



Upper Lachlan Shire Council
Crookwell Landfill
Construction Quality Assurance Plan for Landfill Construction
Works

December 2017

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Appendices

Appendix A - Typical Quality Assurance Reports

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1. Introduction

1.1 General

This plan presents the construction quality assurance (CQA) requirements for the construction of the Works at Crookwell Landfill (the site) and must be read in conjunction with the Specification and other Contract Documents.

1.2 Overview

Careful quality assurance (QA) and quality control (QC) testing of the materials and services used in the construction of waste facilities is an important aspect of the construction process. The CQA program is intended to provide a level of confidence to the Owner, engineer, regulator and the public that the completed project is constructed in accordance with the approved specifications and permit conditions. The programs proposed in this CQA Plan meet and exceed the requirements of EPA guidelines, including additional test methods, increased testing frequencies and increased levels of experience, which provide added control over the quality of the completed project and greater confidence in the long-term performance of the facility.

In general, CQA and construction quality control (CQC) are described as follows.

- CQA consists of a planned and systematic pattern of all means and actions designed to provide adequate confidence that items or services meet contractual requirements and will perform as designed. QA includes the review of work performed in the field and the testing of installed materials to verify compliance with the drawings and specifications. Overall QA means and actions also include QC.
- CQC consists of those actions which provide a means to measure and regulate the characteristics of an item or service to contractual and regulatory requirements. These actions comprise the specification of testing methods and frequencies as well as specifying minimum levels of experience and training for the individuals and organisations performing the work. In general, QC is performed prior to allowing individuals and organisations to perform the work and prior to accepting materials for delivery to the work site as a means for prequalification of services and materials and continues throughout construction to evaluate the consistency of products and services.

1.3 Purpose

The purpose of this CQA Plan is to define construction quality assurance procedures and requirements necessary to demonstrate compliance with the requirements of the Works Documents.

1.4 Scope of Works

The Works to be undertaken are detailed in the Works Documents, however, in general the Works include:

- Installation and maintenance of erosion and sediment control measures
- Setting out including all associated survey work
- Excavation, filling, compaction and grading to develop the subgrade levels
- Installation of a groundwater drainage systems
- Construction of a landfill barrier system

- Installation of a leachate collection and conveyance system including a field trial for the placement of the drainage aggregate
- Installation of surface water drainage works including bunds, drains and swales
- Installation of landfill gas collection system and leachate toe drain
- Installation of landfill cap
- Decommissioning of existing stormwater pipe
- Construction of leachate pond
- Construction of stormwater drainage measures
- Preparation of Works as Executed Drawings.

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2. General requirements

2.1 General

The CQA Engineer will consist of personnel with specific experience in the inspection and CQA monitoring of activities related to the construction of the Works.

2.2 Definitions

As per specification and Contract Documents

2.3 Responsible Parties

The responsible parties for implementation of this CQA Plan, as set forth herein, are as follows:

Principal

.....

Contact:

Phone:

Superintendent

.....

Contact:

Phone:

Contractor

.....

Contact:

Phone:

CQA Engineer

.....

Contact:

Phone:

2.4 Lines of communication

Each individual and organisation associated with the design, construction and testing of the proposed project have defined roles and responsibilities during the progress of the work. Timely communication among the parties can reduce problems and changes encountered in the field, increase the efficiency of the work and improve the quality of the finished project.

By delineating lines of communication, questions, concerns and problems can be more effectively and efficiently addressed and resolved. All items which arise in the field should be directed to the Contractor, who in turn can resolve the situation or bringing it to the attention of the Principal or its representative (including the Superintendent and the CQA Engineer). By developing efficient and direct lines of communication, the reporting and resolution of problems and changes should be efficiently handled, thereby reducing work stoppages and delays. The lines of communication that are proposed for this project are illustrated in Figure 1.

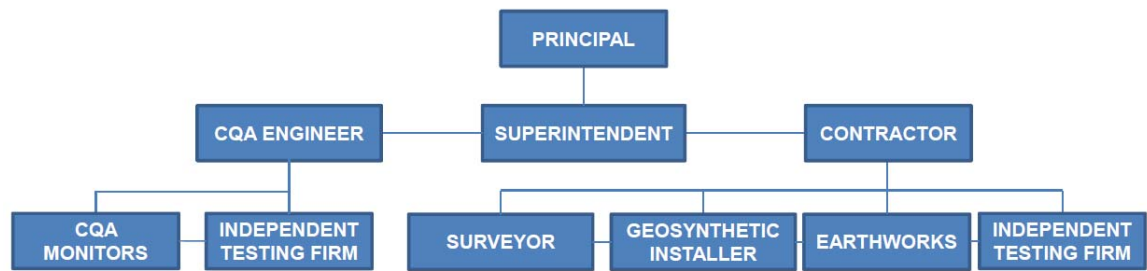


Figure 1 Lines of communication

2.5 Responsibilities

2.5.1 Principal

The general roles and responsibilities of the Principal are as follows:

- Communicate with the CQA Engineer regarding proposed modifications and changes.
- Engage the Leak Location Contractor
- Promptly submit required any requested information to the Regulatory Authority
- Submit a CQA report including Record Drawings to the Regulatory Authority at the completion of the Works.

2.5.2 Superintendent

The Superintendent shall be the liaison between the Contractor and the CQA Engineer while keeping the Principal advised regarding work in progress. The Superintendent shall be responsible for review of schedules, attendance at meetings with the Contractor, recording and receiving samples and shop drawings, reviewing work and interpreting the Contract Documents. Daily construction activities shall be recorded in a daily field report and colour photos of major construction activities shall be taken and labelled.

All CQA functions shall be under the Principal's authority. All coordination, reporting and issues related to non-compliance shall be directed through the Superintendent. Any requests for information, design modifications or proposed changes in the Technical Specification shall be directed through the Superintendent who shall then liaise with the relevant parties to address these.

2.5.3 Contractor

The Contractor shall select products and suppliers that meet the Technical Specification, obtain supplier proposals, execute purchase agreements, process shop drawings, arrange for product delivery, inspect products on delivery, obtain/collect and forward product certifications and warranties, attend progress meetings, and update schedules. The Contractor shall be responsible for ensuring all CQC activities are undertaken in accordance with the Technical Specification.

2.5.4 CQA Engineer

The CQA Engineer shall be responsible for assessing the compliance of the completed Works with the Works Documents. This shall involve a range of activities that are described in this CQA Plan. Generally, the tasks will include:

- Review the Works Documents;

- Review the CQA Plan;
- Review approved changes to the Works Documents;
- Reviewing and recommend rejection or approval of site-specific documentation including Contractor submittals, Manufacturer's information, Geosynthetic Installer's information and referenced standards. The Superintendent shall make the final decision on approval or disapproval of submittals;
- Verify construction is performed in accordance with the Works Documents. CQA Monitors (refer Section 2.5.5) shall be assigned to every major construction activity related to the construction of the landfill barrier system and leachate collection and conveyance system. A minimum of one CQA Monitor shall be on-site during the relevant Works;
- Attend required meetings;
- Coordinate CQA Monitors to observe all CQA activities requiring monitoring;
- Educate CQA Monitors on site specific CQA requirements and procedures;
- Verify calibrations of CQC and CQA conformance testing equipment are correctly performed and recorded;
- Verify that CQC and CQA conformance tests are properly performed, recorded, and the results meet specified requirements;
- Review Contractor qualifications to verify conformance with the Works Documents;
- Review warranty submittals to verify they comply with the specified warranty requirements;
- Verify that the Contractor is following the approved work method statements, including relevant CQC requirements identified in the Technical Specification;
- Review required submittals and recommend rejection or approval;
- Report any unapproved deviations from the CQA Plan to the Superintendent as soon as practicable;
- Report any activities that could result in damage to installed Works to the Superintendent as soon as practicable;
- Prepare and maintain required CQA documentation;
- Prepare Daily Reports for submission to the Superintendent
- Oversee the collection, marking, packaging, and shipping of CQA conformance samples for testing; and
- Review 'as-built' surveys and Works as Executed Drawings.

The CQA Engineer is to work with the Superintendent to determine whether sufficient evidence has been provided to adequately document that the Works comply with the requirements of the Works Documents.

The CQA Engineer (and assigned CQA monitors) shall provide full-time monitoring and inspection of the Works until completion.

2.5.5 CQA Monitors

The CQA Engineer may appoint CQA Monitors as necessary, typically permanent site staff (such as the Superintendent) or specialist personnel (such as Geotechnical Engineers), who will observe the Works on behalf of the CQA Engineer to provide a basis for concluding that the Works conform with the Works Documents.

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2.5.6 Construction Quality Assurance Engineer's Independent Testing Firm

The CQA Engineer's Independent Testing Firm shall be an independent testing firm(s) engaged by the CQA Engineer to conduct quality assurance testing. The CQA Engineer's Independent Testing Firms(s) shall be National Association Testing Authorities (NATA) accredited.

2.6 Meetings

In order to facilitate CQA, close coordination between the CQA Engineer, the Superintendent and other concerned parties is essential and communication shall be ongoing during the construction. The Superintendent shall document all meetings and minutes shall be distributed to all parties. Construction and design issues shall be reviewed on an as-needed basis and shall be resolved and documented by the Superintendent.

2.6.1 Pre-construction meeting

Prior to initiating construction, the following items will be considered by the CQA Engineer:

- Any appropriate modifications to the CQA requirements;
- Review of the responsibilities of each party;
- Review of the lines of authority and communication;
- Review of the Works Documents;
- Review of the procedures for Works documentation and reporting, and distribution of documents and reports;
- Review of the procedures for field and laboratory CQA conformance testing;
- Establishment of procedures for correcting and documenting construction deficiencies;
- Conducting a Site tour; and
- Review of the Construction Program.

2.6.2 Weekly progress meetings

Weekly progress meetings shall be held between the Superintendent, CQA Engineer (including appropriate CQA Monitors) and other concerned parties. The purpose of these meetings is to discuss current progress, planned activities for the next week, issues requiring resolution, and any revisions to the Works. The CQA Engineer shall report any deficiencies noted during the previous week.

2.6.3 Special meetings

Special meetings will be conducted as required to discuss problems or deficiencies and to formulate comprehensive solutions.

2.7 Hold Points

The Works Documents include a number of Hold Points that require the Contractor to obtain the approval of the Superintendent prior to proceeding with the Works. The CQA Engineer shall advise the Superintendent on the release of Hold Points as required. The Superintendent shall make the final decision on the release of Hold Points.

2.8 Regulatory Authority requirements

The Regulatory Authority should be provided with the opportunity to observe key elements of the Works such as:

- Landfill barrier system construction;
- Leachate collection and conveyance system construction;
- Field trials;
- Capping construction;
- Leachate pond construction; and
- Completed Works.

2.9 Independent conformance testing

2.9.1 General

General independent conformance sampling and testing requirements are provided below. Further guidance for each material is provided in the individual sections of this CQA Plan.

2.9.2 Independent conformance sampling

The CQA Engineer shall arrange for independent conformance testing of the materials used in the Works, in accordance with this CQA Plan, to assure conformance with the Technical Specification. Samples shall be collected at locations designated by the CQA Engineer and all independent conformance sampling shall be witnessed by the CQA Engineer. The CQA Engineer shall confirm that all samples are collected, cut, labelled, and packaged in accordance with the Technical Specification and this CQA Plan. Samples shall be labelled with the following:

- Sample number
- Date sampled
- Project name
- Material and source
- Location of test
- Intended use of material.

The location, sample number and purpose of the samples shall be noted on the daily report.

2.9.3 Independent conformance testing

All independent conformance testing shall be undertaken by authorities accredited by the National Association of Testing Authorities (NATA) to test in the relevant field, or an organisation outside Australia recognised by NATA through a mutual recognition agreement. Field tests shall be conducted by suitably qualified personnel.

Subsequent sections of this CQA Plan describe the conformance testing to be performed.

2.9.4 Independent conformance results

The CQA Engineer shall verify the following when reviewing independent conformance test results:

- The correct conformance tests have been performed and specified test procedures have been used
- Test results meet the requirements of the Technical Specification.

The CQA Engineer shall immediately notify the Superintendent of problems with CQA conformance testing procedures or non-compliance of conformance test results, including recommendations for rejection of materials.

The CQA Engineer shall maintain a log of all CQA test results, including date and location of specific tests. This log shall be provided to the Superintendent on a weekly basis. The log may be provided to the Contractor at the discretion of the Superintendent.

2.10 Non-conformance and corrective action procedures

All non-conformances that arise from non-compliance with the Works Documents will be duly noted and appropriately recorded by the CQA Engineer, in the form of a non-conformance report, and made available to the Superintendent within 24 hours of becoming aware of the non-conformance.

Where a non-conformance occurs, the non-conformance report is to include the following information:

- The location of the non-conformance;
- The time of the non-conformance;
- The time that the CQA Engineer was made aware of non-conformance;
- The suspected cause of the non-conformance; and
- A description of the resulting impacts of the non-conformance.

The Superintendent, in consultation with the CQA Engineer, shall prepare a corrective action plan to address the non-conformance. The corrective action plan will at least address the following:

- The nature of the non-conformance and its level of effect on the project;
- Determination if the non-conformance is an isolated incident or a recurring problem;
- How amendments to procedures to prevent future occurrences of the non-conformance will be implemented;
- The nature of corrective action to be applied to rectify that specific non-conformance (eg re-compaction and testing); and
- The need to report the non-conformance to the Regulatory Authority (e.g. major exceptions / variations to the approved Works Documents).

3. Earthworks

3.1 General

The CQA Engineer shall verify the CQA requirements described in this section for earthworks specific to the landfill barrier system and leachate collection and conveyance system. Additional requirements for specific material types are discussed in subsequent Sections.

3.2 Qualifications

The CQA Engineer assigned CQA responsibilities for earthworks shall have provided CQA inspection during installation of soil layers for at least three major earthworks projects totalling a minimum of 50,000 m³ of earthwork activities.

The CQA Engineer may assign CQA Monitors in accordance with Section 2.5.5 as appropriate.

3.3 Submittals

The CQA Engineer shall review all submittals provided by the Contractor and recommend rejection or approval to the Superintendent. This shall include relevant work method statements prepared by the Contractor.

3.4 Materials

The CQA Engineer shall:

- Review all test results/reports provided by the Contractor for the proposed fill material to verify that the relevant fill material is uniform and matches the required properties given in the Technical Specification
- Advise the Superintendent about the need to do additional borrow source assessment testing if visual inspections identify that the properties of the relevant fill material appear to have changed significantly
- Inspect fill material stockpiles prior to use and advise the Superintendent of the presence of any unsuitable material.

3.5 Equipment

The CQA Engineer shall visually inspect and verify soil processing, placement, and compaction equipment meet the requirements of the Specification and the approved work method statement(s).

3.6 Quantities

If requested by the Superintendent, the CQA Engineer shall review and comment on any quantity re-measurements submitted by the Contractor.

3.7 Extent of disturbed areas

The CQA Engineer shall notify the Superintendent if the Contractor is witnessed working outside the Works Area shown on the Contract Drawings.

3.8 Lines and levels

The CQA Engineer shall review as-built survey data of the completed surfaces to verify conforming lines, levels and layer thickness within the allowable tolerance.

3.9 Clearing and grubbing

If requested by the Superintendent, the CQA Engineer shall inspect and comment on any clearing and grubbing works undertaken by the Contractor.

3.10 Excavation

The CQA Engineer shall verify the following during excavation:

- Material that is unsuitable for use shall be excavated and disposed by the Contractor
- Excavation slopes shall be finished in conformance with the required lines and grades
- All debris and loose material is removed from the finished surfaces
- The Contractor has implemented protective measures to ensure that the excavation areas are not damaged during periods of inclement weather.

3.11 Filling

During filling, verify the following:

- Sudden braking or sharp turns are not made;
- Slippage of filling and compaction equipment is not occurring on side slopes. This is especially important when the fill layer is underlain by geosynthetics
- There are no thin areas of fill which could allow underlying geosynthetics to be punctured or torn
- Loose lifts are no greater than the specified maximum allowable thickness
- Fill contains no large clods or other material prohibited by the Works Documents
- Fill is placed to the lines and levels shown in the Works Documents.

3.12 Compaction

- Verify the specified minimum number of passes are being made over all areas of each lift of fill (if applicable)
- Visually observe fill placement around all penetrations and verify that fill placed around penetrations does not contain voids and is adequately compacted
- Inspect pipes which penetrate fill layers for damage due to placement and compaction equipment
- Verify the surface of each lift is adequately scarified prior to placement of the next lift of fill
- Verify low ground pressure equipment is used when compaction is required over piping, geosynthetics, or other appurtenances.

3.13 Conformance testing

3.13.1 Borrow tests

- Check CQC borrow test results to verify that the borrow material is uniform and matches the required properties given in the Works Documents; and
- Advise the Superintendent about the need to do additional borrow source assessment testing if the properties of a borrow source appear to have changed significantly.

3.13.2 In-place moisture content and density tests

Verify the following during testing of the in-place fill:

- CQC moisture content and density tests are performed at the specified frequency
- Additional CQC tests are taken where test results are not in compliance with the Works Documents or the fill is visibly suspect
- The Contractor performs corrective action as a result of failed tests in compliance with the Works Documents and submits documentation describing the corrective measures taken
- The Contractor uses nuclear gauges in the direct transmission mode to measure density.

3.14 Tolerances

The CQA Engineer shall review as-built survey data of the completed surfaces to verify conforming layer thickness within the allowable tolerance.

3.15 Anchoring of geosynthetics

The CQA Engineer shall verify the following when inspecting anchor trenches:

- The anchor trench is constructed to the correct dimensions
- Termination points of geosynthetic layers within the anchor trench are correct
- Corners of the anchor trench are slightly rounded to avoid sharp bends in the geosynthetics
- Loose fill or objectionable materials such as geosynthetic scraps and food containers are removed from the bottom of the anchor trench prior to placement of geosynthetics
- The anchor trench is dewatered (pumped out) if standing water is present in the bottom of the trench
- The anchor trench is backfilled with approved fill placed at the specified moisture content and density
- Compaction work within the anchor trench does not damage the geosynthetics.

3.16 Stockpiles

The CQA Engineer shall inform the Superintendent if the Contractor is witnessed to not be managing stockpiles in accordance with the requirements of the Technical Specification and the approved work method statement.

3.17 Protection

- Verify the Contractor removes puddles and excess moisture from the fill surface prior to placement of additional fill;
- Look for areas of erosion after each rainfall event
- Inspect for damage due to freezing and/or desiccation
- Ensure the Contractor repairs damaged areas and re-establishes grades.

3.18 Weather conditions

Verify that earthworks do not occur during periods of excessive rain, freezing temperatures, or if other detrimental weather conditions exist.

3.19 Defects and repairs

If a fill layer does not conform to the Works Documents, assist the Superintendent in defining the extent of the area requiring repair. This shall be done through the use of additional testing and visual inspection.

After repairs have been made, ensure CQC retests are performed to check the repaired areas. In general, CQC retests shall be performed at the same frequency as the rest of the project. Additional CQC testing shall be performed in suspect areas.

3.20 Acceptance

Prior to the final acceptance of all earthwork activities by the Superintendent, the CQA Engineer shall provide a recommendation to the Superintendent on whether the conditions of final acceptance have been met as per the Technical Specification. This recommendation shall be based on, but not limited to, the following:

- Review of all submittals, including CQC test results
- Review of CQA test results
- Relevant monitoring and inspections undertaken.

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4. Subgrade

4.1 General

The CQA Engineer shall verify the following during subgrade preparation.

The relevant requirements for subgrade preparation in Section 3 shall be considered alongside guidance provided in this section.

All individuals assigned CQA responsibilities for subgrade inspection shall have provided CQA inspection during preparation of subgrade for at least three major earthworks projects totalling a minimum of 50,000 m³ of earthwork activities.

The subgrade shall be constructed and prepared under Level 1 Inspection and Testing by the CQA Engineer in accordance with AS3798.

4.2 Submittals

The CQA Engineer shall review all submittals provided by the Contractor and recommend rejection or approval to the Superintendent. This shall include relevant work method statements prepared by the Contractor.

4.3 Preparation of subgrade

The CQA Engineer shall inspect the subgrade and verify the following during subgrade preparation:

- Suitable protection measures are installed to protect the subgrade from erosion and damage
- The subgrade is kept free of all trash and debris
- The subgrade is smooth, free of voids and composed of satisfactory materials
- The subgrade is compacted as specified
- The elevation of the top surface of the subgrade is correct
- The subgrade surface is scarified as specified prior to placement of the first lift of soil
- The subgrade is smooth, free of voids, and composed of satisfactory materials
- The subgrade provides a stable surface for the overlying liner system.

4.4 Quality control testing

The subgrade shall be constructed and prepared under Level 1 Inspection and Testing by the CQA Engineer in accordance with AS3798. The CQA Engineer shall agree on all sampling locations for testing with the Contractor and Superintendent. The CQA Engineer shall review the test results to confirm they meet the requirements of the Specification.

4.5 Proof rolling

The CQA Engineer shall witness proof rolling to assess the soundness and suitability of the subgrade based on the requirements of the Specification.

4.6 Acceptance

Prior to the final acceptance of the subgrade by the Superintendent/Principal, the CQA Engineer shall provide a recommendation to the Superintendent on whether the conditions of final

acceptance have been met as per the Specification. This recommendation shall be based on, but not limited to, the following:

- Review of all submittals
- Review of CQA test results
- Relevant monitoring and inspections undertaken.

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5. Clay rich fill

5.1 General

The CQA Engineer shall verify the following during placement of the clay rich fill.

All individuals assigned CQA responsibilities for the Clay rich fill shall have provided CQA inspection during installation soil layers for at least three major earthworks projects totalling a minimum of 50,000 m³ of soil layer material.

5.2 Submittals

The CQA Engineer shall review all submittals provided by the Contractor and recommend rejection or approval to the Superintendent. This shall include relevant work method statements prepared by the Contractor, including any updates made based on the results of the field trial.

5.3 Materials

The CQA Engineer shall:

- Review all test results/reports provided by the Contractor for the proposed clay rich fill material to verify that the material is uniform and matches the required properties given in the Specification
- Advise the Superintendent about the need to do additional borrow source assessment testing if the properties of the clay rich fill material appear to have changed significantly
- Inspect material stockpiles prior to use and advise the Superintendent of the presence of any unsuitable material.

5.4 Delivery, storage and handling

The CQA Engineer shall inspect stockpiles prior to use and advise the Superintendent of the presence of any unsuitable material or contamination as per the Specification.

5.5 Preparation of surface to receive clay rich fill

The receiving surface shall be inspected and approved by the CQA Engineer each day that clay rich fill is installed. Additional inspections shall be performed if weather, vehicular traffic or other factors may have damaged the receiving surface after approval. The CQA Engineer shall verify the following during inspections of the receiving surface:

- The receiving surface is complete and accepted by the Superintendent
- The receiving surface is cleared of any debris and/or foreign material
- The receiving surface has not been damaged by inclement weather.

5.6 Installation

The CQA Engineer shall verify the following during installation:

- Installation is undertaken in accordance with the approved work method statement, which includes any adjustments made as a result of the field trial.
- Equipment used for installation and cover are in accordance with the approved work method statement
- Weather conditions are acceptable for installation

- Oversize and angular material which could damage underlying geosynthetics has been removed from the clay rich fill material
- Clay rich fill material is not dumped directly onto underlying geosynthetics from a height greater than specified
- Underlying geosynthetics are not being damaged by placement equipment. Placement equipment should be observed from the front side as clay rich fill material is being spread over the underlying geosynthetics
- Wrinkles in underlying geosynthetics are not folding over onto themselves during clay rich fill material placement
- Low ground pressure equipment is being used where specified
- Placement of clay rich fill material proceeds from a stable working area adjacent to the deployed geosynthetic materials and gradually progresses outward. For slopes, clay rich fill material must be placed by starting at the toe and working up the slope
- Access routes are adequately built up to protect underlying geosynthetics. Access routes generally must be a minimum of 900 mm in thickness
- Tracks and wheels of full scale construction equipment remain on the access routes at all times
- Repairs are made to the access routes as needed. Inspect access routes daily to see if thinning of the clay rich fill material is occurring
- Large stockpiles of clay rich fill material are not placed on top of in-place geosynthetics
- Thin areas of clay rich fill material which could allow underlying geosynthetics to be punctured or torn by construction equipment are repaired immediately.

5.7 Defects and repairs

The CQA Engineer shall visually inspect the clay rich fill for damage or defects after placement. If an area of the clay rich fill does not conform to the Specification, the CQA Engineer shall assist the Superintendent in defining the extent of the area requiring repair. This shall be done through the use of additional testing and visual inspection.

After repairs have been made, the CQA Engineer shall confirm quality control retests are performed to check the repaired areas. In general, CQC retests shall be performed at the same frequency as the rest of the project. Additional CQC testing shall be performed in suspect areas.

5.8 Acceptance

Prior to the final acceptance of the clay rich fill by the Contract Manager, the CQA Engineer shall provide a recommendation to the Superintendent on whether the conditions of final acceptance have been met as per the Specification. This recommendation shall be based on, but not limited to, the following:

- Review of all submittals
- Review of CQA test results
- Relevant monitoring and inspections undertaken.

6. PE geomembrane

6.1 General

The CQA Engineer shall verify the following during PE geomembrane installation.

6.2 Qualifications

The CQA Engineer assigned CQA responsibilities for the PE geomembrane shall have been accredited by the Geosynthetic Certification Institute-Inspectors Certification Program for installation of geosynthetic materials or have provided CQA inspection during installation of PE geomembrane for at least three projects totalling a minimum of 100,000 m².

The CQA Engineer may assign CQA Monitors in accordance with Section 2.5.5 as appropriate.

6.3 Submittals

The CQA Engineer shall review all submittals provided by the Contractor and recommend rejection or approval to the Superintendent. This shall include relevant work method statements prepared by the Contractor.

The CQA shall review the finalised panel placement drawing to confirm it accurately depicts installation.

6.4 Manufacturer's quality control

The CQA Engineer shall review the manufacturer's quality control procedures and test results prior to delivery of PE geomembrane to site to confirm the material conforms to the requirements of the Specification. This shall include verification that the measurements of properties by the manufacturer are properly documented, test methods are acceptable, sampling procedure detailed and that the proposed geomembrane meets the Specification.

6.5 Manufacturer's quality assurance

The CQA Engineer shall review the manufacturer's quality assurance procedures and test results prior to delivery of PE geomembrane to site to confirm the material conforms to the requirements of the Specification. This may include liaison with the manufacturer on the frequency of MQA testing.

6.6 Material

The CQA Engineer shall review all test results/reports provided by the Contractor to confirm the material conforms to the requirements of the Specification.

Prior to installation of geomembrane, the CQA Engineer shall review quality control certificates issued by the resin supplier. The CQA Engineer shall compare resin source lot numbers from the manufacturer with the manufacturer's roll listing to verify the proposed resin was used to manufacture the rolls delivered to the site. This information shall be logged and included as part of the CQA Report.

6.7 Independent conformance testing

The CQA Engineer shall supervise collection of CQA samples by the Geosynthetic Installer for PE geomembrane at the rate specified in Table 1 and forward the samples to the CQA Engineers Independent Testing Firm for testing. The testing frequencies shall apply to all PE geomembrane products provided as part of the Works. Each product supplied shall be treated

as a separate PE geomembrane material with the testing frequencies applied per product and not additively. The samples shall be taken from the rolls delivered to site prior to use. All samples test results shall be received, accepted and reported by the CQA Engineer prior to installation.

The required testing frequencies may be revised by the CQA Engineer 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. Revisions must be approved by the relevant parties before application.

Unless otherwise specified or approved, the CQA Engineer shall verify CQA samples are not taken from the outer wrap of the roll and samples are a minimum of 1 m in length by the roll width.

While sampling, the CQA Engineer shall ensure that the samples are not scratched as this may affect results. The samples shall be packaged with suitable protection to avoid damage during transport.

Table 1 lists the independent conformance testing that shall be performed on the PE geomembrane prior to installation. In addition to the below, for all testing parameters, a minimum of two tests shall be undertaken including the first and last rolls (based on the production order).

Table 1 PE geomembrane independent conformance testing

Test Type	Test Method	Frequency	Comments
Thickness (average)	ASTM D5199 (smooth) ASTM D5994 (textured)	One test per 5,000 m ²	Laboratory measurement
Minimum thickness	ASTM D5199 (smooth) ASTM D5994 (textured)	One test per 5,000 m ²	Laboratory measurement
Asperity height (min)	ASTM D7466	One test per 5,000 m ²	Laboratory measurement
Density	ASTM D1505 or D792 (method B)	One test per 5,000 m ²	Laboratory measurement
Tensile properties (each direction) <ul style="list-style-type: none"> Strength at break Elongation at break Strength at yield Elongation at yield 	ASTM D6693	One test per 5,000 m ²	Laboratory measurement
Tear resistance	ASTM D1004	One test per 5,000 m ²	Laboratory measurement
Puncture resistance	ASTM D4833	One test per 5,000 m ²	Laboratory measurement
Carbon black content	ASTM D4218	One test per 5,000 m ²	Laboratory measurement
Carbon black dispersion	ASTM D5596	One test per 5,000 m ²	Laboratory measurement

Test Type	Test Method	Frequency	Comments
Oxidative Induction Time (OIT) <ul style="list-style-type: none"> Standard OIT (AND) High pressure OIT 	ASTM D 3895 ASTM D 5885	One test per resin type or manufacturing run or per 10,000 m ² of geomembrane. (whichever is greater)	Laboratory measurement
Stress crack resistance	ASTM D5397	One test per resin type or manufacturing run or per 10,000 m ² of geomembrane.	Laboratory measurement

6.8 Roll and sample identification

The CQA Engineer shall verify rolls and samples are identified in accordance with the Specification.

6.9 Delivery, storage and handling

The CQA Engineer shall fill out a receiving inspection report (Section 16.3 and Appendix A) for each delivery of PE geomembrane. The CQA Engineer shall be present during delivery and unloading to verify the following:

- Rolls are shipped, handled and stored in such a manner that no damage occurs to the PE geomembrane
- Rolls are shipped, handled and stored in accordance with the approved work method statement and the manufacturer's instructions
- PE geomembrane rolls are packaged in opaque, waterproof, protective coverings
- Each roll is labelled in accordance with the Specification
- Rolls which are damaged beyond use are removed from the site.

6.10 Preparation of surface to receive geomembrane

The receiving surface shall be inspected and approved each day that PE geomembrane is installed by the CQA Engineer. Additional inspections shall be performed if weather, vehicular traffic or other factors may have damaged the subgrade after approval. The CQA Engineer shall verify the following during inspections of the receiving surface:

- The receiving surface is complete and accepted by the Superintendent
- The receiving surface is free of defects or imperfections that may result in damage to the PE geomembrane
- The receiving surface is free from abrupt breaks, sharp objects, or other foreign material
- The receiving surface has not been damaged by inclement weather
- If the receiving surface is subgrade or fill materials, verify the surface is compacted in accordance with the Specification, does not have areas of roughness that may prevent direct contact of the PE Geomembrane on the surface and is not pebbly, or tracked and rutted by equipment.

The Geosynthetic Installer, the Contractor and the CQA Engineer shall sign a certificate of subgrade acceptance for each day that geomembrane materials are placed.

6.11 Installation

The CQA Engineer shall verify the following during installation:

- Installation is undertaken in accordance with the approved work method statement and manufacturer's instructions
- Each roll is visually inspected for damage and deficiencies with consideration to tears, punctures, abrasions, cracks, indentations, thin spots, or other faults in the material
- Any damaged or defective rolls are identified, inspected and approved or rejected based on criteria within the Specification. This may include blemishes, holes, indentations, thin spots, tears and punctures
- Any repair works are conducted in accordance with the Specification
- Weather conditions are acceptable for installation (with consideration to manufacturer's instructions)
- Winds are not so high as to cause damage during installation
- Any rolls or panels which have been displaced by wind are inspected for damage and approved or rejected
- Equipment used for installation and cover are in accordance with the approved work method statement
- The Contractor has adequate ballasts (e.g. sandbags) on hand and they are properly deployed to prevent uplift of the panels by wind
- Field panels are installed at the locations and positions indicated on the Contractor's approved panel placement drawing. The CQA Engineer shall verify that the identification code, location, and date of installation of each field panel are recorded
- Rolls are laid reasonably flat with a minimum of wrinkles so that they contain no areas that can fold over during covering
- Rolls are placed with the correct side facing up (where relevant)
- The Contractor cuts out and repairs waves that are so large as to cause folding of the PE geomembrane when they are covered
- There are no tensile stresses in the deployed PE geomembrane
- Construction personnel are not smoking or wearing shoes that could damage the PE geomembrane
- Seams are constructed as specified and in accordance with manufacturer's instructions. Also verify seams are not placed in locations prohibited by the Specification
- Rolls are not dragged across the receiving surface or other deployed PE geomembrane. This can result in damage to the PE geomembrane. A sacrificial rub sheet may be used to alleviate this problem
- Rolls are not being damaged during placement or covering
- The Geosynthetic Installer provides sufficient slack in the deployed geomembrane to account for the temperature fluctuations anticipated
- After a significant drop in temperature, the PE geomembrane has not pulled away from the subgrade or anchor trench.

6.12 Trial seams

The CQA Engineer shall be present when trial seams are performed to verify they are conducted in accordance with the Specification. Test results for each trial seam shall be recorded on the geomembrane trial seam data sheet.

6.13 Field seams

The CQA Engineer shall verify the following during field seaming:

- Seaming equipment is in good condition and is functioning properly
- Field seams are laid out as shown on the approved panel layout drawing
- Seams are of high quality. Special attention shall be given to high stress points such as valleys, ridges and at penetrations
- Seam areas are clean and free of moisture, dust, dirt, and foreign material
- If grinding of the surfaces to be seamed is required, the grinding marks are oriented perpendicular to the seam direction and no marks extend beyond the extrudate after placement
- The depth of the grinding marks are no greater than 10% of the sheet thickness
- Where extrusion welds are terminated long enough to cool, they are ground prior to applying new extrudate over the existing seams.

Each seam constructed shall be recorded on a geomembrane seam log.

6.14 Field sampling and testing

6.14.1 Destructive seam testing

The CQA Engineer shall:

- Select locations where seam samples will be cut out for CQA testing. The Contractor shall not be informed in advance of the locations where the seam samples will be taken
- Verify seam strength testing is done as the seaming work progresses, not at the completion of field seaming
- Verify seams are labelled in accordance with the Specification
- Document CQA seam test results and repairs (refer Section 16.5 and Appendix A)
- Verify seams which fail CQA and/or CQC destructive seam testing are repaired in accordance with the Specification.

6.14.2 Non-destructive seam testing

The CQA Engineer shall verify:

- All seams are visually inspected to assess the quality of the workmanship and the appearance of the welded seam
- All seams are non-destructively tested as seaming work progresses and seams which fail are repaired
- The outcome of all non-destructive seam test results are documented.

6.15 Defects and repairs

The CQA Engineer shall visually inspect PE geomembrane for damage after placement. Damaged areas shall be marked. The CQA Engineer shall document the location of the damaged panels, repairs which were performed and panels which were rejected on a geomembrane repair log.

The CQA Engineer shall visually inspect and verify that all deficiencies have been repaired in accordance with the Specification and the manufacturer's instructions prior to final acceptance.

6.16 Acceptance

Prior to the final acceptance of the PE geomembrane by the Superintendent, the CQA Engineer shall provide a recommendation to the Superintendent on whether the conditions of final acceptance have been met as per the Specification. This recommendation shall be based on, but not limited to, the following:

- Review of all submittals, including CQC test results
- Review of CQA test results
- Relevant monitoring and inspections undertaken.

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7. Geotextile

7.1 General

The CQA Engineer shall verify the following during geotextile installation.

7.2 Qualifications

The CQA Engineer assigned CQA responsibilities for the geotextile shall have been accredited by the Geosynthetic Certification Institute-Inspectors Certification Program for installation of geosynthetic materials or have provided CQA inspection during installation of geosynthetics for at least three projects totalling a minimum of 100,000 m² of geosynthetics.

The CQA Engineer may assign CQA Monitors in accordance with Section 2.5.5 as appropriate.

7.3 Submittals

The CQA Engineer shall review all submittals provided by the Contractor and recommend rejection or approval to the Superintendent. This shall include relevant work method statements prepared by the Contractor.

7.4 Manufacturer's quality control

The CQA Engineer shall review the manufacturer's quality control procedures and test results prior to delivery of geotextile to site to confirm the material conforms to the requirements of the Specification.

This shall include verification that the measurements of properties by the manufacturer are properly documented, test methods are acceptable, sampling procedure detailed and that the proposed polymer, fibres and geotextile meet the Specification.

7.5 Manufacturer's quality assurance

The CQA Engineer shall review the manufacturer's quality assurance procedures and test results prior to delivery of geotextile to site to confirm the material conforms to the requirements of the Technical Specification. This may include liaison with the manufacturer on the frequency of MQA testing.

7.6 Material

The CQA Engineer shall review all test results/reports provided by the Contractor to confirm the material conforms to the requirements of the Specification.

7.7 Independent conformance testing

The CQA shall supervise collection of CQA samples by the Geosynthetic Installer for geotextile at the rate specified in and forward the samples to the CQA Engineers Independent Testing Firm for testing. The testing frequencies shall apply to all geotextile products provided as part of the Works.

Each product supplied shall be treated as a separate geotextile material with the testing frequencies applied per product and not additively. The samples shall be taken from the rolls delivered to site prior to use. All samples test results shall be received, accepted and reported by the CQA Engineer prior to installation.

The required testing frequencies may be revised by the CQA Engineer to conform to improvements in testing methods and/or in the state of the art practice and/or to account for the

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criticality of the application. Revisions must be approved by the relevant parties before application.

Unless otherwise specified or approved, the CQA Engineer shall verify CQA samples are not taken from the outer wrap of the roll and samples are a minimum of 1 m metre in length by the roll width.

Table 2 lists the independent conformance testing that shall be performed on the geotextile prior to installation. In addition to the below, for all testing parameters, a minimum of two tests shall be undertaken including the first and last rolls (based on the production order).

Table 2 Geotextile independent conformance testing

Test Type	Test Method	Frequency	Comments
Mass per unit area	AS 3706.1	1 per 2,500 m ²	Protection geotextiles only
Grab Tensile strength	AS 3706.2b	1 per 5,000 m ²	All geotextiles
CBR Puncture Strength	AS 3706.4	1 per 5,000 m ²	All geotextiles
Trapezoidal Tear Strength	AS 3706.3	1 per 5,000 m ²	All geotextiles
Pore size (MaxARV)	ASTM D6767	1 per 5,000 m ²	Separation geotextiles only
Permittivity	AS 3706.9	1 per 5,000 m ²	Separation geotextiles only

7.8 Roll and sample identification

The CQA Engineer shall verify rolls and samples are identified in accordance with the Specification.

7.9 Delivery, storage and handling

The CQA Engineer shall fill out a receiving inspection report for each delivery of geotextile. The CQA Engineer shall be present during delivery and unloading to verify the following:

- Rolls are shipped, handled and stored in such a manner that no damage occurs to the geotextile
- Rolls are shipped, handled and stored in accordance with the approved work method statement and the manufacturer's instructions
- Geotextile rolls are packaged in opaque, waterproof, protective coverings
- Each roll is labelled in accordance with the Specification
- Rolls which are damaged beyond use are removed from the site.

7.10 Preparation of surface to receive geotextile

The receiving surface shall be inspected and approved each day that geotextile is installed by the CQA Engineer. Additional inspections shall be performed if weather, vehicular traffic or other factors may have damaged the receiving surface after approval. The CQA Engineer shall verify the following during inspections of the receiving surface:

- The receiving surface is complete and accepted by the Superintendent
- The receiving surface is free of defects or imperfections that may result in damage to the geotextile
- The receiving surface is free from abrupt breaks, sharp objects, or other foreign material
- The receiving surface has not been damaged by inclement weather

- If the receiving surface is subgrade or fill materials, verify the surface is compacted in accordance with the Specification and not pebbly, or tracked and rutted by equipment.

7.11 Installation

The CQA Engineer shall verify the following during installation:

- Installation is undertaken in accordance with the approved work method statement and manufacturer's instructions
- Each roll is visually inspected for damage and deficiencies with consideration to colour, thickness, needle punching, presence of needles or broken needles, and sewing density or other faults in the material
- Any damaged or defective rolls are identified, inspected and approved or rejected based on criteria within the Specification
- Weather conditions are acceptable for installation (with consideration to manufacturer's instructions)
- Winds are not so high as to cause damage during installation
- Any rolls or panels which have been displaced by wind are inspected for damage and approved or rejected
- Equipment used for installation and cover are in accordance with the approved work method statement
- The Contractor has adequate ballasts (e.g. sandbags) on hand and they are properly deployed to prevent uplift of the panels by wind
- Field panels are installed at the locations and positions indicated on the Contractor's approved panel placement drawing. The CQA Engineer shall verify that the identification code, location, and date of installation of each field panel are recorded
- Rolls are laid reasonably flat with a minimum of wrinkles so that they contain no areas that can fold over during covering
- Rolls are placed with the correct side facing up (where relevant)
- There are no broken needles present in the geotextiles
- The Contractor cuts out and repairs waves that are so large as to cause folding of the geotextile when they are covered
- There are no tensile stresses in the deployed geotextile
- Construction personnel are not smoking or wearing shoes that could damage the geotextile
- Seams are constructed as specified and in accordance with manufacturer's instructions, and lapped in the correct direction (where relevant). Also verify seams are not placed in locations prohibited by the Specification
- Sewn, heat bonded and overlapped seams are constructed in the specified locations
- Sewn seams are constructed using the correct overlap, thread type and stitch type
- Stitch bonded seams are inspected for skipped stitches
- Heat bonded seams are inspected for discontinuities
- The geotextile is not being burned through during the fabrication of heat bonded seams

- Rolls are not dragged across the receiving surface or other deployed geotextile. This can result in damage to the geotextile. A sacrificial rub sheet may be used to alleviate this problem
- Rolls are not being damaged during placement or covering
- Check the Specification to determine the maximum allowable exposure time for the deployed geotextile. If the allowable exposure time has been exceeded, determine if the geotextile has been damaged. If needed, request the performance of additional CQA tests to verify the physical properties of the textile have not diminished due to exposure
- Staples or pins are not used to hold geotextiles in place if the geotextile will be placed immediately above other geosynthetics
- Rolls are inspected for evidence of clogging from eroded or windblown soil.

7.12 Defects and repairs

The CQA Engineer shall visually inspect geotextile for damage after placement. Damaged areas shall be marked. The CQA Engineer shall document the location of the damaged panels, repairs which were performed and panels which were rejected in the daily report.

The CQA Engineer shall visually inspect and verify that all deficiencies have been repaired in accordance with the Specification and the manufacturer's instructions prior to final acceptance.

7.13 Acceptance

Prior to the final acceptance of the geotextile by the Superintendent, the CQA Engineer shall provide a recommendation to the Superintendent on whether the conditions of final acceptance have been met as per the Specification. This recommendation shall be based on, but not limited to, the following:

- Review of all submittals, including CQC test results
- Review of CQA test results
- Relevant monitoring and inspections undertaken.

8. Drainage aggregate

8.1 General

The CQA Engineer shall verify the following during placement of drainage aggregate.

8.2 Qualifications

The CQA Engineer assigned CQA responsibilities for the drainage aggregate installation shall have been accredited by the Geosynthetic Certification Institute-Inspectors Certification Program for installation of geosynthetic materials or have provided CQA inspection during installation of drainage aggregate for at least three projects totalling a minimum of 100,000 m².

The CQA Engineer may assign CQA Monitors in accordance with Section 2.5.5 as appropriate.

8.3 Submittals

The CQA Engineer shall review all submittals provided by the Contractor and recommend rejection or approval to the Superintendent. This shall include relevant work method statements prepared by the Contractor, including any updates made based on the results of the field trial.

8.4 Material

The CQA Engineer shall review all test results/reports provided by the Contractor to confirm the drainage aggregate conforms to the requirements of the Specification.

8.5 Independent conformance testing

The CQA Engineer shall supervise collection of CQA samples for drainage aggregate at a rate specified in Table 3 and forward the samples to the CQA Engineers Independent Testing Firm for testing.

Table 3 Drainage aggregate independent conformance testing

Test Type	Test Method	Frequency	Comments
Particle size distribution	AS 1141.11,12,13 or AS 1289.3.6.1, 3.6.3	1 per 2,000 m ³	In-place sample (following placement)

8.6 Delivery, storage and handling

The CQA Engineer shall inspect drainage aggregate stockpiles prior to use and advise the Superintendent of the presence of any unsuitable material or contamination as per the Specification.

8.7 Preparation of surface to receive drainage aggregate

The receiving surface shall be inspected and approved each day that drainage aggregate is installed by the CQA Engineer. Additional inspections shall be performed if weather, vehicular traffic or other factors may have damaged the receiving surface after approval. The CQA Engineer shall verify the following during inspections of the receiving surface:

- The receiving surface is complete and accepted by the Superintendent
- The receiving surface is free from abrupt breaks, sharp objects, or other foreign material
- The receiving surface has not been damaged by inclement weather

- If the receiving surface is subgrade or fill materials, verify the surface is compacted in accordance with the Specification and not pebbly, or tracked and rutted by equipment.

8.8 Installation

The CQA Engineer shall verify the following during installation:

- Installation is undertaken in accordance with the approved work method statement, which includes any adjustments made as a result of the field trial
- Trafficking with heavy machinery is avoided after placement
- Oversize and angular material which could damage geosynthetics has been removed prior to placement
- Underlying geosynthetics are not being damaged by placement equipment. Placement equipment should be observed from the front side as drainage aggregate is being spread over the underlying geosynthetics
- Excessive fines have not been generated as a result of handling and placement of the drainage aggregate
- Wind-borne and water-borne fines do not contaminate the drainage aggregate after placement
- Erosion controls are placed such that the drainage aggregate is not contaminated by fines
- Watch for ponds of water on top of the drainage aggregate which may be an indication that it is contaminated by an excessive amount of fines
- Wrinkles in underlying geosynthetics are not folding over onto themselves during aggregate placement
- Low ground pressure equipment is being used where specified.

8.9 In situ conformance testing

The CQA Engineer shall review and agree with the Superintendent where in situ conformance testing shall be undertaken as well as monitor the sampling. The CQA Engineer shall review the test results to confirm the material conforms to the requirements of the Specification.

8.10 Defects and repairs

If an area of drainage aggregate does not conform to the Specification, the CQA Engineer shall assist the Superintendent in defining the extent of the area requiring repair. This shall be done through the use of additional testing and visual inspection.

8.11 Acceptance

After repairs have been made, the CQA Engineer shall confirm quality control retests are performed to check the repaired areas. In general, CQC retests shall be performed at the same frequency as the rest of the project. Additional CQC testing shall be performed in suspect areas.

Prior to the final acceptance of the drainage aggregate by the Superintendent, the CQA

Engineer shall provide a recommendation to the Superintendent on whether the conditions of final acceptance have been met as per the Specification. This recommendation shall be based on, but not limited to, the following:

- Review of all submittals, including CQC test results

- Review of CQA test results
- Relevant monitoring and inspections undertaken.

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9. Field trial – drainage aggregate

9.1 General

The CQA Engineer shall verify the following during the drainage aggregate field trial.

9.2 Qualifications

The CQA Engineer assigned CQA responsibilities for the field trials shall have been accredited by the Geosynthetic Certification Institute-Inspectors Certification Program for installation of geosynthetic materials or have provided CQA inspection during a drainage aggregate field trial for at least three projects.

9.3 Submittals

The CQA Engineer shall review all submittals provided by the Contractor and recommend rejection or approval to the Superintendent. This shall include relevant work method statements prepared by the Contractor, including any updates made based on the results of the field trial.

9.4 Drainage aggregate placement method

During the drainage aggregate field trial, the CQA Engineer shall:

- Verify that field trial preparation and completion is undertaken in accordance with the approved work method statement
- Verify underlying geosynthetics are placed in accordance with the approved work method statements and the manufacturer's instructions
- Witness the field trial
- Inspect the underlying geosynthetics for damage and deficiencies following completion of the field trial
- Review any relevant test results/reports
- Review of field trial report prepared by the Contractor, including the updated placement method.

10. Seal bearing layer

10.1 General

The CQA Engineer shall verify the following during placement of the Seal bearing layer.

All individuals assigned CQA responsibilities for the Seal bearing layer shall have provided CQA inspection during installation soil layers for at least three major earthworks projects totalling a minimum of 50,000 m³ of soil layer material.

10.2 Submittals

The CQA Engineer shall review all submittals provided by the Contractor and recommend rejection or approval to the Superintendent. This shall include relevant work method statements prepared by the Contractor, including any updates made based on the results of the field trial.

10.3 Materials

The CQA Engineer shall:

- Review all test results/reports provided by the Contractor for the proposed seal bearing material to verify that the material is uniform and matches the required properties given in the Specification
- Advise the Superintendent about the need to do additional borrow source assessment testing if the properties of the seal bearing material appear to have changed significantly
- Inspect material stockpiles prior to use and advise the Superintendent of the presence of any unsuitable material.

10.4 Delivery, storage and handling

The CQA Engineer shall inspect stockpiles prior to use and advise the Superintendent of the presence of any unsuitable material or contamination as per the Specification.

10.5 Preparation of surface to receive seal bearing layer

The receiving surface shall be inspected and approved by the CQA Engineer each day that Seal bearing layer is installed. Additional inspections shall be performed if weather, vehicular traffic or other factors may have damaged the receiving surface after approval. The CQA Engineer shall verify the following during inspections of the receiving surface:

- The receiving surface is complete and accepted by the Superintendent
- The receiving surface is cleared of any debris and/or foreign material
- The receiving surface has not been damaged by inclement weather.

10.6 Installation

The CQA Engineer shall verify the following during installation:

- Installation is undertaken in accordance with the approved work method statement, which includes any adjustments made as a result of the field trial.
- Equipment used for installation and cover are in accordance with the approved work method statement
- Weather conditions are acceptable for installation

- Oversize and angular material which could damage underlying geosynthetics has been removed from the seal bearing material
- Seal bearing material is not dumped directly onto underlying geosynthetics from a height greater than specified
- Underlying geosynthetics are not being damaged by placement equipment. Placement equipment should be observed from the front side as seal bearing material is being spread over the underlying geosynthetics
- Wrinkles in underlying geosynthetics are not folding over onto themselves during seal bearing material placement
- Low ground pressure equipment is being used where specified
- Placement of seal bearing material proceeds from a stable working area adjacent to the deployed geosynthetic materials and gradually progresses outward. For slopes, seal bearing material must be placed by starting at the toe and working up the slope
- Access routes are adequately built up to protect underlying geosynthetics. Access routes generally must be a minimum of 900 mm in thickness
- Tracks and wheels of full scale construction equipment remain on the access routes at all times
- Repairs are made to the access routes as needed. Inspect access routes daily to see if thinning of the seal bearing material is occurring
- Large stockpiles of seal bearing material are not placed on top of in-place geosynthetics
- Thin areas of seal bearing material which could allow underlying geosynthetics to be punctured or torn by construction equipment are repaired immediately.

10.7 Defects and repairs

The CQA Engineer shall visually inspect the Seal bearing layer for damage or defects after placement. If an area of the sand drainage layer does not conform to the Specification, the CQA Engineer shall assist the Superintendent in defining the extent of the area requiring repair. This shall be done through the use of additional testing and visual inspection.

After repairs have been made, the CQA Engineer shall confirm quality control retests are performed to check the repaired areas. In general, CQC retests shall be performed at the same frequency as the rest of the project. Additional CQC testing shall be performed in suspect areas.

10.8 Acceptance

Prior to the final acceptance of the Seal bearing layer by the Contract Manager, the CQA Engineer shall provide a recommendation to the Superintendent on whether the conditions of final acceptance have been met as per the Specification. This recommendation shall be based on, but not limited to, the following:

- Review of all submittals
- Review of CQA test results
- Relevant monitoring and inspections undertaken.

11. Geonet drainage composite

11.1 General

All individuals' assigned CQA responsibilities for the geonet and geonet drainage composite shall have been accredited by the Geosynthetic Certification Institute-Inspectors Certification Program for installation of geosynthetic materials or have provided CQA inspection during installation of geosynthetics for at least three projects totalling a minimum of 100,000 m² of geosynthetics.

11.2 Submittals

The CQA Engineer shall review all submittals provided by the Contractor and recommend rejection or approval to the Superintendent. This shall include relevant work method statements prepared by the Contractor.

11.3 Manufacturer's quality control

The CQA Engineer shall review the manufacturer's quality control procedures and test results prior to delivery of geonet and geonet drainage composite to site to confirm the material conforms to the requirements of the Specification.

11.4 Manufacturer's quality assurance

The CQA Engineer shall review the manufacturer's quality assurance procedures and test results prior to delivery of geonet and geonet drainage composite to site to confirm the material conforms to the requirements of the Specification.

11.5 Material

The CQA Engineer shall review all test results/reports provided by the Contractor to confirm the material conforms to the requirements of the Specification.

11.6 Independent conformance testing

The CQA Engineer shall supervise collection of CQA samples by the Geosynthetic Installer for geonet and geonet drainage composite at the rate specified in **Error! Reference source not found.** and forward the samples to the CQA Engineers Independent Testing Firm for testing. The samples shall be taken from the rolls delivered to site prior to use. All samples test results shall be received, accepted and reported by the CQA Engineer prior to installation.

The required testing frequencies may be revised by the CQA Engineer 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. Revisions must be approved by the relevant parties before application.

Unless otherwise specified or approved, the CQA Engineer shall verify CQA samples are not taken from the outer wrap of the roll and samples are a minimum of 1 m in length by the roll width.

Table 4 lists the independent conformance testing that shall be performed on the geonet drainage composite prior to installation. In addition to the below, for all testing parameters, a minimum of two tests shall be undertaken including the first and last rolls (based on the production order).

Table 4 Geonet drainage composite independent conformance testing

Test Type	Test Method	Frequency	Comments
Mass per unit area	D5261	1 test per 1,250 m ²	Laboratory measurement
Geonet thickness	ASTM D1621	1 test per 1,250 m ²	
Geocomposite tensile strength (machine direction)	AS 3706.1	1 test per 5,000 m ²	Laboratory measurement
In plane flow rate	D4716	1 test per 1,250 m ²	Laboratory measurement
Geonet compressive strength	D1621	1 test per 1,250 m ²	Laboratory measurement
Geotextile pore size	D6767	1 test per 10,000 m ²	Laboratory measurement
Geotextile permittivity	AS 3706.9	1 test per 10,000 m ²	Laboratory measurement
Ply adhesion (MARV)	D7005	1 test per 1,250 m ²	Laboratory measurement

11.7 Roll and sample identification

The CQA Engineer shall verify rolls and samples are identified in accordance with the Specification.

11.8 Delivery, storage and handling

The CQA Engineer shall fill out a receiving inspection report for each delivery of geonet and geonet drainage composite. The CQA Engineer shall be present during delivery and unloading to verify the following:

- Rolls are shipped, handled and stored in such a manner that no damage occurs to the geonet and geonet drainage composite
- Rolls are shipped, handled and stored in accordance with the approved work method statement and the manufacturer's instructions
- Geonet and geonet drainage composite rolls are packaged in opaque, waterproof, protective coverings
- Each roll is labelled in accordance with the Specification
- Rolls which are damaged beyond use are removed from the site.

11.9 Preparation of surface to receive geonet and geonet drainage composite

The receiving surface shall be inspected and approved each day that geonet and geonet drainage composite is installed by the CQA Engineer. Additional inspections shall be performed if weather, vehicular traffic or other factors may have damaged the receiving surface after approval. The CQA Engineer shall verify the following during inspections of the receiving surface:

- The receiving surface is complete and accepted by the Superintendent
- The receiving surface is free of defects or imperfections that may result in damage to the geonet and geonet drainage composite
- The receiving surface is free from abrupt breaks, sharp objects, or other foreign material
- The receiving surface has not been damaged by inclement weather
- If the receiving surface is subgrade or fill materials, verify the surface is compacted in accordance with the Specification and not pebbly, or tracked and rutted by equipment.

11.10 Installation

The CQA Engineer shall verify the following during installation:

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- Installation is undertaken in accordance with the approved work method statement and manufacturer's instructions
- Any damaged or defective rolls are identified, inspected and approved or rejected
- Weather conditions are acceptable for installation (with consideration to manufacturer's instructions)
- Winds are not so high as to cause damage during installation
- Any rolls or panels which have been displaced by wind are inspected for damage and approved or rejected
- Equipment used for installation and cover are in accordance with the approved work method statement
- The Contractor has adequate ballasts (e.g. sandbags) on hand and they are properly deployed to prevent uplift of the panels by wind
- Field panels are installed at the locations and positions indicated on the Contractor's approved panel placement drawing. The CQA Engineer shall verify that the identification code, location, and date of installation of each field panel are recorded
- Rolls are laid reasonably flat with a minimum of wrinkles so that they contain no areas that can fold over during covering
- Rolls are placed with the correct side facing up (where relevant)
- There are no broken needles present in the geotextiles
- The Contractor cuts out and repairs waves that are so large as to cause folding of the geonet and geonet drainage composite when they are covered
- There are no tensile stresses in the deployed geonet and geonet drainage composite
- Construction personnel are not smoking or wearing shoes that could damage the geonet and geonet drainage composite
- Seams are constructed as specified and in accordance with manufacturer's instructions, and lapped in the correct direction (where relevant). Also verify seams are not placed in locations prohibited by the Specification
- Rolls are not dragged across the receiving surface or other deployed geonet and geonet drainage composite. This can result in damage to the geonet and geonet drainage composite. A sacrificial rub sheet may be used to alleviate this problem
- Rolls are not being damaged during placement or covering
- The ribs of the composite are continuous and are securely attached to each other
- Plastic fasteners are used to join adjacent rolls and they are placed at the specified spacing
- Fasteners are of contrasting colour with the composite to facilitate visual inspection
- Rolls are not being damaged during the fabrication of heat bonded geotextile seams
- Rolls are inspected for evidence of clogging from eroded or windblown soil.

11.11 Defects and repairs

The CQA Engineer shall visually inspect geonet and geonet drainage composite for damage after placement. Damaged areas shall be marked. The CQA Engineer shall document the

location of the damaged panels, repairs which were performed and panels which were rejected in the daily report (Section 16.2).

The CQA Engineer shall visually inspect and verify that all deficiencies have been repaired in accordance with the Specification prior to final acceptance.

11.12 Acceptance

Prior to the final acceptance of the geonet and geonet drainage composite by the Superintendent/Principal, the CQA Engineer shall provide a recommendation to the Superintendent on whether the conditions of final acceptance have been met as per the Specification. This recommendation shall be based on, but not limited to, the following:

- Review of all submittals
- Review of CQA test results
- Relevant monitoring and inspections undertaken.

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12. Revegetation layer

12.1 General

The CQA Engineer shall verify the following during construction of the revegetation layer.

The relevant requirements for the revegetation layer in Section 3 shall be considered alongside guidance provided in this section.

12.2 Qualifications

All individuals assigned CQA responsibilities for the revegetation layer shall have provided CQA inspection during installation soil layers for at least three major earthworks projects totalling a minimum of 50,000 m³ of protective soil layer material.

12.3 Submittals

The CQA Engineer shall review all submittals provided by the Contractor and recommend rejection or approval to the Superintendent. This shall include relevant work method statements prepared by the Contractor.

12.4 Materials

The CQA Engineer shall:

- Review all test results/reports provided by the Principal/Contractor for the proposed revegetation soil material and vegetation to verify that they match the required properties given in the Technical Specification
- Advise the Superintendent about the need to do additional borrow source assessment testing if the properties of the revegetation soil material appear to have changed significantly
- Inspect revegetation soil material stockpiles prior to use and advise the Superintendent of the presence of any unsuitable material
- Review the proposed seed mix

12.5 Preparation of surface to receive revegetation layer

The receiving surface shall be inspected and approved by the CQA Engineer each day that the revegetation layer is installed. Additional inspections shall be performed if weather, vehicular traffic or other factors may have damaged the receiving surface after approval. The CQA Engineer shall verify the following during inspections of the receiving surface:

- The receiving surface is complete and accepted by the Superintendent
- The receiving surface is cleared of any debris and/or foreign material
- The receiving surface has not been damaged by inclement weather.

12.6 Installation

The CQA Engineer shall verify the following during installation:

- Installation is undertaken in accordance with the approved work method statement
- Equipment used for installation are in accordance with the approved work method statement

- Soil layers are not over compacted
- Weather conditions are acceptable for installation.

12.7 Seeding/sowing

The CQA Engineer shall verify the following:

- Seed and fertiliser are stored in a cool, dry location away from contaminants
- Pesticides, insecticides, herbicides and other materials are delivered in their original, unopened containers bearing legible labels indicating the registration number and the manufacturer's registered uses
- Vegetative operations are performed only during periods when weather conditions are acceptable
- Prior to seeding, areas which have been damaged by rain, traffic, or other causes are reworked to restore the specified ground condition
- Seeds are uniformly distributed. The CQA Engineer shall also verify seed are certified to contain no weed seed and meet specified requirements.

12.8 Maintenance

The CQA Engineer shall review the proposed maintenance program provided by the Contractor and recommend rejection or approval to the Superintendent.

12.9 Defects and repairs

The CQA Engineer shall visually inspect the revegetation layer for damage or defects after placement. The CQA Engineer shall assist the Superintendent in defining the extent of the area requiring repair, with reference to test frequencies and results. This shall be done through the use of additional testing and visual inspection.

After repairs have been made, the CQA Engineer shall confirm quality control retests are performed to check the repaired areas. In general, CQC retests shall be performed at the same frequency as the rest of the project. Additional CQC testing shall be performed in suspect areas.

12.10 Acceptance

Prior to the final acceptance of the revegetation layer by the Superintendent/Principal, the CQA Engineer shall provide a recommendation to the Superintendent on whether the conditions of final acceptance have been met as per the Technical Specification. This recommendation shall be based on, but not limited to, the following:

- Review of all submittals
- Review of CQA test results
- Relevant monitoring and inspections undertaken.

13. Plastic pipework

13.1 General

The CQA Engineer or appropriate CQA Monitor shall verify the following for plastic pipework, valves, fittings and other items associated with plastic pipework during construction of the landfill barrier system and leachate collection and conveyance system.

13.2 Equipment

Verify equipment used to place and cover pipe is in accordance with the Works Documents and the manufacturer's recommendations.

13.3 Delivery, storage and handling

Be present during delivery and unloading and verify the following:

- Pipe and appurtenances are not damaged during shipping, storage, and handling;
- Deliveries are properly recorded;
- The correct material type, strength, and pipe sizes have been delivered;
- The size, number and location of pipe perforations are as specified;
- Pipes with gouges deeper than 10% of the wall thickness are rejected or repaired before use; and
- Out-of-round pipe which cannot be properly joined together is rejected.

13.4 Manufacturer quality control testing

Verify that pipe is sampled and tested in accordance with the approved manufacturer's quality control manual and test results not meeting the requirements specified results in the rejection of applicable pipe.

13.5 Independent conformance testing

Table 5 lists the independent conformance testing shall be performed on the plastic pipework prior to installation.

Table 5 Plastic pipe independent conformance testing

Test Type	Test Method	Frequency	Comments
Standard pipe dimensions	-	Spot check each shipment of pipe	Field measurement
Pipe perforation dimensions	-	Spot check each shipment of pipe	Field measurement

13.6 Execution

Verify the following during pipe placement:

- Pipe is carried to the place of installation and not dragged;
- Defective or damaged pipe is not used;
- Pipe is not laid when trench conditions or weather is unsuitable;
- Pipe is not installed if standing water is present;

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- Pipe and accessories are carefully lowered into the trench;
- Pipe is placed at the lines and grades indicated in the Works Documents. Verify the Contractor does not lay pipe on blocks to produce the specified grade;
- Specified bedding is used and the bedding is graded to provide a cradle for proper support of the pipe;
- The full length of each section of pipe rests solidly upon the pipe bedding layer with recesses excavated to accommodate couplings and joints;
- Compaction requirements are being met for bedding layers located around the pipe;
- Perforated pipe is installed in accordance with the Works Documents;
- Pipe and fittings are free of dirt, oil, or other contaminants;
- The interior of pipe and accessories are thoroughly cleaned of foreign matter before being lowered into the trench;
- Pinch bars and tongs for aligning or turning pipe are used only on the bare ends of pipe; and
- When work is not in progress, open ends of pipes, fittings, and valves are securely plugged or capped so that no trench water, earth or other substance enters the pipe and fittings.

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14. Landfill gas system

14.1 General

The CQA Engineer shall verify the following during the installation of the landfill gas system.

14.2 Equipment

Verify equipment used to install landfill gas system is in accordance with the Works Documents and the manufacturer's recommendations.

14.3 Delivery, storage and handling

Be present during delivery and unloading and verify the following:

- Landfill gas system components are not damaged during shipping, storage, and handling;
- Deliveries are properly recorded;
- The correct material type, strength, and sizes have been delivered;
- The size, number and location of pipe perforations are as specified;
- Pipes with gouges deeper than 10% of the wall thickness are rejected or repaired before use; and
- Out-of-round pipe which cannot be properly joined together is rejected.

14.4 Manufacturer quality control testing

Verify that components of the landfill gas system are sampled and tested in accordance with the approved manufacturer's quality control manual and test results not meeting the requirements specified results in the rejection of applicable landfill gas system components.

14.5 Independent conformance testing

Table 6 lists the independent conformance testing shall be performed on the components of the landfill gas system prior to installation.

Table 6 Landfill gas vent components independent conformance testing

Test Type	Test Method	Frequency	Comments
Standard pipe dimensions	-	Spot check each shipment of pipe	Field measurement
Pipe perforation dimensions	-	Spot check each shipment of pipe	Field measurement

14.6 Installation

The CQA Engineer shall verify the following during installation:

- Pipe is carried to the place of installation and not dragged;
- Defective or damaged pipe is not used;
- Pipe is not laid when trench conditions or weather is unsuitable;
- Pipe is not installed if standing water is present;
- Pipe and accessories are carefully lowered into the trench;

- Pipe is placed at the lines and grades indicated in the Works Documents. Verify the Contractor does not lay pipe on blocks to produce the specified grade;
- Specified bedding is used and the bedding is graded to provide a cradle for proper support of the pipe;
- The full length of each section of pipe rests solidly upon the bedding layer with recesses excavated to accommodate couplings and joints;
- Compaction requirements are being met for bedding layers located around the pipe;
- Perforated pipe is installed in accordance with the Works Documents;
- Pipe and fittings are free of dirt, oil, or other contaminants;
- The interior of pipe and accessories are thoroughly cleaned of foreign matter before being lowered into the trench;
- Pinch bars and tongs for aligning or turning pipe are used only on the bare ends of pipe; and
- When work is not in progress, open ends of pipes, fittings, and valves are securely plugged or capped so that no trench water, earth or other substance enters the pipe and fittings.
- Ensure cover of perforated piping in gas collection layer is as per manufacturer's recommendation
- Clamps are fitted tightly to riser pipe
- Riser pipes are secured properly following installation

14.7 Defects and repairs

If a material or component does not conform to the Works Documents, assist the Superintendent in defining the extent of the area requiring repair. This shall be done through the use of additional testing and visual inspection.

14.8 Acceptance

Prior to the final acceptance of construction of the landfill gas system by the Superintendent, the CQA Engineer shall provide a recommendation to the Superintendent on whether the conditions of final acceptance have been met as per the Technical Specification. This recommendation shall be based on, but not limited to, the following:

- Review of all submittals, including CQC test results
- Review of CQA test results
- Relevant monitoring and inspections undertaken

15. Decommissioning of existing stormwater pipe

15.1 General

The CQA Engineer shall verify the following during decommissioning of the existing stormwater pipe.

15.2 Submittals

The CQA Engineer shall review all submittals provided by the Contractor and recommend rejection or approval to the Superintendent. This shall include relevant work method statements prepared by the Contractor.

15.3 Materials

The CQA Engineer shall:

- Review all test results/reports provided by the Contractor for the proposed materials to verify that the material meets the approved requirements
- Inspect materials prior to use and advise the Superintendent of the presence of any damaged or unsuitable material.

15.4 Installation

The CQA Engineer shall verify that the works are undertaken in accordance with the approved work method statement for the works.

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16. CQA documentation

16.1 General

The CQA Engineer shall document all construction inspection and testing activities with logs, reports and photographs. The data sheets to be used for CQA documentation shall be as presented at the end of this section. With the approval of the Superintendent, data sheets presented in this CQA Plan may be revised as necessary by the CQA Engineer. Additional data sheets needed to record test results and observations shall be submitted to the Superintendent for approval.

The Superintendent shall maintain all CQA documentation onsite at all times.

Examples of the following reports are contained in Appendix A.

16.2 CQA Engineer's daily report

The CQA Engineer's Daily Report shall be prepared by the CQA Engineer and submitted weekly to the Superintendent. At a minimum, the Daily Report shall include the following information:

- Date, project name, location, and other identifying information
- Weather and site conditions
- A narrative describing construction activities underway
- Equipment used for each work task
- CQA activities performed
- Summary of CQA and CQC tests performed and test methods used
- Summary of CQA and CQC test results, including corrective actions taken for all construction materials not in compliance with project specifications
- A list of items requiring the Superintendent's attention
- Summary of geosynthetic materials placed including locations, panel numbers, seams completed, test results, repairs, methods of repairs and placement of cover material and temporary protection
- Documentation of borrow sources used and placement activities for all fill materials. Note any visual changes in borrow materials
- Corrective actions taken to repair damage
- Visual observations noted on all construction activities, including any concerns noted
- Summary of results for CQA lift thickness, density, and moisture content measurements
- Record of significant discussions or meetings with the Superintendent, Contractor, Geosynthetic Installer and others
- Signature of CQA Engineer

16.3 Receiving inspection report

Receiving inspection reports shall be completed for incoming geosynthetics and other materials.

16.4 Field moisture and density test result data sheet

All CQA moisture content and density tests shall be recorded on this data sheet.

16.5 Test report

This data sheet shall be used to record all other CQA test results for which a specific data sheet does not exist.

16.6 Survey records

Record drawings resulting from as-built survey data shall be reviewed by the CQA Engineer. Record drawings shall be included as part of the Final CQA Report issued by the CQA Engineer.

16.7 Photographic documentation

The CQA Engineer shall prepare a photographic record of each stage of the Works and this record will be readily available or kept onsite as part of the construction control activities.

Photographs shall include photographs of every phase of construction being performed, problem areas (including potential contractual or regulatory problems), corrective actions and final constructed features.

Photographs shall be identified with the site designation, the date taken, the location and a description of the activity covered by the photograph. The basic file shall contain colour prints and be stored in chronological order.

The photographs shall be available for review by the Principal, Superintendent, the CQA Engineer and other relevant parties as approved by the Principal.

Selected photographs shall be reproduced as part of the final report. The remaining photographs shall be transmitted to the Superintendent for archive as part of the permanent records.

16.8 Final report

- At the completion of work, the CQA Engineer shall be responsible for writing a final report on CQA activities performed at the site. The draft Final Report shall be completed and submitted to the Superintendent no more than 28 days after completion of construction and shall include, at a minimum, the following information:
- Brief description of the Works including type of facility, name of site, location, name of Principal, Superintendent, Contractor and Geosynthetic Installer
- Detailed description of the lining and capping systems, including surface area, cross sections and a summary of all materials used
- Chronological summary of construction activities
- Photographic documentation, including photographs of the site at different phases of construction, photographs of construction details and photographs of all CQA operations
- General record of activities, such as dates of performance of CQA operations, number and names of CQA Monitors and number and names of Geosynthetic Installer's personnel
- Manufacturer's certification sheets and MQC/MQA documentation
- Sampling and testing locations

- Copies of all CQA data sheets and records completed during the Works
- All CQA field and laboratory test results as well as a summary of these results
- Discussion of special problems encountered and their solutions
- Discussion of significant changes from design and material specifications
- As built survey records
- A summary statement sealed and signed by the CQA Engineer documenting that CQA was conducted in accordance with the CQA Plan and, based on visual observations and data generated in accordance with the CQA Plan, the Works shown in the Contract Drawings were constructed in accordance with Contract Documents except as properly authorised and documented in the CQA Final Report.

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Appendices

Appendix A - Typical Quality Assurance Reports

- CQA Engineer's daily report
- Geosynthetics receiving inspection report
- Field moisture and density test result data sheet
- General test report.

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