass, strength and thickness, to protect the underlying geomembrane from damage from the overlying leachate drainage aggregate, with regards to stresses, strains and indentations. Maximum allowable global strain of 4% for HDPE textured geomembrane.

The Principal will provide a sample of the proposed leachate drainage aggregate source/grading and proposed cushion/protection geotextile to an approved laboratory for performance testing of the cushion/protection geotextile.

Acceptance of the cushion protection geotextile/leachate drainage aggregate performance testing constitutes a **Hold Point**.

International methods for examining performance of a protection geotextile and geomembrane include:

- LFE 2 – Cylinder Testing Geomembranes and their Protective Materials: A Methodology for testing protective materials: A methodology for testing protector geotextiles for their performance in specific Site conditions (UK Environment Agency, 2014);
 - The sample shall be subjected to a loading of the height of waste at an assumed density 1.0 tonnes/m³ load plus the thickness of restoration soils at a density of 2.0 tonnes/m³, the total load being factored accordingly to the test duration and temperature. The specific pass and failure criteria for the test should be agreed with

the Superintendent/CQA Consultant following agreement on the specific test method. As guidance a specific strain value may be used for acceptance, with the allowable local strain criteria $\leq 0.25\%$.

- ASTM D5514 / D5514M-14, Standard Test Method for Large Scale Hydrostatic Puncture Testing of Geosynthetics (ASTM International, 2014);
- EN 13719:2016 – Geotextiles and Geotextile-Related Products – Determination of the Long-Term Protection Efficiency of Geotextiles in Contact with Geosynthetic Barriers; and
- EN 14574:2015 Geosynthetics – Determination of the pyramid puncture resistance of supported geosynthetics.

Maximum allowable global strains should be in accordance with Victoria EPA BPEM and NSW EPA Solid Waste Landfills maximum allowable strains, who have adopted values from Peggs, 2003.

Table 6-9: Summary of Maximum Allowable Strains for Varying Geomembranes (from Peggs, 2003)

Geomembrane Type	Maximum Allowable Strain
HDPE Smooth	6%
HDPE randomly textured	4%
HDPE structured profile	6%

Tests should be undertaken with a loading of the 50m height of waste at an assumed density 1.0 tonnes/m³ load plus 1.3m of restoration soils at a density of 2.0 tonnes/m³, the total load being factored accordingly to the test duration and temperature.

The Contractor shall inform the CQA Consultant/Superintendent of the proposed test method, including material parameters/stone gradings/loadings/methodology etc., for approval prior to undertaking the test. The Contractor shall supply the CQA Consultant/Superintendent with a copy of the formal report from the performance testing detailing the procedures used for testing and including a summary of all results, for acceptance prior to incorporation of materials in the works.

The required material properties, test methods, values and units are presented in Table 6-10, as a general guide only. These values are subject to change following completion of the aforementioned strain analysis.

Table 6-10: Physical Properties for Cushion Protection Geotextile

Properties	Test Method	Requirement
CBR Puncture Resistance	AS 3706.4	9,000 N
Strip Tensile Strength MD/CD	AS 3706.2	50/50 kN/m
Tear Strength CD	AS 3706.2	1,200 N
Thickness @ 2kPa	AS 3706.1	TBC mm *
Mass per unit area	AS 3706.1	TBC g/m ² *

*Dependent on MARV of proposed protection geotextile.
 MD = machine direction
 CD = cross direction

6.7.1 Cushion/Protection Geotextile Conformance Testing Requirements

Geotextile conformance testing shall be undertaken by the Contractor. Materials shall not be incorporated into the works until the Superintendent/CQA Consultant has assessed the laboratory results.

The NATA laboratory shall issue all results to the Superintendent/CQA Consultant at the same time as they are issued to the Contractor. The Contractor and the NATA laboratory shall provide a signed disclosure confirming this procedure has been followed.

The Contractor shall submit the laboratory test results to the Superintendent/CQA Consultant for approval of the use of the materials in the works, at the earliest opportunity. This constitutes a **Hold Point**. Any delay by the Contractor in obtaining the test results shall be at the Contractor’s expense and the Contractor shall not be entitled to any extension of time for the Contract due to such delay unless the Superintendent/CQA Consultant has taken more than seven (7) days to reply to the Contractor’s submission.

Testing will be undertaken at an accredited, independent third-party laboratory as approved by the Superintendent/CQA Consultant for the properties detailed in Table 6-11.

Acceptance of the cushion/protection geotextile conformance testing constitutes a **Hold Point**.

Table 6-11: Conformance Testing for Cushion/Protection Geotextile

Property	Standards	Frequency
Thickness	AS 3706.1	One sample per 2,500m ²
Mass per unit area	AS 3706.1	
Tensile Strength	AS 3706.2	One sample per 5,000m ²
Tear Strength	ASTM D4833, AS 3706.3	
Burst Strength	ASTM D6241, AS3706.4	

6.7.2 Cushion/Protection Geotextile Installation

The Manufacturer’s recommended installation procedures will be submitted by the Contractor for the sewing/thermally bonding of the geotextile, including procedures for repair. All seaming shall be performed by trained, experienced and competent personnel. The Contractor may also be requested to submit training, competency or experience records of the installers to the Superintendent for approval.

Non-woven needle-punched geotextile shall be installed to the requirements of the construction specifications. The geotextile shall be placed by the lining contractor at the locations shown on the contract Drawings. All geotextile seams placed on slopes shall be overlapped a minimum of 300mm and thermally bonded using a "Leister" gun. Seams on side slopes will be oriented with the slope. End-of-roll seams will be offset a minimum of 1m between adjacent roll ends. Cross-slope seams shall be avoided. Installed bedding fabric shall be covered with the interfacing material as soon as practical, but in no case longer than 14 calendar days. During periods of high winds, sandbags or

other methods approved by the Manufacturer shall be used to secure any exposed fabric in place. Surcharge will be placed at minimum 1m spacing along joints.

Construction vehicles shall not be allowed to operate directly on top of the geotextile and will only be permitted to travel over the geosynthetics on haul roads that are a minimum of 1m in depth constructed out of soils/drainage materials. Any geotextile that has granular material placed upon it shall have 300mm (minimum) of the material placed onto the fabric and spread in advance of construction equipment with high floatation/low ground pressure equipment. The material will be spread in the same direction as the fabric is seamed. Extreme care is required by the Contractor so that the equipment operator only pushes the materials ahead without damage to the fabric. At no time will construction equipment be permitted to track directly on the fabric.

Any holes or tears in the geotextile will be repaired by placing a patch with at least 300mm of overlap of the same material over the defective area. All patches will be thermally bonded as per normal seaming practices. Any damage to the fabric or lining system will be repaired by the Contractor (using approved methods) at no expense to the Principal. Completed cushion/protection geotextile installation and surcharging shall be approved by the Superintendent/CQA Consultant and constitutes a Hold Point.

6.8 Separation Geotextile

Following placement of the leachate collection layer, a separation geotextile is to be placed directly over the leachate drainage and collection system on the base of the landfill cell. The separation geotextile shall be woven, or non-woven needle punched, constructed from virgin fibres of polypropylene or polyester, incorporating a minimum 1% by weight active carbon black, or another approved UV stabiliser. The geotextile shall be needle free.

Non-woven needle-punched geotextile shall be installed to the requirements of the construction specifications. The geotextile shall extend 1m beyond the leachate collection layer, as shown on the construction Drawings.

A general guide to the required material properties, test methods, values and units are presented in Table 6-12.

Table 6-12: Physical Properties for Separation Geotextile

Properties	Test Method	Requirement
CBR Puncture Resistance	AS 3706.4	2,500 N
Strip Tensile Strength MD/CD	AS 3706.2	14 kN/m
Elongation at MD	AS 3706.2	TBC %
Thickness @ 2kPa	AS 3706.1	TBC mm *
Mass per unit area	AS 3706.1	TBC g/m ² *

*Dependent on MARV of proposed protection geotextile.

MD = machine direction

CD = cross direction

6.8.1 Separation Geotextile Conformance Testing Requirements

Geotextile conformance testing shall be undertaken by the Contractor. Materials shall not be incorporated into the works until the Superintendent/CQA Consultant has assessed the laboratory results.

The NATA laboratory shall issue all results to the Superintendent/CQA Consultant at the same time as they are issued to the Contractor. The Contractor and the NATA laboratory shall provide a signed disclosure confirming this procedure has been followed.

The Contractor shall submit the laboratory test results to the Superintendent/CQA Consultant for approval of the use of the materials in the works, at the earliest opportunity. This constitutes a **Hold Point**. Any delay by the Contractor in obtaining the test results shall be at the Contractor’s expense and the Contractor shall not be entitled to any extension of time for the Contract due to such delay unless the Superintendent/CQA Consultant has taken more than seven (7) days to reply to the Contractor’s submission.

Testing will be undertaken at an accredited, independent third-party laboratory as approved by the Superintendent/CQA Consultant for the properties detailed in Table 6-13.

Acceptance of the cushion/protection geotextile conformance testing constitutes a **Hold Point**.

Table 6-13: Conformance Testing for Separation Geotextile

Property	Standards	Frequency
Thickness	AS 3706.1	One sample per 2,500m ²
Mass per unit area	AS 3706.1	
Tensile Strength	AS 3706.2	One sample per 5,000m ²
Tear Strength	ASTM D4833, AS 3706.3	
Burst Strength	ASTM D6241, AS3706.4	

6.8.2 Separation Geotextile Installation

The Manufacturer’s recommended installation procedures will be submitted by the Contractor for the sewing/thermally bonding of the geotextiles, including procedures for repair. All seaming shall be performed by trained personnel. The Contractor may also be requested to submit training or experience records of the installers to the Superintendent for approval.

Non-woven needle-punched geotextiles shall be installed to the requirements of the construction specifications. The geotextiles shall extend 1m beyond the leachate collection layer, as shown on the construction Drawings.

The separation geotextiles shall be placed by the lining contractor at the locations shown on the contract Drawings. All geotextile seams placed on slopes shall be overlapped a minimum of 300mm and thermally bonded using a "Leister" gun. Seams on side slopes will be oriented with the slope. End-of-roll seams will be offset a minimum of 1m between adjacent roll ends. Cross-slope seams shall be avoided. Installed bedding fabric shall be covered with the interfacing material as soon as

practical, but in no case longer than 14 calendar days. During periods of high winds, sandbags or other methods approved by the Manufacturer shall be used to secure any exposed fabric in place. Surcharge will be placed at minimum 1m spacing along joints.

The separator geotextile will be thermally bonded using a "Leister" gun onto the protection geotextile at the extents of installation on the side slopes and bunds. The Contractor is to place permanent sandbag surcharge on the separator geotextile at a minimum of 5m spacing along the seams and either side of each primary and secondary leachate collection pipe run aggregate mound, change of grade between the basal and side slopes and external perimeter of the separation geotextile. The Contractor is to satisfy himself of surcharging adequacy to prevent uplift and damage of the geotextile.

Construction vehicles shall not be allowed to operate directly on top of the geotextile and will only be permitted to travel over the geosynthetics on haul roads that are a minimum of 1m in depth constructed out of soils/drainage materials. Any geotextile that has granular material placed upon it shall have 300mm (minimum) of the material placed onto the fabric and spread in advance of construction equipment with high floatation/low ground pressure equipment. The material will be spread in the same direction as the fabric is seamed. Extreme care is required by the Contractor so that the equipment operator only pushes the materials ahead without damage to the fabric. At no time will construction equipment be permitted to track directly on the fabric.

Any holes or tears in the geotextile will be repaired by placing a patch with at least 300mm of overlap of the same material over the defective area. All patches will be thermally bonded as per normal seaming practices.

Any damage to the fabric or lining system will be repaired by the Contractor (using approved methods) at no expense to the Principal. Completed separation geotextile installation and surcharging shall be approved by the Superintendent/CQA Consultant and constitutes a **Hold Point**.

6.9 Anchor Trenches

6.9.1.1 Excavation

Anchor trenches for the geosynthetic liner components shall be constructed at the locations shown on the Drawings. The anchor trench shape and dimensions shall be as shown on the Drawings.

Where the Contractor considers that there is insufficient room to handle the geosynthetics alongside the anchor trenches, the Contractor may construct a wider working area than shown in the Drawings. This working area shall be removed prior to Practical Completion. The construction of this working area shall be at the discretion of the Contractor, and its construction, maintenance and removal shall not constitute a variation under the Contract or a cause for Extension of Time.

6.9.1.2 Backfilling

Generally, the excavated material from the anchor trench will be used as backfill over the geosynthetics in the trench. Where this material is unsuitable, it shall be removed and replaced by clay material or other approved by the Superintendent.

The fill shall be placed and suitably compacted with handheld compaction equipment in horizontal layers not exceeding 150mm in thickness to an approved density. This constitutes a **Hold Point**.

Prior to backfilling, the geosynthetic liners shall be checked to ensure that there are no folds or other irregularities. The geosynthetic liners shall be in a stress free, 'lay flat' state over the entire area.

All materials cut from the landfill as part of the excavation for anchor trench works will be levelled and compacted in the vicinity of the anchor trench. As such no movement of waste around the landfill should occur. Any exposed or excavated waste shall be covered as soon as is practicably possible and in any event at the end of each working day.

Marker posts are to be installed once the backfilling has been completed to locate the centreline of the anchor trenches.

6.10 Maintenance

The geosynthetic materials shall be not be exposed for longer than is specified on the Manufacturer's installation guidelines. Each layer of geosynthetic liner shall be kept clean, free from dust, sticks and rocks during its temporary exposure.

The Superintendent will not entertain any claim for financial compensation or extension of time to the Contract as a result of delays in the provision of laboratory or on-site testing of geosynthetic materials.

7 Leachate Collection Layer

The leachate collection layer shall be constructed from a low calcareous aggregate with a hydraulic conductivity of $>1 \times 10^{-3}$ m/s and the properties in Table 7-1.

Table 7-1: Properties of Leachate Collection Layer (Aggregate)

Property	Requirement
Maximum Particle Size	53mm TBC following testing in Section 6.7
Percent Passing 37.5mm sieve	>85% TBC following testing in Section 6.7
Percent Passing a 20mm sieve	<20% TBC following testing in Section 6.7
Percent Passing a 2.36mm sieve	<3% TBC following testing in Section 6.7
Percent fines value (<0.075mm)	<1%
Calcium Carbonate Content	<8.5% wt.
Soaked Ten percent fines value	100kN

The leachate drainage aggregate grading will be confirmed following the aggregate and cushion/protection geotextile performance testing to determine actual passing material combinations.

7.1 Installation

Construction vehicles shall not be allowed to operate directly on top of the geotextiles and will only be permitted to travel over the geosynthetics on haul roads that are a minimum of 1m in depth constructed out of soils/drainage materials. Any geotextile that has granular material placed upon it shall have 300mm (minimum) of the material placed onto the fabric and spread in advance of construction equipment with high floatation/low ground pressure equipment. The material will be spread in the same direction as the fabric is seamed. Extreme care is required by the Contractor so that the equipment operator only pushes the materials ahead without damage to the fabric. At no time will construction equipment be permitted to track directly on the fabric.

The leachate collection layer shall be placed in a single layer. Placement of this layer shall be carried out without any deforming of the underlying materials. The final surface shall be smooth and free from surface aberrations. The Contractor shall provide an as-built survey (and isopachyte) of the installed leachate drainage thickness to the Superintendent/CQA Consultant for approval. This constitutes a Hold Point.

It is a requirement that the proposed material for the leachate collection layer be approved by the Superintendent prior to its intended placement. The Superintendent reserves the right to reject the use of any material that they deem unsuitable for use in the leachate collection layer, whether or not it conforms to this Specification. All expenses for the transport, testing, placing of material that the Superintendent has not approved will be borne by the Contractor.

7.2 Tolerances

The Contractor should ensure all survey data is passed to the Superintendent for approval to demonstrate the required installation levels have been met, comprising a **Hold Point**.

The tolerances for the final leachate collection layer levels are: -0mm /+50mm.

7.3 Testing

The Contractor will undertake four (No. 4) grading analyses from the leachate drainage aggregate materials delivered to Site, for acceptance by the Superintendent/CQA Consultant prior to incorporation into the works. This constitutes a **Hold Point**.

8 Pipework

A network of leachate collection pipework shall be installed across the basal area of the landfill cell to transmit leachate to the Cell 5 sump area.

8.1 Products and Materials

8.1.1 High Density Polyethylene Pipes

High Density Polyethylene (HDPE) pipes shall be supplied in accordance with this Specification and Drawings. All HDPE pipework shall be to the nominal diameter and Standard Dimension Ratio (SDR) as shown on the Drawings. The Contractor shall provide all necessary fittings and accessories including junctions, branches, and other fitments. The Contractor may elect to use prefabricated pipework for complex or bespoke sections.

All pipes shall be formed from solid walled HDPE pipe. Plain pipes shall be tested to 1.5 times the working pressure. For perforated pipes, the pipe Manufacturer shall submit calculation to confirm the integrity of the pipes as not being compromised by the installation of slots/perforations. Unless agreed otherwise by the Superintendent, perforations shall be as indicated on the Drawings.

All leachate collection pipework shall be laid upon 100mm of drainage layer material, shall have twice the pipe diameter of cover. For leachate collection pipes, the Contractor shall submit calculations from the pipework Manufacturer using ATV 127 Method (or similar approved) to demonstrate the following requirements:

- Pipe deflection < 6%;
- D85/hole diameter >1.0 (Circular perforations -5% open area);
- D85/hole diameter >1.2 (Slot perforations - 5% open area);
- Where D85 refers to the pipe granular surround. The following assumptions can be made:
 - waste Density 1000 kg/m³;
 - maximum waste depth = 50m;
 - soil stiffness of an uncompacted unconfined gravel surround on the base of the landfill (Bank installation under ATV); and
 - pipe is perforated.

The acceptance of the leachate collection pipework deflection calculation constitutes a **Hold Point**.

8.2 Installation

8.2.1 Pipe Laying

The installation and butt fusion/electrofusion welding of PE pipes shall only be undertaken by skilled, competent and experienced personnel. The Principal reserves the right to request documentation for proof of competency, training and experience.

All pipes shall be laid in accordance with the manufacturer’s recommendations to uniform gradients and to levels shown. All materials to be used in the pipe laying operations shall be carefully inspected before use to ensure that damaged material is not used in the works. The interior of pipes, specials and fittings shall be carefully cleaned before being installed.

Pipe laying shall not commence until the underlying geosynthetics and the pipe bed has been approved by the CQA Consultant. Pipes shall be brought to the correct alignment and inclination, concentric with the pipes already laid.

Pipes shall be set in an upstream direction unless otherwise approved by the Superintendent. All HDPE pipes shall be butt weld jointed by proprietary welding equipment unless specified elsewhere. Welding shall take place in locations which are protected from unfavourable weather conditions. All butt welds shall be reamed internally in order to remove excess beading.

The Contractor shall prevent any damage from occurring to the underlying geotextile and geomembrane during pipe installation. Should the geotextile or geomembrane be damaged in any way the Contractor shall repair the damage at the Contractor’s cost according to Section 6.6.4.4, 6.7.2 and 6.8.2.

PE pipes should be backfilled/covered as soon as practicable to minimise thermal movements.

8.2.2 Continuity of Laying

All pipelines shall be laid in a continuous operation. It will not be permissible to leave gaps where fittings, etc., occur and return later to infill the gaps. The Contractor shall ensure that all bends and specials are available for each section of the work before work commences on that particular section. Immediately after laying, the open end of a pipe will have to be sealed with a wooden plug or approved stopper of appropriate size to prevent the entry of material which contaminates the pipeline, damages linings or impacts its functionality.

8.2.3 Tolerances

The tolerances shown in Table 8-1 shall apply to all installed pipes, unless specified otherwise.

Table 8-1: Tolerances of Pipes and their Components

Component	Alignment	Level
Pipes	±50mm	±25mm

9 Leak Detection Survey

The Contractor is advised that geomembrane leak location surveys are to be undertaken following installation of the leachate drainage layer and before the separation geotextile installation.

The Contractor is to undertake a dipole survey over the surface area of the completed leachate drainage stone, in accordance with ASTM D7007. An electrical voltage is passed between two electrodes, a fixed electrode placed in the ground outside the lined area and a moveable set of electrodes within the cell area. The Contractor is required to measure the electrical potential and detect any defects within the geomembrane. To ensure no electrical leakage occurs, a strip of geomembrane should be left exposed around the perimeter of the test area to ensure complete electrical isolation.

The Contractor should ensure a 0.5m (minimum) wide strip of geomembrane/geotextile is to be left exposed around the perimeter of the area to be tested, enabling the geomembrane to be electrically isolated from the surrounding ground during testing. The Contractor will be required to place drainage aggregate/reinstate access ramp on the isolation strip upon successful completion of the leak detection test.

The Contractor is to undertake an artificial leak detection sensitivity test prior to the commencement of each day of surveying. The cell area shall be surveyed on a grid system, data shall be recorded, plotted and analysed for leak signals. The Contractor shall also ensure that the drainage blanket is wet enough to conduct electricity and shall be required to wet the drainage stone throughout the survey period.

All anomalies shall be investigated, and where defects are identified the geomembrane shall be repaired. Following repair procedures and reinstatement of geosynthetics and drainage stone, the area shall be locally resurveyed to ensure the defect was not masking further defects in the vicinity.

On completion of the leak detection survey the Contractor is to provide a report as a minimum as described in ASTM D7007 outlining the electrical potential across the landfill cell area, including the location of the internal and external electrodes for each day of surveying, and the location of any detected leaks/defects. All resurveying shall also be recorded and provided within the final report.

The geomembrane above the leachate drainage stone shall also be surveyed with a dipole survey to detect any potential leaks/defects.

The Contractor will investigate all anomalies and, where required by the CQA Consultant/Superintendent, repair the underlying geomembrane. All repair works to the geomembrane, and overlying materials which require removal and reinstatement, will be at the cost of the Contractor.

Completed leak detection survey results and reporting shall be submitted to the Superintendent/CQA Consultant for approval and constitute a **Hold Point**.

APPENDIX A

Drawings

APPENDIX B

Bill of Quantities

APPENDIX C

Construction Quality Assurance Plan



Assets | Engineering | Environment | Noise | Spatial | Waste

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