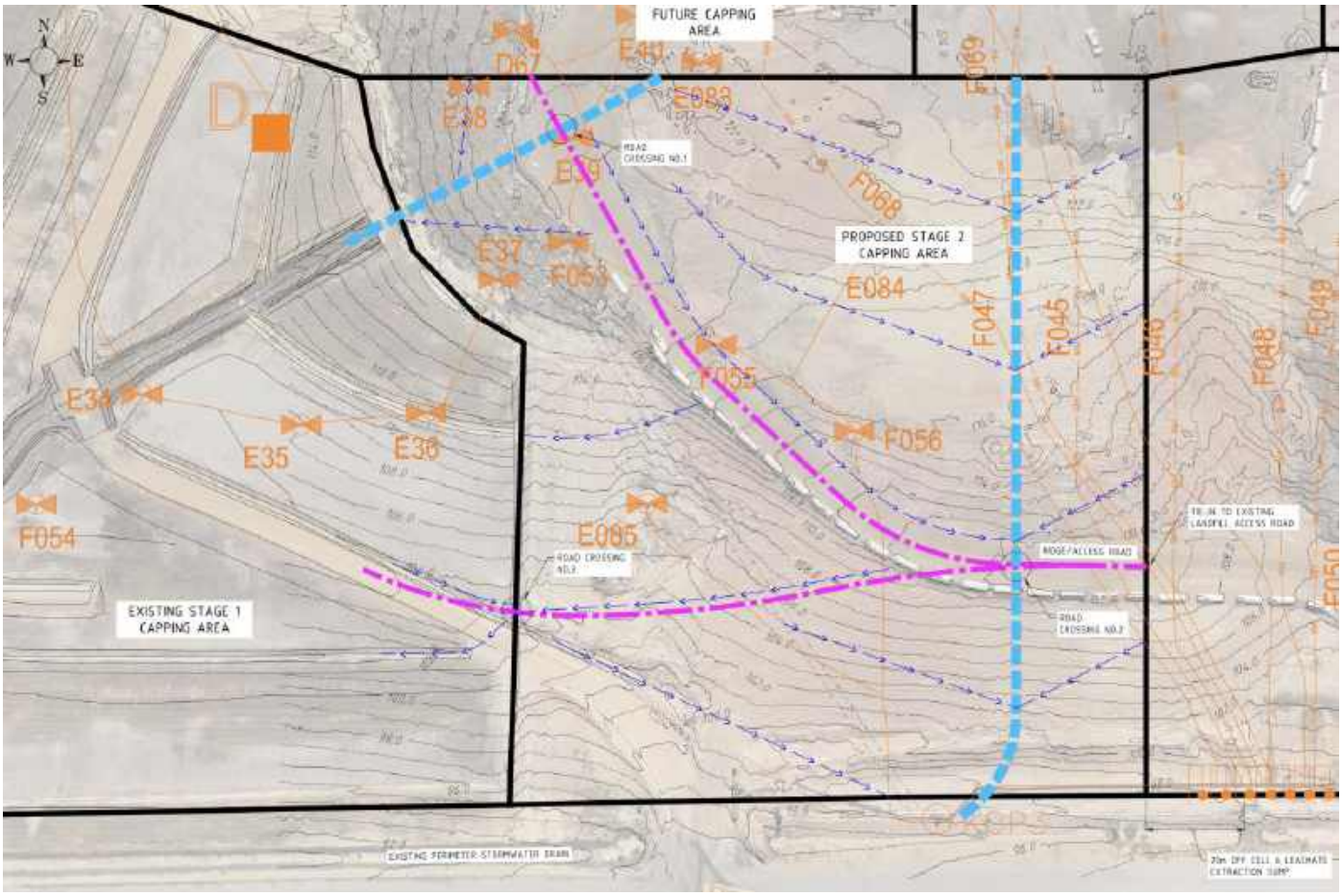
BANKSIA ROAD LANDFILL, DARDANUP

LANDFILL STAGE 2 CAPPING

CONSTRUCTION SPECIFICATION



Proposed Stage 2 Capping Areas

Prepared for

CLEANAWAY SOLID WASTE

IW Projects Pty Ltd

[redacted]

Revision: Final
Date of Issue: 22 Apr 2025

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1 Specification

1.1 Description of Works

The Contract includes all management, operations, labour, plant, materials, supervision, survey and all else required for the construction and completion of the whole of the Works described in this Specification and shown on the Drawings, and for complying with the Conditions of Contract, together with any additional Works or variations ordered by the Superintendent. The Contract also includes a Defects Liability Period as stated in the Annexure to the General Conditions of Contract.

The scope of Works includes:

- Survey and setting out, including assessing the landfill cap surface, before and after construction activities to identify if any areas are steeper than 1 (V) in 3.5 (H);
- Excavation to suit design layout (if required), including stockpiling of the various excavated materials (soft material, clayey material, unsuitable material) as instructed by the Superintendent;
- Fill placement to re-contour the landfill surface (if required);
- Construction of Stage 2 landfill capping;
- Construction of surface water control drainage on the capped surface;
- Construction of access tracks on the capped surface;
- Spreading a thin layer of topsoil over the capped surface and deep ripping it into the surface;
- Such other Works as shown on the Drawings or as described in this Specification;
- Construction Quality Control testing and sampling; and,
- Provision of "As Constructed" information.

1.2 Works Not Included

The scope of the Works does not include:

- Supply of construction water;
- The supply of soil materials;
- Supply of geosynthetic liner materials; and,
- Hydromulching the final capped surface.

1.3 Principal

The Principal for the project will be Cleanaway Solid Waste Pty Ltd.

1.4 Principal Supply Items

The Principal shall supply the following items:

- Water for construction;
- Soil materials for the capping layer works, including topsoil; and,
- Geosynthetic liner materials.

With regards to the supply of the geosynthetic liner materials, the Principal shall supply the GCL (including bentonite powder as required), geomembrane (including welding rods as required) and geocomposite drainage material (excluding the joining cable ties). This material will have been through the necessary quality control process in order to confirm its suitability and acceptability for the Works prior to the Contractor taking position of the liner material. Once handed over to the Contractor, the liner material becomes the responsibility of the Contractor. Any damage to the liner post-handover to the Contractor will be rectified by the Contractor, at no cost to the Principal.

The liner material will either be handed over to the Contractor on site on the back of a flatbed truck, packed within sea containers or appropriately stacked. The Contractor is to fully inspect the liner material and once inspected, sign off on a handover certificate confirming the acceptability of the material and where relevant, documenting any pre-existing damage to the liner material for which the Principal is liable. The Superintendent is to be present during the handover inspection to confirm the state and cause of any pre-existing damaged material.

All handling of the liner material is to be undertaken in accordance with the Specification and as recommended by the material manufacturer.

Any material damaged after the Contractor has taken responsibility will be replaced with equivalent and compatible material with all associated costs borne by the Contractor. Replacement material will need to go through the necessary quality control process in order to confirm its suitability and acceptability prior to the Contractor installing it in the Works. The Principal may order the additional material and carry out the necessary quality control process prior to providing the Contractor with the replacement material. The Contractor will be liable for all of the Principal's costs associated with the replacement of the damaged liner material, including quality control costs and Superintendent costs. The Contractor is to be aware that there will likely be a significant delay in replacing the damaged material, which could be in excess of eight weeks from the time of order (depending on the material type).

During installation of the liner material, there is the possibility that some of the liner material may be rejected by the Superintendent as being of inferior quality and, hence requiring replacement. Where the inferior liner quality is as a result of manufacturing defects, as agreed between the Parties, the Contractor will not be liable for the replacement of the rejected materials, the Principal will replace the rejected material with acceptable material at no cost to the Contractor.

Typically, liner installation has a wastage factor, including overlaps, of between 8% and 15% of the overall area being lined, depending on the complexity of the installation project. The Contractor is to use the liner material in an efficient and professional manner to limit wastage. Should the Superintendent identify that there is excessive material wastage, an independent opinion will be sought to determine if the material wastage is deemed unreasonable. The Contractor will be liable for the cost of any deemed unreasonably excessive wastage.

The Contractor will include in its Works insurance the full replacement value of all Principal supplied liner material. This will include the cost of all necessary quality control testing. Prior to finalising the Works insurance, the Contractor is to obtain the full insurance value of the Principal supplied liner material from the Superintendent. This value is to be included in the Contractor's Works insurance policy.

1.5 Quality Assurance, Inspection and Reporting

The Contractor shall undertake and cover the cost of all Construction Quality Control testing and measurement required in this Specification to demonstrate that the specified standards of construction have been achieved. The exception being that the Principal shall pay for all Construction Quality Assurance (CQA) testing carried out by the Superintendent as stipulated in this Specification. Any repeat Construction Quality Assurance testing due to material damage or excessive wastage shall be borne by the Contractor, other than for Principal Supply material manufacturing defects. For the avoidance of doubt, Construction Quality Assurance testing refers to the testing of materials, where the Superintendent receives material samples and obtains independent testing thereof to confirm the materials conform to the Specification.

The Principal shall supply the GCL, bentonite powder, geomembrane, welding rods, and geocomposite drainage material, including cable ties. This material will have been through the necessary quality control process in order to confirm its suitability and acceptability for the Works prior to the Contractor taking possession of the liner material. Any material damaged after the Contractor has taken responsibility will be replaced with equivalent and compatible material with all associated costs borne by the Contractor. Replacement material will need to go through the necessary quality control process in order to confirm its suitability and acceptability prior to the Contractor installing it in the Works.

The Principal shall appoint and pay for the following:

- Superintendent to manage the project on its behalf; and,
- A CQA Consultant. The duties of the CQA Consultant will include inspections, verifications, audits and evaluation of materials and workmanship, provision of advice on interpretation of the Specification and issuing a final CQA Validation Report to the Superintendent, documenting the quality of the constructed Works.

Within this Specification, the Superintendent is nominated as the responsible party to undertake all Construction Quality Assurance testing, inspections, approvals and reporting as the Superintendent has the management responsibility for these aspects of the Works; however, the Superintendent will allocate some of these activities to the CQA Consultant, depending on the task to be undertaken.

The Contractor is to provide the necessary assistance to the CQA Consultant as if it was dealing with the Superintendent.

If there is any confusion as to which party the Contractor should be dealing with, the Contractor is to always default back to the Superintendent for guidance.

The CQA Consultant is not entitled to provide the Contractor with any advice on construction or design matters. The Contractor is not to rely on any construction or design advice from the CQA Consultant. Any related queries are to be directed to the Superintendent.

1.6 Contract Limits

The Works limits shall be in accordance with the Drawings.

1.7 Areas Available to the Contractor

On written request, the Superintendent will allocate work, storage and laydown areas for use by the Contractor.

1.8 Contractor's Facilities

The Contractor shall be responsible for the supply of its own Site services, including power, potable water, wastewater and communications. The proposed details of the Contractor's power, potable water and sanitation arrangements shall be submitted to the Superintendent for approval and shall be maintained throughout the Works.

The Contractor shall be responsible for the maintenance and watering of the access roads within the Works area as defined by the Drawings and workplaces.

Waste and refuse of all sorts generated by the Contractor or construction activities will be regularly and satisfactorily removed. On completion of the Works all sanitary facilities will be removed, the ground thoroughly disinfected and the Site restored to its original condition.

1.9 Pollution and Spillage

Without limiting the Contractor's obligations under the Contract, it shall be the Contractor's responsibility to:

- Investigate and comply with all applicable laws;
- Investigate and comply with Regulations and Rules relating to pollution and contamination with particular regard to the water discharging off the Site; and,
- Limit airborne dust and noise, which could cause a hazard or nuisance to other persons or property. The Superintendent may require the Contractor to take additional steps to reduce the dust hazard and any steps taken shall be at the Contractor's cost.

During construction and commissioning, spillage of any type whatsoever, including fabricating and hydraulic oils, fuel and any other material, shall be immediately removed and disposed of, and the area cleaned as directed by the Superintendent.

1.10 Hours of Site Work

The Superintendent's hours of work on the project will normally be:

- Monday to Friday (inclusive) 0700 to 1700.

Should the Contractor require to work outside these hours, the Contractor shall submit a request in writing to the Superintendent, stating the reason and working hours required, 24 hours in advance and, in any event, not later than noon. The Superintendent will not refuse a reasonable request.

For the purpose of variations and extensions of time to Contract shall consist of 10 hours per working day. The Contract Price shall be deemed to include all additional costs incurred resulting from compliance with industrial awards.

The Contractor will be required to work outside normal working hours to attend to emergency situations or as directed by the Superintendent to attend to items within the scope of Works.

Any variation to the above will be at the discretion of the Superintendent and subject to prior written approval. Refusal to vary or extend the hours of work will not be grounds for an extension of time or a direction to accelerate the Works.

For the purpose of Liquidated Damages assessment, a day will mean any 24 consecutive hour day including Saturdays, Sundays and statutory holidays.

1.11 Site Meetings/Briefings

The Contractor must attend Site meetings/briefings with the Principal and/or Superintendent at times which will be notified to the Contractor. The Contractor must ensure the attendance of all sub-contractors directly concerned with the Works in progress at the time. The Superintendent will keep records of these meetings and these records will form part of the Contract Documentation. No claims for costs borne by the Contractor in attending Site meetings will be accepted.

1.12 Remedial Work During Defects Liability Period

The Contractor shall be responsible to perform work during the Defects Liability Period in accordance with the General Conditions of Contract.

1.13 Water for use in the Works

Water for will be available on Site via a standpipe adjacent to the primary dam, which is within 1 km by road from the Works area.

The Principal will provide all necessary water supply and equipment to extract and transfer the water from the source into the Contractor’s collection vehicle.

1.14 Setting Out and Measurement of Quantities

The Contractor shall be responsible for setting out the Works and confirm survey control to the Superintendent to the grades and levels shown on the Drawings.

The Contractor shall be responsible for the measurement of quantities under the Contract. Quantities shall be determined by a competent person by field survey, and outcomes of the survey and quantity calculations shall be forwarded to the Superintendent for verification.

The Contractor is to use a suitably qualified surveyor for all survey work. A suitably qualified surveyor includes:

- A qualified and experienced surveyor able to be a fulltime member of the Institution of Mining and Engineering Surveyors Australia;
- A surveyor licensed under the WA Licensing Board; or,
- A surveyor that has undertaken similar works and at the same level of responsibility for a minimum of five years and has a proven track-record of reliable survey works.

Quantities to be measured for variations must be measured in accordance with AS 1181.

1.15 Weather

The Contractor takes all risk associated with delays related to bad weather. The Contractor is to allow within its program of Works for anticipated delays as a result of bad weather. There will be no extension of time or cost variation as a result of bad weather.

This Clause does not release the Contractor from any obligation to weatherproof and protect the Works, and to remove water from the Works as soon as is practical during and after inclement weather.

1.16 Protection from Weather

The Contractor must, at the Contractor's expense, provide all plant, materials and labour necessary to protect the Works from damage by inclement weather.

The Contractor must prevent, insofar as is reasonably possible any materials entering any gully, manhole or pipe, and must remove from the drainage system any materials from any source which may be deposited in the drainage system by any agency up to the date of Practical Completion.

1.17 Dust and Wind-Blown Materials Control

The Contractor shall be responsible for the effective control and suppression of all dust and windborne material emanating from the Site as a result of the Works throughout the period of the Works on Site.

Dust management is a critical environmental emissions aspect on site. The Contractor is to ensure that all construction related activities are carried out in order to minimise dust generation. The Contractor is to adequately wet down all haulage roads to limit dust generation. Should the use of a water cart not be sufficient to adequately manage dust emissions, then the Contractor is to implement other, acceptable dust management measures to decrease dust generation. In the event that the Contractor is unable to adequately control dust during construction, the dust related activities are to be ceased until adequate dust management can be undertaken or the ambient weather conditions improve.

The Contractor is to be aware that the Principal has a comprehensive Dust Management Plan for the overall site. The Contractor is to ensure compliance with this Plan at all times.

1.18 Liaison with Others

During the course of the Works, the Contractor will need to interact with other works being carried out on Site. It shall be the Contractor's responsibility to closely liaise with others on Site to ensure Works are completed in accordance with the requirements of the Specification, Drawings and the Superintendent's directions and instructions.

1.19 Provision for Traffic

When Works are proceeding adjacent to or on any existing access track or haul road, the Contractor shall notify the Superintendent and any other company using that access track or haul road seven days in advance of the date that such Works are due to commence and the proposed duration of such Works and take all steps necessary during the execution of such Works to ensure that disruption to normal traffic is minimised.

1.20 Demobilisation

Prior to the issue of a Certificate of Practical Completion, the Contractor shall, unless otherwise agreed in writing by the Superintendent, have removed all goods and temporary Works from the Site.

All Contractor lay down areas shall be cleaned and graded by the Contractor to the satisfaction of the Superintendent.

1.21 Vegetation and Site Clearing

The Site is an existing waste management facility. There is no native vegetation clearing associated with the landfill cap construction; however, There is some minor vegetation (weeds) clearing and the removal of some residual stormwater control infrastructure (pipes etc.) in the Works area.

The Principal will be responsible for the removal of all landfill gas and leachate management infrastructure within the Works area, be it temporarily or permanently removed.

1.22 Earthworks

1.22.1 Introduction

The Works covered by this Section include, but are not necessarily limited to, the following:

- The setting out of the Works to the lines and levels shown on the Drawings;
- Removal of unsuitable/excess material and disposal to stockpile;
- Excavation within the Works area to remove or shape existing landfill access roads by spreading on side slopes in vicinity of access roads;
- Excavation to expose the existing landfill base liner on perimeter bund;
- Excavation to expose the existing Stage 1 landfill cap liner;
- Excavation to trim the landfill surface to a final gradient of no steeper than 1 (V) in 3.5 (H);
- Filling, grading and rolling of the landfill cap formation to cover any exposed waste material and ensure that the landfill surface final slope is no steeper than 1 (V) in 3.5 (H);
- Surface preparation of completed earthworks prior to liner installation;

- Excavation and haulage of fill, placement and compaction to the required grades and levels for the landfill capping layer Works;
- Excavation and backfill of liner anchor trenches for liner installation;
- Formation of drains and roads on the capped surface, including cross-overs;
- Excavation, haulage of fill and placement to the required grades and levels for the landfill capping growing medium;
- Construction Quality Control testing and sampling; and,
- Control and diversion of surface water and run-off from the Site of the Works.

1.22.2 Earthworks Inspection

The earthworks will be inspected and monitored by the Superintendent and CQA Consultant, which will include the inspection, approval and reporting on all aspects of the earthworks. This is to include:

- Approval of the suitability of the fill material used;
- Approval of the compaction method used;
- Inspection of all fill placement and compaction activities;
- Inspection of all third-party Construction Quality Control testing and sampling (arranged and paid for by the Contractor);
- Assessment of the Construction Quality Control testing results and As-Constructed surveys and drawings, including to confirm that the pre-liner installation slope is no steeper than 1 (V) in 3.5 (H);
- Approval of the earthwork's quality and shape; and,
- Any other activities that are deemed necessary to ensure that appropriate earthworks standard of workmanship and quality of Works is achieved.

Where the Specification refer to inspection, approval or other activities relating to the Superintendent, some of these actions may be carried out by the CQA Consultant, on behalf of the Superintendent.

1.22.3 Applicable Documents

All Works shall be carried out in accordance with the latest editions of all and any Specification, guidelines and standards referenced with the Contract.

1.22.4 Definitions

For all purposes of this Section, the words and phrases listed below shall have the meanings herein ascribed to them:

- "Modified Maximum Dry Density" (MMDD) As determined in accordance with AS 1289.5.2.1-2003.

1.22.5 Handover

On handover of the Site to the Contractor, the Contractor is to undertake a detailed baseline survey of the Works area. As a minimum, the surface shall be surveyed about the perimeter of the Works area and on a maximum 20 m grid and include all changes in grade within the perimeter.

The survey is to identify all necessary details to accurately determine the surface topography for the purposes of measuring construction qualities, and to identify if there are any areas of the handover surface that are steeper than 1 (V) in 3.5 (H). The results of the survey shall be provided to the Superintendent prior to any Works commencing. This baseline survey will be compared to the Principal's baseline survey (which may have been undertaken prior to Site handover) and the handover baseline survey profile will be agreed between the Parties.

This agreed handover baseline survey will then be used for calculating quantities of Works undertaken throughout the project.

No Works shall be undertaken in any area until the handover baseline survey has been agreed between the Parties and without the written confirmation of the Superintendent.

1.22.6 Maximum Lined Surface Slope

The design is based on a maximum synthetic lined surface slope of 1 (V) in 3.5 (H).

The Contractor is to assess the surface slope before and during earthworks construction to ensure that the final, pre-liner installation earthworks slope is no steeper than 1 (V) in 3.5 (H).

1.22.7 Excavation

1.22.7.1 General

The Contractor shall carry out all earthworks excavation to the extent shown on the Drawings or directed by the Superintendent. The Contractor is responsible for assessing the soil/rock types on Site and selecting suitable plant and equipment for undertaking excavation Works.

The Contractor is to remove all soft or unsuitable material identified within the existing soil cover material over the waste.

All completed earthworks are to be inspected and approved by the Superintendent.

1.22.7.2 Excavated Material

All suitable excavated material is to be used as fill material.

The Superintendent will determine the suitability of the excavated fill material for use as fill.

All excavated material that is deemed unsuitable to be used as fill by the Superintendent, will be stockpiled within 500 m of the Works area in a location as directed by the Superintendent.

1.22.7.3 Excavation Around Existing Landfill Base and Cap Liner

The facilitate the tie-in to the existing landfill base and cap liner, the Contractor is required to excavate soil and possibly some waste from the vicinity of the existing liner anchor trench or liner edge. All excavation around the existing liner material is to be carried out with extreme care so as not to damage the liner material. Any damage identified to the liner material, will be repaired by the Contractor, at no cost to the Principal.

1.22.8 Fill Materials

1.22.8.1 General

The Contractor shall carry out all earthworks fill to the extent shown on the Drawings or as directed by the Superintendent. The Contractor is responsible for assessing the fill requirements and selecting suitable plant and equipment for undertaking required Works.

All fill material must be approved for use by the Superintendent, who may reject unsuitable material.

A portion of the earthworks involves the minor re-contouring of the landfill surface to achieve a reasonable surface shape for lining, access track and drain alignment and to control surface water.

Between the design phase of the project and the award of the construction contract, there is likely to have been a degree of differential settlement and possibility waste placement which will have changed the shape of the actual waste surface. Consequently, there will be a need to undertake minor excavation Works to improve the final landfill surface.

1.22.8.2 Material

Select fill material and growing medium shall comprise naturally occurring silty/clayey soil sourced on-site from stockpile or excavation (Cell 9 footprint) within 1 km of the Works area. The material is to be free of debris and deleterious material and with a maximum particle dimension no larger than 40 mm. The suitability of the fill material will be determined by the Superintendent prior to incorporation into the Works.

If the available fill material has a particle size greater than 40 mm, but less than 500 mm, it can be used in the growing medium layer; however, only in the upper layer, at least 300 mm above the synthetic liner.

1.22.8.3 Unsuitable Material

The term "unsuitable material" shall apply to excavated material, which, because of its inherent nature, cannot be satisfactorily reconditioned and is not suitable for use as a fill material. Unsuitable material shall be removed within the limits specified by the Superintendent using whatever equipment is required. All material that is deemed unsuitable by the Superintendent to be used as fill will be stockpiled within 500 m of the Works area in a location as directed by the Superintendent.

1.22.9 Sub-Grade Preparation

All standing water shall be drained or pumped away before surface preparation can commence.

All vegetation (weeds) and any other obstructions shall be removed from areas on which synthetic liner is to be installed.

No fill shall be placed in any area without the written approval of the Superintendent.

1.22.10 Fill Placement and Compaction

1.22.10.1 Inspection

Minor filling will be required in order to re-contour the landfill surface.

Before fill is placed in any area, the Superintendent shall be notified in writing 24 hours prior to Works commencing. The Superintendent may inspect the area to confirm the Works conforms to the Specification. This inspection may include witnessing any proof rolling to detect soft spots on the landfill surface.

1.22.10.2 General Placement and Compaction Standards

Fill below the lined surface, shall be placed, levelled, and if necessary, moisture conditioned to +/- 2 % of optimum and compacted to not less than 90% of the Modified Maximum Dry Density (MMDD) determined in accordance with AS 1289.5.2.1.

Fill to form the access tracks and stormwater drains on top of the growing medium is to be compacted to 95% MMDD. Due to the relatively flexible nature of the substrate (waste and uncompacted growing medium), it is unlikely that this degree of compaction will be achievable in the first or second compaction lift; however, subsequent compaction lifts should be able to achieve the specified degree of compaction. If 95% MMDD compaction is unable to be achieved, the Superintendent is to assess the compactive effort and determine the most suitable solution in order to achieve the maximum compaction on the capped surface.

The Contractor is to determine and then provide the fill placement and compaction methodology to the Superintendent for review and acceptance; however, the Contractor is to ensure that any proposed methodology is able to achieve a minimum compaction density of 90% or 95% of the Modified Maximum Dry Density (MMDD) determined in accordance with AS 1289.5.2.1.

The growing medium is ideally to be placed in a single layer and NOT compacted. If the preference is to install the growing medium in two layers, the upper layer is to be at least 0.8 m thick and NOT compacted.

The placement of growing medium material on top of the synthetic liner and geocomposite drainage layer is to be carried out in accordance with the following minimum requirements so as not to damage the liner materials and not to negatively impact on the slope stability:

- No pushing down the slope, all material is to be moved up the slope;
- Minimum layer thickness of 1.3 m, with the material preferably placed in a single layers (to prevent excessive compaction);
- Positrack vehicles can operate anywhere;

- Excavators (maximum 25 tonne) passing the material up the slope must be static when moving material;
- Swamp dozers can push material vertically up the slope, not at an acute angle; and,
- No dump trucks or any other plant on the slope under any circumstances.

The Contractor is to provide a Work Method Statement (WMS) for the proposed fill placement methodology that needs to consider the dot points above, including measures to prevent damage to the underlying geosynthetics and that won't impact on the slope stability. The superintendent is to have approved the proposed WMS prior to any fill placement.

The Contractor is to be aware that there will be leachate sump access pipes and gas pipe penetrations through the capped surface and that the growing medium will need to be carefully installed around and between the penetrations.

1.22.10.3 Landfill Surface Preparation

The complete surface of the capped area that is to be covered with synthetic liner material (GCL, LLDPE and geocomposite drain) is to be prepared such that there is no exposed waste and no objects on or near the surface that have the potential to damage the synthetic liner.

Following the removal of vegetation and greenwaste from the landfill surface, the Contractor is to track roll the waste surface to flatten and push down any protruding items.

There is an unknown depth of soil over the waste surface. It is not required that this soil be removed, other than to expose the existing base and cap liner.

1.22.10.4 Timing of Growing Medium Installation

The growing medium is to be installed within four weeks of the geocomposite drainage material having been installed. This is to protect the geotextile on the surface of the geocomposite drainage material from excessive UV decay.

1.22.10.5 Final Surface Preparation

The complete surface of the capped area that is to be covered with synthetic liner material (GCL, LLDPE and Geocomposite drain) is to be steel drum rolled to provide a smooth surface on which to place the liner material. Prior to the deployment of the GCL, the surface is to be inspected to confirm there are no excessive irregularities, depressions or obstructions that may affect the integrity of the synthetic liner.

The Contractor is to be aware that the sloping portions of the landfill surface at relatively steep (maximum 1 vertical in 3.5 horizontal) and extreme care is to be taken when working in these areas. In addition, when placing liner material, the Contractor is to ensure that the prepared surface below the liner is not damaged by the liner installation equipment. Any damage to the surface is to be repaired prior to the liner being installed.

1.22.10.6 Compaction Testing

The Contractor shall arrange for the testing and sampling of compacted fill in the access tracks and drain bunds. Fill operations shall be interrupted as necessary to allow the recovery of samples or to carry out control tests on the fill.

If the fill during recontouring the landfill surface is greater than 1 m thick, then these areas are to be compaction tested. Recontouring fill less than 1 m thick does not require to be compaction tested.

All materials testing and density testing shall be undertaken by a laboratory that is NATA accredited for those tests being undertaken. Testing will be used to confirm specified moisture conditions and standards of compaction are achieved. All testing shall be undertaken in accordance with the appropriate sections of AS1289 – Methods for Testing Soils for Engineering Purposes.

Testing and sampling will be undertaken at regular intervals by the Contractor or its nominated representatives. The construction programing and Contract Sum shall include allowances for taking and testing samples and time delays while samples are being collected, tested and reported.

No additional payment will be made for any completed Works requiring removal and/or repair as a result of any tests organised by the Superintendent.

Inspection and testing shall be carried out in accordance with the requirements of this Specification.

The frequency of field density testing during these Works shall not be less than the following:

- One test per 500 m^3 distributed evenly throughout the full depth and area;
- One test per layer per material type per 2,500 m^2, distributed evenly over the surface of the layer;
- One test per layer or per 300 mm thickness per 150 m length constructed horizontal layer;
- Three tests per visit when material is placed in horizontal layers; or
- Whichever frequency is greater of the above or alternative frequencies that may be agreed with the Superintendent.

Dry density ratio for each of the field density tests shall be determined from Nuclear Densometer methods (AS1289.5.8.1) in association with modified compaction (AS1289.5.2.1).

Where nuclear densometer methods are used, compaction shall be carried out in accordance with the Assigned Values Method, as defined by AS1289.5.4.2.

If any areas of the Works are found to be non-compliant with the compaction requirements of this Specification, they shall be re-worked (if necessary), re-compacted and re-tested for compliance.

1.22.10.7 Dimensions and Tolerances

The finished levels of fill shall be within -25 mm and +25 mm of the design levels. The fill surface shall be inspected to ensure accuracy and any irregularities and if identified, shall be corrected prior to the surface treatment being applied.

The impact of waste settlement within the landfill is to be considered when assessing dimensions and tolerances.

1.22.10.8 Control of Water

During excavation and construction, all areas of earthworks shall be kept free of water by temporary drains or other means. Excavation and fill areas shall always be graded to facilitate surface drainage and any loose material compacted to prevent erosion and absorption.

1.22.10.9 Surface Confirmation

The completed surface shall be surveyed by the Contractor on a maximum 20 m grid and include all changes in grade to confirm the accuracy of construction, including that the surface is no steeper than 1 (V) in 3.5 (H). The results of the survey shall be provided to the Superintendent prior to inspecting the completed surface to confirm the Works meets the specified requirements.

No liner installation shall be carried out in any area without the written approval of the Superintendent.

1.22.10.10 Clean-up

On completion of the Works the Site shall be cleared of all materials and debris. Any damage shall be made good and the Site restored to a neat and tidy condition. All Works areas shall be smoothed and graded conforming to the natural appearance of the landscape.

1.23 Installation of Geosynthetic Clay Liner

1.23.1 General

The landfill capping construction incorporates the use of a standard GCL product overlaid by a LLDPE liner and a geocomposite drain.

1.23.1.1 Exposure to Sodium Bentonite

It is noted that sodium bentonite is classified as hazardous for both State and Federal legislation, largely to eliminate any silica and cristobalite risk. Key points are as follows:

- The exposure risk of sodium bentonites and any crystalline silica (quartz and cristobalite) contained within, is based on dust concentrations in the air, and the length of exposure.
- There is no Short-term exposure limit set, it is all 8-hour Time-Weighted Average (TWA). Hence, a maximum average exposure level over an 8 hr/5 day week is considered, the TWA is 0.1 mg/m³ averaged over the 40-hr week.
- This means that exposure levels are considered over a time period, and for GCLs this time period should only apply to people working with GCL's for an extended period.
- The exposure risk for cutting samples or handling onsite is short term, but this fundamentally means that it is easier to analyse the risk, but also easier to adopt full protection controls and not rely on engineering controls.
- **The advice is always to wear suitable PPE as defined in the material manufacturer's Safety Data Sheet (SDS) or in the relevant Australian Standard, wherever the risk of dust generation is observed.**

From a construction point of view, there is an OH&S risk with the exposure of sodium bentonite from the GCL, particularly around the risk of crystalline silica exposure when the GCL is cut for sampling and whilst being installed; consequently, the Contractor is to ensure that the following activities are carried out:

- All parties, including the Contractor's staff, lining sub-contractor and any other relevant sub-contractors, Superintendent, CQA Consultant, the Principal's staff and anyone who may come in contact with the GCL are to be made aware of the risks associated with exposure to sodium bentonite;
- The Contractor (who is accountable for the sampling and installation of the GCL) is to develop a safety plan for the handling, sampling and installation of GCL and bentonite powder, including detailed procedures that will be undertaken to mitigate exposure to dust from the GCL (eg masks or respirators). The safety plan is to be developed in accordance with the manufacturer's SDS and industry best practise.
- The safety plan is to be provided to the Principal, Superintendent and all relevant parties prior to the sampling, installation or testing of the GCL and that procedures mentioned in the plan are being adhered to.
- This risk is to be discussed in toolbox talks at the start and throughout the construction program, when GCL is being handled on site.

1.23.1.2 GCL Installation Sub-Contractor

The Contractor shall only engage the specialist liner sub-contractor, which may also be the main Contractor to install the GCL that was accepted by the Principal at the time of Contract award. Any change to the approved liner sub-contractor must be approved in writing by the Superintendent prior to any lining Works being undertaken on Site.

The GCL shall be installed in all locations as indicated in the Drawings.

The primary function of the lining system is to:

- Limit rainwater from percolating into the waste mass and generating leachate; and,
- Limit the fugitive emission of landfill gas through the cap and into the environment.

Stringent quality assurance standards shall be maintained throughout the Contract to ensure the integrity of the lining system.

The Contractor shall provide all supervision, labour and equipment for the installation of the GCL in accordance with the Specification and Drawings.

Prior to installation, all Principal Supply GCL to be incorporated in the Works shall be approved in writing by the Superintendent.

1.23.1.3 Submittals

Submittal Documentation

The Contractor is to submit the following to the Superintendent for review and approval, within a reasonable time to expedite installation of the GCL. This is not an all-inclusive list; it is the Contractor's responsibility to ensure that it has been through this Specification in sufficient detail to identify all submittal requirements:

- If any proposed change in liner sub-contractor from what was approved at Contract award, documentation of the liner sub-contractor and installer's qualifications:
  - Submit proposed sub-contractor relevant company experience;
- Submit resumes or qualifications of the proposed Field Installation Supervisor, Master Installer and Installer to be assigned to this project; and,
- Liner installation Quality Control Program.

Panel Layout Drawings

Submit copies of panel layout drawings for the Superintendent's approval within a reasonable time so as not to delay the start of GCL installation. Panel layout drawings shall show the proposed panel layout. Panels shall generally follow the direction of the slope. Roll-end joins on the side slopes shall clearly be identified.

Placement of GCL will not be allowed to proceed until the Superintendent has received and approved the panel layout drawings.

Additional Submittals (In-Progress and at Completion):

This is not an all-inclusive list; it is the Contractor's responsibility to ensure that it has been through this Specification in sufficient detail to identify all submittal requirements:

- Daily written acceptance of subgrade surface;
- Daily field installation reports; and,
- Installation record drawing.

1.23.1.4 Quality Control

Installer's Qualifications

Installation and joining of the GCL must be undertaken by GCL installers with extensive experience in installing and joining the same type of GCL being installed and using the same joining procedure to be used on Site.

Installation shall be performed under the direction of a Field Installation Supervisor who shall be responsible throughout the GCL installation, for GCL panel layout, joining, patching, repairs and all other activities of the liner sub-contractor. The Field Installation Supervisor shall have installed or supervised the installation and joining of a minimum of 10 projects involving a total of 500,000 m^2 of GCL of the type specified or similar product.

Joining shall be performed under the direction of a Master Installer (who may also be the Field Installation Supervisor) who has joined a minimum of 300,000 m^2 of GCL of the type specified or similar product, using the same type of joining to be used in the current project. The Field Installation Supervisor and/or Master Installer shall be present whenever installation and joining is performed.

Installation and joining shall be performed by an Installer who has installed and joined a minimum of 100,000 m^2 of GCL of the type specified or similar product, using the same type of joining to be used in the current project.

All joining, patching, other operations shall be performed by qualified installers employed by the GCL sub-contractor.

Independent CQA Consultant

The Principal will appoint an independent CQA Consultant with experience and knowledgeable of GCL and joining performance characteristics to verify that the Works have been carried out in accordance with the Specification.

The duties of the CQA Consultant include inspections, verifications, audits and evaluation of materials and workmanship, provision of advice on installation, repair, and covering of the GCL lining system in accordance with the Environmental Approval, Specification, CQA Plan and Drawings, and issuing a final CQA Validation Report to the Principal documenting the quality of the constructed facility.

The cost associated with the appointment of the CQA Consultant will be covered by the Principal.

The Contractor is to provide the necessary assistance, advanced notification of lining activities and access to all Works area to the CQA Consultant to enable the full inspection of the Works.

1.23.1.5 Delivery, Storage and Handling

Each roll of GCL delivered to the Site will be labeled by the manufacturer. The label will be firmly affixed and shall clearly state the following:

- Manufacturer's name;
- Product identification (material type);
- Date of manufacture;
- Batch number;
- Roll number;
- Roll length;
- Roll weight;
- Roll width; and,
- Label with handling guidelines.

The GCL rolls shall be delivered to the Site by the Principal and handed over to the Contractor. The material will be handled and stored in such manner that no damage occurs to the GCL or its protective wrapping. The GCL rolls shall be wrapped with heavy duty weatherproof wrapping to protect the material from moisture uptake.

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

A dedicated area shall be used for the storage of all GCL material delivered to Site. The material shall be stored and handled as follows:

- In its original, unopened packaging or resealed following the removal of samples from the roll;
- Away from high traffic areas, but sufficiently close to the active Works area to minimise handling;
- On a level, dry, well-drained and stable area;
- Not more than three (3) rolls high;
- Protected from precipitation, chemicals, excessive heat, ultraviolet (UV) radiation, standing water, vandalism and animals;
- Blocks provided to prevent sliding or rolling of stacks;
- All roll labeling shall be clearly visible;
- Handling of GCL rolls is to be via the use of a spreader bar or stinger bar (a bar protruding from the front end of a forklift or other equipment). The bar must be capable of supporting the full weight of the GCL roll without significant bending; and,
- Under no circumstances may the rolls be dragged, lifted with the forks of a forklift or pushed to the ground from the delivery vehicle.

Any damaged material shall be assessed by the Superintendent and if deemed necessary, rejected and the material immediately remove from the Works area.

1.23.1.6 GCL Pre-Construction Meeting

A GCL Pre-Construction Meeting (and simultaneously the Geomembrane Pre-Construction Meeting) shall be held at the Site prior to installation of the GCL. As a minimum, the meeting shall be attended by the GCL Field Installation Supervisor, the Superintendent, the CQA Consultant and the Contractor.

Topics for this meeting shall include:

- Responsibilities of each party;
- Lines of authority and communication;
- Resolution of any project document ambiguity;
- Project QA/QC plan;
- Methods for documenting, reporting and distributing documents and reports;
- Procedures for packaging and storing archive samples;
- Review of time schedule for all installation and inspection;
- Weather limitations;
- Defining acceptable subgrade, GCL, or ambient moisture and temperature conditions for working during liner installation;
- Subgrade conditions, dewatering responsibilities and subgrade maintenance plan;
- Deployment techniques including allowable subgrade for the liner installation and in particular, working on the landfill side slopes;
- Consideration of how subsequent liner/geocomposite material will be placed on top of the GCL, again, with particular focus on working on the landfill side slopes;
- Covering of the GCL – normal practice and in the event of rain;
- Measurement and payment schedules; and,
- Health and safety, including protection from exposure to sodium bentonite powder.

The Superintendent will take minutes of the meeting and the minutes shall be transmitted to all Parties.

1.23.2 Product

1.23.2.1 General

Although the liner material is a Principal Supply Item, this product information has been provided so that the Contractor is aware of the type of liner material that will be utilised in the Works and the extent to which documentation and CQA testing is required.

1.23.2.2 Manufacturing Quality Control

The test methods and frequencies used by the manufacturer for quality control/quality assurance of the GCL prior to delivery shall be in accordance with Section 1.23.5 - Table 1.

The manufacturer's GCL quality control certifications, including results of quality control testing of the products, must be supplied to the Superintendent to verify that the materials supplied for the project are in compliance with all product and/or project Specification. The certification shall be signed by a responsible party employed by the manufacturer, such as the QAlQC Manager, Production Manager or Technical Services Manager. Certifications shall include lot and roll numbers and corresponding shipping information.

1.23.2.3 Minimum Requirements for GCL

The GCL shall be a reinforced, multi-layered system comprising two layers of geotextiles encapsulating a layer of dry bentonite.

The bentonite and GCL will meet the property requirements as shown in Section 1.23.5 - Table 1.

Bentonite used for overlapping shall comply with the same Specification as the bentonite used in the GCL delivered to the Site (same rule applies for sealing penetrations and repairs).

Material Construction Quality Assurance testing by the Superintendent will be conducted in accordance with the project Specification and CQA Plan.

1.23.2.4 Manufacturing Quality Control Documentation

MQC documentation from the manufacturer of the GCL supplied must be submitted for approval by Superintendent. Submissions shall include:

- Location and date of manufacture;
- Lot number, roll number, length and width;
- Bentonite manufacturer quality documentation for the particular lot of clay used in the production of the rolls delivered;
- MSDA or bentonite used during manufacture;
- Geotextile manufacturer quality control documentation for the particular lots of geotextiles used in the production of the rolls delivered;
- Cross-referencing list delineating the corresponding geotextile and bentonite lots for the materials used in the production of the rolls delivered;
- QC program laboratory certified reports in accordance with Section 1.23.5 – Table 1; and
- The manufacturer’s approved QA stamp and the technician’s signature.

1.23.2.5 Acceptance by Superintendent

No materials will be accepted for delivery to Site unless all necessary manufacturer's quality assurance/quality control certification, including results of quality control testing has been provided to the Superintendent. All such data shall be supplied in sufficient time such that no delay shall be caused to the project program.

1.23.3 Installation

1.23.3.1 Project Conditions

GCL shall not be installed in the presence of standing water, while precipitation is occurring or during excessive winds.

1.23.3.2 Surface Preparation

The surface to be lined shall be uniform and free of all sharp or angular objects that may damage the GCL prior to installation of the liner and the quality of the surface maintained until liner has been installed.

The Contractor, liner sub-contractor and Superintendent shall inspect the surface to be covered with the GCL on each day's operations prior to placement of GCL to verify suitability.

The liner sub-contractor shall provide daily written acceptance to the Superintendent for the surface to be covered by the GCL installation, to ensure surface suitability.

All subgrade surface damage caused by construction equipment and deemed unsuitable for GCL deployment shall be repaired by the Contractor prior to placement of the GCL. All repairs require the approval of the Superintendent and the liner sub-contractor.

1.23.3.3 GCL Placement

No GCL shall be deployed until the applicable certifications and quality control certificates are submitted to, and approved by the Superintendent. Should GCL material be deployed prior to approval by the Superintendent it will be at the sole risk of the Contractor. If the material does not meet project Specification, it shall be removed from the Works area and replaced at no cost to the Principal.

The GCL shall be installed such that the panels are continuous down side slopes. The arrangement of the GCL panels shall be according to a predetermined panel layout plan to minimise the amount of end overlaps.

The panels shall be laid in roof tile effect to allow continuous flow of water in the downward slope direction.

The GCL shall be installed to the limits shown on the Drawings and essentially as shown on approved panel layout drawings.

The GCL shall only be placed on adequately prepared surfaces that have been approved by the Superintendent.

Appropriate lifting equipment is to be used to ensure safe and efficient material placement and any damage to the subbase by lifting equipment shall be repaired prior to the laying of any GCL.

Installation of the GCL shall not result in scratching, scoring, tearing or otherwise damaging of the material.

The GCL sub-contractor and Superintendent shall inspect the surface of each roll of material as it is being deployed or after deployment, to verify that the material is free from visual defects such as tears, punctures, abrasions, thin spots or other faults in the material.

If damages are identified, they are to be repaired or replaced according to this Specification or as directed by the Superintendent.

Roll-end joins on the side slopes are to be anchored as indicated in the Drawings.

NO vehicular traffic shall travel on the liner material.

Prior to installation, the Contractor is to provide a method statement on how it is proposed to install the subsequent LLDPE and geocomposite drainage layers without any driving on the lined surface. This method statement must be provided within a reasonable time so as not to delay the installation of the liner material.

GCL placement shall not be carried out during rainfall events, on a wet subbase, if moisture prevents proper surface preparation, panel placement or panel joining. Moisture limitations shall be defined in the pre-construction meeting.

Damaged panels or portions of the damaged panels, which have been rejected, shall be marked and removal from the Works area and the relevant roll number(s) recorded.

The GCL shall not be allowed to "bridge over" voids or low areas in the subgrade. In these areas, the GCL shall be placed to allow the GCL to rest in intimate contact with the subbase.

Wrinkles caused by panel placement shall be minimised. In the event that wrinkles occur in the GCL or where wrinkles extend to the edge of the roll due to manufacturing tolerances, they will need to be removed prior to installation of subsequent layers.

Considerations on Site Geometry: In general, joins shall be oriented parallel to the line of the maximum slope. In corners and odd shaped geometric locations, the total length of joins shall be minimised.

Overlap joins between panels shall be formed by overlapping the panels and sealed by manufactured edge treatment, bentonite paste or powder/granules. The overlap zone shall be kept clean and shall not be contaminated with loose soil or other debris. There shall be no folds or wrinkles in the overlap zone and no traffic or walking shall occur on the completed overlap. The minimum longitudinal overlap shall be 300 mm and the minimum roll-end overlap shall be 1.0 m on the top of the landfill and an anchor trench and 1.5 m overlap on the side slopes.

Bentonite used for overlapping shall comply with the same Specification as the bentonite used in the GCL delivered to the Site (same rule applies for sealing penetrations and repairs).

Particular care shall be taken to avoid contaminating the upper surface of the GCL with bentonite powder. The presence of loose bentonite may affect welding of overlying geomembrane and may also influence interface friction.

GCL installed on slopes is to be fixed in anchor trenches or extend a minimum of 5 m up onto the top of the landfill. This is to secure the GCL and prevent it from sloughing or slipping down the side slopes during construction. The front edge of the trench is to be rounded to prevent the development of stress concentrations on the GCL or any other geosynthetics. The GCL shall be laid on the inside wall and base of the anchor trench only and the trench shall be cleared of any debris, gravel or loose material before the GCL is installed. The trench shall be backfilled and compacted with suitable selected fill in layers of maximum 300 mm, by a minimum two passes with a plate compactor per layer.

The GCL shall be covered by the geomembrane liner as soon as practical to prevent water damage, but at least by the end of each working day. No GCL is to be left uncovered overnight.

In the event of any water damage, the Superintendent will inspect the material to assess the extent of hydration of the liner. Areas of GCL with moisture content equal or above 40% by weight (ASTM D5993) may be rejected, as instructed by the Superintendent. Areas suspected of being over hydrated may be sampled and tested to confirm suitability, with costs borne by the Contractor; however, time constrains may impact the ability to test the hydrated material.

The liner sub-contractor shall surcharge load all lining material during construction with appropriate material (i.e. sandbags or approved equivalent) to ensure the liner is protected from wind uplift and displacement, including down-slope creep. The frequency and spacing of the sandbag shall be as required based on Site conditions and lining sub-contractor's experience/recommendation. The sandbag material shall be sufficiently close-knit to prevent soil fines from working through the bags and discharging on the liner. The sandbags shall be filled with material that does not pose a risk of damage to the geosynthetics. The sandbags must be removed prior to placement of subsequent layers of synthetic liner material.

All material offcuts shall be removed from the Works area and not left under the GCL liner.

1.23.3.4 Joining Procedures

Joining procedures are to be as per the material Manufacture's installation instructions, with the following minimum overlaps:

- Longitudinal joins – 300 mm
- Roll-end joins:
  - On top of landfill – 1.0 m; and,
  - On side slope – anchor trench and 1.5 m.

1.23.3.5 Field Quality Control

Daily Field Installation Reports

At the beginning of each day's Works, the liner sub-contractor shall provide the Superintendent with daily reports for all Works accomplished on the previous Works day. Reports shall include the following:

- Total amount and location of GCL placed; and,
- Drawings of the previous day's installed GCL showing panel numbers.

1.23.3.6 Defects and Damage

The Superintendent shall inspect the GCL as it is rolled out on the surface to be lined. The Superintendent shall be responsible for the acceptance or rejection of GCL being incorporated into the Works and shall make a determination of whether the identified defect or damage is a function of manufacture or installation of the GCL.

Manufacturing defects are areas where the geotextile is not continuous and/or areas where the bentonite in the GCL is missing. If a roll is suspected to be of inferior quality the Superintendent may take samples to assess its conformance with the Specification. All testing is to be carried out in accordance with the appropriate standards and by a NATA accredited laboratory. Construction Quality Assurance testing results will determine the adequacy of the GCL.

Material replacement as a result of identified defects or damage shall be carried out by the Principal. The Principal will be liable for the costs associated with the replacement of all defective liner materials. The Contractor will be liable for the costs associated with the replacement of all damaged liner material, including being liable for all CQA testing costs as a result of replacing damaged liner material.

1.23.3.7 Repair

If the GCL has been damaged during installation, it can be repaired by patching a new piece of GCL of the same material type and thickness extending a minimum of 500 mm on the top of the landfill and 1.0 m on the side slopes beyond the damaged area in all directions. The patched area must be augmented with bentonite powder or granules/paste as per normal joining requirements.

1.23.3.8 Liner Acceptance

GCL liner will be accepted by the Superintendent when:

- The entire installation is finished, or an agreed-upon subsection of the installation is finished;
- All liner sub-contractor's QC documentation is completed, submitted to and approved by the Superintendent; and,
- All CQA testing on the installed material has been completed and approved by the Superintendent.

1.23.3.9 Disposal of Scrap Materials

On completion of installation, the liner sub-contractor shall dispose of all waste and scrap material in a location approved by the Superintendent, remove equipment used in connection with the Works herein, and shall leave the Site in a neat acceptable manner. No scrap material shall be allowed to remain on or under the GCL surface.

1.23.4 Materials Properties and Testing Scope

1.23.4.1 General

This Specification set forth a set of minimum physical, mechanical and chemical properties that must be met, or exceeded by the GCL being manufactured. In a few cases a range is specified.

In the context of quality systems and management, this Specification represents manufacturing quality control (MQC).

Note: Manufacturing quality control represents those actions taken by a manufacturer to ensure that the product represents the stated objective and properties set forth in this Specification.

1.23.4.2 Definitions

Manufacturing Quality Control (MQC) - a planned system of inspections that is used to directly monitor and control the manufacture of a material which is factory originated. MQC is normally performed by the manufacturer of geosynthetic materials and is necessary to ensure minimum (or maximum) specified values in the manufactured product. MQC refers to measures taken by the manufacturer to determine compliance with the requirements for materials and workmanship as stated in certification documents and Contract Specification.

Manufacturing Quality Assurance (MQA) - a planned system of activities that provides assurance that the materials were constructed as specified in the certification documents and Contract Specification. MQA includes manufacturing facility inspections, verifications, audits and evaluation of the raw materials and geosynthetic products to assess the quality of the manufactured materials. MQA refers to measures taken by the MQA organisation to determine if the manufacturer is in compliance with the product certification and Contract Specification for this project.

1.23.4.3 Manufacturing Specification and Quality Control

The quality of the GCL shall be in accordance with the requirements of the Geosynthetic Research Institute (GRI) — GCL3. The minimum Specification for quality GCL products are contained in GRI Test Method GCL3 Standard Specification for "*Test Methods, Required Properties, and Testing Frequencies of Geosynthetic Clay Liners (GCL's)*". The GRI Specification set forth a set of minimum physical and mechanical properties that must be met or exceeded by the GCL being manufactured.

In addition to the above, the bentonite Specification in Section 1.23.5 – Table 1 shall be verified every 50 tonnes of the product.

A statement on the origin of the bentonite must be included, as well as certified copies of the quality control certificates issued by the bentonite supplier and reports on the tests conducted by the manufacturer to verify the quality of the bentonite used to manufacture the GCL rolls assigned to the project.

The geotextile components of the GCL must also have been through a QC program. The manufacturer's geotextile QC program shall be available for auditing.

1.23.4.4 Physical and Mechanical Property Requirements

The GCL shall conform to the test property requirements prescribed in Section 1.23.5 - Table 1.

The properties of the GCL shall be tested at the minimum frequency shown in Section 1.23.5 - Table 1. If the specific manufacturer's quality control guide is more stringent and is certified accordingly, it must be followed in like manner.

1.23.4.5 Workmanship and Appearance

The GCL shall have good appearance qualities. It shall be free from such defects that would affect the specified properties of the GCL.

General manufacturing procedures shall be performed in accordance with the manufacturer's internal quality control guide and/or documents.

1.23.4.6 MQC Sampling

Sampling shall be in accordance with the specific test methods listed in Section 1.23.5 - Table 1. If no sampling protocol is stipulated in the particular test method, then test specimens shall be taken evenly spaced across the entire roll width.

The number of tests shall be in accordance with the appropriate test methods listed in Section 1.23.5 - Table 1.

The average of the test results shall be calculated per the particular standard cited and compared to the minimum value listed in these tables; hence, the values listed are the minimum average values and are designated as "min. ave."; the exception being permeability, which is measured against the maximum average.

1.23.4.7 MQC Retest and Rejection

If the results of any test do not conform to the requirements of this Specification, retesting to determine conformance or rejection shall be carried out in accordance with the manufacturing protocol as set forth in the manufacturer's quality manual.

1.23.4.8 Packaging and Marketing

The GCL shall be rolled onto a substantial core or core segments and held firm by dedicated straps/slings, or other suitable means. The rolls must be adequate for safe transportation to the point of delivery.

The roll cores shall be sufficiently strong to ensure that they do not deflect by more than half their diameter during transit and handling.

1.23.4.9 Certification

A manufacturer's certification that the material was manufactured and tested in accordance with the Specification, together with a report of the test results shall be furnished at the time of shipment.

1.23.4.10 Construction Quality Assurance Testing

The Principal shall provide test results for the rolls delivered to Site to demonstrate that the rolls meet the requirements of the Specification. The test frequency shall be as set out in Section 1.23.5 - Table 1.

The Superintendent will arrange for independent Construction Quality Assurance testing of the material. The Superintendent shall arrange for samples to be recovered from the rolls delivered to Site and tested at an independent NATA accredited laboratory. The results from the independent laboratory shall take precedence over the test results provided by the manufacturer of the material. The Construction Quality Assurance testing shall be at the Principal’s cost.

There is the option for the sampling of the materials for Construction Quality Assurance testing to occur either at the point of manufacturer, at the supplier’s local warehouse or after delivery to the Site.

If sampling for CQA testing is proposed to be undertaken prior to material delivery to site, then sampling and testing is to be undertaken in accordance with the CQA Consultant's instruction to ensure the appropriate chain of custody controls applied for the samples between recovery and testing and chain of custody controls between manufacture and use in the works onsite.

The Superintendent will arrange for independent Construction Quality Assurance testing of the material. In order to achieve this:

- The Superintendent will determine the location of where the samples are to be received, either at the point of manufacture, supplier's warehouse or on Site;
- The timing of when the sampling will occur is to be coordinated by the Superintendent, between all Parties, to ensure the most efficient sampling process and handover of the samples. This will either be during or immediately after manufacture or as soon as is reasonable following delivery to the supplier's local warehouse or to Site;
- The CQA Consultant or nominated representative (for non-local sampling) will be present at the point of sampling to monitor the sampling procedure and to receive the samples;
- The Principal is responsible for providing all samples, as required, from the rolls of liner material that will or have been delivered to Site and handing the samples to the CQA Consultant; and,
- The CQA Consultant will arrange for the delivery and testing of the samples to be carried out at an independent NATA accredited laboratory.

The CQA results from the independent laboratory shall take precedence over the test results provided by the manufacturer of the material. The Construction Quality Assurance testing shall be at the Principal's cost.

Any non-conformance in the materials as identified by the Construction Quality Assurance testing shall be addressed by the Principal and thereafter, if the Superintendent rejects the material, the Principal shall replace the non-conforming material with conforming material. Again, the new delivery of material will be subject to Construction Quality Assurance testing to demonstrate its conformance with the Specification. Any replacement of non-conforming material and subsequent Construction Quality Assurance testing carried out by the Superintendent will be at the Principal's cost.

The material delivered to Site shall meet the Specification relative to the independent laboratory test results, for the material to be considered for incorporation into the Works.

Section 1.23.6 - Table 2 sets out the minimum Construction Quality Assurance testing that will be carried out by the Superintendent.

1.23.5 GCL Material Specification

All GCL material use shall be reinforced and comprised of both woven and non-woven geotextile fully needle punch and heat bonded together to contain the bentonite powder.

The GCL shall have the minimum material Specification as set out in Table 1:

Table 1 - GCL Material Specification

Property	Test	Frequency	Value
Montmorillonite content	XRD (X-ray diffraction) Quantitative Mineralogy Analysis	50 tonnes of GCL	> 70 wt%
Carbonate content (*1*)		50 tonnes of GCL	1 - 2 wt%
Bentonite form		50 tonnes of GCL	Natural Na-bentonite or >80 wt% Sodium as activated bentonite
Particle size	AS 1289-3.6.2	50 tonnes of GCL	Powdered (e.g. 80% passing 75 micron sieve) or Granulated (e.g. < 1% passing 75 micron)
Cation exchange capacity	Methylene Blue Method	50 tonnes of GCL	≥ 70 meq/100 g (or cmol/kg)
Free Swell (bentonite) (min. ave.)	ASTM D5890	50 tonnes of GCL	≥ 24 mL/2g
Moisture Content (bentonite) (min. ave.) (*2*)	ASTM D5993	4,000 m^2	≤ 25% at Manufacture ≤ 35% Site Samples
Fluid Loss (bentonite) (min. ave.) (*2*)	ASTM D5891	50 tonnes of GCL	≤ 18 ml
Top Geotextile Mass (min. ave.) (*3*)	ASTM D5261	20,000 m^2	≥ 220 g/m^2 non-woven
Mass per unit area of GCL (min. ave.) (*4*)	ASTM D5993	4,000 m^2	≥ 4,240 g/m^2
Mass per unit area of Bentonite (min. ave.) (*4*)	ASTM D5993	4,000 m^2	≥ 3,700 g/m^2
Mass per unit area of Bentonite in overlaps (min. ave.) (*4*)	ASTM D5993	4,000 m^2	≥ 4,000 g/m^2 (3,700 g/m^2 + 300 g/m^2)
Bottom Geotextile Mass (min. ave.)	ASTM D5261	20,000 m^2	≥ 320 g/m^2 Woven/Non-woven

Property	Test	Frequency	Value
Elongation (MD) (min. ave.)	ASTM D4632	20,000 m^2	≥ 10%
Tensile Strength (min. ave.)	ASTM D6768	20,000 m^2	≥ 8 kN/m
Peel Strength (min. ave.)	ASTM D6496	4,000 m^2	≥ 360 N/m
Permeability (max. ave.) (2)	ASTM D5887	25,000 m^2	≤ 5 x 10^{-11} m/s

(1) Carbonate here implies calcite, calcium carbonate or other soluble or partially soluble carbonate minerals

(2) These values are maximum (all others are minimum).

(3) For both cap and carrier fabrics for non-woven reinforced GCL's; one, or the other, must contain a scrim component of mass ≥ 100 g/m^2 for dimensional stability. This only applies to GM/GCL composites, which are exposed to the atmosphere for several months or longer so as to mitigate panel separation.

(4) Mass of the GCL and bentonite is measured after oven drying per the stated test method.

The GCL rolls shall include edge treatment on both longitudinal sides of the GCL with 250 dry grams added bentonite per metre length of overlap included in the outer 300 mm strip of the roll. The rolls shall also include edge markings to indicate a minimum 300 mm overlap for panels.

1.23.6 GCL CQA Testing

The GCL shall undergo the minimum CQA testing as set out in Table 2:

Table 2 - GCL CQA Testing

Item	Property	Standard	Frequency
Construction Quality Assurance testing (sampled at the point of manufacture or on Site, as determined by the Superintendent)	Mass per unit area of bentonite component of GCL	ASTM D5993	1 sample per 2,500 m^2
	Mass per unit area of GCL	ASTM D5993	1 sample per 1,000 m^2
	Mass per unit area of Bentonite in overlaps	ASTM D5993	1 sample per 1,000 m^2
	Montmorillonite content	XRD (X-ray diffraction) Quantitative Mineralogy Analysis	1 sample per 10,000 m^2
	Cation exchange capacity of bentonite	Methylene blue method	1 sample per 1,500 m^2
	Moisture content of bentonite	ASTM D5993 AS1289.2.1.1	1 sample per 2,500 m^2
	Swell index/free swell of clay	ASTM D5890	1 sample per 1,500 m^2
	Water absorption	ASTM D5891	1 sample per 1,500 m^2
	Peel strength (for needle-punched products only)	ASTM D6496	1 sample per 1,000 m^2
	Tensile strength	ASTM D6768	1 sample per 10,000 m^2
	Index flux	ASTM 5887	1 sample per 10,000 m^2
	Permeability	ASTM 5887	1 sample per 10,000 m^2
Visual inspection of GCL	Colour, needle punching, presence of needles or broken needles, and sewing density or other faults in the material.	N/A	Every roll during placement
Thickness of GCL (i.e. uniformity of bentonite distribution) and apparent variations in the as placed moisture distribution.	On-Site	N/A	Each roll during placement. If thickness appears to be variable a check of the variability of the mass per unit area shall be conducted

Note:

1. All Construction Quality Assurance tests must be reviewed, accepted, and reported by the Superintendent before deployment of the GCL.
2. All testing must be performed on samples taken from the GCL delivered to Site or at the supplier's/manufacturer's premises under the Superintendent's inspection or delegated authority.
3. All laboratory tests must be performed in an independent NATA accredited laboratory.
4. The required testing frequencies may be revised by the Superintendent to conform with 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 GCL for the stability of Works).

1.24 Installation of LLDPE Geomembrane

1.24.1 General

1.24.1.1 Geomembrane Installation Sub-Contractor

The Contractor shall only engage the specialist liner sub-contractor, which may be the main Contractor to install the geomembrane that was accepted by the Principal at the time of Contract award. Any change to the liner sub-contractor must be approved in writing by the Superintendent prior to any lining Works being undertaken on Site.

Geomembrane shall be installed in all locations as indicated in the Drawings.

The primary function of the lining system is to:

- Limit rainwater from percolating into the waste mass and generating leachate; and,
- Limit the fugitive emission of landfill gas through the cap and into the environment.

Stringent quality assurance standards shall be maintained throughout the Contract to ensure the integrity of the lining system.

The Contractor shall provide all supervision, labour and equipment for the installation of the geomembrane in accordance with the Specification and Drawings.

Prior to installation, all Principal Supply geomembrane to be incorporated in the Works shall be approved in writing by the Superintendent.

1.24.1.2 Submittals

Submittal Documentation

The Principal is to submit the following to the Superintendent for review and approval, within a reasonable time to expedite shipment or installation of the geomembrane. This is not an all-inclusive list; it is the Principal's responsibility to ensure that it has been through this Specification in sufficient detail to identify all submittal requirements:

- Documentation of manufacturer's qualifications;
- Manufacturer's Quality Control program manual or descriptive documentation;
- A material properties sheet, including at a minimum all properties specified, including test methods used;
- Typically, 0.5 m of roll length of material that will or has been delivered to Site to be used by the Superintendent for Construction Quality Assurance testing as required in Section 1.24.7 - Table 5; and,
- Resin Supplier's name, resin production plant identification, resin brand name and number, production date of the resin, resin Manufacturer's quality control certificates, and certification that the properties of the resin meet the requirements for the project.

The Contractor is to submit the following to the Superintendent for review and approval, within a reasonable time to expedite shipment or installation of the geomembrane. This is not an all-inclusive list; it is the Contractor's responsibility to ensure that it has been through this Specification in sufficient detail to identify all submittal requirements:

- If any proposed change in liner sub-contractor from what was approved at Contract award, documentation of the liner sub-contractor and installer's qualifications:
  - Submit proposed sub-contractor relevant company experience; and,
- Submit resumes or qualifications of the proposed Field Installation Supervisor, Master Installer, and Installer to be assigned to this project; and,
- Liner sub-contractor Quality Control Program.

Panel Layout Drawings

Submit copies of panel layout drawings for the Superintendent's approval within a reasonable time so as not to delay the start of geomembrane installation. Panel layout drawings shall show the proposed panel layout identifying seams and details. Seams shall generally follow the direction of the slope. The connecting seam between geomembranes shall be located a distance of at least 1 m from any join in the GCL below.

All primary welds used to connect panel end to sheets shall form T-joins (tees). These T-connections must be a distance of at least 0.5 m apart. The welding seams of the geomembrane cannot cross (no cruciform connections).

Placement of geomembrane will not be allowed to proceed until the Superintendent has received and approved the panel layout drawings.

Additional Submittals (In-Progress and at Completion):

For convenience, the relevant Sections have been highlighted; however, these may not necessarily be the only references to submittal documentation required. This is not an all-inclusive list; it is the Contractor's responsibility to ensure that it has been through this Specification in sufficient detail to identify all submittal requirements:

- Geomembrane installation warranty;
- Daily written acceptance of substrate surface;
- Prequalification test seam samples;
- Field seam non-destructive test results;
- Field seam destructive test results;
- Daily field installation reports; and,
- Installation record drawing.

1.24.1.3 Quality Control

Manufacturer's Qualifications

The manufacturer of geomembrane of the type specified or similar product shall have at least five years' experience in the manufacture of such geomembrane. In addition, the geomembrane manufacturer shall have manufactured at least 1,000,000 m^2 of the specified type of geomembrane or similar product during the last five years.

Installer's Qualifications

Installation and seaming of the geomembrane must be undertaken by geomembrane installers with extensive experience in seaming the same type of geomembrane being installed and using the same seaming procedure to be used on Site.

Installation shall be performed under the direction of a Field Installation Supervisor who shall be responsible throughout the geomembrane installation, for geomembrane panel layout, seaming, patching, testing, repairs and all other activities of geomembrane installation. The Field Installation Supervisor shall have installed or supervised the installation and seaming of a minimum of 10 projects involving a total of 500,000 m^2 of geomembrane of the type specified or similar product.

Seaming shall be performed under the direction of a Master Seamer (who may also be the Field Installation Supervisor) who has seamed a minimum of 300,000 m^2 of geomembrane of the type specified or similar product, using the same type of seaming apparatus to be used in the current project. The Field Installation Supervisor and/or Master Seamer shall be present whenever seaming is performed.

Seaming shall be performed by an Installer who has seamed a minimum of 100,000 m^2 of geomembrane of the type specified or similar product, using the same type of seaming apparatus to be used in the current project.

All seaming, patching, other welding operations and testing shall be performed by qualified technicians employed by the geomembrane liner sub-contractor.

Independent CQA Consultant

The Principal will appoint an independent CQA Consultant with experience and knowledgeable of geomembrane and seam performance characteristics to verify that the Works have been carried out in accordance with the Specification.

The duties of the CQA Consultant include inspections, verifications, audits and evaluation of materials and workmanship, provision of advice on installation, testing, repair, and covering of the geomembrane lining system in accordance with the Environmental Approval, Specification, CQA Plan and Drawings, and issuing a final CQA Validation Report to the Principal documenting the quality of the constructed facility.

The cost associated with the appointment of the CQA Consultant will be covered by the Principal.

The Contractor is to provide the necessary assistance, advanced notification of lining activities and access to all Works area to the CQA Consultant to enable the full inspection of the Works.

1.24.1.4 Delivery, Storage and Handling

Each roll of geomembrane delivered to the Site will be labeled by the manufacturer. The label shall be firmly affixed and shall clearly state the following:

- Manufacturer's name;
- Product identification (material type);
- Material thickness;
- Roll number;
- Roll length;
- Roll weight;
- Roll width;
- Reference number to raw material batch and laboratory certified reports; and,
- Manufacturer's approved QA stamp and the technician's signature. The technician's signature may be omitted from each roll label, but then must be included on each of the manufacturer's test certificates associated with each roll.

A dedicated area shall be used for the storage of all geomembrane material delivered to Site. The material shall be stored as follows:

- The geomembrane shall be protected from mud, dirt, dust, puncture, cutting or any other damaging or deleterious conditions;
- Away from high traffic areas, but sufficiently close to the active Works area to minimise handling;
- Elevated aboveground on a level, dry, well-drained and stable area. Should timber pallets be used, they must be inspected and free of nails/pins prior to roll placement;
- Not more than three rolls high;
- Protected from stormwater runoff, standing water, chemicals, excessive heat, vandalism and animals;
- Blocks provided to prevent sliding or rolling of stacks;
- All roll labeling shall be clearly visible;
- Handling of geomembrane rolls is to be via the use of a spreader bar or stinger bar (a bar protruding from the front end of a forklift or other equipment). The bar must be capable of supporting the full weight of the geomembrane roll without significant bending; and,
- Under no circumstances may the rolls be dragged, lifted with the forks of a forklift or pushed to the ground from the delivery vehicle.

Any damaged material shall be assessed by the Superintendent and if deemed necessary, rejected and the Contractor advised to immediately remove the material from the Works area.

1.24.1.5 Geomembrane Installation Warranty

The geomembrane liner sub-contractor shall guarantee the geomembrane installation against defects in the installation and workmanship for one year commencing with the date of final acceptance by the Superintendent.

1.24.1.6 Geomembrane Pre-Construction Meeting

A Geomembrane Pre-Construction Meeting (and simultaneously the GCL Pre-Construction Meeting) shall be held at the Site prior to installation of the geomembrane. As a minimum, the meeting shall be attended by the geomembrane Field Installation Supervisor, the Superintendent, the CQA Consultant and the Contractor.

Topics for this meeting shall include:

- Responsibilities of each party;
- Lines of authority and communication;
- Resolution of any project document ambiguity;
- Project QA/QC plan;
- Methods for documenting, reporting and distributing documents and reports;
- Procedures for packaging and storing archive samples;
- Review of time schedule for all installation and testing;
- Review of panel layout and numbering systems for panels and seams including details for marking on geomembrane;
- Procedures and responsibilities for preparation and submission of As-Constructed panel and seam drawings;
- Temperature and weather limitations. Installation procedures for adverse weather conditions and temperature conditions for working during liner installation;
- Defining acceptable GCL moisture content prior to over-laying with geomembrane;
- GCL/subgrade conditions, dewatering responsibilities and GCL/subgrade maintenance plan;
- Deployment techniques, especially placement of geomembrane on top of GCL with the geomembrane textured side down;
- Plan for controlling expansion/contraction and wrinkling of the geomembrane;
- Covering of the geomembrane and subsequent material placement;
- Measurement and payment schedules; and,
- Health and safety.

The Superintendent will take minutes of the meeting and the minutes shall be transmitted to all Parties.

1.24.2 Products

1.24.2.1 General

Although the liner material is a Principal Supply Item, this product information has been provided so that the Contractor is aware of the type of liner material that will be utilised in the Works and the extent to which documentation and CQA testing is required.

1.24.2.2 Manufacturing Quality Control Documentation

The test methods and frequencies used by the manufacturer for quality control/quality assurance of the geomembrane prior to delivery shall be in accordance with Section 1.24.5 - Table 3.

The manufacturer's geomembrane quality control certifications, including results of quality control testing of the products, must be supplied to the Superintendent to verify that the materials supplied for the project are in compliance with all product and/or project Specification. The certification shall be signed by a responsible party employed by the manufacturer, such as the QAlQC Manager, Production Manager or Technical Services Manager. Certifications shall include lot and roll numbers and corresponding shipping information.

The Manufacturer will provide Certification that the geomembrane and welding rod supplied for the project have the same base resin and material properties.

1.24.2.3 Geomembrane

The geomembrane shall consist of new, first quality products designed and manufactured specifically for the purpose of this Works which shall have been satisfactorily demonstrated by prior testing to be suitable and durable for such purposes. The geomembrane rolls shall be seamless, Linear Low Density Polyethylene (LLDPE resins of density ≥0.915 g/ml and ≤ 0.926 g/ml, sheet density ≤ 0.939 g/ml) containing no plasticizers, fillers or extenders and shall be free of holes, blisters or contaminants, and leak free verified by 100% in-line spark or equivalent testing. The geomembrane shall be supplied as a continuous sheet with no factory seams in rolls. The geomembrane will meet the property requirements as shown in Section 1.24.5 - Table 3.

Material Construction Quality Assurance testing by the Superintendent will be conducted in accordance with the project Specification and CQA Plan.

The geomembrane seams shall meet the property requirements as shown in Section **Error! Reference source not found.** - Table 4.

1.24.2.4 Acceptance by Superintendent

No materials will be accepted for delivery to Site unless all necessary manufacturer's quality assurance/quality control certification, including results of quality control testing has been provided to the Superintendent. All such data shall be supplied in sufficient time such that no delay shall be caused to the project program.

1.24.3 Installation

1.24.3.1 Project Conditions

Geomembrane shall not be installed in the presence of standing water, while precipitation is occurring, during excessive winds or when material temperatures are outside the limits specified in this Specification.

1.24.3.2 Surface Preparation

The surface to be lined shall be uniform and free of all sharp or angular objects that may damage the geomembrane prior to installation of the geomembrane.

The Contractor, liner sub-contractor and Superintendent shall inspect the surface to be covered with the geomembrane on each day's operations prior to placement of geomembrane to verify suitability.

The liner sub-contractor shall provide daily written acceptance for the surface to be covered by the geomembrane installation, to ensure surface suitability.

All subgrade and GCL surface damage caused by construction equipment and deemed unsuitable for geomembrane deployment shall be repaired by the Contractor prior to placement of the geomembrane. All repairs require the approval of the Superintendent and the liner sub-contractor.

1.24.3.3 Geomembrane Placement

No geomembrane shall be deployed until the applicable certifications and quality control certificates as specified are submitted to and approved by the Superintendent. Should geomembrane material be deployed prior to approval by the Superintendent it will be at the sole risk of the Contractor. If the material does not meet the project Specification, it shall be removed from the Works area and replaced at no cost to the Principal.

The geomembrane shall be installed to the limits shown on the Drawings and essentially as shown on approved panel layout drawings.

The panels shall be laid in roof tile effect to allow continuous flow of water in the downward slope direction.

No geomembrane material shall be unrolled and deployed if the material temperatures are lower than 10°C unless otherwise approved by the Superintendent. The specified minimum temperature for material deployment may be adjusted by the Superintendent based on recommendations by the manufacturer and the Superintendent. Temperature limitations shall be defined in the pre-construction meeting. Only the quantity of geomembrane that will be anchored and seamed together in one day shall be deployed.

Installation of the geomembrane shall not result in scratching, scoring or crimping of the material.

The liner sub-contractor and Superintendent shall inspect the surface of each roll of material as it is being deployed or after deployment, but before welding, to verify that the material is free from visual defects such as tears, punctures, abrasions, indentations, cracks, thin spots or other faults in the material. If damages are identified, they are to be repaired or replaced according to this Specification or as directed by the Superintendent.

NO vehicular traffic shall travel on the liner material.

The liner sub-contractor shall surcharge load all lining material during construction with appropriate material (i.e. sandbags or approved equivalent) to ensure the liner is protected from wind uplift and displacement, including down-slope creep. The frequency and spacing of the sandbag shall be as required based on Site conditions and lining sub-contractor's experience/recommendation. The sandbag material shall be sufficiently close-knit to prevent soil fines from working through the bags and discharging on the liner. The sandbags shall be filled with material that does not pose a risk of damage to the geosynthetics. The sandbags must be removed prior to placement of subsequent layers of synthetic liner material.

Geomembrane placement shall not be carried out if moisture prevents proper surface preparation, panel placement or panel seaming. Moisture limitations shall be defined in the pre-construction meeting.

Damaged panels or portions of the damaged panels, which have been rejected, shall be marked and its removal from the Works area and the roll number(s) recorded.

The geomembrane shall not be allowed to "bridge over" voids or low areas in the subgrade. In these areas, the geomembrane shall be placed to allow the geomembrane to rest in intimate contact with the GCL.

Wrinkles caused by panel placement or thermal expansion shall be minimised in accordance with this Specification.

Considerations on Site Geometry: In general, seams shall be oriented parallel to the line of the maximum slope. In corners and odd shaped geometric locations, the total length of field seams shall be minimised.

Overlapping: The panels shall be overlapped prior to seaming to whatever extent is necessary to affect a good weld and allow for proper testing. In no case shall this overlap be less than 75mm.

1.24.3.4 Defects and Damage

The Superintendent shall inspect the geomembrane as it is rolled out on the surface to be lined. The Superintendent shall be responsible for the acceptance or rejection of geomembrane being incorporated into the Works and shall make a determination of whether the identified defect or damage is a function of manufacture or installation of the geomembrane.

Manufacturing defects are areas where the geomembrane surface and/or texturing is not consistent and uniform. If a roll is suspected to be of inferior quality the Superintendent may take samples to assess its conformance with the Specification. All testing is to be carried out in accordance with the appropriate standards and by a NATA accredited laboratory. Construction Quality Assurance testing results will determine the adequacy of the geomembrane.

Material replacement as a result of identified defects or damage shall be carried out by the Principal. The Principal will be liable for the costs associated with the replacement of all defective liner materials. The Contractor will be liable for the costs associated with the replacement of all damaged liner material, including being liable for all CQA testing costs as a result of replacing damaged liner material.

1.24.3.5 Seaming Procedures

Cold weather installations shall follow guidelines as outlined in GRI GM 9.

No geomembrane material shall be seamed when liner temperatures are less than 10°C unless the following conditions are complied with:

- Seaming of the geomembrane at material temperatures below 10°C is allowed if the liner sub-contractor can demonstrate to the Superintendent, using prequalification test seams, that field seams comply with the project Specification, the safety of the crew is ensured and geomembrane material can be repaired at temperatures less than 10°C;
- The liner sub-contractor shall submit to the Superintendent for approval, detailed procedures for seaming at low temperatures, possibly including the following:
  - Preheating of the geomembrane;
  - The provision of a tent or other device if necessary to prevent heat losses during seaming and rapid heat losses subsequent to seaming; and,
  - Number of test welds to determine appropriate seaming parameters.

No geomembrane material shall be seamed when the sheet temperature is above 75°C as measured by an infrared thermometer or surface thermocouple unless otherwise approved by the Superintendent. This approval will be based on recommendations by the manufacturer and on a field demonstration by the liner sub-contractor using prequalification test seams to demonstrate that seams comply with the Specification.

Seaming shall primarily be performed using automatic fusion welding equipment and techniques. Extrusion welding shall be used where fusion welding is not possible such as at, patches, repairs and short (less than a roll width) runs of seams. Fusion welding can also be used on long patches, as recommended by the installer and agreed by the Superintendent.

The weld surfaces shall be cleaned prior to welding. The weld area shall be free of moisture, dust, debris, markings and foreign materials. In the case of extrusion welding, oxidation by-products shall be removed from the surface to be welded by grinding/buffing. Grind marks shall not be deeper than 10 % of the geomembrane thickness. Welding shall be performed shortly after grinding (within 30 minutes) so that surface oxide formation does not reform.

The Contractor shall be responsible for regularly checking calibrating (as per the manufacturer's recommendation) and recording the following items:

- Preheat air flow and temperature at the extruder nozzle;
- Extrudate flow and temperature at the barrel outlet; and,
- Split copper wedge temperature on both contact points.

The Contractor shall utilise the machine mounted temperature readout (calibrated in accordance with the manufacturer's recommendation) or have an independently calibrated hand-held temperature measuring device to confirm temperatures of each and every welding machine prior to the commencement of any test or field welds. All information regarding the results gained from the temperature device shall be recorded for each welding machine.

Welding of all main joins between adjacent geomembrane panels (primary welds) shall be conducted using hot-wedge welding, producing two parallel seams with an air channel in between (dual track fusion welding). The hot-wedge welding shall be conducted using the split head wedge fusion weld method which will fuse the upper and lower overlapped geomembrane sheets.

The welding equipment shall be a fully automated device comprising of a heated copper wedge, pressure rollers and electronic controls. The copper wedge shall be controlled and constantly monitored by a programmable controller with an audible off temperature alarm and a variable speed drive unit. The copper wedge shall create two contact fusion areas of a minimum width of 15 mm and a 5 mm minimum wide void between each of the separate parallel weld zones. This void shall be created over the entire seam length to allow for field weld pressure testing.

The extrusion process is used primarily for detailed work and repair work (secondary weld) or, where approved, in areas that would be inaccessible to the dual track fusion weld (such as around structures, pipes and other penetrations). The extrusion welding shall be conducted using surface extrusion hand welders.

The minimum width of the surface extruded bead shall be 30 mm. The surface extrusion welder shall be semi-automated and equipped with electronic controls, which constantly monitor outputs for both preheat and extradite. The unit shall be capable of pre-heating the sheet just prior to the casting of the extradite over the upper and lower section of the weld zone.

The extruded welding rod for surface extrusion welding shall be manufactured from the same resin type used in the manufacture of the geomembrane. All physical properties shall be identical to those possessed by the geomembrane raw material. The manufacturer shall provide certified test data with each batch of welding rod. All welding rod supplied shall be packed to prevent the ingress of moisture and other contaminants.

All geomembrane panels subject to hot wedge welding shall be overlapped by a minimum of 125 mm and a minimum of 75 mm for extrusion welding to allow for proper Construction Quality Assurance testing.

The Contractor shall ensure prior to any primary or secondary welding that weld zones be clean, free from moisture, dust and any other foreign matter. All weld zone surfaces shall be either cleaned or abraded no more than 30 minutes prior to the commencement of welding any seam. In extremely bad conditions it may be necessary for the liner Installer to clean and/or abrade the weld zone areas only minutes prior to the required weld.

Fishmouths or excessive wrinkles at the seam overlaps, shall be minimised and when necessary, cut along the ridge of the wrinkles back into the panel to affect a flat overlap. The cut shall be terminated with a keyhole cut (nominal 10 mm diameter hole) to minimise crack/tear propagation. The overlay shall subsequently be seamed. The keyhole cut shall be patched with an oval or round patch of the same base geomembrane material extending a minimum of 150 mm beyond the cut in all directions.

All primary welds used to connect panel end to sheets shall form T-joins (tees). These T-connections must be a distance of at least 0.5 m apart. All T-joins shall be patched. Patches are to be installed as detailed below. The welding seams of the geomembrane cannot cross (no cruciform connections).

1.24.3.6 Field Quality Control

The Superintendent shall be notified prior to all prequalification and production welding and testing, or as agreed upon in the pre-construction meeting.

Pre-qualification Test Seams

Test seams shall be prepared and tested by the liner sub-contractor to verify that seaming parameters (speed, temperature and pressure of welding equipment) are adequate.

Test seams shall be made by each welding technician and tested in accordance with ASTM D 5820 at the beginning of each seaming period. Test seaming shall be performed under the same conditions and with the same equipment and operator combination as production seaming. The test seam shall be approximately 3.5 m long for fusion welding and 1 m long for extrusion welding with the seam centered lengthwise. As a minimum, test seams shall be made by each technician once every 4-6 hours or if any welding machine has been switched off and then restarted; additional tests may be required with changes in environmental conditions.

Two 25 mm wide specimens shall be die-cut using calibrated equipment by the liner sub-contractor from each end of the test seam (total of four specimens). These specimens shall be tested by the liner sub-contractor using a calibrated field tensiometer, testing both tracks for peel strength and also for shear strength. Each specimen shall fail in the parent material and not in the weld, "Film Tear Bond" (FTD) failure. Seam separation equal to or greater than 25% weld area of the track width shall be considered a failing test.

The minimum acceptable seam strength values to be obtained for all specimens tested are listed in Section 1.24.6 - Table 4. All four specimens shall pass for the test seam to be a passing seam.

If a test seam fails, an additional test seam shall be immediately conducted. If the additional test seam fails, the seaming apparatus shall be rejected and not used for production seaming until the deficiencies are corrected and a successful test seam can be produced.

A sample from each test seam shall be labelled. The label shall indicate the date, geomembrane temperature, number of the seaming unit, technician performing the test seam and pass or fail description. The sample shall then be given to the Superintendent for archiving.

Field Seam Non-destructive Testing

All field seams shall be non-destructively tested by the liner sub-contractor over the full seam length before the seams are covered. Each seam shall be numbered or otherwise designated. The location, date, test unit, name of tester and outcome of all non-destructive testing shall be recorded and submitted to the Superintendent.

Section 1.24.7 - Table 5 sets out the minimum non-destructive weld testing that will be carried out by the liner sub-contractor.

Testing shall be carried out as the seaming Works progresses, not at the completion of all field seaming. All defects found during testing shall be numbered and marked immediately after detection. All defects found shall be repaired, retested and remarked to indicate acceptable completion of the repair.

Non-destructive testing shall be performed using vacuum box, air pressure or spark testing equipment.

Non-destructive testing shall be performed by experienced technicians familiar with the specified test methods. The liner sub-contractor shall demonstrate to the Superintendent all test methods to verify the test procedures are valid.

Extrusion seams shall be vacuum box tested by the liner sub-contractor in accordance with ASTM D 5820 and ASTM D 5641 with the following equipment and procedures:

- Testing is to begin no earlier than one (1) hour after welding;
- Equipment for testing extrusion seams shall be comprised of but not limited to: a vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft rubber gasket attached to the base, porthole or valve assembly and a vacuum gauge; a vacuum pump assembly equipped with a pressure controller and pipe connections; a rubber pressure/vacuum hose with fittings and connections; a plastic bucket; wide brush or mop; and a soapy solution;
- The vacuum pump shall be charged, and the tank pressure adjusted to be between 1 to 4 psig (6.9 kPa to 27.5 kPa);
- The liner sub-contractor shall create a leak tight seal between the gasket and geomembrane interface by wetting a strip of geomembrane approximately 0.3 m by 1.2 m (length and width of box) with a soapy solution, placing the box over the wetted area, and then compressing the box against the geomembrane. The liner sub-contractor shall then close the bleed valve, open the vacuum valve, maintain initial pressure of between 1 to 4 psig (6.9 kPa to 27.5 kPa) for approximately five seconds. The geomembrane shall be continuously examined through the viewing window for the presence of soap bubbles, indicating a leak. If no bubbles appear after five seconds, the area shall be considered leak free. The box shall be depressurised and moved over the next adjoining area with an appropriate overlap and the process repeated;
- All areas where soap bubbles appear shall be marked, repaired and then retested;
- At locations where seams cannot be non-destructively tested alternate non-destructive spark testing or equivalent shall be substituted; and,
- All seams that are vacuum tested shall be marked with the date tested, the name of the technician performing the test and the results of the test.

Double fusion seams with an enclosed channel shall be air pressure tested by the liner sub-contractor in accordance with ASTM D 5820 and the following equipment and procedures:

- Equipment for testing double fusion seams shall be comprised of, but not limited to: an air pump equipped with a pressure gauge capable of generating and sustaining a pressure of 210 kPa (30 psig), mounted on a cushion to protect the geomembrane; and a manometer equipped with a sharp hollow needle or other approved pressure feed device;
- The testing activities shall be performed by the liner sub-contractor. Both ends of the seam to be tested shall be sealed and a needle or other approved pressure feed device inserted into the tunnel created by the double wedge fusion weld;
- The air pump shall be adjusted to a pressure of 210 kPa, and the valve closed. Allow two minutes for the air to come to equilibrium in the channel, and sustain pressure for five minutes;

- If pressure loss does not exceed 28 kPa after this five-minute period, the seam shall be considered leak tight. Release pressure from the opposite end verifying pressure drop on needle to ensure testing of the entire seam. The needle or other approved pressure feed device shall be removed, and the feed hole sealed; and,
- If loss of pressure exceeds 28 kPa during the testing period or pressure does not stabilise, the faulty area shall be located, repaired and retested by the liner sub-contractor.

Results of the pressure testing shall be recorded on the liner at the seam tested and on a pressure testing record.

In addition to the above tests, the welds are to be visually inspected to assess the quality of the workmanship and the appearance of the welded seam. For wedge welds there needs to be a consistent “squeeze out” on the weld edge which is an indicator that the correct temperature and pressure were used during installation. In the case of extrusion fillet welds, the weld appearance shall be smooth, uniform and free of streaks and lumps. In addition, there shall be no obvious scoring, notches or deep scratches introduced by the surface grinding.

Destructive Field Seam Testing

One destructive test sample per 150 linear metre seam length of fusion/wedge weld and 120 linear metre of extrusion weld shall be taken by the liner sub-contractor from a random location specified by the Superintendent. The liner sub-contractor shall not be informed in advance of the sample location. In order to obtain test results prior to completion of geomembrane installation, samples shall be cut by the liner sub-contractor as directed by the Superintendent as seaming progresses.

Section 1.24.7 - Table 5 sets out the minimum destructive weld testing that will be carried out by the liner sub-contractor.

All field samples shall be marked with its sample number and seam number. The sample number, date, time, location and seam number shall be recorded. The liner sub-contractor shall repair all holes in the geomembrane resulting from obtaining the seam samples. All patches shall be vacuum box tested, spark tested, or air pressure tested (for long repairs undertaken using wedge welds). If a patch cannot be permanently installed over the test location the same day of sample collection, a temporary patch shall be tack-welded or hot air welded over the opening until a permanent patch can be affixed.

The destructive sample size shall be 300 mm wide by 1m long with the seam centered lengthwise. The sample shall be cut into three equal sections and distributed as follows: one section given to the Superintendent as an archive sample; one section given to the Superintendent for laboratory testing as specified below; and one section retained by the liner sub-contractor for field testing as specified below.

For field testing, the liner sub-contractor shall cut, using a calibrated die cutter, 10 identical 25 mm wide replicate specimens from its sample. The liner sub-contractor shall test five specimens for seam shear strength and five for peel strength. Peel tests will be performed on both inside and outside weld tracks. To be acceptable, all five test specimens must pass the stated criteria in Section 1.24.6 - Table 4 with less than 25% weld area separation. If the field test weld is acceptable, the sample qualifies for testing by the testing laboratory. If the field test weld is unacceptable in accordance with the above, then the weld is deemed failed and is to be treated accordingly.

Independent seam testing arranged by the Superintendent it shall be conducted in accordance with ASTM D 6392. Laboratory testing is the ultimate confirmation of the acceptability of the weld quality. To be acceptable, all five test specimens must pass the stated criteria in Section 1.24.6 - Table 4 with less than 25% weld area separation.

Reports of the results of examinations and testing shall be prepared and submitted to the Superintendent.

For field seams, if a laboratory test fails, that shall be considered as an indicator of the possible inadequacy of the entire seamed length corresponding to the test sample. Additional destructive test portions shall then be taken by the liner sub-contractor, typically 3 m on either side of the failed sample and laboratory seam tests shall be performed. Passing tests shall be an indicator of adequate seams. Failing tests shall be an indicator of inadequate seams and the testing process repeated.

All seams represented by the destructive test location shall be repaired with a cap-strip, extrusion welded, or wedge welded (long patches) to all sides of the capped area. All cap-strip seams shall be non-destructively vacuum box or air pressure tested until adequacy of the seams is achieved. Cap-strip seams exceeding 50 m in length shall be destructively tested. All costs associated with additional sampling and testing, including laboratory testing, shall be at the Contractor's expense.

Identification of Defects

Panels and seams shall be inspected by the liner sub-contractor and Superintendent during and after panel deployment to identify all defects, including holes, blisters, undispersed raw materials and signs of contamination by foreign matter.

Evaluation of Defects

Each suspect location on the liner (both in geomembrane seam and non-seam areas) shall be non-destructively tested using one of the methods described in this Section. Each location which fails non-destructive testing shall be marked, numbered, measured and posted on the daily "installation" drawings and subsequently repaired.

If a destructive sample fails the field or laboratory test, the liner sub-contractor shall repair the seam between the two nearest passed locations on both sides of the failed destructive sample location.

Defective seams, tears or holes shall be repaired by re-seaming or applying an extrusion or wedge welded cap-strip.

Re-seaming may consist of either:

- Removing the defective weld area and re-welding the parent material using the original welding equipment; or,
- Re-seaming by extrusion welding along the overlap at the outside seam edge left by the fusion welding process. Wedge welding can be used for long repairs.

Blisters, larger holes and contamination by foreign matter shall be repaired by patches and/or extrusion weld beads as required. Each patch shall extend a minimum of 150 mm beyond all edges of the defects.

All repairs shall be measured, located and recorded.

Verification of Repairs on Seams

Each repair shall be non-destructively tested using vacuum box, spark testing or air pressure testing (long repairs) methods. Tests which pass the non-destructive test shall be taken as an indication of a successful repair. Failed tests shall be re-seamed and re-tested until a passing test results. The number, date, location, technician and test outcome of each patch shall be recorded.

Daily Field Installation Reports

At the beginning of each day's Works, the liner sub-contractor shall provide the Superintendent with daily reports for all Works accomplished on the previous Works day. Reports shall include the following:

- Total amount and location of geomembrane placed;
- Total length and location of seams completed, name of technicians doing seaming and welding unit numbers;
- Drawings of the previous day's installed geomembrane showing panel numbers, seam numbers and locations of non-destructive and destructive testing;
- Results of prequalification test seams;
- Results of non-destructive testing; and,
- Results of vacuum/spark/air pressure testing of repairs.

Destructive test results shall be reported prior to covering of liner or within 48 hours whichever is the soonest.

1.24.3.7 Liner Acceptance

Geomembrane liner will be accepted by the Superintendent when:

- The entire installation is finished, or an agreed-upon subsection of the installation is finished;
- All liner sub-contractor's QC documentation is completed, submitted and approved by the Superintendent;
- Verification of the adequacy of all field seams and repairs and associated geomembrane testing is complete; and,
- All CQA testing on the installed material has been completed and approved by the Superintendent.

1.24.3.8 Disposal of Scrap Materials

On completion of installation, the liner sub-contractor shall dispose of all waste and scrap material in a location approved by the Superintendent, remove equipment used in connection with the Works herein, and shall leave the Site in a neat acceptable manner. No scrap material shall be allowed to remain on or under the geomembrane surface.

1.24.4 Materials Properties and Testing Scope

1.24.4.1 General

This Specification set forth a set of minimum physical, mechanical and chemical properties that must be met, or exceeded by the geomembrane being manufactured. In a few cases a range is specified.

In the context of quality systems and management, this Specification represents Manufacturing Quality Control (MQC).

Note: Manufacturing quality control represents those actions taken by a manufacturer to ensure that the product represents the stated objective and properties set forth in this Specification.

1.24.4.2 Definitions

Manufacturing Quality Control (MQC) - a planned system of inspections that is used to directly monitor and control the manufacture of a material which is factory originated. MQC is normally performed by the manufacturer of geosynthetic materials and is necessary to ensure minimum (or maximum) specified values in the manufactured product. MQC refers to measures taken by the manufacturer to determine compliance with the requirements for materials and workmanship as stated in certification documents and Contract Specification.

Manufacturing Quality Assurance (MQA) - a planned system of activities that provides assurance that the materials were constructed as specified in the certification documents and Contract Specification. MQA includes manufacturing facility inspections, verifications, audits and evaluation of the raw materials (resins and additives) and geosynthetic products to assess the quality of the manufactured materials. MQA refers to measures taken by the MQA organisation to determine if the manufacturer is in compliance with the product certification and Contract Specification for this project.

1.24.4.3 Manufacturing Specification and Quality Control

LLDPE

The quality of the geomembranes shall be in accordance with the requirements of the Geosynthetic Research Institute (GRI) – GM17. The minimum Specification for a quality LLDPE geomembrane product is contained in GRI Test Method GM-17 Standard Specification "*Test Properties, Testing Frequency and Recommended Warranty for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes*".

In addition to the above, the Principal is to provide a statement on the origin of the resin, its identification (type and lot number), its production date and the maximum amount of recycled polymer material added to the raw resin must be included as well as certified copies of the quality control certificates issued by the resin supplier and reports on the tests conducted by the manufacturer to verify the quality of the resin used to manufacture the geomembrane rolls assigned to this project.

1.24.4.4 Material Classification and Formulation

This Specification cover Linear Low Density Polyethylene (LLDPE) geomembranes with a formulated sheet density of ≤ 0.939 g/ml as measured in accordance with ASTM D 1505 and D 792.

The base resin from which the geomembrane is made will generally be in the density range of ≥0.915 g/ml and ≤ 0.926 g/ml and have a melt flow index value per ASTM D 1238 of less than 1.0 g/10 min. Base resin density is measured without carbon black and additives added.

Resin for the geomembrane shall be virgin, first quality LLDPE resin and shall not be intermixed with other resin types. Furthermore, it shall not contain more than 2% clean recycled polymer by weight of the resin and with no more than 10% rework. If rework is used, it must be a similar LLDPE as the parent material.

No post-consumer resin (PCR) of any type shall be added to the formulation.

1.24.4.5 Physical, Mechanical and Chemical Property Requirements

The geomembrane shall conform to the test property requirements prescribed in Section 1.24.5 - Table 3.

The properties of the geomembrane shall be tested at the minimum frequency shown in Section 1.24.5 - Table 3. If the specific manufacturer's quality control guide is more stringent and is certified accordingly, it must be followed in like manner.

1.24.4.6 Workmanship and Appearance

The geomembrane shall have good appearance qualities. It shall be free from such defects that would affect the specified properties of the geomembrane.

General manufacturing procedures shall be performed in accordance with the manufacturer's internal quality control guide and/or documents.

1.24.4.7 MQC Sampling

Sampling shall be in accordance with the specific test methods listed in Section 1.24.5 - Table 3. If no sampling protocol is stipulated in the particular test method, then test specimens shall be taken evenly spaced across the entire roll width.

The number of tests shall be in accordance with the appropriate test methods listed in Section 1.24.5 - Table 3.

The average of the test results shall be calculated per the particular standard cited and compared to the minimum value listed in these tables, hence the values listed are the minimum average values and are designated as "min. ave."

1.24.4.8 MQC Retest and Rejection

If the results of any test do not conform to the requirements of this Specification, retesting to determine conformance or rejection shall be carried out in accordance with the manufacturing protocol as set forth in the manufacturer's quality manual.

1.24.4.9 Packaging and Marketing

The geomembrane shall be rolled onto a substantial core or core segments and held firm by dedicated straps/slings, or other suitable means. The rolls must be adequate for safe transportation to the point of delivery.

1.24.4.10 Certification

A manufacturer's certification that the material was manufactured and tested in accordance with the Specification, together with a report of the test results shall be furnished at the time of shipment.

1.24.4.11 Construction Quality Assurance Testing

The Principal shall provide manufacturer’s test results for the rolls delivered to Site to demonstrate that the rolls meet the requirements of the Specification. The test frequency shall be as set out in Section 1.24.5 - Table 3.

The Superintendent will arrange for independent Construction Quality Assurance testing of the material. In order to achieve this:

- The Superintendent will determine the location of where the samples are to be received, either at the point of manufacture, supplier’s warehouse or on Site;
- The timing of when the sampling will occur is to be coordinated by the Superintendent, between all Parties, to ensure the most efficient sampling process and handover of the samples. This will either be during or immediately after manufacture or as soon as is reasonable following delivery to Site;
- The CQA Consultant or nominated representative (for non-local sampling) will be present at the point of sampling to monitor the sampling procedure and to receive the samples;
- The Principal is responsible for providing all samples, as required, from the rolls of liner material that will or have been delivered to Site and handing the samples to the CQA Consultant; and,
- The CQA Consultant will arrange for the delivery and testing of the samples to be carried out at an independent NATA accredited laboratory.

The CQA results from the independent laboratory shall take precedence over the test results provided by the manufacturer of the material. The Construction Quality Assurance testing shall be at the Principal’s cost.

Any non-conformance in the delivered materials as identified by the Construction Quality Assurance testing shall be addressed by the Principal and thereafter, if the Superintendent rejects the material, the Principal shall replace the non-conforming material with conforming material. Again, the new material will be subject to Construction Quality Assurance testing to demonstrate its conformance with the Specification. Any replacement of non-conforming material and subsequent Construction Quality Assurance testing carried out by the Superintendent will be at the Principal’s cost.

The material delivered to Site shall meet the Specification relative to the independent laboratory test results, for the material to be considered for incorporation into the Works.

Section 1.24.7 - Table 5 sets out the minimum Construction Quality Assurance testing that will be carried out by the Superintendent.

1.24.5 LLDPE Geomembrane Material Specification

The LLDPE geomembrane shall have the minimum material Specification as set out in Table 3:

Table 3 - LLDPE Geomembrane Material Specification

Property	Test Method	LLDPE Test Value – 1.50 mm Textured/Textured	Testing Frequency (minimum)
Thickness (min. ave.) • Lowest individual for 8 out of 10 values • Lowest individual for any of the 10 values	D 5994	nom. (-5%) -10% -15%	Per roll
Asperity Height (min. ave.)	D 7466	0.40 mm	Every 2nd roll (1)
Sheet Density (max);	D 1505/ D 792	0.939 g/cc	90,000 kg
Tensile Properties (min. ave.) (2) • break strength • break elongation	D 6693 Type IV	≥ 16 kN/m ≥ 250%	9,000 kg
2% Modulus (max)	D 5323	≥ 630 kN/m	Per formulation
Tear Resistance (min. ave.)	D 1004	≥ 150 N	20,000 kg
Puncture Resistance (min. ave.)	D 4833	≥ 300 N	20,000 kg
Axi-Symmetric Break Resistance Strain (min)	D 5617	≥ 30%	Per formulation
Carbon Black Content - Particle size ~20 nm (range)	D 4218 (3)	2.0-3.0%	20,000 kg
Carbon Black Dispersion	D 5596	note (4)	20,000 kg
Oxidative Induction Time (OIT) (min. ave.) (6) (a) Standard OIT, or (b) High Pressure OIT	 D 3895 or D 8117 D 5885	 ≥ 100 min. ≥ 400 min.	90,000 kg
Oven Aging at 85°C (5), (6)	D 5721		

Property	Test Method	LLDPE Test Value – 1.50 mm Textured/Textured	Testing Frequency (minimum)
(a) Standard OIT (min. ave.) - % retained after 90 days, or (b) High Pressure OIT (min. ave.) - % retained after 90 days	D 3895 or D 8117 D 5885	≥ 35% ≥ 60%	Per each formulation
UV Resistance (7) (a) Standard OIT (min. ave.) or (b) High Pressure OIT (min. ave.) - % retained after 1,600 hrs (9)	D 7238 D 3895 or D 8117 D 5885	N.R. (8) ≥ 35%	Per each formulation

(1) Alternate the measurement side for double sided texture sheet.

(2) Machine direction (MD) and cross machine direction (XMD) average values shall be on the basis of 5 test specimens each direction: Break elongation is calculated using a gauge length of 50 mm at 50 mm/min.

(3) Other methods such as D 1603 (tube furnace) or D 6370 (TGA) are acceptable if an appropriate correlation to D 4218 (muffle furnace) can be established.

(4) Carbon black dispersion (only near spherical agglomerates) for 10 different views: 9 in Categories 1 or 2 and 1 in Category 3.

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

(6) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.

(7) The condition of the test shall be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60° C.

(8) 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.

(9) UV resistance is based on percentage retained value regardless of the original HP-OIT value.

For Notes, refer to GRI Test Method GM17.

Minimum Average Roll Value (min. ave.) is defined as the Mean value less 2 standard deviations. Mathematically, this implies that 97.5% of the results of the tested specimens will exceed the min. ave.

1.24.6 LLDPE Geomembrane Weld Properties

The geomembrane shall have the minimum average weld properties as set out in Table 4, with the Sample Strength being applicable to a 25 mm wide, 1.5 mm thick sample. Weld properties are determined in accordance with GRI GM19a Standard Specification:

Table 4 - Minimum Average Weld Properties

Property	Test Method	Sample Strength (N/25 mm)
Fusion/Wedge Weld - Shear strength	ASTM D 6392	394
Fusion/Wedge Weld - Peel strength	ASTM D 6392	328
Extrusion Weld – Shear Strength	ASTM D 6392	394
Extrusion Weld – Peel Strength	ASTM D 6392	290

1.24.7 Geomembrane CQA Testing

The geomembrane shall undergo the minimum Construction Quality Assurance testing as set out in Table 5:

Table 5 - Geomembrane CQA Testing

Item	Property	Standard	Frequency
Construction Quality Assurance testing (sampled at the point of manufacture or on Site, as determined by the Superintendent)	Thickness	ASTM D5994	Each roll
	Asperity Height	ASTM D 7466	One sample per 5,000 m^2, or every five rolls delivered to Site whichever is the greatest number of tests
	Density	ASTM D1505, ASTM D792	
	Tensile properties (break stress and break elongation)	ASTM D6693 type IV	
	Puncture resistance	ASTM D4833	
	Tear resistance	ASTM D1004	
	Carbon black content	ASTM D4218	
	Carbon black dispersion	ASTM D5596	
	Axi-Symmetric Break Resistance Strain (min.)	ASTM D5617	Per formulation
	Oxidative induction time	ASTM D3895, ASTM D5885	One sample every 10,000 m^2, or resin type or manufacturing run

Item	Property	Standard	Frequency
Start-up test weld	Welding equipment	N/A	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	N/A	Test weld strips will be required whenever personnel or equipment are changed and/or wide temperature fluctuations are experienced. Minimum 1.5 m continuous seam
Destructive weld testing	On-Site, hand tensiometer in peel and shear	ASTM D6392	Every 150 m (if fusion weld), every 120 m (if extrusion weld)
	Off-Site — weld seam strength in peel and shear	ASTM D6392	Every 150 m (if fusion weld), every 120 m (if extrusion weld)
Non-destructive weld testing	N/A	Air pressure test, ASTM D5820 Vacuum box test, ASTM D5641	All seams over full length
Visual inspection of geomembrane	Smooth edges on both sides, tears, punctures, abrasions, cracks, indentations, thin spots, or other faults in the material.	N/A	Every roll

Note:

1. All Construction Quality Assurance tests must be reviewed, accepted, and reported by the CQA Consultant before deployment of the geomembrane.
2. All testing must be performed on samples taken from the geomembrane delivered to Site or at the supplier's/manufacturer's premises under the CQA Consultat's inspection or delegated authority.
3. All laboratory tests must be performed in an independent NATA accredited laboratory.
4. The required testing frequencies may be revised by the Superintendent to conform with 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 stability of Works).

1.25 Installation of Geocomposite Drainage Material

1.25.1 Scope of Work

The scope of Works incorporates the installation of geocomposite drainage material as specified and to the extent shown in the Drawings.

The Contractor shall provide all supervision, labour, cable ties (for joins) and equipment for the installation of the geocomposite drainage material in accordance with this Specification and Drawings.

Prior to installation, all geocomposite drainage material to be incorporated in the Works shall be approved in writing by the Superintendent.

1.25.2 General

Although the geocomposite drainage material is a Principal Supply Item, product information has been provided so that the Contractor is aware of the type of material that will be utilised in the Works.

1.25.3 Geocomposite Drainage Material Requirements

The geocomposite drainage material shall consist of a HDPE resin geonet with non-woven 100% polyester or polypropylene (with the exception of inhibitors and/or carbon black added for UV resistance), non-woven needle-punched geotextile fabric heat bonded on both sides. The geocomposite drainage material shall not be made from recycled materials.

The geotextile filaments shall be rot-proof, chemically stable and shall have low water absorbency. It shall resist de-lamination and maintain its relative position in the geotextile.

Geocomposite drainage material shall be free of flaws that may have an adverse effect on the physical and mechanical properties of the material.

Geotextiles shall be free of any manufacturing broken-off needles. Should any needles be found either by visual inspection or the Superintendent using a metal detector, the Principal is to thereafter arrange for the continuous inspection of both sides of each and every roll of geocomposite drainage material prior to installation. Inspection is to be via a Superintendent approved method of metal detection. Should more than 1 manufacturing needle or part thereof be detected per 200 m^2 of material, the Superintendent may reject the complete roll. Should more that 10 rolls, each with more than 1 needle per 200 m^2 be detected, the Superintendent may reject that complete batch of geocomposite drainage material.

The costs in replacing any rejected material will be covered by the Principal, including all necessary Construction Quality Assurance testing undertaken by the CQA Consultant, including the CQA Consultant's time related costs.

Geotextiles shall be stabilised against ultraviolet radiation to the degree that one (1) month exposure of the geotextile to sunlight shall not reduce its strength to less than 90% of the specified values.

The geocomposite drainage material shall have the minimum material Specification as set out in Table 6:

Table 6 - Geocomposite Drainage Material Specification

Property	Value	Test Method & Frequency
Geonet		
Thickness (min. ave)	≥ 5.6 mm	ASTM D 5199, 1 sample per 5,000 m^2
Carbon Black (min. ave)	2-3%	ASTM D 4218, 1 sample per 5,000 m^2
Tensile Strength (min. ave)	≥ 8.7 kN/m	ASTM D 7179, 1 sample per 5,000 m^2
Density (min. ave)	0.94 g/cm^3	ASTM D 1505, 1 sample per 5,000 m^2
Compressive Strength (min. ave)	800 kPa	ASTM D 6364, 1 sample per 5,000 m^2
Composite		
Ply Adhesion (min. ave)	≥ 170 g/m	ASTM D 7005, 1 sample per 5,000 m^2
Transmissivity(1) (min. ave)	≥ 2 x 10^{-3} m^2/sec	ASTM D 4716, 1 sample per 5,000 m^2
Geotextile – non-woven material only - Demonstrated by Geotextile Manufacturer's MQA Documentation		
Grab Tensile (min. ave)	≥ 1,590 N	ASTM D 4632, as per MQA Frequency
Trapezoid Tear (min. ave)	≥ 530 N	ASTM D 4533, as per MQA Frequency
CBR Puncture (min. ave)	≥ 3,950 N	ASTM D 6241, as per MQA Frequency
Water Flow (min. ave)	≥ 60 L/s/m^2	ASTM D 4491, as per MQA Frequency

(1) Transmissivity measured using water at 21 + 2 ^{O}C with a gradient of 0.1 and a confining pressure of 480 kPa between HDPE plates after 15 minutes. Values may vary with individual labs.

The geotextile is to be bonded onto the geonet such that there is no single area greater than 2,500 cm^2 (50 cm x 50 cm) where the geotextile has either delaminated or is unbonded. A minimum of 95% of the roll material surface area is to be securely bonded to the geonet. A maximum of 0.3 m of unbonded material is permissible on the roll edges. This unbonded portion is excluded from the above calculations.

1.25.4 Geocomposite Drainage Material CQA Testing

The geocomposite drainage material shall undergo the minimum CQA testing as set out in Table 7:

Table 7 - Geocomposite Drainage Material CQA Testing

Item	Property	Standard	Frequency
Construction Quality Assurance testing (sampled at the point of manufacture or on Site, as determined by the Superintendent)	Thickness	ASTM D5199	1 sample per 2,500 m^2
	Tensile Strength	ASTM D7179	1 sample per 5,000 m^2
	Compressive Strength	ASTM D6364	1 sample per 5,000 m^2
	Ply Adhesion	ASTM D7005	1 sample per 5,000 m^2
Visual inspection of geocomposite drainage material	Colour, non-adhered or delaminated portions, tears, holes, presence of needles or broken needles, and other faults in the material.	N/A	Each roll during placement.

Note:

1. All Construction Quality Assurance tests must be reviewed, accepted, and reported by the Superintendent before deployment of the geocomposite drainage material.
2. All testing must be performed on samples taken from the geocomposite drainage material delivered to Site or at the supplier's/manufacturer's premises under the Superintendent's inspection or delegated authority.
3. All laboratory tests must be performed in a third-party independent NATA accredited laboratory.
4. The required testing frequencies may be revised by the Superintendent to conform with 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 geocomposite drainage material for the stability of Works).

1.25.5 Manufacturing Specification and Quality Control

The test methods and frequencies used by the manufacturer for quality control/quality assurance of the above geocomposite drainage material prior to delivery shall be in accordance with Section 1.25.3 - Table 6.

The manufacturer's material quality control certifications, including results of quality control testing of the products, must be supplied to the Superintendent to verify that the materials supplied for the project are in compliance with all product and/or project Specification. The certification shall be signed by a responsible party employed by the manufacturer, such as the QAlQC Manager, Production Manager or Technical Services Manager. Certifications shall include lot and roll numbers and corresponding shipping information.

The manufacturer’s QC program shall be available for auditing. The manufacturer shall also provide a written certification that the geocomposite drainage material conforms to the material requirements for this project.

1.25.6 Quality Assurance

Manufacturer quality control (MQC) documentation from the manufacturer of the geocomposite drainage material supplied must be submitted by the Contractor to the Superintendent for approval. Submissions shall include:

- Date of manufacture;
- Lot number, roll number, length and width;
- Polymer quality documentation used in the production of the rolls delivered;
- Fibre quality documentation used in the production of the rolls delivered;
- Manufacturer quality control documentation for the particular lots of geocomposite drainage material used in the production of the rolls delivered;
- QC program laboratory-certified reports; and,
- The manufacturer’s approved QA stamp and the technician’s signature. The technician’s signature may be omitted from each roll label, but then must be included on each of the manufacturer’s test certificates associated with each roll.

Prior to delivery to Site, the Principal is to have provided the relevant certification documents to the Superintendent to substantiate that the material conforms to the required Specification.

1.25.7 Construction Quality Assurance Testing

The Principal shall provide test results for the rolls delivered to Site to demonstrate that the rolls meet the requirements of this Specification. The test frequency shall be as set out in Section 1.25.3 - Table 6.

The Superintendent will arrange for independent Construction Quality Assurance testing of the material. The Superintendent shall arrange for the Principal to provide samples to be recovered from the delivered rolls to Site, and tested at a NATA accredited laboratory. The results from the laboratory shall take precedence over the test results provided by the manufacturer of the material. The Construction Quality Assurance testing shall be at the Principal’s cost.

The Superintendent will arrange for independent Construction Quality Assurance testing of the material. In order to achieve this:

- The Superintendent will determine the location of where the samples are to be received, either at the point of manufacture, supplier's warehouse or on Site;
- The timing of when the sampling will occur is to be coordinated by the Superintendent, between all Parties, to ensure the most efficient sampling process and handover of the samples. This will either be during or immediately after manufacture or as soon as is reasonable following delivery to Site;
- The CQA Consultant or nominated representative (for non-local sampling) will be present at the point of sampling to monitor the sampling procedure and to receive the samples;
- The Principal is responsible for providing all samples, as required, from the rolls of liner material that will or have been delivered to Site and handing the samples to the CQA Consultant; and,
- The CQA Consultant will arrange for the delivery and testing of the samples to be carried out at an independent NATA accredited laboratory.

The CQA results from the independent laboratory shall take precedence over the test results provided by the manufacturer of the material. The Construction Quality Assurance testing shall be at the Principal's cost.

Any non-conformance in the delivered materials as identified by the Construction Quality Assurance testing shall be addressed by the Principal and thereafter, if the Superintendent rejects the material, the Principal shall replace the non-conforming material with conforming material. Again, the new material will be subject to Construction Quality Assurance testing to demonstrate its conformance with the Specification. Any replacement of non-conforming material and subsequent Construction Quality Assurance testing carried out by the Superintendent will be at the Principal's cost.

The material delivered to Site shall meet the Specification relative to the independent laboratory test results, for the material to be considered for incorporation into the Works.

Section 1.25.4 - Table 7 sets out the minimum Construction Quality Assurance testing that will be carried out by the Superintendent.

1.25.8 Delivery, Storage and Handling

Each roll of geocomposite drainage material delivered to the Site shall be labeled by the manufacturer. The label shall be firmly affixed and shall clearly state the following:

- Manufacturer's name;
- Product identification (material type);
- Date of manufacture, batch number, polymer type;
- Roll number;
- Roll length;
- Roll weight; and,
- Roll width.

The geocomposite drainage material rolls shall be delivered to the Site, handled and stored in such manner that no damage occurs to the geocomposite drainage material or its protective wrapping. The geocomposite drainage material rolls shall be wrapped with weatherproof wrapping to protect material from ultraviolet degradation and moisture uptake. In the event that rolls are damaged, the Superintendent shall assess the extent of the damage and consider possible rejection of the damaged rolls.

A dedicated area shall be used for the storage of all geocomposite drainage material delivered to Site. The material shall be stored and handled as follows:

- In its original, unopened packaging or resealed following the removal of samples from the roll;
- All rolls shall be covered and secured using trap material resistant to moisture;
- Away from high traffic areas, but sufficiently close to the active Works area to minimise handling;
- Elevated aboveground, on a level, dry, well-drained and stable area. Should timber pallets be used, they must be inspected and free of nails/pins prior to roll placement;
- Not more than three rolls high;
- Protected from precipitation, stormwater runoff, standing water, chemicals, excessive heat, ultraviolet (UV) radiation, vandalism and animals;
- Blocks provided to prevent sliding or rolling of stacks;
- All roll labeling shall be clearly visible;
- Appropriate slings used when lifting to prevent damage to any material; and,
- Under no circumstances may the rolls be dragged or pushed to the ground from the delivery vehicle.

Any damaged material shall be assessed by the Superintendent and if deemed necessary, rejected and the Contractor advised to immediately remove the material from Site.

1.25.9 Placement

Geocomposite drainage material placement shall be as follows:

- The Contractor is to provide a panel layout drawing to the Superintendent for approval a minimum of one week prior to any geocomposite drainage material installation. Once approved by the Superintendent, the geocomposite drainage material is to be installed in accordance with the approved panel layout;
- There is to be no driving on any liner material. Prior to installation, the Contractor is to provide a method statement on how it is proposed to install the geocomposite drainage layers without any driving on the LLDPE lined surface;
- No installation of geocomposite drainage material is to occur until the Superintendent has approved all manufacturer's QA/QC documentation, and all Construction Quality Assurance testing has been concluded and the material approved by the Superintendent, including the method of geocomposite drainage layer installation over the LLDPE;
- Installation shall be performed by an Installer who has installed a minimum of 50,000 m^2 of geocomposite drainage material of the type specified or similar product, using the same type of installation apparatus to be used in the current project;

- No placement shall occur during heavy rain events or during excessively windy conditions;
- Appropriate lifting equipment is to be used to ensure safe and efficient material placement;
- The Contractor shall ensure that the underlying LLDPE has been approved by the Superintendent prior to the installation of the geocomposite drainage material. The LLDPE surface upon which the geocomposite drainage material will be deployed shall be free of any sharp objects, stones, debris, standing water, or other potentially damaging objects;
- The geocomposite drainage material shall not be installed until inspection of the LLDPE has been undertaken and deemed suitable and in accordance with this Specification by the Superintendent;
- The geocomposite drainage material shall be installed such that the sheets are free of wrinkles and folds. The arrangement of the geocomposite drainage material sheets shall be according to a predetermined layout plan;
- The panels shall be laid in close contact and in accordance with the manufacturer's recommendations to allow continuous flow of water within the geocomposite drainage material;
- NO vehicular traffic shall travel on any liner material.
- The entire surface area of each and every roll shall be inspected by the Superintendent (for example, during unrolling/installation) to ensure that there is no damage or other faults in the material (such as significant and obvious variability in thickness/mass per unit area, tears, holes or presence of broken needles). If damage is identified, it will need to be repaired according to this Specification or as instructed by the Superintendent;
- During installation, adequate sandbags are to be left in place to prevent material being blown around by wind; and,
- The material is to be covered by subsequent layers within four weeks of installation to protect the geotextile from excessive UV decay.

Installation shall comply with the manufacturer's requirements, details of which shall be provided to the Superintendent prior to installation. Installation shall only occur once the Superintendent has accepted the material as being in accordance with the required Specification.

1.26 Cap Penetrations

There are landfill gas and leachate extraction system penetrations through the capped surface.

All penetrations through the cap liner system are to be sealed in accordance with detail contained within the Drawings and where appropriate, the manufacturer's installation recommendations or as agreed with the Superintendent.

The Contractor may propose alternative penetration details based on previous experience or manufacturer recommendations. The Design and CQA Consultants are to be satisfied that any proposed alternative is able to meet the intent of the Specification and are likely to achieve the maximum leakage rate through the liner. Alternative penetration details are to be approved in writing by the Superintendent prior to installation.

1.27 Interaction with Landfill Gas and Leachate Extraction Network

The Contractor is to be aware that there are a number of existing landfill gas and leachate extraction pipes within the Works area. The Contractor is required to install penetrations through the capped surface. As part of the process, the Contractor is to work closely with the landfill gas and leachate extraction contractors and the Principal to ensure that all Works are carried out with due consideration of the landfill gas and leachate extraction networks. The gas and leachate extraction networks are active networks that will be partially interrupted during the capping Works. The landfill gas and leachate contractor will need to disconnect and connect/reconnect various components of the networks during construction to ensure that landfill gas and leachate continues to be extracted from the waste mass with minimal down-time. There will be a need for close coordination and programing of the Works to ensure minimal delays to the Works.

All Works associated with the landfill gas and leachate infrastructure is to be coordinated with the related contractors.

1.28 Capping Stability Requirements

The designer has undertaken a stability assessment of the proposed capping system. The sloping side portions of the cap have the potential to fail if there is insufficient interface friction between the layers of synthetic materials.

In assessing the stability of the capped side slope, the designer used data from previous shear box testing of the various interfaces between the soil and synthetic liner materials. The materials and products used for the shear box testing included:

- Insitu silty clay soil;
- GCL – ELCOSEAL X2000;
- LLDPE – Solmax 1.5 mm double textured; and,
- Geocomposite Drainage Material – Interdrain geonet with top and bottom A39 geotextile.

The Principal is to provide samples of the synthetic liner material to the CQA Consultant, which will be used to undertake additional shear box testing to confirm that the actual liner materials used during construction provide equivalent or greater slope stability.

1.29 Access Tracks and Stormwater Drains

The Contractor is to construct access tracks and stormwater drains on top of the growing medium, in the typical locations indicated in the Drawings. On completion of the installation of the growing medium, the Superintendent will determine the actual location of the access tracks and stormwater drains, which will typically be in the locations indicated; however, will be adjusted to suit the top of cap profile, while achieving access to specific infrastructure and adequate stormwater control of the capped surface.

The growing medium is to be installed to ensure minimal compaction; however, the access track and stormwater drain earthworks are to be constructed to minimum 95% MMDD compaction. Due to the relatively flexible nature of the substrate (waste and uncompacted growing medium), it is unlikely that this degree of compaction will be achievable in the first or second compaction lift; however, subsequent compaction lifts should be able to achieve the specified degree of compaction. If 95% MMDD compaction is unable to be achieved, the Superintendent is to assess the compactive effort and determine the most suitable solution in order to achieve the maximum compaction on the capped surface.

1.30 Topsoil and Deep Ripping

The Contractor is to install the Principal Supply topsoil layer over the competed capped surface, other than on the access road surface and within the stormwater drains.

The topsoil will either be a thin layer of compost fines (approximately 25 mm) or topsoil (approximately 150 mm) available from site or a combination of both material types (approximately 150 mm).

On completion of the topsoil layer installation, the Contractor will deep rip the capped surface (min. 300 mm, max. 500 mm) to loosen the surface and to blend the topsoil layer.

1.31 Quality Assurance and Testing

1.31.1 General

The Contractor shall at all times be responsible for achieving the specified standards and demonstrating such achievement through testing and measurement and the provision of documentation which shall cover all Works under the Contract, both on-site and off-site and shall include the activities of all sub-contractors and suppliers. The exception being, that the Principal will be responsible for the quality of all Principal Supply Items.

1.31.2 Traceability

Traceability is required for all materials as stipulated in this Specification or if not stipulated, as per the relevant Standard, Code of industry norm. The trace shall start at the specified or nominated source point and finish at the location where the material is incorporated into the Works.

Traceability shall apply to:

- Geosynthetic Clay Liner;
- Geomembrane Liner; and,
- Geocomposite drainage material.

1.31.3 Inspection

The Superintendent or its nominated representative shall at all times be provided access to any facility where Works associated with the Contract is being performed, including the facilities of sub-contractors or suppliers either on-site, and any laboratory used for testing.

1.31.4 Testing Personnel

All quality control testing unless specified otherwise shall be carried out by a laboratory holding current NATA accreditation for all test methods referred to or required by this Specification. NATA accreditation for all test methods shall be held at the time of tendering and be maintained until completion of the Contract. All test reports shall be NATA endorsed by a current NATA signatory approved for the laboratory conducting the testing.

Surveying processes to verify conformance shall be conducted by suitably qualified personnel, which includes:

- A qualified and experienced surveyor able to be a fulltime member of the Institution of Mining and Engineering Surveyors Australia;
- A surveyor licensed under the WA Licensing Board; or,
- A surveyor that has undertaken similar works and at the same level of responsibility for a minimum of five years and has a proven track-record of reliable survey works.

1.31.5 Sampling and Test Frequency

Sampling methods shall be unbiased and either random or systematic in concept or as specified. The minimum frequency of tests shall be as stipulated in this Specification or if not stipulated, as per the relevant Standard, Code of industry norm.

1.31.6 Testing

1.31.6.1 Limits of Work to be Tested

The minimum frequency of tests shall be as stipulated in this Specification.

1.31.6.2 Test Methods

The tests methods shall be as stipulated in this Specification or equivalent alternative test methods approved by the Superintendent.

1.31.7 Measurement and Test Equipment

Measurement and test equipment shall include all equipment necessary for the proper setting out and for production and Construction and Construction Quality Assurance testing of the Works. Calibration and certification of test equipment shall comply with NATA stipulations.

1.31.8 Records and Reporting

The Contractor shall complete all As-Constructed and quality verification documentation and submit all records to the Superintendent at regular intervals during the Contract period as agreed with the Superintendent.

Manufacturers' and suppliers' certificates provided by the Principal shall enable a clear trace of items from source to the location within the Works.

1.31.9 Payment for Quality Control and Testing

The cost of Construction Quality Control testing to the extent required by this Specification shall be borne by the Contractor.

The Principal shall pay for all Construction Quality Assurance testing as stipulated in this Specification.

1.32 As-Constructed Drawings

The Contractor is to provide a set of As-Constructed drawings in AutoCAD format and A3 size hard copy. The As-Constructed drawings are to show the following minimum detail:

- Top of surface of re-contoured landfill;
- Top of GCL position, including anchor trench position;
- Location of all penetrations through the liner;
- Top of growing medium;
- Location of all access tracks and stormwater drains;
- Other miscellaneous items as required; and,
- Any changes to the Approved For Construction Drawings that occurred during construction.

The Contractor will be provided with an electronic copy of the Approved For Construction Drawings. These original Drawings are to be modified to include all As-Constructed details. In addition, the Contractor is to remove the Design Consultant's Logo and contact details and replace the information with the Contractor's logo and contact details.