

Shire of Upper Gascoyne

TECHNICAL SPECIFICATION

GACOYNE JUNCTION WASTE DISPOSAL SITE EVAPORATION POND

November 2024

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CONTENTS

1	GENERAL	5
1.1	Scope	5
1.2	Definitions.....	5
1.3	Drawings	6
1.4	Codes and standards.....	6
1.5	Construction management plans.....	7
1.6	Specified products	9
1.7	Weather	9
1.8	Surface Water Management	9
1.9	Dust and Wind-Borne Material Control	9
1.10	Quality Control.....	9
1.10.1	<i>Contractor Supervision</i>	<i>9</i>
1.10.2	<i>Inspection and test plans</i>	<i>9</i>
1.10.3	<i>Hold Points/Witness Points</i>	<i>10</i>
1.10.4	<i>Soil Testing</i>	<i>10</i>
2	EARTHWORKS	10
2.1	Survey and Set out	11
2.2	Clearing, Grubbing, and Topsoil Stripping	11
2.2.1	<i>Topsoil Stripping.....</i>	<i>11</i>
2.2.2	<i>Clearing</i>	<i>11</i>
2.2.3	<i>Grubbing</i>	<i>12</i>
2.3	Unsuitable Material	12
2.4	Areas of fill	12
2.5	Areas of cut.....	12
2.6	Preparation of geomembrane laydown area.....	13
2.7	Fill materials.....	13
2.7.1	<i>Site won fill criteria</i>	<i>13</i>
2.8	Fill placement and compaction.....	14
2.8.1	<i>General.....</i>	<i>14</i>
2.8.2	<i>Layer thickness and compaction</i>	<i>14</i>
2.8.3	<i>Anchor trench backfill and compaction.....</i>	<i>14</i>
2.8.4	<i>Frequency of testing.....</i>	<i>15</i>
2.8.5	<i>Proof rolling.....</i>	<i>15</i>
2.8.6	<i>Rejection and reinstatement.....</i>	<i>15</i>
2.9	Final trim and tolerances	16
2.9.1	<i>Lining subgrade surface</i>	<i>16</i>
2.9.2	<i>Embankment Construction Tolerances</i>	<i>16</i>
3	HDPE GEOMEMBRANE SUPPLY.....	16
3.1	Quality control	16
3.1.1	<i>Manufacturers quality control (MQC).....</i>	<i>17</i>
3.1.2	<i>Warranty.....</i>	<i>17</i>
3.2	HDPE material properties	17
3.3	Extrudate rod	18
3.4	Transportation and storage	18
4	HDPE GEOMEMBRANE INSTALLATION.....	19
4.1	General requirements.....	19
4.1.1	<i>Inspection and handover.....</i>	<i>19</i>

4.1.2	<i>Temporary anchorage of liner during installation</i>	20
4.1.3	<i>Care and protection of the works</i>	20
4.2	Submittals	20
4.3	Handling and placement	21
4.4	Field welding	21
4.4.1	<i>General</i>	21
4.4.2	<i>Weld preparation</i>	21
4.4.3	<i>Fusion welding</i>	21
4.4.4	<i>Extrusion welding</i>	21
4.5	Trial welds	21
4.6	Non-destructive testing	22
4.6.1	<i>Air pressure testing</i>	22
4.6.2	<i>Vacuum box testing</i>	22
4.7	Destructive testing	23
4.8	Inspection and repair	23
4.9	Patching repair	24
4.10	Capping repair	24
4.11	Installation Quality Assurance report	24
4.12	Installation warranty	24
4.13	Liner acceptance	24

1 GENERAL

1.1 Scope

This Technical Specification describes the standards required for the physical works associated with the construction of the new Evaporation Pond for the Shire of Upper Gascoyne at the Gascoyne Junction Waste Disposal Site. The Contractor shall provide all supervision, labour and equipment necessary for the construction of the Evaporation Pond and installation of the 2.0 mm smooth/smooth black HDPE geomembrane in accordance with this Specifications and Drawings. The Works shall include, but not limited to:

- Site establishment including facilities, laydown areas, temporary fencing, access control.
- Construction of the embankment based on a cut to fill operation.
- Supply and install 2.0mm black smooth/smooth High-Density Polyethylene (HDPE) geomembrane within the evaporation pond to the extent shown on the drawings.
- Install permanent ballasting on the geomembrane in accordance with the Drawings.
- Excavate and backfill of anchor trenches.
- Construction Quality Control testing, sampling and record keeping.
- Provision of "As Constructed" information.
- Such other Works as shown on the Drawings or as described in these Specifications.

1.2 Definitions

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

Term	Definition
'The Works'	All construction works required to deliver the project as defined by this Specification and as shown on the Drawings
'Company'	Shire of Upper Gascoyne (also referred to as 'Principal')
'Contractor'	Party awarded the Contract to complete the Works
'Superintendent'	Has the meaning given to it in the amended AS4000-1997 General Conditions of Contract (including the Annexures) and, so far as concerns the functions exercisable by Superintendent's Representative.
'Company Representative'	A Company nominated representative independent of the Contractor responsible for the review of QA documentation, observation and inspection of the Works, and maintenance of quality assurance records. Also referred to as "Construction Quality Assurance (CQA) Consultant".
Witness Point	An identified point in the construction of the Works sequence where the Contractor is required to provide notification in advance of commencing work on identified items in order to allow the opportunity for the Superintendent or Company Representative, to directly inspect the work; the notification must be provided when indicated and in no case less than 24 hours in advance of commencing the work.
Hold Point	An identified point in the construction sequence where the Contractor must halt work and provide required information to the Superintendent. The Contractor must not resume work until the hold point is released, in writing, by the Superintendent.
Roller Pass	One pass of the vibratory roller is defined as the movement of the roller in vibratory mode over a specific point once at an operating speed not exceeding 3 kph. A minimum of 10% overlap is required between adjacent compaction passes.

1.3 Drawings

The drawings detailed in Table 1 below form part of the Construction Documentation.

Table 1: Drawing List

Drawing Ref	Title	Revision
11974-C1-DG-0000	Cover Page	A
11974-C1-DG-0001	Locality plan and drawing index	A
11974-C1-DG-0101	General arrangement plan	A
11974-C1-DG-0102	Contour plan	A
11974-C1-DG-0201	Typical sections and details 1 of 2	A
11974-C1-DG-0202	Typical sections and details 1 of 2	A

1.4 Codes and standards

All materials, fabrication, installation and testing shall be in accordance with the latest revision of the codes and standards listed in Table 2. Codes and Standards shall be read in conjunction with, and form part of this Specification. Where there is a conflict between this Specification and the applicable codes and standards, the highest standard shall apply.

Table 2: Codes and Standards

Code/Standard	Title
AS/NZS ISO 9001	Quality management system – Requirements
ASTM D746	Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact
ASTM D792	Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
ASTM D1004	Standard Test Method for Tear Resistance (Graves Tear) of Plastic Film and Sheeting
ASTM D1204	Standard Test Method for Linear Dimensional Changes of Nonrigid Thermoplastic Sheeting or Film at Elevated Temperature
ASTM D1238	Standard Test Method for Melt Flow Rates of Thermoplastics By Extrusion Plastometer
ASTM D1505	Standard Test Method for Density of Plastics by the Density-Gradient Technique
ASTM D1603	Standard Test Method for Carbon Black Content in Olefin Plastics
ASTM D4833	Standard Test Method for Index Puncture Resistance Geomembranes and Related Products
ASTM D5199	Standard Test Method for Measuring the Nominal Thickness of Geosynthetics
ASTM D5397	Standard Test Method for Evaluation of Stress Crack Resistance of Polyolefin Geomembranes Using Notched Constant Tensile Load Test
ASTM D5596	Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics
ASTM D5885	Standard Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by High-Pressure Differential Scanning Calorimetry
ASTM D6693	Standard Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes
ASTM D5641	Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber
ASTM D5820	Standard Practice for Pressurized Air Channel Evaluation of Dual-Seamed Geomembranes
GRI-GM9	Standard Practice for Cold weather seaming of geomembranes
GRI-GM10	Specification for the Stress crack resistance of geomembrane Sheet
GRI-GM13	Standard Specification for test methods, test properties, and testing frequency for high density polyethylene (HDPE) smooth and textured geomembranes
GRI-GM14	Standard guide for selecting variable intervals for taking geomembrane destructive seam samples using the method of attributes
GRI-GM19	Standard specification for seam strength and related properties of thermally bonded polyolefin geomembranes

GRI-GM20	Standard guide for selecting variable intervals for taking geomembrane destructive seam samples using controls charts
GRI-GM29	Standard practice for field integrity evaluation of geomembrane seams (and sheet) using destructive and/or non-destructive testing

1.5 Construction management plans

The Contractor is required to prepare Construction Management Plans (CMP's) to be implemented for the duration of the Works. These management plans shall be prepared in appropriate form and be issued to the Principal for review and acceptance, two (2) weeks prior to the commencement of construction. The Contractor shall allow for two iterations of review for each suite of management plans. The Contractor will not be awarded possession of site until the Principal has confirmed in writing acceptance of these management plans.

Acceptance of the management plans by the Principal shall not constitute approval or remove the Contractor's responsibility to ensure that all requirements of relevant legislation, guidelines and best practice are satisfied.

Table 3: Construction Management Plans minimum requirements

Management Plan	Definition
Construction	<p>A Construction Management Plan (CMP) shall provide a management framework for the efficient management of work activities.</p> <p>The fundamental aim of this plan is to ensure that all construction is properly facilitated, integrated and coordinated as to deliver certainty to the effective management of work activities i.e. effective communication, enhanced quality control, elimination or minimisation of risk and injury.</p> <p>The minimum requirement of the CMP shall include:</p> <ul style="list-style-type: none"> • Management structure and responsibilities • Site layout and planning • Skills and training • Work methodologies and procedures.
Construction Schedule	<p>A programme shall be prepared that shows activities to be performed under the Contract in enough detail that the works can be planned. The programme shall include, as a minimum, a schedule for all construction activities and associated works, and a proposed timeframe for completion and demobilisation. The programme shall clearly show the critical path of the Works.</p> <p>An updated schedule shall be issued to all parties working under the Contract within 24 hours of a change to the critical path.</p> <p>The programme shall be provided in MS project or similar Principal approved form.</p>
Occupational Health and Safety	<p>The Health and Safety Management Plan shall provide a management framework to effectively protect the health and well-being of all site workers during the construction period. The HSMP shall include, but not necessarily limited to:</p> <ul style="list-style-type: none"> • Commitment to comply with the provisions of the relevant Acts. • Risk identification and assessment of all construction activities, with control measures to reduce risks. • Induction and training requirements for site access. • Provisions to ensure that all plant and equipment undergoes all necessary checks to ensure operability/serviceability, is maintained in a safe a serviceable condition, is operated safely and competently, and that suitable precautions and safeguards are applied during construction.

	<ul style="list-style-type: none"> • Provisions for safety around batters and excavations. • Provisions for communicating material safety issues. • A Material Safety Data Sheet (MSDS) register of potentially dangerous substances to be stored on-site. • Safe work procedures when handling chemical products. • Incident reporting processes and corrective actions. <p>The Contractor shall review and adopt the site specific emergency response plan of the Company, and co-ordinate their emergency response activities to align with any existing plans.</p>
<p>Quality</p>	<p>The Contractor should prepare and submit a project Quality Management Plan (QMP) for the duration of the Works, which shall comply with the Contract requirements. The QMP should, as a minimum, address the following areas:</p> <ol style="list-style-type: none"> 1. The quality objectives to be attained for the Contract 2. Allocation of responsibilities and authority during each phase of the Contract. 3. Shall clearly reference all related procedures envisaged to cover all activities and meet the requirements of the Specifications and Standard. The Contractor shall comply with the approved quality plan for the duration of the Works. The construction activities may include on-site set-out, auditing, inspection, lifting studies, mechanical items, electrical works, testing, no-load commissioning, and any other items necessary or required for the proper and timely completion of the Works. 4. Engage suitably qualified personnel to carry out all inspection and testing activities. Personnel should be NATA accredited and provide documentation and test certificates to the Company in a timely manner for review and approval. 5. Must include the completion of Inspection and Test Plans (ITPs), including witness and hold points and manufacturer’s data. <ol style="list-style-type: none"> a. Specific ITPs, nominating the verification checklists for each location of the project, should be prepared and submitted 14 days prior to commencement of the Works for approval by the Company. b. The ITPs for earthworks shall include, as a minimum, witness and hold points for earthworks preparation/compaction to the line and level/placement of fill of various kinds and include Lot plans and Borrow Material Management Plan. 6. Control and distribution of Quality Records. 7. Method for managing changes, exceptions, and modifications in the Quality Management Plan as the Contract proceeds. 8. Production of record documents at the completion of the Contract and (Implement approved documentation throughout the project duration, and ensure that all up-to-date documents are made available to the Company at any time) 9. Other measures necessary to meet the objectives of the Contract.
<p>Stockpile</p>	<p>A Stockpile Management Plan (SMP) shall be provided by the Contractor to the Company prior to the commencement of the project earthworks (hold point). The Stockpile Management Plan should include the following, at a minimum:</p> <ul style="list-style-type: none"> • The location and area for each material unit to be stockpiled. This shall include all imported and site won materials. • The proposed method for monitoring volumes and moisture conditioning.

	<ul style="list-style-type: none"> • The proposed method for ensuring cross contamination does not occur between material units. • Stockpiles shall be developed to have stable slopes and minimise the effects of erosion from runoff. Berms and catch shall be provided as appropriate.
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1.6 Specified products

This Specification identifies some products by specific brand names. Whilst this identifies the design intent for the project, alternative products may be used. The Contractor must clearly identify any alternate products and demonstrate to the Company that the alternative product is of an equivalent or higher standard. The Contractor must have the Company's Representative approval prior to order and placement of any product other than those specified.

1.7 Weather

The Contractor shall implement measures as identified in its Health Safety and Environment (HSE) Management Plan to ensure the safety of site personnel in the advent that windy conditions arise during earthworks or liner installation. Such measures may include liner venting as well as provision of additional sand bags or other weights, particularly on leading edges. The Contractor shall be responsible for all expenses associated with delays due to prevailing weather conditions.

1.8 Surface Water Management

The Contractor shall maintain all temporary water diversion, drainage controls and protection of works against water run-off, which are necessary for the construction of the Works. The Contractor shall keep all excavations and working areas free of surface and ground water during excavation and placement of fill material.

Softening of materials due to the Contractor's failure to drain any low points shall not be grounds for unsuitable material claims. It remains the Contractor's responsibility to obtain all approvals for surface water management where required.

1.9 Dust and Wind-Borne Material Control

The work site conditions are such that wind conditions may subject adjacent residences and nearby amenities to nuisance from dust and wind-borne material (such as smoke) from the Works site during the Contract.

The Contractor shall make themselves familiar with the Department of Environment's publication "A guideline for managing the impacts of dust and associated contaminants from land development sites, contaminated sites remediation and other related activities" (March 2011) document and have a copy of this document onsite for the duration of the Contract.

1.10 Quality Control

1.10.1 Contractor Supervision

An experienced civil works supervisor shall be employed to supervise the works. Before any work is commenced, the name and qualifications of the supervisor proposed to be employed on the Works shall be submitted to the Company for acceptance, together with details of their previous experience. Notwithstanding previous acceptance having been given, the Company may, at its absolute discretion, require the removal and replacement of any supervisor whom the Company considers to be unsuitable for the supervision of the works.

All nominated key personnel, including supervisors, will not be permitted to undertake any other labour work/tasks and/or operate machinery during any supervisory and management tasks.

1.10.2 Inspection and test plans

Inspection and Test Plans (ITPs) shall be submitted by the Contractor to the Superintendent/Company Representative on an ongoing basis during the course of the Work.

An ITP shall apply to, and be initiated for, each Lot of the Work. For the purposes of this Clause, a Lot is defined as a section, element, or complete component of the work commensurate with a required conformance decision and shall be designated by the Contractors Quality Assurance Representative unless otherwise modified by the Superintendent.

1.10.3 Hold Points/Witness Points

Throughout the Works, hold points and witness points shall apply whereby the Contractor shall submit relevant information and/or allow inspection of works by the Superintendent or Company Representative for prior approval.

The Contractor shall provide the Superintendent/Company Representative with a reasonable amount of notice prior to expected completion of works on a Lot-by-Lot basis, where inspections are required as part of the hold point/witness point requirements of this document. Notice should be provided to ensure inspections can be planned and executed with minimal delays to works, and that safe access to inspection areas is available.

The Contractor may subdivide the area into Lots such that approval of a hold point/witness point can allow work to continue in the specific area of the Lot. These Lots must be detailed on a Lot layout plan and be surveyed and set out/pegged prior to works being commenced. This map shall be reviewed for approval by the Company Representative and on an ongoing basis where changes are proposed, reviewed, and accepted.

If the Contractor proceeds to construct beyond the designated hold point without the Superintendent's inspection and/or without the Superintendent's approval, then the Superintendent may direct the Contractor to uncover and remediate the Works to the hold point at the Contractor's expense.

The Contractor shall be deemed to have allowed for all time delays and costs associated with the hold points during the Works.

1.10.4 Soil Testing

A NATA Registered soils technician shall be engaged by the Contractor to perform soil sampling, in-situ density testing, and other such soil tests as necessary. The Contractor shall provide access at all times to the site during construction for the Company to undertake their own testing if directed. All testing shall be generally carried out in accordance with AS 1289.

Soil samples for classification testing shall be collected from representative materials within the stockpiles. This may require the mixing of the stockpile to form a homogenous material and excavation into the stockpile to retrieve representative samples from non-wind nor moisture affected zones.

In-situ density testing shall be carried out no later than 24 hours after compaction has been completed and confined to a lot-by-lot basis. Testing locations are to be selected by the Company Representative in consultation with NATA accredited tester and Contractor, ensuring the representative condition of the layer is accounted for. Locations should be random and evenly spread throughout the extent of the Lot undergoing testing. Locations should be selected at the time of testing, with layer volume and area data provided to establish required frequency of testing, in accordance with this Specification.

Test results shall be issued to the Contractor and Company, including the Company Representative, for review and approval, in accordance with the material specification and compaction criteria (**hold point**).

2 EARTHWORKS

At the time of preparing this Specification, no detailed geotechnical information was made available for the Site. Therefore, the below assumptions have been made to generate the requirements of this specification. Following the completion of a geotechnical investigation, the details relevant to the assumptions below may be updated.

1. Peak groundwater is located at least 2 m below existing ground level.
1. The topsoil is nominally 100 mm thick and during excavation will remove all unsuitable materials.
2. Below the topsoil, the near surface soils will consist of sandy Clays with no gravel or rock fragments greater than 20 mm.

3. No areas or zones of loose/soft material exist within the footprint which may require remediation.
4. The soils below the footprint of the Pond are clays and in a stiff to hard state.

The depth of excavations shall be undertaken to the depth and extent shown on the Drawings or as required to meet the clearing and grubbing requirements provided in Section 2.2. All excavations shall be kept free and clean of loose materials, water and rubbish. Should excavation to the nominated depth reveal unstable or unsuitable ground/material, the Contractor shall immediately inform the Company Representative.

2.1 Survey and Set out

It is the responsibility of the Contractor to undertake the initial set out of the construction footprint based on the details set out in the Drawings. A walkover of the set out with the Contractor and Company Representative shall be undertaken to visually inspect the footprint of the works (hold point). The Contractor shall give a minimum five (5) days' notice for this inspection.

Following sign off of the set out, this shall represent the handover of the Works area to the Contractor and all future survey shall be the responsibility of the Contractor.

2.2 Clearing, Grubbing, and Topsoil Stripping

The Works consists of the clearing of all vegetation including the grubbing of trees and stumps, all rubbish, and other materials which are unsuitable for use in the Works. The contractor will be required to provide a site clearing plan for review and approval by the Superintendent prior to commencement of any clearing and grubbing works.

Areas to be cleared and grubbed shall be generally limited to the area required to construct the Works. Clearing shall not extend outside the limit of the Site unless approved by the Company.

2.2.1 Topsoil Stripping

Topsoil shall be defined as the surface or top layer of soil including fine roots and other organics. All clearing equipment shall be inspected and deemed clean prior to any topsoil removal to prevent the spread of declared weed species.

The topsoil will be stripped and stockpiled separately in accordance with the site Stockpile Management Plan. The thickness of topsoil within the footprint may vary, however the stripped surface should provide a sound foundation for embankments free of organic material (<2% by weight).

A witness point shall be initiated upon completion of the topsoil strip prior to the beginning of construction works. This inspection may be undertaken within defined Lots and include ongoing sign off and approval within the ITP's. The inspections should be undertaken by the Company's Representative to confirm that topsoil and organic material have been removed so that there is <2% by weight of vegetation and all roots/sticks no greater than 30 mm in diameter have been removed.

The provisional depth of the topsoil strip shall be 100 mm unless shown otherwise on the drawings or to a depth that the above criteria can be met.

2.2.2 Clearing

Clearing shall extend over the cut and fill areas of the site as shown on the Drawings. Clearing shall consist of the removal of all debris, farming infrastructure, trees (standing or fallen), brush, shrubs, grass, and other vegetation, rubbish or boulders.

Machines used for pushing and heaping operations shall be fitted with root stakes or similar equipment and operated in such a manner that as little soil as possible is removed during the process. No material from the clearing works is to be pushed beyond the limits of the site.

All cleared vegetation shall be stockpiled on site in a location to be directed and agreed by the Company Representative. All other unsuitable material, uncontrolled fill and rubbish shall be removed from site as soon as practicable to an approved refuse site.

Fires will not be permitted to be used on-site for clearing or any other purpose at any time.

2.2.3 Grubbing

All trees and stumps, roots, rocks, rubbish, and other objectionable material below ground level shall be removed by grubbing. Any non-organic material encountered should be disposed of appropriately in accordance with site-based requirements.

Before any backfilling commences, the exposed ground surface shall be inspected and approved by the Company Representative (**witness point**), and the inspection shall be reflected on the ITP for each defined Lot. If any roots, sticks, or other deleterious materials are observed during this inspection, they shall be removed as per this specification prior to fill placement.

2.3 Unsuitable Material

Material that is deemed to be Unsuitable shall be excavated and disposed of off-site or by direction of the Company. Material deemed unsuitable for inclusion within the construction of the Pond may include:

- Organic soils, root-affected subsoils and peat.
- Roots, branches, or sticks with a 30 mm diameter or greater.
- Fill containing wood, metal, plastics, boulders or other deleterious material.
- Cobble and boulder filled soils.
- Alluvium (soft silts with some organics)

Such material shall be excavated to the extent specified within this Specification or as directed by the Company. The remediation of the affected area shall be in accordance with the fill type, placement, and compaction requirements laid out within this Specification. It shall be the responsibility of the Contractor to notify the Company of areas where significant quantities of Unsuitable Material are identified. If significant Unsuitable Materials are identified, the contractor shall develop a proposed methodology for remediation and submit to the Company Representative for review and approval (**hold point**).

Any area affected by unsuitable materials shall be inspected by the Company Representative prior to backfill to inspect that a suitable depth and extent of excavation has occurred (**hold point**).

Unsuitable Material does not include that which has become saturated due to inadequate drainage, or otherwise suitable material in a wet condition which can be removed, dried out and reused. Where it is not practical to undertake works due to excess moisture in the material, the Contractor shall carry out all operations necessary on the moisture-affected material to enable work to proceed. This may include:

- Allowing the material to dry until it will support equipment and allow compaction.
- Scarifying the material, working as necessary, including draining, to accelerate drying, and re-compacting when the moisture content is satisfactory; or
- Excavating the material and removing spoil and backfilling excavated areas with appropriate material.

2.4 Areas of fill

The subgrade below areas of fill or underneath the embankments shall be scarified/tined and moisture condition to a minimum depth of 300 mm to allow bonding between the natural ground and placed fill materials. These works shall be undertaken immediately prior to placement of fill materials to avoid deterioration of ripped natural ground and drying out and shall be inspected by the Company Representative via visual assessment for approval prior to placement of fill material (**witness point**).

2.5 Areas of cut

Following the excavation of cut areas, the exposed subgrade shall be ripped or loosened to a minimum depth of 300 mm below the designed subgrade level. The exposed soils shall be visually inspected by the Company Representative for the presence of Unsuitable Materials and the maximum dimensions of any particle within the ripped or loosened zone shall

not exceed 50 mm. This zone shall then be moisture conditioned and compacted in accordance with this Specification to provide the lining subgrade surface. Therefore, final surface approval should be undertaken in accordance with the tolerances presented in Section 2.9 and shall be subject to approval by the Company Representative (**hold point**).

2.6 Preparation of geomembrane laydown area

HDPE Geomembrane shall be stored on a prepared laydown area consisting of a smooth, dry, compacted hardstand area with adequate drainage to prevent pooling of water underneath the rolls. Where necessary the rolls shall be elevated off the ground using a free draining clean sand or structural supports. Any method shall ensure the even distribution of weight and shall not result in bending of the rolls.

2.7 Fill materials

It is the responsibility of the Contractor to ensure that the Site Won materials meet the requirements of the Specification and shall demonstrate compliance as outlined in this Specification. The Contractor shall submit representative samples, photos, material gradings, plasticity indices, liquid limits and linear shrinkage values (where applicable) to the Company Representative for approval prior to importing or placing any such materials.

Unless otherwise specified, the following laboratory testing standards shall be used to determine the required geotechnical properties of the fill material:

- Particle gradings shall be determined in accordance with AS 1289.3.6.1
- Plasticity index shall be determined in accordance with AS 1289.3.3.2
- Liquid limits shall be determined in accordance with AS 1289.3.1.1
- Specific gravity shall be determined in accordance with AS 1289.3.5.1
- Optimum moisture content shall be determined in accordance with AS 1289.5.5.1
- Maximum dry density for fine grained soils (standard) shall be determined in accordance with AS 1289.5.1.1
- Maximum dry density for granular soils (modified) shall be determined in accordance with AS 1289.5.2.1
- Input parameters for CBR or permeability testing shall be determined by the designer as necessary.

The material definitions are detailed in the following table and the acceptance criteria for each material is presented in the sections below.

Table 4: Fill material definition

Material Type	Description	Material Source
Site won fill	Assumed to be a Sandy CLAY Pending geotechnical investigation	Site won

2.7.1 Site won fill criteria

Where excavated materials are to be assessed for their re-use within the project, relevant soil classification testing shall be carried out on representative soil samples. The results of the testing shall be provided to the Company Representative for review and approval a minimum of three (3) days prior to their use within the project (**witness point**). The laboratory testing and frequency should be in accordance with Section 2.8.4.

The site won fill material shall satisfy the following criteria:

- Free from demolition materials, construction rubble, timber, and other non-natural waste materials.
- Maximum allowable amount of sticks is 1 stick <30 mm diameter per cubic meter of stockpiled material, this is to be visually assessed.
- Have less than 2% organic material by weight (assessed by visual inspection).
- Be able to achieve a smooth, flat lining surface.
- Conform to the requirements of the particle size distribution in Table 5.
- Liquid Limit, LL ≤ 50%
- Plasticity Index, 15% ≤ PI ≤ 30%

The grading of the material should be based on laboratory testing in accordance with this Specification. The results are to be reviewed by the Company Representative for approval prior to placement and compaction (**hold point**).

Table 5: Sandy Clay (liner subgrade) particle size distribution criteria.

Sieve Size	Percentage Passing (by mass)
37.5	100
19	95-100
4.75	80-100
2.36	70-100
1.18	60-95
0.425	50-85
0.075	30-70

2.8 Fill placement and compaction

2.8.1 General

Embankments and compacted surfaces shall be subject to compaction testing in accordance with AS 1289.5. The maximum size of a production Lot for the purpose of compaction testing, shall be defined by the Company. The Contractor shall provide all necessary access and facilities for testing and shall reinstate the compacted surface where test samples are taken.

The Company may from time to time direct the Contractor to carry out check tests for moisture content, fill thickness, and achieved compaction at nominated locations, however the Contractor is, and shall remain, wholly responsible for achieving the required compaction everywhere. The Contractor shall immediately forward the test reports to the Company.

Filling and compaction operations shall be arranged in a way that will allow for the required testing to be undertaken as work proceeds. This includes allowing for the time to receive the results of the testing and sign off by the Company Representative.

A hold point shall be initiated for each compacted Lot/Layer prior to further placement of fill, to allow a review of compaction results by the Company Representative. The Contractor may work ahead at their own risk, pending completion and review of compaction testing. If completed layers do not meet the minimum compaction requirements as outlined within this Specification, all additional works conducted on subsequent layers, and the failed layer, must be removed and reinstated at the Contractors expense.

2.8.2 Layer thickness and compaction

The embankments of the Pond shall be constructed using the Site Won Fill and placed in accordance with the method statement provided by the Contractor. This method statement may be developed and adapted in agreement with the Company Representative during the course of the Works.

The Site Won material shall be placed and compacted in uniform layers, not exceeding a compacted layer thickness of 300 mm. Each layer shall be compacted to achieve a minimum 98% of Standard Maximum Dry Density (MMDD) and $\pm 2\%$ of Optimum Moisture Content (OMC).

2.8.3 Anchor trench backfill and compaction

Anchor trenches shall be constructed and maintained by the Contractor in accordance with and to the extent shown on the Drawings during installation of the geosynthetic materials. Prior to placement of the geosynthetic materials, the surface of the trenches shall be inspected and approved by the Company Representative (**witness point**), which shall be free of debris, sharp or angular particles of any size, roots, and water.

Following installation of the geosynthetic materials, the anchor trench shall be backfilled with the excavated material while the liner is in a relaxed state (i.e. not a state of tension) and in full intimate contact with the subgrade without folds or wrinkles. Where minor folds or wrinkles are encountered, they should be cut and/or removed to allow the liner to be in full intimate contact.

The backfill shall be undertaken in a minimum of two uniform layers, which shall be moisture conditioned and compacted to achieve a minimum of 98% SMDD 95% SMDD and $\pm 2\%$ of Optimum Moisture Content (OMC).

2.8.4 Frequency of testing

The minimum test frequency shall be at least in accordance with the table below or at such other rate as may be required by the Company during the course of the work. The location of tests will be at the Company's discretion, selected by the Company Representative.

Test type	Test Frequency
Soil classification testing <ul style="list-style-type: none"> • Particle Size Distribution • Atterberg Limits + Linear Shrinkage 	For site-won materials: <ul style="list-style-type: none"> • A minimum of 1 sample per 1,000 m³. • Testing of cut materials shall be undertaken progressively throughout the Works. Additional samples should be undertaken by the Contractor if a change of material is encountered or at the direction of the Company.
Field nuclear density testing and laboratory MDD (maximum test thickness of 300 mm)	For lining subgrade, embankment fill, and anchor trenches: A minimum of 1 test per two layers per material type per 2,500 m ²

2.8.5 Proof rolling

Proof rolling will be required over identified work areas as directed by the Company. The method of proof rolling shall be approved by the Company Representative. The objective is to delineate differential near surface subsoil conditions, by observations of the compaction plant performance, and to provide a strong, uniform, near-surface soil diaphragm.

The tests must not exhibit visible deformation, rutting, or yielding and/or show signs of distress or instability. Should any of the above occur the work area will need to be reworked and retested. Costs associated with rectification including reworking, retesting, resurveying and reproof rolling shall be borne by the Contractor.

Remedial work, such as local excavation, conditioning, and replacement with approved fill where required shall be carried out in accordance with the Company's instruction. If further proof rolling is required at a later date, the layer must be re-conditioned such that the moisture content is within the above-specified range and re-verified as conforming for density and survey requirements of this Specification.

Presentation of an area of proof rolling shall be undertaken in the presence of the Company. A visual assessment of proof rolling works shall be undertaken by the Company Representative (**witness point**). Proof rolling should be undertaken with a minimum of 15t roller.

2.8.6 Rejection and reinstatement

Conformance of testing shall be reviewed by the Company Representative prior to further works being undertaken within each individually tested Lot. Where minimum compaction requirements are not met, it is the Contractors responsibility to reinstate the failed layer by removing, reworking and recompacting suitable fill material at the Contractors cost.

If during the excavation works, or as identified by the soil classification testing, there is not enough volume of the site-won Sandy CLAY to form a suitable lining subgrade, an imported material may be required. This material shall meet the minimum criteria for the Sandy CLAY material presented within this Specification, and all test certificates shall be provided to the Company Representative for approval prior to use within the works (**hold point**).

2.9 Final trim and tolerances

The finished surfaces of earthworks, both excavation and fill, shall be trimmed and rolled as necessary to ensure that the finished surfaces, including batter slopes, are tight and uniform with maximum resistance to weathering and erosion.

2.9.1 Lining subgrade surface

The Site won fill material should be homogeneous in nature and properties, with no sandy patches exceeding the liner specification or rocks retained on a 37.5 mm sieve. Any non-conforming liner subgrade material shall be removed and replaced with conforming soil. The subgrade surface to be lined shall be uniform and free of all sharp or angular objects that may damage the HDPE prior to liner installation.

The Installation Contractor and the Company's Representative shall inspect the surface to be covered with the geomembrane on each day's operations prior to HDPE placement to verify suitability. The Installation Contractor shall provide daily written acceptance for the surface to be covered by HDPE to ensure surface suitability.

All subgrade and HDPE surface damage caused by construction equipment and deemed unsuitable for HDPE deployment shall be repaired prior to HDPE placement. All repairs require the approval of the Company's Representative and the Installation Contractor.

2.9.2 Embankment Construction Tolerances

Embankment dimensions shall not be less, nor the slopes steeper, than those specified on the Drawings. Dimensional tolerances shall be the following unless specifically otherwise noted:

- Finished Levels
 - Vertical tolerance: -0 mm to +100 mm; As Con
 - Horizontal Tolerance: -0 mm to + 250 mm; As Con

No further works shall be undertaken until survey work is completed for each cut surface to the design level to check above tolerances are met.

Unless more stringent tolerances are nominated on the drawings, tolerances for earthworks shall be as follows:

Description	Tolerance
Level tolerance for excavations	± 50 mm
Level tolerance for embankments	-0 mm +75 mm
Level tolerance for backfill	-0 mm +25 mm
Deviation of nominally flat surface from a 5-metre straight edge	25 mm unless permitted otherwise by the Company
Deviation of batter points from nominated alignment	± 200 mm
Subgrade (at any point on the surface)	-35 mm, + 5 mm
Sub-base (at any point on the surface)	+5 mm, -25 mm

3 HDPE GEOMEMBRANE SUPPLY

3.1 Quality control

The Contractor is responsible for ensuring all quality control testing (MQC and CQA) is undertaken in accordance with this Specification and that the material parameters meet the minimum criteria as set out in this Specification. If the data is insufficient to prove the material meets the requirements of the specification, the Company at their discretion may

reject any roll at any point in the process. Any rejected roll shall be returned to the manufacturer and a replacement roll shall be supplied at the Contractor's expense.

3.1.1 Manufacturers quality control (MQC)

The Manufacturer shall provide Quality Assurance (QA) documentation that includes raw material control, process control and finished product control in accordance with the requirements of AS/NZS ISO 9001 for the geomembrane and extrudate rod. The following MQC data shall be provided to the Company for approval prior to the rolls leaving the manufacturing plant:

- Statement from the manufacturer confirming the material properties of the supplied liner meet the minimum criteria set up in Table 6 (provided in .xlsx and pdf format).
- Quality Assurance Certification with the property values given for each roll supplied. The QA certificate must include:
 - Roll numbers and identification
 - Resin lot
 - Batch number
 - Sampling procedures
 - Results of quality control tests
- Certification from the manufacturer that the supplied extrudate rod has been made from the same material and resin batch as the supplied geomembrane liner.
- The origin and production details of the resin used in production, including; resin brand name and identification, resin production plant, suppliers name and production date.
- Evidence from the Manufacturer which shows the performance of the selected HDPE product in a RO brine solution.

3.1.2 Warranty

The Manufacturer shall provide a written warranty stating the duration of time that the HDPE liner, when handled and installed in accordance with the Manufacturer's recommended procedures, shall perform without deterioration when subject to the in-service conditions. This duration shall not be less than 25 years from the time of installation.

3.2 HDPE material properties

The HDPE Geomembrane shall contain a minimum of 2.0% carbon black properly dispersed, antioxidants, and heat stabilizers and shall contain no additives or fillers which can leach out and cause deterioration over time. The HDPE liner shall be manufactured from new materials except where approved otherwise by the Company's Representative.

The HDPE Geomembrane shall be a 2.0 mm smooth/smooth HDPE that meets or exceeds the minimum requirements stated in Table 6 (Solmax GSE HX or Atarfil HD EVO AR or similar product).

Table 6: Minimum requirements of HDPE geomembrane

HDPE Specification	Value	Units	Test Method	MQC Frequency
	Smooth/ smooth			
Raw material (resin)				
Resin Density	>0.932	g/cc	ASTM D1505	Per batch
Melt index	1.0	g/10 min	ASTM D1237	Per batch
Geomembrane sheet material				
Thickness (min. ave.)	2.0	mm	ASTM D5199	Per roll
Thickness (min. ave.)	1.8	Mm	ASTM D5199	Per roll
Density (min.)	>0.940	g/cc	ASTM D792-00 ASTM D1505-03	90,000 kg

Carbon Black Content (range)	2.0 – 3.0	%	ASTM D1603-06	9,000 kg
Tear Resistance (min. ave.)	>250	N	ASTM D1004-07	20,000 kg
Puncture Resistance	>695	N	ASTM D4833-07	20,000 kg
Tensile Properties (each direction) (min. ave.)				
Tensile Strength @ Break	>57	kN/m	ASTM D6693-04 Type IV	9,000 kg
Tensile Strength @ Yield	>29	kN/m		
Elongation @ Break	>700	%		
Elongation @ Yield	>13	%		
Carbon Black Dispersion for 10 different views	9 in Categories 1 or 2, or 1 in Category 3	-	ASTMD5596-03	20,000 kg
Dimensional stability	± 2	%	ASTM D1204	Manufacturer statement
Stress Crack Resistance	>1000	Hrs	ASTM D5397-07	Per formulation
Standard Oxidative Induction Time (ST-OIT) Or High Pressure Oxidative Induction Time (HP-OIT)	>100 >400	Min	ASTM D5885-06	90,000 kg
Oven aging at 85°C % retained after 90 days Standard OIT (min. ave.) or High Pressure OIT (min. ave.)	>55 >80	% %	ASTM D8117 ASTM D5885	Per formulation
UV Resistance Standard OIT (min. ave.) or High Pressure OIT (min. ave.) - % retained after 1,600 hrs	>50	%	ASTM D5885-06	Per formulation

3.3 Extrudate rod

The extrudate rod shall be manufactured from the same resin type used in the manufacture of the geomembrane. All physical properties shall be identical to the geomembrane raw material. The manufacturer shall provide certified test data with each batch of extrudate rod. All supplied granulate or rod shall be packed to protect from UV exposure and prevent ingress of moisture and other contaminants.

3.4 Transportation and storage

The Contractor shall be responsible for all packaging, loading, unloading, transport costs, inspections, taxes or other fees involved with shipping the HDPE geomembrane from the Manufacturer to site. The Contractor shall be responsible for providing suitable equipment and experienced personnel for unloading and handling of the rolls in accordance with Manufacturer's requirements and this Specification. The Contractor shall be responsible for unloading the HDPE from the delivery truck and placement in the laydown area in accordance with the Manufacturer's requirements.

The HDPE geomembrane shall be provided in rolls, each clearly labelled with the following identifying information:

- Product name and grade
- Length and width of roll (m)
- Total weight of roll (kg)
- Production lot number and individual roll number

The rolls shall be stacked no more than two rolls high, unless specified otherwise in the Manufacturer's recommendations. The Contractor will be responsible for maintaining roll identification labels for the duration of the works after delivery of the material to the Site.

Any rolls damaged during shipping beyond their ability to be effectively utilised within the Project may be rejected by the Company upon delivery.

Rolls of HDPE liner shall not be dragged, lifted by one end, or dropped to the ground during handling. A lifting pipe or bar of sufficient strength to support the full weight of the roll without bending shall be used for all lifting activities. The diameter of the lifting pipe/bar shall be small enough to allow for easy insertion through the roll core.

4 HDPE GEOMEMBRANE INSTALLATION

4.1 General requirements

The Installation Contractor shall install the HDPE in accordance with the Manufacturer's installation guidelines, to the lines and levels in compliance with the approved drawings and HDPE Panel Layout Plan.

Unless specified otherwise in the Manufacturer's installation guidelines, installation of the HDPE liner shall be in accordance with the following general requirements as a minimum:

- The HDPE shall only be installed upon subgrade that has been inspected and approved by the Company's Representative and the Installation Contractor.
- The HDPE liner shall be placed in a relaxed state over the prepared, level and cleared surface free from rock fragments and sharp debris, allowing the material to respond to thermal changes without causing excessive buckling, wrinkling or tensioning.
- No "fishmouths" or other signs of stress will be permitted within welds made during installation of the liner. Any such occurrences being identified will be repaired or remediated by the Contractor.
- The Contractor shall inspect the entire surface area of each and every sheet of HDPE liner during unrolling and placement to ensure that there are no tears, abrasions, indentations, cracks, thin spots or other faults in the material. The materials shall be free from holes, blisters, un-dispersed raw materials and any sign of contamination by foreign matter. Sheets shall be rejected where manufacturing process irregularities are evident including irregular thickness and imperfections that will not provide even stress distribution throughout the sheet. The Contractor shall inform the Company's Representative of any such occurrence. It shall be the responsibility of the Contractor to ensure that any such damage or imperfections are repaired or replaced in accordance with the requirements of this Specification.
- The Contractor shall be responsible for making any allowances considered necessary to accommodate predictable differential settlements of the subgrade and/or variations in temperature. In particular, allowances shall be made to accommodate the ultimate thermal movement of the HDPE liner during the coldest periods in the region.
- The HDPE liner shall be installed in continuous sheets down embankments with no transverse joints on the slope or within 2.0 m of the toe of the pond.
- Cross-over or T joint welds must be offset a minimum of 500 mm to avoid multi-layer weld lapping.
- The HDPE liner shall terminate in the anchor trench. There shall be sufficient HDPE liner to cover the base and near side of the anchor trench and come part way up the far side of the trench to ensure sufficient anchorage following backfill of the trench.
- The layout of the panels shall be positioned so that the quantity of welding is minimized.

4.1.1 Inspection and handover

The Installation Contractor will report any damage or material defects identified during this inspection to the Company's Representative via submission of a Form of Acceptance. The Form of Acceptance will include the following information:

- A list of HDPE roll numbers that have been inspected and are found to be acceptable.

- A list of HDPE roll numbers that have been inspected and are found to be unacceptable. The Installation Contractor must provide justification for rejection of each individual HDPE roll by way of a detailed description of the observed damage or material.

Following submission of the Form of Acceptance to the Company's Representative and receipt of the Manufacturer's QA documentation, HDPE rolls identified as acceptable shall become the responsibility of the Installation Contractor.

4.1.2 Temporary anchorage of liner during installation

The Contractor shall supply and install temporary ballast to protect the deployed liner material during installation from wind uplift and damage. The temporary ballast shall be sand bags or equivalent. Sand bags shall be UV stable, sealed at both ends and placed at no more than 1 m centers. Sand bags shall be tied together on the slopes.

The Contractor shall implement measures as identified in its Health Safety and Environment (HSE) Management Plan to ensure the safety of site personnel in the advent that windy conditions arise during HDPE liner installation works. Such measures may include liner venting as well as provision of additional sand bags or other weights, particularly on leading edges.

Such measures shall be implemented subject to the approval of the Company's Representative. Ad hoc measures shall not be acceptable and may result in the Company's Representative standing down installation work until satisfied that appropriate measures are in place to ensure personnel safety. Expenses resulting from such stand down shall be borne by the Contractor.

4.1.3 Care and protection of the works

During installation of the HDPE liner, precautions should be taken to prevent damage to the liner and the subgrade. It shall be the responsibility of all project personnel to report any damage or acts that may have caused damage to the Contractor's Supervisor, who shall report such damage or acts to the Company's Representative.

Properly protected tools and equipment shall be used at all times. The electric generator shall be mounted on a wheeled trolley so that it is not dragged across the geomembrane. A smooth insulating plate or fabric shall be placed beneath the hot welding apparatus after usage to protect the geomembrane. The wheeled trolley shall be inspected prior to being moved onto the geomembrane to identify any trapped particles that could pose a risk to the geomembrane.

Trafficking of personnel or equipment over the HDPE liner and the subgrade shall be kept to the minimum necessary to complete the works and then only in areas where adequate precautions have been taken.

Under no circumstances shall petrol-driven generators or cans of solvent or petrol be placed directly on the HDPE liner or the liner subgrade.

At no time are straight blade Stanley cutting knives or similar to be used in the installation of the HDPE liner unless approved by the Company's Representative.

4.2 Submittals

The Installation Contractor is to submit the following documents for review and approval, within a reasonable time to expedite liner installation. This is not an all-inclusive list; it is the Contractor's responsibility to ensure they have been through the Specification in sufficient detail to identify all submittal requirements:

- Relevant company experience.
- Resumes or qualifications of the proposed Field Installation Supervisor, Lead Welder and Installers to be assigned to this project.
- Panel layout Drawing.
- Project specific QA Plan to the Company's Representative for review and approval prior to commencement of the works. The QA plan shall include the following:
 - A proposed HDPE Panel Layout Plan which includes all proposed weld locations.
 - Method statements for handling and installing the HDPE liner.

- Details of the materials and equipment to be used for installation, welding and repair work.
- A QA program that satisfies the requirements of AS/NZS ISO 9001 and this Specification.
- Calibration certificates for each module of the field tensiometer
- Calibration certificates for all other welding and testing equipment.

Placement of HDPE will not be allowed to proceed until the Company's Representative has received and approved the above submittals.

4.3 Handling and placement

Field panels shall be deployed as close as possible to the location and positions identified on the Panel Layout Plan. Deployment of the sheets of geomembrane shall be carried out using suitable spindles to allow for the smooth unrolling of each roll. Each panel shall be laid out and overlapped to provide a minimum overlap of 125 mm for fusion welds and 75 mm for extrusion welds.

4.4 Field welding

4.4.1 General

The general requirements for welding are as follows:

- Welding shall commence as soon as practicable after the sheet is deployed.
- All seams shall be welded while the sheets are in a relaxed state and free of tension.
- Welding shall extend to the outside edge of the panels to be placed in the anchor trench.
- The Contactor shall ensure at least one spare, operable welding unit of each type is on-site for the duration of the lining portion of the Works.

4.4.2 Weld preparation

Contact surfaces of material to be seamed shall be wiped with clean, dry, white, absorbent, lint-free cotton rags until all foreign matter, dust, etc., have been removed. When a rag shows discolouration from use, it shall be discarded and replaced with a fresh one.

In harsh conditions such as high temperatures or high winds, or when other conditions increase the possibility of dirt or foreign material being deposited on the contact surfaces, the time between wiping and seaming shall be varied as necessary to produce acceptable seams.

4.4.3 Fusion welding

All fusion welds shall be undertaken using a dual track hot wedge self-propelled apparatus with suitable controls for adjustment of operating temperature and speed of travel along the seam. The fusion weld equipment must be equipped with gauges giving the applicable temperature and speed.

4.4.4 Extrusion welding

Extrusion welding shall only be used for repair of defects or other areas inaccessible by fusion method. The extrusion apparatus shall be equipped with gauges giving temperature in the apparatus and at the nozzle. The extruder shall be purged before beginning a weld and until all heat-degraded extrudate has been removed from the barrel. Whenever the extruder is stopped, the barrel shall be purged of all heat degraded extrudate.

4.5 Trial welds

Trial welds shall be made on off-cut or fragment pieces of HDPE liner in order to verify that adequate seams can be produced by the chosen equipment and settings in the prevailing conditions. It is important that the conditions under which these seams are made reflect the actual conditions influencing the seam welding.

Trial welds shall be undertaken for each welding device and welding technician and made at the following times and carried out by the Contractor in the presence of the Company's Representative:

- Prior to commencement of extrusion and fusion welding activity.

- Following changes in equipment control parameters including temperature and speed.
- Following welding stoppage which exceeds 1 hour.

Trial welds shall be at least 1.5 m in length and shall be clearly marked with the corresponding HDPE roll No., date, and prevailing environmental conditions that will influence performance of the weld. Two 25 mm wide specimens shall be die-cut from each end of the trial weld (total of 4 specimens). These specimens shall be tested using a calibrated field tensiometer by the Installation Contractor and observed by the Company's Representative. Each specimen shall fail in the parent material (Film Tear Bond – FTB failure) and not in the weld. The Contractor shall supply evidence the tensiometer has been calibrated within the previous 12-month period. In the event that a trial weld fails, the entire weld procedure shall be repeated after the appropriate adjustments to the welding device and/or operator have been made.

The minimum acceptable seam strength values to be obtained for all specimens are presented in Table 7.

Table 7: Minimum trial weld criteria

Test type	Method	Minimum requirement for Fusion Welds	Minimum requirement for Extrusion Welds
Shear Strength (tensile)	ASTM D6392	701 N/25 mm	701 N/25 mm
Peel Strength	ASTM D6392	530 N/25mm	455 N/25mm

4.6 Non-destructive testing

4.6.1 Air pressure testing

The following procedures are applicable only to welds that produce a double weld with an enclosed air channel. Air pressure testing shall be undertaken in accordance with ASTM D5820 "Standard Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes".

Initial pressure settings should be recorded after a two (2) minute stabilisation period. The purpose of this "relaxing period" is to permit the air temperature and pressure to stabilise. Once an initial pressure is recorded, the test shall be run for a further five (5) minutes. The air pressure shall be held between 210 kPa and 240 kPa for the entire duration of the test.

If loss of pressure exceeds the above or if the pressure does not stabilise the suspect area shall be deemed to have failed, the faulty section shall be identified by successively testing shorter lengths. If the fault is of short length and isolated, it may either be repaired by the application of a patch or where acceptable to the Company's Representative, repaired by manual hot air or extrudate fusion. Where more than one fault is found, the weld shall be reconstructed. The entire weld shall then be air pressure tested again. If the second weld test passes, the weld will be accepted. In the event that the second test fails, the Company's Representative will direct that independent destructive testing of that entire weld be undertaken. The cost of this test work shall be borne by the Contractor.

4.6.2 Vacuum box testing

Vacuum box testing in accordance with ASTM D5641 shall be conducted on each T-joint, repair location, and extrusion weld. Each section of seam shall be vacuum tested for a period of not less than 10 seconds by examining the geomembrane through the viewing window for the presence of soap bubbles.

Where a fault within any weld is found, the weld shall be repaired by the Contractor, at no cost to the Company, and shall be re-tested using a vacuum box to ensure suitability. The Company's Representative may direct that independent destructive testing of that weld be undertaken. The repaired fault and the results of the independent testing shall be clearly detailed in a report submitted to the Company's Representative and shall be clearly identified on the As-Built Drawings.

4.7 Destructive testing

One destructive sample shall be collected for every 150 linear meters of field weld performed. Each specimen shall be 1.0 m long (measured with the direction of the weld) x 0.3 m wide. The location of the Destructive samples shall be determined by the Company Representative. The sample shall be cut into three specimens of equal dimensions (cut across the weld direction) and the following test work shall be carried out:

Specimen 1 - shall be tested by the Contractor on site using the calibrated tensiometer. A minimum of two (2) "peel" tests and two (2) "tensile" shall be undertaken. The testing will be carried out in the presence of the Company's Representative and the results shall meet the minimum requirements specified in Table 7.

A field test report, detailing the results of this test work, shall be submitted to the Company's Representative and shall then be included within Contractor's QA Report as detailed in this Specification.

Specimen 2 and 3 – Reference samples to be kept on-site for the duration of the Works in a shaded, cool, dry place away from exposure to weather.

All test data shall be matched and qualified prior to that weld or liner area being released for commissioning. Certification for release by the Company's Representative shall in no way relieve the Contractor of its responsibility for the quality of the installation.

Where any tests record failure, two further samples shall be extracted from typically 3 m on either side of the specimen weld area, and the same field test shall be conducted. Passing tests shall be an indicator of adequate seams. Failing tests shall be an indicator of inadequate seams, and the testing process will be repeated. All seams represented by the destructive test location shall be repaired with a cap-strip, extrusion welded to all sides of the capped area. All cap-strip seams shall be non-destructively vacuum box tested until adequacy of the seams is achieved. Cap strip seams exceeding 50 m in length shall be destructively tested. All costs associated with the additional sampling and testing shall be at the Contractor's expense.

The locations of all repair work will be recorded on the "As-Built" Panel Layout Drawing and shall be documented in the Contractor's QA Report.

4.8 Inspection and repair

All punctures, cuts, tears, severe abrasions, and similar damage or abuse suffered by the HDPE liner during installation shall be repaired by patching. The location, time and extent of the patching shall be noted in the Contractor's Daily Progress Report.

Areas requiring repair or patching shall be prominently identified by suitable marking applied to the HDPE material outside the area to be repaired so as not to introduce marking substances into the seam area.

Patches shall be cut from flat, unwrinkled scraps of HDPE liner and shall be free of defects, field seams and factory seams. Patches shall be of sufficient size to extend a minimum of 150 mm in all directions beyond the limits of any puncture, cut, tear, abrasion, etc.

Patches shall be applied as per the requirements for welded joints. The parent material shall be gently pulled and held flat in the area to be patched so as to provide an acceptable surface to receive the patch. The applied extrusion weld shall be continuous around the patch.

Where patches over fishmouths are required, they shall extend a minimum of 150 mm on each side of the edge of the overlap and a minimum of 150m beyond the ends of the cut in the fishmouth.

All patches shall be inspected and tested using a Vacuum Box as detailed in this Specification.

4.9 Patching repair

Patches shall be used to repair defects such as holes, cuts and tears (including areas from which destructive test samples were obtained). The edges of the patch shall extend a minimum of 100mm beyond the limits of the defect. The defective area shall be cleaned and trimmed so that the patch can be flat along all edges with no wrinkles or folds. Extrusion beads can be used to seal pinholes (exclusive for non-destructive testing air pressure needle holes) which penetrate the entire geomembrane thickness.

Patches and defect areas shall be free of dirt, moisture, debris and markings. Patches shall be temporarily bonded by heat welding. Chemical adhesives and tape are prohibited. The patch weld area shall be abraded no more than 1 hour in advance of permanent welding. Heat welding and abrasion shall not cause excessive melting, wear or puncturing of the geomembrane material; such occurrences shall be considered defects and shall be repaired by patching.

4.10 Capping repair

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

Caps over failed welds shall be carried out only if no other method of repair is feasible. Where welds are being repaired by caps, the failed weld shall be cut out, and the cap welded using fusion welding over most of the joint. The length of extrusion weld required to close-off the cap shall be kept to a minimum and shall be closed-off after the fusion weld has been pressure tested. All cap welds shall be non-destructively tested in accordance with this Specification.

Where a length of dual-track fusion weld that is less than 20m long is not holding air when tested by the air pressure testing method, the weld may be repaired by bevelling the edge, abrading the sheet surface and applying an extrusion weld along the exposed edge (flap) of the seam. Failed welds repaired in this manner must conform to the requirements of this Specification and be vacuum box tested.

4.11 Installation Quality Assurance report

At completion of the lining works, the installation Contractor shall submit a QA Report to the Company's Representative. The report shall include the following:

- "As-Built" Panel Layout Drawing showing panel numbers and locations of all welds, test samples, and repair work.
- Trial weld logs.
- Non-destructive and destructive test logs.
- Reference samples taken during destructive testing (Specimen 2).

4.12 Installation warranty

The Installation Contractor shall warrant the installation of the HDPE liner for a period of 1 year from the date of completion of installation as formally acknowledged by the Company's Representative.

4.13 Liner acceptance

Geomembrane liner will be accepted by the Company Representative when:

- The entire installation is finished or an agreed upon subsection of the installation is finished;
- All Contractors QC documentation is completed, submitted and approved by the Company Representative;
- 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 Company Representative.