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HYDRO REMEDIATION PROJECT
CONTAINMENT CELL MANAGEMENT PLAN

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HYDRO REMEDIATION PROJECT
CONTAINMENT CELL MANAGEMENT PLAN

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Description	**Ramboll Australia was engaged by Hydro Aluminium Kurri Kurri Pty Ltd to prepare a Remediation Works Environmental Management Plan (RWEMP) to describe how environmental management will be undertaken at the former Hydro Aluminium Kurri Kurri aluminium smelter at Hart Road Loxford, NSW and the surrounding land owned by Hydro. This Containment Cell Management Plan (CCMP) forms a component of the ERWMP**

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ACRONYMS AND ABBREVIATIONS

CCMP	Containment Cell Management Plan
CQA	Construction Quality Assurance
CQC	Construction Quality Control
DQIs	Data Quality Indicators
DQOs	Data Quality Objectives
EC	Electrical Conductivity
EMP	Environmental Management Plan
EIS	Environmental Impact Statement
EP&A Act	*Environmental Planning and Assessment Act 1979*
EPL	Environment Protection Licence
F	Fluoride
Hydro	Hydro Aluminium Kurri Kurri Pty Ltd
ITP	Inspection and Test Plans
IPMP	Integrated Project Management Plan
RAP	Remedial Action Plan
RtS	Response to Submissions
RWEMP	Remediation Works Environmental Management Plan
SAQP	Sampling and Quality Plan
SEARs	
SEPP 55	State Environmental Planning Policy 55: Remediation of Land
SSD	State Significant Development
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
WHS	Workplace Health and Safety

GLOSSARY

Council	Cessnock City Council
The Department	The Department of Planning, Industry and the Environment
Hydro	Hydro Aluminium Kurri Kurri Pty Ltd
Hydro Land	The land owned by Hydro Aluminium Kurri Kurri Pty Ltd which includes the Smelter and surrounding land.
Construction Quality Assurance	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. It includes the review of work performed in the field and the testing of installed materials to verify compliance with the drawings and specifications. Overall construction quality assurance means and actions also include construction quality controls.
Construction Quality Control	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, construction quality control 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.
Remediation Works	Construction of the containment cell and associated infrastructure, relocation and treating of material from the Capped Waste Stockpile and treatment of leachate and groundwater as described in the RAP, EIS and RtS.
Stage 1 Demolition	Demolition of Smelter buildings addressed in the development application to Cessnock City Council 8/2015/399/1.
Stage 2 Demolition	Demolition of Smelter buildings, three concrete stacks, a water tower, subsurface structures to 1.5m below ground surface and operation of a concrete crushing plant addressed in the development application to Cessnock City Council 8/2018/46/1.
The Smelter	The former Hydro Aluminium Kurri Kurri Pty Ltd aluminium smelter at Hart Road, Loxford.

1. INTRODUCTION

1.1 Background

This Containment Cell Management Plan (CCMP) has been prepared by Ramboll Australia Pty Ltd on behalf of Hydro Aluminium Kurri Kurri Pty Ltd (Hydro) to support the Remediation Works Environmental Management Plan (RWEMP) for the decommissioning, demolition and remediation activities at the former Hydro Aluminium Kurri Kurri Smelter (the Smelter) at Hart Road Loxford and the management of the surrounding land owned by Hydro (the Hydro Land).

1.2 Objectives

The objectives of this CCMP are to:

- Detail the construction quality assurance procedures and measures to be implemented during construction of the Containment Cell
- Detail the quality controls to be implemented during construction of the Containment Cell
- Detail the validation procedures and measures to be implemented during construction of the Containment Cell
- Describe the environmental management measures to be implemented during construction of the Containment Cell
- Establish the roles and responsibilities of all parties involved in Containment Cell construction and quality management.

1.3 Purpose and Scope

The purpose of the CCMP is to:

- Present the construction quality assurance, construction quality control and remediation validation procedures for the Containment Cell
- Satisfy the relevant conditions of the development consent for remediation activities (SSD 6666).

1.4 Regulatory Requirements

1.4.1 Project Approval

A list of the development consent conditions related to this CCMP and where they are addressed in this document are outlined in **Table 1-1.**

Table 1-1: Project Approval Conditions and Where Addressed in CCMP

No.	Condition	Where in CCMP
B5	Prior to the commencement of remediation works, the Applicant must prepare a Containment Cell Management Plan (CCMP) to the satisfaction of the Planning Secretary. The CCMP must form part of the Remediation Works Environmental Management Plan (RWEMP) required by Condition C2 and be prepared in accordance with Condition C1. The CCMP must:	
B5(a)	be prepared by a suitably qualified and experienced person(s);	Appendix 9
B5(b)	be prepared in consultation with the EPA and Environmental Services Group of Housing and Property Group of the Department (H&P Group);	Section 4
B5(c)	describe the design of the containment cell and its construction methodology, including evidence that engineering drawings have been certified by appropriately qualified structural or civil engineers	Section 2, Appendix 1, Appendix 2, Appendix 3

No.	Condition	Where in CCMP
B5(d)	include details of the quality control and quality assurance procedures, program and performance specifications for the construction of the containment cell;	Section 3, Section 5, Section 6 and Section 7
B5(e)	describe the measures to be implemented to ensure adequate control of environmental impacts associated with the containment cell construction activities	Section 8, Appendix 7
B5(f)	include details of a proposed construction program, including a mechanism for informing relevant agencies of the progress of construction of the containment cell; and	Section 2, Appendix 8
B5(g)	be prepared as described in the RAP and the CCDDR.	Section 7 and Appendix 6
B6	The Applicant must:	
B6(a)	not commence remediation works until the CCMP required by Condition B3 is approved by the Planning Secretary; and	Noted
B6(b)	implement the most recent version of the CCMP approved by the Planning Secretary.	Noted

1.5 Structure of the Plan

Table 1-1 outlines the structure of the CCMP and the key project documents that form the basis of quality assurance, quality control and remediation validation for the project.

Table 1-2: Structure of the CCMP

Section	Purpose of Section	Reference Documents
Introduction		N/A
Key Containment Cell Elements and Construction Activities	Provide information on the key elements of the Containment Cell and the associated construction activities	Detailed Design Drawings (Appendix 1) Constructability Assessment (Appendix 2) Technical Specification (Appendix 3)
Implementation	Identify the project team members with responsibilities for implementation of the CCMP	N/A
Construction Quality Assurance	To define, for the landfill barrier system and leachate collection and conveyance system, construction quality assurance procedures and requirements necessary to demonstrate compliance with the requirements of the detailed design.	Construction Quality Assurance Plan (Appendix 4)
Contractor's Construction Quality Control	To define how the Remediation Contractor will comply with the project specification and the design.	Technical Specification (Appendix 3) Quality Control extracts from the Remediation Contractor's Integrated Project Management Plan (IPMP) (Appendix 5)

Section	Purpose of Section	Reference Documents
Remediation Validation	Provide a detailed plan of the validation works required to validate that the containment cell has been constructed in accordance with the design and that contaminated materials are appropriately placed	Containment Cell Validation Plan (Appendix 6)
Containment Cell Construction Environmental Management	To describe the environmental management measures to be implemented in construction of the Containment Cell	Environmental management measures extracts from the Remediation Works Environmental Management Plan and supporting management plans.

Details on the people responsible for preparation of this CCMP and the contributing documents are provided in **Appendix 9**.

2. KEY FEATURES OF THE CONTAINMENT CELL

2.1 Containment Cell Design

Appendix 1 is the detailed design drawings from the Containment Cell Detailed Design Report (CCDDR) that have been prepared by the cell designer, GHD Pty Ltd (GHD). The drawings provide details on how the Containment Cell is to be constructed, including:

- Site Clearance Plan
- General Arrangements
- Setout Plans
- Perimeter and Access Roads
- Liner Details
- Sump Details
- Capping Details
- Leachate Buffer Storage Dam
- Leachate Transfer System
- Stormwater Infrastructure
- Sediment Detention Basins
- Landfill Gas Management System
- Vehicle Tracking Plan
- Security and Utilities Plan
- Erosion and Sediment Control Plan

2.2 Key Containment Cell Construction Activities

Appendix 2 is the Constructability Assessment from the CCDDR. This assessment describes the ten stages of construction of the Containment Cell:

- Stage 1 – Construct containment cell access roads and temporary haul roads
- Stage 2 – Relocate stockpiles located within containment cell site
- Stage 3 – Excavation of containment cell to subgrade level
- Stage 4 – Construction of containment cell liner
- Stage 5 – Placement of demolition stockpiles within containment cell
- Stage 6 – Removal and stockpiling of capped waste stockpile topsoil and capping material
- Stage 7 – Placement of capped waste stockpile within containment cell
- Stage 8 – Placement of relocated stockpiles from containment cell site
- Stage 9 – Placement of final cap for containment cell
- Stage 10 – Removal of haul roads and finalising of access road (surfacing)

Staging plans are also provided showing the location of work areas and infrastructure during each of these stages.

It also describes the other key associated activities:

- The waste filling procedures
- The interfaces of the Containment Cell construction activities with other activities at the Smelter
- The location of the construction compound and other ancillary facilities
- The management of travelling to and from and transporting material to the Containment Cell through the Smelter
- The type and sources of material required for construction of the Containment Cell

2.3 Construction Program

Appendix 8 is the program for the Project, including construction of the Containment Cell.

The key tasks and durations in the program are:

• Stage 1: Construct containment cell access roads and temporary haul roads	18 weeks
• Stage 2: Relocate stockpiles located within containment cell site	Completed in SP1
• Stage 3: Excavation of containment cell to subgrade level	9 weeks
• Stage 4: Construction of containment cell liner	23 weeks
• Stage 5: Placement of demolition stockpiles within containment cell	8 weeks
• Stage 6: Removal and stockpiling of capped waste stockpile topsoil and capping material Stage 7: Placement of capped waste stockpile within containment cell (concurrent)	21 weeks
• Stage 8: Placement of relocated stockpiles from containment cell site	9 weeks
• Stage 9: Placement of final cap for containment cell	22 weeks
• Stage 10: Removal of haul roads and finalising of access road (surfacing)	13 weeks

2.3.1 Progress Reporting

As noted in **Table 1-1** Hydro is required to inform relevant agencies of the progress of construction of the Containment Cell. For the purpose of this report Hydro nominates the following as the relevant agencies:

- Department of Planning, Industry and Environment (the Department)
- Environment Protection Authority (EPA)
- Environmental Services Group of Housing and Property Group of the Department

These agencies will be informed on the progress of the construction of the Containment Cell through the following mechanisms:

- Compliance Reporting as required by Condition C11
- Independent Environmental Audits as required by Condition C13
- The Annual Progress Report

2.4 Technical Specification

Appendix 3 is the Technical Specification reproduced from the CCDDR. It contains the technical requirements for materials and procedures to be implemented for the elements to be installed in construction of the Containment Cell.

3. IMPLEMENTATION

3.1 Roles and Responsibilities

Key personnel responsible for implementation of this CCMP are in **Table 3-1** and consistent with the RWEMP.

Table 3-1: Hydro Personnel and Environmental Management Responsibilities

Position	Responsibilities
Managing Director	Make certain that the Hydro Team and contractors are implementing this CCMP. Provide adequate resources and funding for the implementation of this CCMP. Review and approve RWEMP (including this CCMP).
Construction Quality Assurance Engineer (tbc)	Implementation of the Construction Quality Assurance Plan (refer to **Appendix 4**) Assessing the compliance of the construction activities with the CCMP and the Detailed Design Report
Principal Environmental Consultant (Ramboll)	Implement the validation requirements of the CCMP (refer to **Appendix 6**) Review and modify the CCMP as directed by the Managing Director and/or Project Manager.
Principal Communications Consultant (GHD)	Manage the mechanisms available for the community to receive information and to make enquiries or complaints about activities
Remediation Contractor (Daracon)	Comply with the requirements of the CCMP as it applies to Smelter and relevant Hydro Land remediation activities. Implement the quality control measures and actions as described in the CCMP through a Remediation Works EMP, sub-plans and specific procedures that comply with this CCMP. Develop and implement procedures for self-checking management compliance with the Remediation Contractor's procedures and this CCMP. Report potential or actual incidents associated with Containment Cell construction activities, and assist as required in the investigation, implementation of corrective actions and recording of the incident.
Project Manager	Make certain that the quality control, quality assurance and validation actions and measures are adequately addressed in the CCMP. Make certain that any proposed works or changes to existing activities that may have an impact on the Containment Cell construction have the necessary legislative approval prior to the commencement of works and are reflected in this CCMP. Review and approve the CCMP on an annual basis or when changes to activities associated with the Containment Cell construction occur. Facilitate implementation of the CCMP. Approve the Inspection and Test Plans (ITP's) and authorise the Remediation Contractor to progress to subsequent stage of construction of the Containment Cell

Position	Responsibilities
Construction Manager	Verify that the work of contractors and Hydro personnel on the Project are undertaken in accordance with this CCMP, the RWEMP and specialist management plans, procedures and standards. Review and approve the contractors' environmental management documentation prior to commencement of activities and inform contractors of changes to the CCMP.

4. EPA AND H&P GROUP CONSULTATION

Hydro has undertaken extensive consultation with the NSW Environment Protection Authority (EPA) in the development of the Containment Cell design and construction methodology since 2014.

An invitation was issued to the EPA on 12 October 2020 to consult on this CCMP. A response received on 16 October 2020 noted that the EPA offered no comments on the CCMP.

Hydro has also consulted with the Housing and Property Group (H&P Group) on the methodology and environmental management for the construction of the Containment Cell. This included provision of a draft copy of this CCMP by the Department to the H&P Group on 13 August 2020 for review and comment. The Department advised on 8 September 2020 that the H&P Group had no comments on the draft CCMP.

During the review of the Response to Submissions Report the Department commissioned Senversa to undertake a review of the Containment Cell Detailed Design Report (which formed part of the Response to Submissions Report). The Department, Senversa and Hydro discussed the outcome of this review, which resulted in some changes to the detailed design and the report. These changes are reflected in the documents presented in **Appendix 1**, **Appendix 2**, **Appendix 3** and **Appendix 4**.

Table 4-1 provides a record of the meetings and correspondence with the EPA and the H&P Group associated with the Containment Cell design and construction.

Table 4-1: Details of Key EPA and H&P Group Consultation on the Containment Cell Design and Construction Methodology

Date	Form of Communication	Key Items
Environment Protection Authority		
7 December 2016	Meeting	Discussion of management of Capped Waste Stockpile material placement in the Containment Cell
7 February 2017	Meeting/ Site Visit	Discussion of management of Capped Waste Stockpile material placement in the Containment Cell
14 July 2017	Meeting	Discussion of the Capped Waste Stockpile Management Options Evaluation Study
30 October 2017	Email and Report	Submission of the Capped Waste Stockpile Management Options Evaluation Study to the EPA
6 December 2017	Letter from EPA	EPA feedback on the Capped Waste Stockpile Management Options Evaluation Study advising: that the Containment Cell with material treatment is the preferred option; and what additional investigations are required to assess and define the treatment option
8 December 2017	Meeting	Discussion of the EPA's feedback on the Capped Waste Stockpile Management Options Evaluation Study

Date	Form of Communication	Key Items
22 December 2017	Report	Submission of the CWS Waste Management Option 4 (treatment of Capped Waste Stockpile Material prior to placement in the Containment Cell) Remediation Design and Proposed Validation of Treatment Report
2 February 2018	Meeting/ Site Visit	Discussion of EPA’s response to the CWS Waste Management Option 4 Remediation Design and Proposed Validation of Treatment Report
9 February 2018	Meeting	Presentation of the Detailed Design of the Containment Cell
20 April 2018	Letter from EPA	EPA in principle agreement to the gypsum application for treatment of Capped Waste Stockpile material
27 April 2018	Meeting	Discussion of the proposed gypsum material treatment strategy, and the proposed validation process
8 June 2018	Letter and Report to EPA	Submission of the revised CWS Waste Management Option 4 Remediation Design and Proposed Validation of Treatment Report
9 June 2018	Letter from EPA	EPA agreement to the gypsum material treatment strategy, and the proposed validation process
23 November 2018	Letter from EPA	EPA comment on the Draft Response to Submissions Report. EPA advised that the report (which included the Detailed Design Report) addressed the EPA’s concerns in respect of containment cell design and the methods and the procedures for managing the waste

5. CONSTRUCTION QUALITY ASSURANCE

Containment Cell Design: Construction Quality Assurance (CQA) Plan (GHD, 2017) is an appendix to the *Containment Cell Design: Design Report* (GHD, 2018). It is presented in **Appendix 4**.

The Construction Quality Assurance Plan (CQA Plan) details the following:

- The overall requirements for implementation of the CQA Plan
- The specific CQA activities to be implemented during construction of the elements of the Containment Cell. This includes (where applicable) but not limited to:
  - Submittals
  - Manufacturer's quality control
  - Manufacturer's quality assurance
  - Materials
  - Equipment
  - Independent conformance testing
  - Roll and sample identification
  - Delivery, storage and handling
  - Surface preparation
  - Installation
  - Defects and repairs
  - Recommendation to the Superintendent for Acceptance
- The CQA documentation to be prepared and retained for all construction inspection and testing activities.

The following are the key CQA reports and documents to be prepared throughout and on completion of construction of the Containment Cell.

5.1 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
- CQC and 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

5.2 Receiving Inspection Report

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

5.3 Certificate of Subgrade Acceptance

A certificate of subgrade acceptance shall be signed each day geomembrane or GCL materials are placed. Each certificate shall be signed by the Geosynthetic Installer, the Contractor and CQA Engineer prior to installation of the geomembrane or GCL. The area being accepted must be described on the certificate.

5.4 Geomembrane Panel Deployment Log

This data sheet shall be used to record geomembrane panel numbers as they are placed in the field and to cross-reference assigned panel numbers with roll numbers. The weather conditions, time and temperature at placement shall be recorded on the log. Measured dimensions of the geomembrane shall also be recorded on the log.

5.5 Geomembrane Trial Seam Data Sheet

Test results for each trial seam shall be recorded on the geomembrane trial seam data sheet.

5.6 Geomembrane Seam Log

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

5.7 Geomembrane Defects and Repairs

Each geomembrane defect and repair shall be recorded on a geomembrane repair log.

5.8 Non-destructive and Destructive Geomembrane Seam Testing Data Sheets

These data sheets shall be used to record test results for all non-destructive and destructive geomembrane seam tests.

5.9 Field Moisture and Density Test Result Data Sheet

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

5.10 Test Report

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

5.11 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.

5.12 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.

5.13 Interim Report (Containment Cell Construction)

Following the satisfactory completion of construction of the Containment Cell, but prior to its filling, 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
- A reviewed copy of all CQC reports undertaken, including earthworks, geosynthetics and other works aforementioned in this CQA Plan
- Detailed description of the lining system, 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 and CQC reports
- Record Drawings which include the final geomembrane panel placement layout and all survey conformance data:
  - Plan view of the perimeter of the cell;
  - The installed alignments and grades of the groundwater drainage system within the cell;
  - Finished installed contours of the prepared subgrade within the cell (determined prior to placement of the geosynthetics);
  - The installed alignments and grades of the leachate collection pipework within the cell (all determined prior to placement of the leachate drainage layer);
  - Finished installed contours of the leachate drainage layer and covering geotextile within the cell; and
  - All test locations, showing as a minimum: approximate location, identification number, date sampled and type of testing completed.
- 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.

5.14 Final Report (Containment Cell Filling and Capping)

Following the satisfactory completion of filling and capping of the Containment Cell, 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 the capping. It shall incorporate information from the Interim Report and will include, at a minimum, the following information regarding filling and capping:

- Brief description of the Works including type of facility, name of site, location, name of Principal, Superintendent, Contractor and Geosynthetic Installer
- A reviewed copy of all CQC reports undertaken, including earthworks, geosynthetics and other works aforementioned in this CQA Plan
- Detailed description of the capping systems, including surface area, cross sections and a summary of all materials used
- Chronological summary of filling and capping activities
- Photographic documentation, including photographs of the site at different phases of filling and capping, photographs of filling and capping 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 and CQC reports
- Record Drawings which include the final geomembrane panel placement layout and all survey conformance data:
  - Plan view of the perimeter of the cell;
  - All test locations, showing as a minimum: approximate location, identification number, date sampled and type of testing completed.
- 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.

6. CONTRACTOR'S CONSTRUCTION QUALITY CONTROL

The Remediation Contractor, Daracon, has prepared an Integrated Project Management Plan (IPMP) for the project. The IPMP and its supporting management plans and procedures address the quality, workplace health and safety and environmental procedures to be implemented throughout remediation of the Smelter and construction of the Containment Cell.

As an integrated plan, CQA and CQC measures and procedures are described throughout the IPMP. However, the "Construction Quality Assurance" and "Records Management & Document Control" sections of the IPMP specifically address the following regarding CQA and CQC:

- Traceability (lot and product)
- Process control documents:
  - Inspection and test plans
  - Material testing
  - Hold points
  - Work Method Statements
- Survey
- Measuring and test equipment
- Incoming material and product conformance
- Non-conformance and corrective action
- Design, change and contract variation
- Design and development control
- Design assessments
- Design control records
- Records management and document control
  - Document control
  - Management of project records
  - Client issued documents
  - Project completion
  - Project data report

These sections of the IPMP are presented in **Appendix 5**.

The GHD Drawings and Technical Specification are also key documents for use by the Contractor to monitor Construction Quality Control. Refer **Appendix 1** and **Appendix 3**.

7. REMEDIATION VALIDATION

A Remedial Action Plan (RAP) for the Smelter was prepared as a requirement of the SEARs (Ramboll, 2018). The RAP included a Validation Plan, which incorporated validation data quality objectives, validation criteria and validation requirements for the Smelter Site. This RAP was reviewed by the Site Auditor who issued a Part B Site Audit Statement confirming the suitability of the RAP for achieving the remediation objectives for the Smelter.

The Containment Cell Sampling and Quality Plan (SAQP) presented in **Appendix 6** expands on the requirements for validation described in the RAP and presents the specific validation requirements for the construction of the Containment Cell.

The objectives of the Containment Cell SAQP are to:
- Outline the adopted validation criteria to be used to validate completion of the Containment Cell
- Provide a detailed plan of the validation works required to validate that the Containment Cell has been constructed in accordance with the design and that contaminated materials are appropriately placed
- Define the Data Quality Objectives (DQOs) and Data Quality Indicators (DQIs) for each validation task, to ensure the data collected is sufficient and reliable.

Data Quality Objectives (DQOs) have been specifically developed for the Containment Cell validation. The DQO process is a systematic, seven step process that defines the criteria that the validation sampling should satisfy in accordance with the *Guidelines for the NSW Site Auditor Scheme (3rd Edition)* (NSW EPA 2017).

The seven step DQO process comprises:
- Step 1: State the problem
- Step 2: Identify the decisions/ goal of the study
- Step 3: Identify the information inputs
- Step 4: Define the boundaries of the study
- Step 5: Develop the analytical approach
- Step 6: Specify the performance or acceptance criteria
- Step 7: Develop the plan for obtaining data.

The Containment Cell SAQP has been prepared for review and approval by the Site Auditor required to be commissioned for the project under Condition B1. Of the development consent for SSD 6666. The plan has been prepared by a team that has the qualifications and experience required by Condition B5 (refer to **Appendix 9** for details).

8. CONTAINMENT CELL CONSTRUCTION ENVIRONMENTAL MANAGEMENT

In accordance with Condition C2 of the development consent for SSD 6666 Hydro has produced the Remediation Works Environmental Management Plan (RWEMP), which includes the following specialist management plans:

- Site Access Plan
- Traffic Management Plan
- Air Quality Management Plan (Condition B32)
- Noise and Vibration Management Plan
- Soil and Water Management Plan, which includes:
  - Erosion and Sediment Control Plan (Condition B16)
  - Contaminated Soil Management Plan
  - Leachate Management Plan
- Waste Management Plan
- Energy Efficiency Plan
- Biodiversity Management Plan (Condition B44)
- Aboriginal Heritage Management Plan
- Stakeholder Engagement Plan (Condition B52)
- Work Health and Safety management Plan (Condition B13)

In accordance with Condition B5 this CCMP has been prepared and forms an appendix to the RWEMP.

The RWEMP is the primary environmental management document for the Project, including the construction of the Containment Cell. The RWEMP describes the roles and responsibilities for environmental management. One requirement of the RWEMP is for the Remediation Contractor to prepare a Remediation EMP consistent with the RWEMP.

Appendix 7 is a collation of the environmental management measures that specifically apply to construction of the Containment Cell. These measures, however, form part of the overall environmental management for the Project and are not implemented in isolation.

9. REFERENCES

GHD (2020). *Hydro Aluminium Kurri Kurri Pty Ltd Containment Cell Design - Design Report*.

Ramboll Environ (2016). *Environmental Impact Statement: Former Hydro Aluminium Kurri Kurri Smelter Demolition and Remediation*.

Ramboll (2020). *Response to Submissions Report: Former Hydro Aluminium Kurri Kurri Smelter Remediation*.

10. LIMITATIONS

Ramboll Australia prepared this report in accordance with the scope of work as outlined in our proposal to Hydro Aluminium Kurri Kurri Pty Ltd dated 20 July 2018 and in accordance with our understanding and interpretation of current regulatory standards.

A representative program of sampling and laboratory analyses was undertaken as part of this investigation, based on past and present known uses of the site. While every care has been taken, concentrations of contaminants measured may not be representative of conditions between the locations sampled and investigated. We cannot therefore preclude the presence of materials that may be hazardous.

Site conditions may change over time. This report is based on conditions encountered at the site at the time of the report and Ramboll Australia disclaims responsibility for any changes that may have occurred after this time.

The conclusions presented in this report represent Ramboll Australia's professional judgment based on information made available during the course of this assignment and are true and correct to the best of Ramboll Australia's knowledge as at the date of the assessment. Ramboll Australia did not independently verify all of the written or oral information provided to Ramboll Australia during the course of this investigation. While Ramboll Australia has no reason to doubt the accuracy of the information provided to it, the report is complete and accurate only to the extent that the information provided to Ramboll Australia was itself complete and accurate. This report does not purport to give legal advice. This advice can only be given by qualified legal advisors.

10.1 User Reliance

This report has been prepared exclusively for Hydro Aluminium Kurri Kurri Pty Ltd and may not be relied upon by any other person or entity without Ramboll Australia's express written permission.

APPENDIX 1
DETAILED DESIGN DRAWINGS

HYDRO ALUMINIUM KURRI KURRI PTY LTD
CONTAINMENT CELL DETAILED DESIGN
CONTRACT No: SR 2015-001

N

LOCALITY PLAN
NTS

DRAWING LIST

DRAWING NO.	DESCRIPTION
22-18015-C001	COVER SHEET, LOCALITY PLAN AND DRAWING LIST
22-18015-C011	EXISTING SITE PLAN - SHEET 1 OF 2
22-18015-C012	EXISTING SITE PLAN - SHEET 2 OF 2
22-18015-C013	SITE CLEARANCE PLAN
22-18015-C021	GENERAL ARRANGEMENT - CONTAINMENT CELL
22-18015-C022	GENERAL ARRANGEMENT - ACCESS ROADS
22-18015-C023	GENERAL ARRANGEMENT - STORMWATER
22-18015-C024	DETAIL PLAN - SEDIMENT BASINS AND STORAGE DAM
22-18015-C025	GENERAL ARRANGEMENT - FINAL CAP
22-18015-C032	SETOUT PLAN - CONTAINMENT CELL AND PONDS
22-18015-C033	SETOUT PLAN - CONTAINMENT CELL AND PONDS - SHEET 1 OF 2
22-18015-C034	SETOUT PLAN - CONTAINMENT CELL AND PONDS - SHEET 2 OF 2
22-18015-C041	SECTION A - LONGITUDINAL SECTION
22-18015-C042	SECTION B - LONGITUDINAL SECTION
22-18015-C043	ACCESS ROAD - LONGITUDINAL SECTION
22-18015-C044	PERIMETER ROAD - LONGITUDINAL SECTION - SHEET 1 OF 3
22-18015-C045	PERIMETER ROAD - LONGITUDINAL SECTION - SHEET 2 OF 3
22-18015-C046	PERIMETER ROAD - LONGITUDINAL SECTION - SHEET 3 OF 3
22-18015-C047	RAMP 01 LONGITUDINAL SECTIONS - SHEET 1 OF 4
22-18015-C048	RAMP 02 LONGITUDINAL SECTIONS - SHEET 2 OF 4
22-18015-C049	RAMP 03 LONGITUDINAL SECTIONS - SHEET 3 OF 4
22-18015-C050	RAMP 04 LONGITUDINAL SECTIONS - SHEET 4 OF 4
22-18015-C051	ACCESS ROAD RETURN LONGITUDINAL SECTION
22-18015-C052	VEHICLE TURN AROUND PAD01 PLAN & PROFILE
22-18015-C061	ACCESS ROAD CROSS SECTIONS - SHEET 1 OF 2
22-18015-C062	ACCESS ROAD CROSS SECTIONS - SHEET 2 OF 2
22-18015-C063	PERIMETER ROAD CROSS SECTIONS - SHEET 1 OF 7
22-18015-C064	PERIMETER ROAD CROSS SECTIONS - SHEET 2 OF 7
22-18015-C065	PERIMETER ROAD CROSS SECTIONS - SHEET 3 OF 7
22-18015-C066	PERIMETER ROAD CROSS SECTIONS - SHEET 4 OF 7
22-18015-C067	PERIMETER ROAD CROSS SECTIONS - SHEET 5 OF 7
22-18015-C068	PERIMETER ROAD CROSS SECTIONS - SHEET 6 OF 7
22-18015-C069	PERIMETER ROAD CROSS SECTIONS - SHEET 7 OF 7
22-18015-C071	LINER DETAILS - SHEET 1 OF 3
22-18015-C072	LINER DETAILS - SHEET 2 OF 3
22-18015-C073	LINER DETAILS - SHEET 3 OF 3
22-18015-C081	SUMP DETAILS - SHEET 1 OF 4
22-18015-C082	SUMP DETAILS - SHEET 2 OF 4
22-18015-C083	SUMP DETAILS - SHEET 3 OF 4
22-18015-C084	SUMP DETAILS - SHEET 4 OF 4
22-18015-C091	CAPPING DETAILS - SHEET 1 OF 2
22-18015-C092	CAPPING DETAILS - SHEET 2 OF 2

DRAWING NO.	DESCRIPTION
22-18015-C101	LEACHATE BUFFER STORAGE DAM DETAILS
22-18015-C102	LEACHATE TRANSFER SYSTEM - PLAN AND DETAILS
22-18015-C103	LEACHATE TRANSFER SYSTEM - UTILITIES SLAB DETAILS
22-18015-C111	STORMWATER DETAILS - SHEET 1 OF 2
22-18015-C112	STORMWATER DETAILS - SHEET 2 OF 2
22-18015-C113	CULVERT LONGITUDINAL SECTIONS - SHEET 1 OF 2
22-18015-C114	CULVERT LONGITUDINAL SECTION - SHEET 2 OF 2
22-18015-C121	SEDIMENT DETENTION BASIN DETAILS
22-18015-C131	ACCESS ROAD DETAILS - SHEET 1 OF 3
22-18015-C132	ACCESS ROAD DETAILS - SHEET 2 OF 3
22-18015-C133	ACCESS ROAD DETAILS - SHEET 3 OF 3
22-18015-C141	LANDFILL GAS MANAGEMENT SYSTEM DETAILS
22-18015-C151	SWALE - LONGITUDINAL SECTION - SHEET 1 OF 8
22-18015-C152	SWALE - LONGITUDINAL SECTION - SHEET 2 OF 8
22-18015-C153	SWALE - LONGITUDINAL SECTION - SHEET 3 OF 8
22-18015-C154	SWALE - LONGITUDINAL SECTION - SHEET 4 OF 8
22-18015-C155	SWALE - LONGITUDINAL SECTION - SHEET 5 OF 8
22-18015-C156	SWALE - LONGITUDINAL SECTION - SHEET 6 OF 8
22-18015-C157	SWALE - LONGITUDINAL SECTION - SHEET 7 OF 8
22-18015-C158	SWALE - LONGITUDINAL SECTION - SHEET 8 OF 8
22-18015-C161	VEHICLE TRACKING PLAN
22-18015-C162	SECURITY AND UTILITIES PLAN
22-18015-C163	EROSION AND SEDIMENT CONTROL - PLANS AND DETAILS

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
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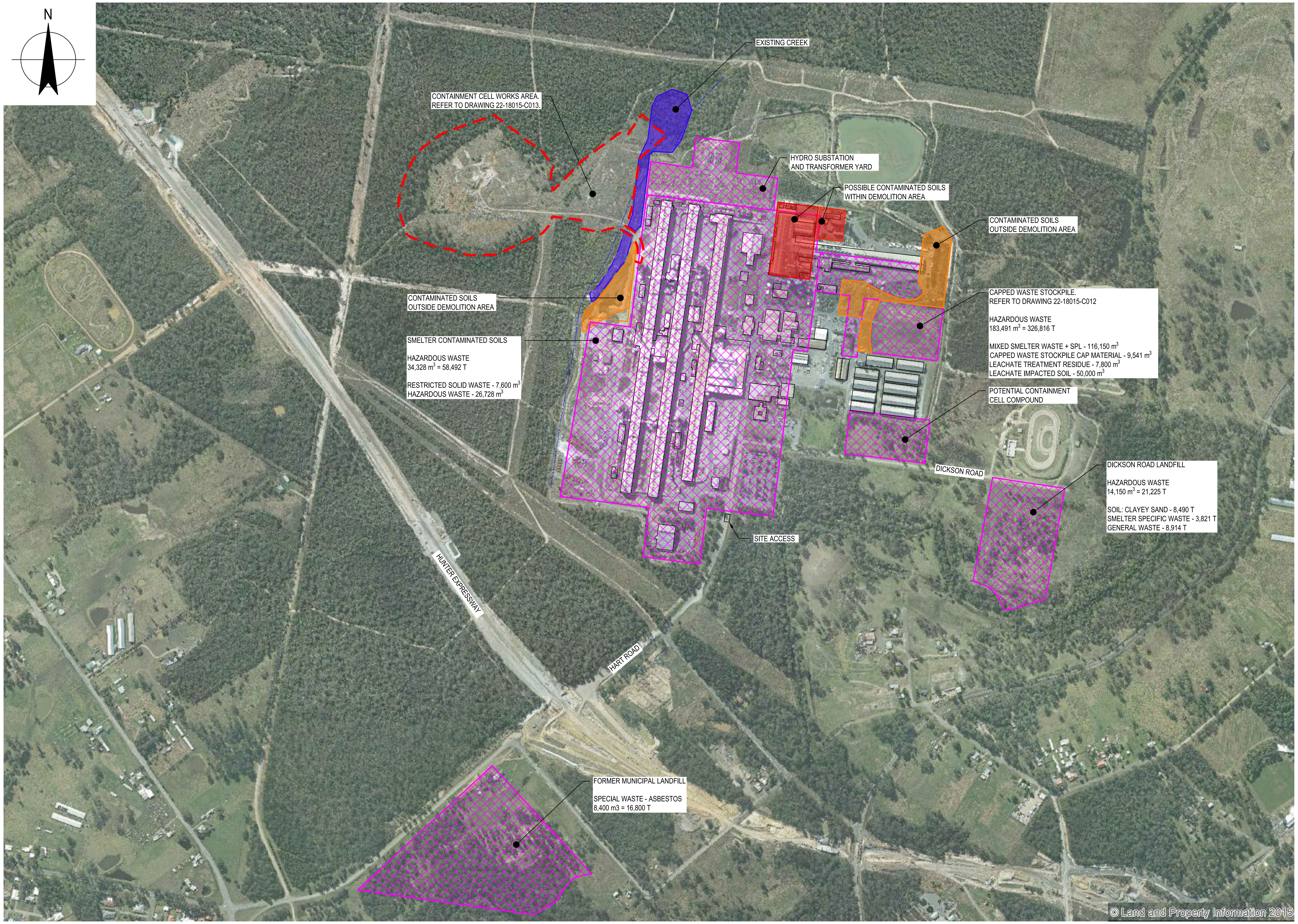
Drafting Check	R. PRASAD	Design Check	A. ROBERTS
Approved (Project Director)	I. GREGSON*		
Date	27.09.19		
Scale	NOT TO SCALE	This Drawing must not be used for Construction unless signed as Approved	

Client: HYDRO ALUMINIUM KURRI KURRI PTY LTD
Project: CONTAINMENT CELL DETAILED DESIGN
Title: COVER SHEET, LOCALITY PLAN AND DRAWING LIST

Original Size: A1 | Drawing No: 22-18015-C001 | Rev: 0

Plot Date: 27 September 2019 - 9:51 AM Plotted by: Renzel Keena Ignacio Cad File No: \\mnl-svm-001\MNL_Projects\22\18015\CADD\Drawings\22-18015-C001.dwg



EXISTING SITE PLAN

SCALE 1:50,000

LEGEND:

- CONTAINMENT CELL WORKS AREA
- WASTE SOURCES
- CONTAMINATED SOIL OUTSIDE DEMOLITION AREA
- EXISTING CREEK
- CONTAMINATED SOIL WITHIN DEMOLITION AREA

NOTE:

1. ALL QUOTED VOLUMES WERE PROVIDED BY HYDRO ALUMINIUM KURRI KURRI PTY LTD 01/06/2016.

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0 500 1000 1500 2000 2500m

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Approved (Project Director)	I. GREGSON*		
Date	26.09.19		
Scale	1:50,000	This Drawing must not be used for Construction unless signed as Approved	

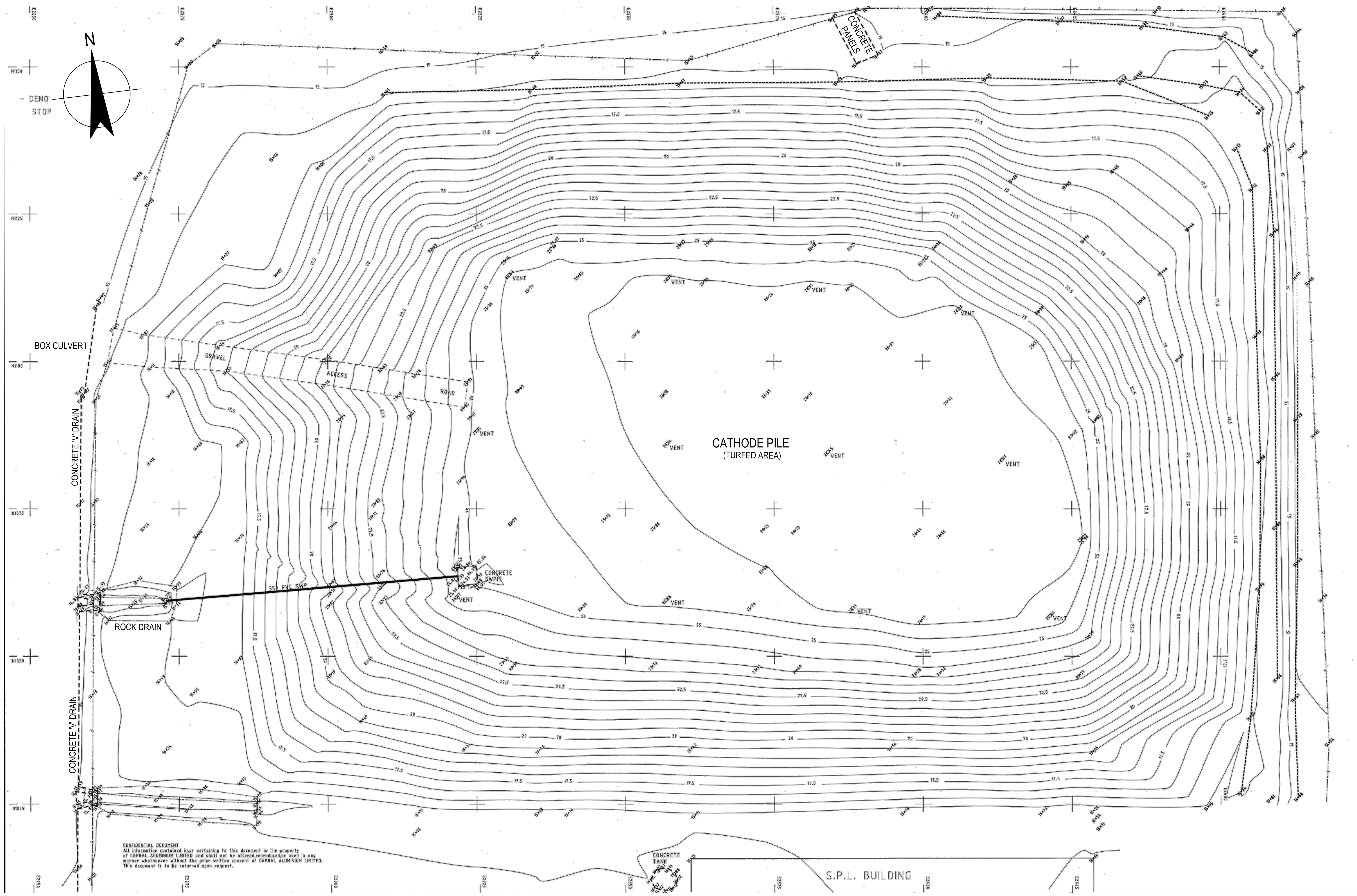
Client: **HYDRO ALUMINIUM KURRI KURRI PTY LTD**

Project: **CONTAINMENT CELL DETAILED DESIGN**

Title: **EXISTING SITE PLAN**
SHEET 1 OF 2

Original Size: A1 | Drawing No: **22-18015-C011** | Rev: **0**

Plot Date: 27 September 2019 - 9:58 AM   Plotted by: Renzel Keena Ignacio   Cad File No: G:\22\18015\CADD\Drawings\22-18015-C011.dwg



EXISTING CAPPED WASTE STOCKPILE

NTS

EXISTING CAPPED WASTE STOCKPILE

EXISTING CAPPED WASTE STOCKPILE LOOKING WEST

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LEGEND

- VENT
- MONITORING WELL

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Drafting Check P. PRASAD
Design Check A. ROBERTS
Approved (Project Director) I. GREGSON*
Date 26.09.19
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Client HYDRO ALUMINIUM KURRI KURRI PTY LTD
Project CONTAINMENT CELL DETAILED DESIGN
Title EXISTING SITE PLAN
SHEET 2 OF 2

Original Size A1
Drawing No: 22-18015-C012
Rev: 0

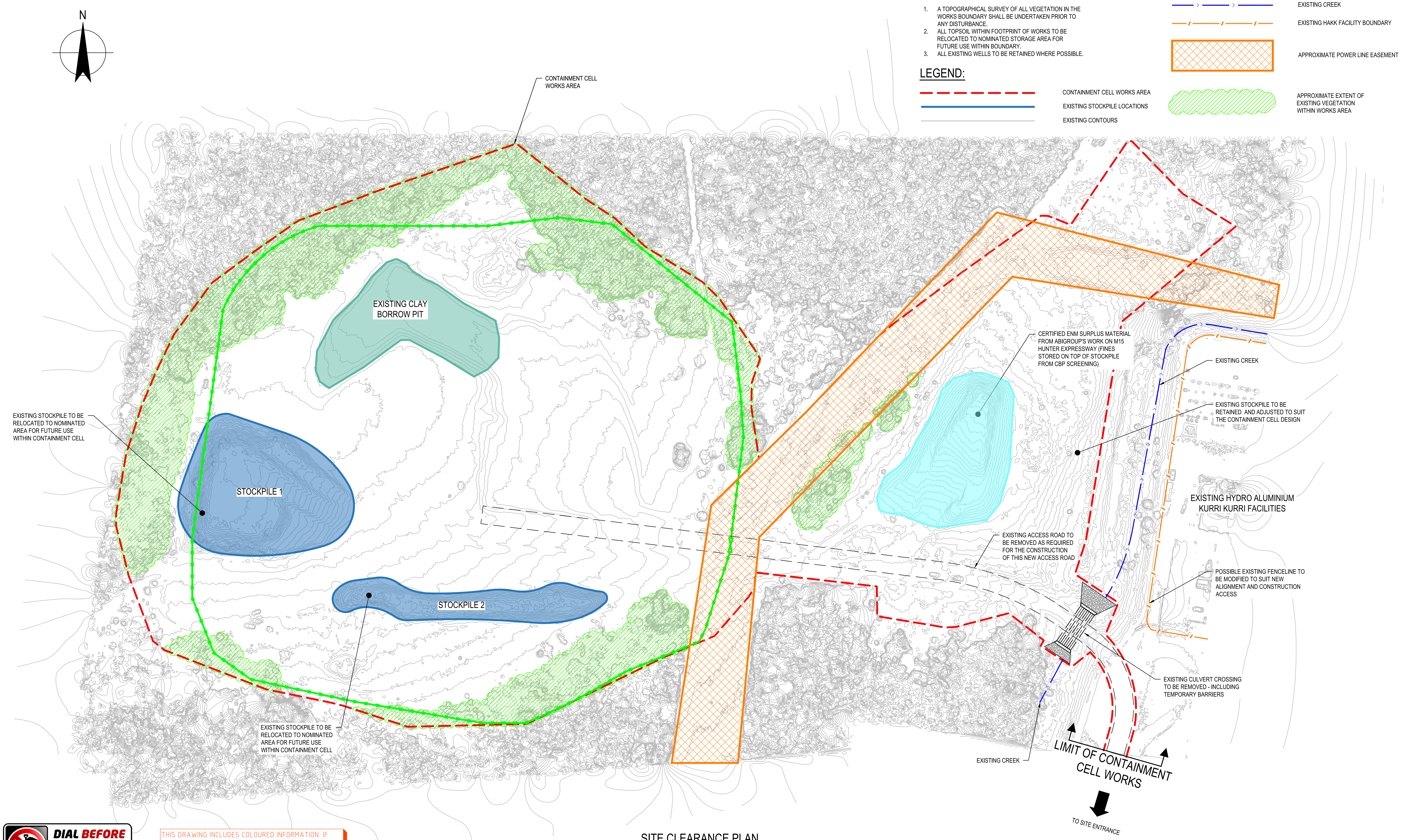
Plot Date: 27 September 2019 - 9:58 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C012.dwg

NOTES:

1. A TOPOGRAPHICAL SURVEY OF ALL VEGETATION IN THE WORKS BOUNDARY SHALL BE UNDERTAKEN PRIOR TO ANY DISTURBANCE.
2. ALL TOPSOIL WITHIN FOOTPRINT OF WORKS TO BE RELOCATED TO NOMINATED STORAGE AREA FOR FUTURE USE WITHIN BOUNDARY.
3. ALL EXISTING WELLS TO BE RETAINED WHERE POSSIBLE.

LEGEND:

- CONTAINMENT CELL WORKS AREA
- EXISTING STOCKPILE LOCATIONS
- EXISTING CONTOURS
- EXISTING CREEK
- EXISTING HAKK FACILITY BOUNDARY
- APPROXIMATE POWER LINE EASEMENT
- APPROXIMATE EXTENT OF EXISTING VEGETATION WITHIN WORKS AREA



SITE CLEARANCE PLAN

SCALE 1:1000

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Drafting Check P. PRASAD
Design Check A. ROBERTS
Approved (Project Director) I. GREGSON*
Date 26.09.19
Scale 1:1000
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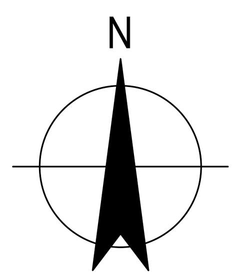
Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **SITE CLEARANCE PLAN**

Original Size A1
Drawing No: **22-18015-C013**
Rev: 0

Plot Date: 27 September 2019 - 9:58 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C013.dwg

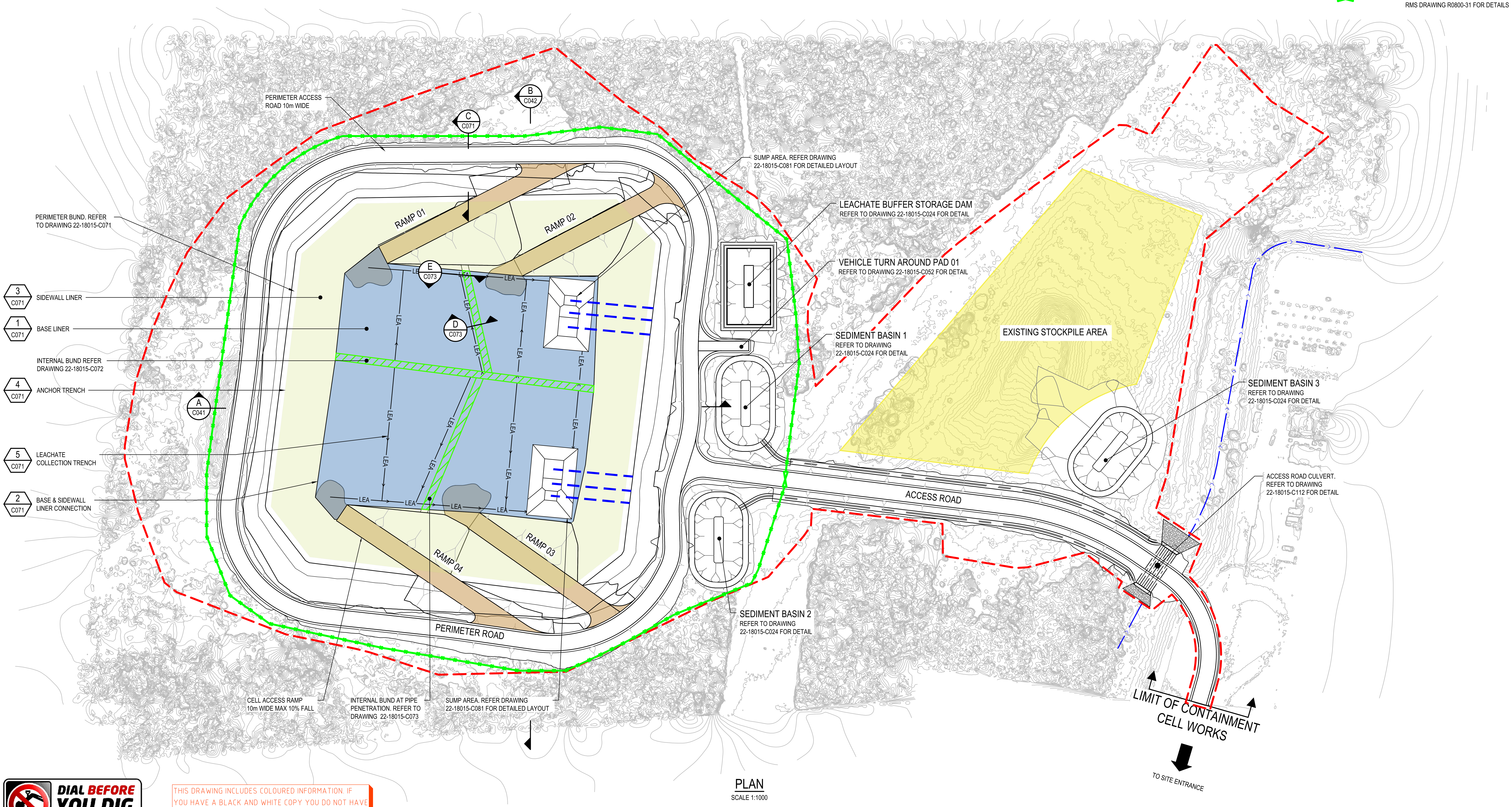


NOTES:

1. REFER TO DRG. 22-18015-C022 FOR ACCESS ROAD ARRANGEMENT.
2. REFER TO DRG. 22-18015-C023 FOR STORMWATER ARRANGEMENT.
3. REFER TO DRG. 22-18015-C024 FOR POND ARRANGEMENT.
4. REFER TO DRG. 22-18015-C025 FOR FINAL CAP ARRANGEMENT.

LEGEND:

- SIDEWALL LINER AREA
- BASE LINER AREA
- CELL ACCESS RAMP
- EXISTING STOCKPILE AREA
- INTERNAL BUND AREA
- CULVERT WITH HEADWALLS
- CONTAINMENT CELL WORKS AREA
- LEACHATE COLLECTION TRENCH
- GROUNDWATER, LEAK DETECTION AND LEACHATE RISER PIPEWORK
- DESIGN CONTOURS
- EXISTING CONTOURS
- FAUNA EXCLUSION FENCE. REFER TO RMS DRAWING R0800-31 FOR DETAILS
- FAUNA EXCLUSION GATE. REFER TO RMS DRAWING R0800-31 FOR DETAILS



PLAN
SCALE 1:1000

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Drafting Check P. PRASAD
Design Check A. ROBERTS
Approved (Project Director) I. GREGSON*
Date 26.09.19
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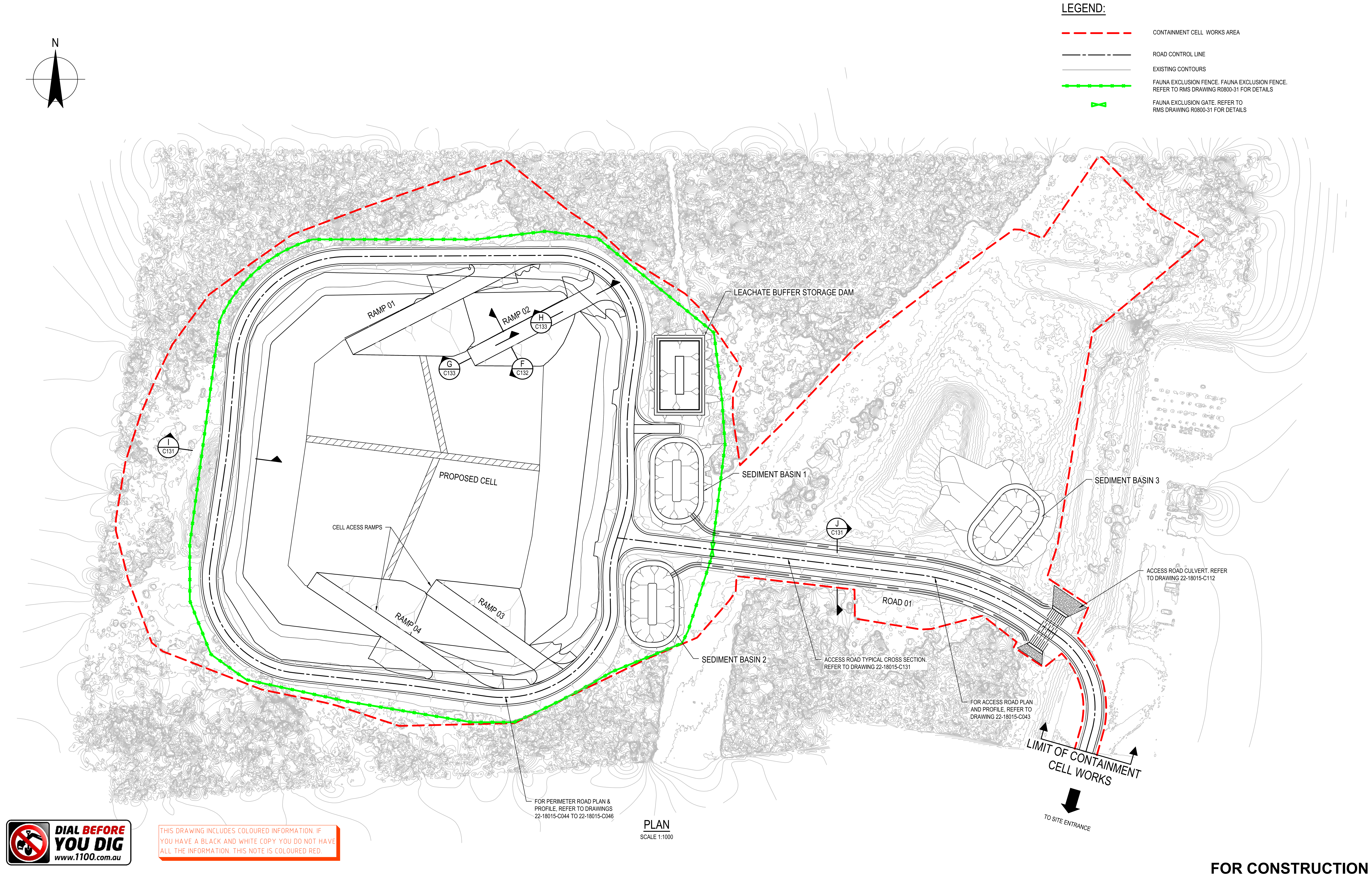
Original Size A1

Client HYDRO ALUMINIUM KURRI KURRI PTY LTD
Project CONTAINMENT CELL DETAILED DESIGN
Title GENERAL ARRANGEMENT CONTAINMENT CELL

Drawing No: 22-18015-C021 Rev: 0

Plot Date: 27 September 2019 - 9:58 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C021.dwg



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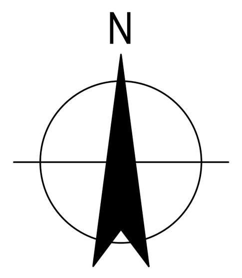
Scale	1:1000	This Drawing must not be used for Construction unless signed as Approved	

Client: **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project: **CONTAINMENT CELL DETAILED DESIGN**
Title: **GENERAL ARRANGEMENT ACCESS ROADS**

Original Size: A1 | Drawing No: **22-18015-C022** | Rev: 0

Plot Date: 27 September 2019 - 9:59 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C022.dwg

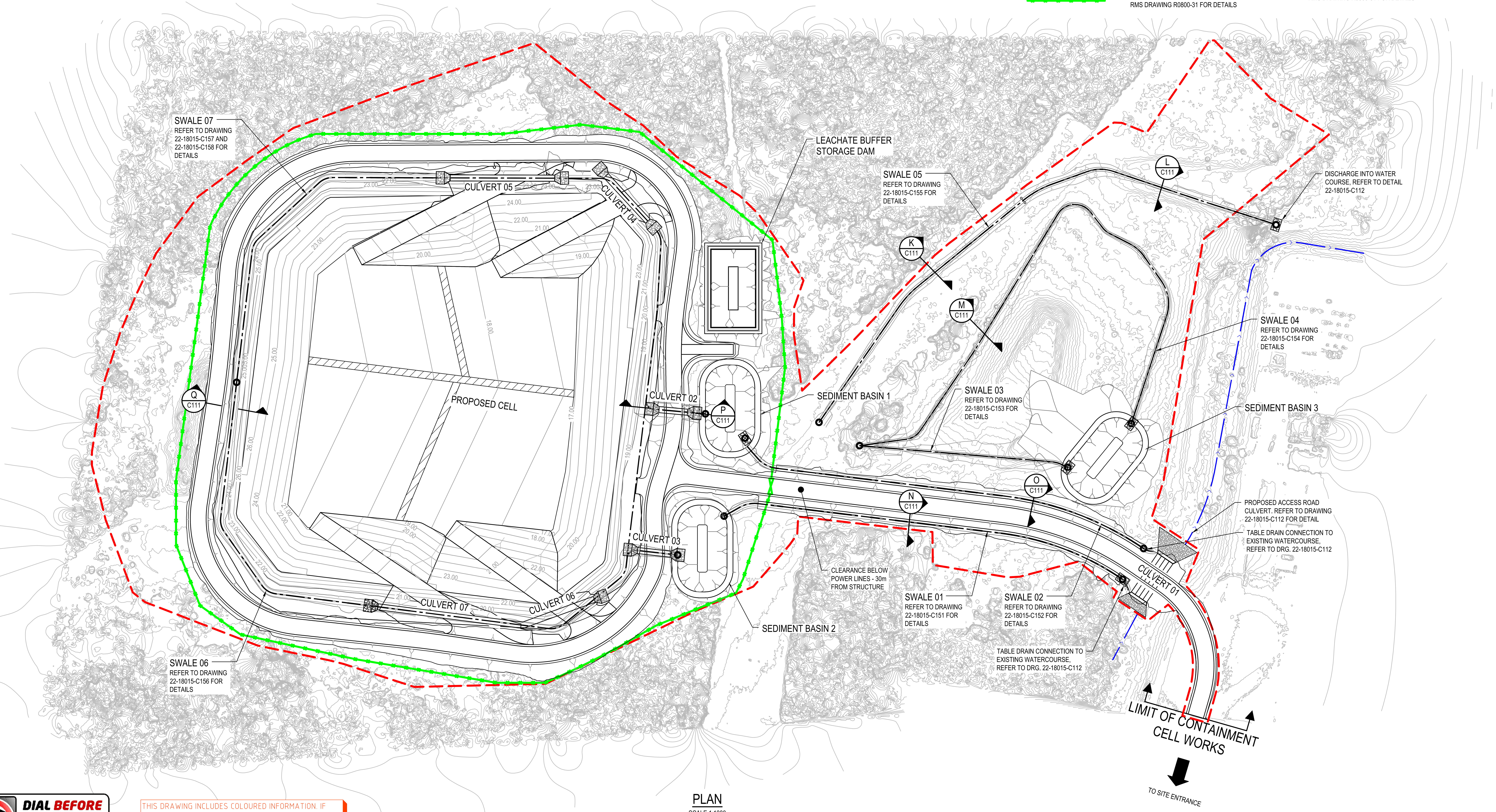


NOTE:

1. REFER TO DRAWING 22-18015-C113 TO 22-18015-C114 FOR CULVERT DETAILS.

LEGEND:

- SWALE CENTRE LINE
- CONTAINMENT CELL WORKS AREA
- DESIGN CONTOURS
- EXISTING CONTOURS
- DRAINAGE PATH
- FAUNA EXCLUSION FENCE. REFER TO RMS DRAWING R0800-31 FOR DETAILS
- CULVERT
- HEADWALL
- EROSION PROTECTION
- DISCHARGE POINT
- FAUNA EXCLUSION GATE. REFER TO RMS DRAWING R0800-31 FOR DETAILS



PLAN
SCALE 1:1000

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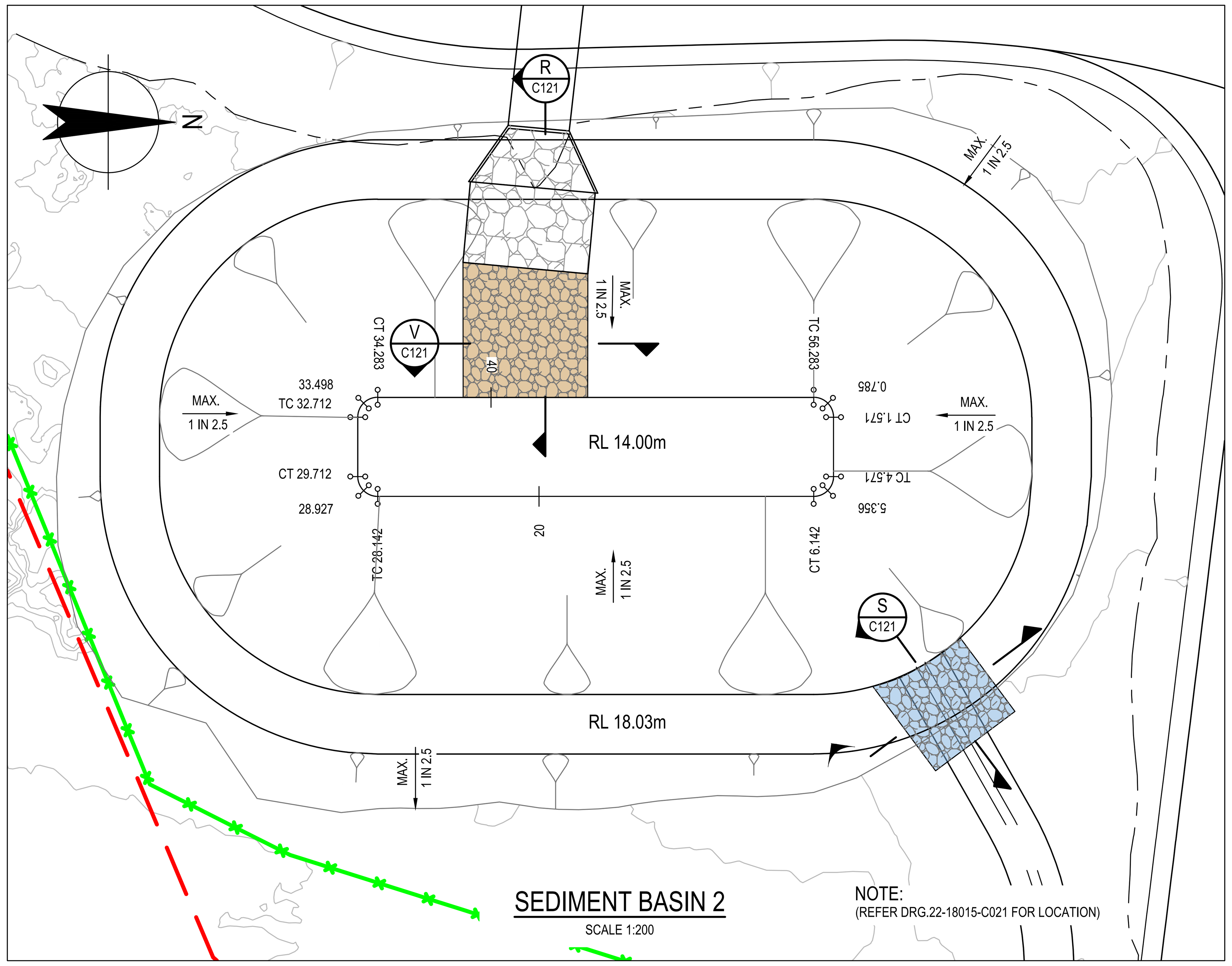
Drafting Check	P. PRASAD	Design Check	A. ROBERTS
Approved (Project Director)	I. GREGSON*		
Date	26.09.19		
Scale	1:1000	This Drawing must not be used for Construction unless signed as Approved	

Client: HYDRO ALUMINIUM KURRI KURRI PTY LTD
Project: CONTAINMENT CELL DETAILED DESIGN
Title: GENERAL ARRANGEMENT STORMWATER

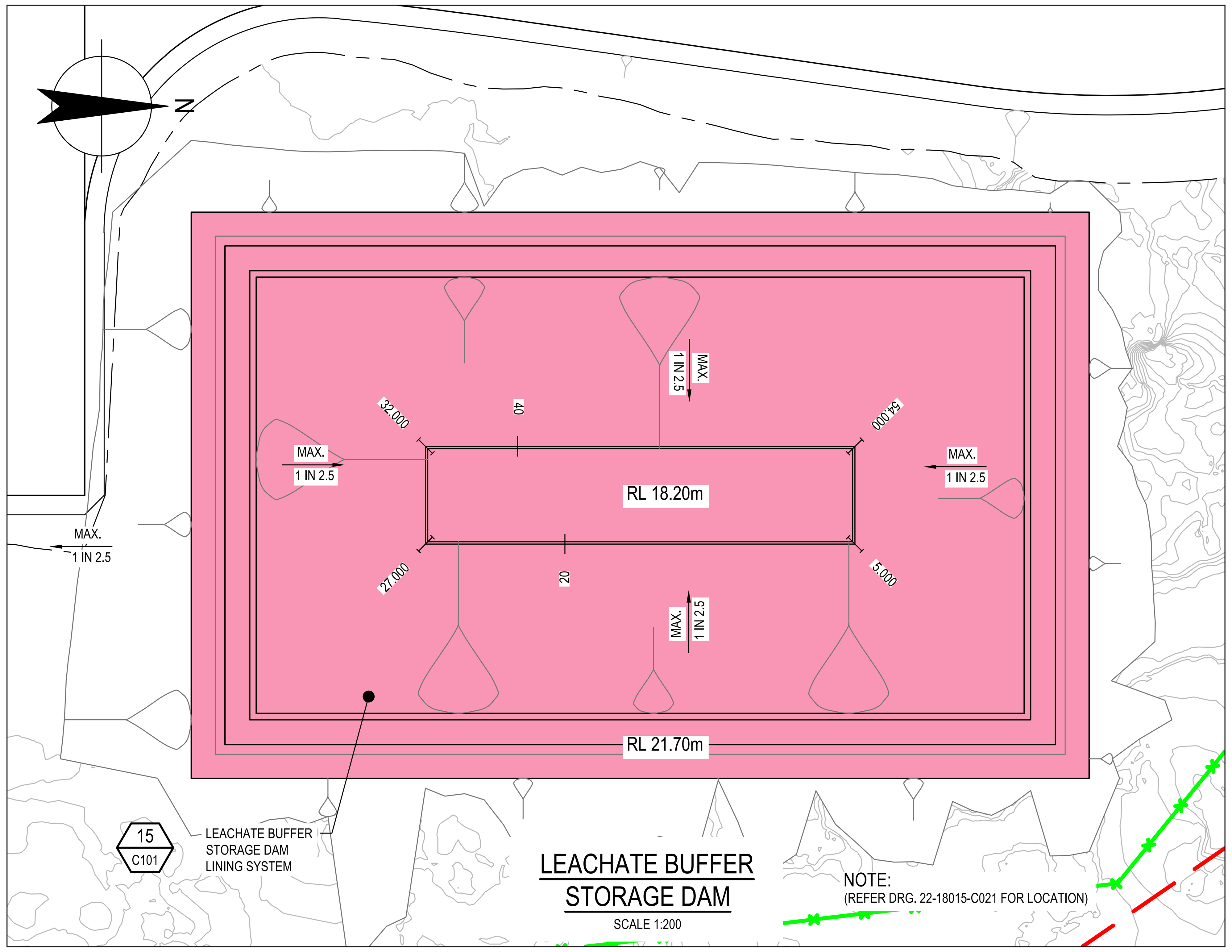
Original Size A1 | Drawing No: 22-18015-C023 | Rev: 0

Plot Date: 27 September 2019 - 9:59 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C023.dwg



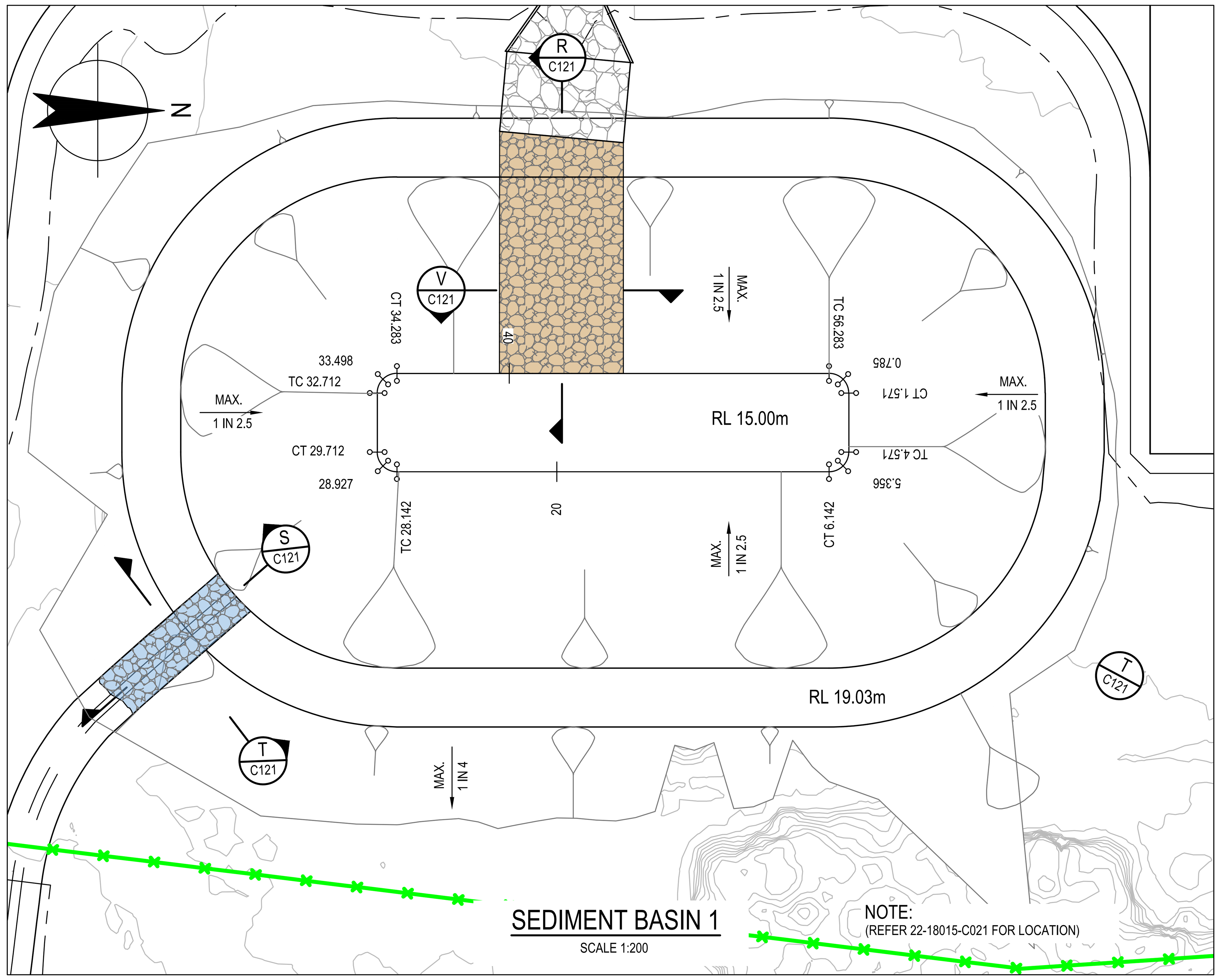
SEDIMENT BASIN 2
SCALE 1:200

NOTE:
(REFER DRG.22-18015-C021 FOR LOCATION)



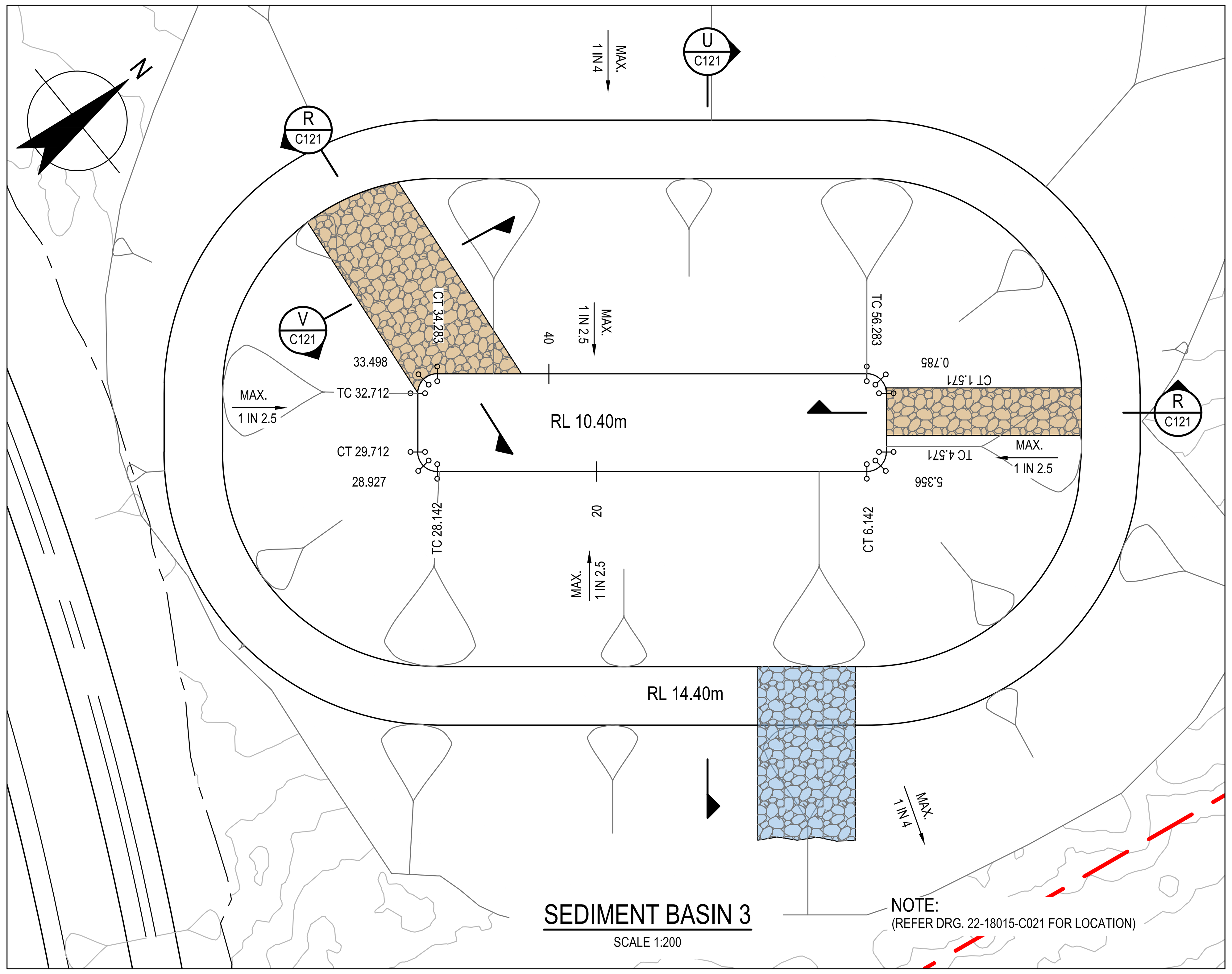
LEACHATE BUFFER STORAGE DAM
SCALE 1:200

NOTE:
(REFER DRG. 22-18015-C021 FOR LOCATION)



SEDIMENT BASIN 1
SCALE 1:200

NOTE:
(REFER 22-18015-C021 FOR LOCATION)



SEDIMENT BASIN 3
SCALE 1:200

NOTE:
(REFER DRG. 22-18015-C021 FOR LOCATION)

LEGEND:

- CONTAINMENT CELL WORKS AREA
- EXISTING CONTOURS
- DESIGN CONTOURS
- FAUNA EXCLUSION FENCE. REFER TO RMS DRAWING R0800-31 FOR DETAILS
- INLET CHANNEL
- OVERFLOW CHANNEL
- LEACHATE BUFFER STORAGE DAM LINING

NOTES:

1. LEACHATE BUFFER STORAGE DAM HAS BEEN SIZED TO CONTAIN ONE MONTH PEAK GENERATION VOLUME.
2. SEDIMENT DETENTION BASIN SIZED TO ACCOMMODATE 5.2ha OF DISTURBED AREA.

SEDIMENT BASIN 01 SETOUT POINTS

CHAINAGE	EASTING	NORTHING	HEIGHT
0.000	357191.998	6371450.369	15.000
0.785	357191.998	6371451.369	15.000
1.571	357192.998	6371451.369	15.000
4.571	357195.998	6371451.369	15.000
5.356	357196.998	6371451.369	15.000
6.142	357196.998	6371450.369	15.000
28.142	357196.998	6371428.369	15.000
28.927	357196.998	6371427.369	15.000
29.712	357195.998	6371427.369	15.000
32.712	357192.998	6371427.369	15.000
33.498	357191.998	6371427.369	15.000
34.283	357191.998	6371428.369	15.000

SEDIMENT BASIN 02 SETOUT POINTS

CHAINAGE	EASTING	NORTHING	HEIGHT
0.000	357177.947	6371379.363	14.000
0.785	357177.947	6371380.363	14.000
1.571	357178.947	6371380.363	14.000
4.571	357181.947	6371380.363	14.000
5.356	357182.947	6371380.363	14.000
6.142	357182.947	6371379.363	14.000
28.142	357182.947	6371357.363	14.000
28.927	357182.947	6371356.363	14.000
29.712	357181.947	6371356.363	14.000
32.712	357178.947	6371356.363	14.000
33.498	357177.947	6371356.363	14.000
34.283	357177.947	6371357.363	14.000

LEACHATE BUFFER STORAGE DAM SETOUT POINTS

CHAINAGE	EASTING	NORTHING	HEIGHT
0.000	357193.586	6371511.164	17.600
5.000	357198.586	6371511.164	17.600
27.000	357198.586	6371489.164	17.600
32.000	357193.586	6371489.164	17.600

SEDIMENT BASIN 03 SETOUT POINTS

CHAINAGE	EASTING	NORTHING	HEIGHT
0.000	357389.148	6371424.286	10.400
0.785	357389.779	6371425.062	10.400
1.571	357390.555	6371424.432	10.400
4.571	357392.883	6371422.540	10.400
5.356	357393.659	6371421.909	10.400
6.142	357393.029	6371421.133	10.400
28.142	357379.154	6371404.060	10.400
28.927	357378.523	6371403.283	10.400
29.712	357377.747	6371403.914	10.400
32.712	357375.419	6371405.806	10.400
33.498	357374.643	6371406.437	10.400
34.283	357375.274	6371407.213	10.400

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
0	ISSUED FOR CONSTRUCTION	RK	AR	IG	29.09.19

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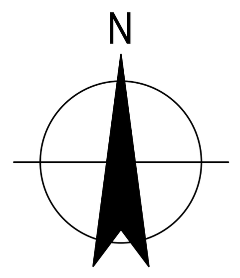
Drawn J. CASIO | Designer P. ETCHELLS
Drafting Check P. PRASAD | Design Check A. ROBERTS
Approved (Project Director) I. GREGSON*
Date 26.09.19
Scale 1:200
This Drawing must not be used for Construction unless signed as Approved

Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **DETAIL PLAN**
SEDIMENT BASINS & STORAGE DAM

Original Size A1 Drawing No: **22-18015-C024** Rev: 0

Plot Date: 27 September 2019 - 9:59 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C024.dwg



NOTES:

1. LANDFILL GAS MANAGEMENT SYSTEM LAYOUT IS CONCEPT ONLY.
2. PERIMETER GAS MONITORING BORES TYPICALLY AT 50m SPACINGS ASSUMING UNIFORM LOW PERMEABILITY STRATA AND DEVELOPMENT WITHIN 150M OR 250M (EPA VICTORIA OPEN DOCUMENT 2015).

LEGEND:

- CONTAINMENT CELL WORKS AREA
- DESIGN CONTOURS
- EXISTING CONTOURS
- GROUNDWATER, LEAK DETECTION AND LEACHATE RISER PIPEWORK
- FINAL CAP
- FAUNA EXCLUSION FENCE. REFER TO RMS DRAWING R0800-31 FOR DETAILS
- HORIZONTAL GAS TRENCH
- VERTICAL GAS BORE
- CENTRAL GAS VENT
- PERIMETER GAS MONITORING BORE
- FAUNA EXCLUSION GATE. REFER TO RMS DRAWING R0800-31 FOR DETAILS

PLAN
SCALE 1:1000

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0 10 20 30 40 50m
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Drafting Check P. PRASAD — Design Check A. ROBERTS
Approved (Project Director) I. GREGSON*
Date 26.09.19
Scale 1:1000
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Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **GENERAL ARRANGEMENT FINAL CAP**

Original Size A1 — Drawing No: **22-18015-C025** — Rev: 0

Plot Date: 27 September 2019 - 10:00 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C025.dwg

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Drafting Check	P. PRASAD	Design Check	A. ROBERTS
Approved (Project Director)	I. GREGSON*		
Date	26.09.19		
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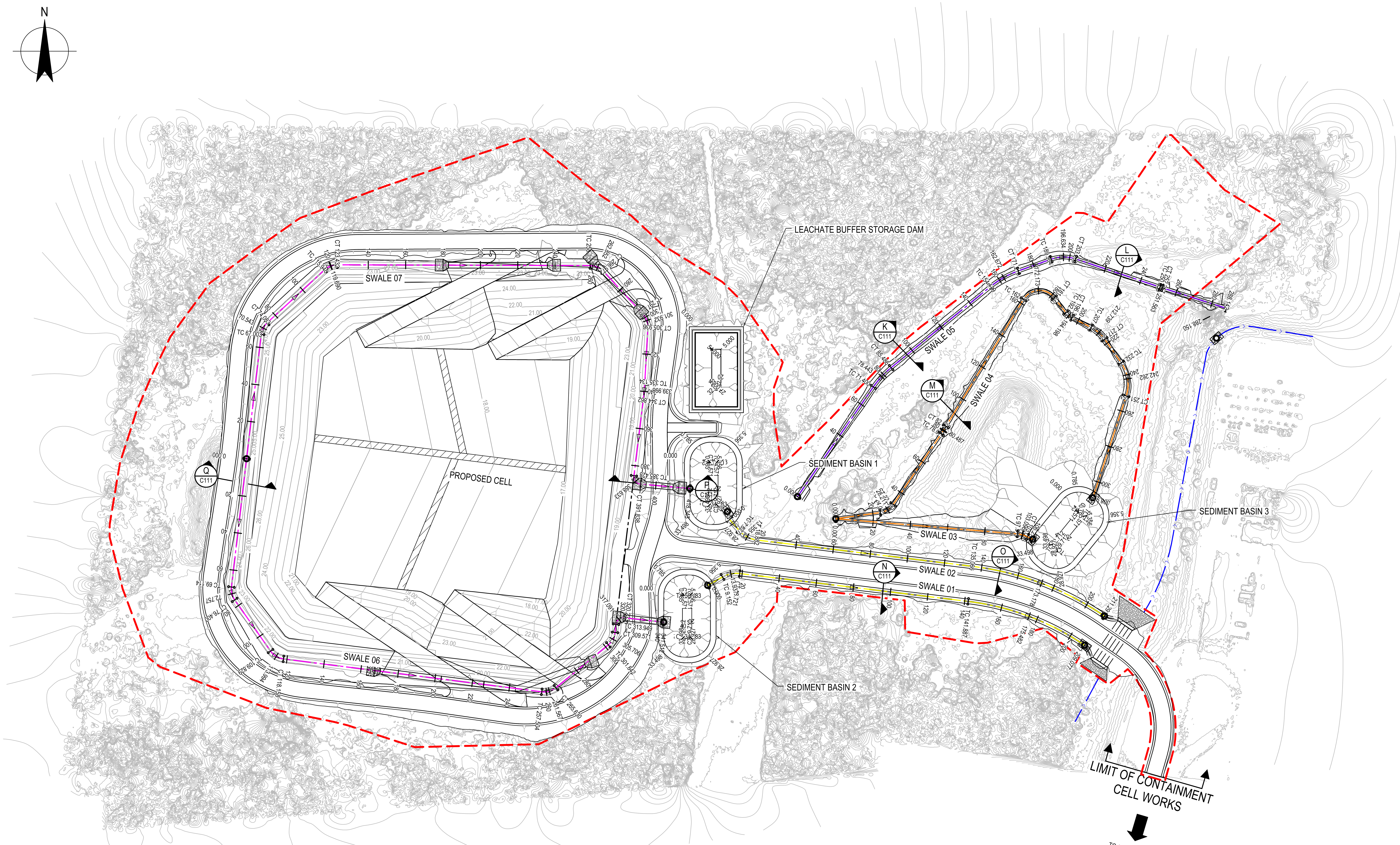
Client: HYDRO ALUMINIUM KURRI KURRI PTY LTD
Project: CONTAINMENT CELL DETAILED DESIGN
Title: SETOUT PLAN
CONTAINMENT CELL AND PONDS - SHEET 1 OF 2

Original Size: A1
Drawing No: 22-18015-C031
Rev: 0

Plot Date: 27 September 2019 - 10:00 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C031.dwg



PLAN
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Drafting Check	P. PRASAD	Design Check	A. ROBERTS
Approved (Project Director)	I. GREGSON*		
Date	26.09.19		
Scale	1:1000	This Drawing must not be used for Construction unless signed as Approved	

Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **SETOUT PLAN CONTAINMENT CELL AND PONDS**

Original Size A1 Drawing No: **22-18015-C032** Rev: 0

Plot Date: 27 September 2019 - 10:00 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C032.dwg

ACCESS ROAD (ROAD01) SETOUT POINTS

PT	CHAINAGE	EASTING	NORTHING	HEIGHT	BEARING	RAD/SPIRAL	A.LENGTH	DEFL.ANGLE
IP 1	0.000	357430.199	6371283.416	13.505	15°55'18.49"			
TC	12.212	357433.549	6371295.159	13.828	15°55'18.49"			
IP 2	43.443	357443.437	6371329.822	13.470		R = -50.000	62.462	71°34'34.00"
CT	74.673	357413.676	6371350.158	11.823	304°20'44.49"			
TC	93.070	357398.487	6371360.537	12.053	304°20'44.49"			
IP 3	128.924	357368.307	6371381.160	13.666		R = -150.000	71.708	27°23'24.91"
CT	164.778	357332.024	6371385.586	15.280	276°57'19.58"			
IP 4	337.913	357160.163	6371406.552	19.798	276°57'19.58"			

PERIMETER ROAD (ROAD02) SETOUT POINTS

PT	CHAINAGE	EASTING	NORTHING	HEIGHT	BEARING	RAD/SPIRAL	A.LENGTH	DEFL.ANGLE
IP 1	0.000	357160.163	6371406.552	19.798	197°15'56.61"			
TC	5.203	357158.619	6371401.584	19.783	197°15'56.61"			
IP 2	15.011	357155.682	6371392.134	19.634		R = -60.000	19.616	18°43'53.53"
CT	24.819	357155.935	6371382.241	19.367	178°32'03.08"			
TC	41.812	357156.369	6371365.253	19.361	178°32'03.08"			
IP 3	48.097	357156.534	6371358.834	19.515		R = 25.000	12.570	28°48'29.10"
CT	54.382	357153.585	6371353.131	19.672	207°20'32.18"			
TC	58.176	357151.842	6371349.760	19.767	207°20'32.18"			
IP 4	98.385	357130.591	6371308.662	20.745		R = 65.000	80.419	70°53'13.15"
CT	138.595	357084.800	6371315.284	20.900	278°13'45.33"			
TC	173.689	357050.067	6371320.308	20.900	278°13'45.33"			
IP 5	182.647	357041.200	6371321.590	20.900		R = -495.000	17.917	2°04'25.88"
CT	191.606	357032.292	6371322.551	20.900	276°09'19.45"			
TC	249.869	356974.365	6371328.798	21.188	276°09'19.45"			
IP 6	294.239	356917.300	6371334.952	22.261		R = 55.000	88.738	92°26'32.83"
CT	338.608	356925.880	6371391.703	23.947	8°35'52.27"			
TC	389.734	356933.523	6371442.255	25.238	8°35'52.27"			
IP 7	405.888	356935.939	6371458.234	25.288		R = -495.000	32.309	3°44'22.94"
CT	422.043	356937.308	6371474.336	25.164	4°51'29.33"			
TC	456.865	356940.257	6371509.033	24.530	4°51'29.33"			
IP 8	504.962	356945.283	6371568.166	23.673		R = 65.000	96.195	84°47'35.42"
CT	553.060	357004.628	6371568.527	23.391	89°39'04.76"			
TC	674.771	357126.336	6371569.267	23.191	89°39'04.76"			
IP 9	713.435	357178.523	6371569.585	22.437		R = 45.000	77.329	98°27'31.77"
CT	752.100	357171.160	6371517.920	21.470	188°06'36.53"			
TC	776.063	357167.780	6371494.196	20.930	188°06'36.53"			
IP 10	791.230	357165.636	6371479.151	20.682		R = -195.000	30.333	8°54'45.41"
CT	806.396	357165.848	6371463.955	20.454	179°11'51.12"			
TC	832.695	357166.217	6371437.660	20.060	179°11'51.12"			
IP 11	843.732	357166.373	6371426.531	19.902		R = 70.000	22.075	18°04'07.08"
CT	854.770	357163.069	6371415.902	19.812	197°15'58.19"			
IP 12	864.561	357160.163	6371406.552		197°15'58.19"			

BASIN 01 SETOUT POINTS

PT	CHAINAGE	EASTING	NORTHING	HEIGHT	BEARING	RAD/SPIRAL	A.LENGTH	DEFL.ANGLE
IP 1	0.000	357177.947	6371379.363	14.000				
IP 2	0.785	357177.947	6371380.363	14.000		R = 1.000	1.571	90°00'00.00"
CT	1.571	357178.947	6371380.363	14.000	90°00'00.00"			
TC	4.571	357181.947	6371380.363	14.000	90°00'00.00"			
IP 3	5.356	357182.947	6371380.363	14.000		R = 1.000	1.571	90°00'00.00"
CT	6.142	357182.947	6371379.363	14.000	180°00'00.00"			
TC	28.142	357182.947	6371357.363	14.000	180°00'00.00"			
IP 4	28.927	357182.947	6371356.363	14.000		R = 1.000	1.571	90°00'00.00"
CT	29.712	357181.947	6371356.363	14.000	270°00'00.00"			
TC	32.712	357178.947	6371356.363	14.000	270°00'00.00"			
IP 5	33.498	357177.947	6371356.363	14.000		R = 1.000	1.571	90°00'00.00"
CT	34.283	357177.947	6371357.363	14.000	0°00'00.00"			

BASIN 02 SETOUT POINTS

PT	CHAINAGE	EASTING	NORTHING	HEIGHT	BEARING	RAD/SPIRAL	A.LENGTH	DEFL.ANGLE
IP 1	0.000	357191.998	6371450.369	15.000				
IP 2	0.785	357191.998	6371451.369	15.000		R = 1.000	1.571	90°00'00.00"
CT	1.571	357192.998	6371451.369	15.000	90°00'00.00"			
TC	4.571	357195.998	6371451.369	15.000	90°00'00.00"			
IP 3	5.356	357196.998	6371451.369	15.000		R = 1.000	1.571	90°00'00.00"
CT	6.142	357196.998	6371450.369	15.000	180°00'00.00"			
TC	28.142	357196.998	6371428.369	15.000	180°00'00.00"			
IP 4	28.927	357196.998	6371427.369	15.000		R = 1.000	1.571	90°00'00.00"
CT	29.712	357195.998	6371427.369	15.000	270°00'00.00"			
TC	32.712	357192.998	6371427.369	15.000	270°00'00.00"			
IP 5	33.498	357191.998	6371427.369	15.000		R = 1.000	1.571	90°00'00.00"
CT	34.283	357191.998	6371428.369	15.000	0°00'00.00"			

BASIN 03 SETOUT POINTS

PT	CHAINAGE	EASTING	NORTHING	HEIGHT
IP 1	0.000	357193.586	6371511.164	17.600
IP 2	5.000	357198.586	6371511.164	17.600
IP 3	27.000	357198.586	6371489.164	17.600
IP 4	32.000	357193.586	6371489.164	17.600

SWALE 01 HORIZONTAL POINTS

PT	CHAINAGE	EASTING	NORTHING	HEIGHT	BEARING	RAD/SPIRAL	A.LENGTH	DEFL.ANGLE
IP 1	0.000	357191.437	6371384.753	17.650	60°24'06.16"			
TC	9.152	357199.395	6371389.274	16.791	60°24'06.16"			
IP 2	13.937	357203.702	6371391.721	16.683		R = 15.000	9.570	36°33'13.42"
CT	18.721	357208.620	6371391.121	16.576	96°57'19.58"			
TC	141.887	357330.880	6371376.206	14.138	96°57'19.58"			
IP 3	175.482	357364.877	6371372.058	11.975		R = 140.550	67.190	27°23'24.91"
IP 4	209.077	357393.155	6371352.735	10.487	124°20'44.49"			

SWALE 02 HORIZONTAL POINTS

PT	CHAINAGE	EASTING	NORTHING	HEIGHT	BEARING	RAD/SPIRAL	A.LENGTH	DEFL.ANGLE
IP 1	0.000	357203.188	6371420.045	18.600	139°11'00.49"			
TC	7.827	357208.304	6371414.121	17.393	139°11'00.49"			
IP 2	13.355	357212.090	6371409.737	16.543		R = -15.000	11.055	42°13'40.92"
CT	18.882	357217.840	6371409.036	16.419	96°57'19.58"			
TC	135.066	357333.168	6371394.966	14.142	96°57'19.58"			
IP 3	173.178	357371.738	6371390.261	11.975		R = 159.450	76.225	27°23'24.91"
IP 4	211.291	357403.819	6371368.340	10.508				
IP 5	211.291	357403.819	6371368.340	10.508	124°20'41.41"			

SWALE 03 HORIZONTAL POINTS

PT	CHAINAGE	EASTING	NORTHING	HEIGHT	BEARING	RAD/SPIRAL	A.LENGTH	DEFL.ANGLE
IP 1	0.000	357260.048	6371420.446	16.200	94°47'24.31"			
TC	97.519	357357.227	6371412.303	14.273	94°47'24.31"			
IP 2	100.307	357360.037	6371412.067	14.218		R = 15.000	5.576	21°17'57.30"
CT	103.096	357362.571	6371410.827	14.163	116°05'21.61"			
IP 3	106.273	357365.425	6371409.429	14.100	116°05'21.61"			

SWALE 04 HORIZONTAL POINTS

PT	CHAINAGE	EASTING	NORTHING	HEIGHT	BEARING	RAD/SPIRAL	A.LENGTH	DEFL.ANGLE
IP 1	0.000	357260.048	6371420.446	16.200	82°02'54.20"			
TC	24.032	357283.849	6371423.771	16.037	82°02'54.20"			
IP 2	28.211	357288.247	6371424.385	16.009		R = -10.000	8.357	47°53'04.87"
CT	32.390	357290.740	6371428.059	15.981	34°09'49.33"			
TC	78.074	357316.395	6371465.860	15.671	34°09'49.33"			
IP 3	80.487	357317.750	6371467.857	15.655		R = -100.000	4.825	2°45'53.30"
CT	82.900	357319.007	6371469.917	15.639	31°23'56.03"			
TC	162.507	357360.482	6371537.866	15.100	31°23'56.03"			
IP 4	172.173	357368.030	6371550.232	15.034		R = 10.000	19.333	110°46'10.50"
CT	181.840	357376.916	6371538.789	14.969	142°10'06.53"			
TC	192.009	357383.153	6371530.758	14.900	142°10'06.53"			
IP 5	194.198	357384.517	6371529.001	14.885		R = -10.000	4.378	25°05'02.21"
CT	196.387	357386.498	6371527.988	14.870	117°05'04.31"			
TC	207.876	357396.727	6371522.757	14.792	117°05'04.31"			
IP 6	212.739	357401.144	6371520.498	14.760		R = 20.000	9.726	27°51'46.01"
CT	217.602	357403.993	6371516.437	14.727	144°56'50.32"			
TC	232.972	357412.821	6371503.854	14.623	144°56'50.32"			
IP 7	242.262	357418.576	6371495.651	14.560		R = 20.000	18.579	53°13'29.89"
CT	251.551	357415.451	6371486.130	14.497	198°10'20.22"			
IP 8	308.918	357397.560	6371431.625	14.098	198°10'20.22"			

BASIN 04 SETOUT POINTS

PT	CHAINAGE	EASTING	NORTHING	HEIGHT	BEARING	RAD/SPIRAL	A.LENGTH	DEFL.ANGLE
IP 1	0.000	357389.148	6371424.286	10.400				
IP 2	0.785	357389.779	6371425.062	10.400		R = 1.000	1.571	90°00'00.00"
CT	1.571	357390.555	6371424.432	10.400	129°05'56.19"			
TC	4.571	357392.883	6371422.540	10.400	129°05'56.19"			
IP 3	5.356	357393.659	6371421.909	10.400		R = 1.000	1.571	90°00'00.00"
CT	6.142	357393.029	6371421.133	10.400	219°05'56.19"			
TC	28.142	357379.154	6371404.060	10.400	219°05'56.19"			
IP 4	28.927	357378.523	6371403.283	10.400		R = 1.000	1.571	90°00'00.00"
CT	29.712	357377.747	6371403.914	10.400	309°05'56.19"			
TC	32.712	357375.419	6371405.806	10.400	309°05'56.19"			
IP 5	33.498	357374.643	6371406.437	10.400		R = 1.000	1.571	90°00'00.00"
CT	34.283	357375.274	6371407.213	10.400	39°05'56.19"			

SWALE 05 HORIZONTAL POINTS

PT	CHAINAGE	EASTING	NORTHING	HEIGHT	BEARING	RAD/SPIRAL	A.LENGTH	DEFL.ANGLE
IP 1	0.000	357239.500	6371432.256	16.600	34°39'42.90"			
TC	71.400	357280.107	6371490.984	15.135	34°39'42.90"			
IP 2	78.443	357284.140	6371496.815	14.991		R = 50.000	14.086	16°08'29.10"
CT	85.486	357289.634	6371501.296	14.846	50°48'12.00"			
TC	154.129	357342.832	6371544.677	13.438	50°48'12.00"			
IP 3	162.672	357349.518	6371550.130	13.263		R = 50.000	17.086	19°34'46.42"
CT	171.216	357357.644	6371553.026	13.088	70°22'58.42"			
TC	189.984	357375.324	6371559.328	12.703	70°22'58.42"			
IP 4	196.634	357381.828	6371561.646	12.566		R = 20.000	13.299	38°05'51.87"
CT	203.283	357388.378	6371559.457	12.430	108°28'50.29"			
TC	250.859	357433.501	6371544.376	11.454	108°28'50.29"			
IP 5	251.563	357434.168	6371544.153	11.440		R = -100.000	1.408	0°48'23.77"
CT	252.267	357434.839	6371543.939	11.425	107°40'26.52"			
IP 6	288.150	357469.028	6371533.045	8.618	107°40'26.52"			

SWALE 06 HORIZONTAL POINTS

PT	CHAINAGE	EASTING	NORTHING	HEIGHT	BEARING	RAD/SPIRAL	A.LENGTH	DEFL.ANGLE
IP 1	0.000	356944.680	6371452.538	24.200	186°43'25.06"			
TC	69.114	356936.588	6371383.899	22.127	186°43'25.06"			
IP 2	72.757	356936.142	6371380.112	22.017		R = -10.000	7.286	41°44'38.48"
CT	76.400	356938.330	6371376.989	21.908	144°58'46.59"			
TC	109.829	356957.514	6371349.613	20.978	144°58'46.59"			
IP 3	113.994	356960.052	6371345.990	20.905		R = -10.000	8.330	47°43'28.41"
CT	118.158	356964.440	6371345.432	20.832	97°15'18.17"			
TC	257.504	357102.670	6371327.834	18.490	97°15'18.17"			
IP 4	261.567	357106.938	6371327.291	18.449		R = -10.000	8.126	46°33'33.53"
CT	265.630	357110.267	6371330.016	18.409	50°41'44.64"			
TC	301.842	357138.288	6371352.954	18.047	50°41'44.64"			
IP 5	305.706	357141.437	6371355.532	18.008		R = -10.000	7.729	44°17'09.72"
CT	309.571	357141.891	6371359.576	17.969	6°24'34.93"			
TC	313.949	357142.380	6371363.927	17.926	6°24'34.93"			
IP 6	317.091	357142.826	6371367.902	17.894		R = 4.000	6.283	90°00'00.00"
CT	320.233	357146.801	6371367.455	17.863	96°24'34.93"			
IP 7	341.512	357167.947	6371365.080	17.650	96°24'34.93"			

SWALE 07 HORIZONTAL POINTS

PT	CHAINAGE	EASTING	NORTHING	HEIGHT	BEARING	RAD/SPIRAL	A.LENGTH	DEFL.ANGLE
IP 1	0.000	356944.680	6371452.538	24.200	6°43'25.06"			
TC	67.003	356952.525	6371519.080	23.195	6°43'25.06"			
IP 2	70.543	356952.958	6371522.751	23.142		R = 10.000	7.080	40°34'03.36"
CT	74.083	356955.673	6371525.257	23.089	47°17'28.42"			
TC	115.948	356986.436	6371553.653	22.461	47°17'28.42"			
IP 3	119.690	356989.322	6371556.317	22.405		R = 10.000	7.484	42°52'51.35"
CT	123.432	356993.249	6371556.305	22.349	90°10'19.76"			
TC	258.732	357128.548	6371555.898	20.595	90°10'19.76"			
IP 4	262.852	357132.918	6371555.885	20.544		R = 10.000	8.241	47°12'57.45"
CT	266.972	357135.877	6371552.669	20.492	137°23'17.22"			
TC	297.928	357156.835	6371529.887	20.105	137°23'17.22"			
IP 5	301.932	357159.700	6371526.772	20.055		R = 10.000	8.008	45°52'53.88"
CT	305.936	357159.459	6371522.546	20.005	183°16'11.10"			
TC	335.134	357157.794	6371493.395	19.640	183°16'11.10"			
IP 6	339.998	357157.516	6371488.537	19.579		R = 150.000	9.728	3°42'56.71"
CT	344.862	357156.924	6371483.708	19.519	186°59'07.81"			
TC	385.428	357151.991	6371443.443	19.011	186°59'07.81"			
IP 7	388.633	357151.489	6371439.345	18.971		R = -4.000	6.410	91°49'07.73"
CT	391.838	357155.601	6371438.973	18.931	95°10'00.08"			
IP 8	418.343	357181.998	6371436.586	18.600	95°10'00.08"			

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
0	ISSUED FOR CONSTRUCTION	RK	AR	IG	29.09.19

Note: * indicates signatures on original issue of drawing or last revision of drawing

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DO NOT SCALE

Drawn J. CASIO | Designer P. ETCHELLS
Drafting Check P. PRASAD | Design Check A. ROBERTS
Approved (Project Director) I. GREGSON*
Date 26.09.19
Scale NOT TO SCALE
This Drawing must not be used for Construction unless signed as Approved

Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **SETOUT TABLE**
CONTAINMENT CELL AND PONDS - SHEET 1 OF 2

Original Size **A1** | Drawing No: **22-18015-C033** | Rev: **0**

Plot Date: 27 September 2019 - 9:52 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C033.dwg

PAD01 SETOUT POINTS

PT	CHAINAGE	EASTING	NORTHING	HEIGHT	BEARING	RAD/SPIRAL	A.LENGTH	DEFL.ANGLE
IP 1	0.000	357261.898	6371398.171	16.745	276°57'19.58"			
IP 2	9.425	357249.986	6371399.624	16.794		R = 12.000	18.850	90°00'00.00"
CT	18.850	357251.439	6371411.536	16.535	6°57'19.58"			
IP 3	21.242	357251.729	6371413.911	16.570				
IP 4	30.242	357242.795	6371415.001	16.702				
TC	32.635	357242.505	6371412.625	16.737	186°57'19.58"			
IP 5	42.060	357241.052	6371400.714	17.156		R = 12.000	18.850	90°00'00.00"
IP 6	51.485	357229.141	6371402.167	17.487	276°57'19.58"			

PAD02 SETOUT POINTS

PT	CHAINAGE	EASTING	NORTHING	HEIGHT	BEARING	RAD/SPIRAL	A.LENGTH	DEFL.ANGLE
IP 1	0.000	357170.694	6371484.842	20.614	185°27'16.09"			
IP 2	9.996	357169.439	6371471.701	20.326		R = -12.000	19.992	95°27'16.09"
CT	19.992	357182.640	6371471.701	19.931	90°00'00.00"			
IP 3	33.438	357196.086	6371471.701	19.460				
IP 4	38.438	357196.086	6371466.701	19.285				
TC	52.545	357181.980	6371466.701	19.834	270°00'00.00"			
IP 5	62.053	357169.810	6371466.701	20.136		R = -12.000	19.018	90°48'08.89"
IP 6	71.562	357169.981	6371454.533	20.152	179°11'51.12"			

RETENTION - ROAD01 TO ROAD02 S SETOUT POINTS

PT	CHAINAGE	EASTING	NORTHING	HEIGHT	BEARING	RAD/SPIRAL	A.LENGTH	DEFL.ANGLE
IP 1	0.000	357173.675	6371400.874	19.074	276°57'19.58"			
IP 2	9.444	357161.725	6371402.332	19.418		R = -12.000	18.888	90°11'07.38"
IP 3	18.888	357160.306	6371390.377	19.445	186°46'12.20"			

RETENTION - ROAD02 TO ROAD01 N SETOUT POINTS

PT	CHAINAGE	EASTING	NORTHING	HEIGHT	BEARING	RAD/SPIRAL	A.LENGTH	DEFL.ANGLE
IP 1	0.000	357168.848	6371422.478	19.705	191°03'52.25"			
IP 2	9.855	357166.374	6371409.824	19.375		R = -12.000	19.710	94°06'32.68"
IP 3	19.710	357179.172	6371408.263	18.891	96°57'19.58"			

RETENTION - ROAD02 TO RAMP01 E SETOUT POINTS

PT	CHAINAGE	EASTING	NORTHING	HEIGHT	BEARING	RAD/SPIRAL	A.LENGTH	DEFL.ANGLE
IP 1	0.000	357115.793	6371564.203	23.400	269°39'04.76"			
IP 2	5.836	357109.849	6371564.167	23.427		R = -25.000	11.673	26°45'07.09"
IP 3	11.673	357104.557	6371561.459	23.507	242°53'57.67"			

RETENTION - ROAD02 TO RAMP01 W SETOUT POINTS

PT	CHAINAGE	EASTING	NORTHING	HEIGHT	BEARING	RAD/SPIRAL	A.LENGTH	DEFL.ANGLE
IP 1	0.000	357076.402	6371558.285	23.968	62°53'57.77"			
IP 2	2.006	357078.512	6371559.364	23.761		R = -3.000	4.012	76°37'26.51"
CC	4.012	357077.950	6371561.667	23.576	346°16'31.26"			
IP 3	6.018	357077.388	6371563.970	23.444		R = -3.000	4.012	76°37'26.51"
IP 4	8.024	357075.017	6371563.955	23.400	269°39'04.76"			

RETENTION - ROAD02 TO RAMP02 E SETOUT POINTS

PT	CHAINAGE	EASTING	NORTHING	HEIGHT	BEARING	RAD/SPIRAL	A.LENGTH	DEFL.ANGLE
IP 1	0.000	357165.308	6371534.393	22.119	345°20'15.53"			
IP 2	10.770	357161.500	6371548.947	22.555		R = -12.000	21.539	102°50'34.58"
IP 3	21.539	357148.157	6371541.999	23.070	242°29'40.95"			

RETENTION - ROAD02 TO RAMP02 W SETOUT POINTS

PT	CHAINAGE	EASTING	NORTHING	HEIGHT	BEARING	RAD/SPIRAL	A.LENGTH	DEFL.ANGLE
IP 1	0.000	357144.307	6371551.269	23.233	62°29'41.10"			
IP 2	2.758	357147.036	6371552.690	23.131		R = -5.000	5.516	63°12'23.78"
CC	5.516	357146.998	6371555.766	23.061	359°17'17.32"			
IP 3	8.274	357146.959	6371558.843	23.040		R = -5.000	5.516	63°12'23.78"
IP 4	11.032	357144.196	6371560.195	23.085	296°04'53.55"			

RETENTION - ROAD02 TO RAMP03 E SETOUT POINTS

PT	CHAINAGE	EASTING	NORTHING	HEIGHT	BEARING	RAD/SPIRAL	A.LENGTH	DEFL.ANGLE
IP 1	0.000	357121.470	6371336.229	21.285	125°15'07.01"			
IP 2	8.466	357129.817	6371330.330	20.709		R = -12.000	16.933	80°50'52.17"
IP 3	16.933	357136.969	6371337.632	20.451	44°24'14.84"			

RETENTION - ROAD02 TO RAMP03 W SETOUT POINTS

PT	CHAINAGE	EASTING	NORTHING	HEIGHT	BEARING	RAD/SPIRAL	A.LENGTH	DEFL.ANGLE
IP 1	0.000	357110.358	6371321.859	21.089	74°16'53.79"			
IP 2	2.815	357113.396	6371322.714	21.144		R = -5.000	5.630	64°30'53.39"
CC	5.630	357113.931	6371325.824	21.335	9°46'00.40"			
IP 3	8.445	357114.467	6371328.934	21.620		R = -5.000	5.630	64°30'53.39"
IP 4	11.260	357111.890	6371330.755	21.954	305°15'07.01"			

RETENTION -ROAD02 TO RAMP04 E SETOUT POINTS

PT	CHAINAGE	EASTING	NORTHING	HEIGHT	BEARING	RAD/SPIRAL	A.LENGTH	DEFL.ANGLE
IP 1	0.000	357080.702	6371323.858	21.235	123°51'22.84"			
IP 2	7.574	357087.191	6371319.505	21.129		R = -25.000	15.148	34°43'01.63"
IP 3	15.148	357095.005	6371319.622	21.100	89°08'21.20"			

RETNETION - ROAD02 TO RAMP04 SETOUT POINTS

PT	CHAINAGE	EASTING	NORTHING	HEIGHT	BEARING	RAD/SPIRAL	A.LENGTH	DEFL.ANGLE
IP 1	0.000	357050.334	6371325.321	21.100	98°10'38.12"			
IP 2	2.020	357052.703	6371324.981	21.225		R = -3.000	4.040	77°09'37.64"
CC	4.040	357053.561	6371327.215	21.599	21°01'00.48"			
IP 3	6.060	357054.419	6371329.448	22.029		R = -3.000	4.040	77°09'37.64"
IP 4	8.080	357052.432	6371330.782	22.321	303°51'22.84"			

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
0	ISSUED FOR CONSTRUCTION	RK	AR	IG	29.09.19

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DO NOT SCALE

Drawn J.CASIO
Designer P. ETCHELLS
Drafting Check P. PRASAD
Design Check A. ROBERTS
Approved (Project Director) I. GREGSON*
Date 26.09.19
Scale NOT TO SCALE
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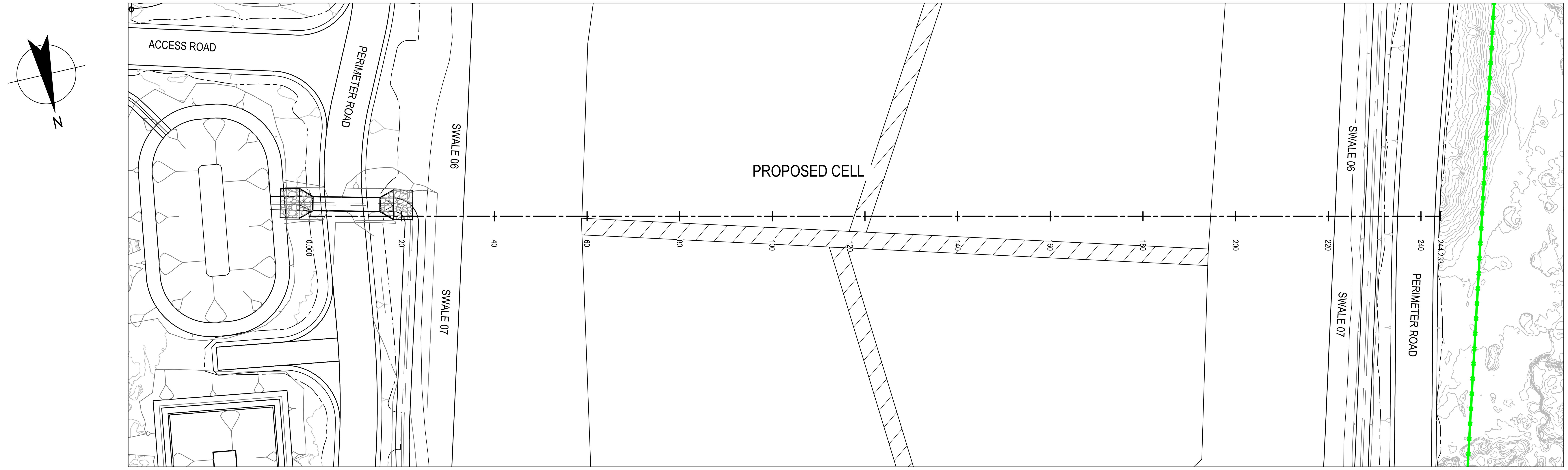
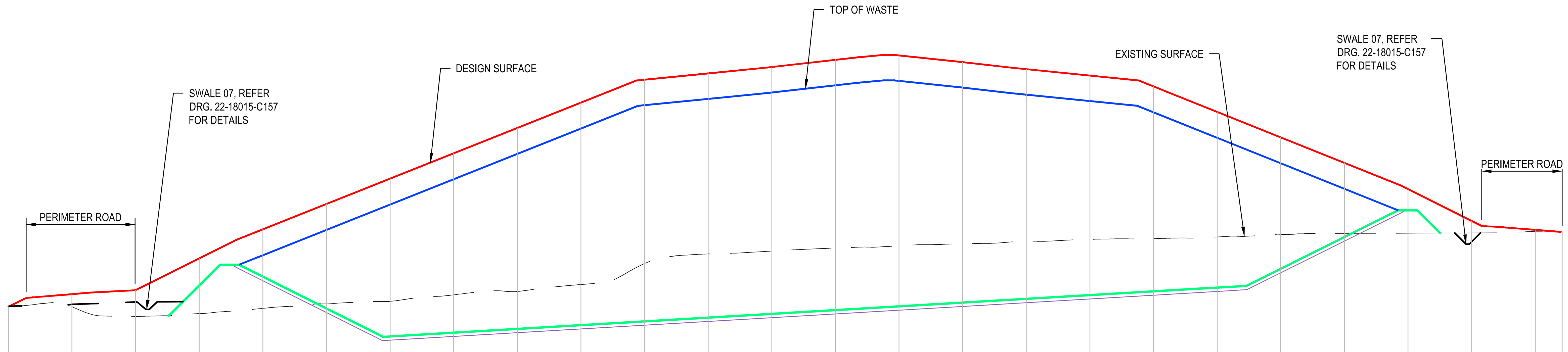
Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title

Original Size **A1**
Drawing No: 22-18015-C034
Rev: 0

Plot Date: 27 September 2019 - 9:52 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C034.dwg



PLAN
SCALE 1:500



DATUM RL. 9.0

DESIGN FINAL SURFACE	19.196	20.194	20.517	23.009	25.291	27.283	29.275	31.267	33.259	35.251	37.053	37.550	38.053
DESIGN FILL SURFACE					23.251	25.244	27.236	29.228	31.220	33.212	35.051	35.548	36.051
DESIGN SUBGRADE				20.884	21.569	19.066	16.870	17.166	17.461	17.756	18.051	18.346	18.641
DESIGN EXCAVATION				20.884	21.250	18.747	16.573	16.867	17.162	17.457	17.752	18.047	18.342
EXISTING SURFACE LEVEL	19.196	19.211	18.432	18.663	19.076	19.427	19.630	20.138	20.402	20.949	22.606	23.358	23.582
CHAINAGE	0.000	10.000	20.000	30.000	40.000	50.000	60.000	70.000	80.000	90.000	100.000	110.000	120.000

DESIGN FINAL SURFACE	38.618	38.961	38.437	37.881	37.377	36.527	34.523	32.518	30.513	28.453	25.948	25.248	
DESIGN FILL SURFACE	36.616	36.959	36.435	35.881	35.376	34.488	32.483	30.478	28.474				
DESIGN SUBGRADE	18.937	19.232	19.527	19.822	20.117	20.413	20.708	22.188	24.679	26.780			
DESIGN EXCAVATION	18.636	18.931	19.226	19.521	19.816	20.111	20.406	21.869	24.360	26.780			
EXISTING SURFACE LEVEL	23.818	23.971	24.150	24.348	24.504	24.554	24.694	24.896	24.970	24.989	25.008	25.104	25.100
CHAINAGE	130.000	140.000	150.000	160.000	170.000	180.000	190.000	200.000	210.000	220.000	230.000	240.000	244.233

A SECTION
C021
SCALE 1 : H500 - V250

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
0	ISSUED FOR CONSTRUCTION	RK	AR	IG	29.09.19

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VERTICAL 1:250 AT ORIGINAL SIZE 0 2.5 5 7.5 10 12.5m
HORIZONTAL 1:500 AT ORIGINAL SIZE 0 5 10 15 20 25m

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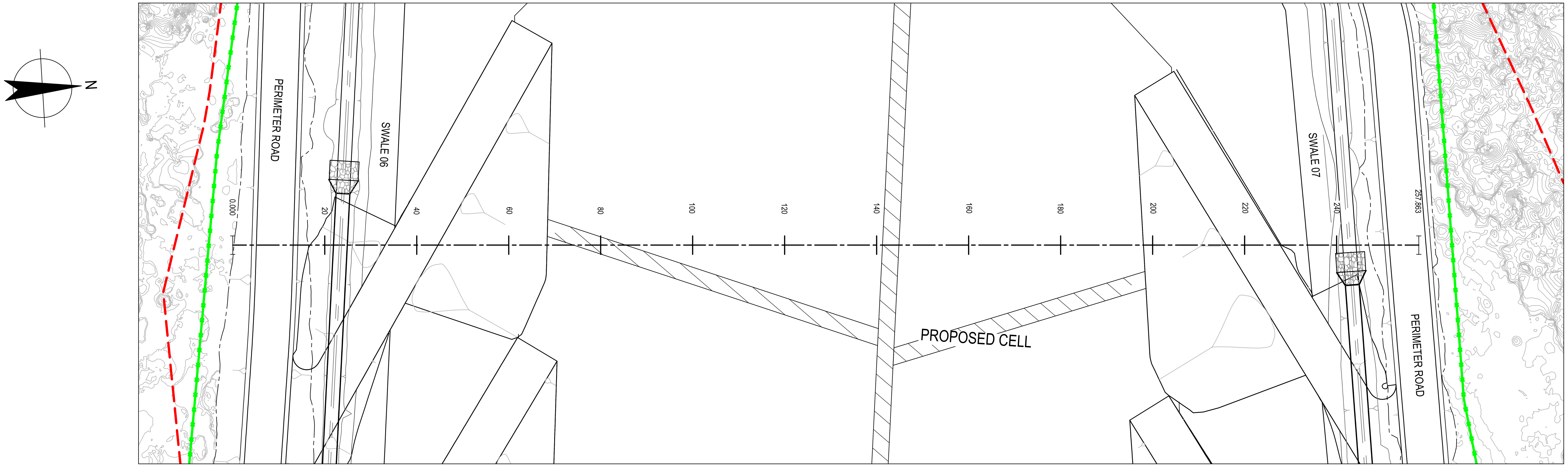
DO NOT SCALE

Drawn J. CASIO
Designer P. ETCHELLS
Drafting Check P. PRASAD
Design Check A. ROBERTS
Approved (Project Director) I. GREGSON*
Date 26.09.19
Scale AS SHOWN
This Drawing must not be used for Construction unless signed as Approved

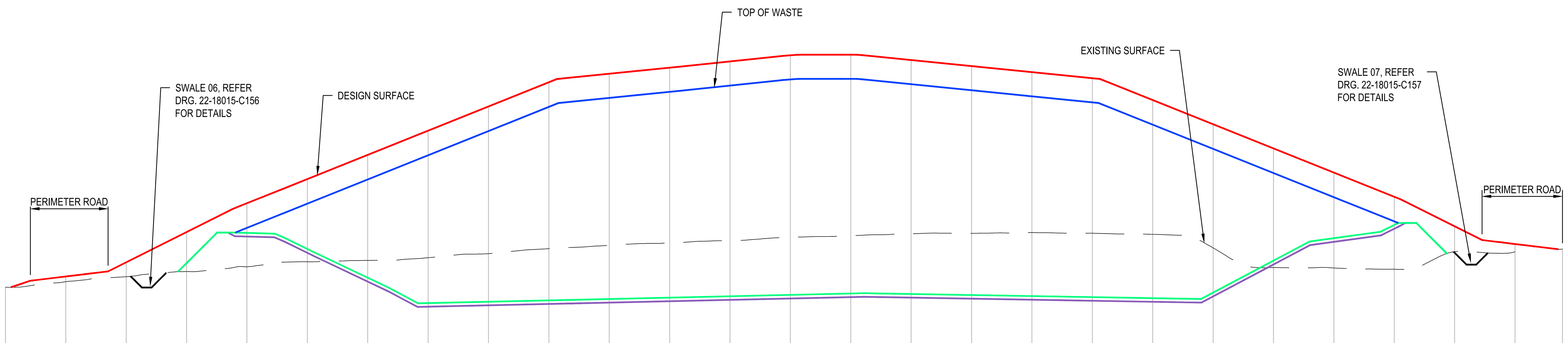
Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **SECTION A LONGITUDINAL SECTION**

Original Size A1
Drawing No: **22-18015-C041**
Rev: 0

Plot Date: 27 September 2019 - 9:52 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C041.dwg



PLAN
SCALE 1:500



DATUM RL. 10.00

DESIGN FINAL SURFACE		20.630	21.804	24.309	26.694	28.699	30.704	32.709	34.713	36.718	37.422	37.921	38.440	38.950	39.002	38.556	38.054	37.554	37.055	35.245	33.242	31.238	29.235	27.231	24.784	23.319	
DESIGN FILL SURFACE					24.655	26.659	28.664	30.669	32.674	34.679	35.420	35.919	36.438	36.948	37.000	36.554	36.052	35.552	35.052	33.206	31.202	29.199	27.195	25.192			
DESIGN SUBGRADE				21.733	24.239	22.905	20.526	18.426	18.539	18.653	18.766	18.879	18.993	19.106	19.220	19.178	19.092	19.006	18.919	18.833	19.295	21.942	23.802	24.901			
DESIGN EXCAVATION				21.733	23.938	22.587	20.207	18.127	18.239	18.352	18.465	18.579	18.692	18.806	18.919	18.878	18.792	18.705	18.619	18.533	18.975	21.623	23.501	24.581			
EXISTING SURFACE LEVEL	19.735	20.199	20.610	21.037	21.433	21.844	21.964	22.186	22.521	22.932	23.211	23.397	23.586	23.876	24.013	24.169	24.204	24.264	24.211	24.119	23.001	21.369	21.335	21.227	22.686	22.683	22.906
CHAINAGE	0.000	10.000	20.000	30.000	40.000	50.000	60.000	70.000	80.000	90.000	100.000	110.000	120.000	130.000	140.000	150.000	160.000	170.000	180.000	190.000	200.000	210.000	220.000	230.000	240.000	250.000	257.863

B SECTION
C021
SCALE 1 : H500 - V250

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
0	ISSUED FOR CONSTRUCTION	RK	AR	IG	29.09.19

Note: * indicates signatures on original issue of drawing or last revision of drawing

VERTICAL 1:250 AT ORIGINAL SIZE: 0 2.5 5 7.5 10 12.5m
HORIZONTAL 1:500 AT ORIGINAL SIZE: 0 5 10 15 20 25m

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DO NOT SCALE

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Drafting Check P. PRASAD
Design Check A. ROBERTS
Approved (Project Director) I. GREGSON*
Date 26.09.19
Scale AS SHOWN
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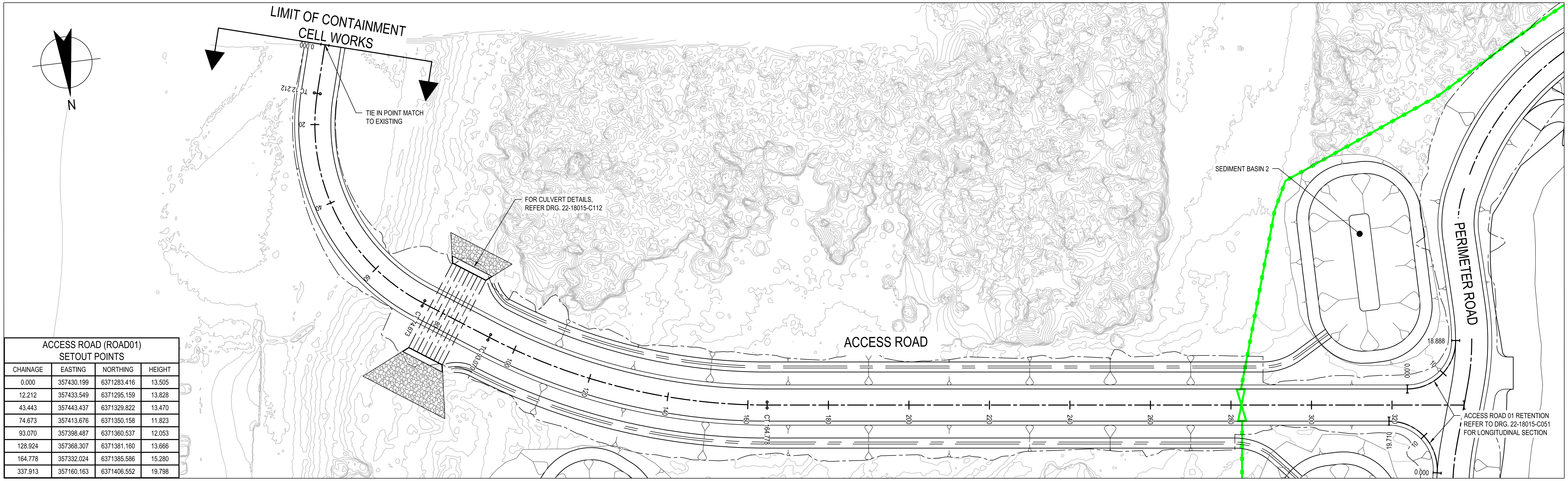
Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **SECTION B LONGITUDINAL SECTION**

Original Size A1
Drawing No: **22-18015-C042**
Rev: 0

Plot Date: 27 September 2019 - 9:52 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C042.dwg

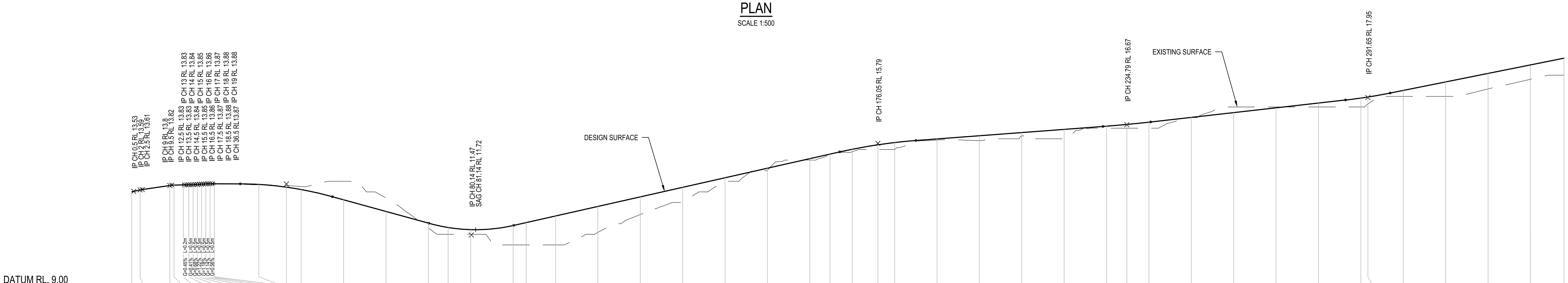


ACCESS ROAD (ROAD01) SETOUT POINTS

CHAINAGE	EASTING	NORTHING	HEIGHT
0.000	357430.199	6371283.416	13.505
12.212	357433.549	6371295.159	13.828
43.443	357443.437	6371329.822	13.470
74.673	357413.676	6371350.158	11.823
93.070	357398.487	6371360.537	12.053
128.924	357368.307	6371381.160	13.666
164.778	357332.024	6371385.586	15.280
337.913	357160.163	6371406.552	19.798

PLAN

SCALE 1:500



VERTICAL ALIGNMENT: K=4 L=21.73m; L=22.76m G=-5.5%; K=2 L=20m; L=76.92m G=4.5%; K=6 L=18m; L=44.11m G=1.5%; K=15 L=11.25m; L=45.99m G=2.25%; K=6 L=10.5m; L=41.01m G=4%

HORIZONTAL ALIGNMENT: L=12.21m; L=62.46m R=-50.00m; L=18.40m; L=71.71m R=-150.00m; L=173.14m

CHAINAGE	LEVEL DIFFERENCE CUT - / FILL +	DESIGN SURFACE LEVEL	EXISTING SURFACE LEVEL
0.00	0.00	13.505	13.50
2.00	0.00	13.592	13.59
9.00	0.00	13.802	13.80
10.00	0.00	13.818	13.82
12.21	0.00	13.828	13.83
13.50	0.00	13.834	13.83
14.50	0.00	13.839	13.84
15.50	0.00	13.852	13.85
16.50	0.00	13.863	13.86
17.50	0.00	13.875	13.87
18.50	0.00	13.883	13.88
19.50	0.00	13.882	13.88
30.00	0.02	13.851	13.84
36.51	-0.08	13.723	13.80
40.00	-0.14	13.610	13.75
50.00	-0.87	13.128	14.00
60.00	-0.64	12.578	13.21
70.00	0.23	12.028	11.79
74.67	0.32	11.823	11.50
80.00	0.22	11.721	11.50
90.00	0.91	11.915	11.00
93.07	1.05	12.053	11.00
100.00	1.36	12.365	11.00
110.00	1.22	12.815	11.59
120.00	0.83	13.265	12.43
130.00	0.70	13.715	13.02
140.00	0.16	14.165	14.00
150.00	0.08	14.615	14.53
160.00	0.06	15.065	15.00
164.78	0.02	15.280	15.26
170.00	0.12	15.507	15.39
176.05	0.22	15.720	15.50
180.00	0.32	15.825	15.50
190.00	0.05	15.996	15.94
200.00	0.23	16.146	15.91
210.00	0.16	16.296	16.13
220.00	0.45	16.446	16.00
230.00	0.10	16.596	16.50
234.79	0.18	16.679	16.50
240.00	0.29	16.785	16.50
250.00	0.01	17.010	17.00
260.00	-0.26	17.235	17.50
270.00	-0.04	17.460	17.50
280.00	0.19	17.685	17.50
290.00	0.42	17.921	17.50
291.65	0.33	17.970	17.64
300.00	0.28	18.281	18.00
310.00	0.68	18.681	18.00
320.00	0.73	19.081	18.35
330.00	0.67	19.481	18.81
337.91	0.80	19.798	19.00

LONGITUDINAL SECTION

SCALE HOR. 1:500 VERT. 1:100

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
0	ISSUED FOR CONSTRUCTION	RK	AR	IG	29.09.19

Note: * indicates signatures on original issue of drawing or last revision of drawing

VERTICAL 1:100 AT ORIGINAL SIZE 0 1 2 3 4 5m
HORIZONTAL 1:500 AT ORIGINAL SIZE 0 5 10 15 20 25m

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PO Box 3220 Tuggerah NSW 2259
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E centralcoastmail@ghd.com W www.ghd.com

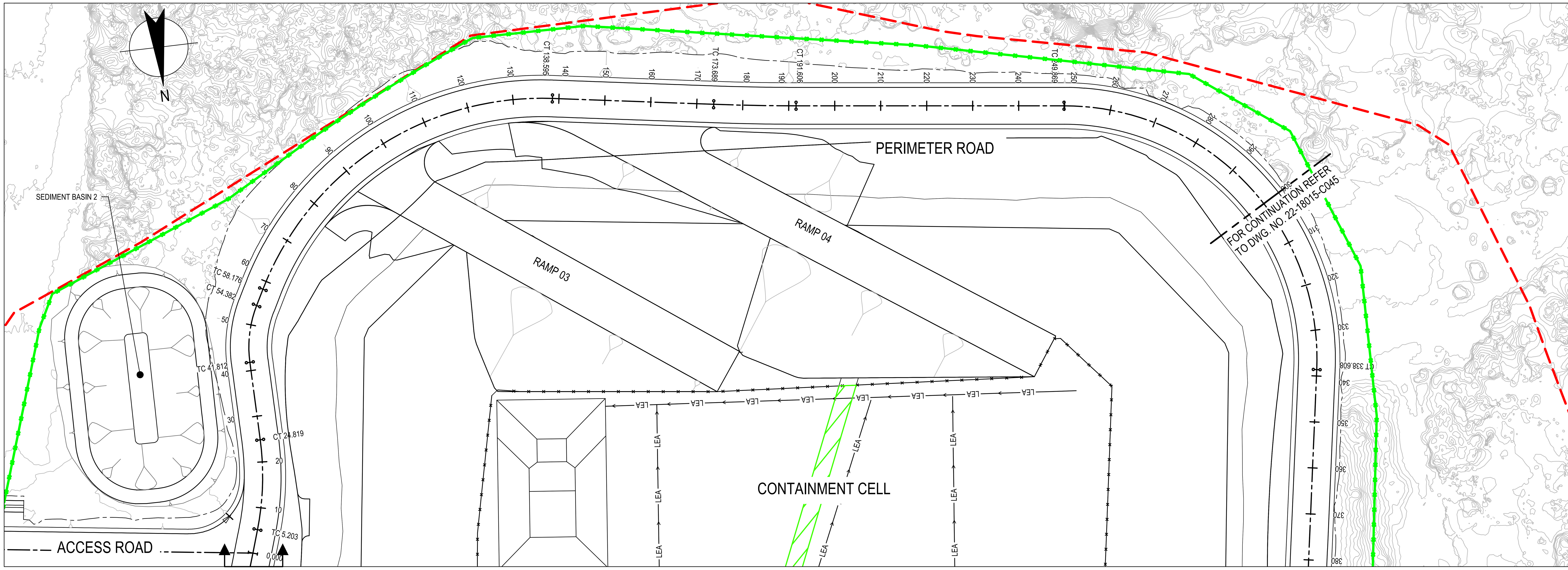
DO NOT SCALE

Drawn J. CASIO | Designer P. ETCHELLS
Drafting Check P. PRASAD | Design Check A. ROBERTS
Approved (Project Director) I. GREGSON*
Date 26.09.19
Scale AS SHOWN
This Drawing must not be used for Construction unless signed as Approved

Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **ACCESS ROAD LONGITUDINAL SECTION**

Original Size A1 | Drawing No: **22-18015-C043** | Rev: 0

Plot Date: 27 September 2019 - 9:53 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C043.dwg



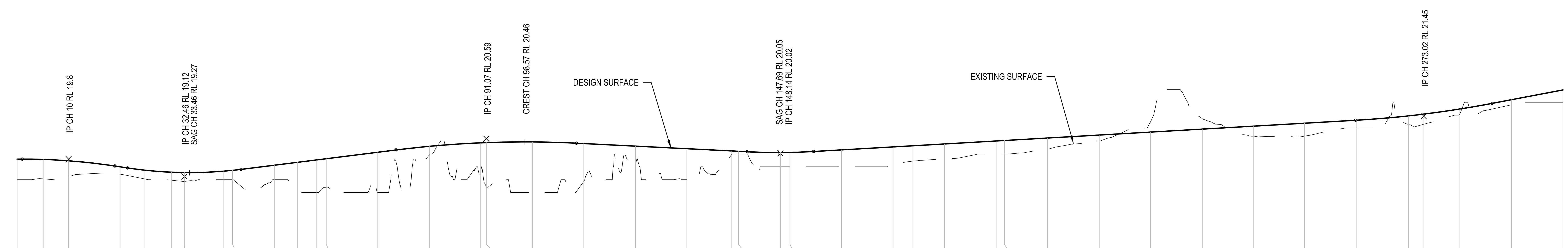
START OF WORKS
(INTERSECTION POINT BETWEEN ACCESS ROAD AND PERIMETER ROAD CHAINAGE 0.00)

PERIMETER ROAD (ROAD02) SETOUT POINTS

CHAINAGE	EASTING	NORTHING	HEIGHT
0.000	357160.163	6371406.552	19.798
5.203	357158.619	6371401.584	19.783
15.011	357155.682	6371392.134	19.634
24.819	357155.935	6371382.241	19.367
41.812	357156.369	6371365.253	19.361
48.097	357156.534	6371358.834	19.515
54.382	357153.585	6371353.131	19.672
58.176	357151.842	6371349.760	19.767
98.385	357130.591	6371308.662	20.745
138.595	357084.800	6371315.284	20.900
173.689	357050.067	6371320.308	20.900
182.647	357041.200	6371321.590	20.900
191.606	357032.292	6371322.551	20.900
249.869	356974.365	6371328.798	21.188
294.239	356917.300	6371334.952	22.261
338.608	356925.880	6371391.703	23.947
389.734	356933.523	6371442.255	25.238
405.888	356935.939	6371458.234	25.288
422.043	356937.308	6371474.336	25.164
456.865	356940.257	6371509.033	24.530
504.962	356945.283	6371568.166	23.673
553.060	357004.628	6371568.527	23.391
674.771	357126.336	6371569.267	23.191
713.435	357178.523	6371569.585	22.437
752.100	357171.160	6371517.920	21.470
776.063	357167.780	6371494.196	20.930
791.230	357165.636	6371479.151	20.682
806.396	357165.848	6371463.955	20.454
832.695	357166.217	6371437.660	20.060
843.732	357166.373	6371426.531	19.902
854.770	357163.069	6371415.902	19.812
864.561	357160.163	6371406.552	

PLAN

SCALE 1:500



DATUM RL. 16.00

VERTICAL ALIGNMENT: L=1m G=0% | K=6 L=18m | L=2.46m G=-3% | K=4 L=22m | L=30.11m G=2.5% | K=10 L=35m | L=33.12m G=-1% | K=6 L=12.9m | L=105.18m G=1.15% | K=10 L=26.5m | L=59.23m G=3.8%

HORIZONTAL ALIGNMENT: L=5.20m | L=19.62m R=-60.00m | L=16.99m | L=12.57m R=25.00m | L=3.79m | L=80.42m R=65.00m | L=35.09m | L=17.92m R=-495.00m | L=58.26m | L=88.74m R=55.00m

CHAINAGE	EXISTING SURFACE LEVEL	DESIGN SURFACE LEVEL	LEVEL DIFFERENCE CUT - / FILL +
0.00	19.00	19.798	0.80
5.20	19.03	19.783	0.75
10.00	19.12	19.730	0.61
20.00	19.21	19.498	0.28
24.82	19.03	19.367	0.34
30.00	18.98	19.289	0.31
32.46	18.93	19.275	0.35
40.00	19.00	19.327	0.33
41.81	19.00	19.361	0.36
50.00	19.00	19.563	0.56
54.38	18.62	19.672	1.05
58.18	18.50	19.767	1.27
60.00	18.70	19.813	1.11
70.00	18.50	20.063	1.56
80.00	19.96	20.292	0.33
90.00	19.23	20.428	1.20
91.07	18.71	20.436	1.72
100.00	18.50	20.463	1.96
110.00	18.93	20.400	1.47
120.00	19.58	20.300	0.72
130.00	19.00	20.200	1.20
138.59	19.96	20.114	0.16
140.00	20.00	20.100	0.10
148.14	19.50	20.053	0.55
150.00	19.50	20.058	0.56
160.00	19.50	20.155	0.66
170.00	19.56	20.270	0.71
173.69	19.71	20.312	0.60
180.00	19.80	20.385	0.59
190.00	20.00	20.500	0.50
191.61	20.00	20.518	0.52
200.00	20.18	20.615	0.43
210.00	20.50	20.730	0.23
220.00	21.26	20.845	-0.41
230.00	21.36	20.960	-0.40
240.00	20.69	21.075	0.39
249.87	20.69	21.188	0.50
260.00	21.00	21.305	0.31
270.00	21.12	21.472	0.35
273.02	21.15	21.542	0.39
280.00	21.55	21.740	0.19
290.00	21.90	22.100	0.20
300.00	22.00	22.480	0.48

LONGITUDINAL SECTION

SCALE HOR. 1:500 VERT. 1:100

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
0	ISSUED FOR CONSTRUCTION	RK	AR	IG	29.09.19

Note: * indicates signatures on original issue of drawing or last revision of drawing

VERTICAL 1:100 AT ORIGINAL SIZE 0 1 2 3 4 5m
HORIZONTAL 1:500 AT ORIGINAL SIZE 0 5 10 15 20 25m

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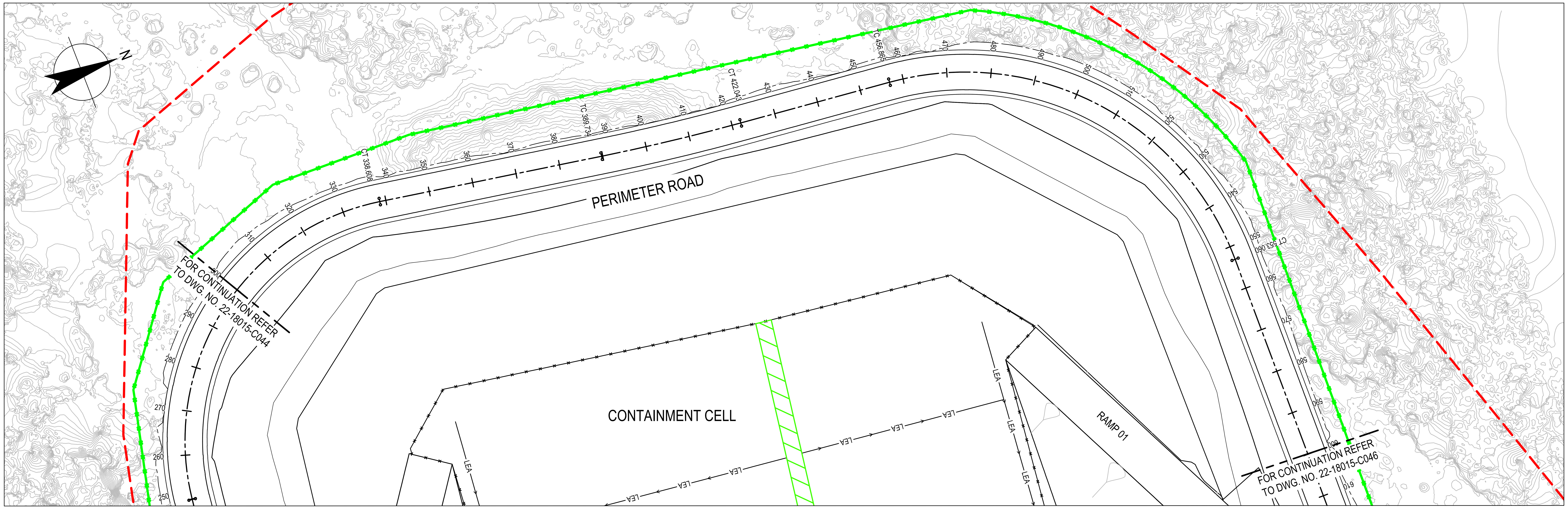
DO NOT SCALE

Drawn J. CASIO | Designer P. ETCHELLS
Drafting Check P. PRASAD | Design Check A. ROBERTS
Approved (Project Director) I. GREGSON*
Date 26.09.19
Scale AS SHOWN
This Drawing must not be used for Construction unless signed as Approved

Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **PERIMETER ROAD LONGITUDINAL SECTION - SHEET 1 OF 3**
Original Size **A1** Drawing No: **22-18015-C044** Rev: **0**

Plot Date: 27 September 2019 - 9:53 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C044.dwg

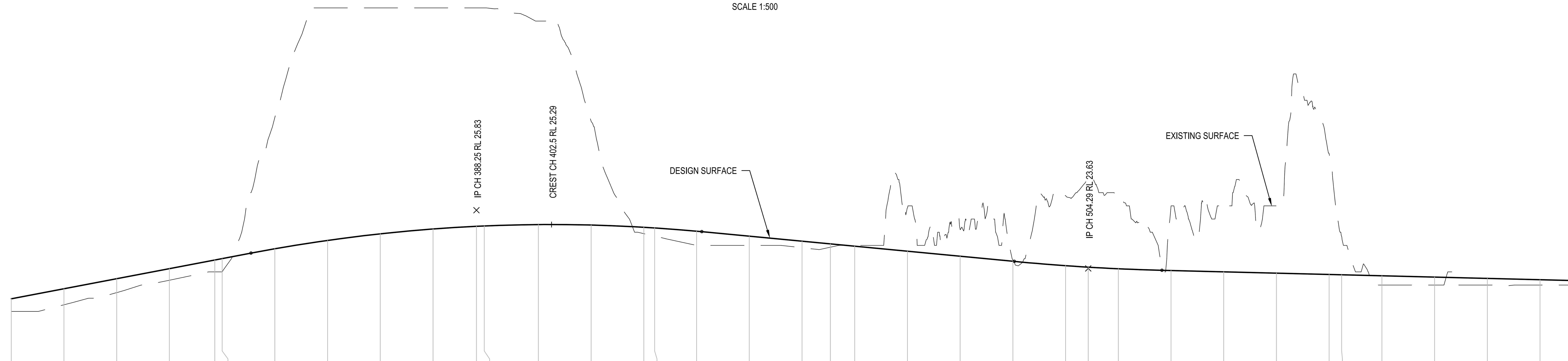


PLAN

SCALE 1:500

NOTE:

1. REFER DRG. 22-18015-C044 FOR SETOUT TABLE.



DATUM RL. 20.00

VERTICAL ALIGNMENT: L=59.23m G=3.8% | K=15 L=85.5m | L=59.29m G=-1.9% | K=20 L=28m | L=94.21m G=-0.5%

HORIZONTAL ALIGNMENT: L=88.74m R=55.00m | L=51.13m | L=32.31m R=-495.00m | L=33.34m | L=96.98m R=65.00m | L=121.17m

CHAINAGE	LEVEL DIFFERENCE CUT - / FILL +	DESIGN SURFACE LEVEL	EXISTING SURFACE LEVEL
300.00	0.48	22.480	22.00
310.00	0.61	22.860	22.25
320.00	0.53	23.240	22.71
330.00	0.44	23.620	23.18
338.61	0.45	23.947	23.50
340.00	0.50	24.000	23.50
350.00	-4.97	24.373	29.35
360.00	-8.81	24.690	33.50
370.00	-8.56	24.940	33.50
380.00	-8.38	25.123	33.50
388.25	-8.28	25.224	33.50
389.73	-8.26	25.238	33.50
400.00	-7.71	25.290	33.00
410.00	-3.93	25.273	29.20
420.00	0.24	25.190	24.95
422.04	0.31	25.164	24.85
430.00	0.54	25.040	24.50
440.00	0.35	24.850	24.50
450.00	0.25	24.660	24.41
455.38	0.12	24.558	24.43
460.00	-0.03	24.470	24.50
470.00	-1.64	24.280	25.92
480.00	-1.02	24.090	25.11
490.00	-0.05	23.900	23.95
500.00	-2.65	23.734	26.39
504.29	-3.32	23.678	26.99
510.00	-2.70	23.617	26.31
520.00	-2.44	23.550	25.99
530.00	-2.35	23.500	25.85
540.00	-2.55	23.450	26.00
550.00	-4.57	23.400	27.97
552.36	-1.45	23.388	24.84
560.00	0.35	23.350	23.00
570.00	0.30	23.300	23.00
580.00	0.25	23.250	23.00
590.00	0.20	23.200	23.00
600.00	0.15	23.150	23.00

LONGITUDINAL SECTION

SCALE HOR. 1:500 VERT. 1:100

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
0	ISSUED FOR CONSTRUCTION	RK	AR	IG	29.09.19

Note: * indicates signatures on original issue of drawing or last revision of drawing

VERTICAL 1:100 AT ORIGINAL SIZE 0 1 2 3 4 5m

HORIZONTAL 1:500 AT ORIGINAL SIZE 0 5 10 15 20 25m

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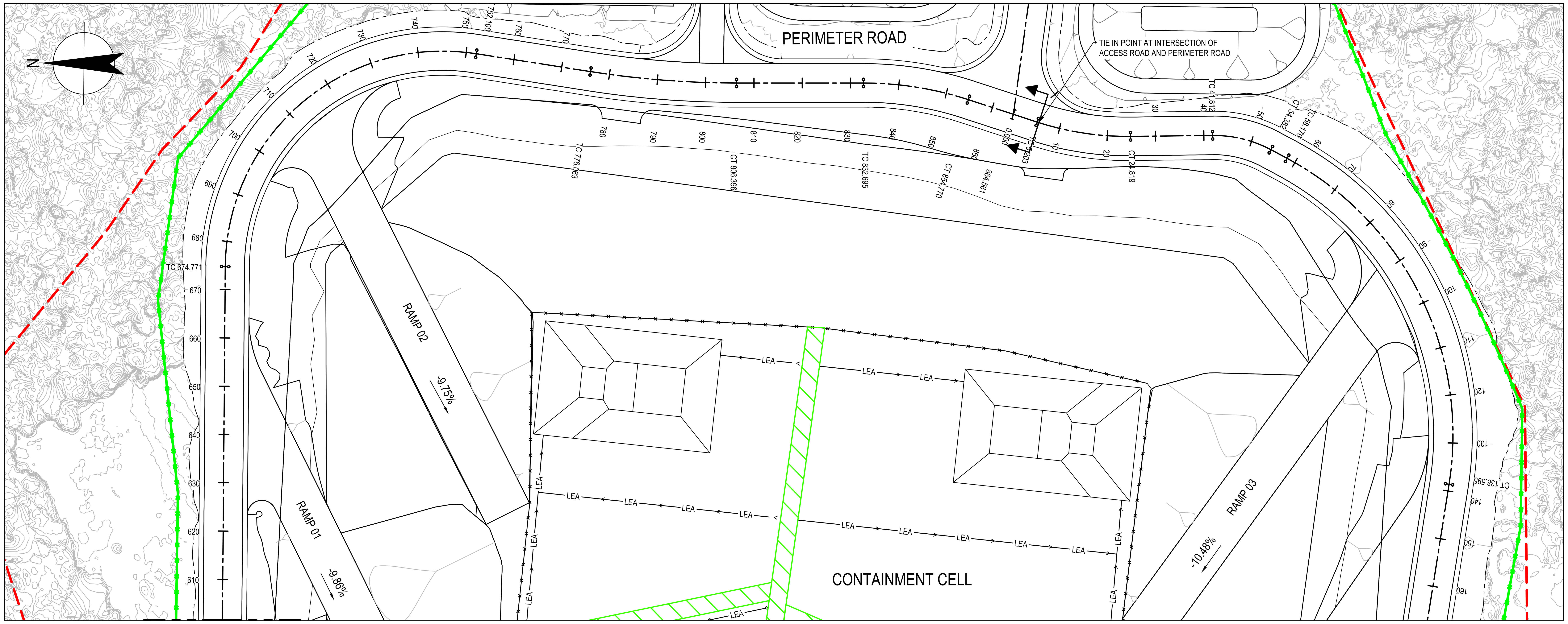
DO NOT SCALE

Drawn J. CASIO | Designer P. ETCHELLS
Drafting Check P. PRASAD | Design Check A. ROBERTS
Approved (Project Director) I. GREGSON*
Date 26.09.19
Scale AS SHOWN
This Drawing must not be used for Construction unless signed as Approved

Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **PERIMETER ROAD LONGITUDINAL SECTION - SHEET 2 OF 3**

Original Size A1 | Drawing No: **22-18015-C045** | Rev: **0**

Plot Date: 27 September 2019 - 9:53 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C045.dwg



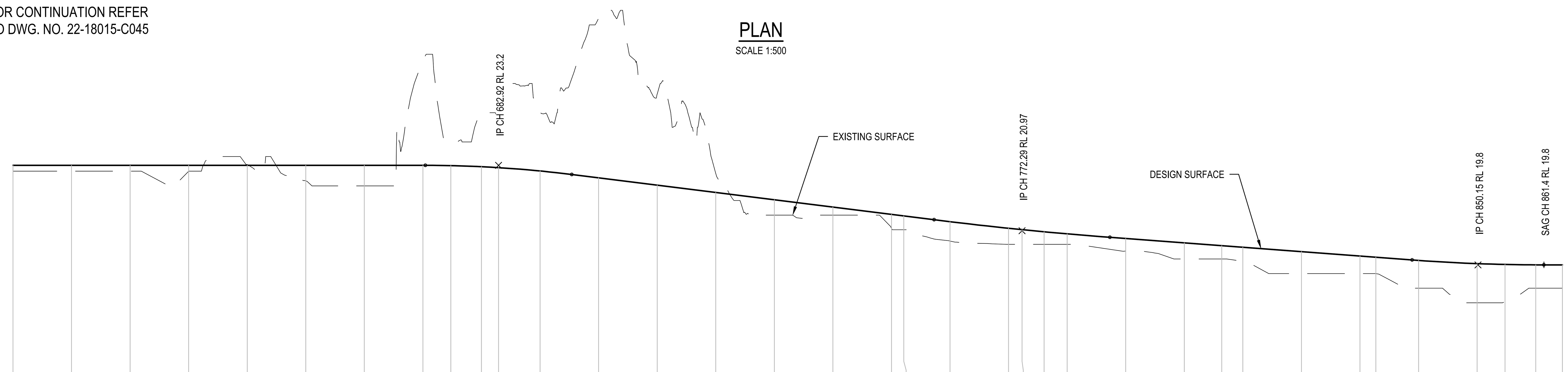
FOR CONTINUATION REFER TO DWG. NO. 22-18015-C045

PLAN

SCALE 1:500

NOTE:

1. REFER DRG. 22-18015-C044 FOR SETOUT TABLE.



VERTICAL ALIGNMENT: L=71.61m G=0% | K=10 L=25m | L=61.88m G=-2.5% | K=30 L=30m | L=51.6m G=-1.5% | K=15 L=22.5m | L=3.16m G=0%

HORIZONTAL ALIGNMENT: L=121.71m | L=77.33m R=45.00m | L=23.96m | L=30.33m R=-195.00m | L=26.30m | L=22.07m R=70.00m | L=9.79m

CHAINAGE	600.00	610.00	620.00	630.00	640.00	650.00	660.00	670.00	674.77	680.00	682.92	690.00
LEVEL DIFFERENCE CUT - / FILL +	0.20	0.20	0.20	0.20	-0.03	0.53	0.70	-3.55	-0.81	-1.85	-1.68	-1.99
DESIGN SURFACE LEVEL	23.200	23.200	23.200	23.200	23.200	23.200	23.200	23.200	23.191	23.154	23.122	23.008
EXISTING SURFACE LEVEL	23.00	23.00	23.00	23.00	23.23	22.67	22.50	26.75	24.00	25.00	24.80	25.00

CHAINAGE	700.00	710.00	720.00	730.00	740.00	750.00	752.10	760.00	770.00	772.29	776.06	780.00
LEVEL DIFFERENCE CUT - / FILL +	-5.46	-3.12	-0.65	0.52	0.27	0.46	0.47	0.66	0.55	0.50	0.43	0.36
DESIGN SURFACE LEVEL	22.773	22.523	22.273	22.023	21.773	21.523	21.470	21.274	21.050	21.003	20.930	20.859
EXISTING SURFACE LEVEL	28.23	25.64	22.93	21.50	21.50	21.06	21.00	20.61	20.50	20.50	20.50	20.50

CHAINAGE	790.00	800.00	806.40	810.00	820.00	830.00	832.69	840.00	850.00	854.77	860.00	864.56
LEVEL DIFFERENCE CUT - / FILL +	0.43	0.55	0.45	0.48	0.75	0.60	0.56	0.95	1.34	1.27	0.80	0.80
DESIGN SURFACE LEVEL	20.700	20.550	20.454	20.400	20.250	20.100	20.060	19.950	19.841	19.812	19.798	19.798
EXISTING SURFACE LEVEL	20.27	20.00	20.00	19.92	19.50	19.50	19.50	19.00	18.50	18.54	19.00	19.00

LONGITUDINAL SECTION

SCALE HOR. 1:500 VERT. 1:100

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
0	ISSUED FOR CONSTRUCTION	RK	AR	IG	29.09.19

Note: * indicates signatures on original issue of drawing or last revision of drawing

VERTICAL 1:100 AT ORIGINAL SIZE 0 1 2 3 4 5m

HORIZONTAL 1:500 AT ORIGINAL SIZE 0 5 10 15 20 25m

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DO NOT SCALE

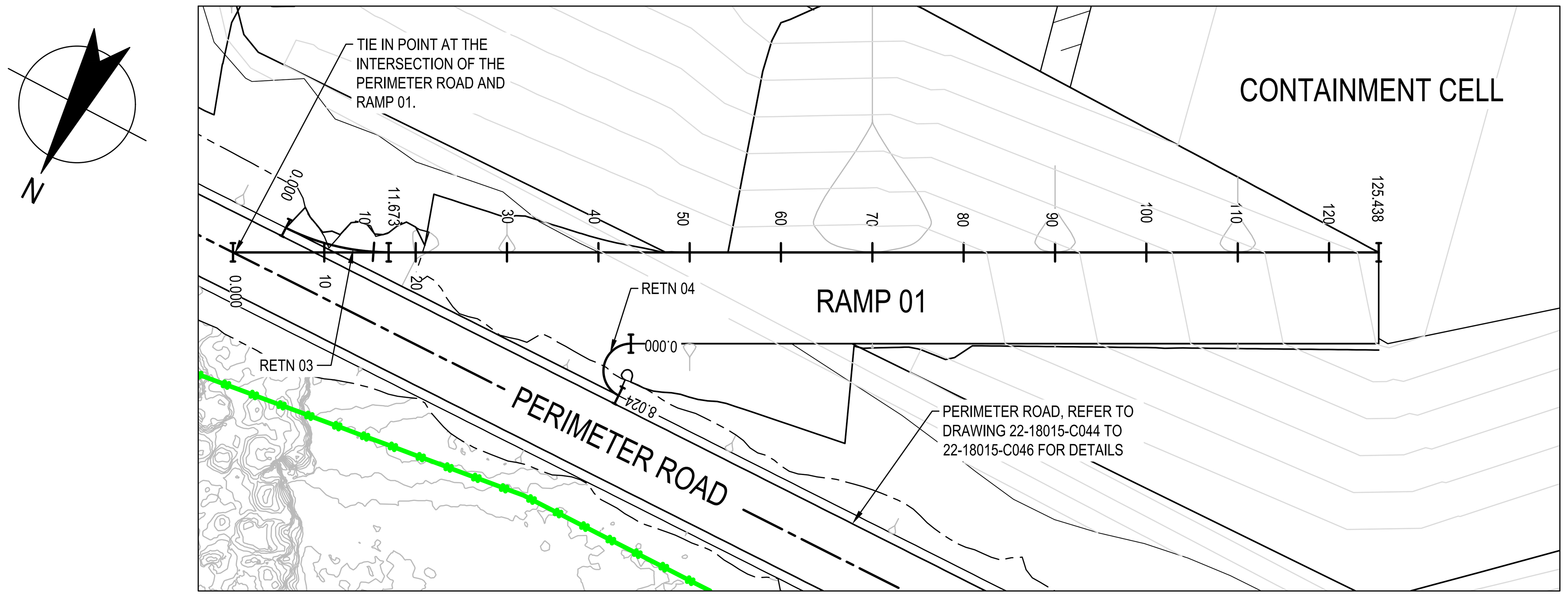
Drawn J. CASIO | Designer P. ETCHELLS
Drafting Check P. PRASAD | Design Check A. ROBERTS
Approved (Project Director) I. GREGSON*
Date 26.09.19
Scale AS SHOWN

This Drawing must not be used for Construction unless signed as Approved

Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **PERIMETER ROAD LONGITUDINAL SECTION - SHEET 3 OF 3**

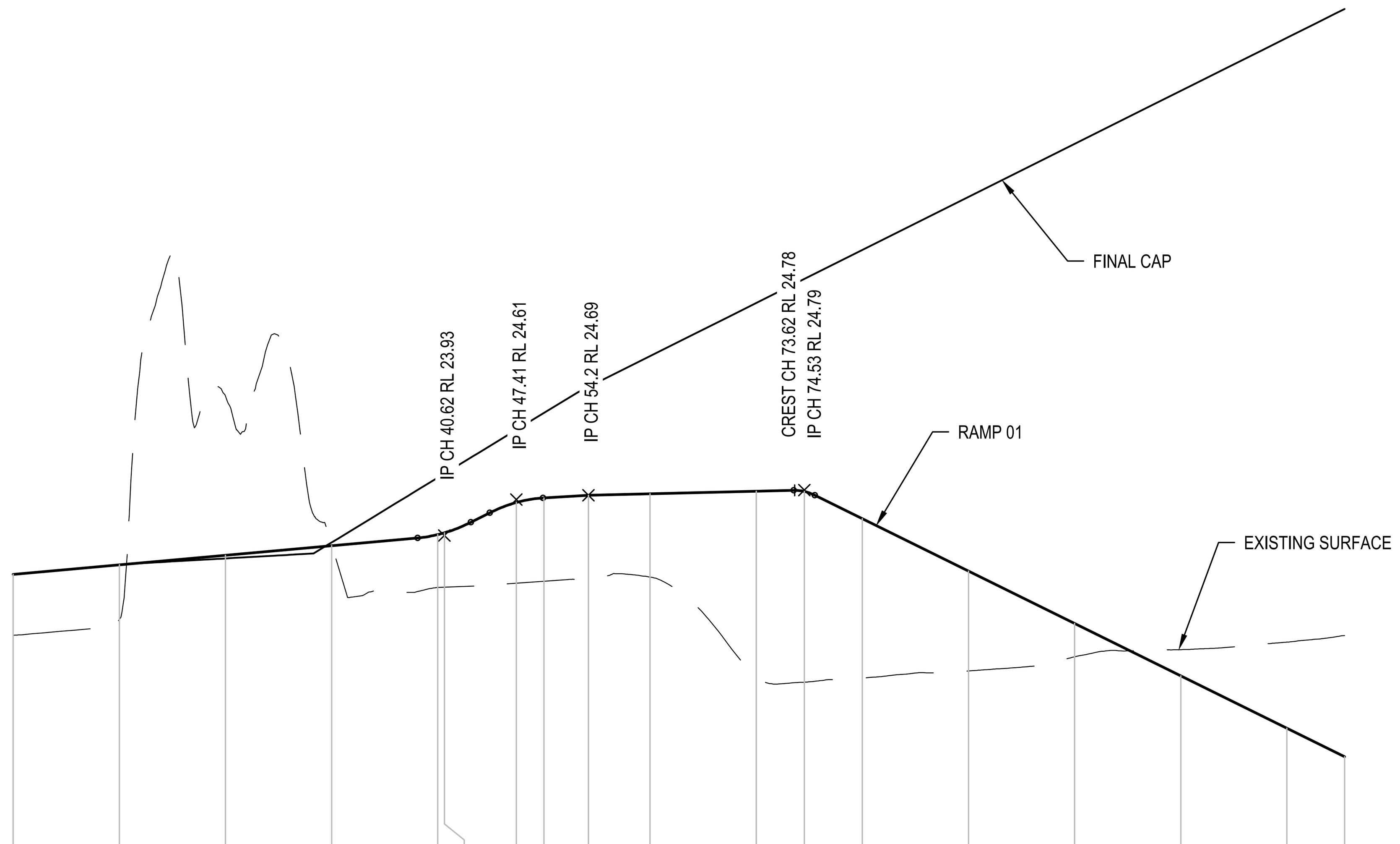
Original Size A1 Drawing No: **22-18015-C046** Rev: **0**

Plot Date: 27 September 2019 - 9:53 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C046.dwg



PLAN - RAMP 01

SCALE 1:500



DATUM RL. 18.00

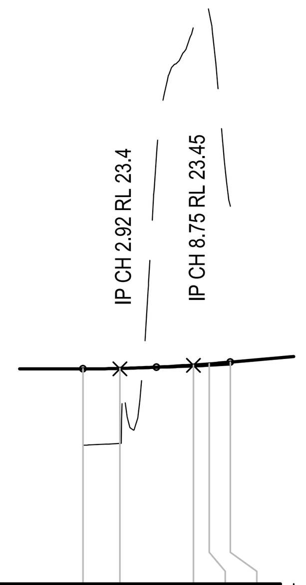
VERTICAL ALIGNMENT: L=38.12m G=1.8% | K=0.61 L=5m | L=1.79m G=10% | K=0.57 L=5m | L=4.29m G=1.17% | L=19.34m G=0.48% | K=0.19 L=2m | L=49.91m G=-9.86%

HORIZONTAL ALIGNMENT: L=125.44m

LEVEL DIFFERENCE CUT - / FILL +	1.15	1.03	-3.00	-0.01	1.00	1.02	1.52	1.57	1.58	1.57	3.48	3.59	3.00	1.88	0.63	-0.49	-1.62	-2.28
DESIGN SURFACE LEVEL	23.200	23.380	23.560	23.740	23.949	23.983	24.555	24.641	24.690	24.718	24.766	24.762	24.248	23.262	22.276	21.289	20.303	19.767
EXISTING SURFACE LEVEL	22.05	22.35	26.56	23.75	22.95	22.96	23.03	23.07	23.11	23.15	21.28	21.17	21.25	21.38	21.65	21.78	21.92	22.05
CHAINAGE	0.00	10.00	20.00	30.00	40.00	40.62	47.41	50.00	54.20	60.00	70.00	74.53	80.00	90.00	100.00	110.00	120.00	125.44

LONGITUDINAL SECTION - RAMP 01

SCALE HOR. 1:500 VERT. 1:100



DATUM RL. 20.00

VERTICAL ALIGNMENT: L=5m G=0% | K=6.25 L=5.84m | G=0.93% | K=6.73 L=5.84m | L=5m G=1.8%

HORIZONTAL ALIGNMENT: L=11.67m R=-25.00m

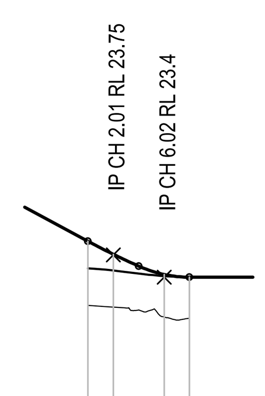
LEVEL DIFFERENCE CUT - / FILL +	1.21	1.19	-5.34	-5.55	-2.46
DESIGN SURFACE LEVEL	23.400	23.407	23.461	23.479	23.507
EXISTING SURFACE LEVEL	22.19	22.22	28.81	29.02	25.97
CHAINAGE	0.00	2.92	8.75	10.00	11.67

LONGITUDINAL SECTION - RETURN 03

SCALE HOR. 1:500 VERT. 1:100

RETURN 03 SETOUT POINTS

CHAINAGE	EASTING	NORTHING	HEIGHT
0.000	357115.793	6371564.203	23.400
5.836	357109.849	6371564.167	23.427
11.673	357104.557	6371561.459	23.507



DATUM RL. 21.00

VERTICAL ALIGNMENT: L=5m G=-10.79% | K=1.97 L=4.01m | G=-8.75% | K=0.46 L=4.01m | L=5m G=0%

HORIZONTAL ALIGNMENT: L=8.02m R=-3.00m

LEVEL DIFFERENCE CUT - / FILL +	1.01	0.83	0.68	0.64
DESIGN SURFACE LEVEL	23.968	23.761	23.444	23.400
EXISTING SURFACE LEVEL	22.95	22.93	22.76	22.76
CHAINAGE	0.00	2.01	6.02	8.02

LONGITUDINAL SECTION - RETURN 04

SCALE HOR. 1:500 VERT. 1:100

RETURN 04 SETOUT POINTS

CHAINAGE	EASTING	NORTHING	HEIGHT
0.000	357076.402	6371558.285	23.968
2.006	357078.512	6371559.364	23.761
4.012	357077.950	6371561.667	23.576
6.018	357077.388	6371563.970	23.444
8.024	357075.017	6371563.955	23.400

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
0	ISSUED FOR CONSTRUCTION	RK	AR	IG	29.09.19

Note: * indicates signatures on original issue of drawing or last revision of drawing

VERTICAL 1:100 AT ORIGINAL SIZE 0 1 2 3 4 5m

HORIZONTAL 1:500 AT ORIGINAL SIZE 0 5 10 15 20 25m

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Drawn J. CASIO | Designer P. ETCHELLS

Drafting Check P. PRASAD | Design Check A. ROBERTS

Approved (Project Director) I. GREGSON*

Date 26.09.19

Scale AS SHOWN

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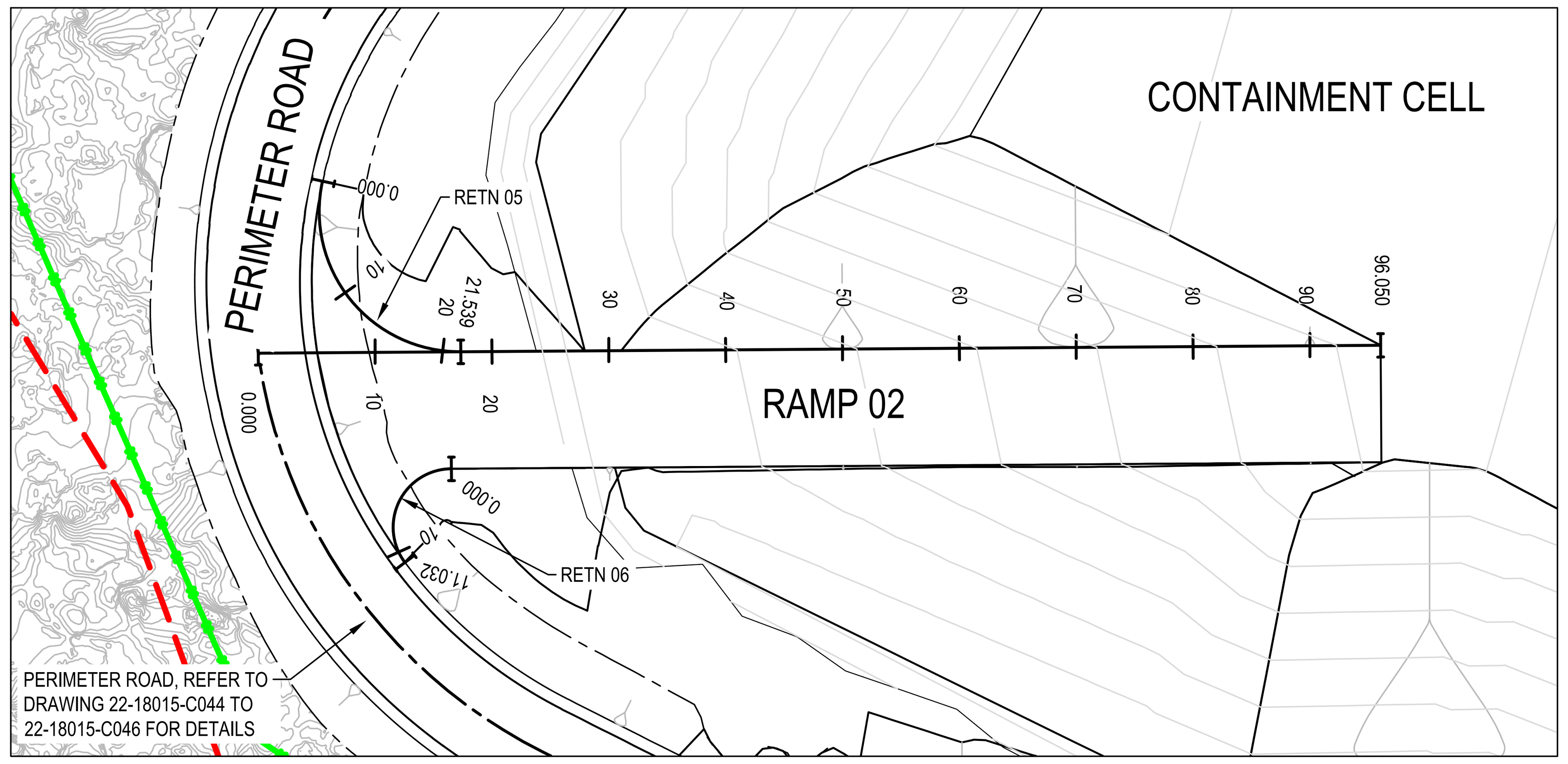
Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**

Project **CONTAINMENT CELL DETAILED DESIGN**

Title **RAMP01 LONGITUDINAL SECTIONS SHEET 1 OF 4**

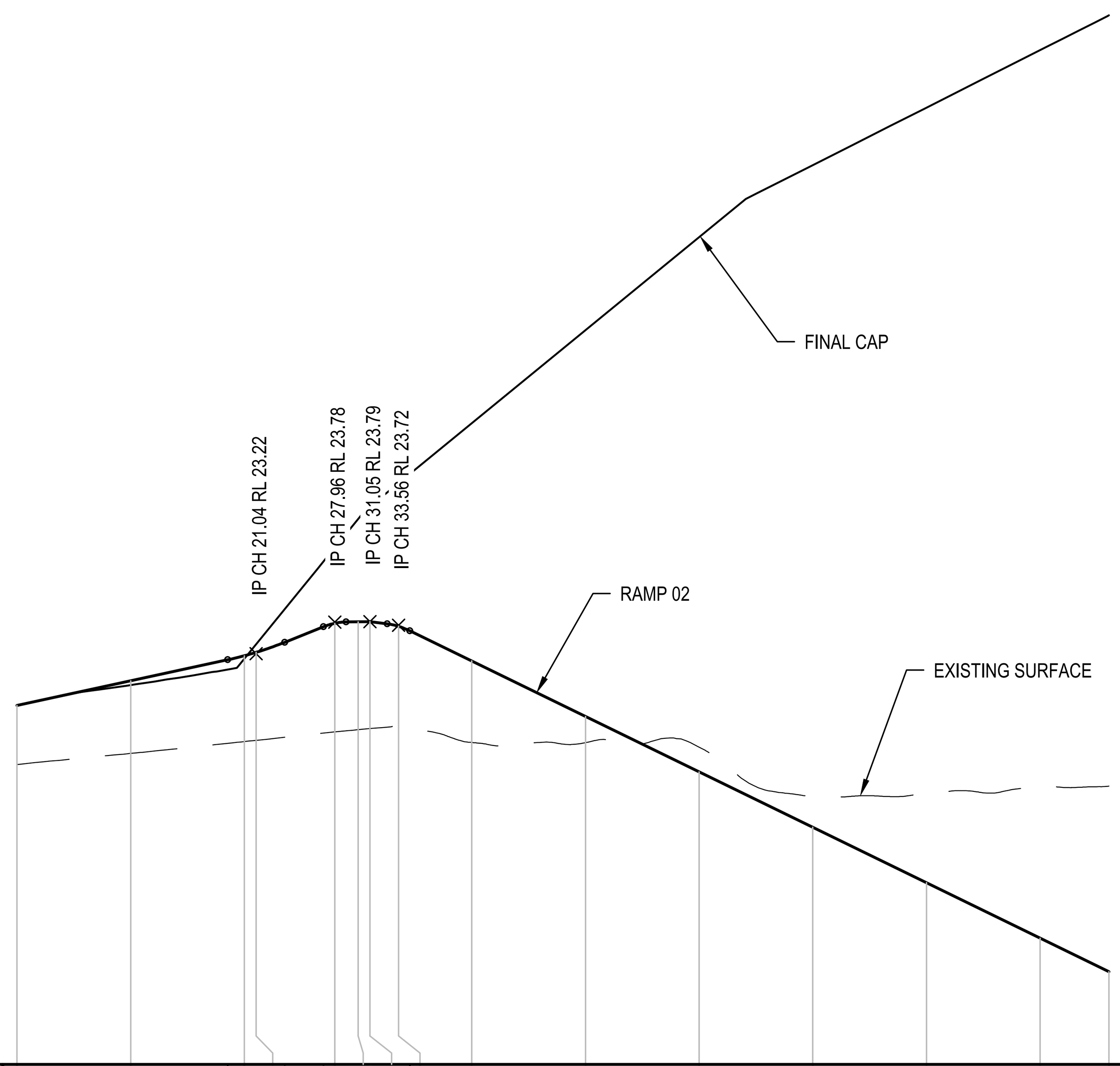
Original Size A1 Drawing No: **22-18015-C047** Rev: 0

Plot Date: 27 September 2019 - 9:54 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C047.dwg



PLAN - RAMP 02

SCALE 1:500



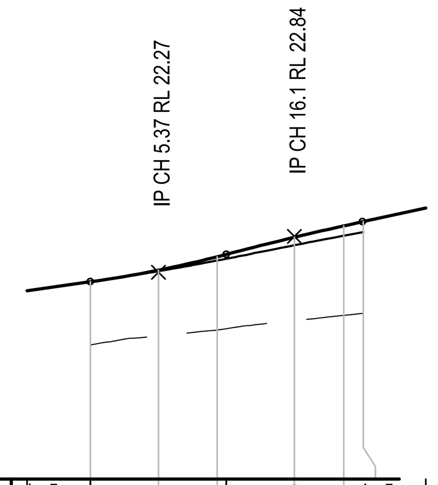
DATUM RL. 16.00

VERTICAL ALIGNMENT	L=18.54m G=4.32%; L=3.42m K=1.36 L=5m G=8%; L=2.1m L=1.51m K=0.26 L=2m G=0.32%; K=0.28 L=2m G=-2.6%; L=61.49m G=-9.75%
HORIZONTAL ALIGNMENT	L=96.05m

CHAINAGE	LEVEL DIFFERENCE CUT - / FILL +	DESIGN SURFACE LEVEL	EXISTING SURFACE LEVEL
0.00	1.04	22.315	21.27
10.00	1.28	22.747	21.47
20.00	1.51	23.187	21.68
21.04	1.55	23.247	21.70
27.96	1.91	23.758	21.85
30.00	1.90	23.784	21.89
31.05	1.88	23.788	21.91
33.56	1.76	23.705	21.95
40.00	1.43	23.095	21.66
50.00	0.46	22.120	21.66
60.00	-0.44	21.145	21.58
70.00	-0.54	20.171	20.71
80.00	-1.57	19.196	20.76
90.00	-2.66	18.221	20.88
96.05	-3.26	17.632	20.89

LONGITUDINAL SECTION - RAMP 02

SCALE HOR. 1:500 VERT. 1:100



DATUM RL. 19.00

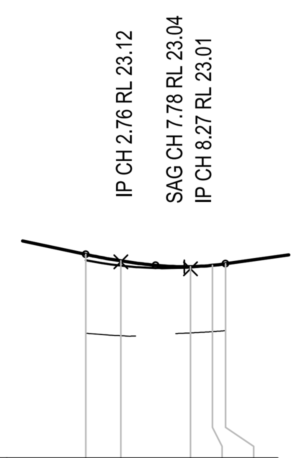
VERTICAL ALIGNMENT	L=5m G=2.81%; K=4.37 L=10.73m G=5.27%; K=11.39 L=10.73m; L=5m G=4.32%
HORIZONTAL ALIGNMENT	L=21.54m R=-12.00m

CHAINAGE	LEVEL DIFFERENCE CUT - / FILL +	DESIGN SURFACE LEVEL	EXISTING SURFACE LEVEL
0.00	1.00	22.119	21.12
5.37	1.04	22.303	21.26
10.00	1.16	22.515	21.36
16.10	1.32	22.823	21.50
20.00	1.42	23.003	21.59
21.54	1.45	23.070	21.62

LONGITUDINAL SECTION - RETURN 05

SCALE HOR. 1:500 VERT. 1:100

RETURN 05 SETOUT POINTS			
CHAINAGE	EASTING	NORTHING	HEIGHT
0.000	357165.308	6371534.393	22.119
10.770	357161.500	6371548.947	22.555
21.539	357148.157	6371541.999	23.070



DATUM RL. 20.00

VERTICAL ALIGNMENT	L=5m G=-4.27%; K=2.39 L=5.52m G=-1.96%; K=1.16 L=5.52m; L=5m G=2.81%
HORIZONTAL ALIGNMENT	L=11.03m R=-5.00m

CHAINAGE	LEVEL DIFFERENCE CUT - / FILL +	DESIGN SURFACE LEVEL	EXISTING SURFACE LEVEL
0.00	1.25	23.233	21.99
2.76	1.18	23.131	21.95
8.27	1.05	23.040	21.99
10.00	1.05	23.060	22.01
11.03	1.06	23.085	22.03

LONGITUDINAL SECTION - RETURN 06

SCALE HOR. 1:500 VERT. 1:100

RETURN 06 SETOUT POINTS			
CHAINAGE	EASTING	NORTHING	HEIGHT
0.000	357144.307	6371551.269	23.233
2.758	357147.036	6371552.690	23.131
5.516	357146.998	6371555.766	23.061
8.274	357146.959	6371558.843	23.040
11.032	357144.196	6371560.195	23.085

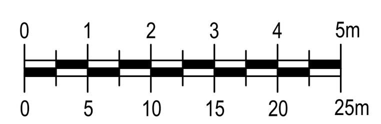
FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
0	ISSUED FOR CONSTRUCTION	RK	AR	IG	29.09.19

Note: * indicates signatures on original issue of drawing or last revision of drawing

VERTICAL 1:100 AT ORIGINAL SIZE

HORIZONTAL 1:500 AT ORIGINAL SIZE



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Drawn	J. CASIO	Designer	P. ETCHELLS
Drafting Check	P. PRASAD	Design Check	A. ROBERTS
Approved (Project Director)	I. GREGSON*		
Date	26.09.19		
Scale	AS SHOWN	This Drawing must not be used for Construction unless signed as Approved	

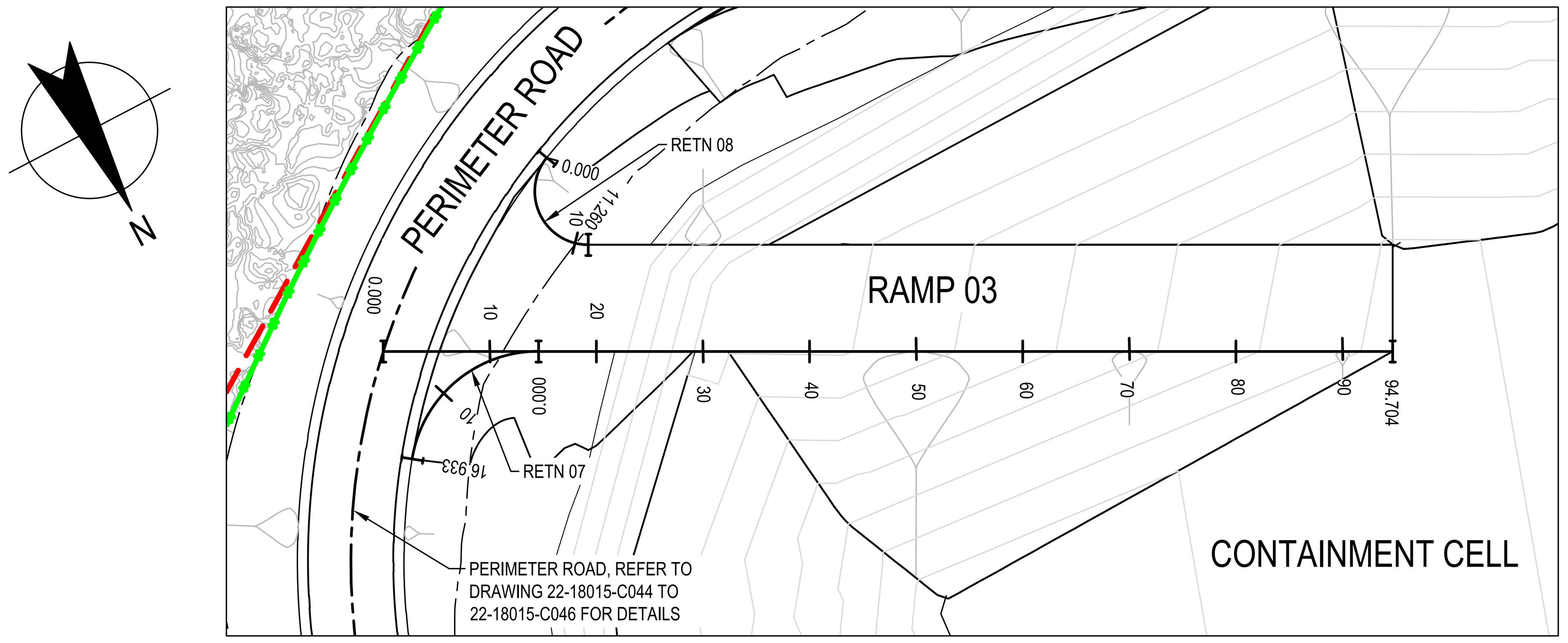
Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**

Project **CONTAINMENT CELL DETAILED DESIGN**

Title **RAMP02 LONGITUDINAL SECTIONS SHEET 2 OF 4**

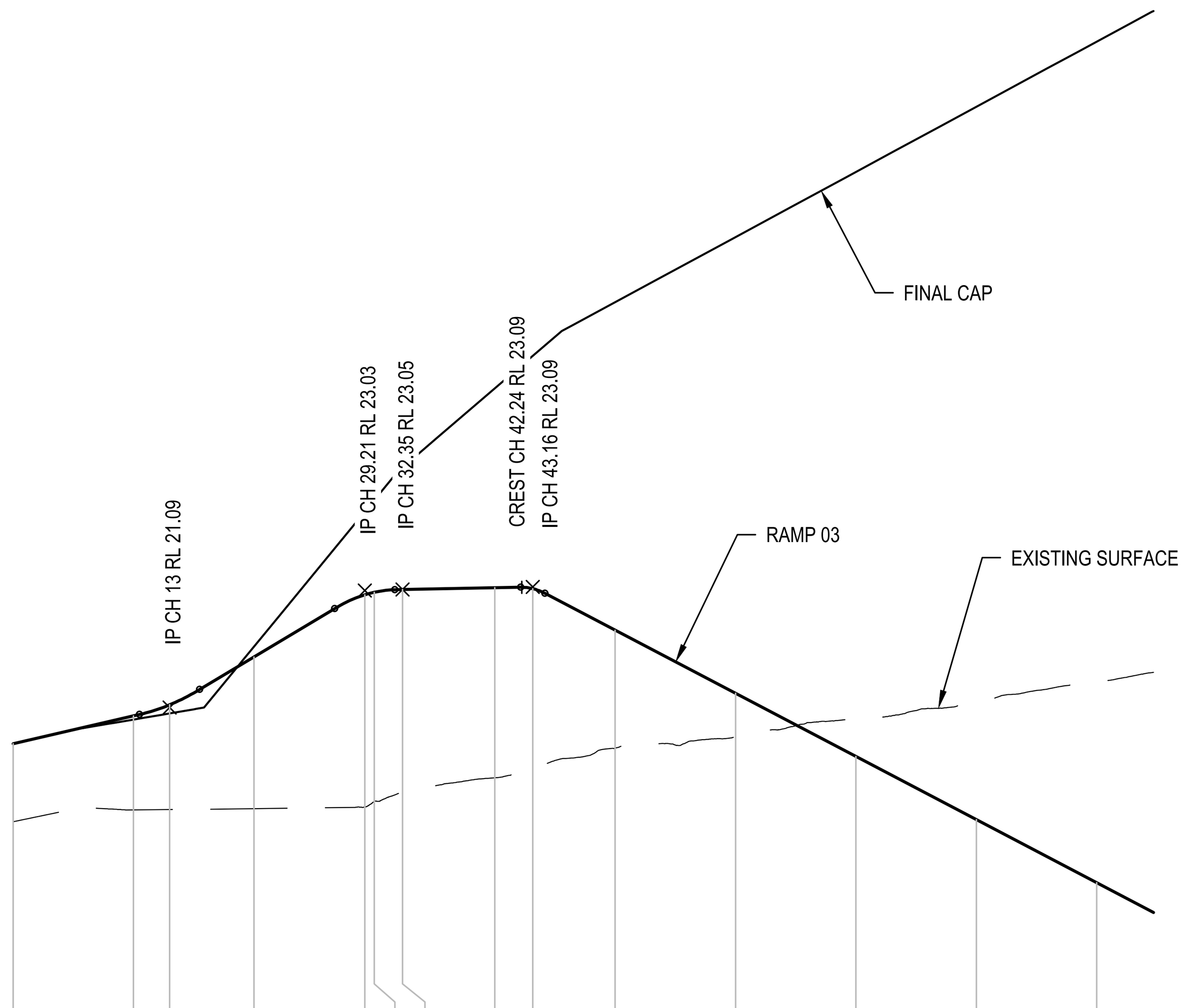
Original Size **A1** Drawing No: **22-18015-C048** Rev: **0**

Plot Date: 27 September 2019 - 9:54 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C048.dwg



PLAN - RAMP 03

SCALE 1:500

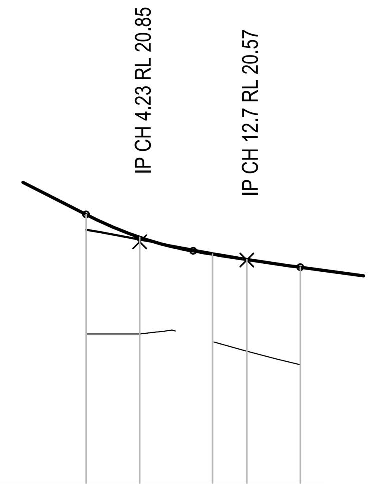


DATUM RL. 16.00

VERTICAL ALIGNMENT	L=10.5m G=4.62%	K=0.68 L=5m	L=11.21m G=12%	L=0.64m K=0.43 L=5m G=0.45%	L=9.81m K=0.18 L=2m G=0.39%	L=50.54m G=-10.48%								
HORIZONTAL ALIGNMENT	L=94.70m													
LEVEL DIFFERENCE CUT - / FILL +	1.29	1.56	1.74	2.52	3.52	3.47	3.36	3.16	3.01	1.96	0.72	-0.62	-1.95	-3.33
DESIGN SURFACE LEVEL	20.490	20.951	21.136	21.930	22.963	23.005	23.049	23.079	23.064	22.375	21.326	20.278	19.229	18.181
EXISTING SURFACE LEVEL	19.20	19.39	19.40	19.41	19.44	19.54	19.69	19.92	20.05	20.42	20.60	20.90	21.18	21.51
CHAINAGE	0.00	10.00	13.00	20.00	29.21	30.00	32.35	40.00	43.16	50.00	60.00	70.00	80.00	90.00

LONGITUDINAL SECTION - RAMP 03

SCALE HOR. 1:500 VERT. 1:100



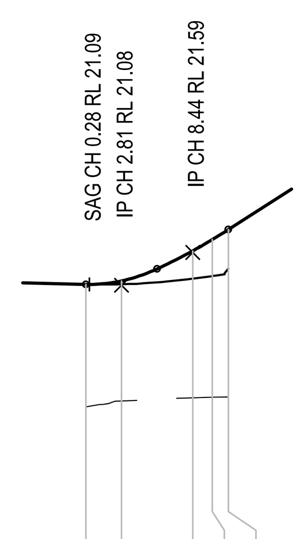
DATUM RL. 17.00

VERTICAL ALIGNMENT	L=5m G=-10.2%	K=1.24 L=8.47m G=-3.4%	K=12.3 L=8.47m	L=5m G=-2.71%	
HORIZONTAL ALIGNMENT	L=16.93m R=-12.00m				
LEVEL DIFFERENCE CUT - / FILL +	1.89	1.53	1.38	1.45	1.54
DESIGN SURFACE LEVEL	21.285	20.925	20.658	20.573	20.451
EXISTING SURFACE LEVEL	19.40	19.40	19.28	19.12	18.91
CHAINAGE	0.00	4.23	10.00	12.70	16.93

LONGITUDINAL SECTION - RETURN 07

SCALE HOR. 1:500 VERT. 1:100

RETURN 07 SETOUT POINTS			
CHAINAGE	EASTING	NORTHING	HEIGHT
0.000	357121.470	6371336.229	21.285
8.466	357129.817	6371330.330	20.709
16.933	357136.969	6371337.632	20.451



DATUM RL. 17.00

VERTICAL ALIGNMENT	L=5m G=-0.49%	K=0.58 L=5.63m G=9.21%	K=1.57 L=5.63m	L=5m G=12.79%	
HORIZONTAL ALIGNMENT	L=11.26m R=-5.00m				
LEVEL DIFFERENCE CUT - / FILL +	1.93	1.90	2.32	2.49	2.64
DESIGN SURFACE LEVEL	21.089	21.144	21.620	21.798	21.954
EXISTING SURFACE LEVEL	19.16	19.25	19.30	19.31	19.31
CHAINAGE	0.00	2.81	8.44	10.00	11.26

LONGITUDINAL SECTION - RETURN 08

SCALE HOR. 1:500 VERT. 1:100

RETURN 08 SETOUT POINTS			
CHAINAGE	EASTING	NORTHING	HEIGHT
0.000	357110.358	6371321.859	21.089
2.815	357113.396	6371322.714	21.144
5.630	357113.931	6371325.824	21.335
8.445	357114.467	6371328.934	21.620
11.260	357111.890	6371330.755	21.954

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
0	ISSUED FOR CONSTRUCTION	RK	AR	IG	29.09.19

Note: * indicates signatures on original issue of drawing or last revision of drawing

VERTICAL 1:100 AT ORIGINAL SIZE 0 1 2 3 4 5m

HORIZONTAL 1:500 AT ORIGINAL SIZE 0 5 10 15 20 25m

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Drawn J. CASIO | Designer P. ETCHELLS
Drafting Check P. PRASAD | Design Check A. ROBERTS
Approved (Project Director) I. GREGSON*
Date 26.09.19
Scale AS SHOWN

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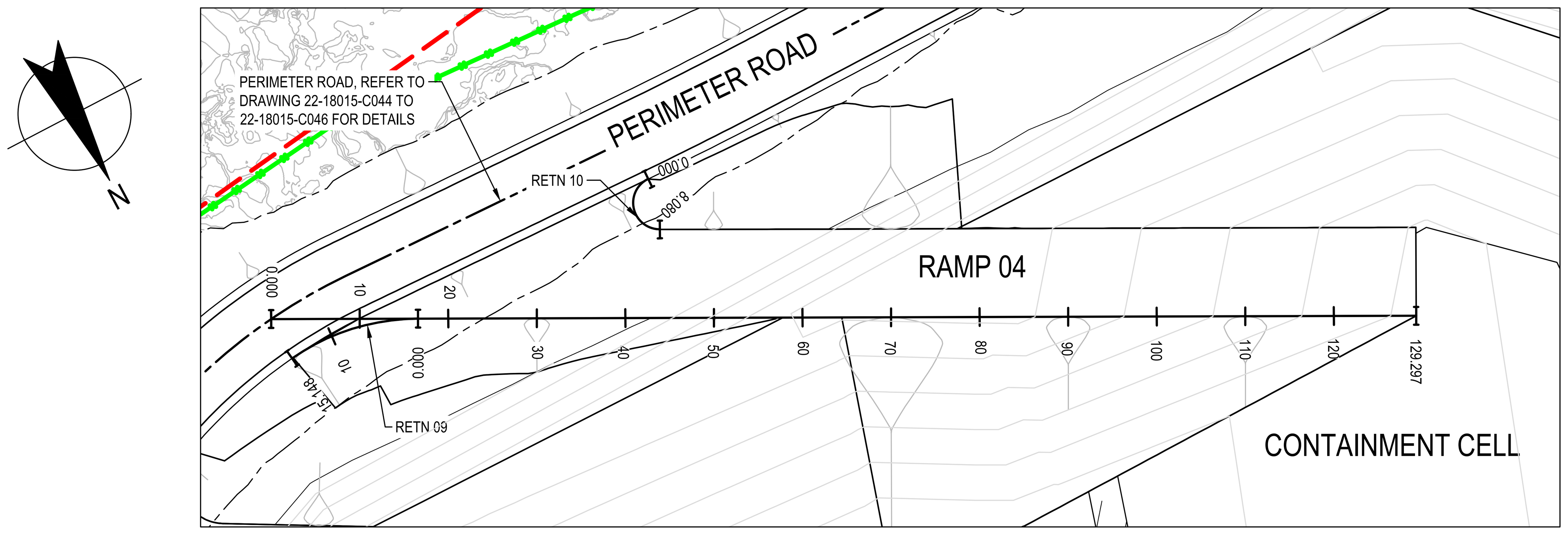
Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **RAMP03 LONGITUDINAL SECTIONS SHEET 3 OF 4**

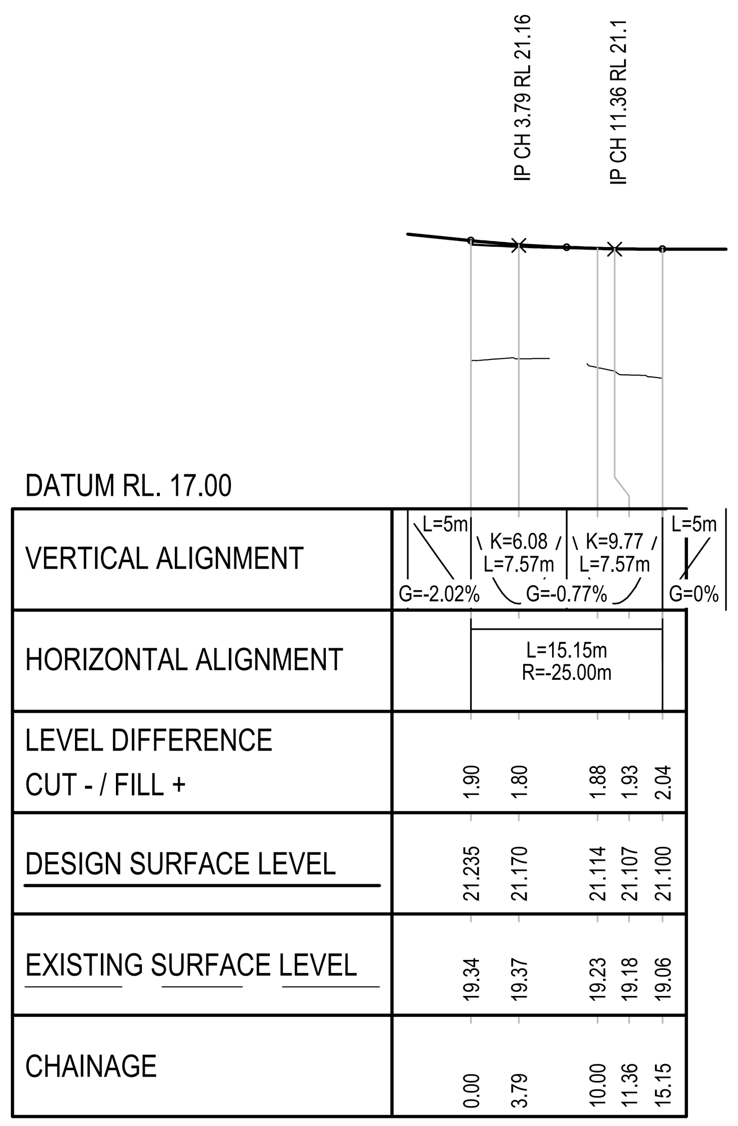
Original Size A1 Drawing No: **22-18015-C049** Rev: 0

Plot Date: 27 September 2019 - 9:54 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C049.dwg



PLAN - RAMP 04

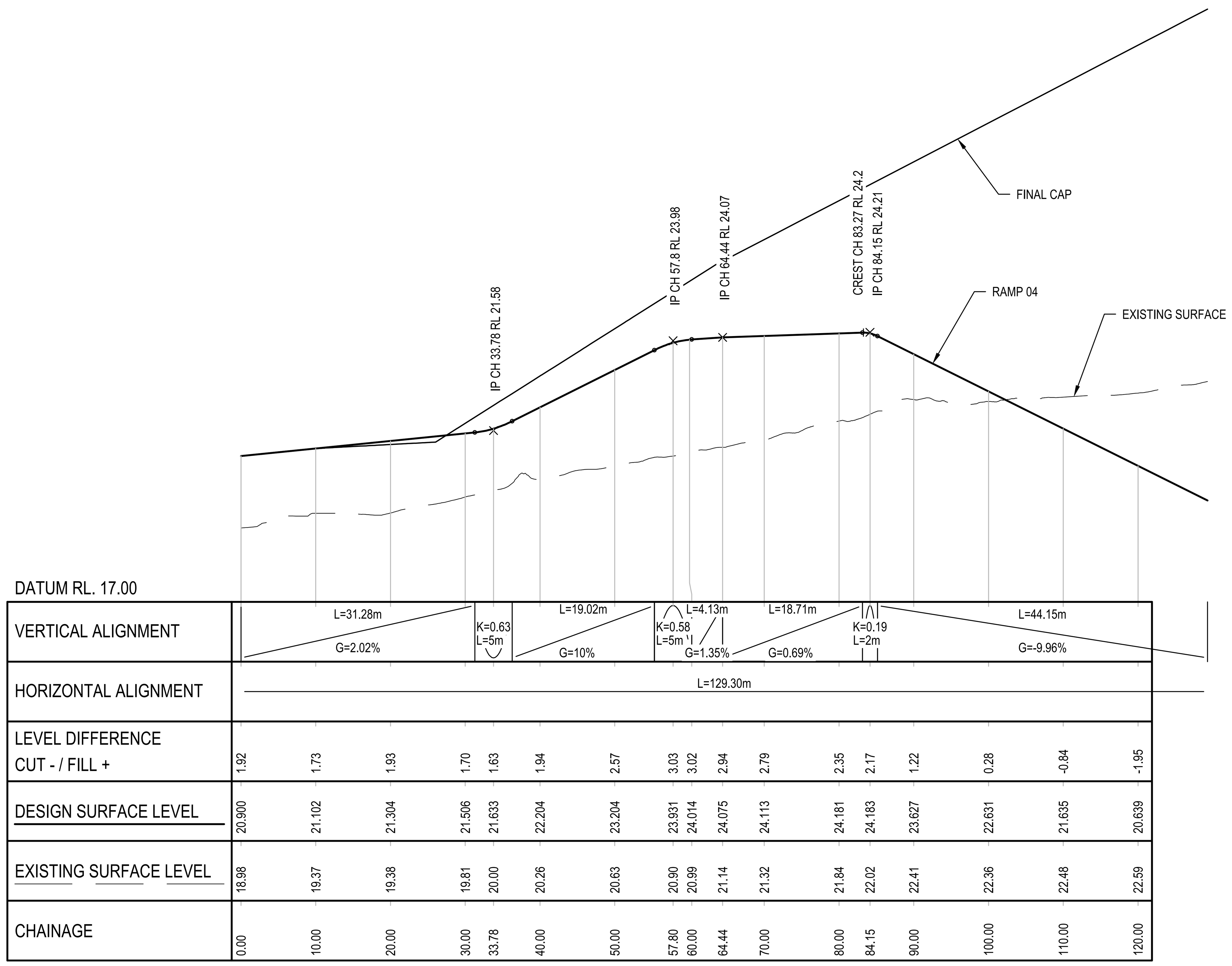
SCALE 1:500



LONGITUDINAL SECTION - RETURN 09

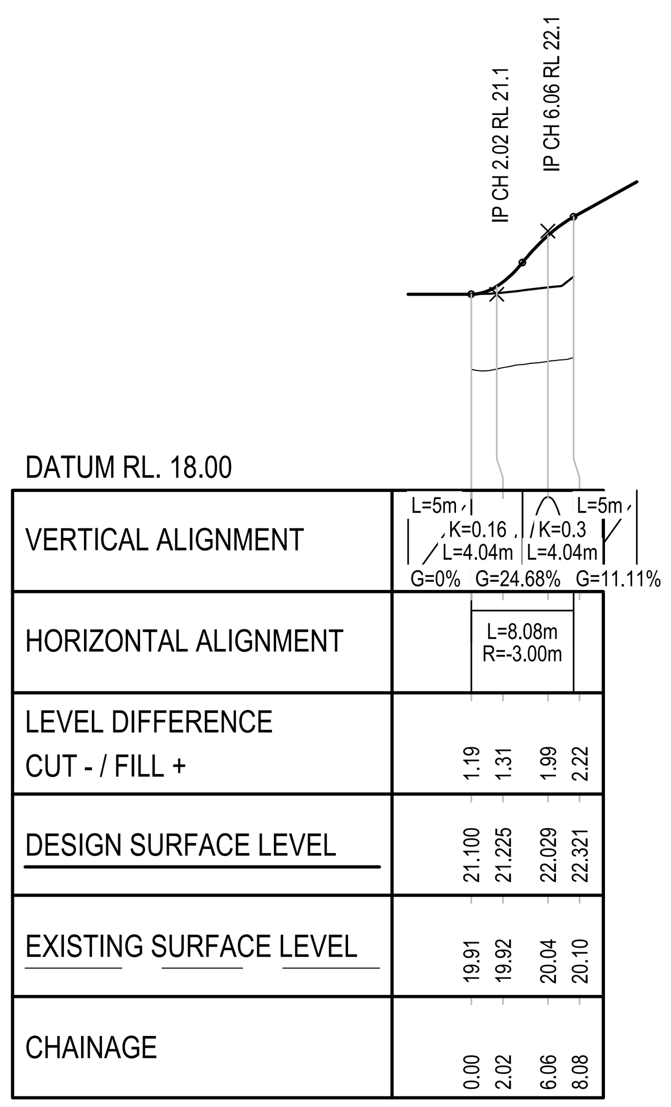
SCALE HOR. 1:500 VERT. 1:100

RETURN 09 SETOUT POINTS			
CHAINAGE	EASTING	NORTHING	HEIGHT
0.000	357080.702	6371323.858	21.235
7.574	357087.191	6371319.505	21.129
15.148	357095.005	6371319.622	21.100



LONGITUDINAL SECTION - RAMP 04

SCALE HOR. 1:500 VERT. 1:100



LONGITUDINAL SECTION - RETURN 10

SCALE HOR. 1:500 VERT. 1:100

RETURN 10 SETOUT POINTS			
CHAINAGE	EASTING	NORTHING	HEIGHT
0.000	357050.334	6371325.321	21.100
2.020	357052.703	6371324.981	21.225
4.040	357053.561	6371327.215	21.599
6.060	357054.419	6371329.448	22.029
8.080	357052.432	6371330.782	22.321

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
0	ISSUED FOR CONSTRUCTION	RK	AR	IG	29.09.19

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VERTICAL 1:100 AT ORIGINAL SIZE 0 1 2 3 4 5m
HORIZONTAL 1:500 AT ORIGINAL SIZE 0 5 10 15 20 25m

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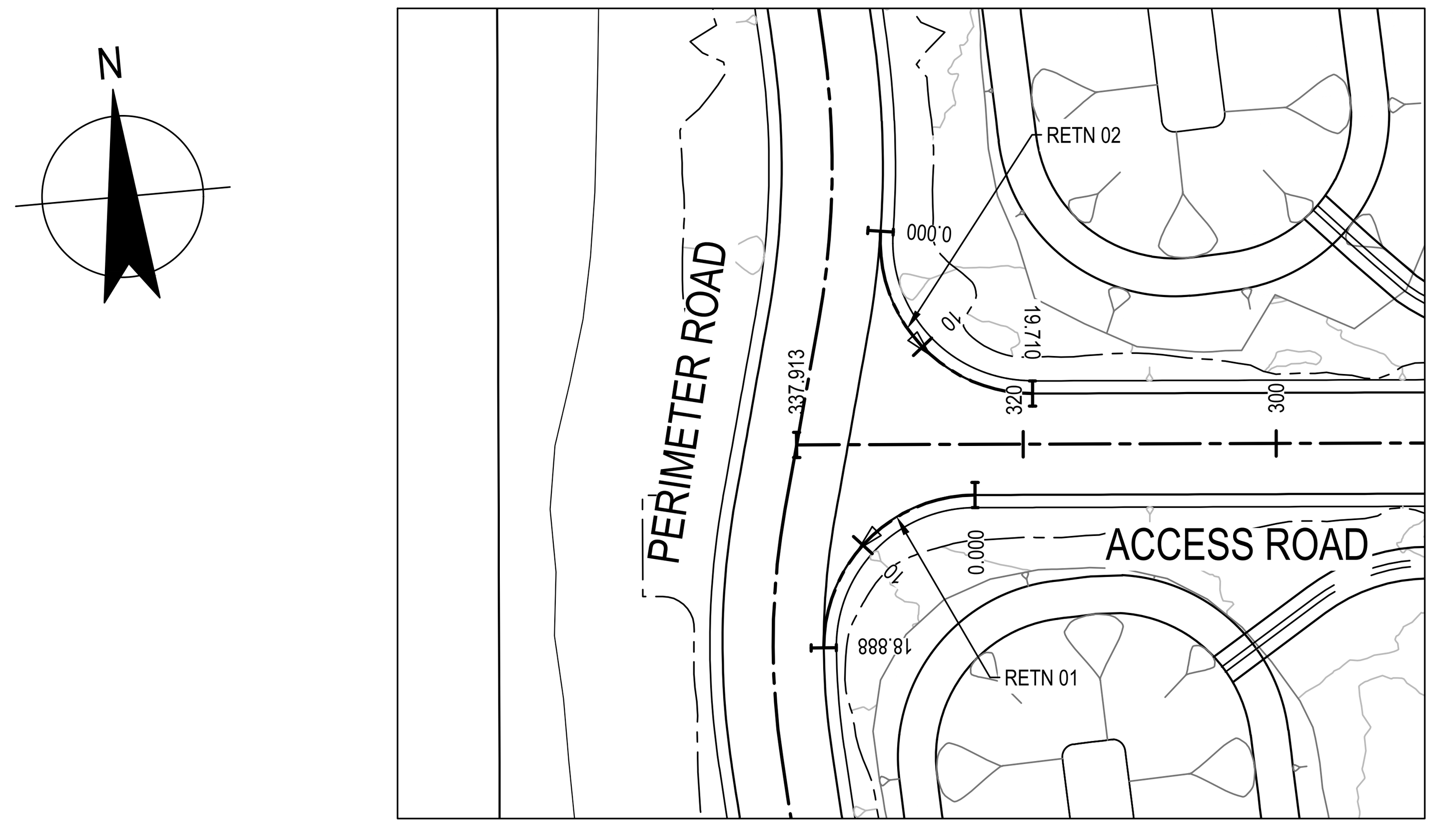
Drawn	J. CASIO	Designer	P. ETCHELLS
Drafting Check	P. PRASAD	Design Check	A. ROBERTS
Approved (Project Director)	I. GREGSON*		
Date	26.09.19		
Scale	AS SHOWN	This Drawing must not be used for Construction unless signed as Approved	

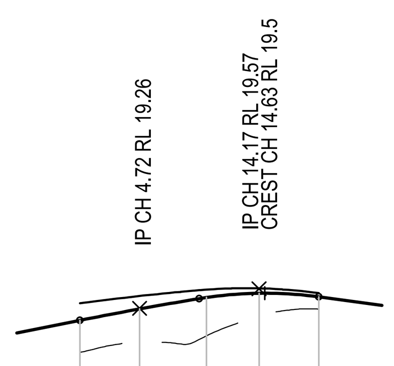
Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **RAMP04 LONGITUDINAL SECTIONS SHEET 4 OF 4**

Original Size **A1** Drawing No: **22-18015-C050** Rev: **0**

Plot Date: 27 September 2019 - 9:54 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C050.dwg



PLAN
SCALE 1:500



DATUM RL. 17.00

VERTICAL ALIGNMENT	L=5m G=4%	K=13.17 L=9.44m	G=3.28%	K=1.58 L=9.44m	L=5m G=-2.7%
HORIZONTAL ALIGNMENT	L=18.89m R=-12.00m				
LEVEL DIFFERENCE CUT - / FILL +	0.50	0.52	0.61	0.35	0.19
DESIGN SURFACE LEVEL	19.074	19.254	19.435	19.502	19.445
EXISTING SURFACE LEVEL	18.57	18.74	18.83	19.15	19.25
CHAINAGE	0.00	4.72	10.00	14.17	18.89

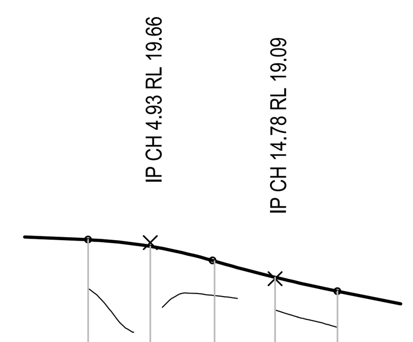
LONGITUDINAL SECTION - RETURN 01
SCALE HOR. 1:500 VERT. 1:100

RETURN 01 SETOUT POINTS

CHAINAGE	EASTING	NORTHING	HEIGHT
0.000	357173.675	6371400.874	19.074
9.444	357161.725	6371402.332	19.418
18.888	357160.306	6371390.377	19.445

RETURN 02 SETOUT POINTS

CHAINAGE	EASTING	NORTHING	HEIGHT
0.000	357168.848	6371422.478	19.705
9.855	357166.374	6371409.824	19.375
19.710	357179.172	6371408.263	18.891



DATUM RL. 16.00

VERTICAL ALIGNMENT	L=5m G=-0.9%	K=2.01 L=9.86m	G=-5.81%	K=5.45 L=9.86m	L=5m G=-4%
HORIZONTAL ALIGNMENT	L=19.71m R=-12.00m				
LEVEL DIFFERENCE CUT - / FILL +	0.77	1.20	0.54	0.52	0.57
DESIGN SURFACE LEVEL	19.705	19.600	19.366	19.111	18.891
EXISTING SURFACE LEVEL	18.93	18.40	18.82	18.59	18.32
CHAINAGE	0.00	4.93	10.00	14.78	19.71

LONGITUDINAL SECTION - RETURN 02
SCALE HOR. 1:500 VERT. 1:100

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
0	ISSUED FOR CONSTRUCTION	RK	AR	IG	29.09.19

Note: * indicates signatures on original issue of drawing or last revision of drawing

VERTICAL 1:100 AT ORIGINAL SIZE — 0 1 2 3 4 5m
HORIZONTAL 1:500 AT ORIGINAL SIZE — 0 5 10 15 20 25m

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Drawn J. CASIO | Designer P. ETCHELLS
Drafting Check P. PRASAD | Design Check A. ROBERTS
Approved (Project Director) I. GREGSON*
Date 26.09.19
Scale AS SHOWN

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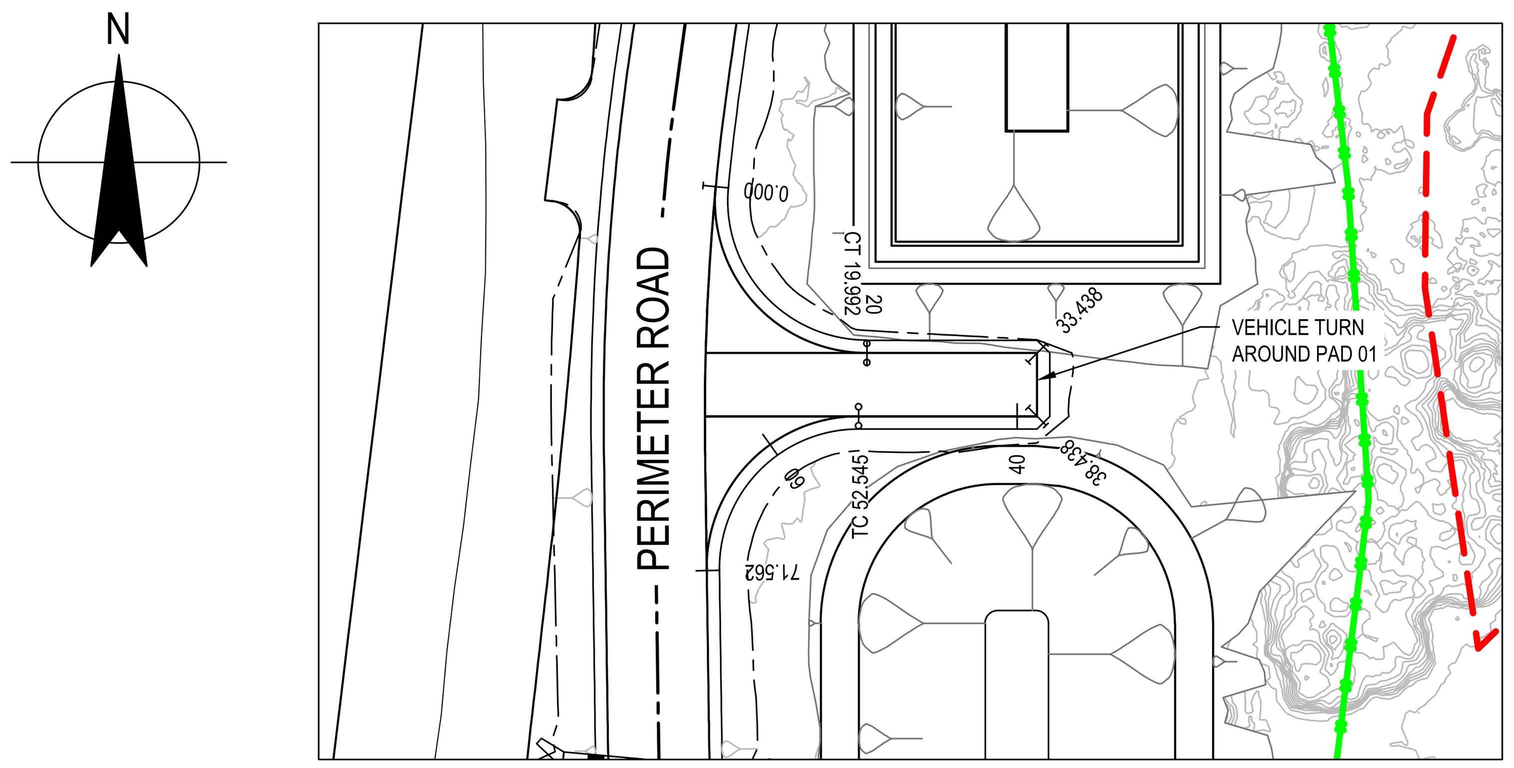
Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **ACCESS ROAD RETURN LONGITUDINAL SECTION**

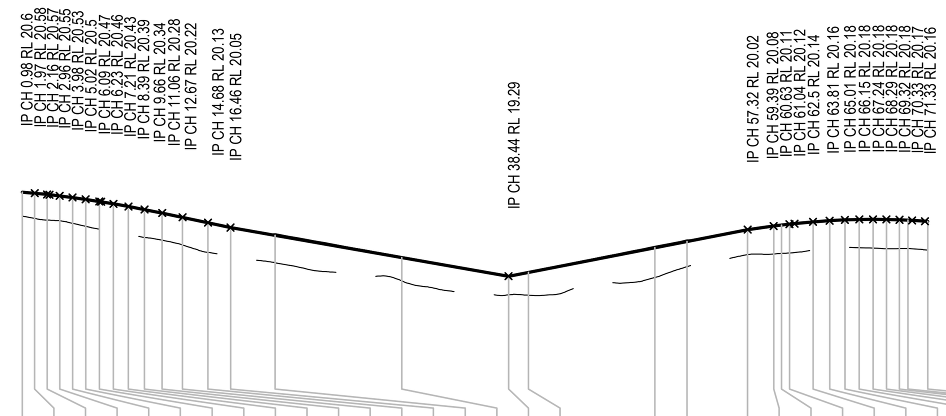
Original Size **A1** Drawing No: **22-18015-C051** Rev: **0**

Plot Date: 27 September 2019 - 9:55 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C051.dwg



PLAN - PAD 01

SCALE 1:500



DATUM RL. 17.00

VERTICAL ALIGNMENT: L=21.98m G=-3.5%; L=18.89m G=3.89%

HORIZONTAL ALIGNMENT: L=19.99m R=-12.00m; L=13.45m; L=5.00m; L=14.11m; L=19.02m R=-12.00m

CHAINAGE	EXISTING SURFACE LEVEL	DESIGN SURFACE LEVEL	LEVEL DIFFERENCE CUT - / FILL +
0.00	20.23	20.614	0.38
0.98	20.20	20.597	0.39
1.97	20.18	20.577	0.40
2.96	20.16	20.555	0.39
3.98	20.13	20.529	0.40
5.02	20.07	20.500	0.43
6.09	20.03	20.467	0.43
7.21	20.00	20.429	0.43
8.39	19.95	20.387	0.43
9.66	19.90	20.339	0.44
11.06	19.86	20.283	0.43
12.67	19.78	20.217	0.44
14.68	19.66	20.131	0.47
16.46	19.61	20.054	0.45
19.99	19.50	19.931	0.43
30.00	19.21	19.580	0.37
38.44	18.99	19.285	0.29
40.00	18.99	19.346	0.36
50.00	19.27	19.735	0.47
52.54	19.44	19.834	0.40
57.32	19.63	20.021	0.39
59.39	19.64	20.079	0.44
60.00	19.65	20.093	0.45
60.63	19.65	20.108	0.45
62.50	19.70	20.145	0.44
63.81	19.73	20.163	0.43
65.01	19.74	20.176	0.44
66.15	19.74	20.182	0.44
67.24	19.73	20.185	0.45
68.29	19.72	20.183	0.46
69.32	19.73	20.177	0.45
70.00	19.72	20.171	0.45
71.56	19.70	20.152	0.45

LONGITUDINAL SECTION - PAD 01

SCALE HOR. 1:500 VERT. 1:100

PAD01 SETOUT POINTS

CHAINAGE	EASTING	NORTHING	HEIGHT
0.000	357170.694	6371484.842	20.614
9.996	357169.439	6371471.701	20.326
19.992	357182.640	6371471.701	19.931
33.438	357196.086	6371471.701	19.460
38.438	357196.086	6371466.701	19.285
52.545	357181.980	6371466.701	19.834
62.053	357169.810	6371466.701	20.136
71.562	357169.981	6371454.533	20.152

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
0	ISSUED FOR CONSTRUCTION	RK	AR	IG	29.09.19

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HORIZONTAL 1:500 AT ORIGINAL SIZE 0 5 10 15 20 25m

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Date 26.09.19
Scale AS SHOWN
This Drawing must not be used for Construction unless signed as Approved

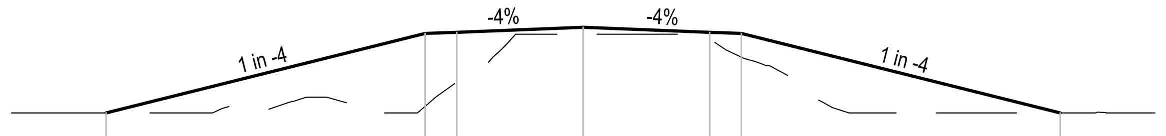
Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **VEHICLE TURN AROUND - PAD01 PLAN AND PROFILE**

Original Size A1 Drawing No: **22-18015-C052** Rev: 0

Plot Date: 27 September 2019 - 9:55 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C052.dwg

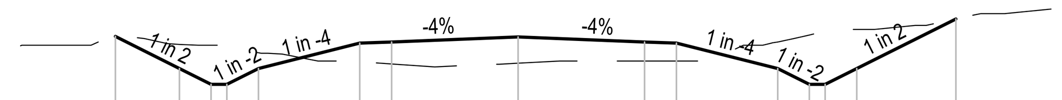
DATUM R.L. 12.00							
DESIGN SURFACE LEVEL	13.668	13.410	13.450	13.610	13.450	13.410	14.000
DEPTH CUT - / FILL +	0.000	-0.266	-0.243	-0.143	-0.550	-0.590	0.000
EXISTING SURFACE LEVEL	13.668	13.677	13.693	13.754	14.000	14.000	14.000
OFFSET FROM CENTRELINE	-5.52	-5	-4	0	4	5	6.18

CH 40



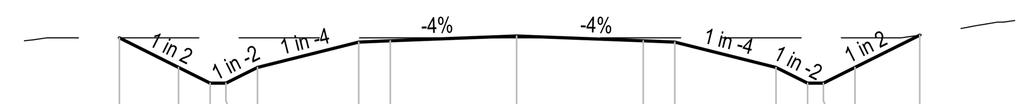
DATUM R.L. 7.00							
DESIGN SURFACE LEVEL	9.000	11.521	11.561	11.721	11.561	11.521	9.000
DEPTH CUT - / FILL +	0.000	2.311	1.587	0.221	0.207	0.750	0.000
EXISTING SURFACE LEVEL	9.000	9.211	9.975	11.500	11.354	10.772	9.000
OFFSET FROM CENTRELINE	-15.09	-5	-4	0	4	5	15.09

CH 80



DATUM R.L. 10.00															
DESIGN SURFACE LEVEL	13.276	12.265	11.765	11.765	12.265	13.065	13.105	13.265	13.105	13.065	12.265	11.765	11.765	12.265	13.834
DEPTH CUT - / FILL +	0.000	-0.765	-1.235	-1.177	-0.495	0.589	0.697	0.833	0.605	0.565	-0.842	-1.560	-1.676	-1.235	0.000
EXISTING SURFACE LEVEL	13.276	13.030	13.000	12.942	12.760	12.475	12.407	12.432	12.500	12.500	13.106	13.324	13.441	13.500	13.834
OFFSET FROM CENTRELINE	-12.72	-10.7	-9.7	-9.2	-8.2	-5	-4	0	4	5	8.2	9.2	9.7	10.7	13.84

CH 120

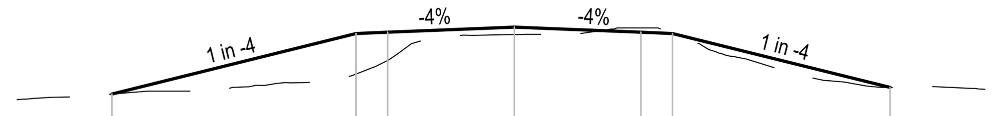


DATUM R.L. 12.00															
DESIGN SURFACE LEVEL	15.000	14.065	13.565	13.565	14.065	14.865	14.905	15.065	14.905	14.865	14.065	13.565	13.565	14.065	15.089
DEPTH CUT - / FILL +	0.000	-0.935	-1.435	-1.435	-0.935	-0.135	-0.095	0.065	-0.095	-0.135	-0.935	-1.435	-1.435	-0.935	0.000
EXISTING SURFACE LEVEL	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.089
OFFSET FROM CENTRELINE	-12.57	-10.7	-9.7	-9.2	-8.2	-5	-4	0	4	5	8.2	9.2	9.7	10.7	12.75

CH 160

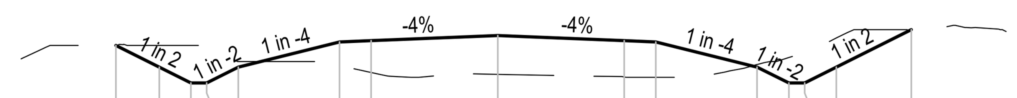
DATUM R.L. 12.00							
DESIGN SURFACE LEVEL	13.738	13.651	13.691	13.851	13.691	13.651	13.950
DEPTH CUT - / FILL +	0.000	-0.090	-0.068	0.015	-0.227	-0.287	0.000
EXISTING SURFACE LEVEL	13.738	13.741	13.759	13.836	13.918	13.938	13.950
OFFSET FROM CENTRELINE	-5.17	-5	-4	0	4	5	5.6

CH 30



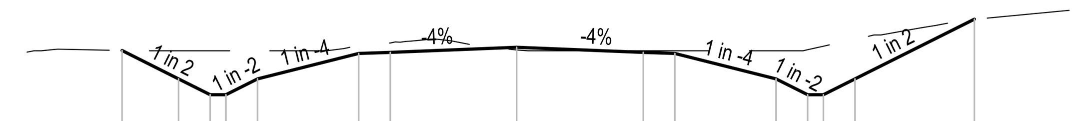
DATUM R.L. 8.00							
DESIGN SURFACE LEVEL	9.900	11.828	11.868	12.028	11.868	11.828	10.111
DEPTH CUT - / FILL +	0.000	1.294	0.895	0.234	-0.132	0.037	0.000
EXISTING SURFACE LEVEL	9.900	10.535	10.973	11.794	12.000	11.791	10.111
OFFSET FROM CENTRELINE	-12.71	-5	-4	0	4	5	11.87

CH 70



DATUM R.L. 10.00															
DESIGN SURFACE LEVEL	12.500	11.815	11.315	11.315	11.815	12.615	12.655	12.815	12.655	12.615	11.815	11.315	11.315	11.815	13.000
DEPTH CUT - / FILL +	0.000	-0.685	-1.185	-1.185	-0.185	0.742	1.005	1.223	1.146	1.115	-0.089	-0.804	-0.964	-0.923	0.000
EXISTING SURFACE LEVEL	12.500	12.500	12.500	12.500	12.000	11.873	11.650	11.591	11.508	11.500	11.904	12.119	12.279	12.737	13.000
OFFSET FROM CENTRELINE	-12.07	-10.7	-9.7	-9.2	-8.2	-5	-4	0	4	5	8.2	9.2	9.7	10.7	13.07

CH 110

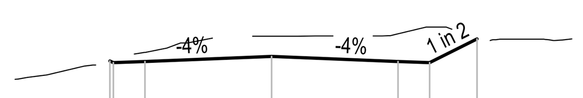


DATUM R.L. 11.00															
DESIGN SURFACE LEVEL	14.507	13.615	13.115	13.115	13.615	14.415	14.455	14.615	14.455	14.415	13.615	13.115	13.115	13.615	15.500
DEPTH CUT - / FILL +	0.000	-0.885	-1.385	-1.385	-0.885	-0.244	-0.295	0.084	-0.045	-0.085	-0.885	-1.417	-1.528	-1.251	0.000
EXISTING SURFACE LEVEL	14.507	14.500	14.500	14.500	14.500	14.658	14.749	14.531	14.500	14.500	14.500	14.531	14.643	14.865	15.500
OFFSET FROM CENTRELINE	-12.48	-10.7	-9.7	-9.2	-8.2	-5	-4	0	4	5	8.2	9.2	9.7	10.7	14.47

CH 150

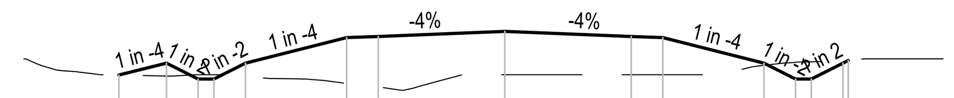
DATUM R.L. 12.00							
DESIGN SURFACE LEVEL	13.782	13.712	13.746	13.881	13.747	13.714	13.987
DEPTH CUT - / FILL +	0.000	-0.073	-0.059	0.000	-0.211	-0.263	0.000
EXISTING SURFACE LEVEL	13.782	13.785	13.804	13.881	13.958	13.976	13.987
OFFSET FROM CENTRELINE	-5.14	-5	-4	0	4	5	5.55

CH 20



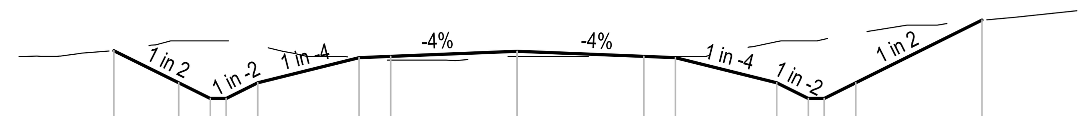
DATUM R.L. 10.00							
DESIGN SURFACE LEVEL	12.434	12.378	12.418	12.578	12.418	12.378	13.126
DEPTH CUT - / FILL +	0.000	-0.088	-0.287	-0.636	-0.872	-1.122	0.000
EXISTING SURFACE LEVEL	12.434	12.466	12.705	13.214	13.290	13.500	13.126
OFFSET FROM CENTRELINE	-5.11	-5	-4	0	4	5	6.5

CH 60



DATUM R.L. 9.00															
DESIGN SURFACE LEVEL	10.988	11.365	10.865	10.865	11.365	12.165	12.205	12.365	12.205	12.165	11.365	10.865	10.865	11.365	11.447
DEPTH CUT - / FILL +	0.000	0.405	-0.135	-0.135	0.416	1.443	1.581	1.365	1.205	1.165	0.071	-0.526	-0.543	-0.070	0.000
EXISTING SURFACE LEVEL	10.988	10.959	11.000	11.000	10.948	10.722	10.623	11.000	11.000	11.000	11.293	11.391	11.407	11.434	11.447
OFFSET FROM CENTRELINE	-12.21	-10.7	-9.7	-9.2	-8.2	-5	-4	0	4	5	8.2	9.2	9.7	10.7	10.86

CH 100

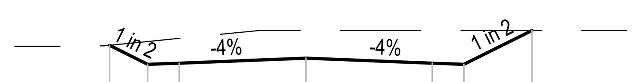


DATUM R.L. 11.00															
DESIGN SURFACE LEVEL	14.187	13.165	12.665	12.665	13.165	13.965	14.005	14.165	14.005	13.965	13.165	12.665	12.665	13.165	15.156
DEPTH CUT - / FILL +	0.000	-1.335	-1.835	-1.835	-1.191	0.013	0.119	0.165	0.005	-0.035	-1.307	-1.835	-1.885	-1.566	0.000
EXISTING SURFACE LEVEL	14.187	14.500	14.500	14.500	14.355	13.952	13.885	14.000	14.000	14.000	14.471	14.500	14.550	14.731	15.156
OFFSET FROM CENTRELINE	-12.74	-10.7	-9.7	-9.2	-8.2	-5	-4	0	4	5	8.2	9.2	9.7	10.7	14.68

CH 140

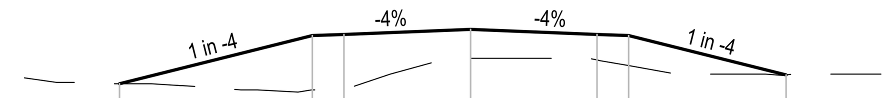
DATUM R.L. 12.00						
DESIGN SURFACE LEVEL	13.694	13.731	13.818	13.736	13.715	13.899
DEPTH CUT - / FILL +	0.000	0.011	0.000	-0.149	-0.183	0.000
EXISTING SURFACE LEVEL	13.694	13.720	13.818	13.885	13.898	13.899
OFFSET FROM CENTRELINE	-5.06	-4	0	4	5	5.37

CH 10



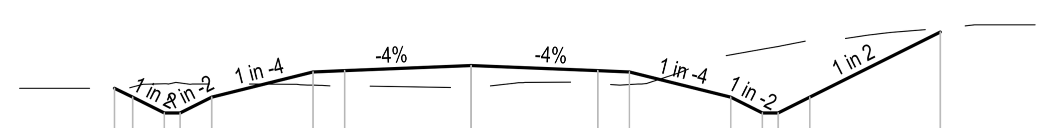
DATUM R.L. 11.00							
DESIGN SURFACE LEVEL	13.531	12.928	12.968	13.128	12.968	12.928	14.000
DEPTH CUT - / FILL +	0.000	-0.722	-0.782	-0.872	-1.032	-1.072	0.000
EXISTING SURFACE LEVEL	13.531	13.651	13.750	14.000	14.000	14.000	14.000
OFFSET FROM CENTRELINE	-6.21	-5	-4	0	4	5	7.14

CH 50



DATUM R.L. 8.00							
DESIGN SURFACE LEVEL	10.190	11.715	11.755	11.915	11.755	11.715	10.470
DEPTH CUT - / FILL +	0.000	1.715	1.738	0.915	0.810	0.949	0.000
EXISTING SURFACE LEVEL	10.190	10.000	10.017	11.000	10.944	10.766	10.470
OFFSET FROM CENTRELINE	-11.1	-5	-4	0	4	5	9.98

CH 90



DATUM R.L. 10.00															
DESIGN SURFACE LEVEL	13.000	12.715	12.215	12.215	12.715	13.515	13.555	13.715	13.555	13.515	12.715	12.215	12.215	12.715	14.774
DEPTH CUT - / FILL +	0.000	-0.327	-0.928	-0.950	-0.417	0.419	0.487	0.698	0.422	0.399	-1.344	-2.016	-2.104	-1.785	-0.119
EXISTING SURFACE LEVEL	13.000	13.042	13.142	13.164	13.131	13.095	13.067	13.016	13.133	13.115	14.058	14.231	14.318	14.500	14.893
OFFSET FROM CENTRELINE	-11.27	-10.7	-9.7	-9.2	-8.2	-5	-4	0	4	5	8.2	9.2	9.7	10.7	14.82

CH 130

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
0	ISSUED FOR CONSTRUCTION	RK	AR	IG	29.09.19

Note: * indicates signatures on original issue of drawing or last revision of drawing

0 2 4 6 8 10m
SCALE 1:200 AT ORIGINAL SIZE

Suite 10, 6 Reliance Drive Tuggerah Business Park
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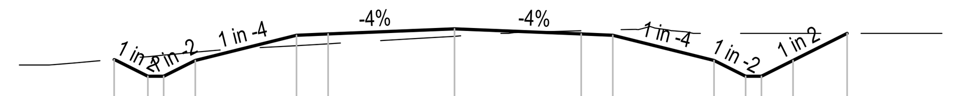
DO NOT SCALE

Drawn J. CASIO
Designer P. ETCHELLS
Drafting Check P. PRASAD
Design Check A. ROBERTS
Approved (Project Director) I. GREGSON*
Date 26.09.19
Scale 1:200
This Drawing must not be used for Construction unless signed as Approved

Client HYDRO ALUMINIUM KURRI KURRI PTY LTD
Project CONTAINMENT CELL DETAILED DESIGN
Title ACCESS ROAD CROSS SECTIONS SHEET 1 OF 2
Original Size A1
Drawing No: 22-18015-C061
Rev: 0

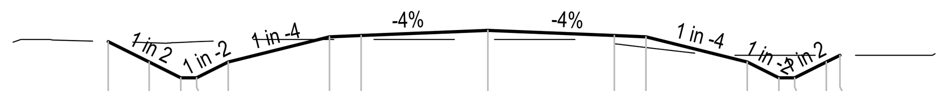
Plot Date: 27 September 2019 - 9:55 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C061.dwg



DATUM R.L. 13.00

DESIGN SURFACE LEVEL	15.177	14.646	14.646	15.146	15.946	15.986	16.146	15.986	15.946	15.146	14.646	14.646	15.146	16.000
DEPTH CUT - / FILL +	0.000	-0.623	-0.668	-0.260	0.329	0.310	0.234	-0.098	-0.166	-0.854	-1.354	-1.354	-0.854	0.000
EXISTING SURFACE LEVEL	15.177	15.269	15.314	15.406	15.617	15.676	15.912	16.085	16.113	16.000	16.000	16.000	16.000	16.000
OFFSET FROM CENTRELINE	-10.76	-9.7	-9.2	-8.2	-5	-4	0	4	5	8.2	9.2	9.7	10.7	12.41

CH 200



DATUM R.L. 14.00

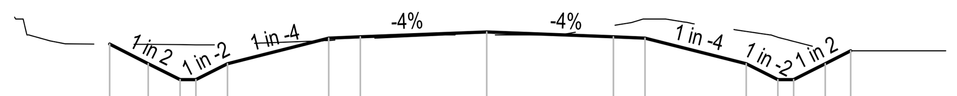
DESIGN SURFACE LEVEL	16.433	15.785	15.285	15.285	15.785	16.585	16.625	16.785	16.625	16.585	15.785	15.285	15.285	15.785	16.000
DEPTH CUT - / FILL +	0.000	-0.611	-1.120	-1.141	-0.682	0.085	0.125	0.285	0.264	0.339	-0.215	-0.715	-0.715	-0.215	0.000
EXISTING SURFACE LEVEL	16.433	16.396	16.405	16.426	16.468	16.500	16.500	16.500	16.361	16.246	16.000	16.000	16.000	16.000	16.000
OFFSET FROM CENTRELINE	-12	-10.7	-9.7	-9.2	-8.2	-5	-4	0	4	5	8.2	9.2	9.7	10.7	11.13

CH 240

DATUM R.L. 13.00

DESIGN SURFACE LEVEL	16.000	14.996	14.496	14.496	14.996	15.796	15.836	15.996	15.836	15.796	14.996	14.496	14.496	14.996	16.438
DEPTH CUT - / FILL +	0.000	-1.004	-1.504	-1.501	-0.698	0.133	0.114	0.053	-0.164	-0.204	-1.335	-1.900	-1.933	-1.498	0.000
EXISTING SURFACE LEVEL	16.000	16.000	16.000	15.997	15.694	15.663	15.722	15.943	16.000	16.000	16.331	16.396	16.429	16.494	16.438
OFFSET FROM CENTRELINE	-12.71	-10.7	-9.7	-9.2	-8.2	-5	-4	0	4	5	8.2	9.2	9.7	10.7	13.58

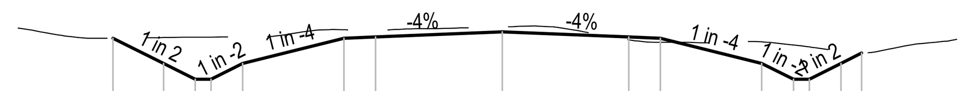
CH 190



DATUM R.L. 13.00

DESIGN SURFACE LEVEL	16.210	15.596	15.096	15.096	15.596	16.396	16.436	16.596	16.436	16.396	15.596	15.096	15.096	15.596	16.000
DEPTH CUT - / FILL +	0.000	-0.603	-1.095	-1.091	-0.602	0.071	0.063	0.096	-0.355	-0.604	-1.016	-1.331	-1.201	-0.445	0.000
EXISTING SURFACE LEVEL	16.210	16.200	16.192	16.187	16.198	16.326	16.373	16.500	16.792	17.000	16.612	16.427	16.298	16.041	16.000
OFFSET FROM CENTRELINE	-11.93	-10.7	-9.7	-9.2	-8.2	-5	-4	0	4	5	8.2	9.2	9.7	10.7	11.51

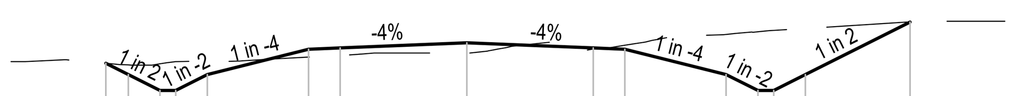
CH 230



DATUM R.L. 14.00

DESIGN SURFACE LEVEL	17.260	16.460	15.960	15.960	16.460	17.260	17.300	17.460	17.300	17.260	16.460	15.960	15.960	16.460	16.788
DEPTH CUT - / FILL +	0.000	-0.820	-1.331	-1.335	-0.845	-0.266	-0.198	-0.155	0.093	0.131	-0.683	-1.084	-1.023	-0.379	0.000
EXISTING SURFACE LEVEL	17.260	17.280	17.292	17.295	17.305	17.526	17.499	17.615	17.208	17.129	17.143	17.044	16.983	16.840	16.788
OFFSET FROM CENTRELINE	-12.3	-10.7	-9.7	-9.2	-8.2	-5	-4	0	4	5	8.2	9.2	9.7	10.7	11.36

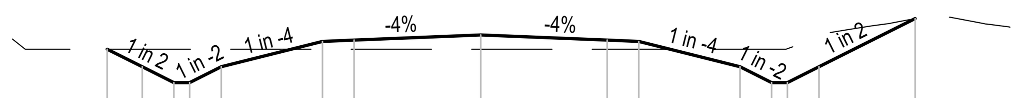
CH 270



DATUM R.L. 13.00

DESIGN SURFACE LEVEL	15.179	14.825	14.325	14.325	14.825	15.625	15.665	15.825	15.665	15.625	14.825	14.325	14.325	14.825	16.480
DEPTH CUT - / FILL +	0.000	-0.303	-0.838	-0.906	-0.416	0.249	0.234	0.325	0.037	-0.124	-1.263	-1.845	-1.888	-1.450	0.000
EXISTING SURFACE LEVEL	15.179	15.128	15.163	15.231	15.241	15.376	15.431	15.500	15.628	15.749	16.087	16.170	16.213	16.275	16.480
OFFSET FROM CENTRELINE	-11.41	-10.7	-9.7	-9.2	-8.2	-5	-4	0	4	5	8.2	9.2	9.7	10.7	14.01

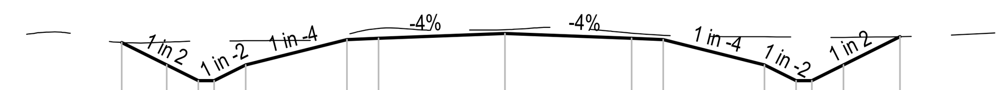
CH 180



DATUM R.L. 13.00

DESIGN SURFACE LEVEL	16.000	15.446	14.946	14.946	15.446	16.246	16.286	16.446	16.286	16.246	15.446	14.946	14.946	15.446	16.964
DEPTH CUT - / FILL +	0.000	-0.554	-1.054	-1.054	-0.554	0.246	0.286	0.446	0.286	0.246	-0.554	-1.054	-1.069	-0.945	0.000
EXISTING SURFACE LEVEL	16.000	16.000	16.000	16.000	16.000	16.000	16.000	16.000	16.000	16.000	16.000	16.000	16.015	16.391	16.964
OFFSET FROM CENTRELINE	-11.81	-10.7	-9.7	-9.2	-8.2	-5	-4	0	4	5	8.2	9.2	9.7	10.7	13.74

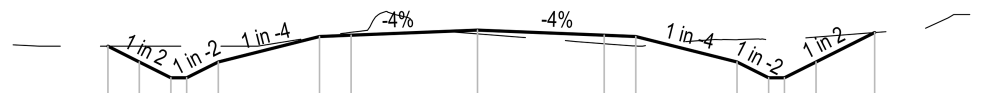
CH 220



DATUM R.L. 14.00

DESIGN SURFACE LEVEL	16.946	16.235	15.735	15.735	16.235	17.035	17.075	17.235	17.075	17.035	16.235	15.735	15.735	16.235	17.128
DEPTH CUT - / FILL +	0.000	-0.724	-1.252	-1.259	-0.764	-0.166	-0.318	-0.117	-0.168	-0.139	-0.891	-1.376	-1.370	-0.871	0.000
EXISTING SURFACE LEVEL	16.946	16.959	16.988	16.994	16.999	17.201	17.393	17.352	17.243	17.174	17.127	17.111	17.106	17.106	17.128
OFFSET FROM CENTRELINE	-12.12	-10.7	-9.7	-9.2	-8.2	-5	-4	0	4	5	8.2	9.2	9.7	10.7	12.48

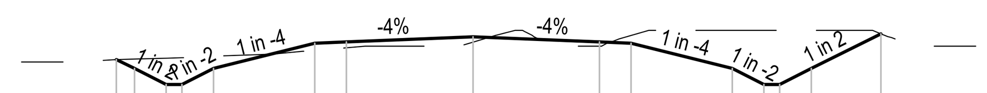
CH 260



DATUM R.L. 12.00

DESIGN SURFACE LEVEL	15.000	14.507	14.007	14.007	14.507	15.307	15.347	15.507	15.347	15.307	14.507	14.007	14.007	14.507	15.435
DEPTH CUT - / FILL +	0.000	-0.493	-0.993	-0.993	-0.493	-0.006	-0.092	0.115	0.265	0.295	-0.701	-1.202	-1.208	-0.780	0.000
EXISTING SURFACE LEVEL	15.000	15.000	15.000	15.000	15.000	15.313	15.440	15.392	15.083	15.012	15.208	15.210	15.215	15.287	15.435
OFFSET FROM CENTRELINE	-11.69	-10.7	-9.7	-9.2	-8.2	-5	-4	0	4	5	8.2	9.2	9.7	10.7	12.56

CH 170



DATUM R.L. 13.00

DESIGN SURFACE LEVEL	15.581	15.296	14.796	14.796	15.296	16.096	16.136	16.296	16.136	16.096	15.296	14.796	14.796	15.296	16.395
DEPTH CUT - / FILL +	0.000	-0.299	-0.827	-0.841	-0.387	0.227	0.185	0.162	0.136	-0.243	-1.204	-1.704	-1.704	-1.204	0.000
EXISTING SURFACE LEVEL	15.581	15.595	15.623	15.637	15.683	15.869	15.952	16.134	16.000	16.339	16.500	16.500	16.500	16.500	16.395
OFFSET FROM CENTRELINE	-11.27	-10.7	-9.7	-9.2	-8.2	-5	-4	0	4	5	8.2	9.2	9.7	10.7	12.9

CH 210

DATUM R.L. 14.00

DESIGN SURFACE LEVEL	16.515	16.010	15.510	15.510	16.010	16.810	16.850	17.010	16.850	16.810	16.010	15.510	15.510	16.010	16.325
DEPTH CUT - / FILL +	0.000	-0.564	-1.123	-1.153	-0.712	-0.100	-0.117	0.010	0.076	0.125	-0.490	-0.920	-0.879	-0.324	0.000
EXISTING SURFACE LEVEL	16.515	16.575	16.633	16.663	16.722	16.910	16.967	17.000	16.775	16.685	16.500	16.430	16.389	16.335	16.325
OFFSET FROM CENTRELINE	-11.71	-10.7	-9.7	-9.2	-8.2	-5	-4	0	4	5	8.2	9.2	9.7	10.7	11.33

CH 250

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
0	ISSUED FOR CONSTRUCTION	RK	AR	IG	29.09.19

Note: * indicates signatures on original issue of drawing or last revision of drawing

0 2 4 6 8 10m
SCALE 1:200 AT ORIGINAL SIZE

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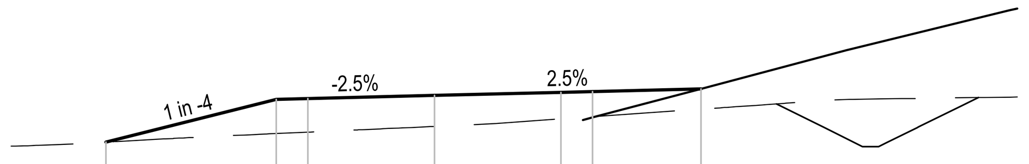
DO NOT SCALE

Drawn J. CASIO
Designer P. ETCHELLS
Drafting Check P. PRASAD
Design Check A. ROBERTS
Approved (Project Director) I. GREGSON*
Date 26.09.19
Scale 1:200
This Drawing must not be used for Construction unless signed as Approved

Client HYDRO ALUMINIUM KURRI KURRI PTY LTD
Project CONTAINMENT CELL DETAILED DESIGN
Title ACCESS ROAD CROSS SECTIONS SHEET 2 OF 2
Original Size A1
Drawing No: 22-18015-C062
Rev: 0

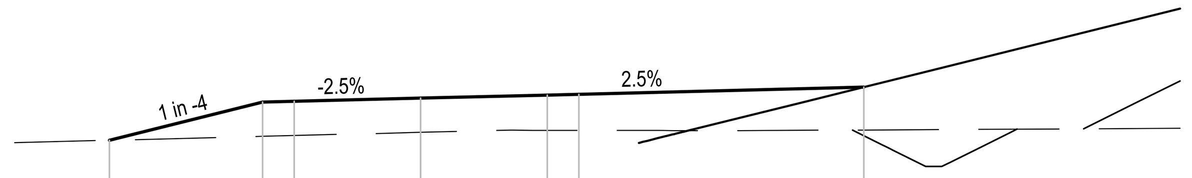
Plot Date: 27 September 2019 - 9:55 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C062.dwg



DATUM R.L. 16.00

DESIGN SURFACE LEVEL	18.092	19.438	19.462	19.563	19.663	19.688	19.773
DEPTH CUT - / FILL +	0.000	1.076	1.056	0.975	0.840	0.795	0.643
EXISTING SURFACE LEVEL	18.092	18.362	18.407	18.588	18.823	18.892	19.130
OFFSET FROM CENTRELINE	-10.38	-5	-4	0	4	5	8.42

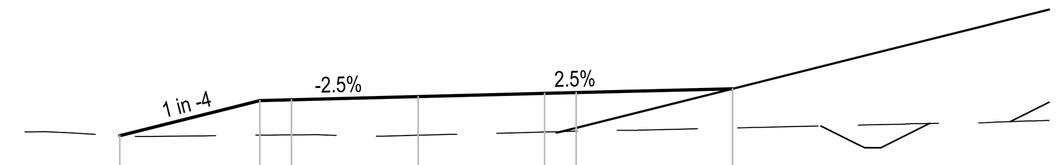
CH 50



DATUM R.L. 17.00

DESIGN SURFACE LEVEL	19.092	20.303	20.328	20.428	20.528	20.553	20.778
DEPTH CUT - / FILL +	0.000	1.087	1.087	1.085	1.121	1.147	1.360
EXISTING SURFACE LEVEL	19.092	19.216	19.241	19.343	19.406	19.405	19.418
OFFSET FROM CENTRELINE	-9.84	-5	-4	0	4	5	14.01

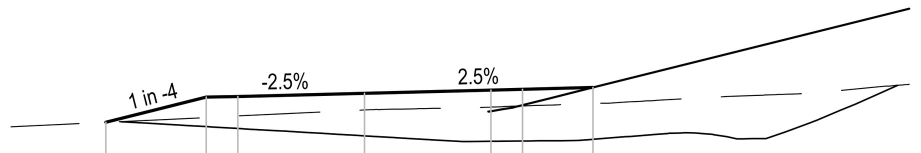
CH 90



DATUM R.L. 17.00

DESIGN SURFACE LEVEL	18.968	20.075	20.100	20.200	20.300	20.325	20.449
DEPTH CUT - / FILL +	0.000	1.095	1.110	1.221	1.219	1.218	1.240
EXISTING SURFACE LEVEL	18.968	18.980	18.990	18.979	19.081	19.107	19.209
OFFSET FROM CENTRELINE	-9.43	-5	-4	0	4	5	9.95

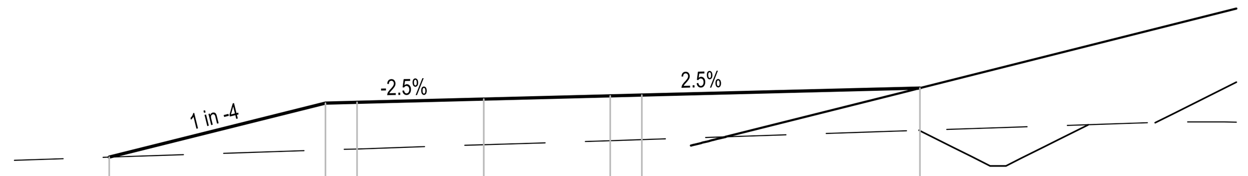
CH 130



DATUM R.L. 16.00

DESIGN SURFACE LEVEL	18.409	19.202	19.227	19.327	19.427	19.452	19.508
DEPTH CUT - / FILL +	0.000	0.643	0.620	0.530	0.538	0.527	0.508
EXISTING SURFACE LEVEL	18.409	18.560	18.607	18.797	18.889	18.925	19.000
OFFSET FROM CENTRELINE	-8.17	-5	-4	0	4	5	7.22

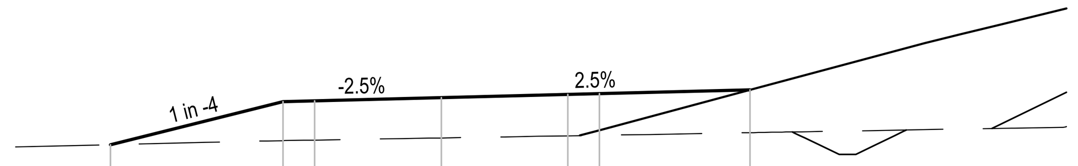
CH 40



DATUM R.L. 16.00

DESIGN SURFACE LEVEL	18.459	20.167	20.192	20.292	20.392	20.417	20.637
DEPTH CUT - / FILL +	0.000	1.482	1.474	1.442	1.410	1.402	1.331
EXISTING SURFACE LEVEL	18.459	18.685	18.718	18.850	18.982	19.015	19.305
OFFSET FROM CENTRELINE	-11.83	-5	-4	0	4	5	13.79

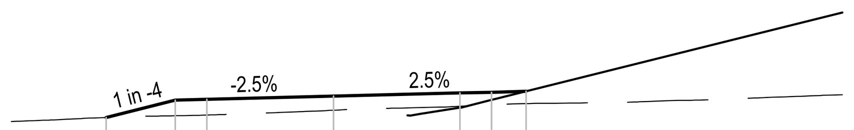
CH 80



DATUM R.L. 17.00

DESIGN SURFACE LEVEL	18.812	20.175	20.200	20.300	20.400	20.425	20.544
DEPTH CUT - / FILL +	0.000	1.235	1.243	1.276	1.308	1.317	1.352
EXISTING SURFACE LEVEL	18.812	18.940	18.957	19.024	19.092	19.108	19.192
OFFSET FROM CENTRELINE	-10.45	-5	-4	0	4	5	9.76

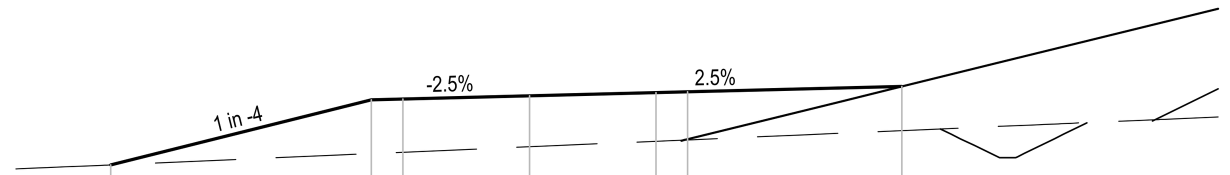
CH 120



DATUM R.L. 17.00

DESIGN SURFACE LEVEL	18.618	19.164	19.189	19.289	19.389	19.414	19.441
DEPTH CUT - / FILL +	0.000	0.495	0.496	0.444	0.416	0.393	0.388
EXISTING SURFACE LEVEL	18.618	18.669	18.693	18.845	18.973	19.021	19.053
OFFSET FROM CENTRELINE	-7.18	-5	-4	0	4	5	6.09

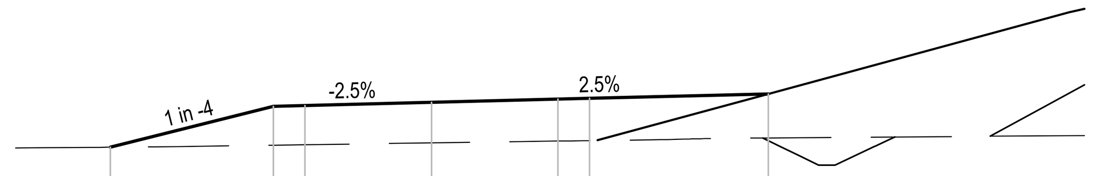
CH 30



DATUM R.L. 16.00

DESIGN SURFACE LEVEL	17.879	19.938	19.962	20.063	20.163	20.188	20.357
DEPTH CUT - / FILL +	0.000	1.702	1.683	1.610	1.536	1.518	1.394
EXISTING SURFACE LEVEL	17.879	18.236	18.279	18.453	18.626	18.669	18.963
OFFSET FROM CENTRELINE	-13.24	-5	-4	0	4	5	11.77

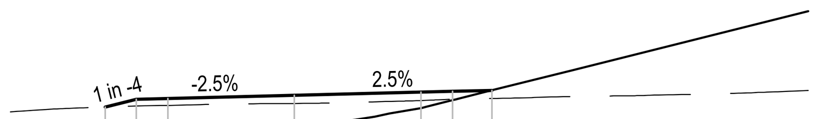
CH 70



DATUM R.L. 17.00

DESIGN SURFACE LEVEL	18.985	20.275	20.300	20.400	20.500	20.525	20.666
DEPTH CUT - / FILL +	0.000	1.228	1.238	1.279	1.320	1.335	1.391
EXISTING SURFACE LEVEL	18.985	19.047	19.062	19.121	19.180	19.190	19.275
OFFSET FROM CENTRELINE	-10.16	-5	-4	0	4	5	10.65

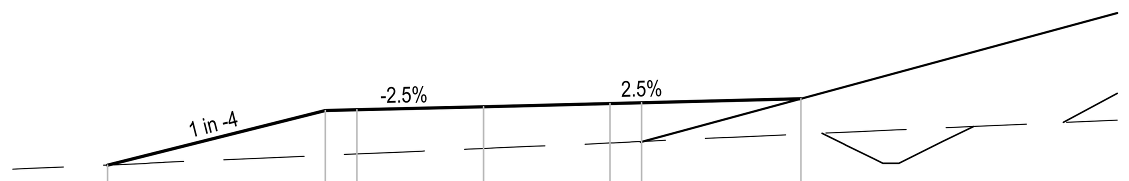
CH 110



DATUM R.L. 17.00

DESIGN SURFACE LEVEL	19.128	19.373	19.398	19.498	19.598	19.623	19.654
DEPTH CUT - / FILL +	0.000	0.216	0.220	0.259	0.266	0.249	0.256
EXISTING SURFACE LEVEL	19.128	19.157	19.178	19.239	19.331	19.373	19.398
OFFSET FROM CENTRELINE	-5.98	-5	-4	0	4	5	6.24

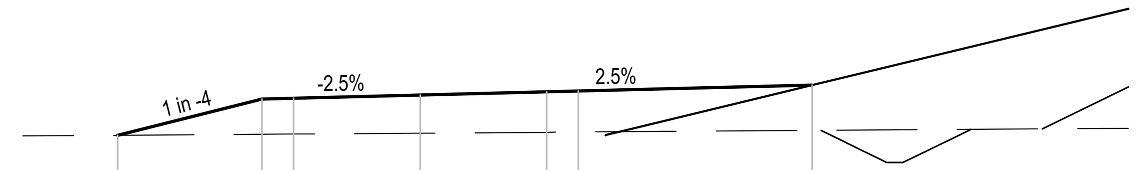
CH 20



DATUM R.L. 16.00

DESIGN SURFACE LEVEL	17.967	19.688	19.712	19.813	19.913	19.938	20.063
DEPTH CUT - / FILL +	0.000	1.413	1.394	1.321	1.248	1.225	1.122
EXISTING SURFACE LEVEL	17.967	18.275	18.318	18.491	18.664	18.713	18.941
OFFSET FROM CENTRELINE	-11.88	-5	-4	0	4	5	10.03

CH 60



DATUM R.L. 17.00

DESIGN SURFACE LEVEL	19.196	20.338	20.363	20.463	20.563	20.588	20.773
DEPTH CUT - / FILL +	0.000	1.111	1.129	1.202	1.275	1.293	1.428
EXISTING SURFACE LEVEL	19.196	19.227	19.234	19.261	19.288	19.295	19.345
OFFSET FROM CENTRELINE	-9.57	-5	-4	0	4	5	12.39

CH 100

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
0	ISSUED FOR CONSTRUCTION	RK	AR	IG	29.09.19

Note: * indicates signatures on original issue of drawing or last revision of drawing

0 2 4 6 8 10m
SCALE 1:200 AT ORIGINAL SIZE

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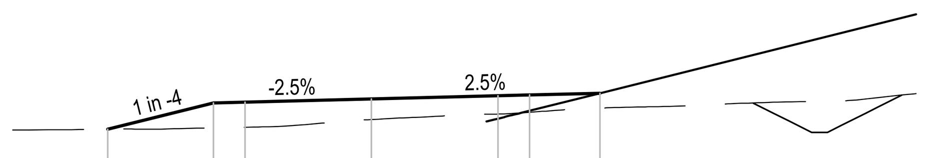
DO NOT SCALE

Drawn J.CASIO
Designer P. ETCHELLS
Drafting Check R. PRASAD
Design Check A. ROBERTS
Approved (Project Director) I. GREGSON*
Date 26.09.19
Scale 1:200
This Drawing must not be used for Construction unless signed as Approved

Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **PERIMETER ROAD CROSS SECTIONS SHEET 1 OF 7**

Original Size A1
Drawing No: **22-18015-C063**
Rev: 0

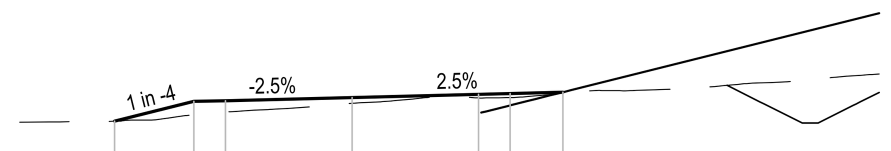
Plot Date: 27 September 2019 - 9:55 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C063.dwg



DATUM R.L. 17.00

DESIGN SURFACE LEVEL	19.309	20.145	20.170	20.270	20.370	20.395	20.451
DEPTH CUT - / FILL +	0.000	0.798	0.801	0.652	0.578	0.548	0.472
EXISTING SURFACE LEVEL	19.309	19.347	19.369	19.618	19.792	19.847	19.979
OFFSET FROM CENTRELINE	-8.35	-5	-4	0	4	5	7.23

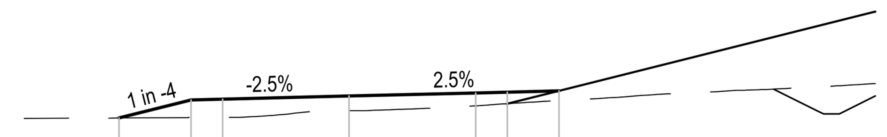
CH 170



DATUM R.L. 18.00

DESIGN SURFACE LEVEL	19.978	20.605	20.630	20.730	20.830	20.855	20.897
DEPTH CUT - / FILL +	0.000	0.417	0.359	0.181	0.114	0.129	0.031
EXISTING SURFACE LEVEL	19.978	20.188	20.271	20.549	20.716	20.726	20.866
OFFSET FROM CENTRELINE	-7.51	-5	-4	0	4	5	6.67

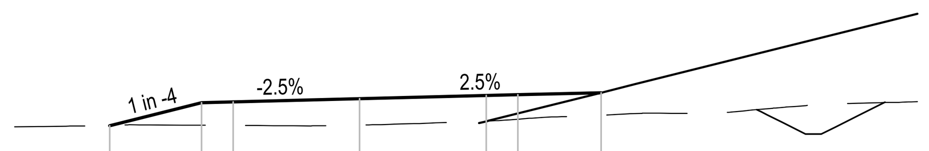
CH 210



DATUM R.L. 19.00

DESIGN SURFACE LEVEL	20.497	21.065	21.090	21.190	21.290	21.315	21.356
DEPTH CUT - / FILL +	0.000	0.547	0.576	0.466	0.409	0.364	0.306
EXISTING SURFACE LEVEL	20.497	20.518	20.514	20.724	20.881	20.951	21.050
OFFSET FROM CENTRELINE	-7.27	-5	-4	0	4	5	6.64

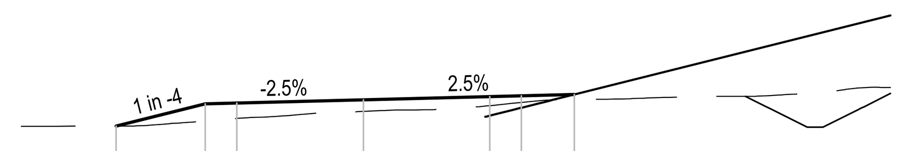
CH 250



DATUM R.L. 17.00

DESIGN SURFACE LEVEL	19.304	20.030	20.055	20.155	20.255	20.280	20.346
DEPTH CUT - / FILL +	0.000	0.714	0.745	0.834	0.811	0.773	0.714
EXISTING SURFACE LEVEL	19.304	19.316	19.310	19.321	19.444	19.507	19.632
OFFSET FROM CENTRELINE	-7.9	-5	-4	0	4	5	7.64

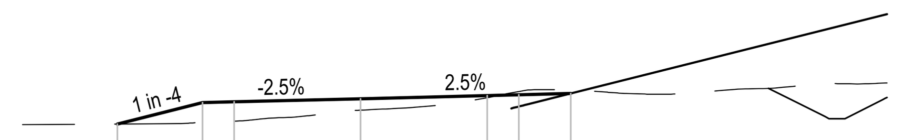
CH 160



DATUM R.L. 18.00

DESIGN SURFACE LEVEL	19.786	20.490	20.515	20.615	20.715	20.740	20.782
DEPTH CUT - / FILL +	0.000	0.546	0.487	0.369	0.285	0.207	0.145
EXISTING SURFACE LEVEL	19.786	19.944	20.028	20.246	20.430	20.533	20.637
OFFSET FROM CENTRELINE	-7.82	-5	-4	0	4	5	6.68

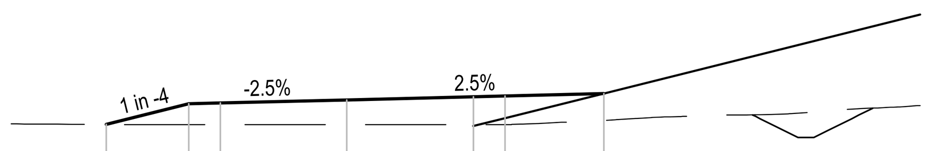
CH 200



DATUM R.L. 19.00

DESIGN SURFACE LEVEL	20.279	20.950	20.975	21.075	21.175	21.200	21.241
DEPTH CUT - / FILL +	0.000	0.620	0.609	0.361	0.067	-0.101	-0.109
EXISTING SURFACE LEVEL	20.279	20.330	20.366	20.714	21.108	21.301	21.350
OFFSET FROM CENTRELINE	-7.69	-5	-4	0	4	5	6.65

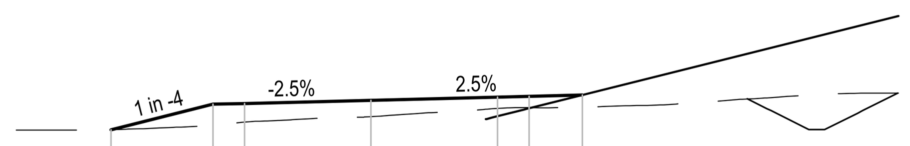
CH 240



DATUM R.L. 17.00

DESIGN SURFACE LEVEL	19.281	19.933	19.958	20.058	20.158	20.183	20.261
DEPTH CUT - / FILL +	0.000	0.658	0.683	0.786	0.884	0.907	0.853
EXISTING SURFACE LEVEL	19.281	19.275	19.274	19.271	19.274	19.275	19.408
OFFSET FROM CENTRELINE	-7.61	-5	-4	0	4	5	8.13

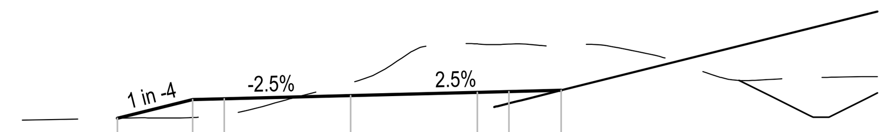
CH 150



DATUM R.L. 18.00

DESIGN SURFACE LEVEL	19.570	20.375	20.400	20.500	20.600	20.625	20.667
DEPTH CUT - / FILL +	0.000	0.664	0.590	0.519	0.358	0.359	0.383
EXISTING SURFACE LEVEL	19.570	19.711	19.810	19.981	20.242	20.266	20.284
OFFSET FROM CENTRELINE	-8.22	-5	-4	0	4	5	6.69

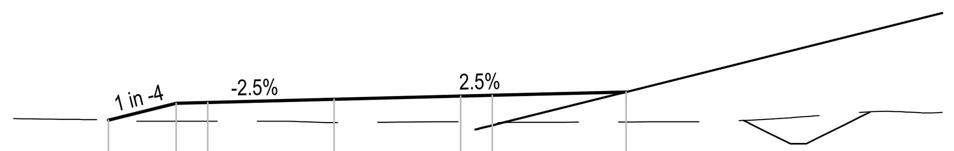
CH 190



DATUM R.L. 18.00

DESIGN SURFACE LEVEL	20.240	20.835	20.860	20.960	21.060	21.085	21.126
DEPTH CUT - / FILL +	0.000	0.571	0.506	-0.405	-1.540	-1.507	-1.400
EXISTING SURFACE LEVEL	20.240	20.264	20.354	21.365	22.600	22.592	22.527
OFFSET FROM CENTRELINE	-7.38	-5	-4	0	4	5	6.65

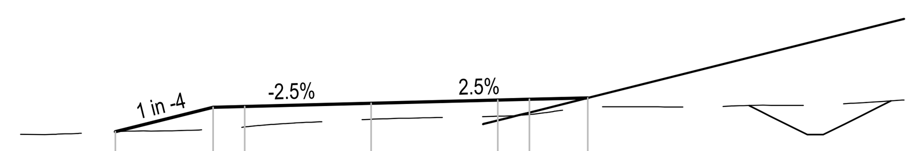
CH 230



DATUM R.L. 17.00

DESIGN SURFACE LEVEL	19.440	19.975	20.000	20.100	20.200	20.225	20.331
DEPTH CUT - / FILL +	0.000	0.571	0.596	0.735	0.812	0.850	0.950
EXISTING SURFACE LEVEL	19.440	19.404	19.404	19.365	19.388	19.375	19.381
OFFSET FROM CENTRELINE	-7.14	-5	-4	0	4	5	9.24

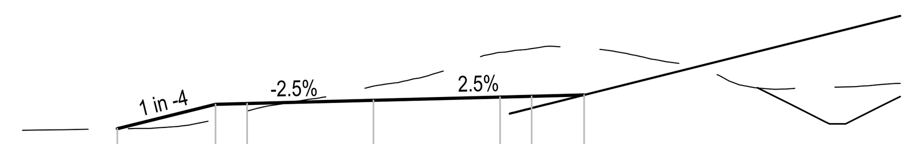
CH 140



DATUM R.L. 18.00

DESIGN SURFACE LEVEL	19.489	20.260	20.285	20.385	20.485	20.510	20.556
DEPTH CUT - / FILL +	0.000	0.702	0.646	0.504	0.508	0.476	0.301
EXISTING SURFACE LEVEL	19.489	19.558	19.639	19.881	19.977	20.034	20.255
OFFSET FROM CENTRELINE	-8.09	-5	-4	0	4	5	6.85

CH 180



DATUM R.L. 18.00

DESIGN SURFACE LEVEL	19.944	20.720	20.745	20.845	20.945	20.970	21.012
DEPTH CUT - / FILL +	0.000	0.486	0.240	-0.447	-1.414	-1.511	-1.493
EXISTING SURFACE LEVEL	19.944	20.234	20.505	21.292	22.359	22.481	22.505
OFFSET FROM CENTRELINE	-8.1	-5	-4	0	4	5	6.66

CH 220

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
0	ISSUED FOR CONSTRUCTION	RK	AR	IG	29.09.19

Note: * indicates signatures on original issue of drawing or last revision of drawing

0 2 4 6 8 10m
SCALE 1:200 AT ORIGINAL SIZE

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DO NOT SCALE

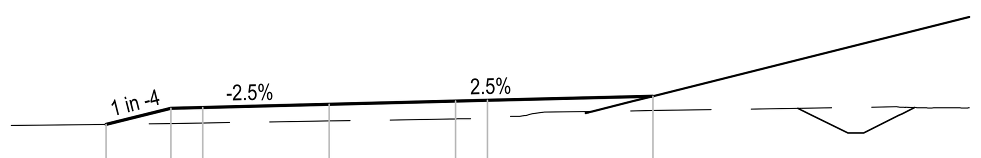
Drawn J.CASIO | Designer P. ETCHELLS
Drafting Check P. PRASAD | Design Check A. ROBERTS
Approved (Project Director) I. GREGSON*
Date 26.09.19
Scale 1:200

This Drawing must not be used for Construction unless signed as Approved

Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **PERIMETER ROAD CROSS SECTION SHEET 2 OF 7**

Original Size **A1** Drawing No: **22-18015-C064** Rev: **0**

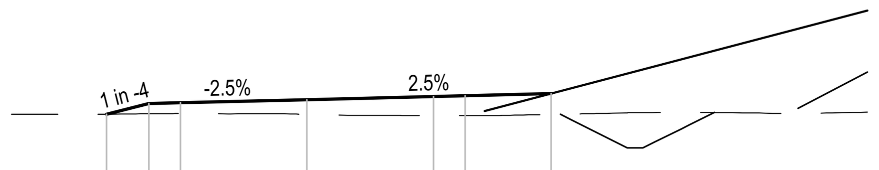
Plot Date: 27 September 2019 - 9:55 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C064.dwg



DATUM R.L. 19.00

DESIGN SURFACE LEVEL	21.462	21.975	22.000	22.100	22.200	22.225	22.356
DEPTH CUT - / FILL +	0.000	0.480	0.490	0.526	0.562	0.571	0.454
EXISTING SURFACE LEVEL	21.462	21.495	21.510	21.574	21.638	21.654	21.902
OFFSET FROM CENTRELINE	-7.05	-5	-4	0	4	5	10.24

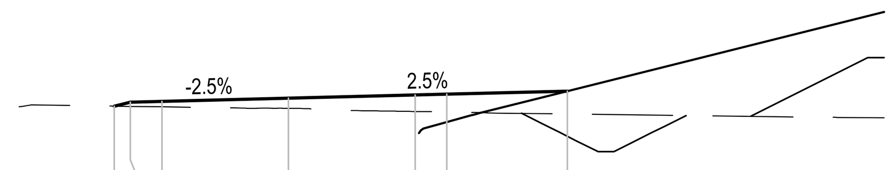
CH 290



DATUM R.L. 20.00

DESIGN SURFACE LEVEL	23.161	23.495	23.520	23.620	23.720	23.745	23.813
DEPTH CUT - / FILL +	0.000	0.320	0.339	0.465	0.600	0.626	0.662
EXISTING SURFACE LEVEL	23.161	23.175	23.181	23.155	23.120	23.119	23.151
OFFSET FROM CENTRELINE	-6.34	-5	-4	0	4	5	7.72

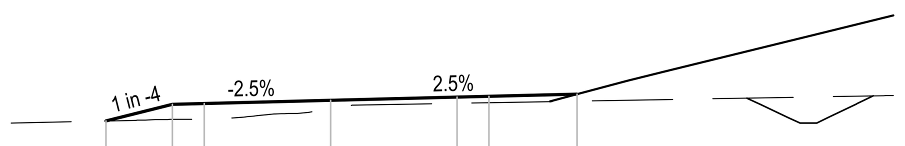
CH 330



DATUM R.L. 22.00

DESIGN SURFACE LEVEL	24.688	24.815	24.840	24.940	25.040	25.065	25.160
DEPTH CUT - / FILL +	0.000	0.134	0.173	0.319	0.522	0.559	0.720
EXISTING SURFACE LEVEL	24.688	24.681	24.666	24.621	24.518	24.506	24.440
OFFSET FROM CENTRELINE	-5.51	-5	-4	0	4	5	8.82

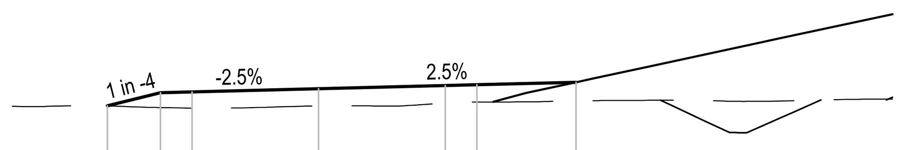
CH 370



DATUM R.L. 19.00

DESIGN SURFACE LEVEL	21.089	21.615	21.640	21.740	21.840	21.865	21.934
DEPTH CUT - / FILL +	0.000	0.478	0.489	0.230	0.196	0.203	0.222
EXISTING SURFACE LEVEL	21.089	21.137	21.151	21.510	21.644	21.662	21.712
OFFSET FROM CENTRELINE	-7.1	-5	-4	0	4	5	7.79

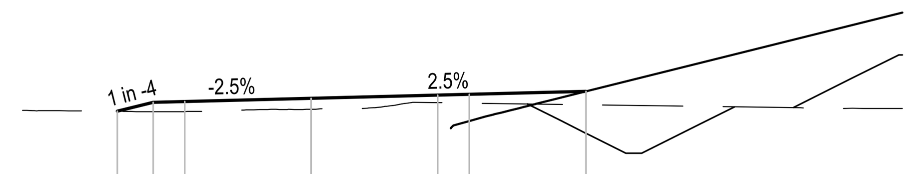
CH 280



DATUM R.L. 20.00

DESIGN SURFACE LEVEL	22.696	23.115	23.140	23.240	23.340	23.365	23.443
DEPTH CUT - / FILL +	0.000	0.475	0.517	0.546	0.551	0.548	0.588
EXISTING SURFACE LEVEL	22.696	22.640	22.623	22.694	22.789	22.817	22.855
OFFSET FROM CENTRELINE	-6.68	-5	-4	0	4	5	8.13

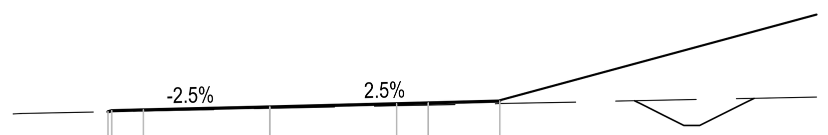
CH 320



DATUM R.L. 21.00

DESIGN SURFACE LEVEL	24.283	24.565	24.590	24.690	24.790	24.815	24.907
DEPTH CUT - / FILL +	0.000	0.302	0.322	0.348	0.238	0.277	0.422
EXISTING SURFACE LEVEL	24.283	24.263	24.267	24.342	24.552	24.538	24.485
OFFSET FROM CENTRELINE	-6.13	-5	-4	0	4	5	8.7

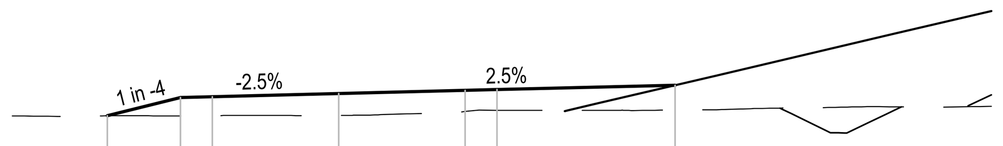
CH 360



DATUM R.L. 19.00

DESIGN SURFACE LEVEL	21.319	21.347	21.372	21.472	21.572	21.597	21.654
DEPTH CUT - / FILL +	0.000	0.026	0.030	0.047	0.064	0.069	0.078
EXISTING SURFACE LEVEL	21.319	21.321	21.342	21.425	21.508	21.529	21.576
OFFSET FROM CENTRELINE	-5.11	-5	-4	0	4	5	7.26

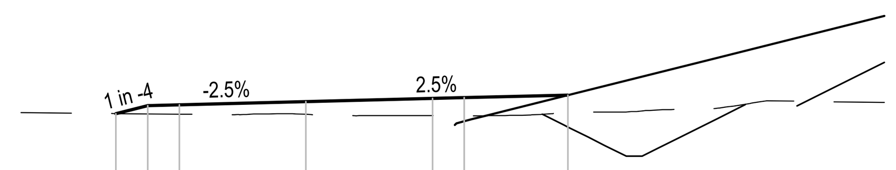
CH 270



DATUM R.L. 20.00

DESIGN SURFACE LEVEL	22.155	22.735	22.760	22.860	22.960	22.985	23.126
DEPTH CUT - / FILL +	0.000	0.586	0.600	0.696	0.668	0.653	0.789
EXISTING SURFACE LEVEL	22.155	22.149	22.160	22.164	22.292	22.332	22.337
OFFSET FROM CENTRELINE	-7.32	-5	-4	0	4	5	10.63

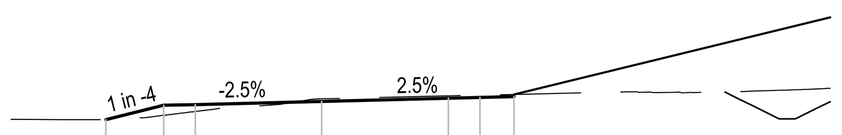
CH 310



DATUM R.L. 21.00

DESIGN SURFACE LEVEL	23.998	24.248	24.273	24.373	24.473	24.498	24.580
DEPTH CUT - / FILL +	0.000	0.260	0.294	0.398	0.539	0.577	0.566
EXISTING SURFACE LEVEL	23.998	23.989	23.979	23.975	23.934	23.921	24.014
OFFSET FROM CENTRELINE	-6	-5	-4	0	4	5	8.28

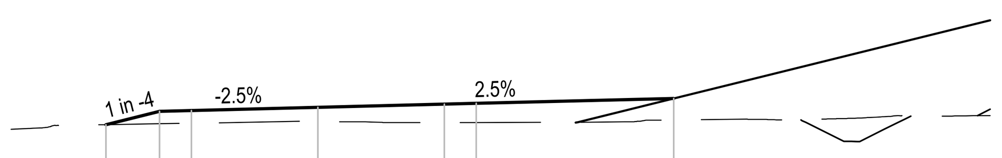
CH 350



DATUM R.L. 19.00

DESIGN SURFACE LEVEL	20.723	21.180	21.205	21.305	21.405	21.430	21.457
DEPTH CUT - / FILL +	0.000	0.316	0.220	-0.078	-0.072	-0.070	-0.069
EXISTING SURFACE LEVEL	20.723	20.864	20.985	21.383	21.477	21.500	21.526
OFFSET FROM CENTRELINE	-6.83	-5	-4	0	4	5	6.07

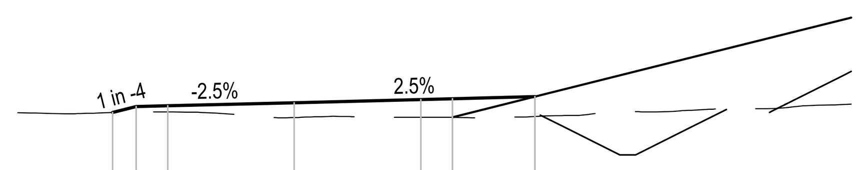
CH 260



DATUM R.L. 20.00

DESIGN SURFACE LEVEL	21.931	22.355	22.380	22.480	22.580	22.605	22.761
DEPTH CUT - / FILL +	0.000	0.395	0.403	0.457	0.579	0.603	0.680
EXISTING SURFACE LEVEL	21.931	21.960	21.977	22.023	22.001	22.002	22.081
OFFSET FROM CENTRELINE	-6.7	-5	-4	0	4	5	11.25

CH 300



DATUM R.L. 21.00

DESIGN SURFACE LEVEL	23.690	23.875	23.900	24.000	24.100	24.125	24.190
DEPTH CUT - / FILL +	0.000	0.171	0.189	0.469	0.564	0.588	0.622
EXISTING SURFACE LEVEL	23.690	23.704	23.711	23.531	23.536	23.537	23.568
OFFSET FROM CENTRELINE	-5.74	-5	-4	0	4	5	7.61

CH 340

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
0	ISSUED FOR CONSTRUCTION	RK	AR	IG	29.09.19

Note: * indicates signatures on original issue of drawing or last revision of drawing

0 2 4 6 8 10m
SCALE 1:200 AT ORIGINAL SIZE

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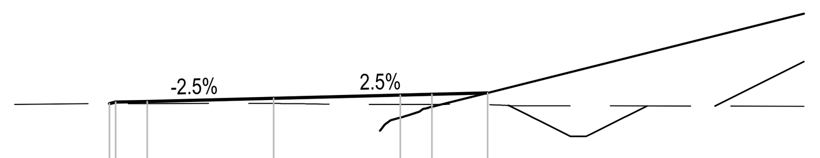
DO NOT SCALE

Drawn J.CASIO | Designer P. ETCHELLS
Drafting Check P. PRASAD | Design Check A. ROBERTS
Approved (Project Director) I. GREGSON*
Date 26.09.19
Scale 1:200
This Drawing must not be used for Construction unless signed as Approved

Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **PERIMETER ROAD CROSS SECTION SHEET 3 OF 7**

Original Size **A1** Drawing No: **22-18015-C065** Rev: **0**

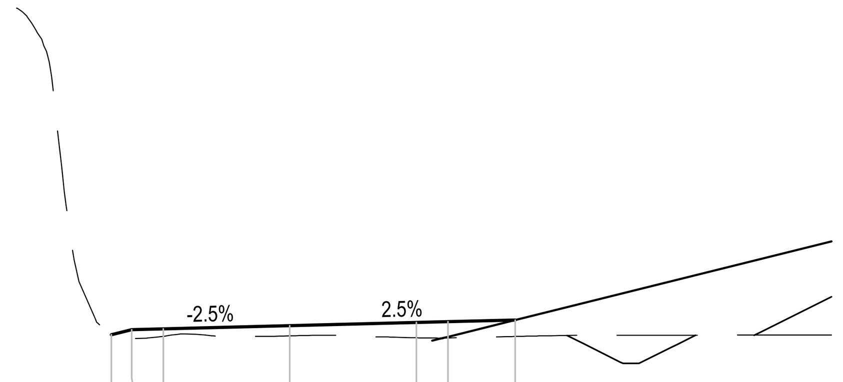
Plot Date: 27 September 2019 - 9:56 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C065.dwg



DATUM R.L. 22.00

DESIGN SURFACE LEVEL	25.100	25.148	25.173	25.273	25.373	25.398	25.442
DEPTH CUT - / FILL +	0.000	0.048	0.071	0.165	0.296	0.323	0.377
EXISTING SURFACE LEVEL	25.100	25.100	25.103	25.108	25.077	25.075	25.065
OFFSET FROM CENTRELINE	-5.19	-5	-4	0	4	5	6.76

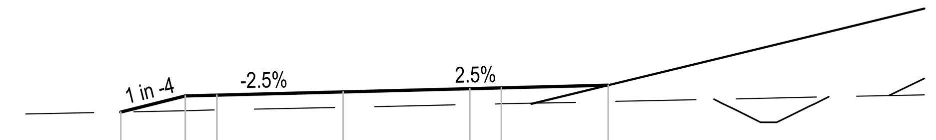
CH 410



DATUM R.L. 22.00

DESIGN SURFACE LEVEL	24.375	24.535	24.560	24.660	24.760	24.785	24.838
DEPTH CUT - / FILL +	0.000	0.283	0.237	0.324	0.483	0.514	0.518
EXISTING SURFACE LEVEL	24.375	24.252	24.323	24.336	24.277	24.271	24.320
OFFSET FROM CENTRELINE	-5.64	-5	-4	0	4	5	7.13

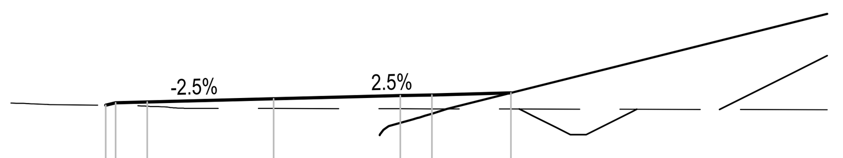
CH 450



DATUM R.L. 21.00

DESIGN SURFACE LEVEL	23.264	23.775	23.800	23.900	24.000	24.025	24.110
DEPTH CUT - / FILL +	0.000	0.467	0.471	0.485	0.500	0.503	0.516
EXISTING SURFACE LEVEL	23.264	23.308	23.329	23.415	23.500	23.522	23.594
OFFSET FROM CENTRELINE	-7.04	-5	-4	0	4	5	8.38

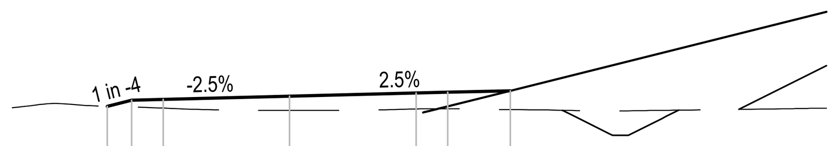
CH 490



DATUM R.L. 22.00

DESIGN SURFACE LEVEL	25.087	25.165	25.190	25.290	25.390	25.415	25.477
DEPTH CUT - / FILL +	0.000	0.080	0.133	0.306	0.415	0.442	0.510
EXISTING SURFACE LEVEL	25.087	25.084	25.056	24.984	24.975	24.973	24.967
OFFSET FROM CENTRELINE	-5.31	-5	-4	0	4	5	7.5

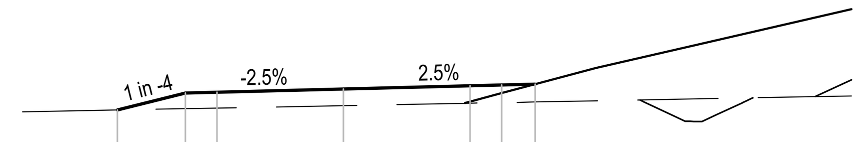
CH 400



DATUM R.L. 22.00

DESIGN SURFACE LEVEL	24.532	24.725	24.750	24.850	24.950	24.975	25.025
DEPTH CUT - / FILL +	0.000	0.210	0.274	0.444	0.502	0.518	0.597
EXISTING SURFACE LEVEL	24.532	24.515	24.476	24.406	24.448	24.457	24.428
OFFSET FROM CENTRELINE	-5.77	-5	-4	0	4	5	6.98

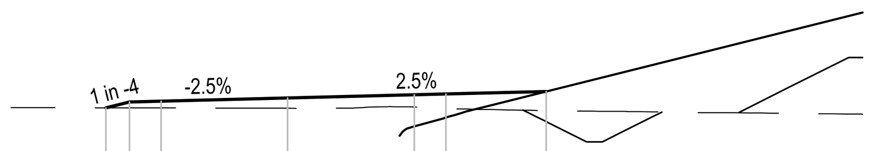
CH 440



DATUM R.L. 21.00

DESIGN SURFACE LEVEL	23.429	23.965	23.990	24.090	24.190	24.215	24.241
DEPTH CUT - / FILL +	0.000	0.496	0.501	0.525	0.549	0.555	0.561
EXISTING SURFACE LEVEL	23.429	23.469	23.489	23.565	23.641	23.660	23.680
OFFSET FROM CENTRELINE	-7.15	-5	-4	0	4	5	6.06

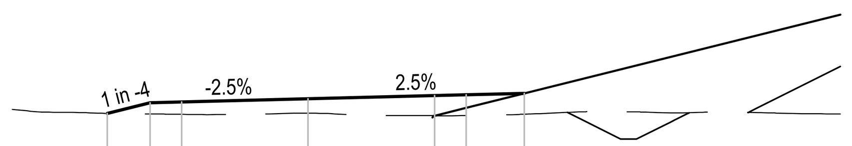
CH 480



DATUM R.L. 22.00

DESIGN SURFACE LEVEL	24.929	25.115	25.140	25.240	25.340	25.365	25.444
DEPTH CUT - / FILL +	0.000	0.188	0.215	0.325	0.386	0.458	0.601
EXISTING SURFACE LEVEL	24.929	24.927	24.925	24.915	24.954	24.907	24.843
OFFSET FROM CENTRELINE	-5.74	-5	-4	0	4	5	8.16

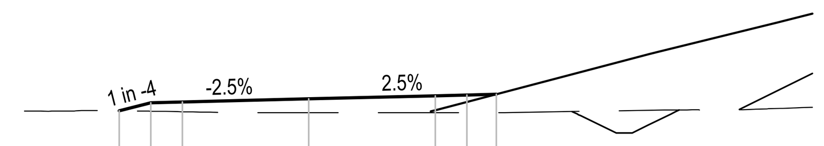
CH 390



DATUM R.L. 22.00

DESIGN SURFACE LEVEL	24.575	24.915	24.940	25.040	25.140	25.165	25.211
DEPTH CUT - / FILL +	0.000	0.357	0.392	0.455	0.636	0.657	0.660
EXISTING SURFACE LEVEL	24.575	24.558	24.547	24.585	24.503	24.508	24.551
OFFSET FROM CENTRELINE	-6.36	-5	-4	0	4	5	6.84

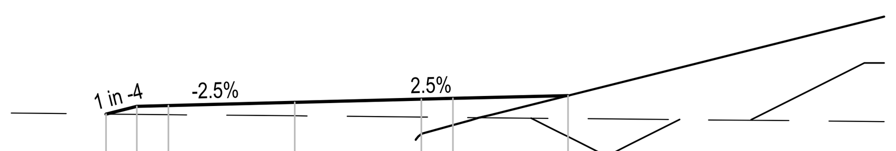
CH 430



DATUM R.L. 21.00

DESIGN SURFACE LEVEL	23.906	24.155	24.180	24.280	24.380	24.405	24.428
DEPTH CUT - / FILL +	0.000	0.265	0.307	0.435	0.536	0.560	0.583
EXISTING SURFACE LEVEL	23.906	23.890	23.873	23.845	23.844	23.845	23.845
OFFSET FROM CENTRELINE	-5.99	-5	-4	0	4	5	5.93

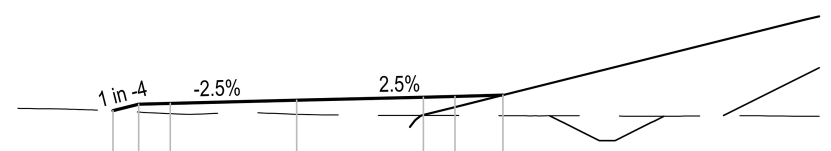
CH 470



DATUM R.L. 22.00

DESIGN SURFACE LEVEL	24.756	24.998	25.023	25.123	25.223	25.248	25.339
DEPTH CUT - / FILL +	0.000	0.252	0.287	0.426	0.564	0.599	0.725
EXISTING SURFACE LEVEL	24.756	24.746	24.736	24.698	24.659	24.649	24.614
OFFSET FROM CENTRELINE	-5.97	-5	-4	0	4	5	8.64

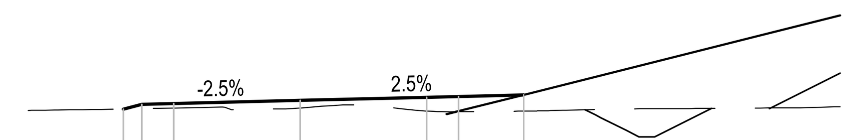
CH 380



DATUM R.L. 22.00

DESIGN SURFACE LEVEL	24.861	25.065	25.090	25.190	25.290	25.315	25.353
DEPTH CUT - / FILL +	0.000	0.248	0.322	0.443	0.582	0.602	0.649
EXISTING SURFACE LEVEL	24.861	24.816	24.767	24.746	24.707	24.712	24.704
OFFSET FROM CENTRELINE	-5.81	-5	-4	0	4	5	6.52

CH 420



DATUM R.L. 22.00

DESIGN SURFACE LEVEL	24.197	24.345	24.370	24.470	24.570	24.595	24.646
DEPTH CUT - / FILL +	0.000	0.136	0.141	0.239	0.434	0.481	0.514
EXISTING SURFACE LEVEL	24.197	24.209	24.229	24.231	24.136	24.114	24.132
OFFSET FROM CENTRELINE	-5.59	-5	-4	0	4	5	7.06

CH 460

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
0	ISSUED FOR CONSTRUCTION	RK	AR	IG	29.09.19

Note: * indicates signatures on original issue of drawing or last revision of drawing

0 2 4 6 8 10m
SCALE 1:200 AT ORIGINAL SIZE

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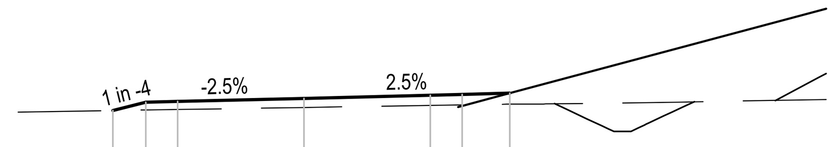
DO NOT SCALE

Drawn J.CASIO | Designer P. ETCHELLS
Drafting Check P. PRASAD | Design Check A. ROBERTS
Approved (Project Director) I. GREGSON*
Date 26.09.19
Scale 1:200
This Drawing must not be used for Construction unless signed as Approved

Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **PERIMETER ROAD CROSS SECTION SHEET 4 OF 7**

Original Size A1 Drawing No: **22-18015-C066** Rev: 0

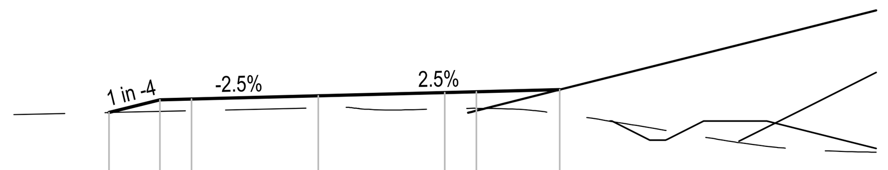
Plot Date: 27 September 2019 - 9:56 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C066.dwg



DATUM R.L. 21.00

DESIGN SURFACE LEVEL	23.115	23.375	23.400	23.500	23.600	23.625	23.663
DEPTH CUT - / FILL +	0.000	0.244	0.253	0.288	0.324	0.333	0.346
EXISTING SURFACE LEVEL	23.115	23.131	23.147	23.212	23.276	23.292	23.317
OFFSET FROM CENTRELINE	-6.04	-5	-4	0	4	5	6.51

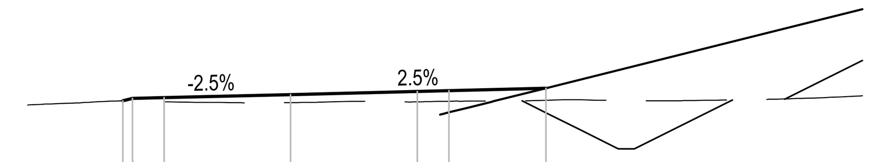
CH 530



DATUM R.L. 20.00

DESIGN SURFACE LEVEL	22.772	23.175	23.200	23.300	23.400	23.425	23.491
DEPTH CUT - / FILL +	0.000	0.368	0.371	0.383	0.508	0.519	0.757
EXISTING SURFACE LEVEL	22.772	22.807	22.829	22.917	22.892	22.906	22.734
OFFSET FROM CENTRELINE	-6.61	-5	-4	0	4	5	7.63

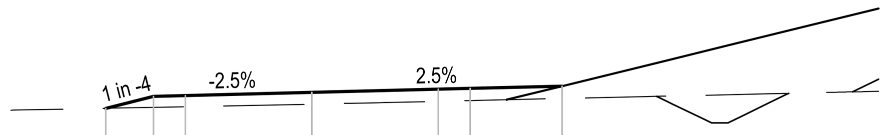
CH 570



DATUM R.L. 20.00

DESIGN SURFACE LEVEL	22.898	22.975	23.000	23.100	23.200	23.225	23.302
DEPTH CUT - / FILL +	0.000	0.079	0.131	0.257	0.332	0.338	0.380
EXISTING SURFACE LEVEL	22.898	22.896	22.869	22.843	22.868	22.887	22.921
OFFSET FROM CENTRELINE	-5.31	-5	-4	0	4	5	8.07

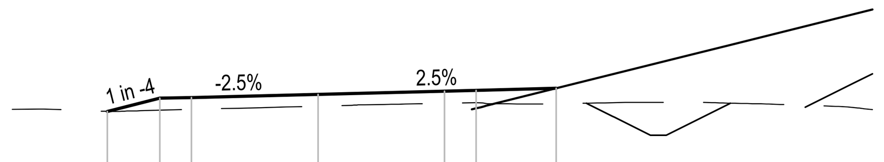
CH 610



DATUM R.L. 21.00

DESIGN SURFACE LEVEL	23.048	23.425	23.450	23.550	23.650	23.675	23.748
DEPTH CUT - / FILL +	0.000	0.347	0.352	0.370	0.382	0.384	0.390
EXISTING SURFACE LEVEL	23.048	23.078	23.098	23.180	23.268	23.291	23.357
OFFSET FROM CENTRELINE	-6.51	-5	-4	0	4	5	7.91

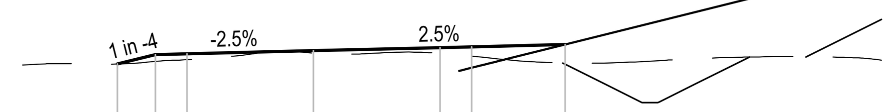
CH 520



DATUM R.L. 20.00

DESIGN SURFACE LEVEL	22.809	23.225	23.250	23.350	23.450	23.475	23.538
DEPTH CUT - / FILL +	0.000	0.380	0.379	0.376	0.384	0.390	0.488
EXISTING SURFACE LEVEL	22.809	22.845	22.871	22.974	23.066	23.085	23.051
OFFSET FROM CENTRELINE	-6.67	-5	-4	0	4	5	7.52

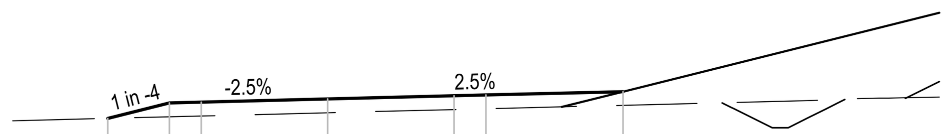
CH 560



DATUM R.L. 20.00

DESIGN SURFACE LEVEL	22.726	23.025	23.050	23.150	23.250	23.275	23.349
DEPTH CUT - / FILL +	0.000	0.211	0.186	0.076	0.187	0.298	0.593
EXISTING SURFACE LEVEL	22.726	22.814	22.864	23.074	23.063	22.977	22.756
OFFSET FROM CENTRELINE	-6.2	-5	-4	0	4	5	7.96

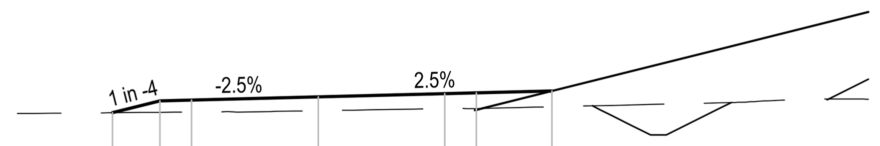
CH 600



DATUM R.L. 21.00

DESIGN SURFACE LEVEL	23.004	23.492	23.517	23.617	23.717	23.742	23.851
DEPTH CUT - / FILL +	0.000	0.439	0.439	0.438	0.437	0.437	0.436
EXISTING SURFACE LEVEL	23.004	23.053	23.078	23.179	23.280	23.305	23.415
OFFSET FROM CENTRELINE	-6.95	-5	-4	0	4	5	9.34

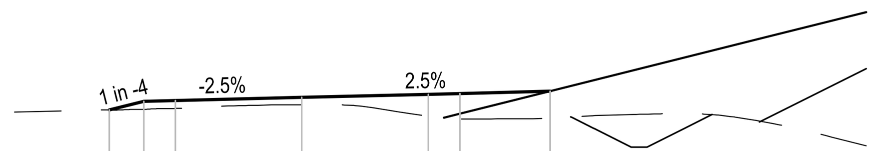
CH 510



DATUM R.L. 20.00

DESIGN SURFACE LEVEL	22.899	23.275	23.300	23.400	23.500	23.525	23.585
DEPTH CUT - / FILL +	0.000	0.364	0.381	0.437	0.468	0.494	0.497
EXISTING SURFACE LEVEL	22.899	22.911	22.919	22.963	23.032	23.031	23.087
OFFSET FROM CENTRELINE	-6.5	-5	-4	0	4	5	7.38

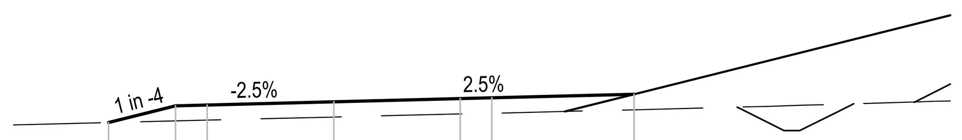
CH 550



DATUM R.L. 20.00

DESIGN SURFACE LEVEL	22.803	23.075	23.100	23.200	23.300	23.325	23.396
DEPTH CUT - / FILL +	0.000	0.253	0.247	0.230	0.691	0.807	0.852
EXISTING SURFACE LEVEL	22.803	22.822	22.853	22.970	22.609	22.518	22.545
OFFSET FROM CENTRELINE	-6.09	-5	-4	0	4	5	7.85

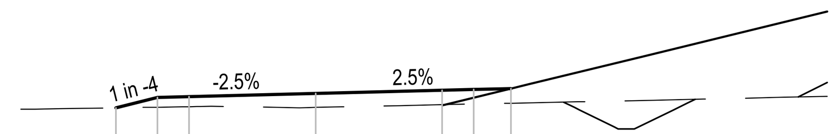
CH 590



DATUM R.L. 21.00

DESIGN SURFACE LEVEL	23.079	23.609	23.634	23.734	23.834	23.859	23.971
DEPTH CUT - / FILL +	0.000	0.479	0.480	0.483	0.486	0.487	0.491
EXISTING SURFACE LEVEL	23.079	23.130	23.154	23.251	23.347	23.371	23.480
OFFSET FROM CENTRELINE	-7.12	-5	-4	0	4	5	9.49

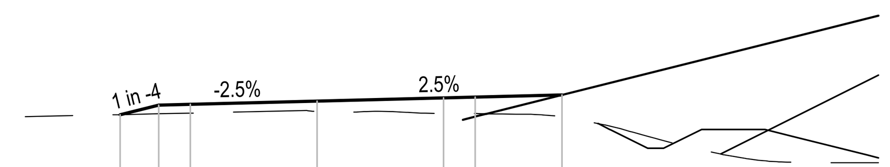
CH 500



DATUM R.L. 21.00

DESIGN SURFACE LEVEL	22.995	23.325	23.350	23.450	23.550	23.575	23.604
DEPTH CUT - / FILL +	0.000	0.309	0.319	0.441	0.456	0.459	0.464
EXISTING SURFACE LEVEL	22.995	23.016	23.031	23.009	23.094	23.116	23.141
OFFSET FROM CENTRELINE	-6.32	-5	-4	0	4	5	6.17

CH 540



DATUM R.L. 20.00

DESIGN SURFACE LEVEL	22.820	23.125	23.150	23.250	23.350	23.375	23.444
DEPTH CUT - / FILL +	0.000	0.278	0.281	0.341	0.494	0.518	0.694
EXISTING SURFACE LEVEL	22.820	22.847	22.869	22.909	22.856	22.857	22.749
OFFSET FROM CENTRELINE	-6.22	-5	-4	0	4	5	7.74

CH 580

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
0	ISSUED FOR CONSTRUCTION	RK	AR	IG	29.09.19

Note: * indicates signatures on original issue of drawing or last revision of drawing

0 2 4 6 8 10m
SCALE 1:200 AT ORIGINAL SIZE

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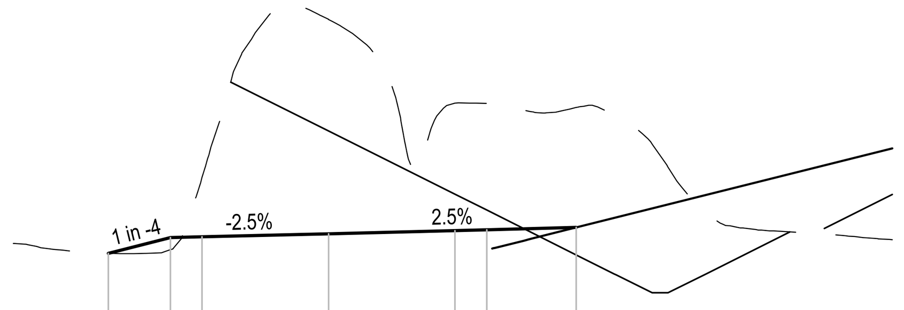
Drawn J.CASIO
Designer P. ETCHELLS
Drafting Check P. PRASAD
Design Check A. ROBERTS
Approved (Project Director) I. GREGSON*
Date 26.09.19
Scale 1:200
This Drawing must not be used for Construction unless signed as Approved

Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **PERIMETER ROAD CROSS SECTIONS SHEET 5 OF 7**

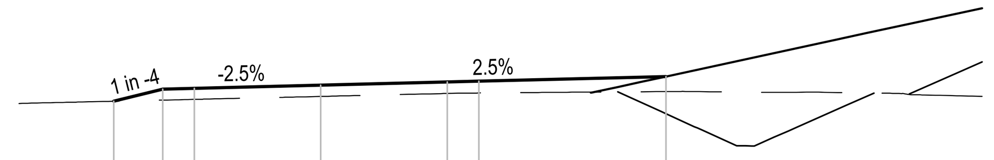
Original Size A1 Drawing No: **22-18015-C067** Rev: **0**

Plot Date: 27 September 2019 - 9:56 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C067.dwg



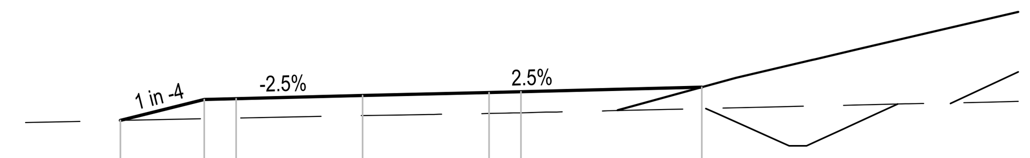
DATUM R.L. 19.00							
DESIGN SURFACE LEVEL	22.132	22.625	22.650	22.750	22.850	22.875	22.946
DEPTH CUT - / FILL +	0.000	0.380	-1.883	-6.772	-4.030	-3.992	-3.793
EXISTING SURFACE LEVEL	22.132	22.245	24.533	29.522	26.880	26.867	26.739
OFFSET FROM CENTRELINE	-6.97	-5	-4	0	4	5	7.83

CH 650



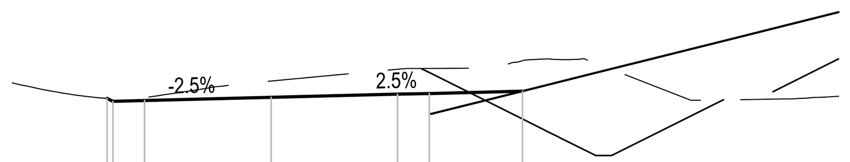
DATUM R.L. 19.00							
DESIGN SURFACE LEVEL	21.838	22.225	22.250	22.350	22.450	22.475	22.623
DEPTH CUT - / FILL +	0.000	0.351	0.352	0.359	0.365	0.377	0.478
EXISTING SURFACE LEVEL	21.838	21.874	21.898	21.991	22.085	22.098	22.145
OFFSET FROM CENTRELINE	-6.55	-5	-4	0	4	5	10.92

CH 690



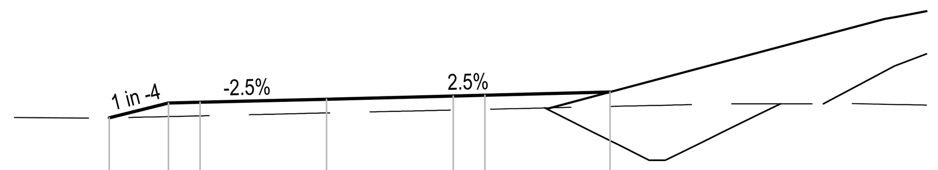
DATUM R.L. 18.00							
DESIGN SURFACE LEVEL	20.887	21.550	21.575	21.675	21.775	21.800	21.943
DEPTH CUT - / FILL +	0.000	0.608	0.613	0.633	0.664	0.669	0.679
EXISTING SURFACE LEVEL	20.887	20.942	20.962	21.042	21.111	21.131	21.264
OFFSET FROM CENTRELINE	-7.65	-5	-4	0	4	5	10.72

CH 730



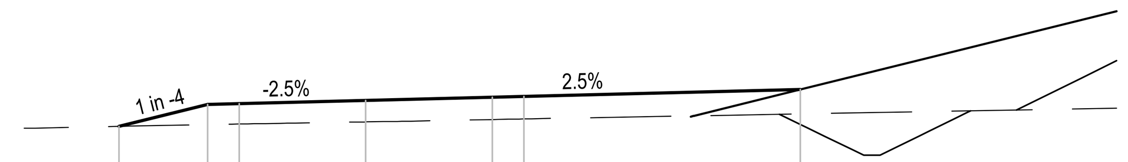
DATUM R.L. 19.00							
DESIGN SURFACE LEVEL	22.819	22.725	22.750	22.850	22.950	22.975	23.049
DEPTH CUT - / FILL +	0.000	-0.081	-0.097	-0.520	-0.791	-0.793	-0.962
EXISTING SURFACE LEVEL	22.819	22.806	22.847	23.370	23.741	23.768	24.011
OFFSET FROM CENTRELINE	-5.19	-5	-4	0	4	5	7.95

CH 640



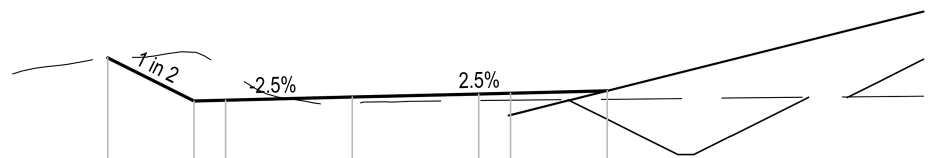
DATUM R.L. 19.00							
DESIGN SURFACE LEVEL	21.858	22.325	22.350	22.450	22.550	22.575	22.674
DEPTH CUT - / FILL +	0.000	0.424	0.426	0.435	0.444	0.446	0.454
EXISTING SURFACE LEVEL	21.858	21.901	21.924	22.015	22.106	22.129	22.220
OFFSET FROM CENTRELINE	-6.87	-5	-4	0	4	5	8.95

CH 680



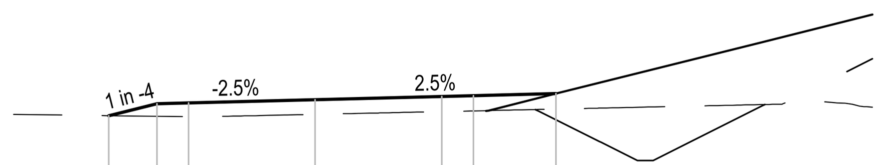
DATUM R.L. 18.00							
DESIGN SURFACE LEVEL	21.089	21.789	21.814	21.914	22.014	22.039	22.257
DEPTH CUT - / FILL +	0.000	0.643	0.650	0.684	0.708	0.713	0.773
EXISTING SURFACE LEVEL	21.089	21.146	21.164	21.230	21.306	21.325	21.484
OFFSET FROM CENTRELINE	-7.8	-5	-4	0	4	5	13.74

CH 720



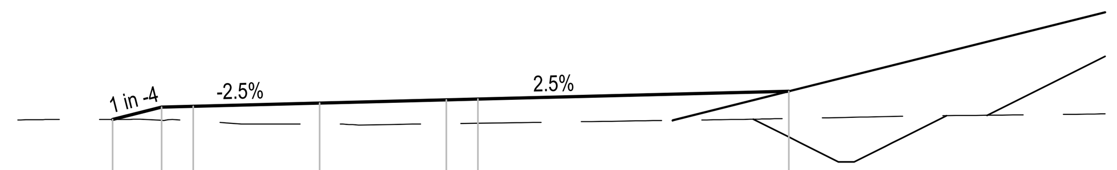
DATUM R.L. 19.00							
DESIGN SURFACE LEVEL	24.192	22.825	22.850	22.950	23.050	23.075	23.152
DEPTH CUT - / FILL +	0.000	-1.542	-0.978	0.228	0.211	0.226	0.271
EXISTING SURFACE LEVEL	24.192	24.367	23.828	22.722	22.839	22.849	22.881
OFFSET FROM CENTRELINE	-7.73	-5	-4	0	4	5	8.06

CH 630



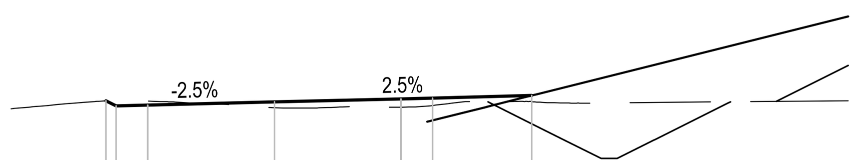
DATUM R.L. 19.00							
DESIGN SURFACE LEVEL	22.044	22.425	22.450	22.550	22.650	22.675	22.740
DEPTH CUT - / FILL +	0.000	0.402	0.441	0.464	0.476	0.479	0.487
EXISTING SURFACE LEVEL	22.044	22.023	22.009	22.086	22.174	22.196	22.253
OFFSET FROM CENTRELINE	-6.53	-5	-4	0	4	5	7.61

CH 670



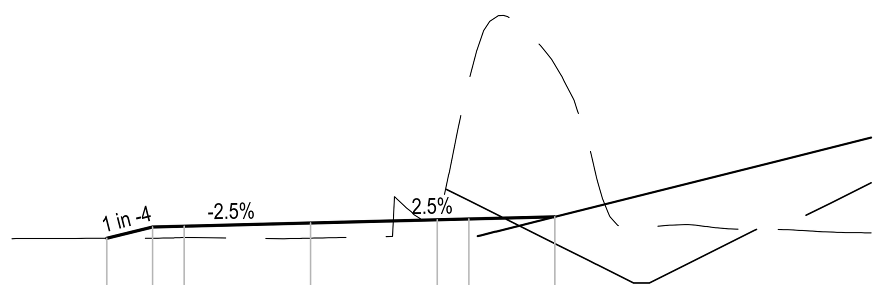
DATUM R.L. 19.00							
DESIGN SURFACE LEVEL	21.594	21.981	22.006	22.106	22.206	22.231	22.476
DEPTH CUT - / FILL +	0.000	0.419	0.451	0.662	0.746	0.759	0.856
EXISTING SURFACE LEVEL	21.594	21.562	21.555	21.444	21.459	21.472	21.621
OFFSET FROM CENTRELINE	-6.55	-5	-4	0	4	5	14.83

CH 710



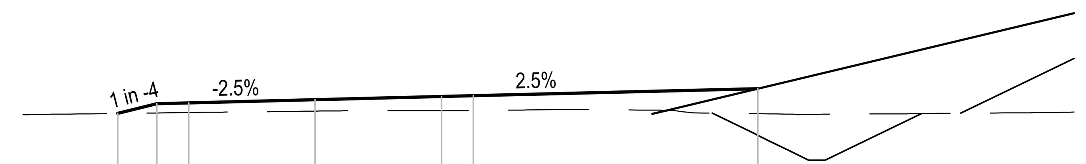
DATUM R.L. 20.00							
DESIGN SURFACE LEVEL	23.077	22.916	22.941	23.041	23.141	23.166	23.244
DEPTH CUT - / FILL +	0.000	-0.169	-0.127	0.184	0.267	0.236	0.192
EXISTING SURFACE LEVEL	23.077	23.085	23.068	22.857	22.874	22.929	23.052
OFFSET FROM CENTRELINE	-5.32	-5	-4	0	4	5	8.13

CH 620



DATUM R.L. 19.00							
DESIGN SURFACE LEVEL	22.165	22.525	22.550	22.650	22.750	22.775	22.843
DEPTH CUT - / FILL +	0.000	0.356	0.359	0.482	-0.157	-4.380	-4.805
EXISTING SURFACE LEVEL	22.165	22.169	22.191	22.168	22.907	27.155	27.648
OFFSET FROM CENTRELINE	-6.44	-5	-4	0	4	5	7.72

CH 660



DATUM R.L. 19.00							
DESIGN SURFACE LEVEL	21.813	22.122	22.147	22.247	22.347	22.372	22.597
DEPTH CUT - / FILL +	0.000	0.294	0.307	0.361	0.448	0.470	0.791
EXISTING SURFACE LEVEL	21.813	21.828	21.841	21.886	21.899	21.902	21.806
OFFSET FROM CENTRELINE	-6.24	-5	-4	0	4	5	13.99

CH 700

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
0	ISSUED FOR CONSTRUCTION	RK	AR	IG	29.09.19

Note: * indicates signatures on original issue of drawing or last revision of drawing

0 2 4 6 8 10m
SCALE 1:200 AT ORIGINAL SIZE

GHD
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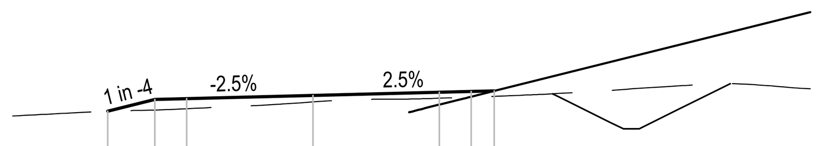
DO NOT SCALE

Drawn J.CASIO
Designer P. ETCHELLS
Drafting Check P. PRASAD
Design Check A. ROBERTS
Approved (Project Director) I. GREGSON*
Date 26.09.19
Scale 1:200
This Drawing must not be used for Construction unless signed as Approved

Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **PERIMETER ROAD CROSS SECTION SHEET 6 OF 7**

Original Size A1 Drawing No: **22-18015-C068** Rev: 0

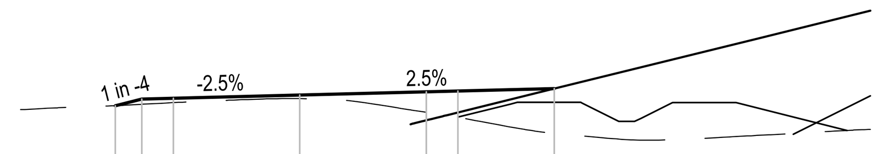
Plot Date: 27 September 2019 - 9:56 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C068.dwg



DATUM R.L. 18.00

DESIGN SURFACE LEVEL	20.206	20.581	20.606	20.706	20.806	20.831	20.849
DEPTH CUT - / FILL +	0.000	0.335	0.318	0.203	0.187	0.182	0.172
EXISTING SURFACE LEVEL	20.206	20.245	20.288	20.503	20.619	20.649	20.677
OFFSET FROM CENTRELINE	-6.5	-5	-4	0	4	5	5.73

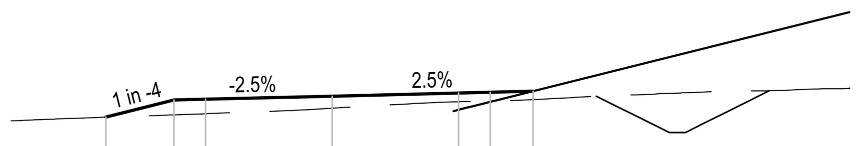
CH 770



DATUM R.L. 17.00

DESIGN SURFACE LEVEL	19.626	19.835	19.860	19.960	20.060	20.085	20.161
DEPTH CUT - / FILL +	0.000	0.165	0.138	0.112	0.638	0.824	1.405
EXISTING SURFACE LEVEL	19.626	19.670	19.722	19.848	19.422	19.261	18.756
OFFSET FROM CENTRELINE	-5.84	-5	-4	0	4	5	8.05

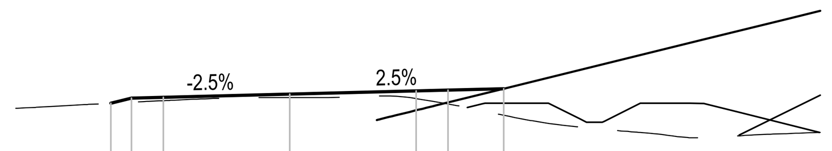
CH 810



DATUM R.L. 18.00

DESIGN SURFACE LEVEL	20.264	20.802	20.827	20.927	21.027	21.052	21.086
DEPTH CUT - / FILL +	0.000	0.468	0.458	0.383	0.278	0.283	0.266
EXISTING SURFACE LEVEL	20.264	20.335	20.369	20.544	20.749	20.769	20.820
OFFSET FROM CENTRELINE	-7.15	-5	-4	0	4	5	6.36

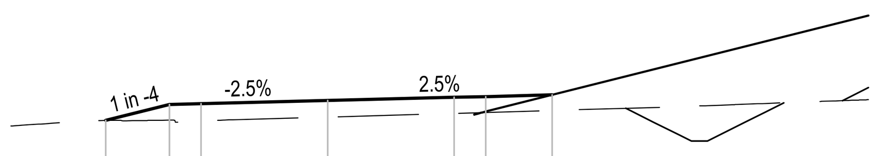
CH 760



DATUM R.L. 17.00

DESIGN SURFACE LEVEL	19.856	20.020	20.045	20.145	20.245	20.270	20.314
DEPTH CUT - / FILL +	0.000	0.132	0.110	0.108	0.241	0.438	0.839
EXISTING SURFACE LEVEL	19.856	19.888	19.935	20.037	20.004	19.832	19.476
OFFSET FROM CENTRELINE	-5.66	-5	-4	0	4	5	6.77

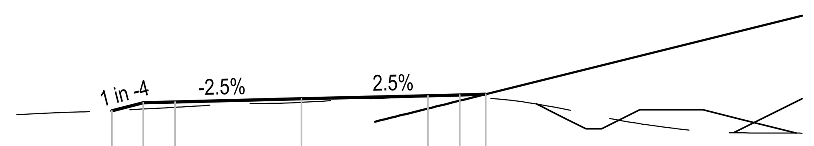
CH 800



DATUM R.L. 18.00

DESIGN SURFACE LEVEL	20.547	21.050	21.075	21.175	21.275	21.300	21.352
DEPTH CUT - / FILL +	0.000	0.493	0.549	0.520	0.504	0.500	0.491
EXISTING SURFACE LEVEL	20.547	20.557	20.526	20.655	20.771	20.800	20.861
OFFSET FROM CENTRELINE	-7.01	-5	-4	0	4	5	7.1

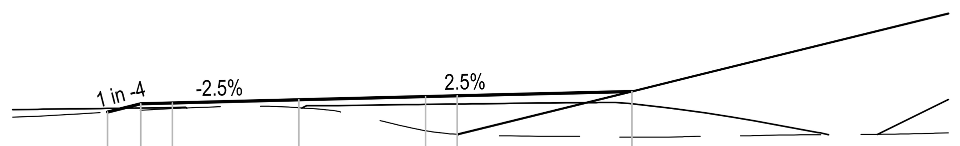
CH 750



DATUM R.L. 17.00

DESIGN SURFACE LEVEL	19.956	20.205	20.230	20.330	20.430	20.455	20.476
DEPTH CUT - / FILL +	0.000	0.196	0.167	0.110	0.027	0.046	0.116
EXISTING SURFACE LEVEL	19.956	20.009	20.063	20.220	20.403	20.409	20.360
OFFSET FROM CENTRELINE	-6	-5	-4	0	4	5	5.82

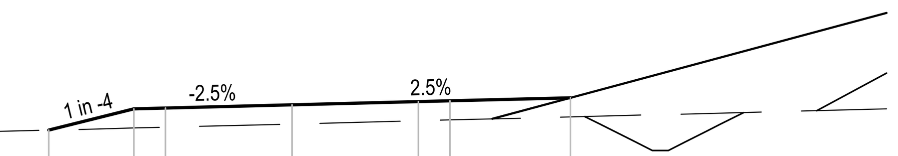
CH 790



DATUM R.L. 17.00

DESIGN SURFACE LEVEL	19.206	19.468	19.493	19.593	19.693	19.718	19.856
DEPTH CUT - / FILL +	0.000	0.203	0.178	0.251	1.083	1.220	1.449
EXISTING SURFACE LEVEL	19.206	19.264	19.315	19.342	18.610	18.497	18.406
OFFSET FROM CENTRELINE	-6.05	-5	-4	0	4	5	10.52

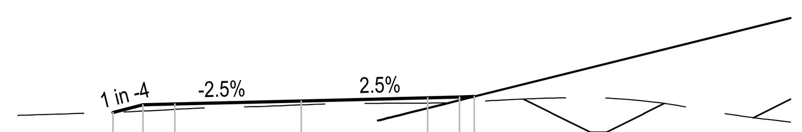
CH 830



DATUM R.L. 18.00

DESIGN SURFACE LEVEL	20.626	21.300	21.325	21.425	21.525	21.550	21.645
DEPTH CUT - / FILL +	0.000	0.606	0.605	0.604	0.602	0.602	0.601
EXISTING SURFACE LEVEL	20.626	20.694	20.720	20.821	20.923	20.948	21.045
OFFSET FROM CENTRELINE	-7.7	-5	-4	0	4	5	8.81

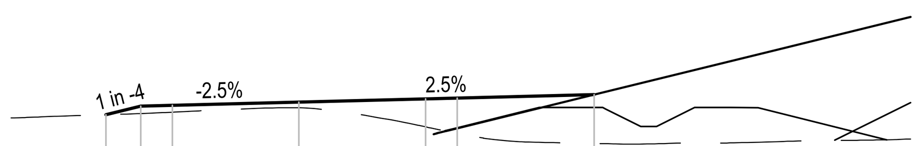
CH 740



DATUM R.L. 18.00

DESIGN SURFACE LEVEL	20.151	20.390	20.415	20.515	20.615	20.640	20.652
DEPTH CUT - / FILL +	0.000	0.196	0.170	0.126	0.168	0.166	0.156
EXISTING SURFACE LEVEL	20.151	20.194	20.245	20.389	20.447	20.474	20.496
OFFSET FROM CENTRELINE	-5.96	-5	-4	0	4	5	5.47

CH 780



DATUM R.L. 17.00

DESIGN SURFACE LEVEL	19.376	19.650	19.675	19.775	19.875	19.900	20.008
DEPTH CUT - / FILL +	0.000	0.237	0.219	0.179	0.882	1.116	1.541
EXISTING SURFACE LEVEL	19.376	19.413	19.456	19.596	18.993	18.784	18.468
OFFSET FROM CENTRELINE	-6.09	-5	-4	0	4	5	9.33

CH 820

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
0	ISSUED FOR CONSTRUCTION	RK	AR	IG	29.09.19

Note: * indicates signatures on original issue of drawing or last revision of drawing

0 2 4 6 8 10m
SCALE 1:200 AT ORIGINAL SIZE

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DO NOT SCALE

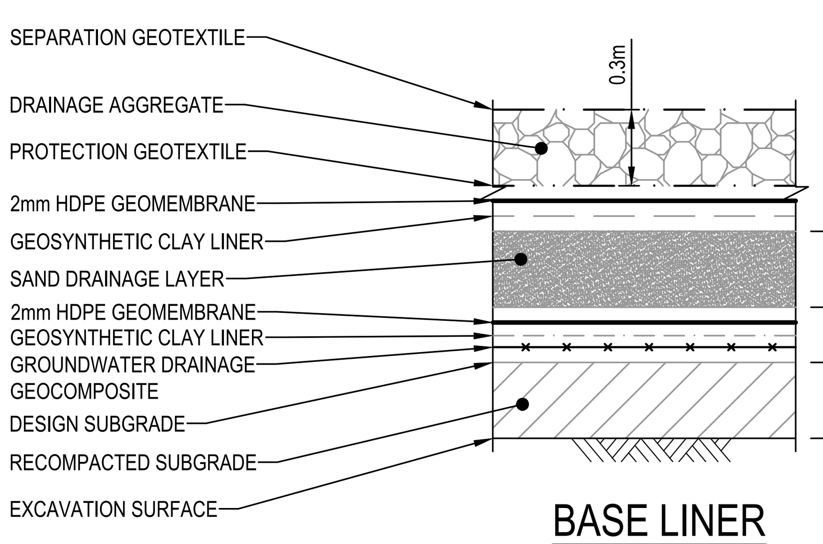
Drawn J.CASIO | Designer P. ETCHELLS
Drafting Check P. PRASAD | Design Check A. ROBERTS
Approved (Project Director) I. GREGSON*
Date 26.09.19
Scale 1:200

This Drawing must not be used for Construction unless signed as Approved

Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **PERIMETER ROAD CROSS SECTION SHEET 7 OF 7**

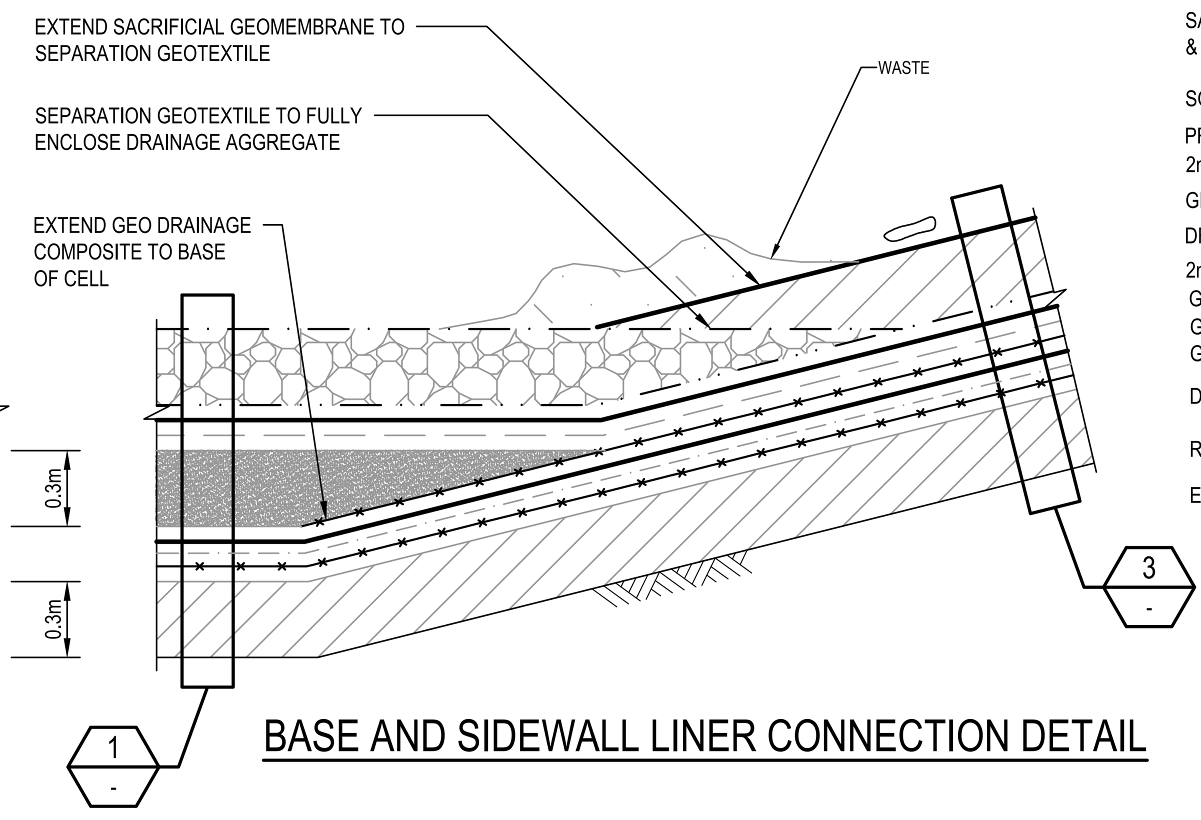
Original Size A1 | Drawing No: **22-18015-C069** | Rev: 0

Plot Date: 27 September 2019 - 9:56 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C069.dwg



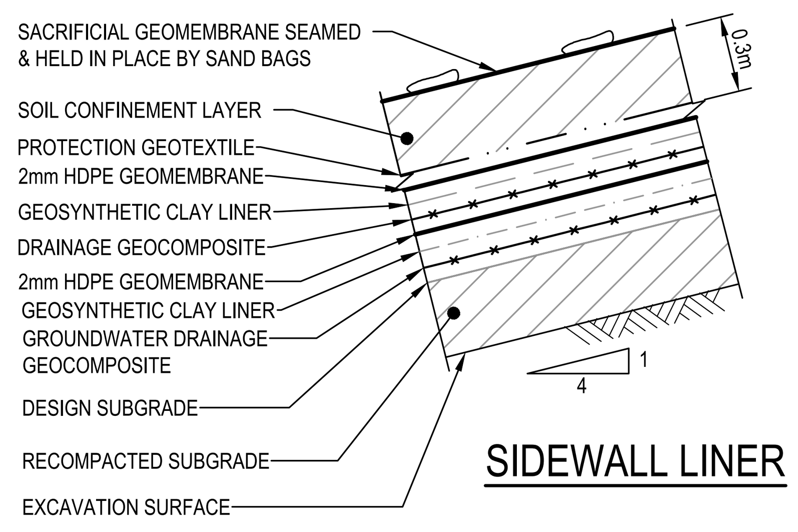
BASE LINER

1 DETAIL
C021,82,133 SCALE 1 : 25



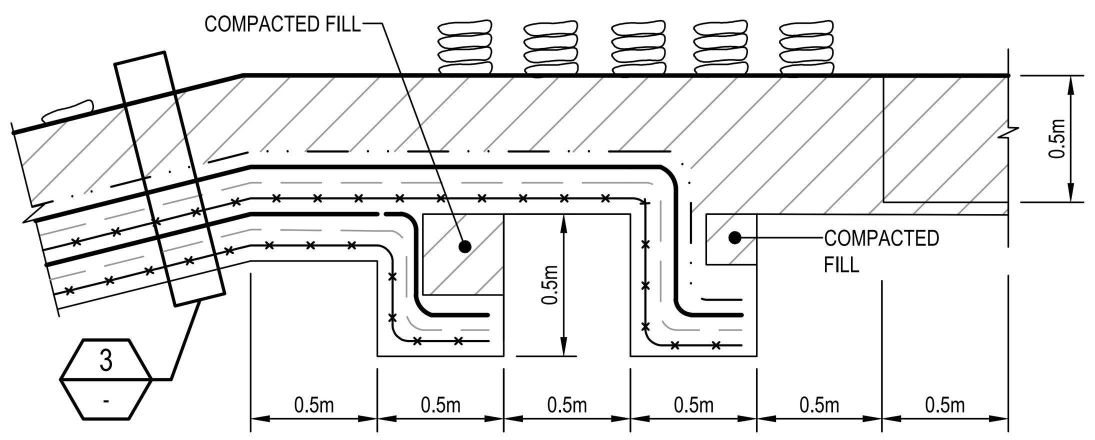
BASE AND SIDEWALL LINER CONNECTION DETAIL

2 DETAIL
C021 & 82 SCALE 1 : 25



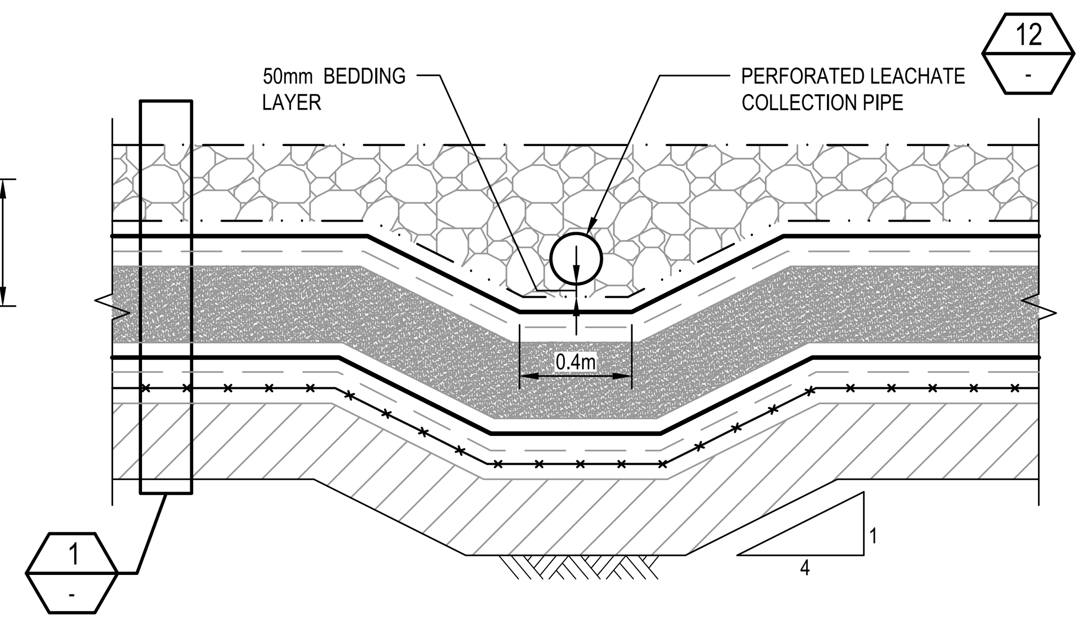
SIDEWALL LINER

3 DETAIL
C021,82,91,132 SCALE 1 : 25



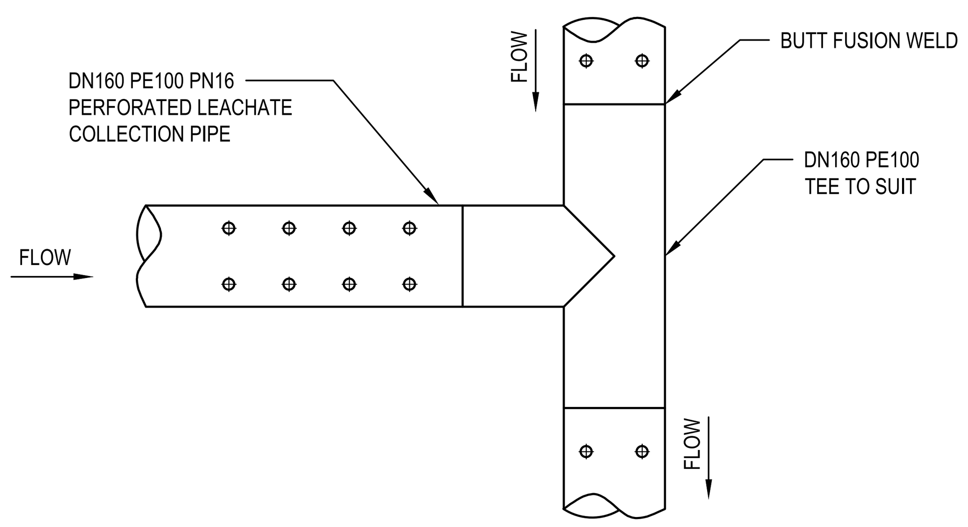
ANCHOR TRENCH TYPICAL DETAIL

4 DETAIL
C021 SCALE 1 : 25

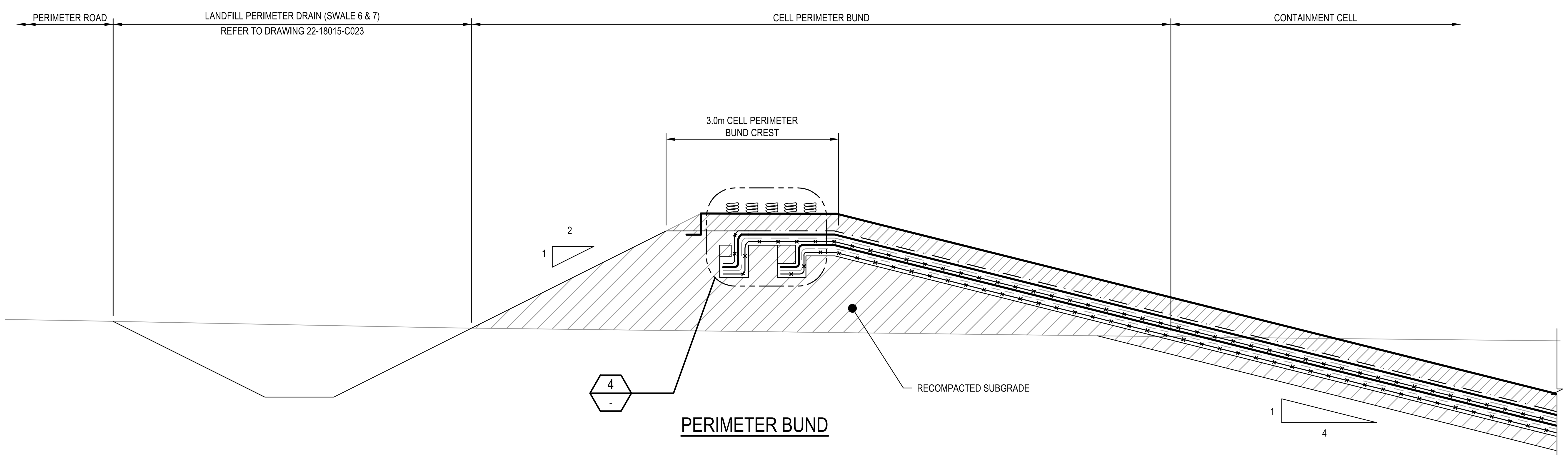


LEACHATE COLLECTION TRENCH

5 DETAIL
C021,72,73 SCALE 1 : 25

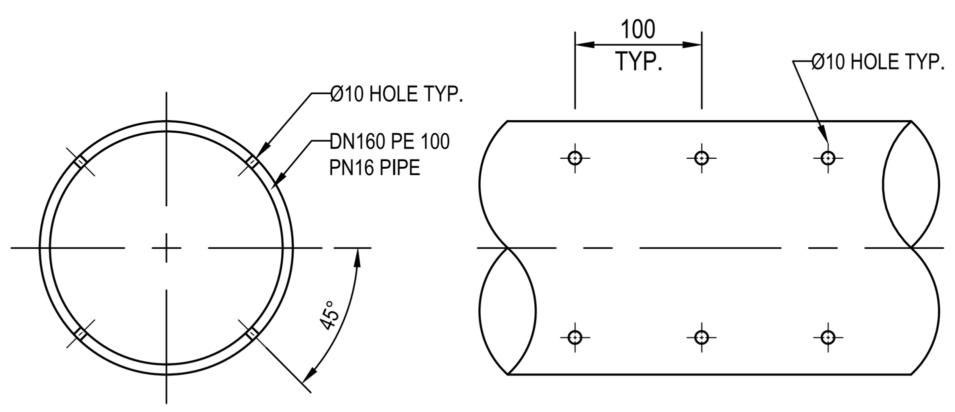


TYPICAL LEACHATE COLLECTION PIPE CONNECTION DETAIL
SCALE 1:10



PERIMETER BUND

C SECTION
C021 SCALE 1 : 50



LEACHATE COLLECTION PIPE PERFORATION

12 DETAIL
SCALE 1 : 5

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
0	ISSUED FOR CONSTRUCTION	RK	AR	IG	29.09.19

Note: * indicates signatures on original issue of drawing or last revision of drawing

0 0.5 1.0 1.5 2.0 2.5m — SCALE 1:50 AT ORIGINAL SIZE
0 0.1 0.2 0.3 0.4 0.5m — SCALE 1:10 AT ORIGINAL SIZE
0 0.25 0.5 0.75 1.0 1.25m — SCALE 1:25 AT ORIGINAL SIZE
0 0.05 0.1 0.15 0.2 0.25m — SCALE 1:5 AT ORIGINAL SIZE

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DO NOT SCALE

Drawn J. CASIO
Designer P. ETCHELLS
Drafting Check P. PRASAD
Design Check A. ROBERTS
Approved (Project Director) I. GREGSON*
Date 26.09.19
Scale AS SHOWN
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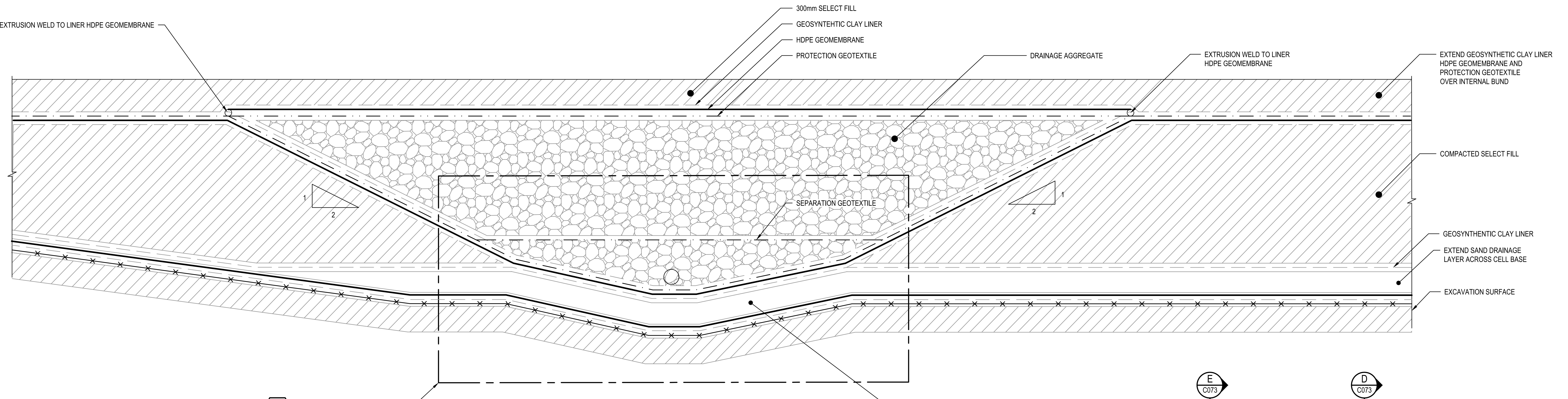
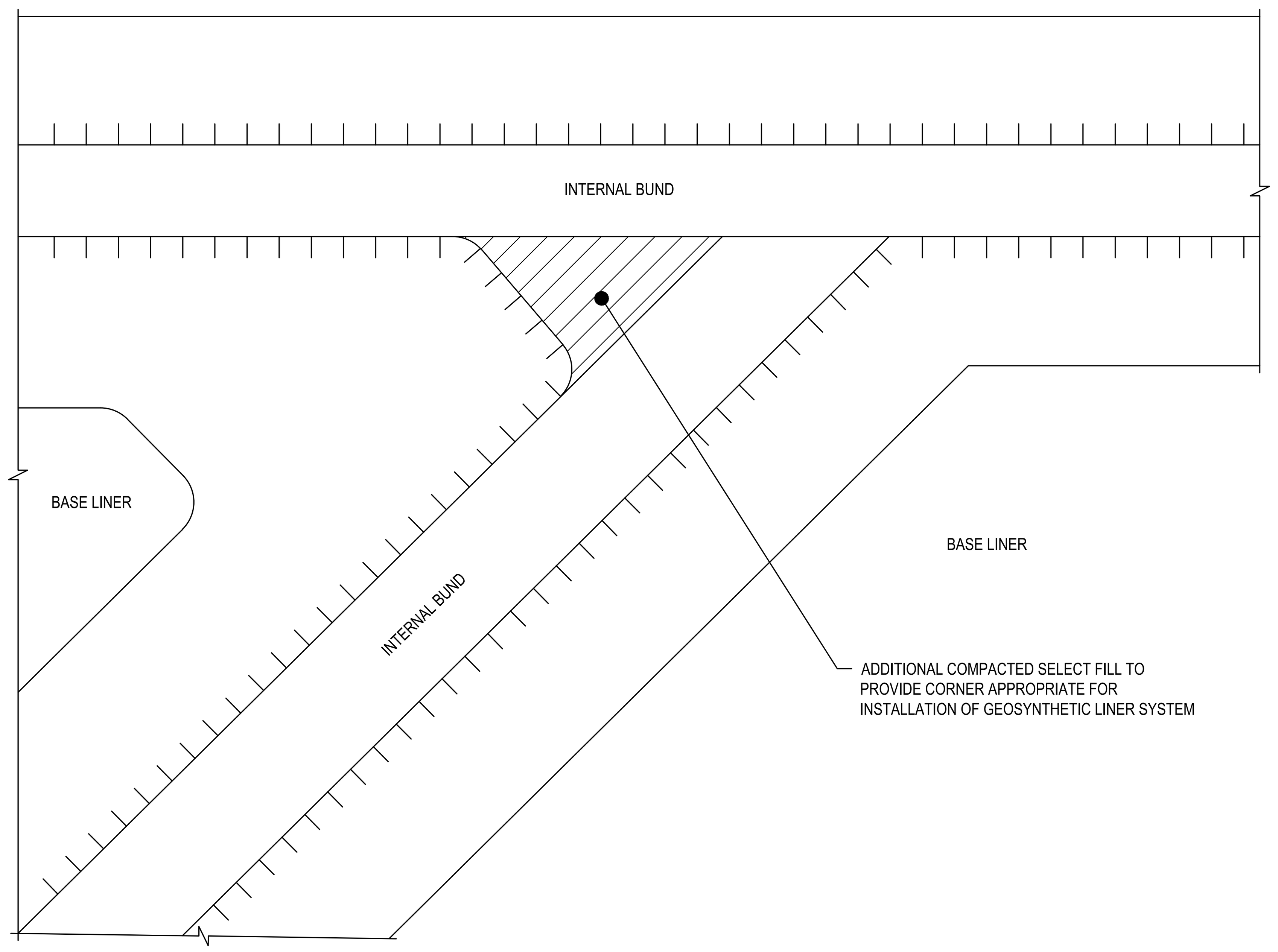
Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **LINER DETAILS**
SHEET 1 OF 3
Original Size A1 Drawing No: **22-18015-C071** Rev: 0

Plot Date: 27 September 2019 - 9:57 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C071.dwg

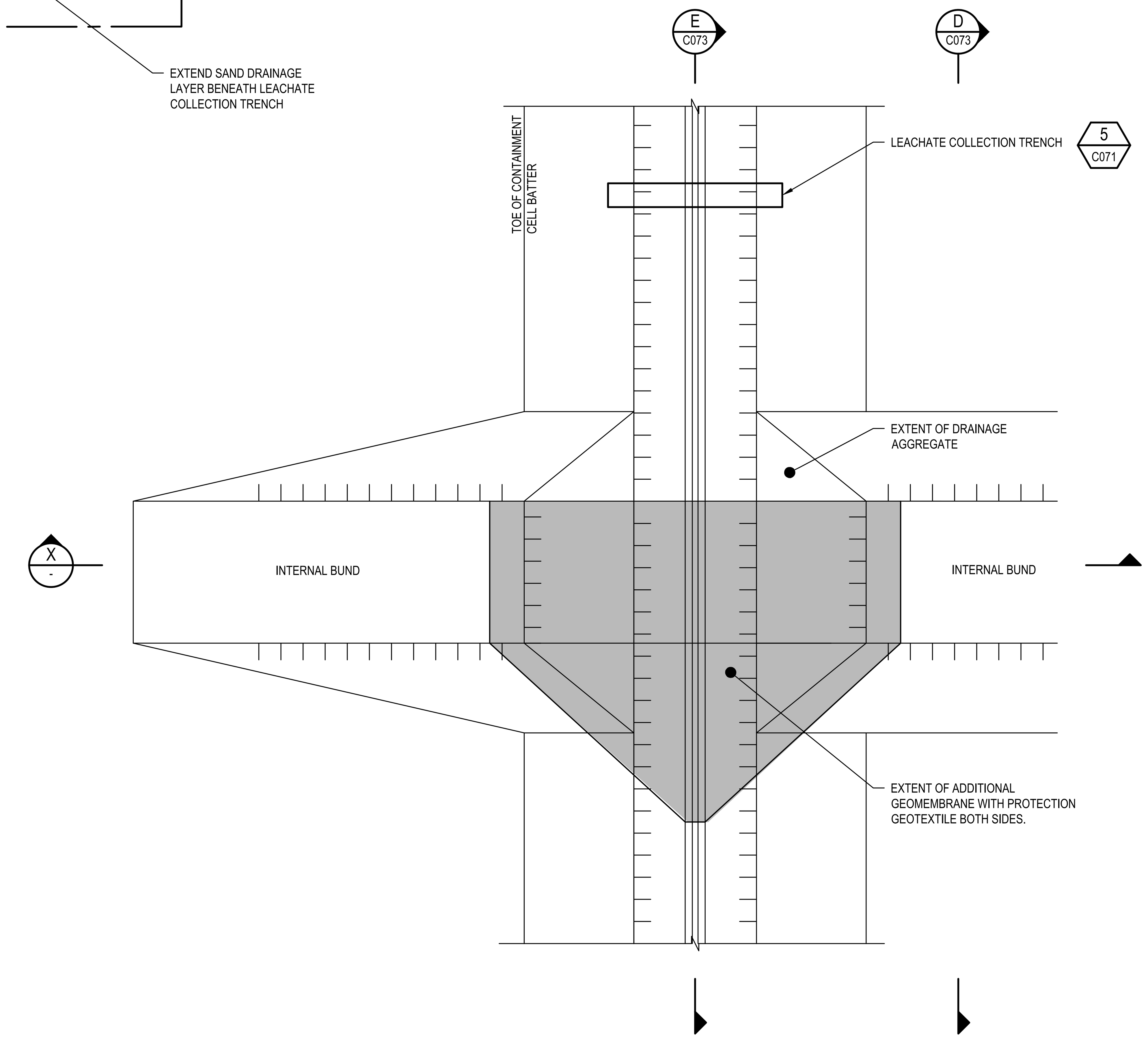


INTERNAL BUND AT PIPE PENETRATION

X - SECTION
SCALE : NTS



CONNECTION OF INTERNAL BUNDS
NTS



PLAN INTERNAL BUND
AT PIPE PENETRATION
NTS

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
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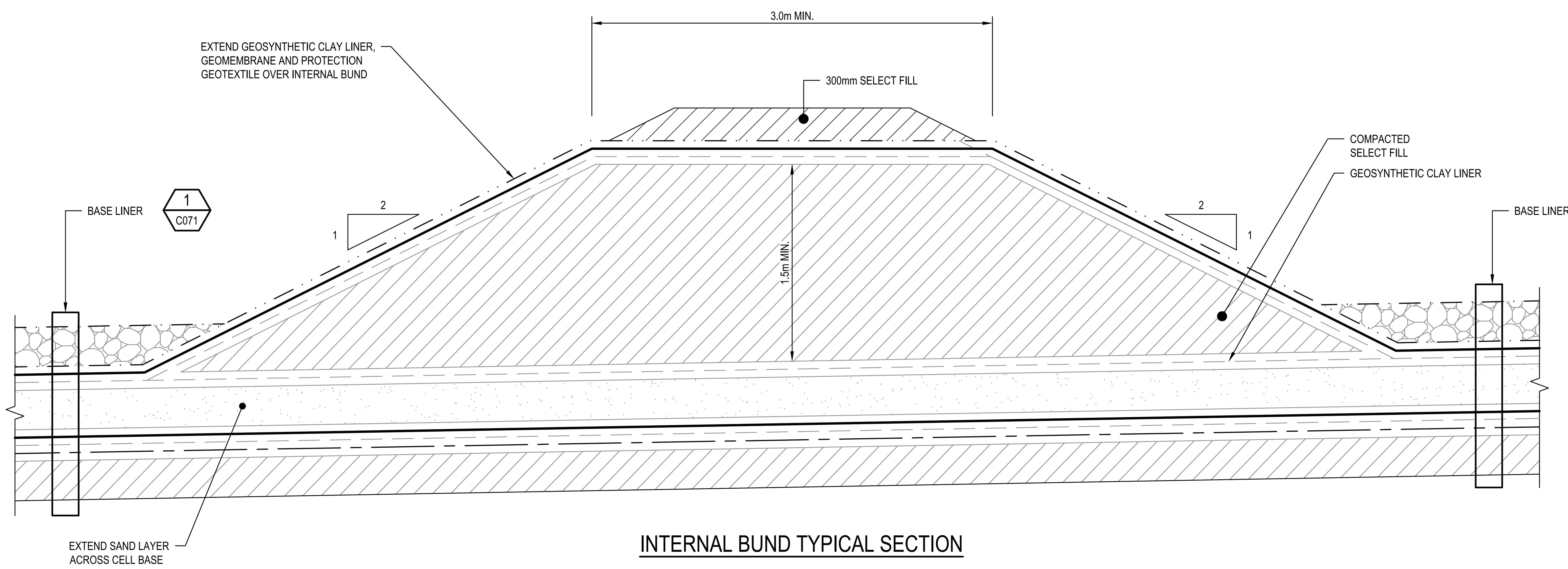
DO NOT SCALE

Drawn	J. CASIO	Designer	P. ETCHELLS
Drafting Check	P. PRASAD	Design Check	A. ROBERTS
Approved (Project Director)	I. GREGSON*		
Date	26.09.19		
Scale	NOT TO SCALE	This Drawing must not be used for Construction unless signed as Approved	

Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **LINER DETAILS SHEET 2 OF 3**

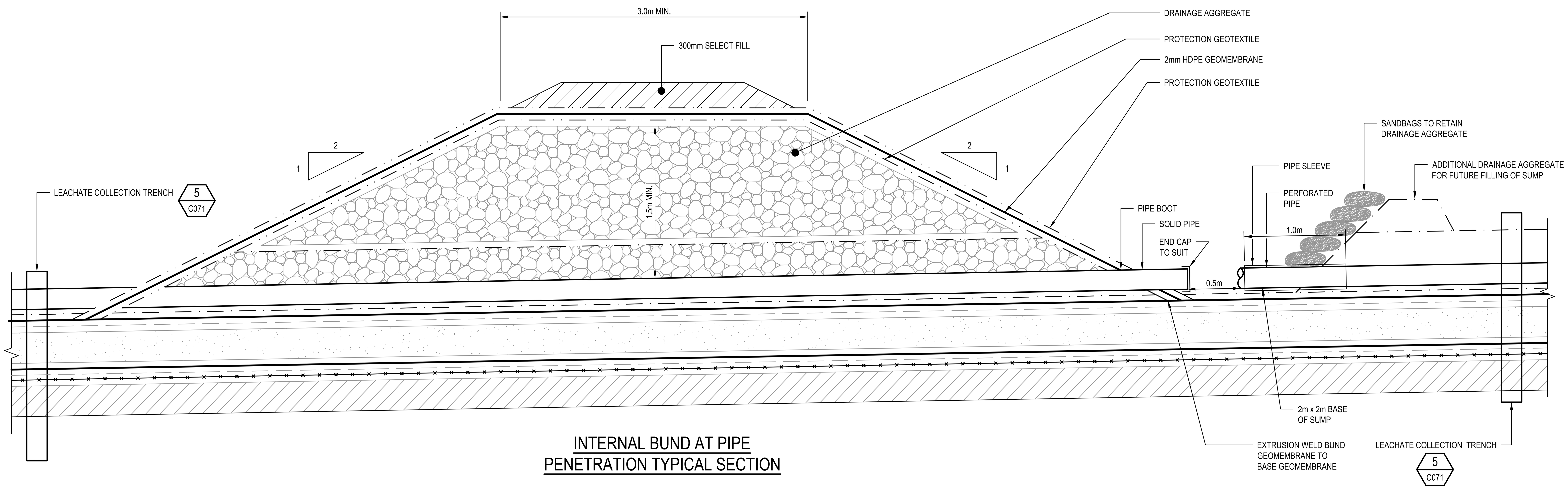
Original Size **A1** Drawing No: **22-18015-C072** Rev: **0**

Plot Date: 27 September 2019 - 9:57 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C072.dwg



INTERNAL BUND TYPICAL SECTION

D SECTION
C021 & 72 SCALE 1 : 25



INTERNAL BUND AT PIPE
PENETRATION TYPICAL SECTION

E SECTION
C021 & 72 SCALE 1 : 25

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
0	ISSUED FOR CONSTRUCTION	RK	AR	IG	29.09.19

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0 0.25 0.5 0.75 1.0 1.25m
SCALE 1:25 AT ORIGINAL SIZE

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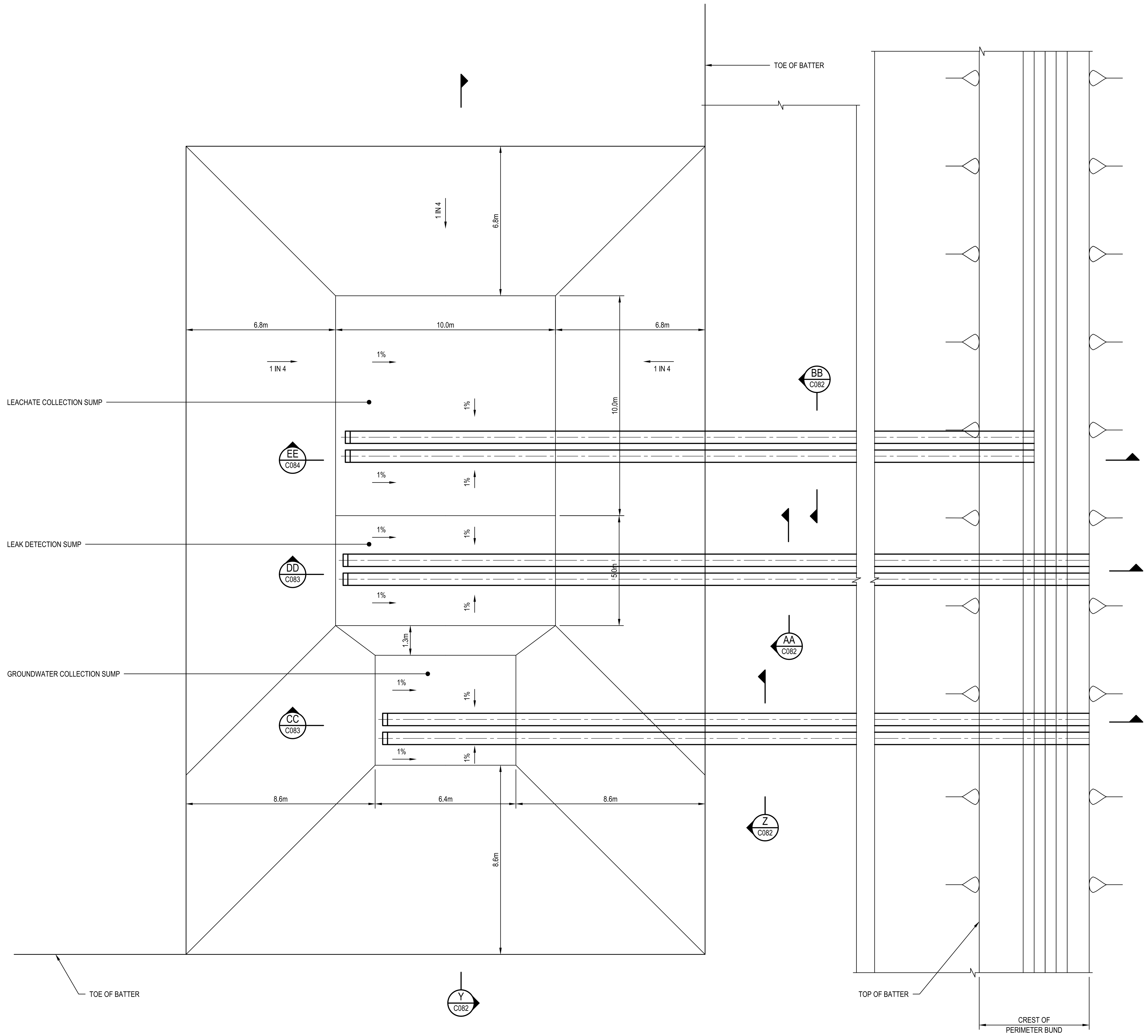
Drafting Check	P. PRASAD	Design Check	A. ROBERTS
Approved (Project Director)	I. GREGSON*		
Date	26.09.19		
Scale	1:25	This Drawing must not be used for Construction unless signed as Approved	

Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **LINER DETAILS SHEET 3 OF 3**

Original Size **A1** Drawing No: **22-18015-C073** Rev: **0**

Plot Date: 27 September 2019 - 9:57 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C073.dwg



SOUTHERN SUMP AREA PLAN - (SIMILAR FOR NORTHERN SUMP AREA)

SCALE 1:100

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
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Note: * indicates signatures on original issue of drawing or last revision of drawing

0 1 2 3 4 5m

SCALE 1:100 AT ORIGINAL SIZE

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Drawn J. CASIO
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Design Check A. ROBERTS
Approved (Project Director) I. GREGSON*
Date 26.09.19
Scale 1:100

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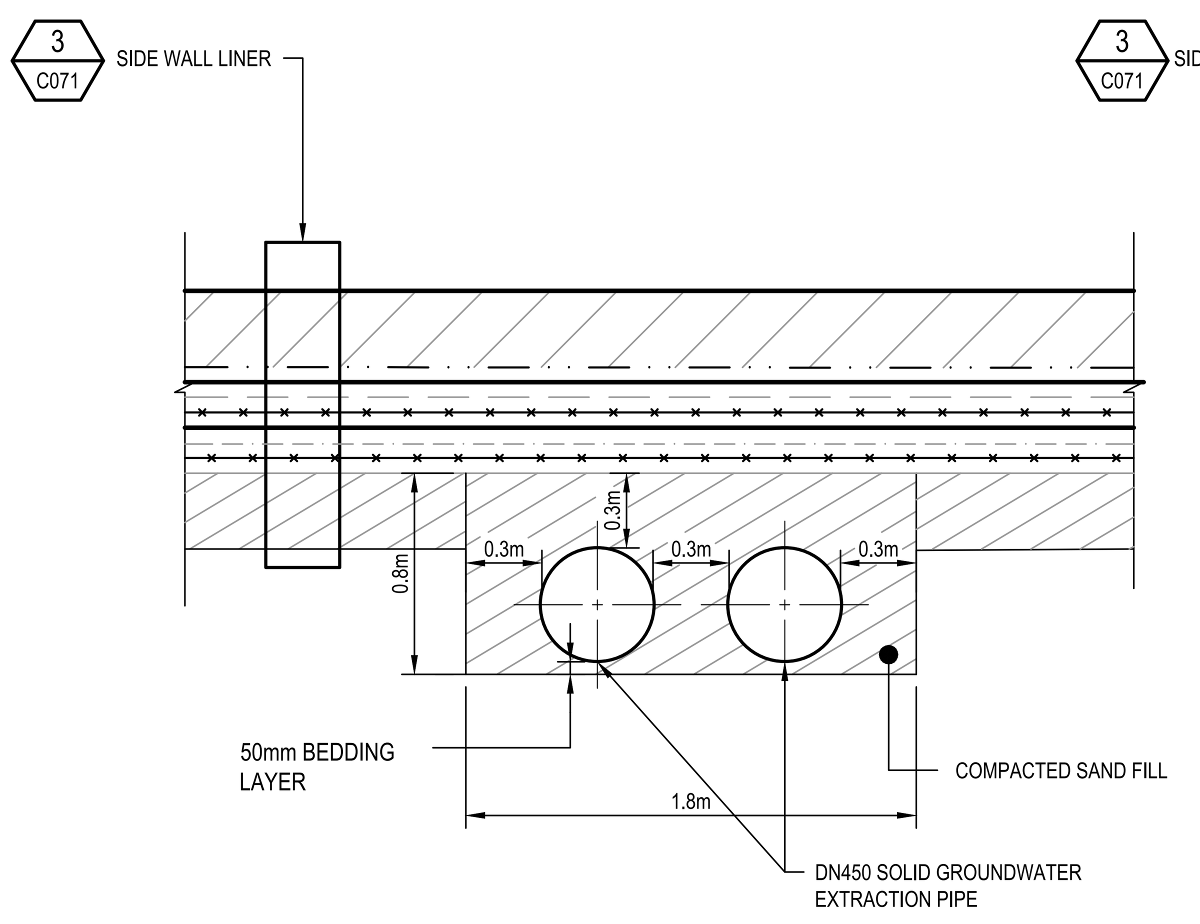
Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **SUMP DETAILS**
SHEET 1 OF 4

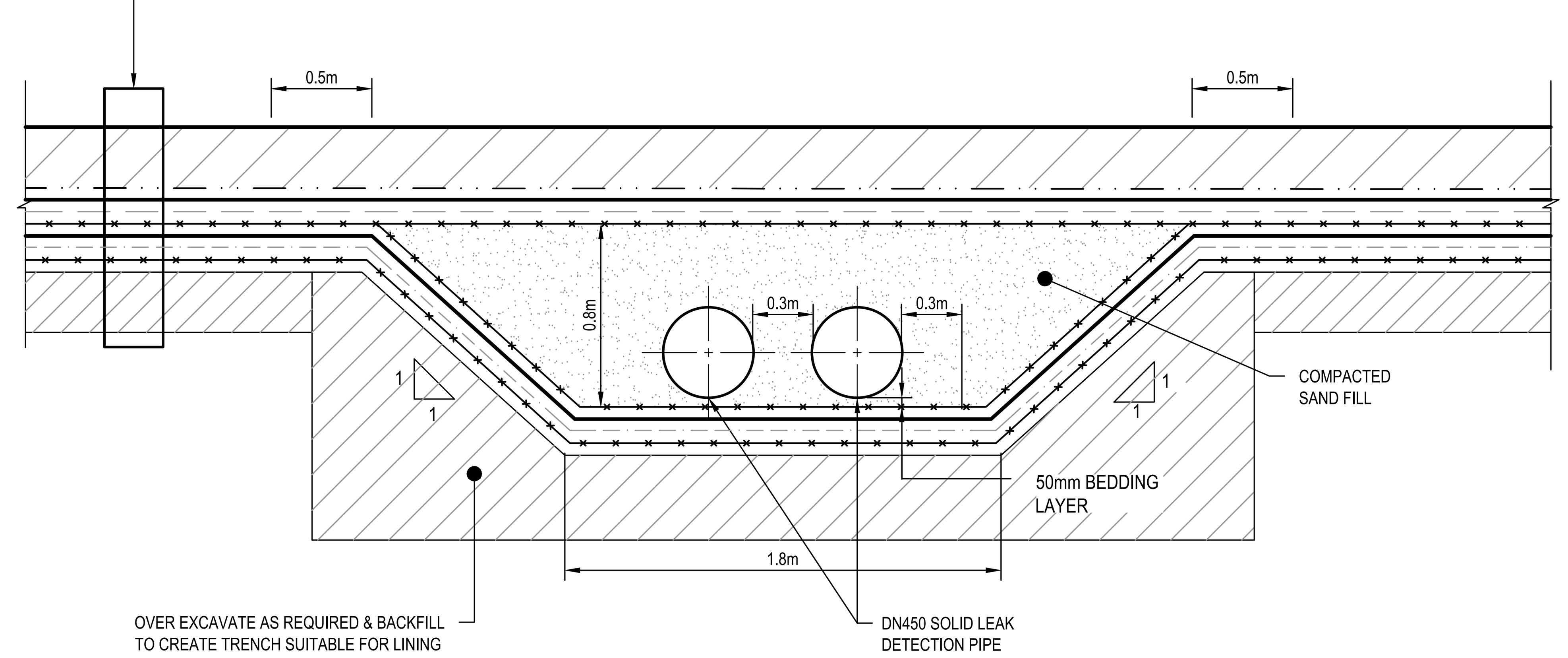
Original Size **A1** Drawing No: **22-18015-C081** Rev: **0**

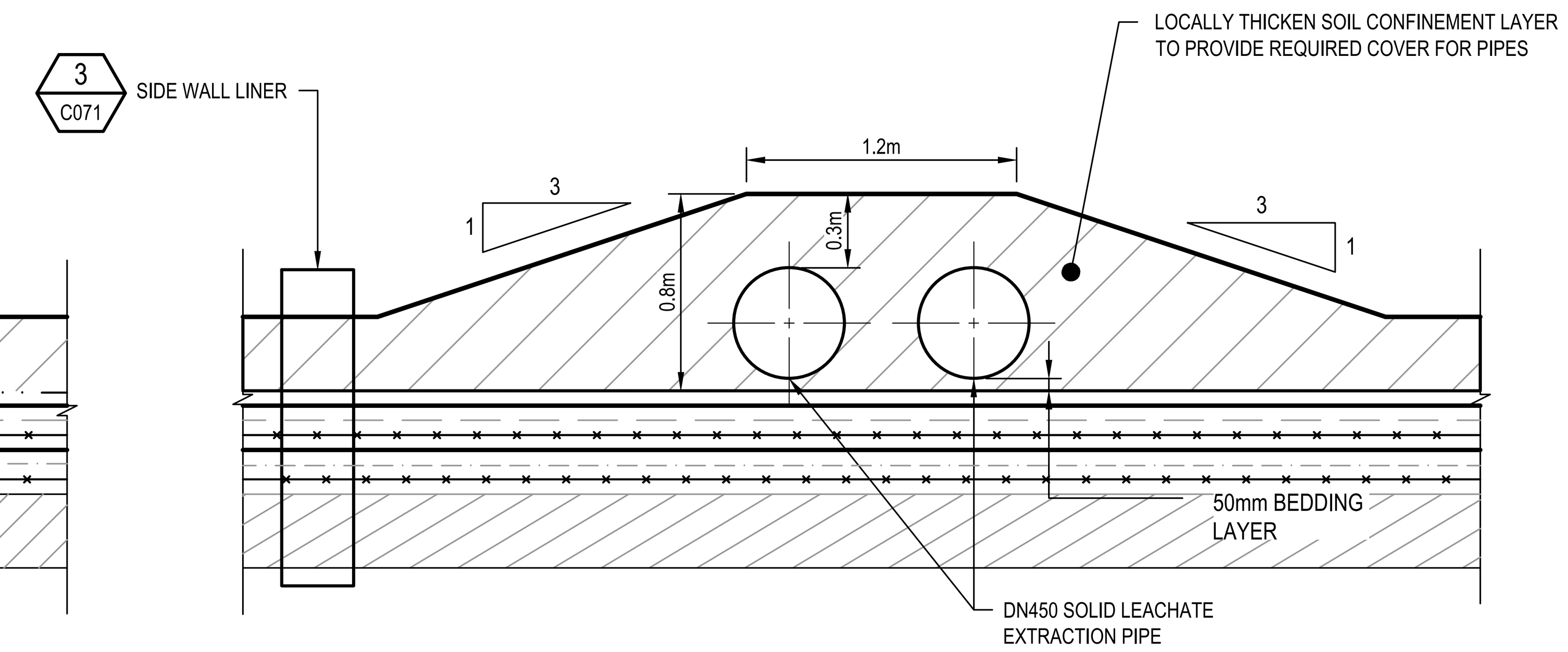
Plot Date: 27 September 2019 - 9:57 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C081.dwg

SUMP SECTION

Y SECTION
C081 SCALE 1 : 50







GROUNDWATER RISER

Z SECTION
C081 SCALE 1 : 25

LEAK DETECTION RISER

AA SECTION
C081 SCALE 1 : 25

LEACHATE RISER

BB SECTION
C081 SCALE 1 : 25

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
0	ISSUED FOR CONSTRUCTION	RK	AR	IG	29.09.19

Note: * indicates signatures on original issue of drawing or last revision of drawing

0 0.5 1.0 1.5 2.0 2.5m
SCALE 1:50 AT ORIGINAL SIZE
0 0.25 0.5 0.75 1.0 1.25m
SCALE 1:25 AT ORIGINAL SIZE

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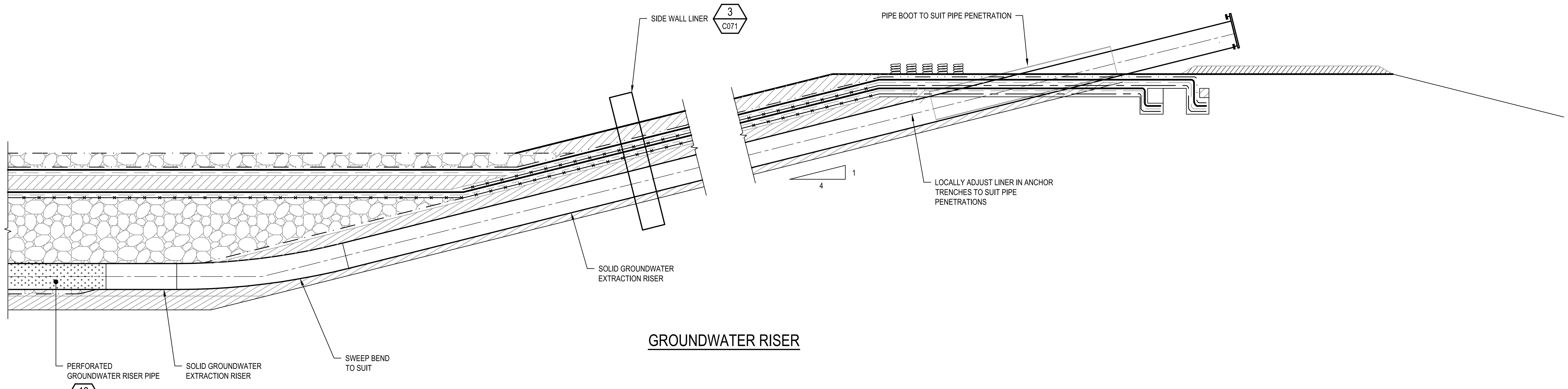
Drafting Check	P. PRASAD	Design Check	A. ROBERTS
Approved (Project Director)	I. GREGSON*		
Date	26.09.19		
Scale	AS SHOWN	This Drawing must not be used for Construction unless signed as Approved	

Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **SUMP DETAILS**
SHEET 2 OF 4

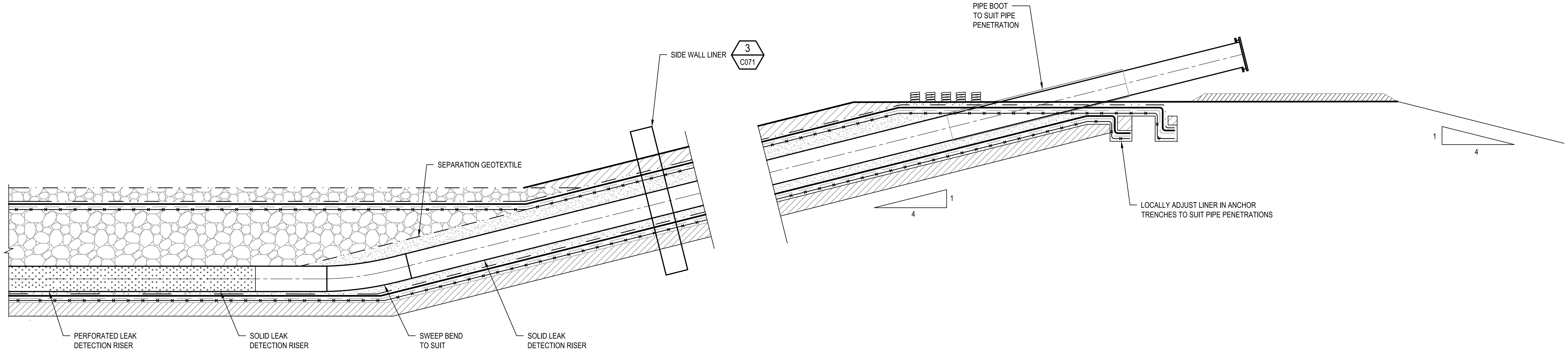
Original Size A1 Drawing No: **22-18015-C082** Rev: 0

Plot Date: 27 September 2019 - 9:57 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C082.dwg



GROUNDWATER RISER

CC SECTION
C081 SCALE 1 : 50



LEAK DETECTION RISER

DD SECTION
C081 SCALE 1 : 50

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
0	ISSUED FOR CONSTRUCTION	RK	AR	IG	29.09.19

Note: * indicates signatures on original issue of drawing or last revision of drawing

0 0.5 1.0 1.5 2.0 2.5m
SCALE 1:50 AT ORIGINAL SIZE

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DO NOT SCALE

Drawn J. CASIO
Designer P. ETCHELLS
Drafting Check P. PRASAD
Design Check A. ROBERTS
Approved (Project Director) I. GREGSON*
Date 26.09.19
Scale 1:50
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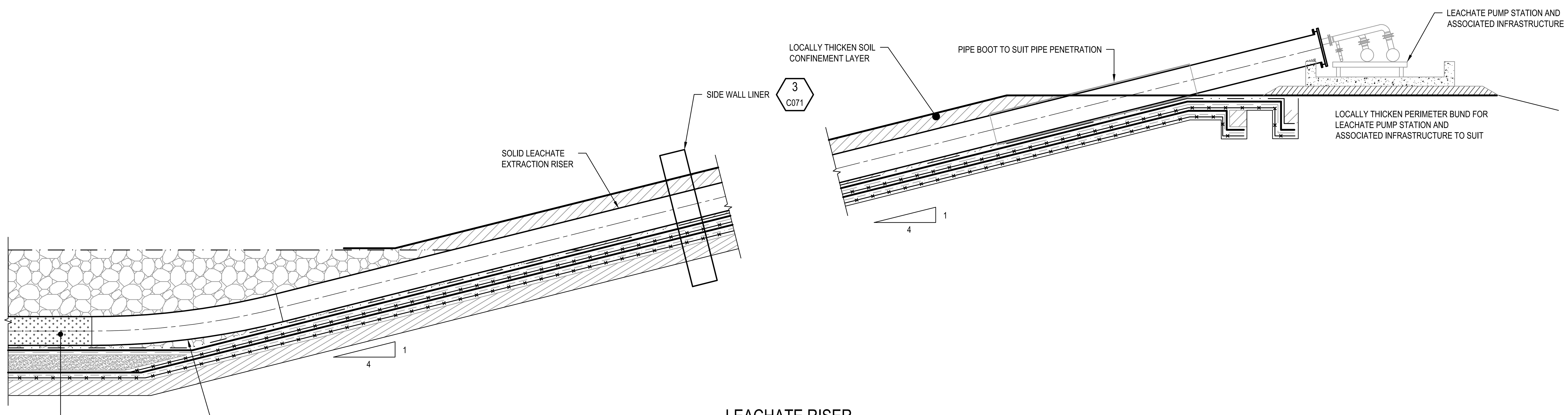
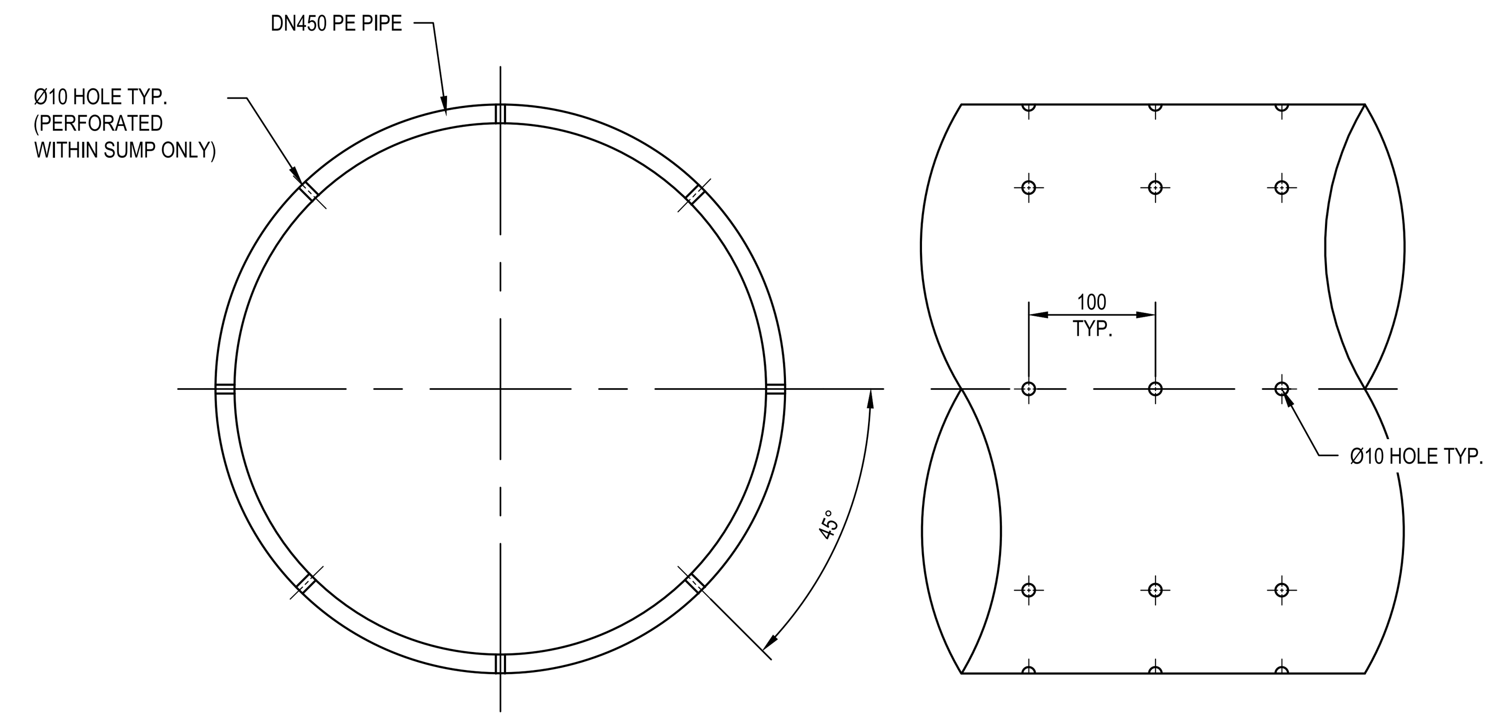
Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **SUMP DETAILS**
SHEET 3 OF 4
Original Size **A1**
Drawing No: **22-18015-C083**
Rev: **0**



LEACHATE RISER

EE C081 SECTION
SCALE 1 : 50



RISER PIPE PERFORATION

13 - DETAIL
SCALE 1 : 5

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
0	ISSUED FOR CONSTRUCTION	RK	AR	IG	29.09.19

Note: * indicates signatures on original issue of drawing or last revision of drawing

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SCALE 1:5 AT ORIGINAL SIZE

0 0.5 1.0 1.5 2.0 2.5m
SCALE 1:50 AT ORIGINAL SIZE

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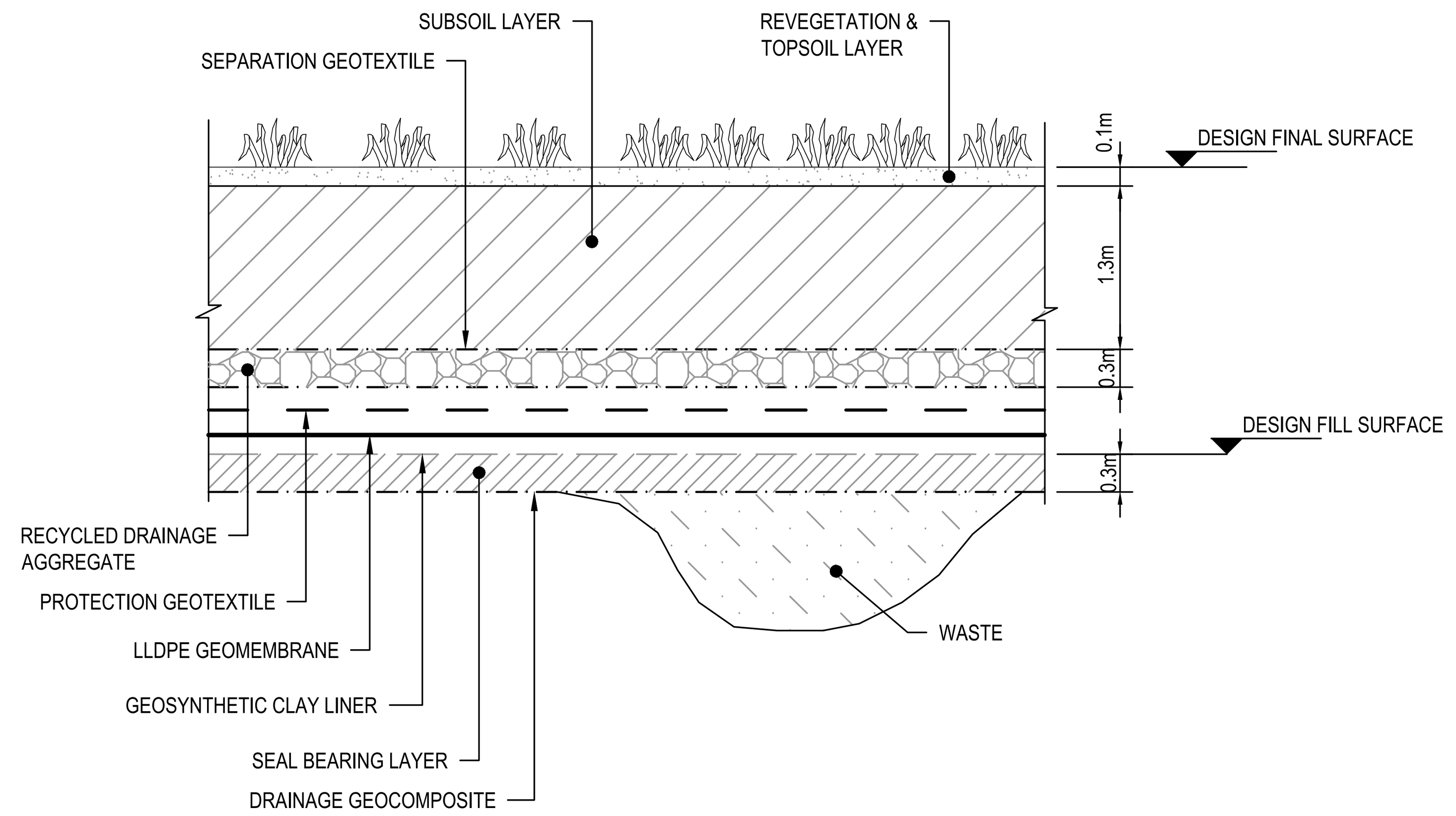
DO NOT SCALE

Drawn	J. CASIO	Designer	P. ETCHELLS
Drafting Check	P. PRASAD	Design Check	A. ROBERTS
Approved (Project Director)	I. GREGSON*		
Date	26.09.19		
Scale	AS SHOWN	This Drawing must not be used for Construction unless signed as Approved	

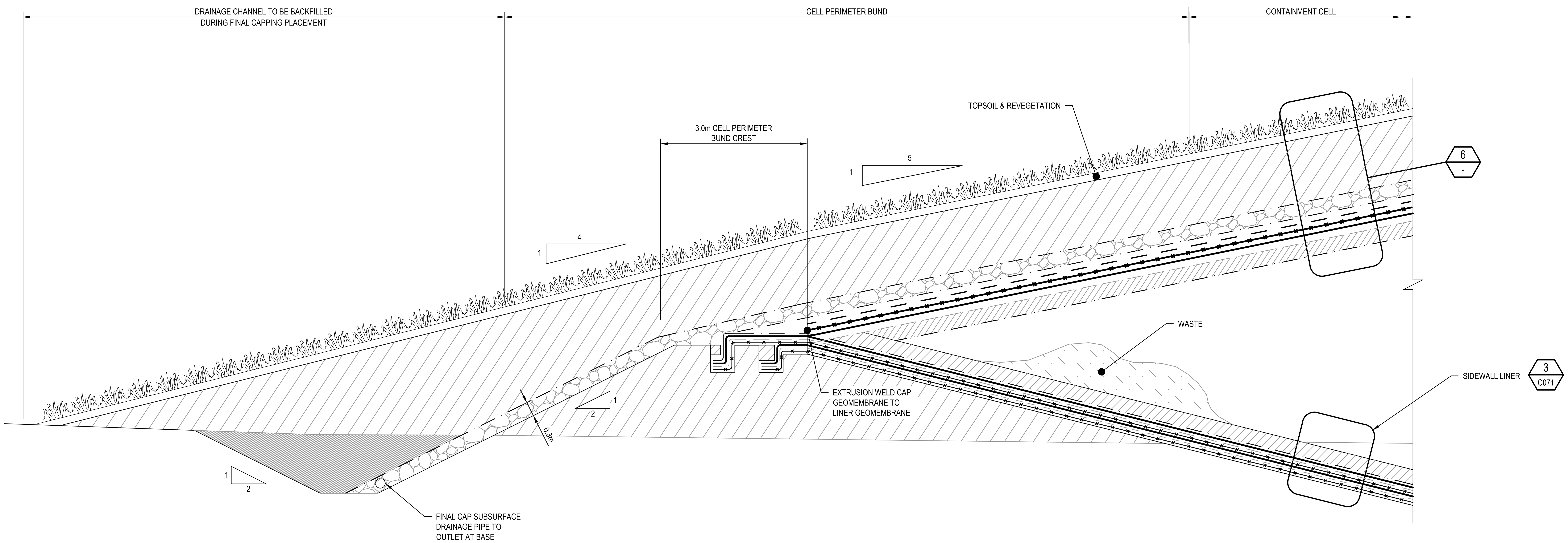
Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **SUMP DETAILS**
SHEET 4 OF 4

Original Size **A1** Drawing No: **22-18015-C084** Rev: **0**



CAP DETAIL

6 DETAIL
C025,92,141 SCALE 1 : 50



CAP TERMINATION DETAIL

W SECTION
C025 SCALE 1 : 50

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
0	ISSUED FOR CONSTRUCTION	RK	AR	IG	29.09.19

Note: * indicates signatures on original issue of drawing or last revision of drawing

0 0.5 1.0 1.5 2.0 2.5m
SCALE 1:50 AT ORIGINAL SIZE

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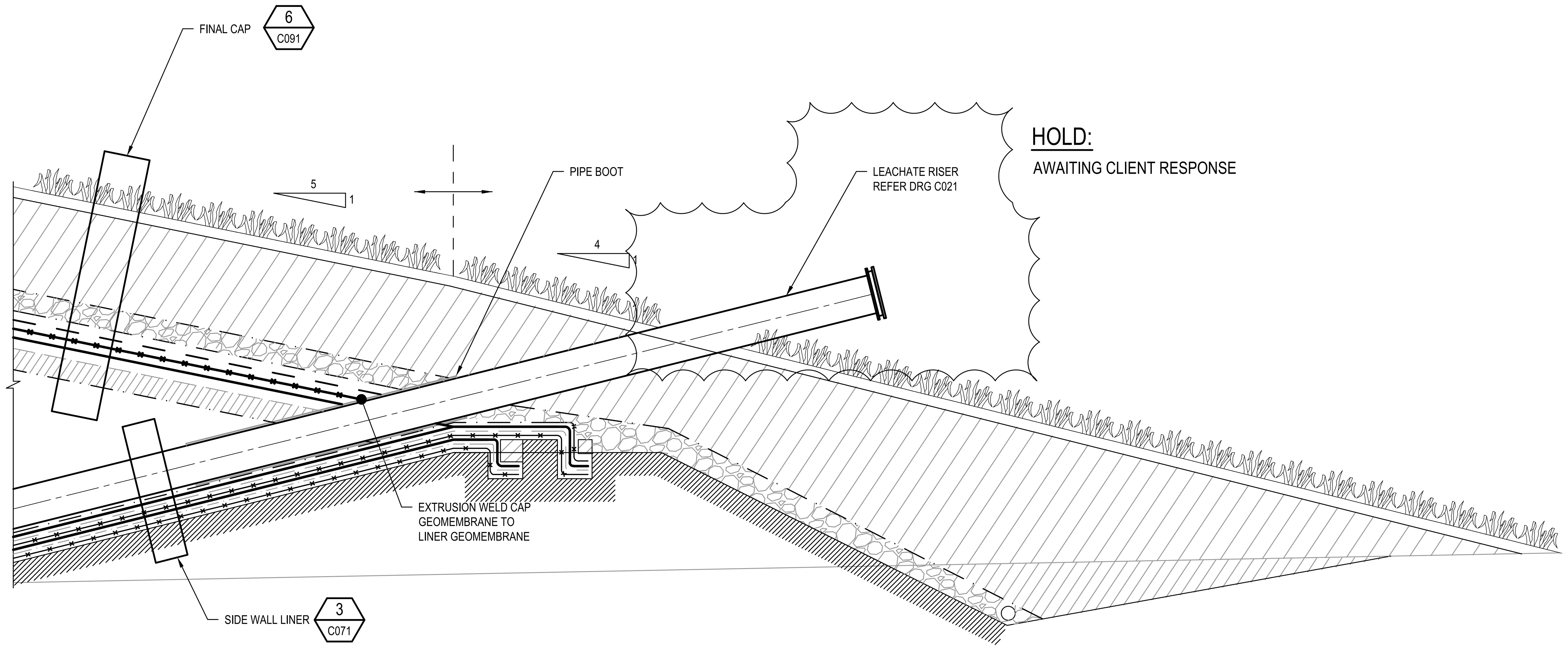
DO NOT SCALE

Drawn J. CASIO
Designer P. ETCHELLS
Drafting Check P. PRASAD
Design Check A. ROBERTS
Approved (Project Director) I. GREGSON*
Date 26.09.19
Scale 1:50
This Drawing must not be used for Construction unless signed as Approved

Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **CAPPING DETAILS**
SHEET 1 OF 2

Original Size **A1** Drawing No: **22-18015-C091** Rev: **0**

Plot Date: 27 September 2019 - 10:01 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C091.dwg



CAP TO RISER PIPE CONNECTION DETAIL

11 C025 DETAIL
SCALE 1 : 50

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
0	ISSUED FOR CONSTRUCTION	RK	AR	IG	29.09.19

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0 0.5 1.0 1.5 2.0 2.5m
SCALE 1:50 AT ORIGINAL SIZE

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Drawn J. CASIO | Designer P. ETCHELLS
Drafting Check P. PRASAD | Design Check A. ROBERTS
Approved (Project Director) I. GREGSON*
Date 26.09.19
Scale 1:50
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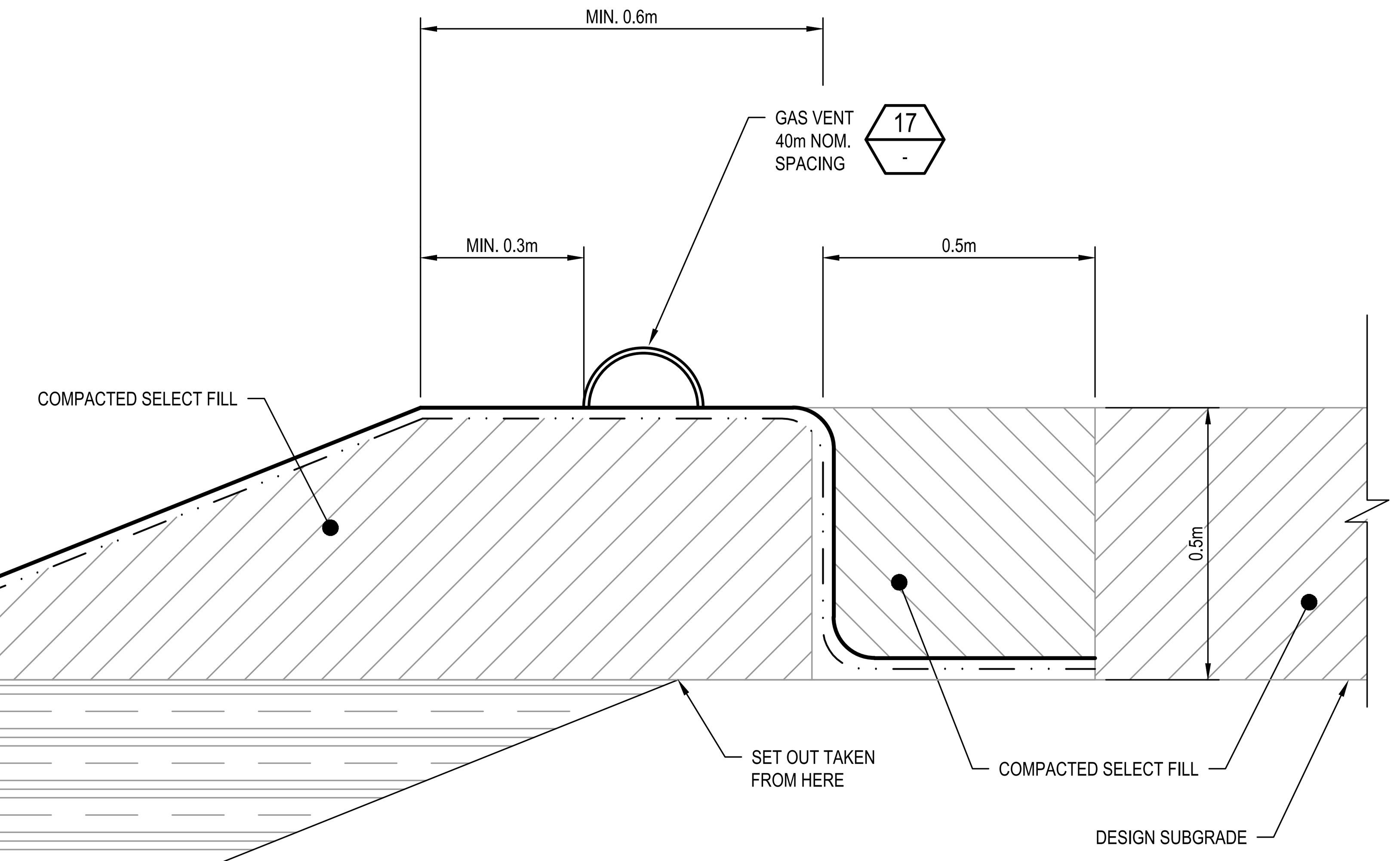
Client HYDRO ALUMINIUM KURRI KURRI PTY LTD
Project CONTAINMENT CELL DETAILED DESIGN
Title CAPPING DETAILS
SHEET 2 OF 2

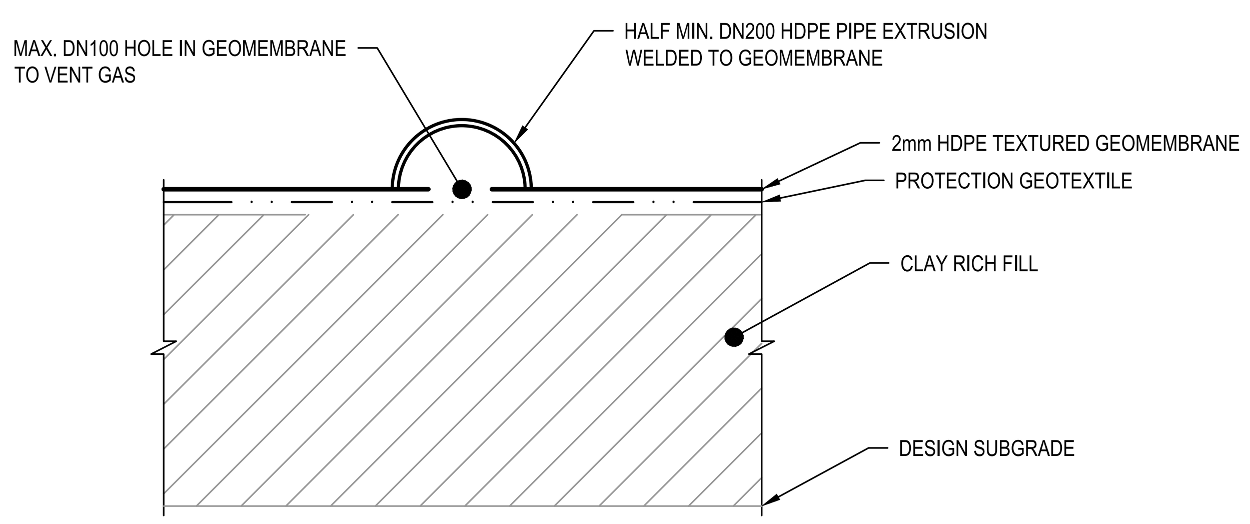
Original Size A1 Drawing No: 22-18015-C092 Rev: 0

Plot Date: 27 September 2019 - 10:01 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C092.dwg



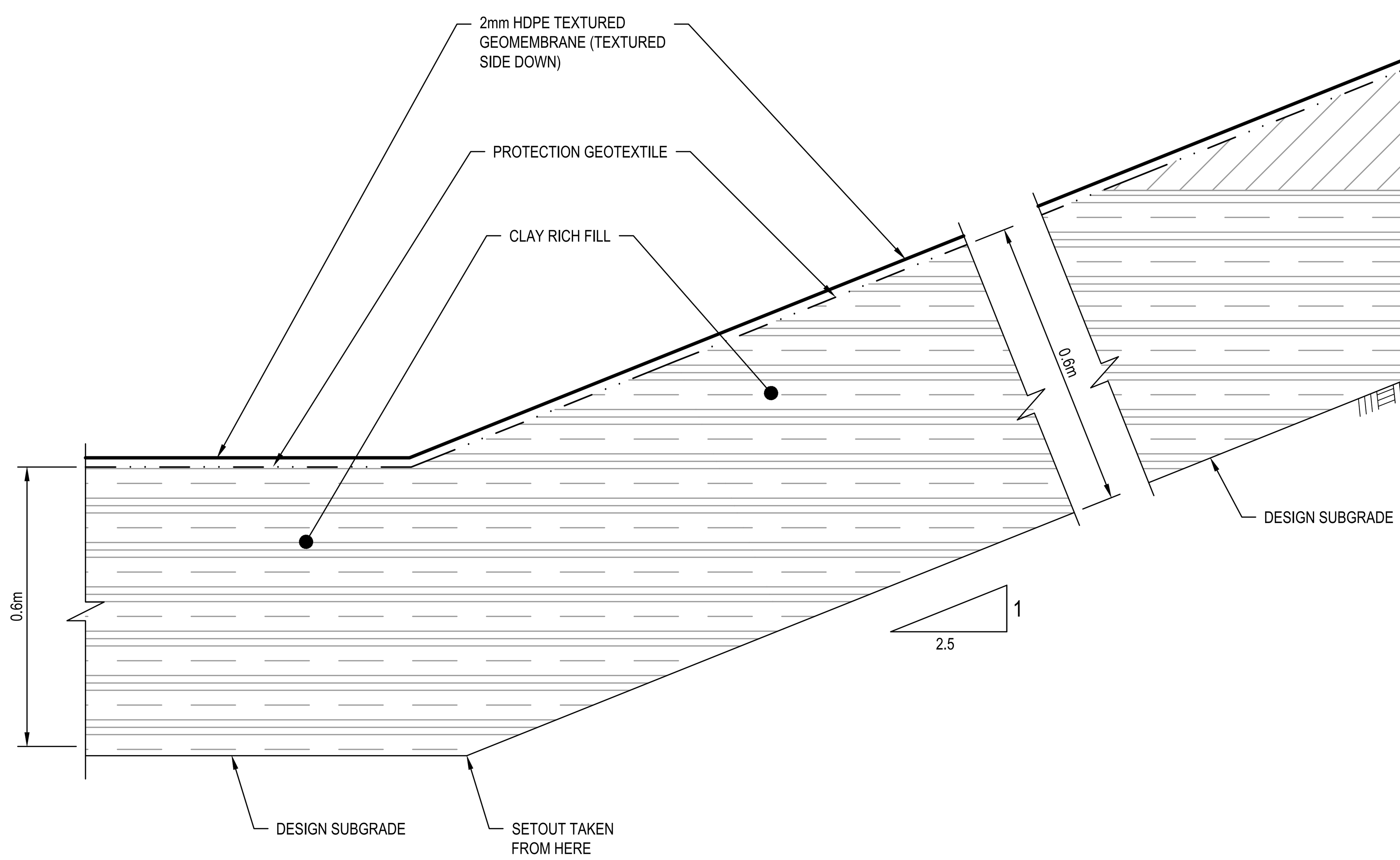
ANCHOR TRENCH AND GAS VENT

16 - DETAIL
SCALE 1 : 10



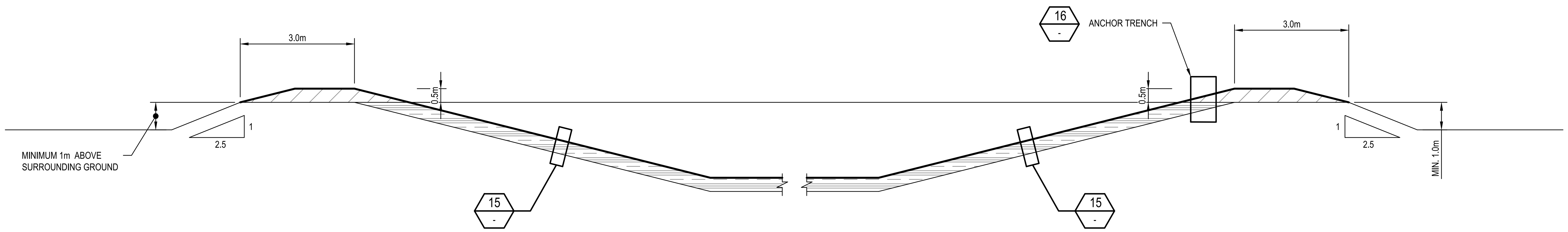
GAS VENT

17 - DETAIL
SCALE 1 : 10



LEACHATE BUFFER STORAGE DAM LINING SYSTEM

15 - DETAIL
SCALE 1 : 10



TYPICAL SECTION
LEACHATE BUFFER STORAGE DAM

JJ C102 SECTION
SCALE 1 : 100

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
0	ISSUED FOR CONSTRUCTION	RK	AR	IG	29.09.19

Note: * indicates signatures on original issue of drawing or last revision of drawing

0 0.1 0.2 0.3 0.4 0.5m
SCALE 1:10 AT ORIGINAL SIZE

0 1 2 3 4 5m
SCALE 1:100 AT ORIGINAL SIZE

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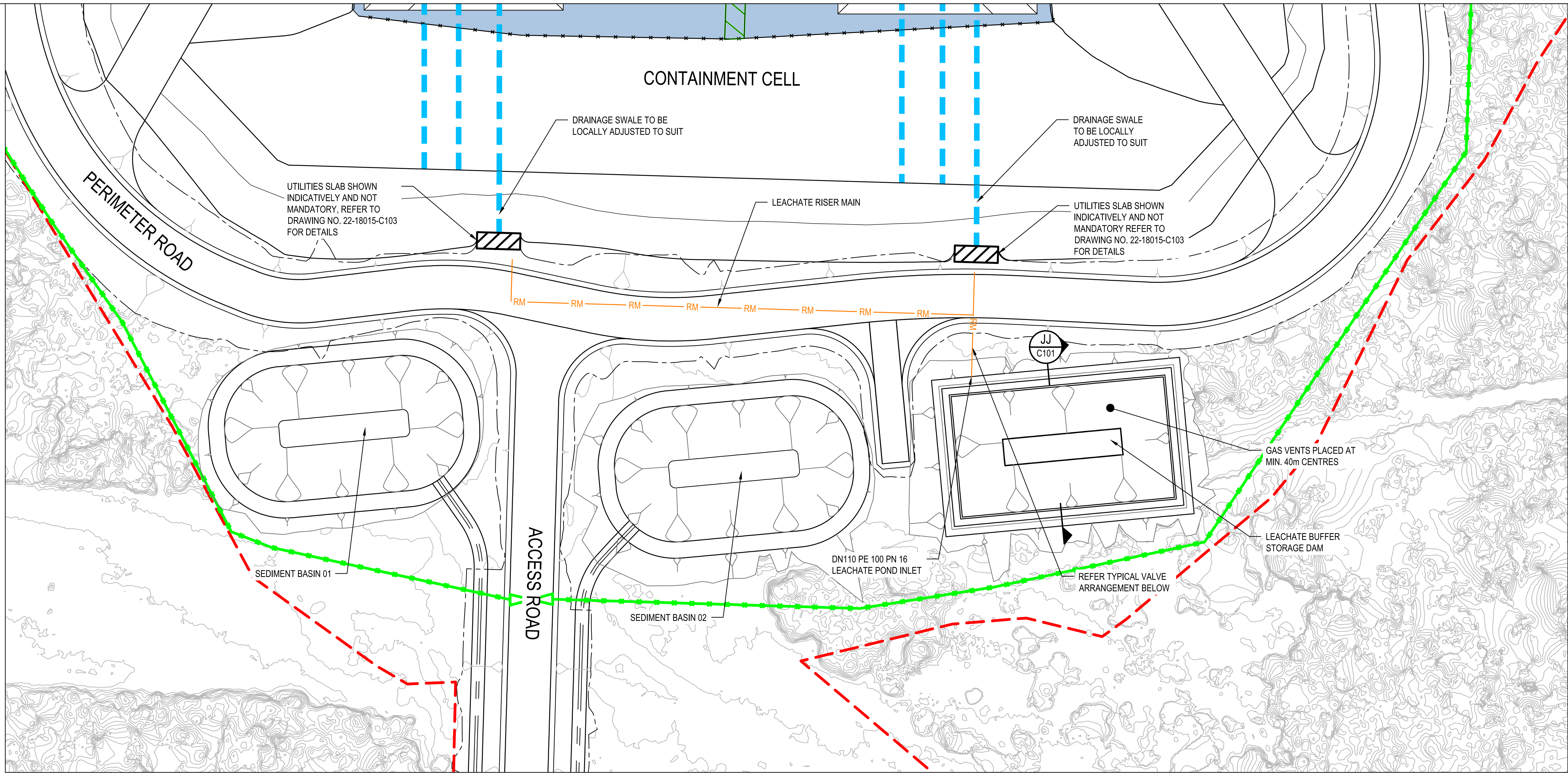
Designer P. ETCHELLS
Drafting Check P. PRASAD
Design Check A. ROBERTS
Approved (Project Director) I. GREGSON*
Date 26.09.19
Scale AS SHOWN
This Drawing must not be used for Construction unless signed as Approved

Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **LEACHATE BUFFER STORAGE DAM DETAILS**

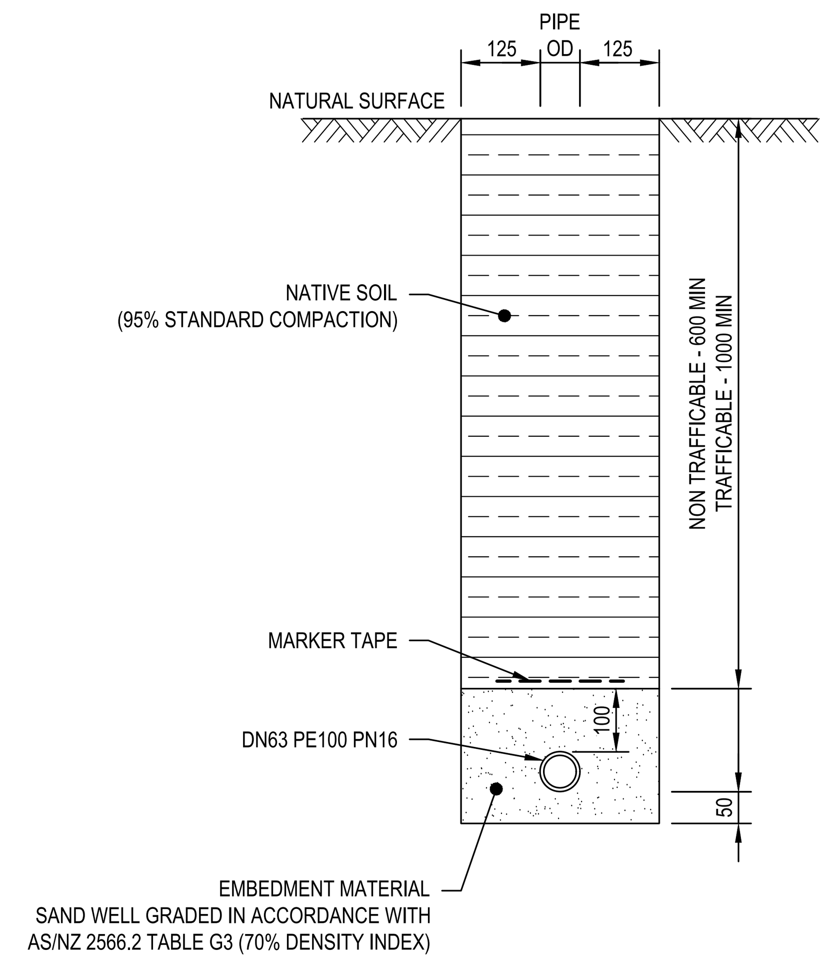
Original Size A1
Drawing No: **22-18015-C101**
Rev: 0

Plot Date: 27 September 2019 - 10:01 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C101.dwg



LEACHATE POND INLET WORKS PLAN

SCALE 1:500



TYPICAL TRENCH DETAIL

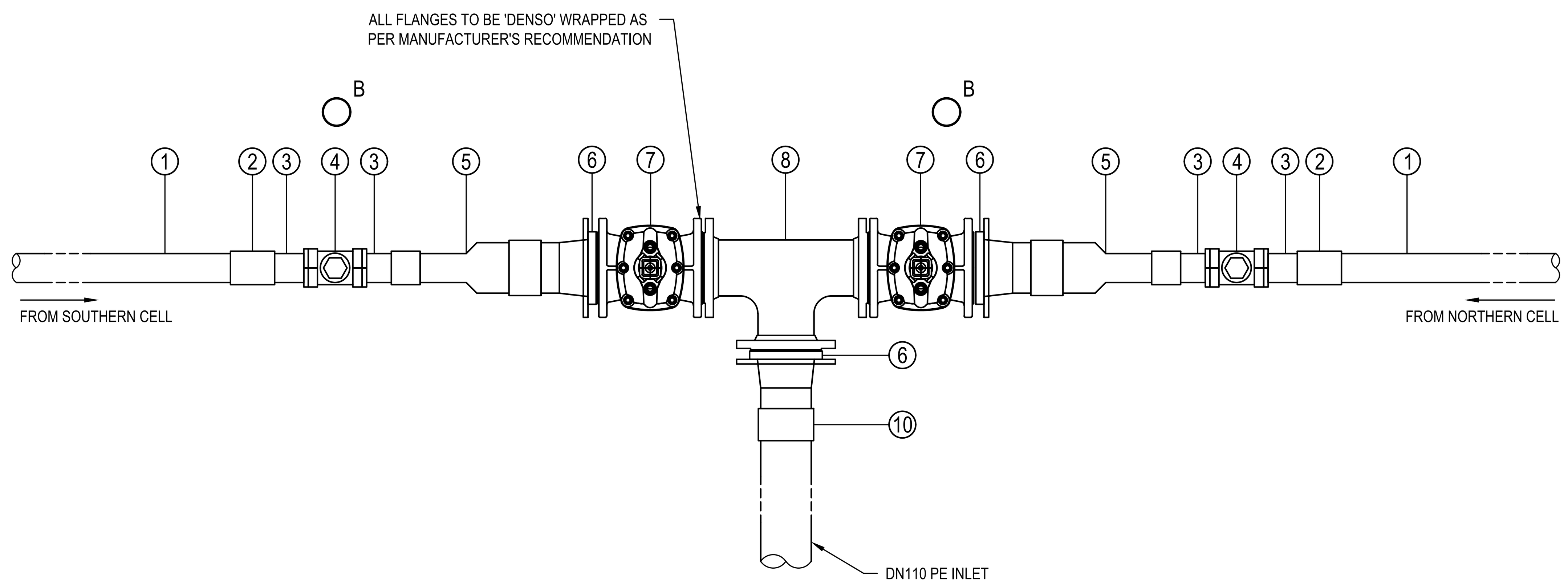
SCALE 1:10

PIPEWORK FITTINGS SCHEDULE

ITEM No.	DESCRIPTION	QTY.
1	DN63 PE100 PN16 PIPE LENGTH TO SUIT	2
2	DN63 PE ELECTROFUSION COUPLING	2
3	DN63 PE TO 2" SS TRANSITION COUPLING	4
4	2" SS SPRING CHECK VALVE. PROVIDE 150 PVC RISER TO SURFACE FOR VALVE SPIGOT CAP RISER AT SURFACE	2
5	DN110 DN63 PE REDUCING COUPLING C/W ELECTROFUSION COUPLINGS	2
6	OD110 PE STUB FLANGE AND S/S BACKING RING TO AS4087	3
7	DN100 DICL SLUICE VALVE FL-FL. PROVIDE 150 PVC RISER TO SURFACE FOR SURFACE BOX	2
8	DN100x100 DICL TEE FL-FL-FL	1
9	DN100 BLANK FLANGE	1
10	DN110 PE ELETROFUSION COUPLING	1

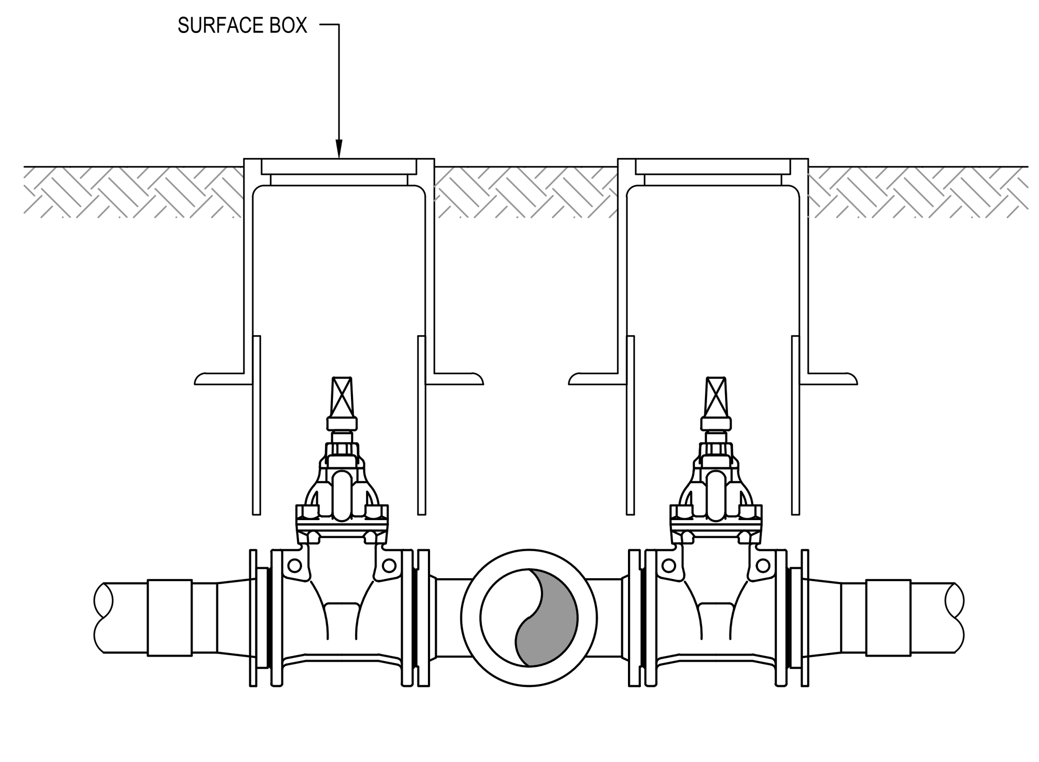
B BOLLARD

- PROVIDE 165 x 6 CHS 6 PL CAP TOP 1100mm HIGH PAINTED YELLOW DRIVEN 1200mm INTO GROUND



TYPICAL VALVE ARRANGEMENT

SCALE 1:10



TYPICAL VALVE COVER DETAIL

SCALE 1:10

NOTE: DETAIL TO BE READ IN CONJUNCTION WITH TCC STANDARD DRAWINGS SD-350 AND SD-355

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
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0 0.1 0.2 0.3 0.4 0.5m
SCALE 1:10 AT ORIGINAL SIZE

0 5 10 15 20 25m
SCALE 1:500 AT ORIGINAL SIZE

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Drawn J. CASIO
Drafting Check P. PRASAD
Approved (Project Director) I. GREGSON*
Date 26.09.19
Scale AS SHOWN
Designer P. ETCHELLS
Design Check A. ROBERTS
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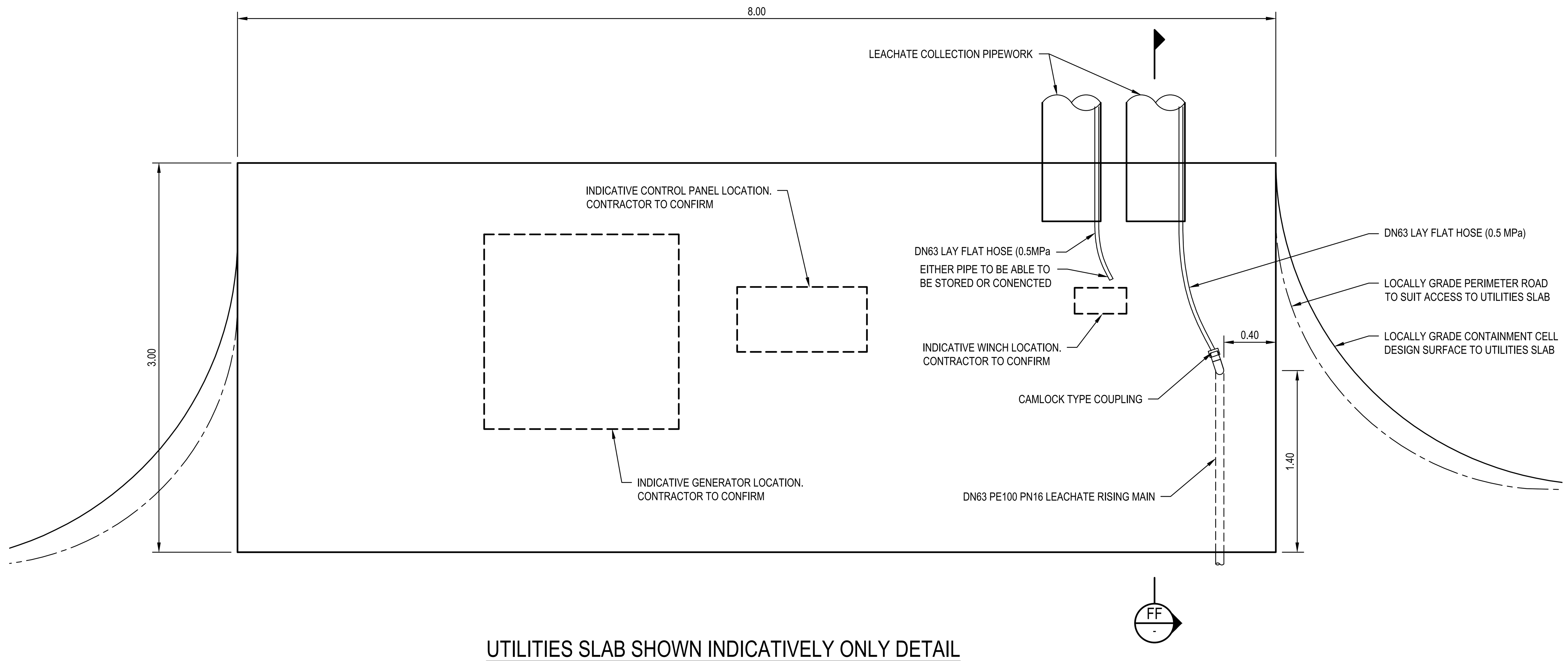
Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **LEACHATE TRANSFER SYSTEM PLAN AND DETAILS**

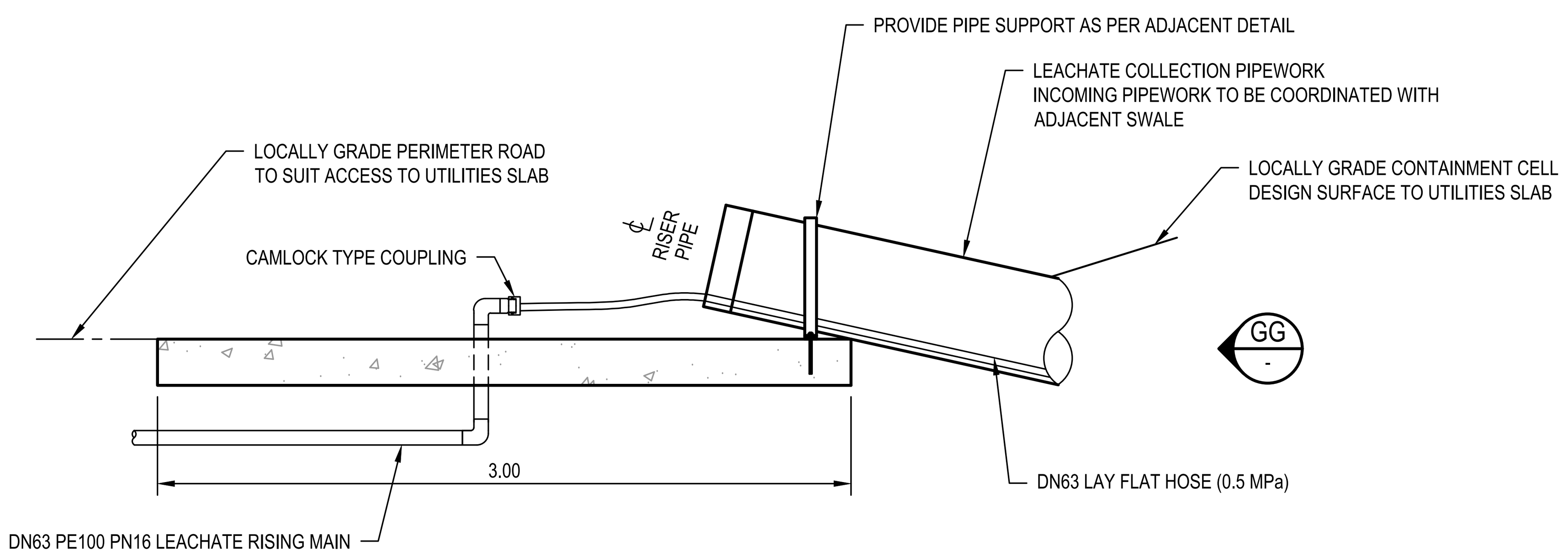
Original Size A1 Drawing No: **22-18015-C102** Rev: 0

Plot Date: 27 September 2019 - 10:01 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C102.dwg



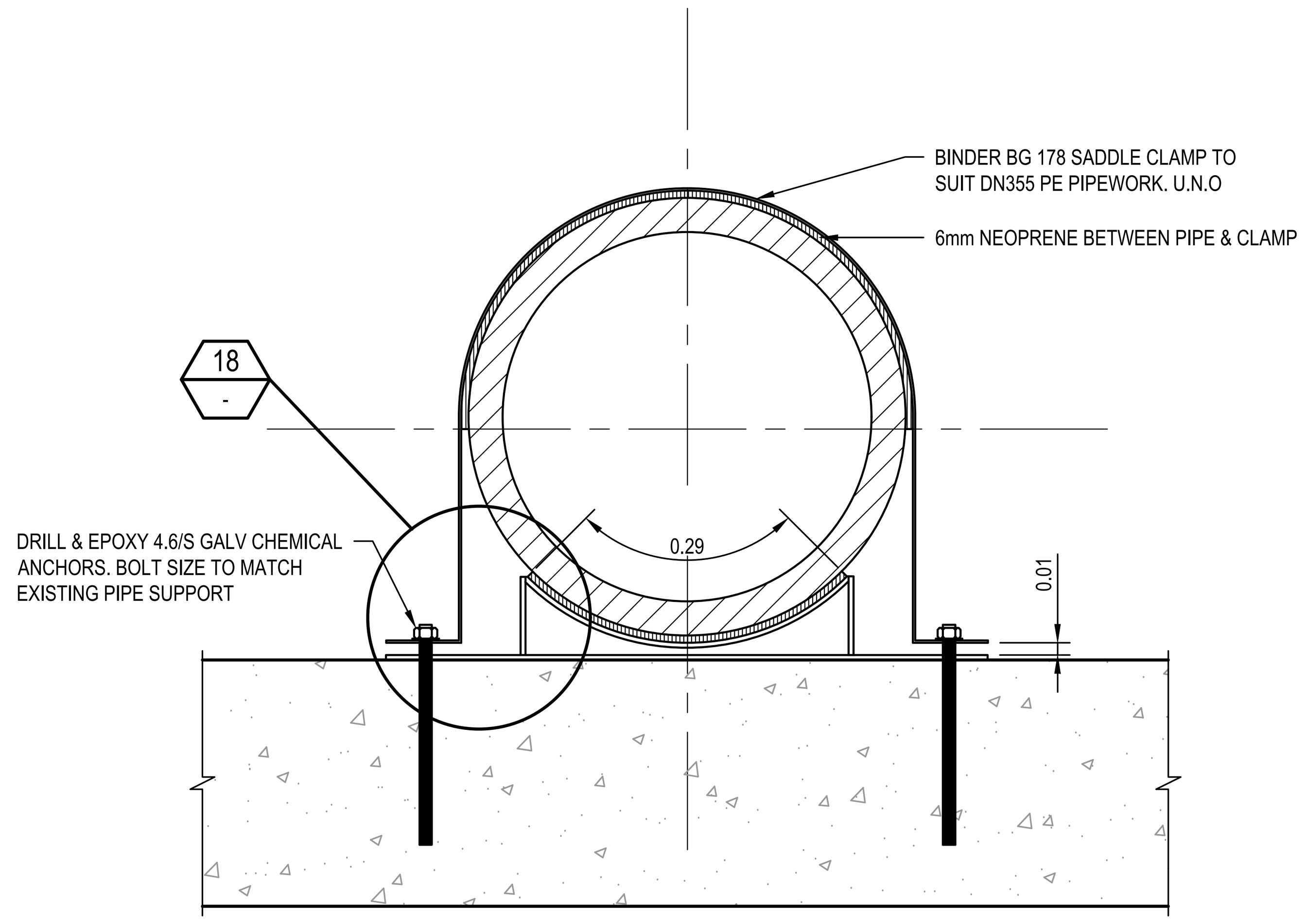
UTILITIES SLAB SHOWN INDICATIVELY ONLY DETAIL

SCALE 1:25
(REFER TO DRG No. C102 FOR PLAN LOCATION)



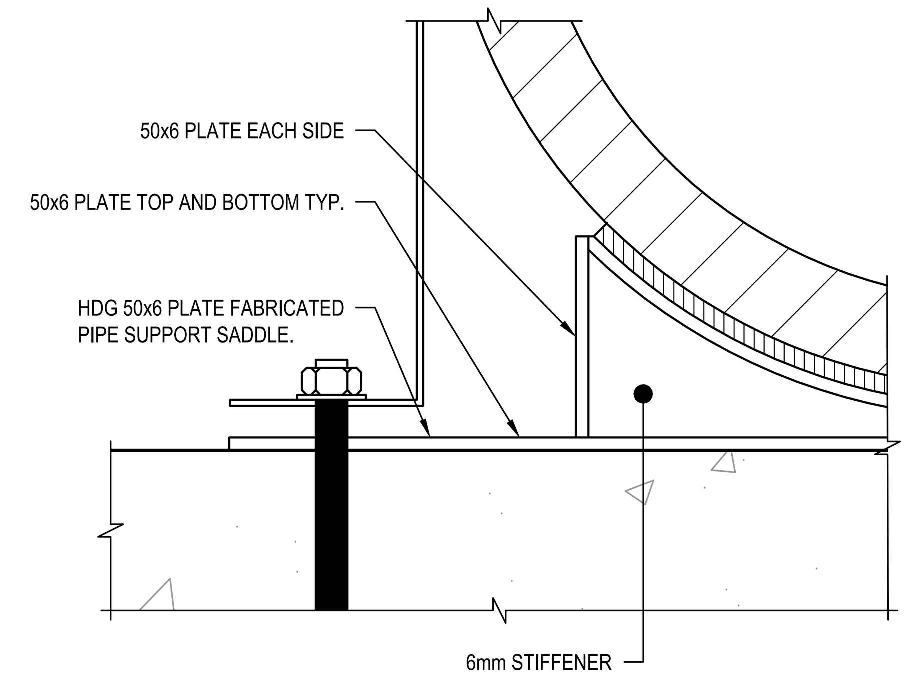
FF - SECTION

SCALE 1 : 25



GG - ELEVATION

SCALE 1 : 5



18 - DETAIL

SCALE 1 : 2

NOTE

1. ALL PIPE SUPPORTS TO BE HDG AND FULLY WELDED

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
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Note: * indicates signatures on original issue of drawing or last revision of drawing

0 0.25 0.5 0.75 1.0 1.25m
SCALE 1:25 AT ORIGINAL SIZE

0 0.05 0.1 0.15 0.2 0.25m
SCALE 1:5 AT ORIGINAL SIZE

0 0.02 0.04 0.06 0.08 0.1m
SCALE 1:20 AT ORIGINAL SIZE

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Drawn	J. CASIO	Designer	P. ETCHELLS
Drafting Check	R. PRASAD	Design Check	A. ROBERTS
Approved (Project Director)	I. GREGSON*		
Date	26.09.19		
Scale	AS SHOWN		This Drawing must not be used for Construction unless signed as Approved

Client: **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project: **CONTAINMENT CELL DETAILED DESIGN**
Title: **LEACHATE TRANSFER SYSTEM UTILITIES SLAB DETAILS**

Original Size: A1 Drawing No: **22-18015-C103** Rev: 0

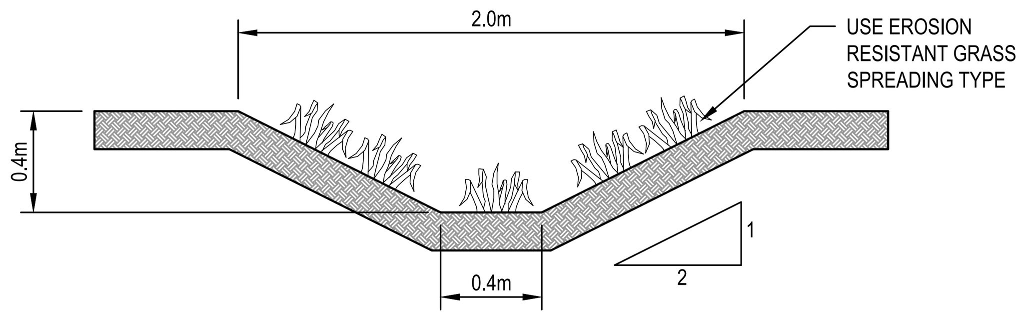
Plot Date: 27 September 2019 - 10:01 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C103.dwg

NOTES:

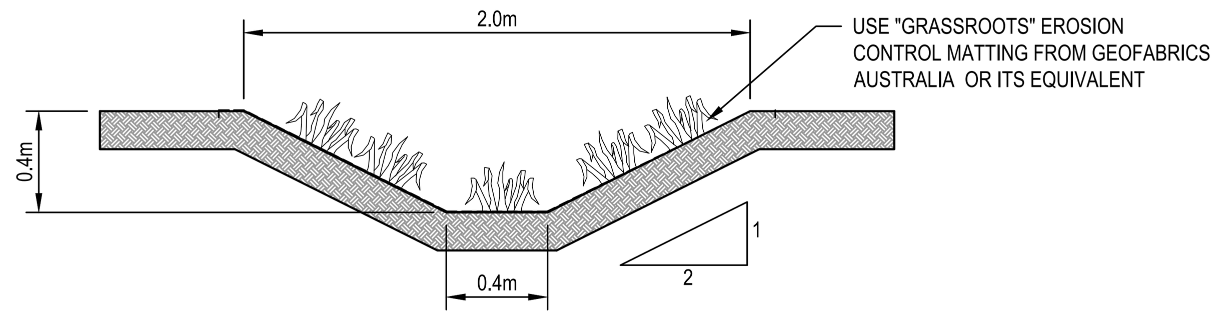
1. ALL DRAINAGE WORKS TO BE CONSTRUCTED WITH MIN. LONGITUDINAL 1% FALL.
2. ALL DISTURBED AREAS TO BE REVEGETATED.
3. SURFACE PREPARATION AS REQUIRED FOR ESTABLISHMENT OF GRASS LINING.
4. REFER 22-18015-C151 TO 22-18015-C158 FOR SWALE DETAILS.

LEGEND:

DENOTE SURFACE AREA TO BE PREPARED FOR GRASS LINING ESTABLISHMENT

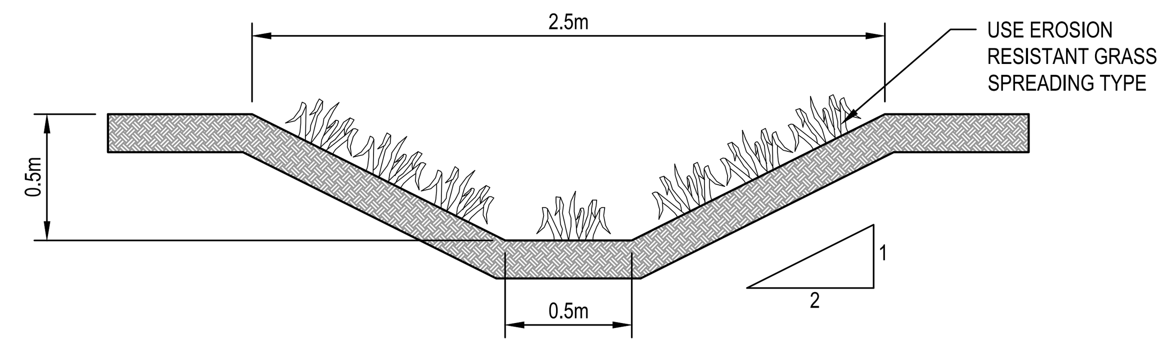


K SECTION
C023 SCALE 1 : 25



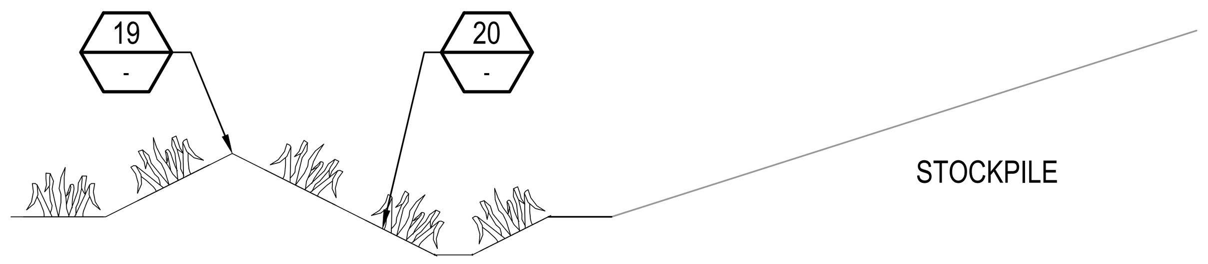
L SECTION
C023 & C032 SCALE 1 : 25

DIVERSION DRAIN



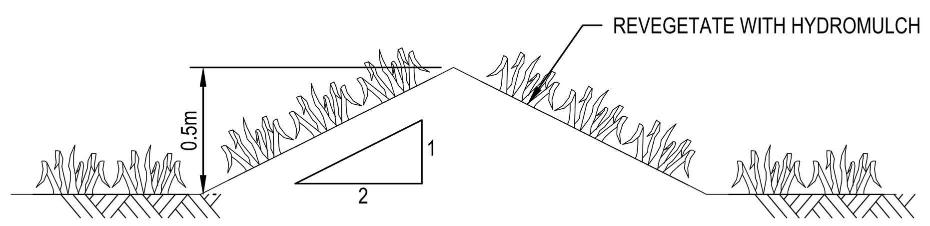
O N SECTION
C023 C023 SCALE 1 : 25

ACCESS ROAD TABLE DRAIN



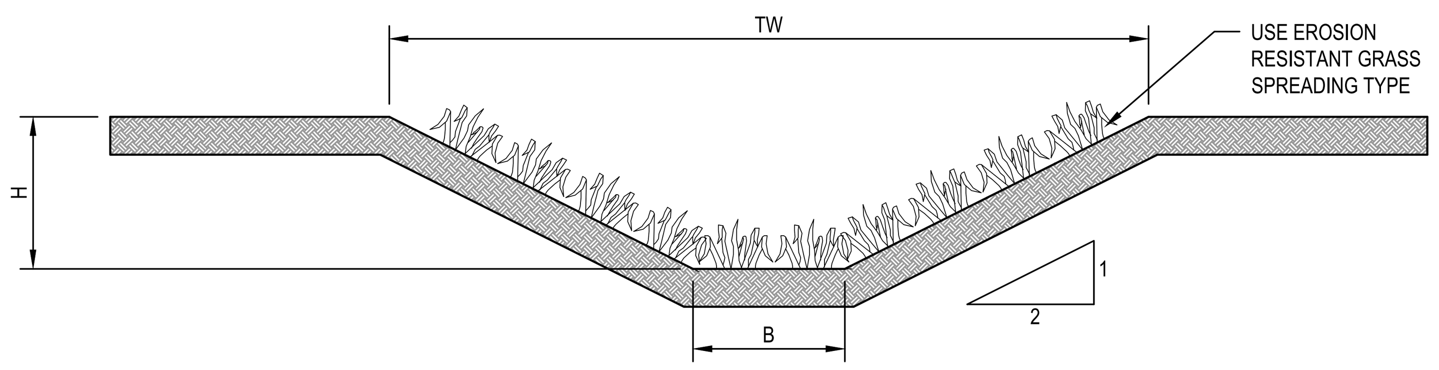
M SECTION
C023 & C032 SCALE 1 : 50

STOCKPILE PERIMETER DRAIN



19 DETAIL
- SCALE 1 : 25

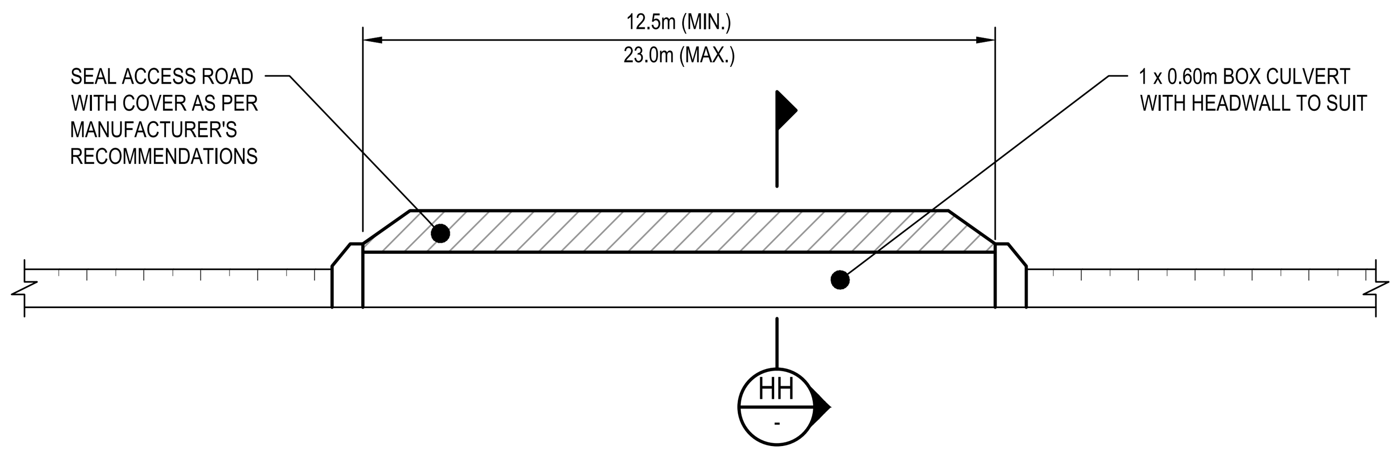
TYPICAL BUND DETAIL



20 DETAIL
- SCALE 1 : 25

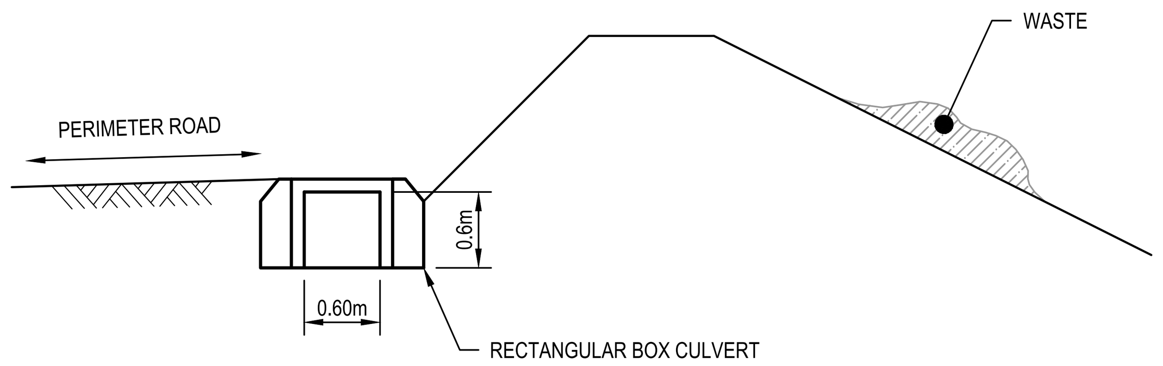
STOCKPILE PERIMETER DRAIN DETAIL

SWALE DIMENSIONS			
SWALE	TW (m)	H (m)	B (m)
1	2.5	0.5	0.5
2	2.0	0.4	0.4
3	1.6	0.3	0.4
4	3.0	0.6	0.6
5	2.0	0.4	0.4
6	3.0	0.6	0.6
7	3.0	0.6	0.6

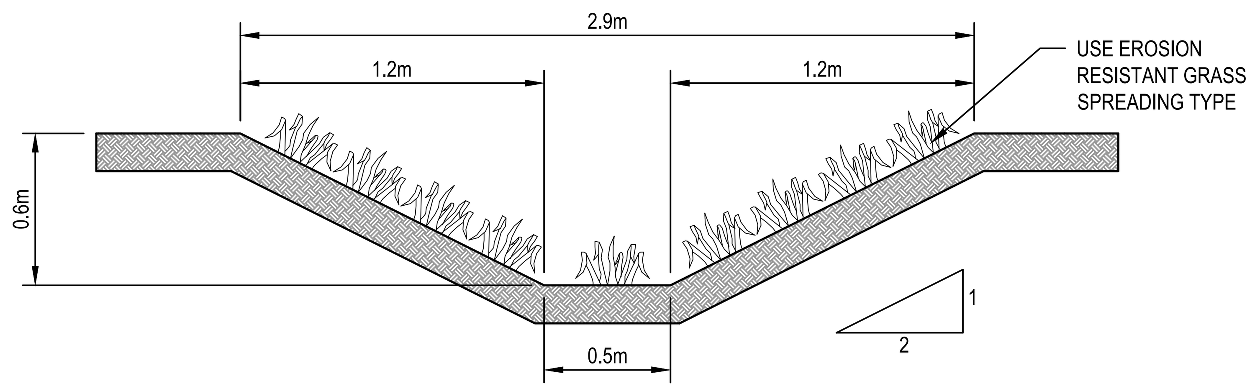


P SECTION
C023 SCALE 1 : 50

ACCESS ROAD CULVERTS



HH SECTION
- SCALE 1 : 50



Q SECTION
C023 SCALE 1 : 25

CONTAINMENT CELL PERIMETER DRAIN

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
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Note: * indicates signatures on original issue of drawing or last revision of drawing

0 0.25 0.5 0.75 1.0 1.25m
SCALE 1:25 AT ORIGINAL SIZE

0 0.5 1.0 1.5 2.0 2.5m
SCALE 1:50 AT ORIGINAL SIZE

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Drafting Check P. PRASAD
Design Check A. ROBERTS
Approved (Project Director) I. GREGSON*
Date 26.09.19
Scale AS SHOWN
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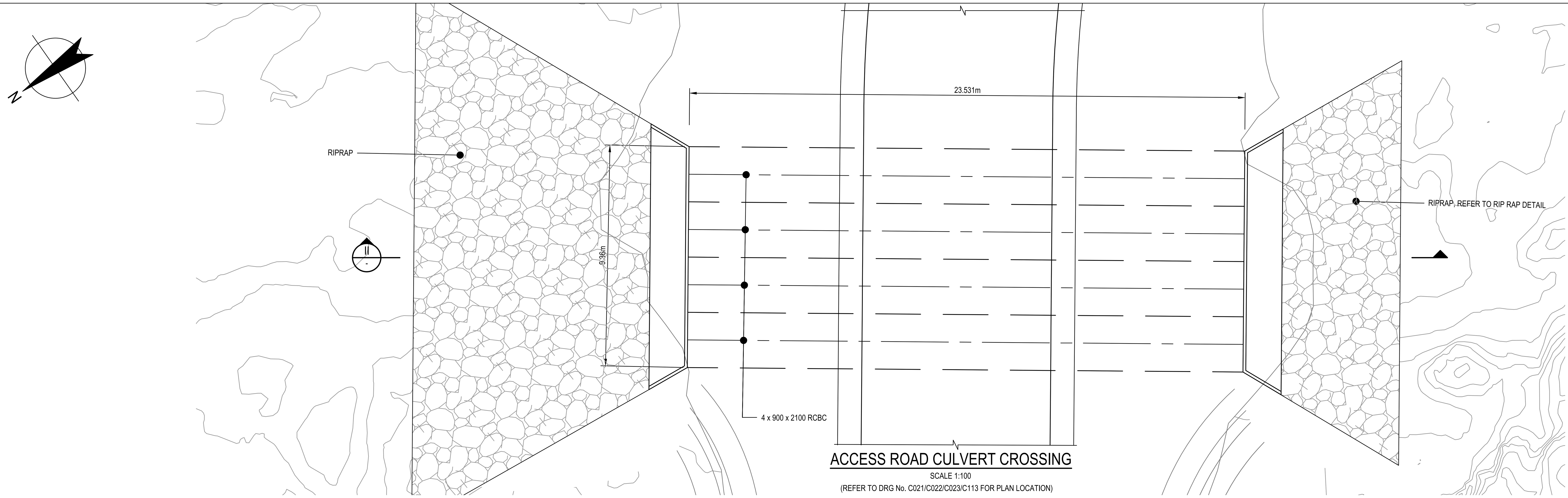
Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **STORMWATER DETAILS SHEET 1 OF 2**

Original Size A1
Drawing No: **22-18015-C111**
Rev: 0

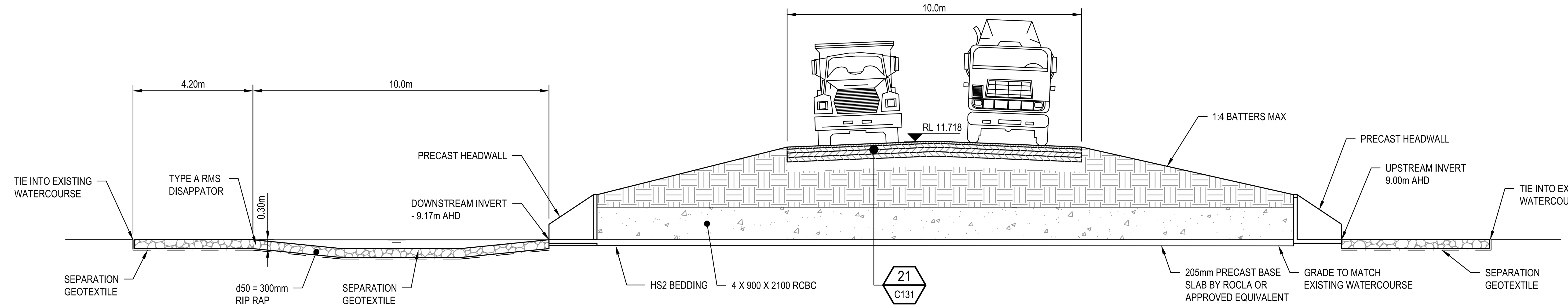
Plot Date: 27 September 2019 - 10:02 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C111.dwg



ACCESS ROAD CULVERT CROSSING

SCALE 1:100

(REFER TO DRG No. C021/C022/C023/C113 FOR PLAN LOCATION)



II SECTION

SCALE 1 : 100

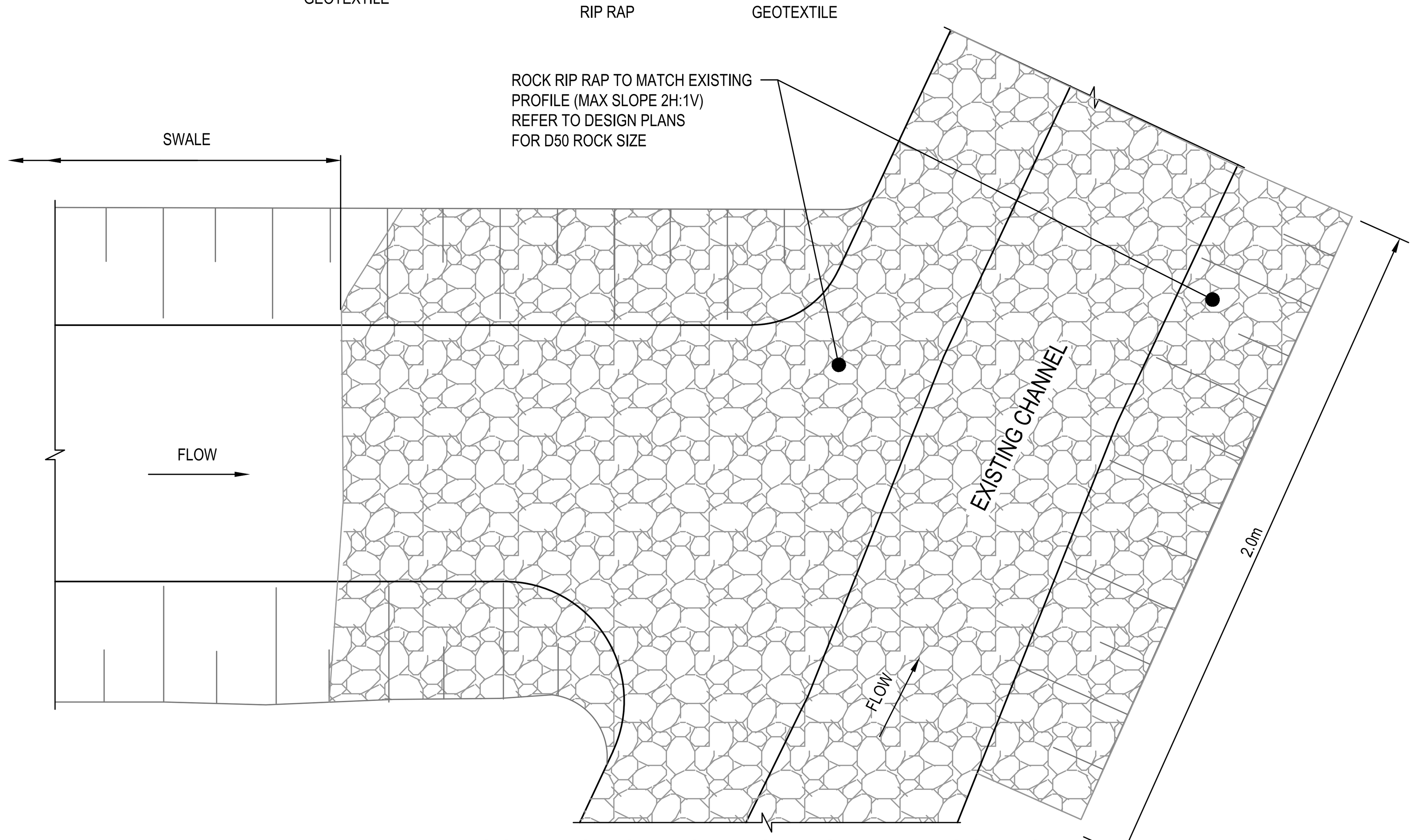
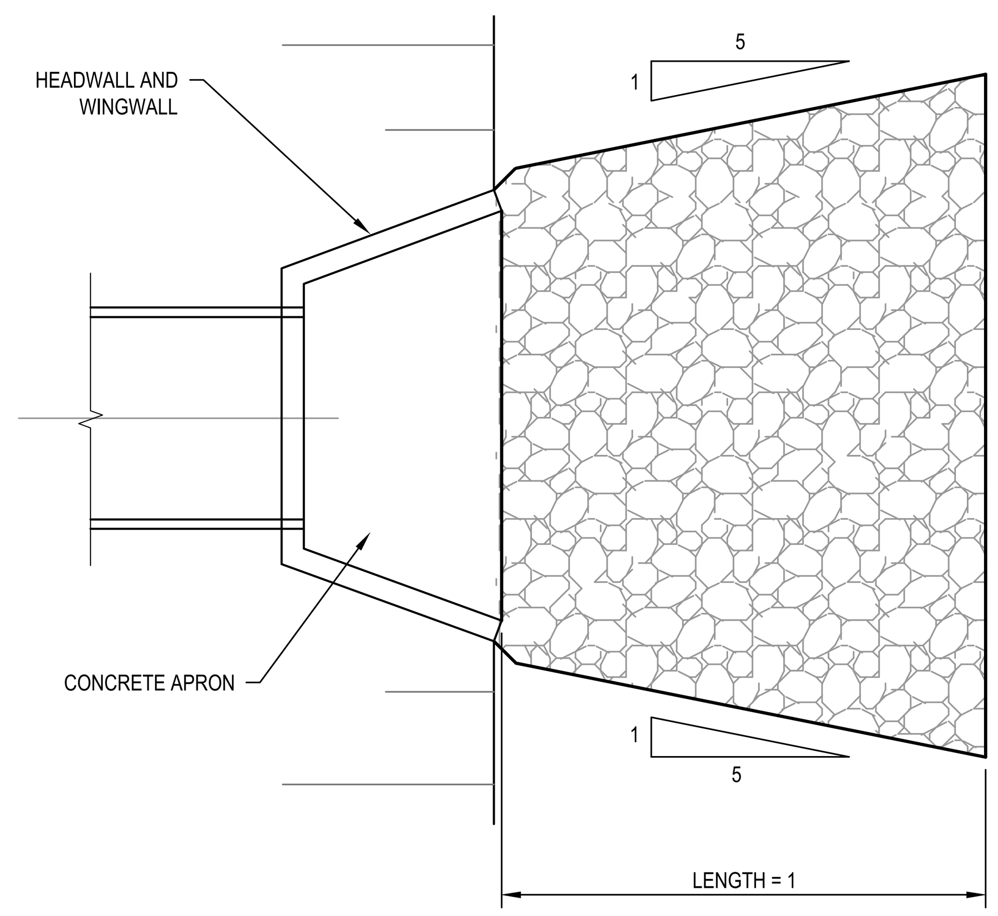


TABLE DRAIN CONNECTION TO EXISTING WATERCOURSE

NTS

(REFER TO DRG No. C023 FOR PLAN LOCATION)



CULVERT RIP RAP APRON

NTS

(REFER TO DRG No. C023 FOR PLAN LOCATION)

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
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Note: * indicates signatures on original issue of drawing or last revision of drawing

0 1 2 3 4 5m
SCALE 1:100 AT ORIGINAL SIZE

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Drafting Check P. PRASAD | Design Check A. ROBERTS
Approved (Project Director) I. GREGSON*
Date 26.09.19
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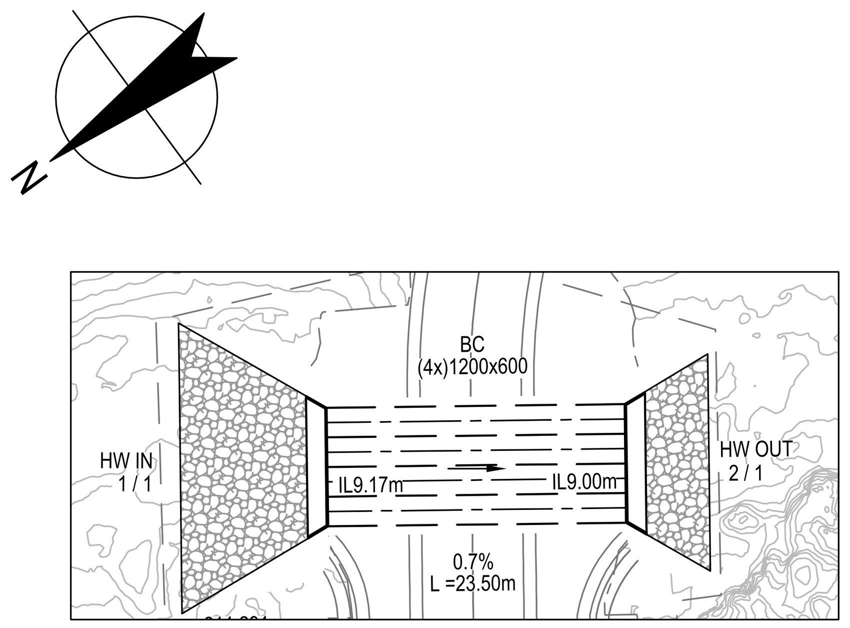
Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **STORMWATER DETAILS SHEET 2 OF 2**

Original Size A1 Drawing No: **22-18015-C112** Rev: 0

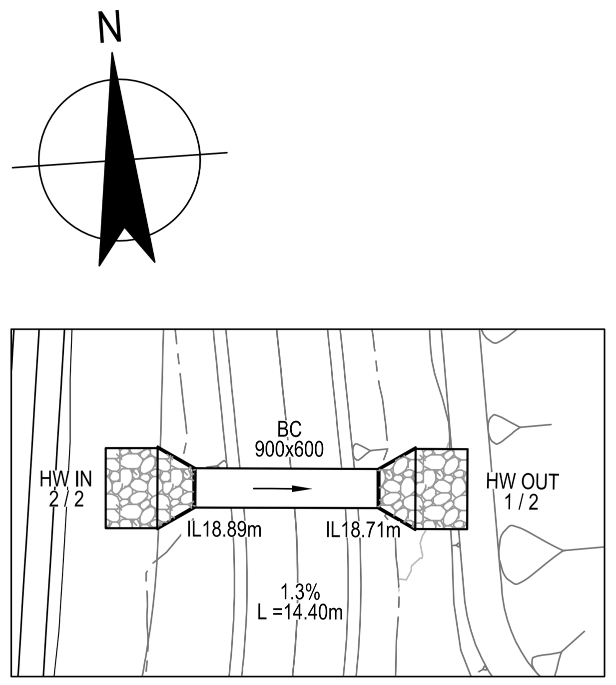
Plot Date: 27 September 2019 - 10:02 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C112.dwg

NOTE:

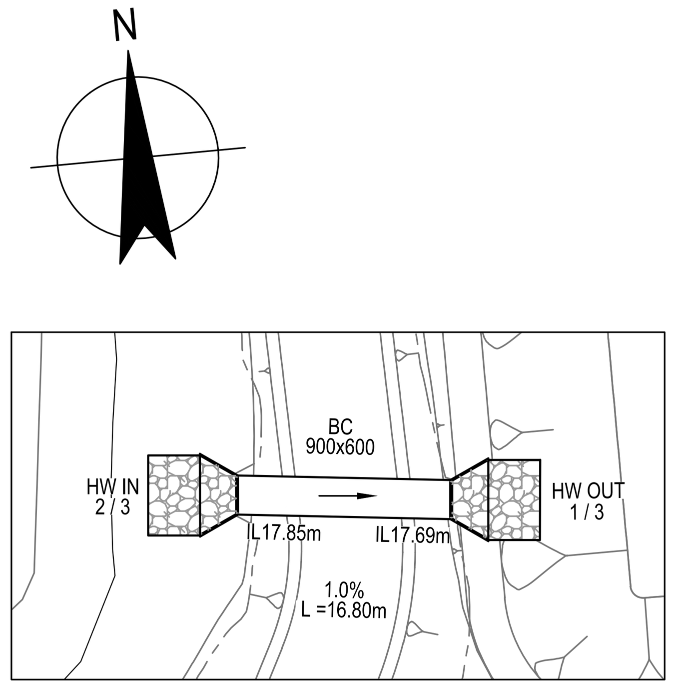
1. REFER DRAWING 22-18015-C023 FOR CULVERT LOCATION.



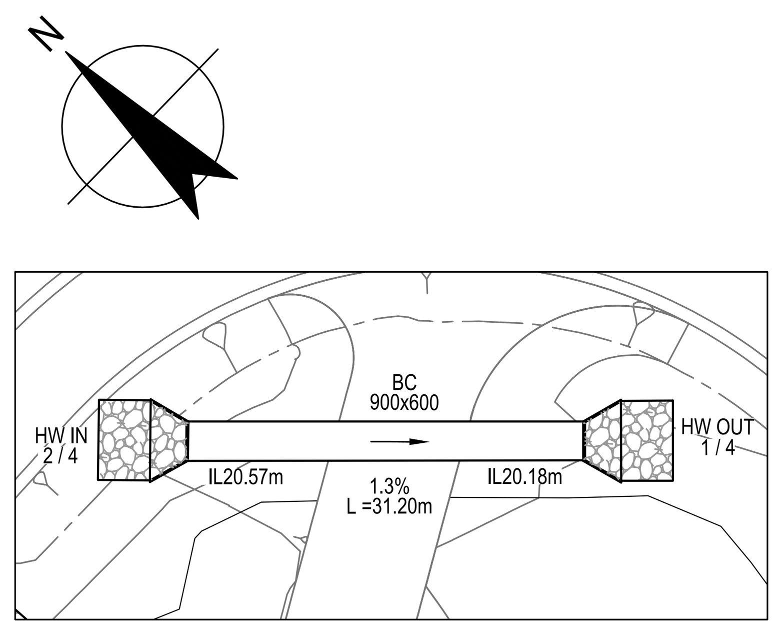
CULVERT 01



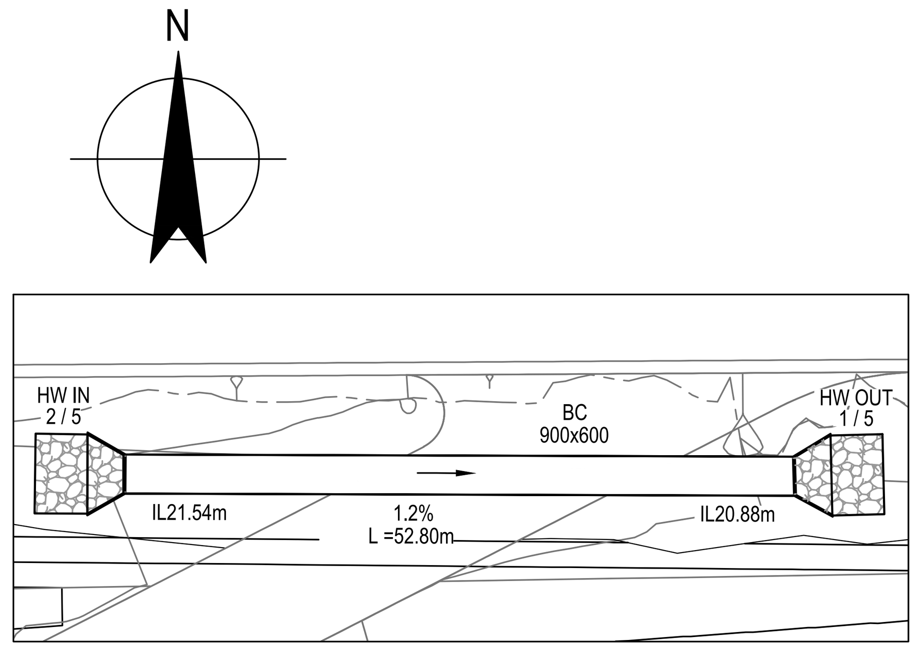
CULVERT 02



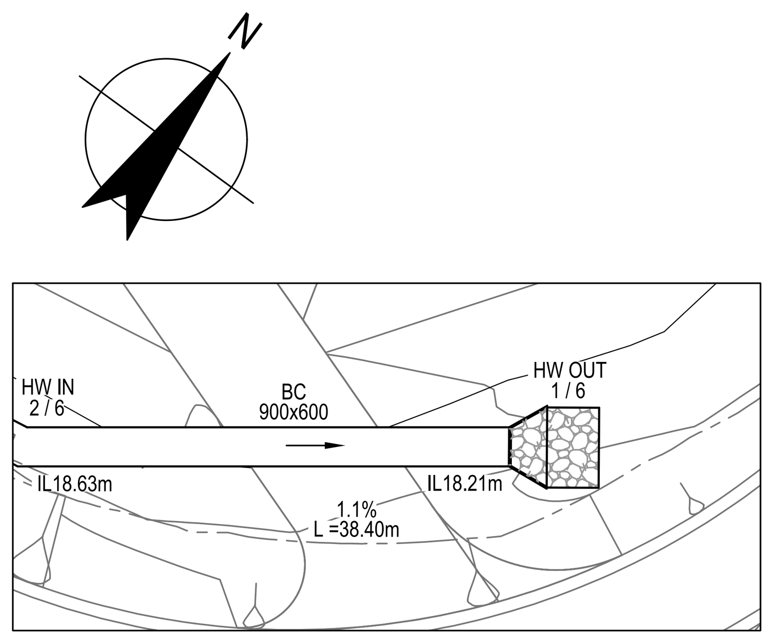
CULVERT 03



CULVERT 04



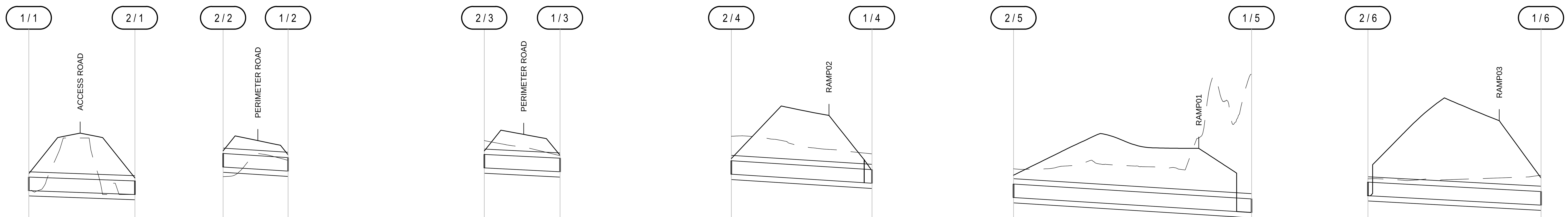
CULVERT 05



CULVERT 06

PLAN - CULVERTS

SCALE 1:500



CULVERT 01

PIPE GRADE (%)		-0.7%	
PIPE SLOPE (1 IN X)		240.0	
PIPE SIZE (mm)		(4x)1200x600	
PIPE CLASS		BC	
DATUM R.L.	-9.00		
DEPTH TO INVERT FROM DESIGN SURFACE	0.600 0.600		0.600
INVERT LEVEL	9.169 9.169		9.000
DESIGN SURFACE LEVEL	9.769		9.600
EXISTING SURFACE LEVEL	9.166		9.000
CHAINAGE	0.000	23.531	23.500

CULVERT 02

PIPE GRADE (%)		1.3%	
PIPE SLOPE (1 IN X)		79.9	
PIPE SIZE (mm)		900x600	
PIPE CLASS		BC	
DATUM R.L.			9.00
DEPTH TO INVERT FROM DESIGN SURFACE	0.600		0.600 0.600
INVERT LEVEL	18.894		18.714 18.714
DESIGN SURFACE LEVEL	19.494		19.314
EXISTING SURFACE LEVEL	18.466		19.190
CHAINAGE	14.400	14.400	0.000

CULVERT 03

PIPE GRADE (%)		1.0%	
PIPE SLOPE (1 IN X)		100.0	
PIPE SIZE (mm)		900x600	
PIPE CLASS		BC	
DATUM R.L.			8.00
DEPTH TO INVERT FROM DESIGN SURFACE	0.600		0.600 0.600
INVERT LEVEL	17.854		17.686 17.686
DESIGN SURFACE LEVEL	18.454		18.286
EXISTING SURFACE LEVEL	19.069		18.396
CHAINAGE	16.800	16.800	0.000

CULVERT 04

PIPE GRADE (%)		1.3%	
PIPE SLOPE (1 IN X)		79.0	
PIPE SIZE (mm)		900x600	
PIPE CLASS		BC	
DATUM R.L.			11.00
DEPTH TO INVERT FROM DESIGN SURFACE	0.600		0.600 0.600
INVERT LEVEL	20.574		20.179 20.179
DESIGN SURFACE LEVEL	21.174		20.779
EXISTING SURFACE LEVEL	22.257		21.476
CHAINAGE	31.200	31.200	0.000

CULVERT 05

PIPE GRADE (%)		1.2%	
PIPE SLOPE (1 IN X)		80.0	
PIPE SIZE (mm)		900x600	
PIPE CLASS		BC	
DATUM R.L.			13.00
DEPTH TO INVERT FROM DESIGN SURFACE	0.600		0.600 0.600
INVERT LEVEL	21.542		20.882 20.882
DESIGN SURFACE LEVEL	22.142		21.482
EXISTING SURFACE LEVEL	22.817		27.004
CHAINAGE	52.800	52.800	0.000

CULVERT 06

PIPE GRADE (%)		1.1%	
PIPE SLOPE (1 IN X)		92.5	
PIPE SIZE (mm)		900x600	
PIPE CLASS		BC	
DATUM R.L.			10.00
DEPTH TO INVERT FROM DESIGN SURFACE	0.600		0.600 0.600
INVERT LEVEL	18.625		18.210 18.210
DESIGN SURFACE LEVEL	19.225		18.810
EXISTING SURFACE LEVEL	19.372		19.512
CHAINAGE	38.400	38.400	0.000

LONGITUDINAL SECTION - CULVERTS

SCALE HOR. 1:500 VERT. 1:100

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
0	ISSUED FOR CONSTRUCTION	RK	AR	IG	29.09.19

Note: * indicates signatures on original issue of drawing or last revision of drawing

VERTICAL 1:100 AT ORIGINAL SIZE 0 1 2 3 4 5m
HORIZONTAL 1:500 AT ORIGINAL SIZE 0 5 10 15 20 25m

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DO NOT SCALE

Drawn	J. CASIO	Designer	P. ETCHELLS
Drafting Check	P. PRASAD	Design Check	A. ROBERTS
Approved (Project Director)	I. GREGSON*		
Date	26.09.19		
Scale	AS SHOWN	This Drawing must not be used for Construction unless signed as Approved	

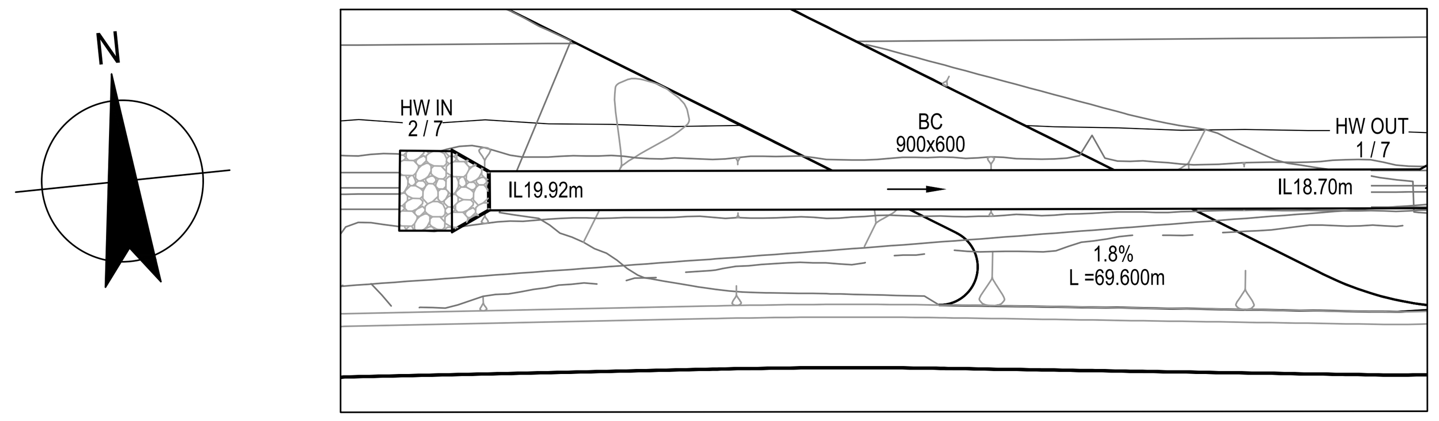
Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **CULVERT LONGITUDINAL SECTIONS SHEET 1 OF 2**

Original Size **A1** Drawing No: **22-18015-C113** Rev: **0**

Plot Date: 27 September 2019 - 10:02 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C113.dwg

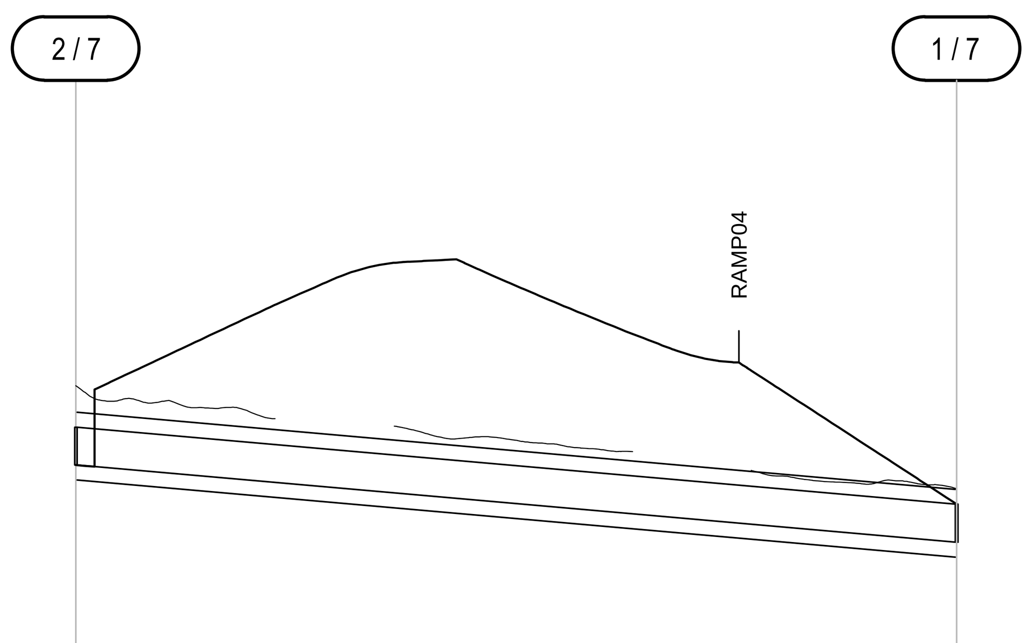
NOTE:

1. REFER DRAWING 22-18015-C023 FOR CULVERT LOCATION.



PLAN - CULVERT 07

SCALE 1:500



PIPE GRADE (%) — 1.8%
PIPE SLOPE (1 IN X) — 57.1
PIPE SIZE (mm) — 900x600
PIPE CLASS — BC

DATUM R.L. 10.00

	2 / 7		1 / 7
DEPTH TO INVERT FROM DESIGN SURFACE	0.600		0.600 0.600
INVERT LEVEL	19.918		18.700 18.700
DESIGN SURFACE LEVEL	20.518		19.300
EXISTING SURFACE LEVEL	21.172		19.546
CHAINAGE	69.600	69.600	0.000

LONGITUDINAL SECTION - CULVERT 07

SCALE HOR. 1:500 VERT. 1:100

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
0	ISSUED FOR CONSTRUCTION	RK	AR	IG	29.09.19

Note: * indicates signatures on original issue of drawing or last revision of drawing

VERTICAL 1:100 AT ORIGINAL SIZE 0 1 2 3 4 5m
HORIZONTAL 1:500 AT ORIGINAL SIZE 0 5 10 15 20 25m

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Drafting Check P. PRASAD | Design Check A. ROBERTS
Approved (Project Director) I. GREGSON*
Date 26.09.19
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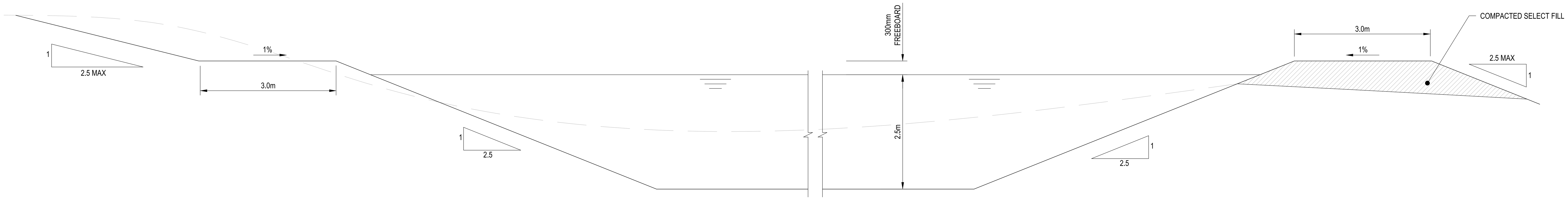
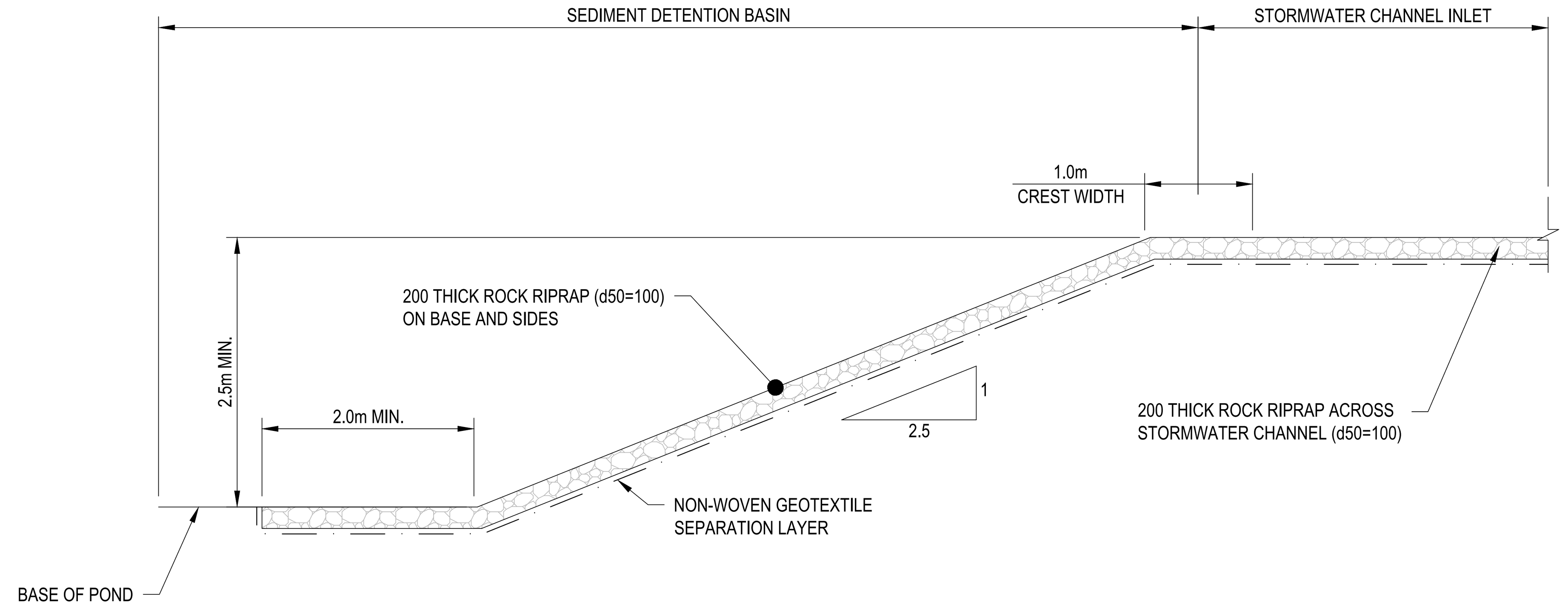
Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **CULVERT LONGITUDINAL SECTION SHEET 2 OF 2**
Original Size A1 Drawing No: **22-18015-C114** Rev: 0

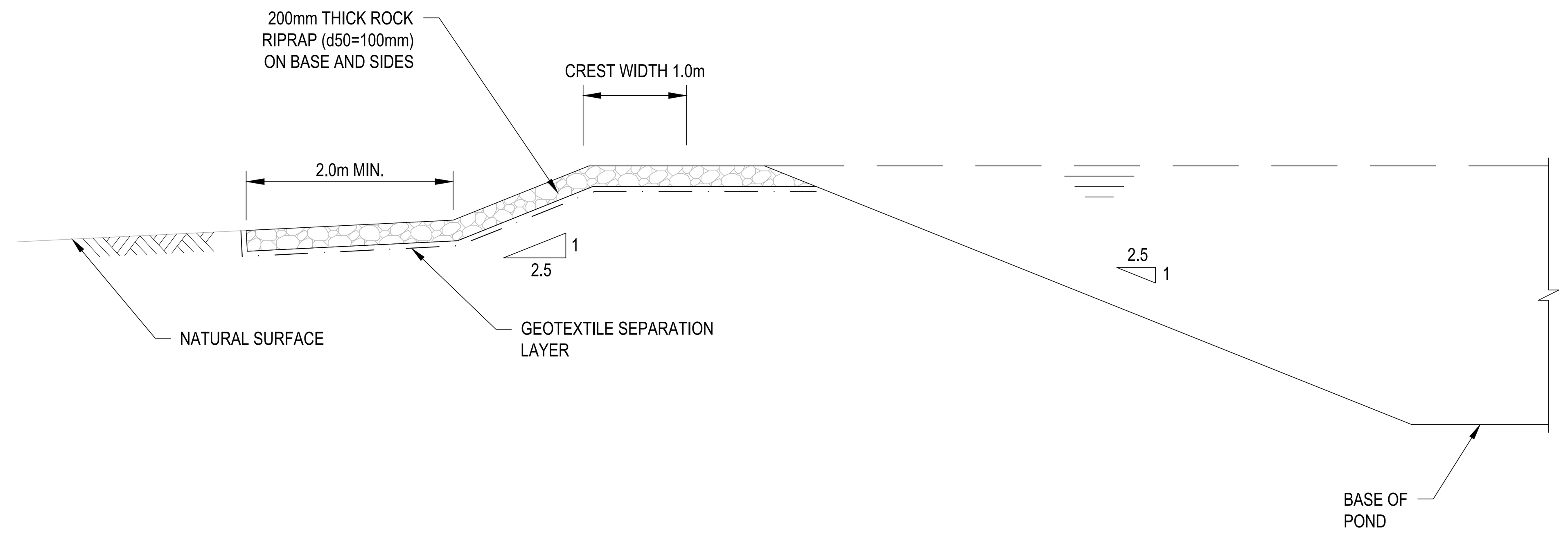
Plot Date: 27 September 2019 - 10:02 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C114.dwg



SEDIMENT BASIN TYPICAL SECTION

U SECTION
C024 SCALE 1 : 50



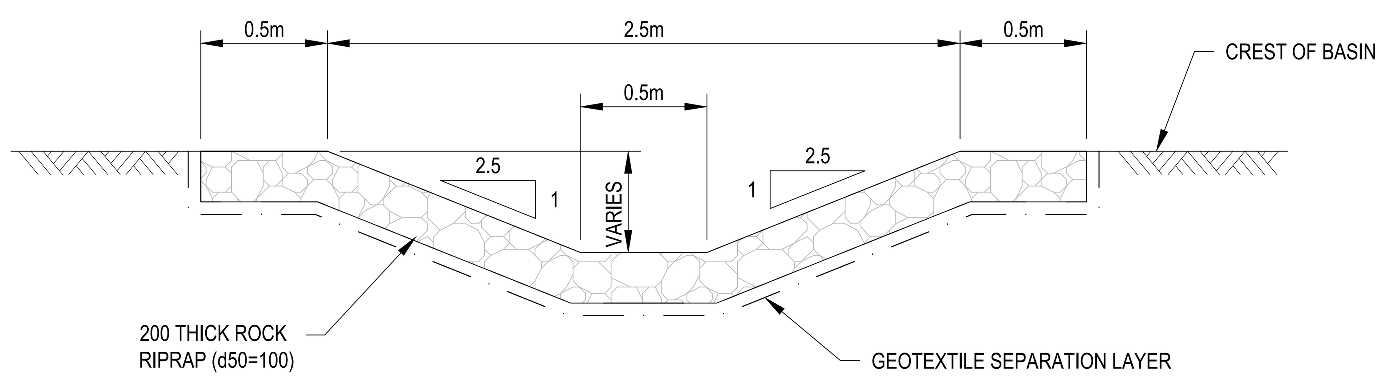


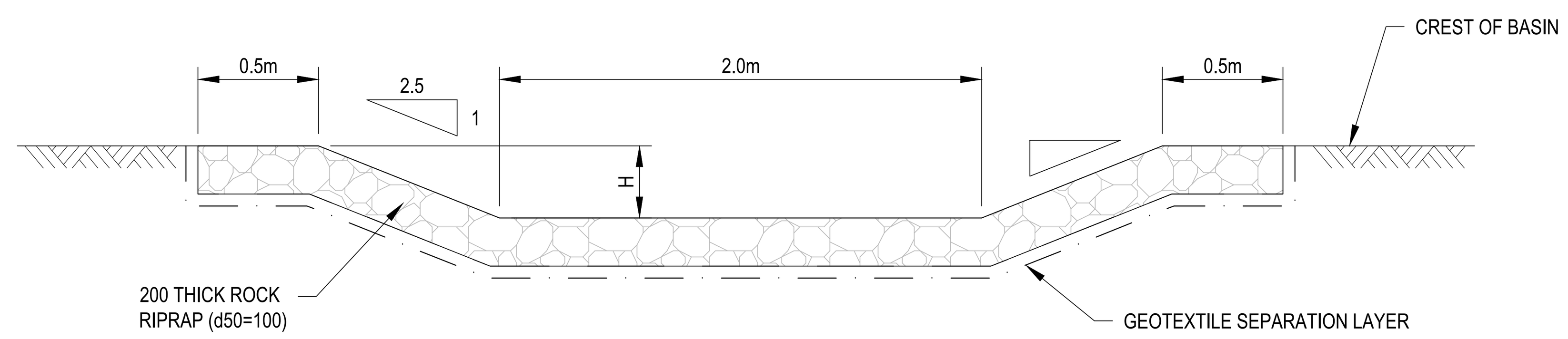
SEDIMENT BASIN INLET CHANNEL TYPICAL SECTION

R SECTION
C024 SCALE 1 : 50

SEDIMENT BASIN OVERFLOW CHANNEL TYPICAL SECTION

S SECTION
C024 SCALE 1 : 50





INLET CHANNEL

V SECTION
C024 SCALE 1 : 25

OVERFLOW CHANNEL

T SECTION
C024 SCALE 1 : 25

SPILLWAY DIMENSIONS

SEDIMENT BASIN	H (mm)
1	400
2	350
3	300

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
0	ISSUED FOR CONSTRUCTION	RK	AR	IG	29.09.19

Note: * indicates signatures on original issue of drawing or last revision of drawing

0 0.25 0.5 0.75 1.0 1.25m
SCALE 1:25 AT ORIGINAL SIZE

0 0.5 1.0 1.5 2.0 2.5m
SCALE 1:50 AT ORIGINAL SIZE

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Drawn J. CASIO
Designer P. ETCHELLS
Drafting Check P. PRASAD
Design Check A. ROBERTS
Approved (Project Director) I. GREGSON*
Date 26.09.19
Scale AS SHOWN
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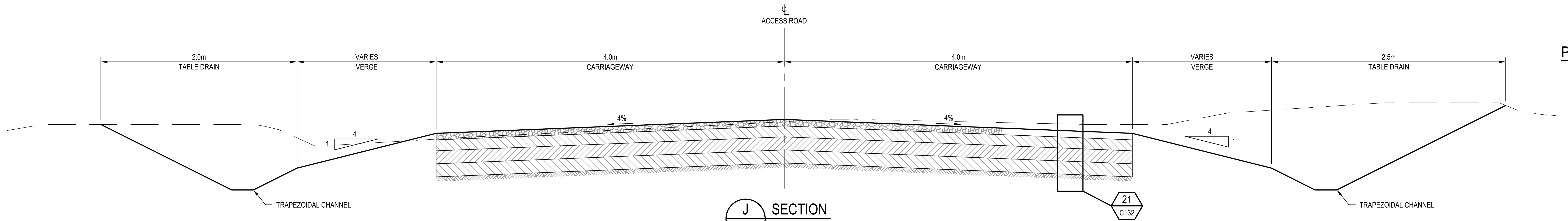
Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **SEDIMENT DETENTION BASIN DETAILS**

Original Size A1 Drawing No: **22-18015-C121** Rev: 0

Plot Date: 27 September 2019 - 10:03 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C121.dwg



J SECTION
C022 SCALE 1 : 25

CONTAINMENT CELL ACCESS ROAD TYPICAL SECTION

SCALE 1:25

PAVEMENT DESIGN NOTES

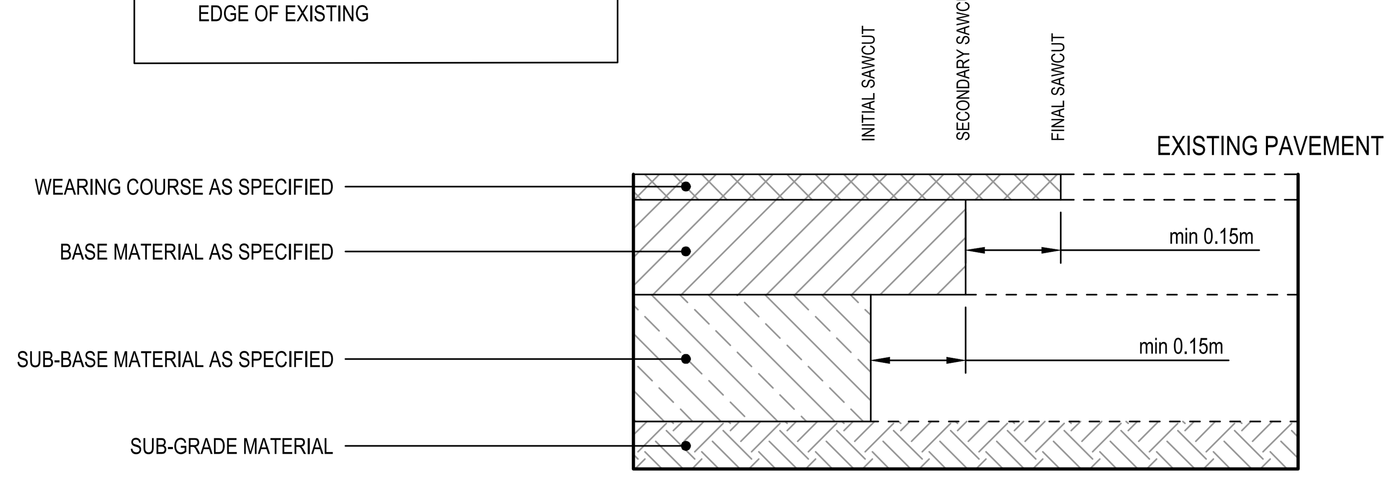
1. GRAVEL PAVEMENT DESIGN IS BASED ON TRAFFIC LOADING 1.81 x 10 ESA AND ASSUMED SUBGRADE CBR OF 3%.
2. THE CONTRACTOR SHALL ORGANIZE SUBGRADE CBR TESTING TO VERIFY THE ASSUMPTION MADE CBR VALUES.
3. TESTING SHALL BE DONE PRIOR TO CONSTRUCTION.

I SECTION
C022 SCALE 1 : 25

PERIMETER ROAD TYPICAL SECTION

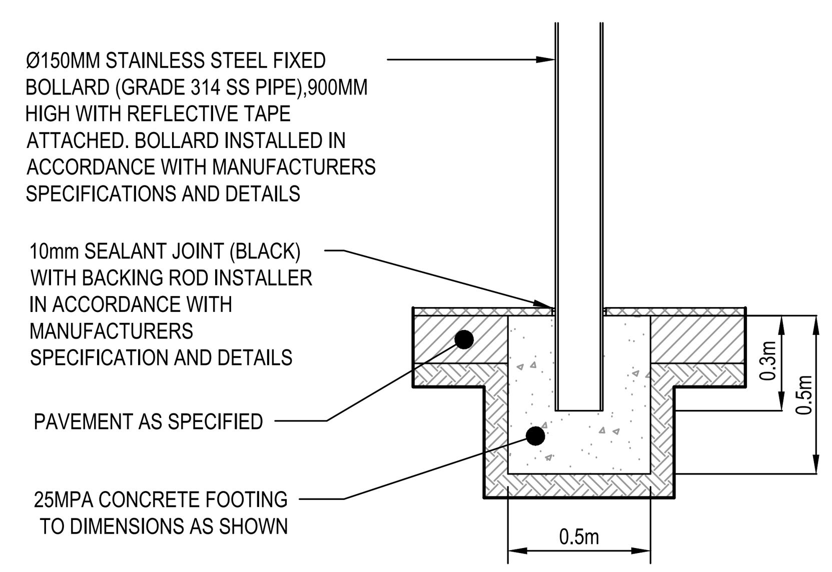
SCALE 1:25

NOTES:
- MATCH ASPHALT NEATLY WITH EXISTING
- FINAL SAWCUT TO BE UNDERTAKEN AT A TIME TO ENSURE MINIMAL DAMAGE / CHIPPING OCCURS TO EDGE OF EXISTING



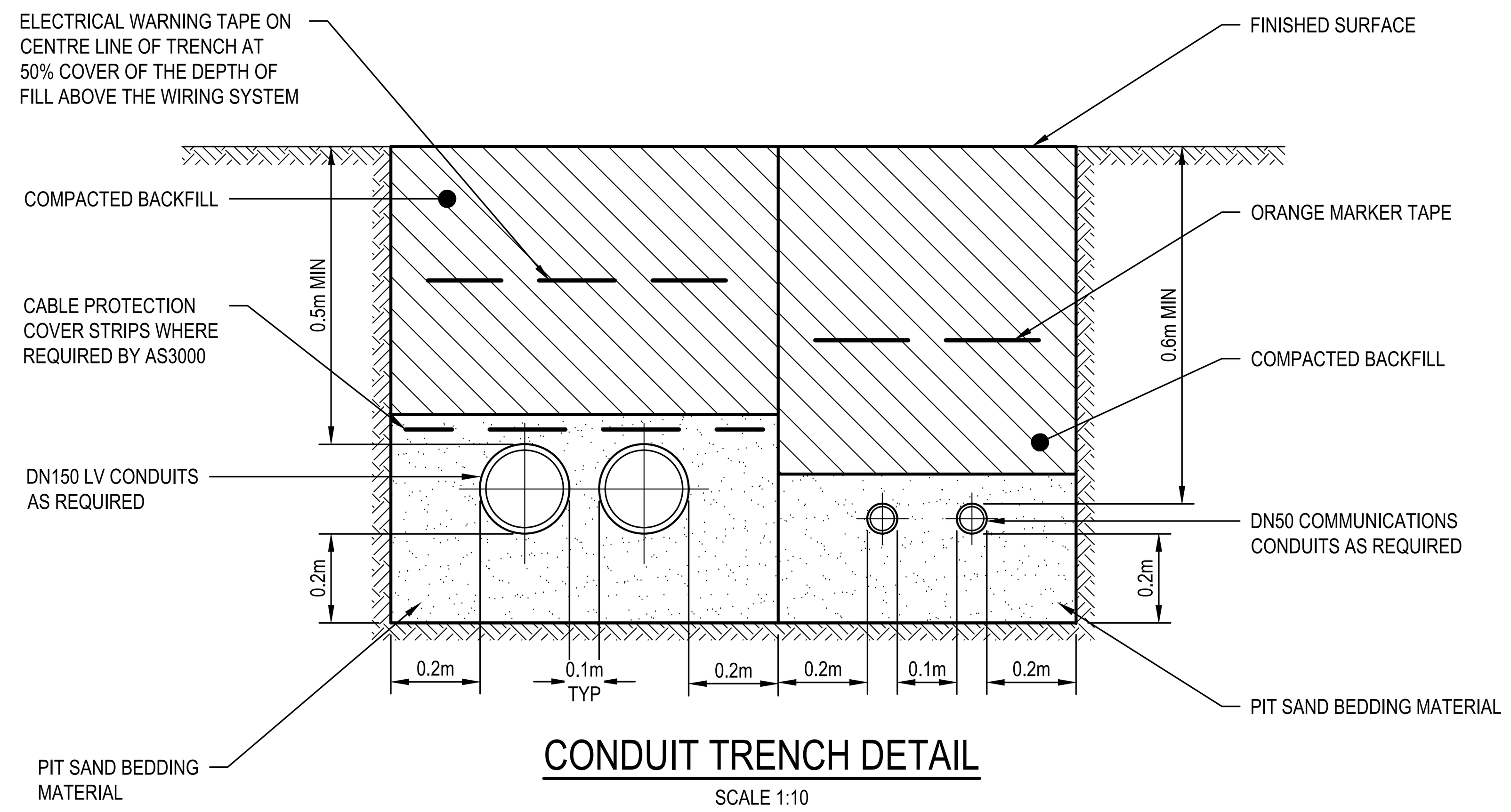
PAVEMENT INTERFACE DETAIL

SCALE 1:10



BOLLARD DETAIL

SCALE 1:20



CONDUIT TRENCH DETAIL

SCALE 1:10

FOR CONSTRUCTION

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0 0.25 0.5 0.75 1.0 1.25m
SCALE 1:25 AT ORIGINAL SIZE

0 0.2 0.4 0.6 0.8 1.0m
SCALE 1:20 AT ORIGINAL SIZE

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Drafting Check P. PRASAD | Design Check A. ROBERTS
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Date 26.09.19
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Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **ACCESS ROAD DETAILS SHEET 1 OF 3**

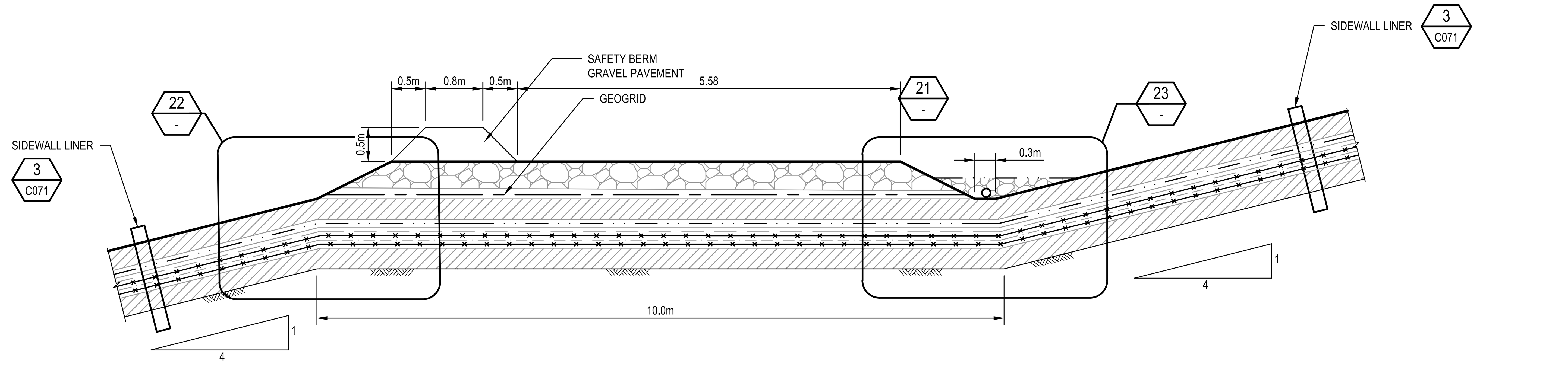
Original Size A1 Drawing No: **22-18015-C131** Rev: 0

Plot Date: 27 September 2019 - 10:03 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C131.dwg

TABLE 1 - WEARING COURSE MATERIALS PROPERTIES	
PROPERTY	VALUE
	WEARING COURSE
SIEVE SIZE (mm)	
19.000	80-100
9.500	-
4.750	-
2.360	35 - 65
0.425	15 - 50
0.075	10 - 40
PLASTIC INDEX	MAX. 12
WEIGHTED PLASTICITY INDEX	MAX. 250
LINEAR SHRINKLE x % PASSING 0.425mm	N/A
4 DAY SOAKED CBR	MIN. 40%
MAXIMUM AGGREGATE SIZE	20mm
% PASSING 0.075mm	10 - 40

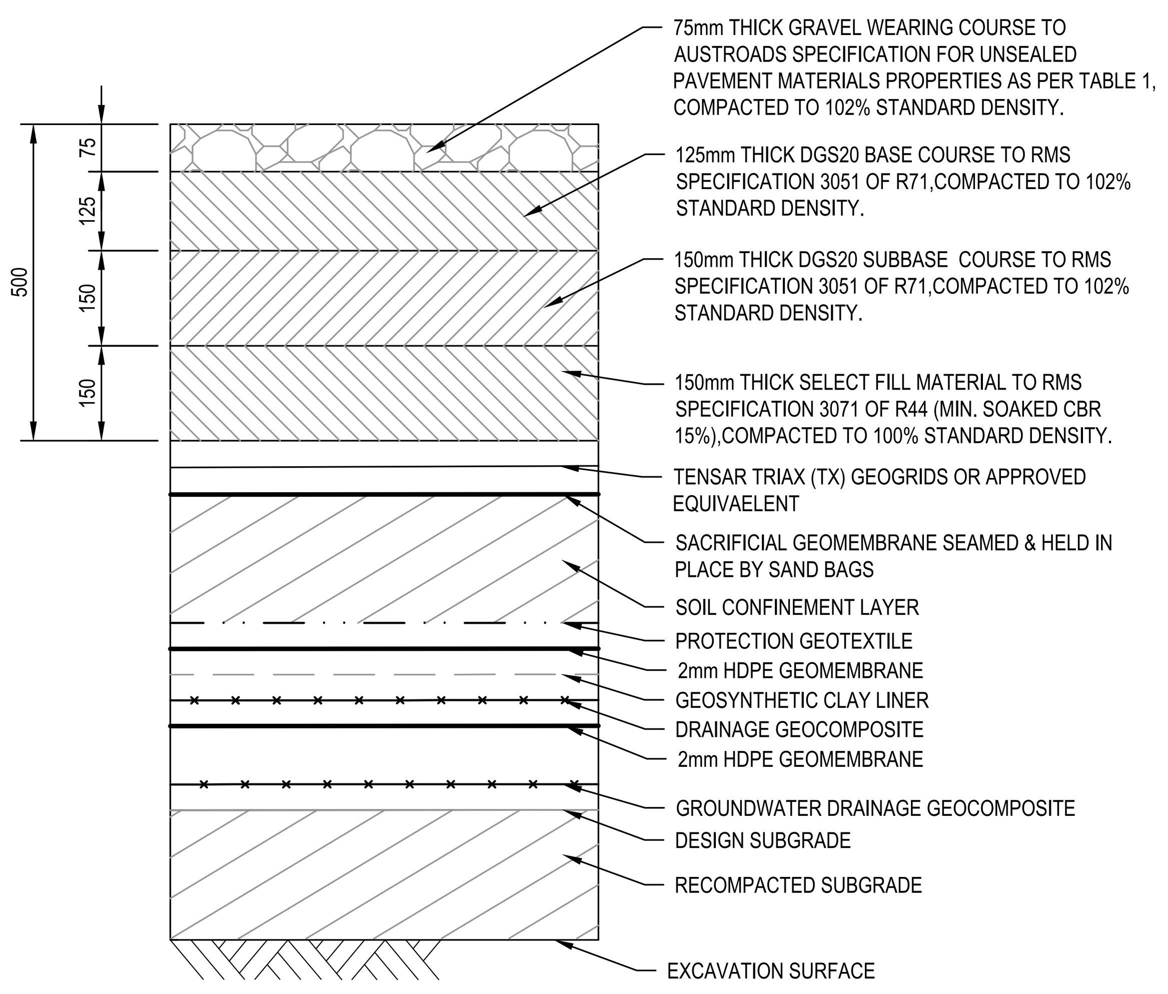
PAVEMENT DESIGN NOTES

1. GRAVEL PAVEMENT DESIGN IS BASED ON TRAFFIC LOADING 1.81 x 10^6 ESA AND ASSUMED SUBGRADE CBR OF 3%.
2. THE CONTRACTOR SHALL ORGANIZE SUBGRADE CBR TESTING TO VERIFY THE ASSUMPTION MADE CBR VALUES.
3. TESTING SHALL BE DONE PRIOR TO DELIVERY OF MATERIALS.



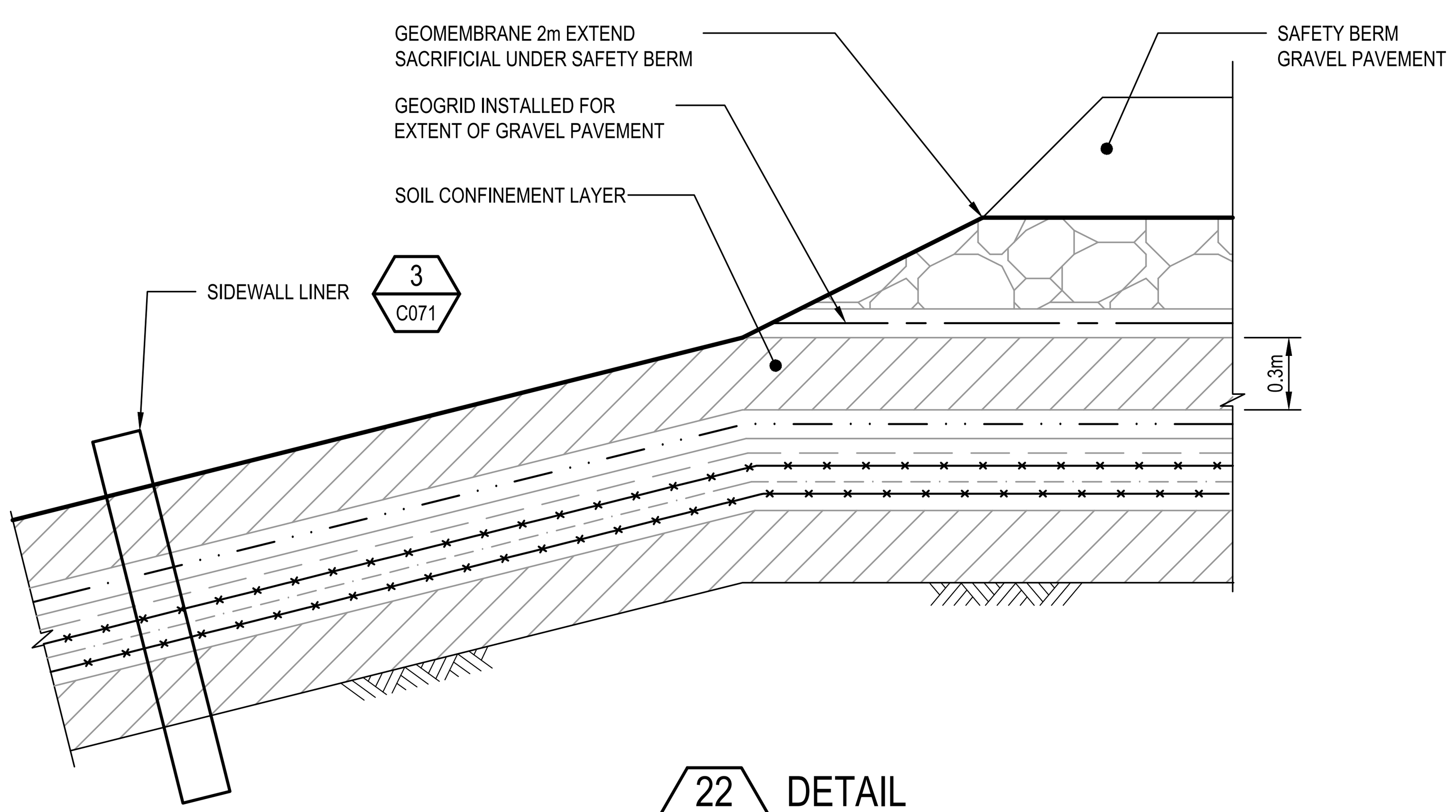
ACCESS RAMP TYPICAL SECTION

F SECTION
C022 SCALE 1 : 50

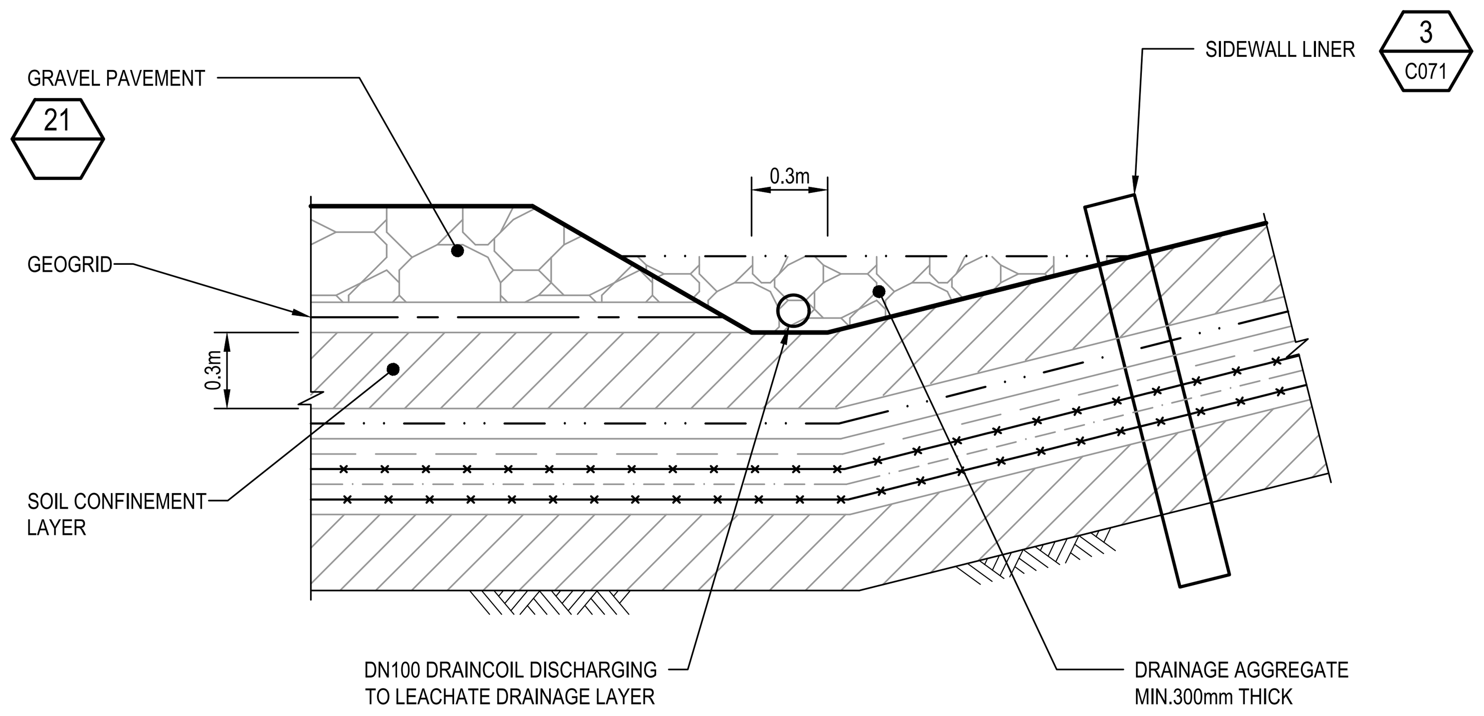


GRAVEL PAVEMENT

21 DETAIL
C131 SCALE 1 : 10



22 DETAIL
- SCALE 1: 25



23 DETAIL
- SCALE 1: 25

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
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0 0.1 0.2 0.3 0.4 0.5m
SCALE 1:10 AT ORIGINAL SIZE

0 0.25 0.5 0.75 1.0 1.25m
SCALE 1:25 AT ORIGINAL SIZE

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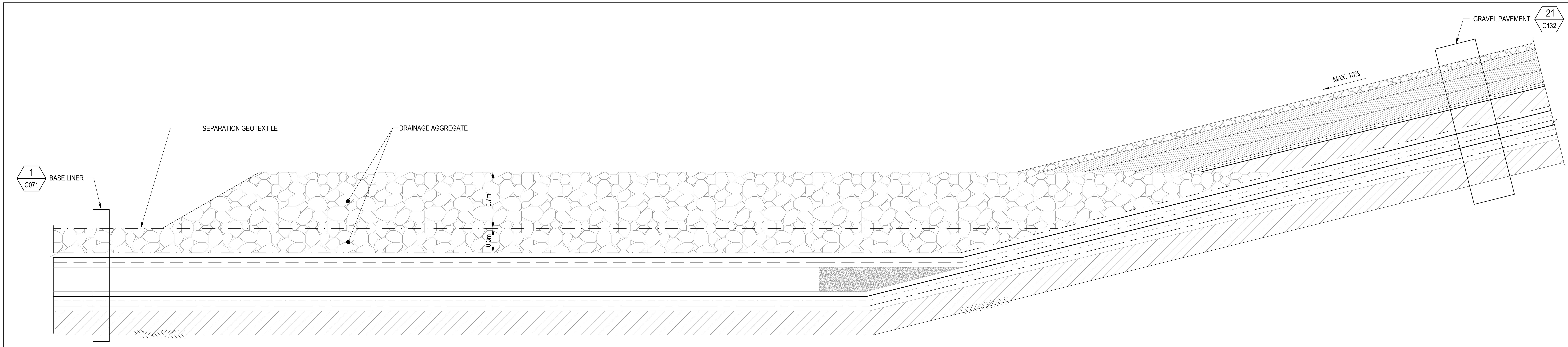
Drafting Check	P. PRASAD	Design Check	A. ROBERTS
Approved (Project Director)	I. GREGSON*		
Date	26.09.19		
Scale	AS SHOWN	This Drawing must not be used for Construction unless signed as Approved	

Client: **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project: **CONTAINMENT CELL DETAILED DESIGN**
Title: **ACCESS ROAD DETAILS SHEET 2 OF 3**

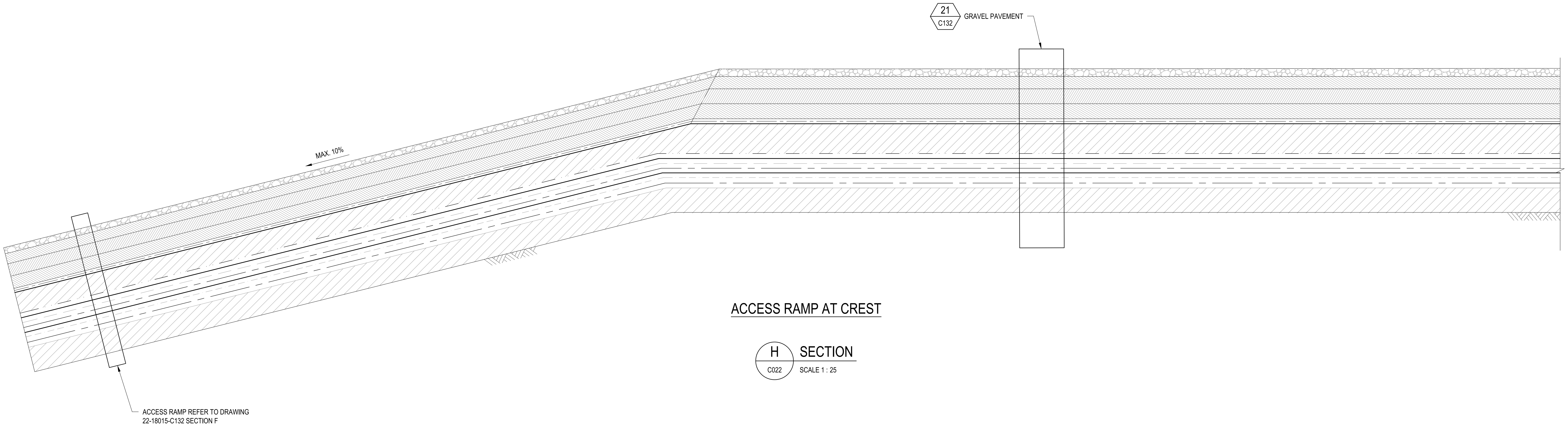
Original Size A1 Drawing No: **22-18015-C132** Rev: 0

Plot Date: 27 September 2019 - 10:03 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C132.dwg



ACCESS RAMP AT TOE

G SECTION
C022 SCALE 1 : 25



ACCESS RAMP AT CREST

H SECTION
C022 SCALE 1 : 25

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
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0 0.25 0.5 0.75 1.0 1.25m
SCALE 1:25 AT ORIGINAL SIZE

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Design Check A. ROBERTS
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Scale 1:25
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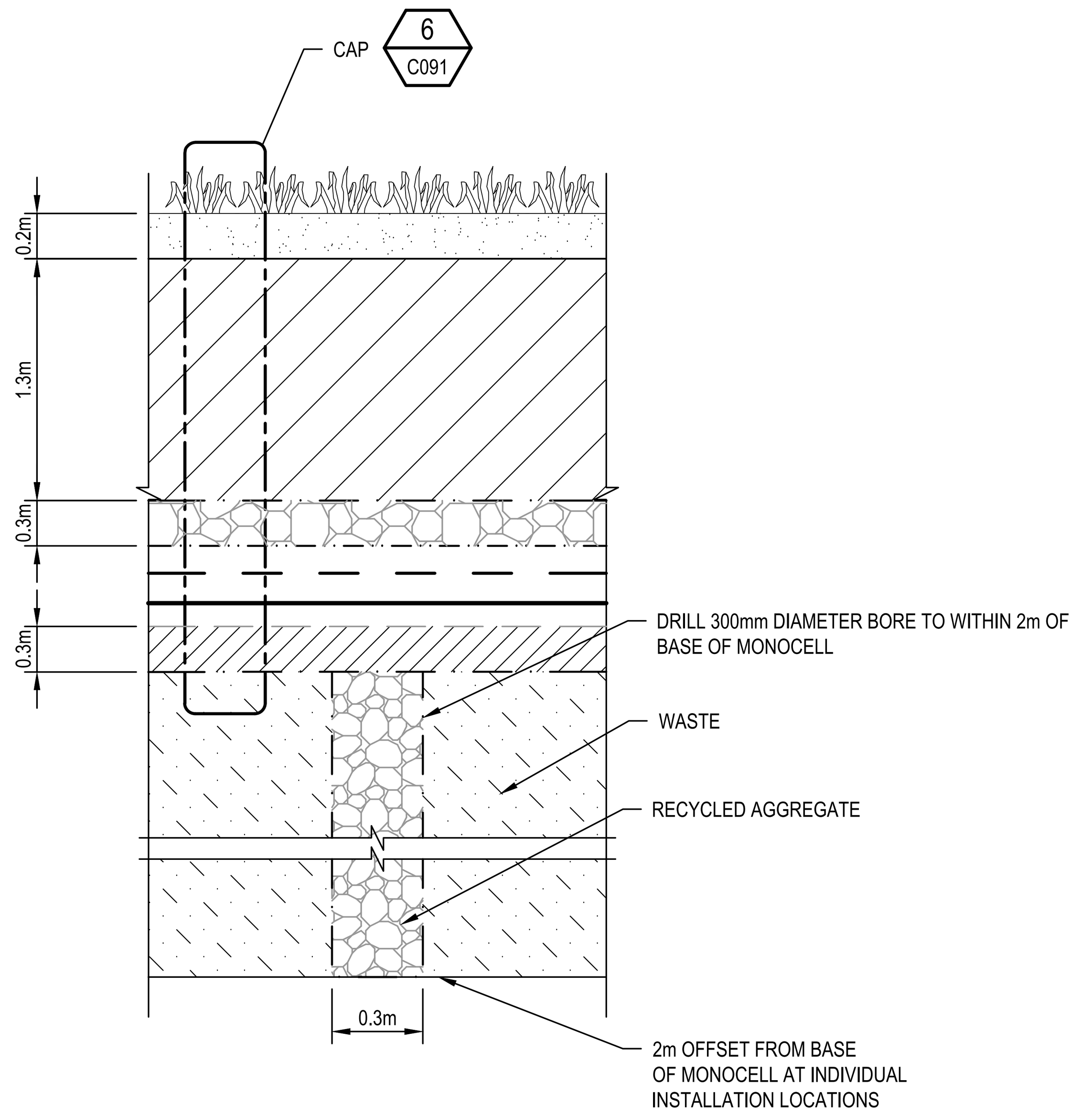
Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **ACCESS ROAD DETAILS**
SHEET 3 OF 3

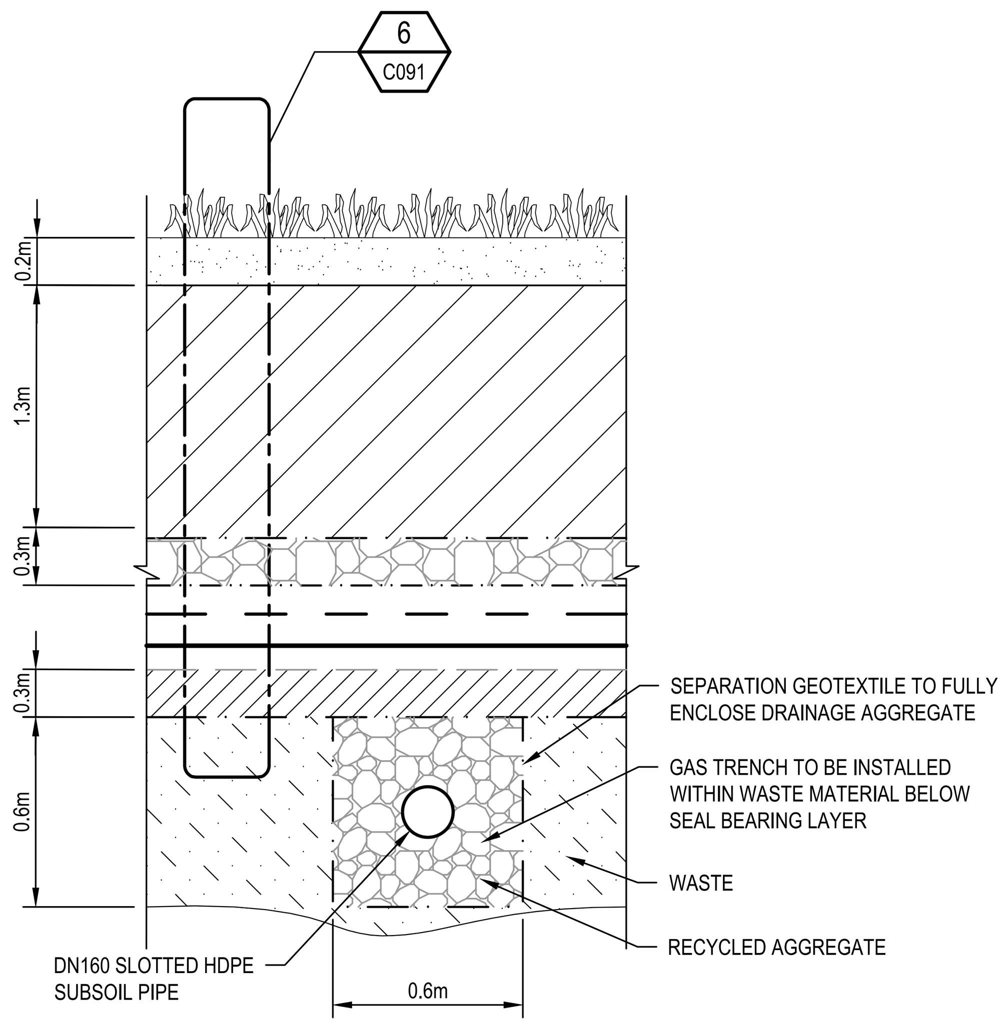
Original Size **A1**
Drawing No: **22-18015-C133**
Rev: **0**

Plot Date: 27 September 2019 - 10:03 AM Plotted by: Renzel Keena Ignacio
Cad File No: G:\22\18015\CADD\Drawings\22-18015-C133.dwg



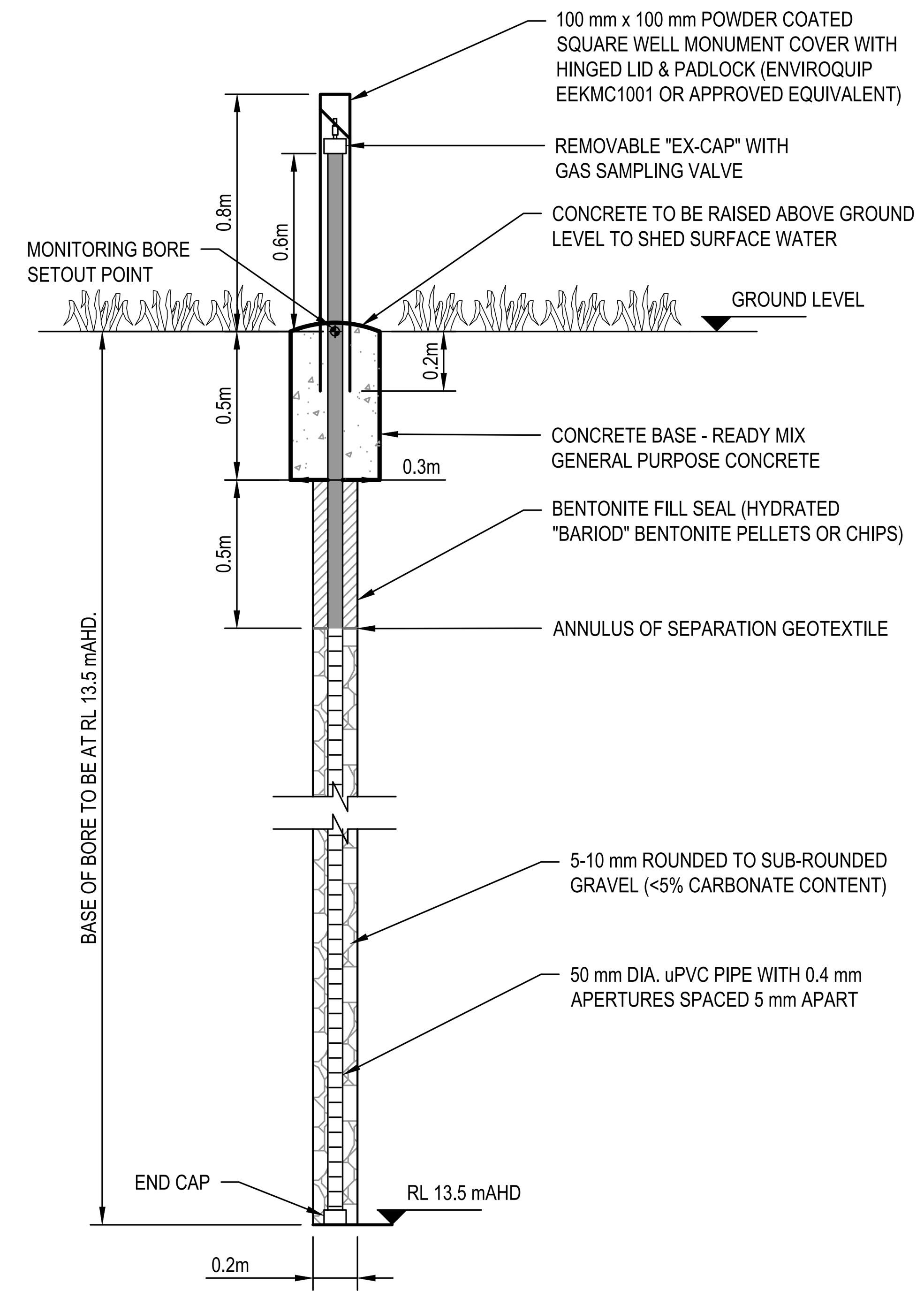
VERTICAL GAS BORE

7 C025 DETAIL
SCALE 1 : 20



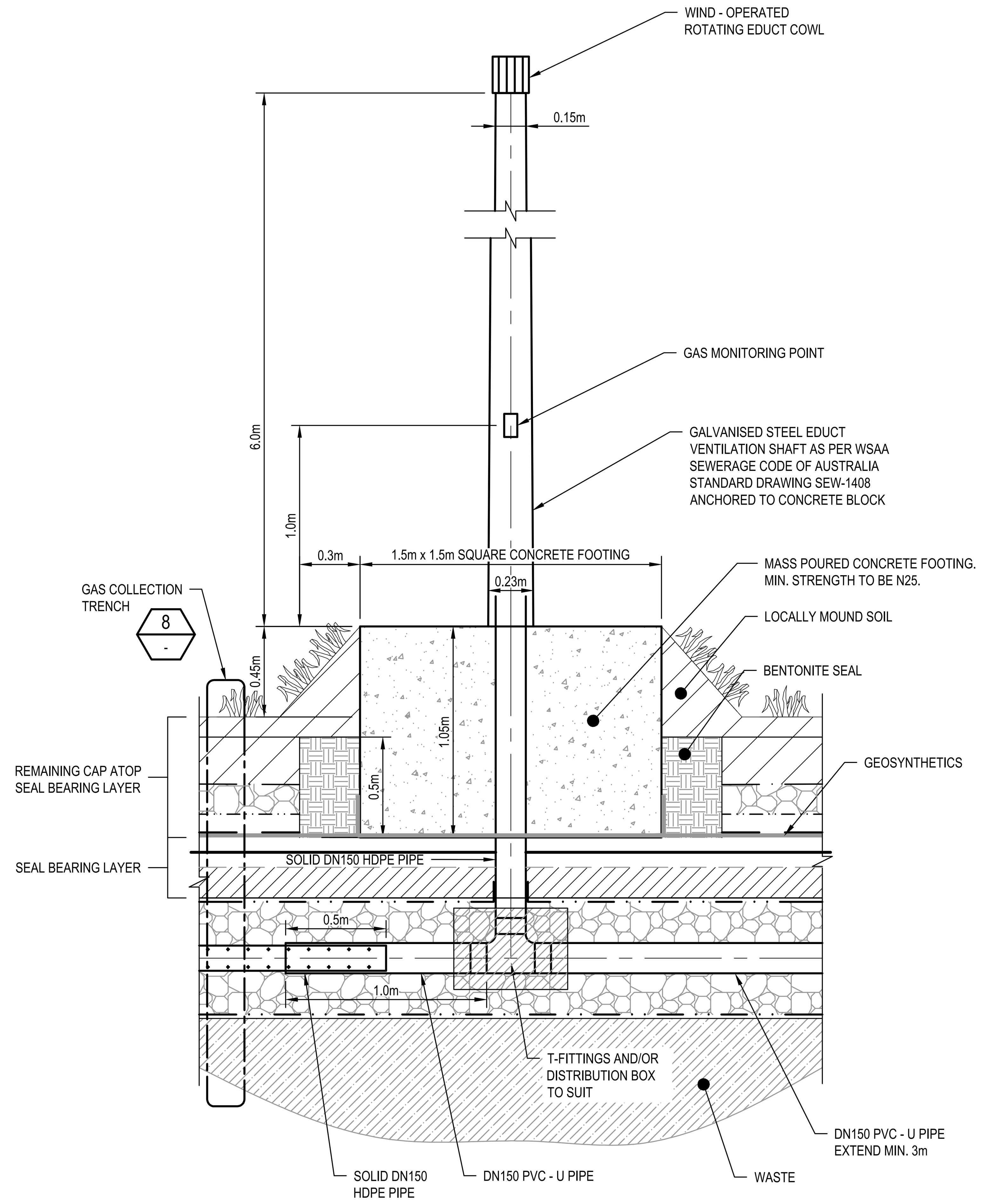
HORIZONTAL GAS TRENCH

8 C025 DETAIL
SCALE 1 : 20



PERIMETER LANDFILL GAS MONITORING BORE

9 C025 DETAIL
SCALE 1 : 20



LANDFILL GAS VENT

10 C025 DETAIL
SCALE 1 : 20

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
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0 0.2 0.4 0.6 0.8 1.0m
SCALE 1:20 AT ORIGINAL SIZE

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Design Check A. ROBERTS
Approved (Project Director) I. GREGSON*
Date 26.09.19
Scale 1:20
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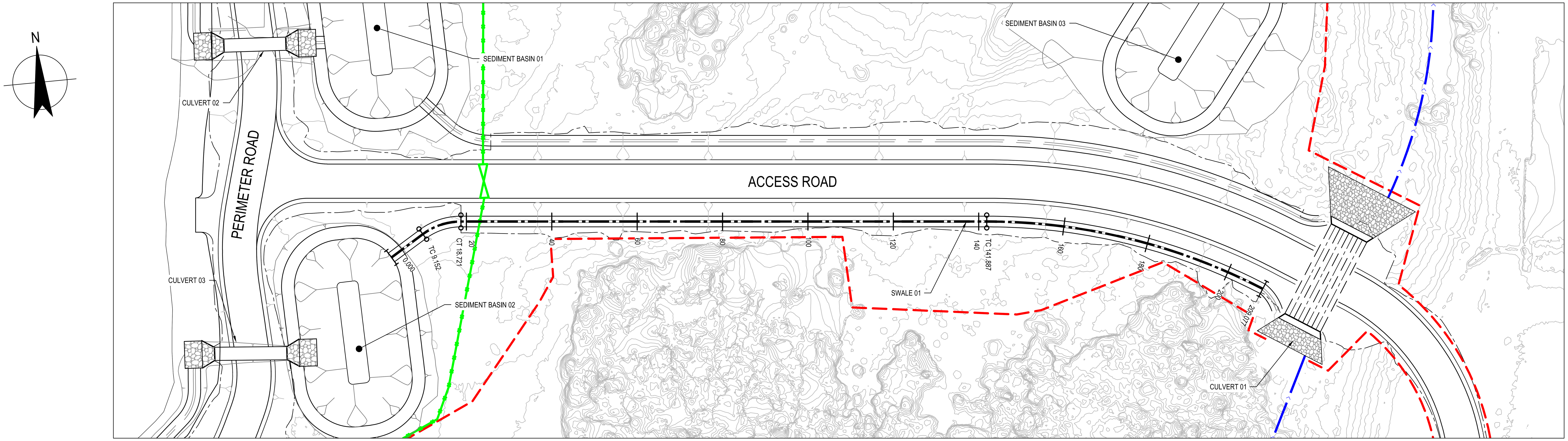
Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **LANDFILL GAS MANAGEMENT SYSTEM DETAILS**

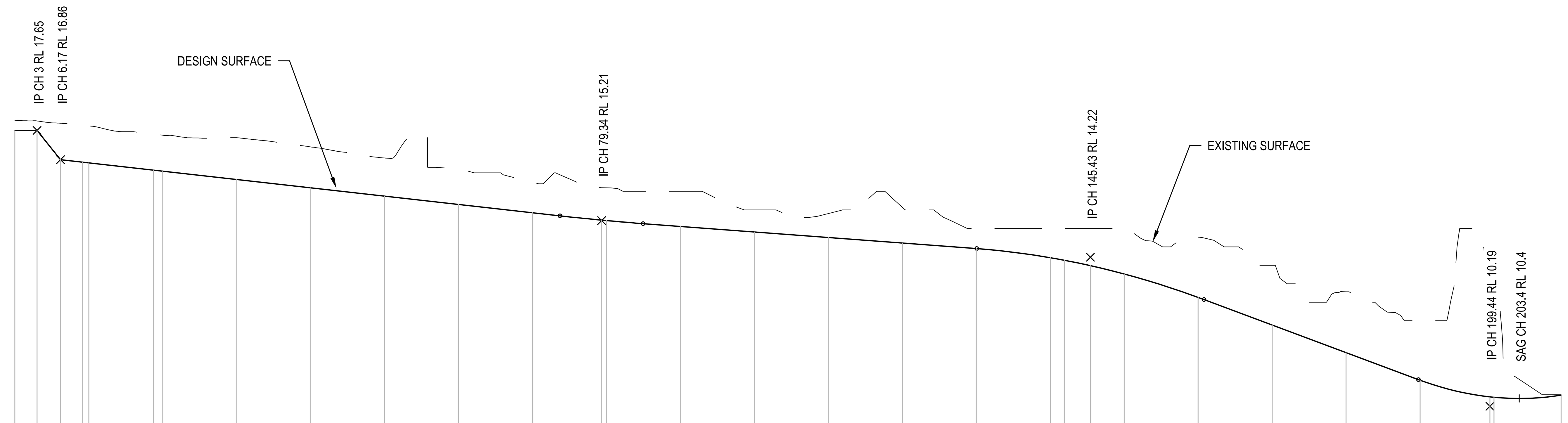
Original Size A1 Drawing No: **22-18015-C141** Rev: 0

Plot Date: 27 September 2019 - 10:03 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C141.dwg



PLAN

SCALE 1:500



DATUM RL. 8.00

VERTICAL ALIGNMENT: L=3m G=0% | L=3.17m G=-25% | L=67.55m G=-2.25% | K=15 L=11.25m | L=45.09m G=-1.5% | K=5.15 L=30.75m | L=28.99m G=-7.47% | K=1.82 L=19.28m | G=3.12%

HORIZONTAL ALIGNMENT: L=9.15m | L=9.57m R=15.00m | L=123.17m | L=67.19m R=140.55m

CHAINAGE	LEVEL DIFFERENCE CUT - / FILL +	DESIGN SURFACE LEVEL	EXISTING SURFACE LEVEL
0.00	-0.27	17.650	17.92
3.00	-0.26	17.650	17.91
6.17	-0.99	16.858	17.84
9.15	-1.01	16.791	17.80
10.00	-1.00	16.772	17.77
18.72	-0.96	16.576	17.54
20.00	-0.97	16.547	17.52
30.00	-1.13	16.322	17.45
40.00	-1.11	16.097	17.20
50.00	-1.03	15.872	16.90
60.00	-0.94	15.647	16.59
70.00	-0.83	15.422	16.25
79.34	-0.88	15.222	16.10
80.00	-0.89	15.210	16.10
90.00	-0.95	15.052	16.00
100.00	-0.60	14.902	15.50
110.00	-0.65	14.752	15.40
120.00	-0.97	14.602	15.57
130.00	-0.55	14.452	15.00
140.00	-0.79	14.206	15.00
141.89	-0.86	14.138	15.00
145.43	-1.01	13.991	15.00
150.00	-1.23	13.766	15.00
160.00	-1.61	13.131	14.75
170.00	-1.62	12.385	14.00
180.00	-1.65	11.638	13.28
190.00	-1.61	10.891	12.50
199.44	-3.47	10.441	13.91
200.00	-3.39	10.430	13.82
209.08	-0.01	10.487	10.50

LONGITUDINAL SECTION - SWALE 01

SCALE HOR. 1:500 VERT. 1:100

SWALE 01 SETOUT POINTS			
CHAINAGE	EASTING	NORTHING	HEIGHT
0.000	357191.437	6371384.753	17.650
9.152	357199.395	6371389.274	16.791
13.937	357203.702	6371391.721	16.683
18.721	357208.620	6371391.121	16.576
141.887	357330.880	6371376.206	14.138
175.482	357364.877	6371372.058	11.975
209.077	357393.155	6371352.735	10.487

NOTE:

1. REFER DRAWING 22-18015-C111 FOR SWALE DETAILS.
2. REFER DRAWING 22-18015-C023 FOR PLAN LOCATION.

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
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VERTICAL 1:100 AT ORIGINAL SIZE 0 1 2 3 4 5m
HORIZONTAL 1:500 AT ORIGINAL SIZE 0 5 10 15 20 25m

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Drafting Check P. PRASAD | Design Check A. ROBERTS
Approved (Project Director) I. GREGSON*
Date 26.09.19
Scale AS SHOWN
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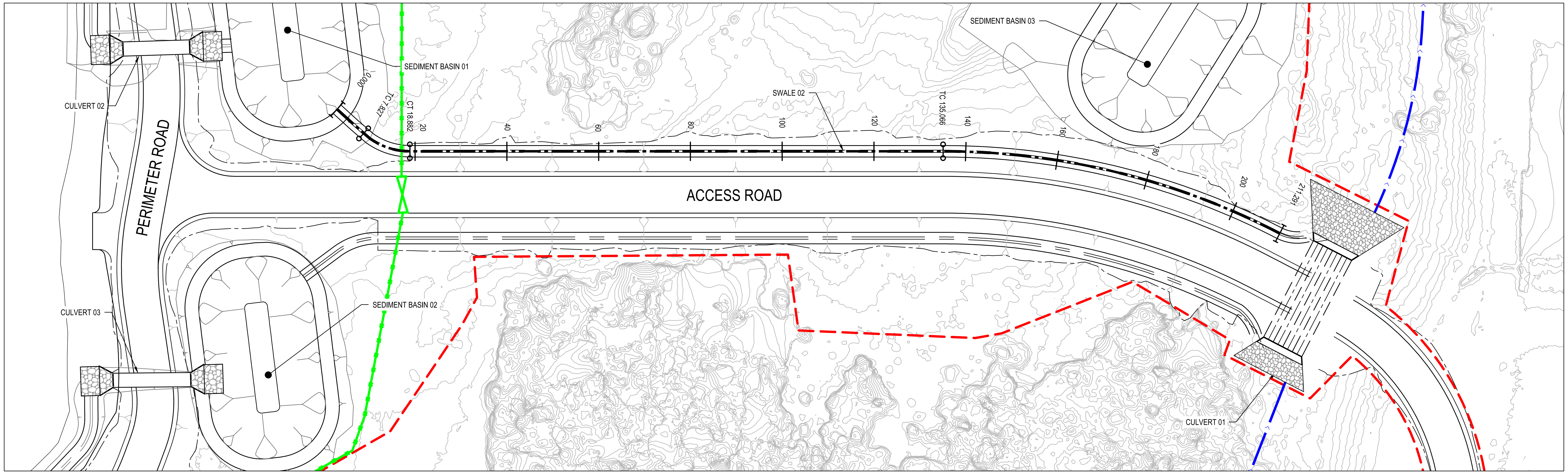
Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **SWALE LONGITUDINAL SECTION SHEET 1 OF 8**

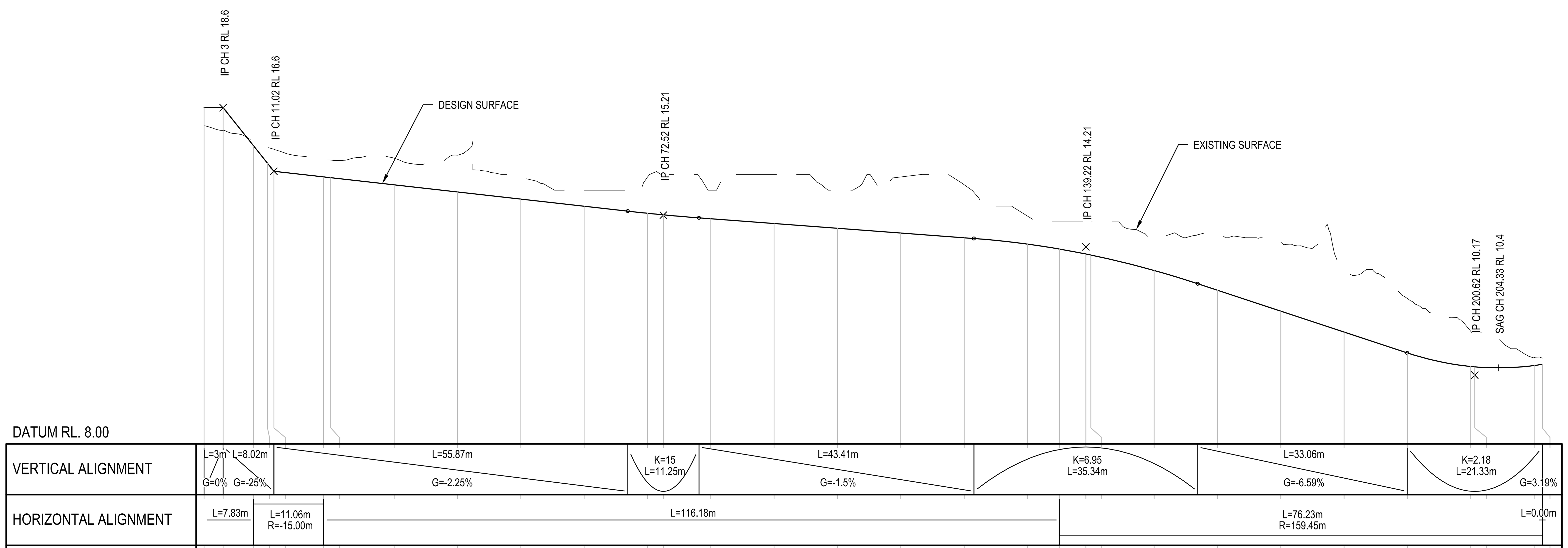
Original Size A1 Drawing No: **22-18015-C151** Rev: 0

Plot Date: 27 September 2019 - 10:03 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C151.dwg



PLAN

SCALE 1:500



CHAINAGE	LEVEL DIFFERENCE CUT - / FILL +	DESIGN SURFACE LEVEL	EXISTING SURFACE LEVEL
0.00	0.57	18.600	18.03
3.00	0.72	18.600	17.88
7.83	-0.12	17.393	17.52
10.00	-0.50	16.850	17.35
11.02	-0.70	16.596	17.29
18.88	-0.54	16.419	16.96
20.00	-0.55	16.393	16.95
30.00	-0.84	16.168	17.01
40.00	-1.16	15.943	17.10
50.00	-0.68	15.718	16.40
60.00	-0.51	15.493	16.00
70.00	-1.14	15.272	16.41
72.52	-1.28	15.222	16.50
80.00	-0.90	15.100	16.00
90.00	-1.55	14.950	16.50
100.00	-1.20	14.800	16.00
110.00	-1.77	14.650	16.42
120.00	-1.67	14.500	16.17
130.00	-0.89	14.298	15.18
135.07	-0.86	14.142	15.00
139.22	-1.01	13.987	15.00
140.00	-1.05	13.955	15.00
150.00	-1.10	13.467	14.56
160.00	-1.79	12.843	14.63
170.00	-2.18	12.185	14.36
180.00	-1.98	11.526	13.51
190.00	-1.71	10.868	12.58
200.00	-1.11	10.440	11.55
200.62	-1.07	10.428	11.50
210.00	-0.25	10.471	10.72
211.29	-0.20	10.508	10.70

LONGITUDINAL SECTION - SWALE 02

SCALE HOR. 1:500 VERT. 1:100

SWALE 02 SETOUT POINTS

CHAINAGE	EASTING	NORTHING	HEIGHT
0.000	357203.188	6371420.045	18.600
7.827	357208.304	6371414.121	17.393
13.355	357212.090	6371409.737	16.543
18.882	357217.840	6371409.036	16.419
135.066	357333.168	6371394.966	14.142
173.178	357371.738	6371390.261	11.975
211.291	357403.819	6371368.340	10.508
211.291	357403.819	6371368.340	10.508

NOTE:

1. REFER DRAWING 22-18015-C111 FOR SWALE DETAILS.
2. REFER DRAWING 22-18015-C023 FOR PLAN LOCATION.

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
0	ISSUED FOR CONSTRUCTION	RK	AR	IG	29.09.19

Note: * indicates signatures on original issue of drawing or last revision of drawing

VERTICAL 1:100 AT ORIGINAL SIZE 0 1 2 3 4 5m
HORIZONTAL 1:500 AT ORIGINAL SIZE 0 5 10 15 20 25m

GHD
Suite 10, 6 Reliance Drive Tuggerah Business Park
PO Box 3220 Tuggerah NSW 2259
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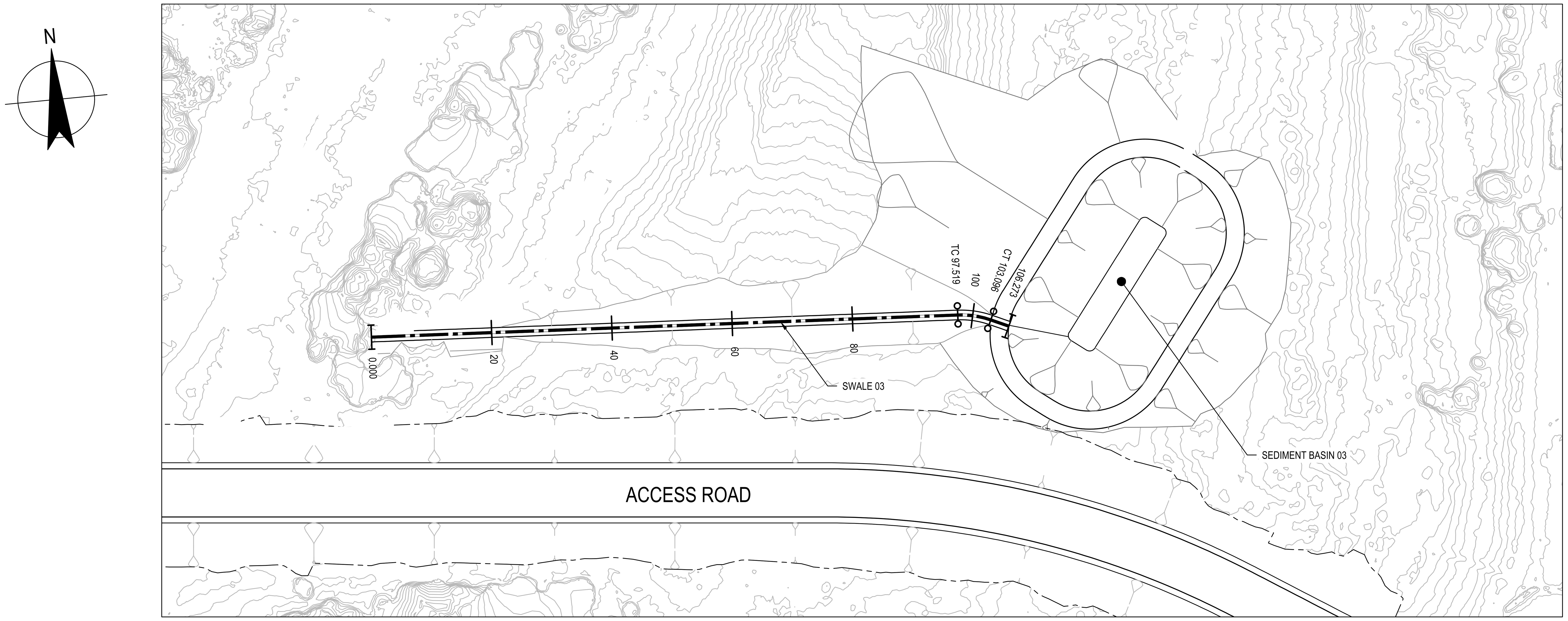
E centralcoastmail@ghd.com W www.ghd.com

DO NOT SCALE

Drawn J. CASIO
Drafting Check P. PRASAD
Approved (Project Director) I. GREGSON*
Date 26.09.19
Scale AS SHOWN
This Drawing must not be used for Construction unless signed as Approved
Designer P. ETCHELLS
Design Check A. ROBERTS

Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **SWALE LONGITUDINAL SECTION SHEET 2 OF 8**
Original Size A1
Drawing No: **22-18015-C152**
Rev: 0

Plot Date: 27 September 2019 - 10:04 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C152.dwg



PLAN

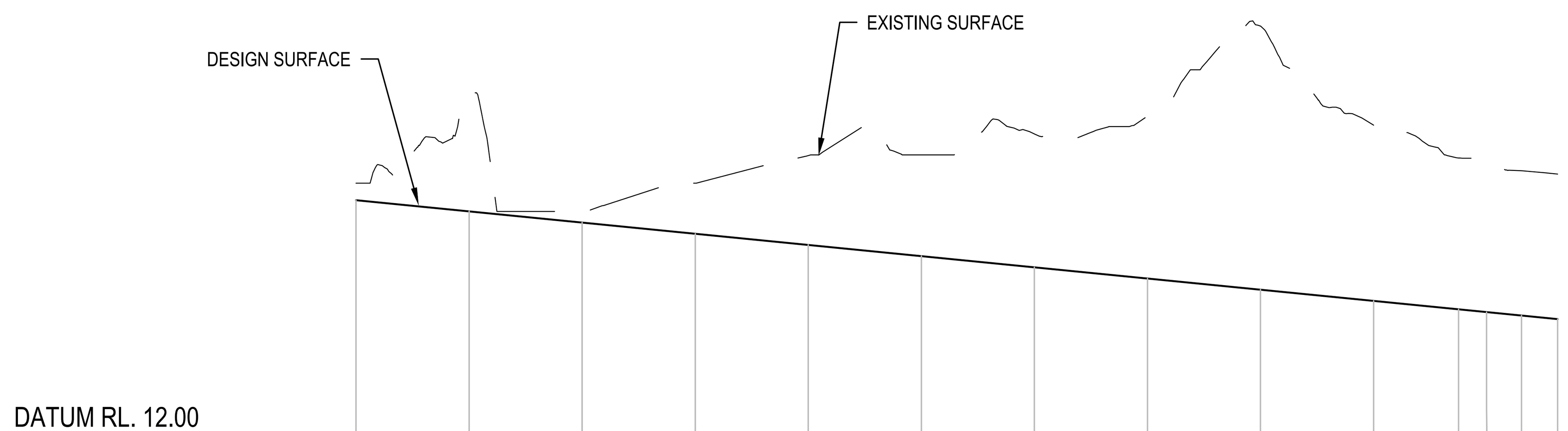
SCALE 1:500

(REFER TO DRG No. C022 FOR PLAN LOCATION)

SWALE 03 SETOUT POINTS			
CHAINAGE	EASTING	NORTHING	HEIGHT
0.000	357260.048	6371420.446	16.200
97.519	357357.227	6371412.303	14.273
100.307	357360.037	6371412.067	14.218
103.096	357362.571	6371410.827	14.163
106.273	357365.425	6371409.429	14.100

NOTE:

1. REFER DRAWING 22-18015-C111 FOR SWALE DETAILS.
2. REFER DRAWING 22-18015-C023 FOR PLAN LOCATION.



VERTICAL ALIGNMENT	L=106.27m G=-1.98%													
HORIZONTAL ALIGNMENT	L=97.52m										L=5.58m R=15.00m		L=3.18m	
LEVEL DIFFERENCE CUT - / FILL +	-0.30	-2.10	-0.20	-0.89	-1.58	-1.79	-2.35	-2.87	-4.65	-3.10	-2.67	-2.67	-2.56	-2.56
DESIGN SURFACE LEVEL	16.200	16.002	15.805	15.607	15.410	15.212	15.014	14.817	14.619	14.422	14.273	14.224	14.163	14.100
EXISTING SURFACE LEVEL	16.50	18.10	16.00	16.50	16.99	17.00	17.37	17.68	19.27	17.53	16.95	16.89	16.72	16.66
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	97.52	100.00	103.10	106.27

LONGITUDINAL SECTION - SWALE 03

SCALE HOR. 1:500 VERT. 1:100

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
0	ISSUED FOR CONSTRUCTION	RK	AR	IG	29.09.19

Note: * indicates signatures on original issue of drawing or last revision of drawing

VERTICAL 1:100 AT ORIGINAL SIZE 0 1 2 3 4 5m

HORIZONTAL 1:500 AT ORIGINAL SIZE 0 5 10 15 20 25m

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E centralcoastmail@ghd.com W www.ghd.com

DO NOT SCALE

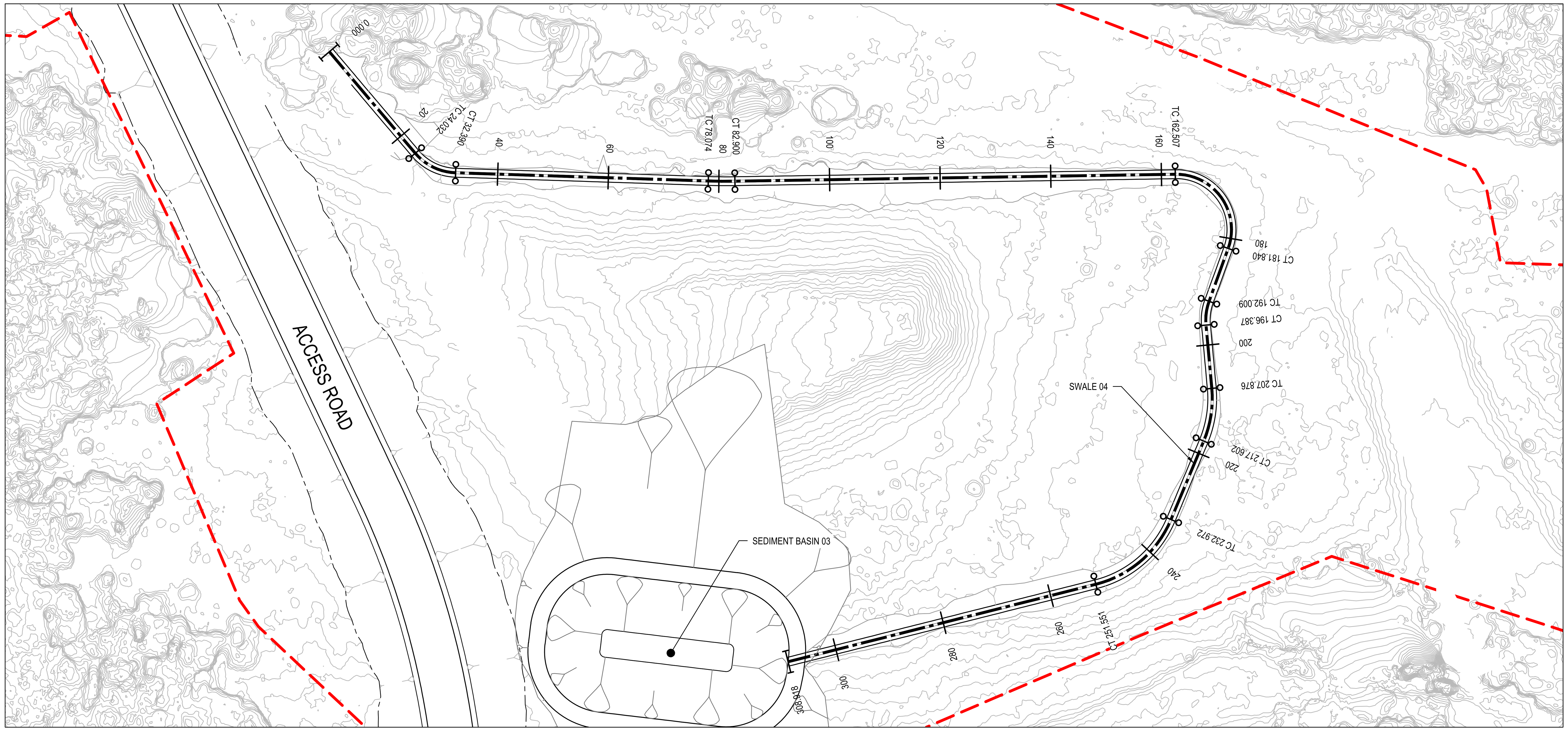
Drawn J. CASIO | Designer P. ETCHELLS
Drafting Check P. PRASAD | Design Check A. ROBERTS
Approved (Project Director) I. GREGSON*
Date 26.09.19
Scale AS SHOWN

This Drawing must not be used for Construction unless signed as Approved

Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **SWALE LONGITUDINAL SECTION SHEET 3 OF 8**

Original Size A1 Drawing No: **22-18015-C153** Rev: 0

Plot Date: 27 September 2019 - 10:04 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C153.dwg



PLAN

SCALE 1:500

SWALE 04 SETOUT POINTS			
CHAINAGE	EASTING	NORTHING	HEIGHT
0.000	357260.048	6371420.446	16.200
24.032	357283.849	6371423.771	16.037
28.211	357288.247	6371424.385	16.009
32.390	357290.740	6371428.059	15.981
78.074	357316.395	6371465.860	15.671
80.487	357317.750	6371467.857	15.655
82.900	357319.007	6371469.917	15.639
162.507	357360.482	6371537.866	15.100
172.173	357368.030	6371550.232	15.034
181.840	357376.916	6371538.789	14.969
192.009	357383.153	6371530.758	14.900
194.198	357384.517	6371529.001	14.885
196.387	357386.498	6371527.988	14.870
207.876	357396.727	6371522.757	14.792
212.739	357401.144	6371520.498	14.760
217.602	357403.993	6371516.437	14.727
232.972	357412.821	6371503.854	14.623
242.262	357418.576	6371495.651	14.560
251.551	357415.451	6371486.130	14.497
308.918	357397.560	6371431.625	14.098

NOTE:

1. REFER DRAWING 22-18015-C111 FOR SWALE DETAILS.
2. REFER DRAWING 22-18015-C023 FOR PLAN LOCATION.

DATUM RL. 12.00

VERTICAL ALIGNMENT: L=305.71m, G=-0.68%; L=3.21m, G=-1%

HORIZONTAL ALIGNMENT: L=24.03m | L=8.36m R=-10.00m | L=45.68m | L=4.83m R=-100.00m | L=79.61m | L=19.33m R=10.00m | L=10.17m | L=4.38m R=-10.00m | L=11.49m | L=9.73m R=20.00m | L=15.37m | L=18.58m R=20.00m | L=57.37m

CHAINAGE	LEVEL DIFFERENCE CUT - / FILL +	DESIGN SURFACE LEVEL	EXISTING SURFACE LEVEL
0.00	-0.30	16.200	16.50
10.00	-2.87	16.132	19.00
20.00	0.06	16.065	16.00
24.03	-0.27	16.037	16.30
30.00	-1.50	15.997	17.50
32.39	-0.86	15.981	16.84
40.00	-0.55	15.929	16.48
50.00	-0.95	15.861	16.81
60.00	-0.55	15.794	16.34
70.00	-0.65	15.726	16.37
78.07	-0.60	15.671	16.28
80.00	-0.72	15.658	16.38
82.90	-0.86	15.639	16.50
90.00	-0.94	15.591	16.53
100.00	-1.23	15.523	16.75
110.00	-1.08	15.455	16.53
120.00	-1.15	15.387	16.53
130.00	-1.06	15.320	16.38
140.00	-1.16	15.252	16.42
150.00	-0.76	15.184	15.94
160.00	-0.49	15.117	15.61
162.51	-0.54	15.100	15.64
170.00	-0.57	15.049	15.62
180.00	-0.52	14.981	15.50
181.84	-0.53	14.969	15.50
190.00	-0.43	14.913	15.34
192.01	-0.43	14.900	15.33
196.39	-0.41	14.870	15.28
200.00	-0.47	14.846	15.31
207.88	-0.65	14.792	15.44
210.00	-0.72	14.778	15.50
217.60	-0.77	14.727	15.50
220.00	-0.62	14.710	15.33
230.00	-0.62	14.643	15.27
232.97	-0.63	14.623	15.25
240.00	-0.80	14.575	15.38
250.00	-0.96	14.507	15.47
251.55	-1.15	14.497	15.65
260.00	-1.33	14.439	15.77
270.00	-1.29	14.372	15.66
280.00	-0.54	14.304	14.84
290.00	-1.26	14.236	15.50
300.00	-0.83	14.169	15.00
305.71	-0.74	14.130	14.87
308.92	-0.66	14.098	14.76

LONGITUDINAL SECTION - SWALE 04

SCALE HOR. 1:500 VERT. 1:100

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
0	ISSUED FOR CONSTRUCTION	RK	AR	IG	29.09.19

Note: * indicates signatures on original issue of drawing or last revision of drawing

VERTICAL 1:100 AT ORIGINAL SIZE 0 1 2 3 4 5m
HORIZONTAL 1:500 AT ORIGINAL SIZE 0 5 10 15 20 25m

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PO Box 3220 Tuggerah NSW 2259
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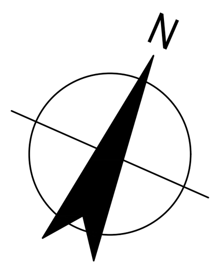
E centralcoastmail@ghd.com W www.ghd.com

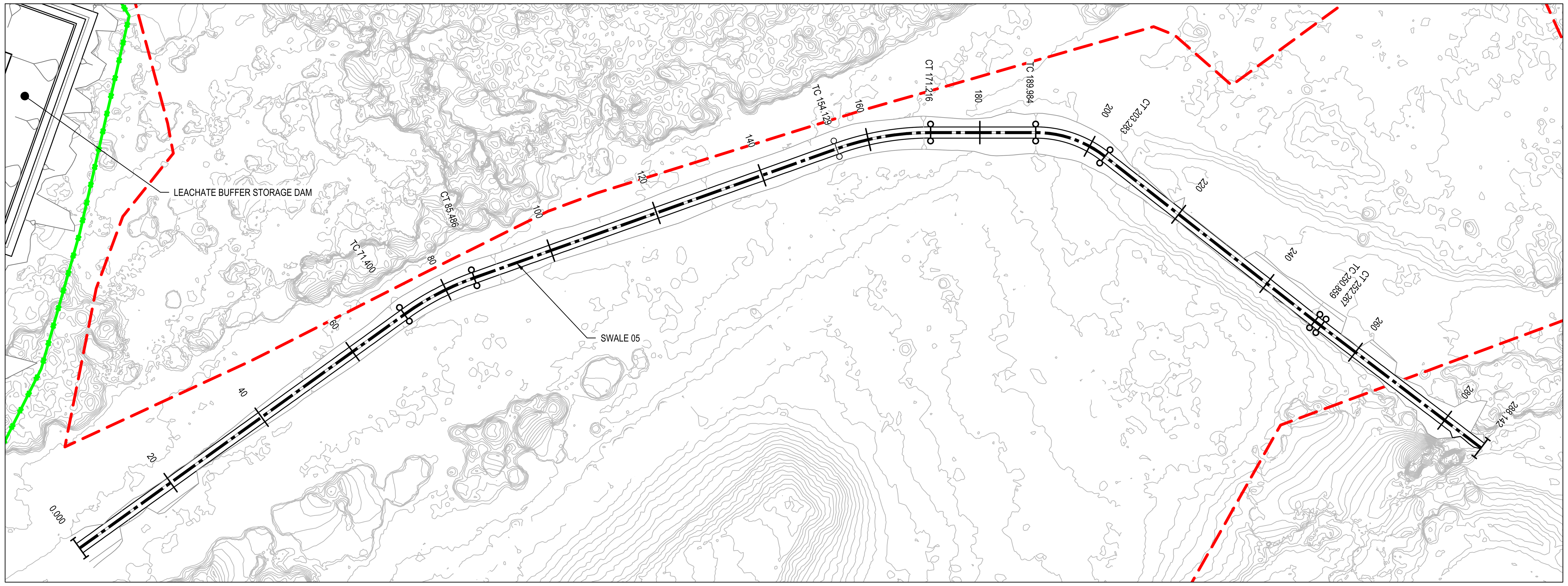
DO NOT SCALE

Drawn J. CASIO | Designer P. ETCHELLS
Drafting Check P. PRASAD | Design Check A. ROBERTS
Approved (Project Director) I. GREGSON*
Date 26.09.19
Scale AS SHOWN
This Drawing must not be used for Construction unless signed as Approved

Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **SWALE LONGITUDINAL SECTION SHEET 4 OF 8**
Original Size **A1** Drawing No: **22-18015-C154** Rev: **0**

Plot Date: 27 September 2019 - 10:04 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C154.dwg





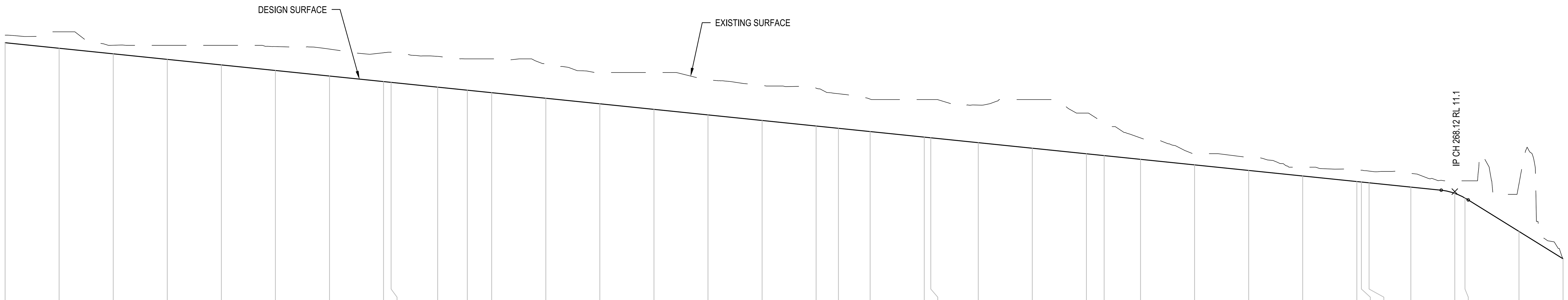
PLAN

SCALE 1:500

SWALE 05 SETOUT POINTS			
CHAINAGE	EASTING	NORTHING	HEIGHT
0.000	357239.500	6371432.256	16.600
71.400	357280.107	6371490.984	15.135
78.443	357284.140	6371496.815	14.991
85.486	357289.634	6371501.296	14.846
154.129	357342.832	6371544.677	13.438
162.672	357349.518	6371550.130	13.263
171.216	357357.644	6371553.026	13.088
189.984	357375.324	6371559.328	12.703
196.634	357381.828	6371561.646	12.566
203.283	357388.378	6371559.457	12.430
250.859	357433.501	6371544.376	11.454
251.563	357434.168	6371544.153	11.440
252.267	357434.839	6371543.939	11.425
288.150	357469.028	6371533.045	8.618

NOTE:

1. REFER DRAWING 22-18015-C111 FOR SWALE DETAILS.
2. REFER DRAWING 22-18015-C023 FOR PLAN LOCATION



DATUM RL. 7.00

VERTICAL ALIGNMENT: L=265.62m, G=-2.05%; K=0.48, L=5m; L=17.53m, G=-12.39%

HORIZONTAL ALIGNMENT: L=71.40m; L=14.09m R=50.00m; L=68.64m; L=17.09m R=50.00m; L=18.77m; L=13.30m R=20.00m; L=47.58m; L=1.41m R=-100.00m; L=35.88m

CHAINAGE	EXISTING SURFACE LEVEL	DESIGN SURFACE LEVEL	LEVEL DIFFERENCE CUT - / FILL +
0.00	16.88	16.600	-0.28
10.00	17.00	16.395	-0.61
20.00	16.50	16.190	-0.31
30.00	16.50	15.985	-0.52
40.00	16.50	15.779	-0.72
50.00	16.46	15.574	-0.88
60.00	16.36	15.369	-1.00
70.00	16.23	15.164	-1.06
71.40	16.25	15.135	-1.11
80.00	16.09	14.959	-1.14
85.49	16.00	14.846	-1.15
90.00	16.00	14.754	-1.25
100.00	15.82	14.549	-1.27
110.00	15.50	14.344	-1.16
120.00	15.50	14.138	-1.36
130.00	15.22	13.933	-1.29
140.00	15.02	13.728	-1.29
150.00	14.92	13.523	-1.40
154.13	14.71	13.438	-1.27
160.00	14.52	13.318	-1.20
170.00	14.50	13.113	-1.39
171.22	14.50	13.088	-1.41
180.00	14.29	12.908	-1.39
189.98	14.50	12.703	-1.80
200.00	14.00	12.497	-1.50
203.28	13.64	12.430	-1.21
210.00	13.08	12.292	-0.79
220.00	12.50	12.087	-0.41
230.00	12.36	11.882	-0.48
240.00	12.00	11.677	-0.32
250.00	11.89	11.472	-0.42
250.86	11.89	11.454	-0.44
252.27	11.86	11.425	-0.43
260.00	11.77	11.267	-0.50
268.12	11.52	11.035	-0.48
270.00	11.50	10.863	-0.64
280.00	11.39	9.628	-1.76
288.15	8.62	8.618	0.00

LONGITUDINAL SECTION - SWALE 05

SCALE HOR. 1:500 VERT. 1:100

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
0	ISSUED FOR CONSTRUCTION	RK	AR	IG	29.09.19

Note: * indicates signatures on original issue of drawing or last revision of drawing

VERTICAL 1:100 AT ORIGINAL SIZE: 0 1 2 3 4 5m

HORIZONTAL 1:500 AT ORIGINAL SIZE: 0 5 10 15 20 25m

GHD
Suite 10, 6 Reliance Drive Tuggerah Business Park
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DO NOT SCALE

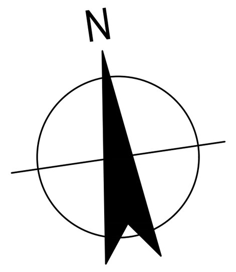
Drawn J. CASIO | Designer P. ETCHELLS
Drafting Check P. PRASAD | Design Check A. ROBERTS
Approved (Project Director) I. GREGSON*
Date 26.09.19
Scale AS SHOWN

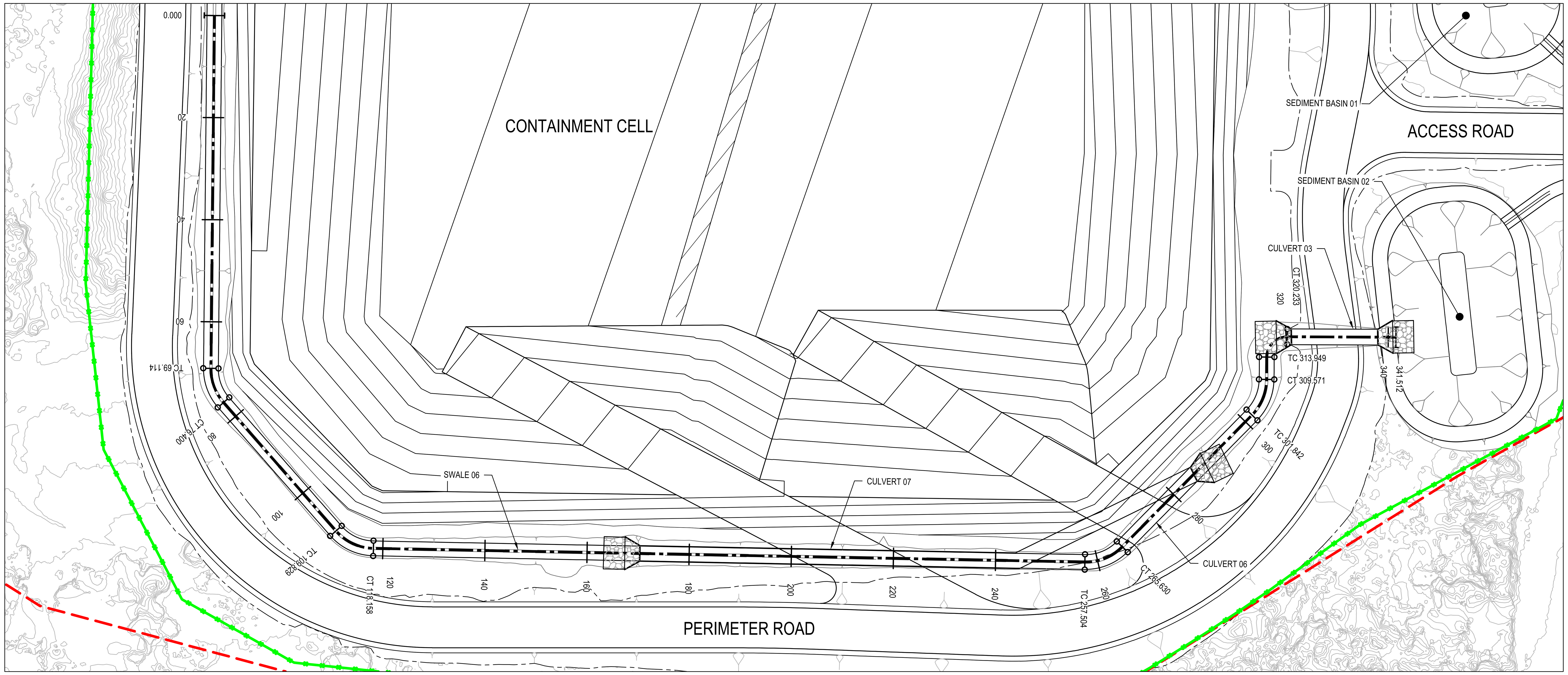
This Drawing must not be used for Construction unless signed as Approved

Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **SWALE LONGITUDINAL SECTION SHEET 5 OF 8**

Original Size A1 | Drawing No: **22-18015-C155** | Rev: **0**

Plot Date: 27 September 2019 - 10:04 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C155.dwg





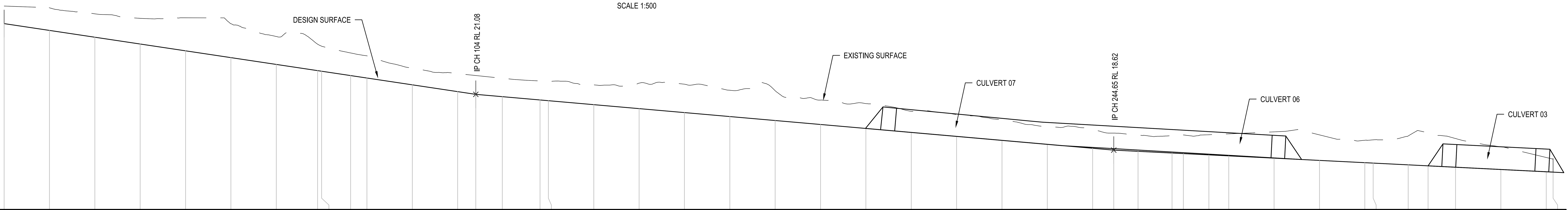
SWALE 06 SETOUT POINTS			
CHAINAGE	EASTING	NORTHING	HEIGHT
0.000	356944.680	6371452.538	24.200
69.114	356936.588	6371383.899	22.127
72.757	356936.142	6371380.112	22.017
76.400	356938.330	6371376.989	21.908
109.829	356957.514	6371349.613	20.978
113.994	356960.052	6371345.990	20.905
118.158	356964.440	6371345.432	20.832
257.504	357102.670	6371327.834	18.490
261.567	357106.938	6371327.291	18.449
265.630	357110.267	6371330.016	18.409
301.842	357138.288	6371352.954	18.047
305.706	357141.437	6371355.532	18.008
309.571	357141.891	6371359.576	17.969
313.949	357142.380	6371363.927	17.926
317.091	357142.826	6371367.902	17.894
320.233	357146.801	6371367.455	17.863
341.512	357167.947	6371365.080	17.650

NOTE:

1. REFER DRAWING 22-18015-C111 FOR SWALE DETAILS.
3. REFER DRAWING 22-18015-C023 FOR PLAN LOCATION.

PLAN

SCALE 1:500



DATUM RL. 16.00

VERTICAL ALIGNMENT: L=104m, G=-3%; L=140.65m, G=-1.75%; L=96.86m, G=-1%

HORIZONTAL ALIGNMENT: L=69.11m; L=7.29m R=-10.00m; L=33.43m; L=8.33m R=-10.00m; L=139.35m; L=8.13m R=-10.00m; L=36.21m; L=4.38m; L=7.73m R=-10.00m; L=6.28m R=4.00m; L=21.28m

CHAINAGE	LEVEL DIFFERENCE CUT - / FILL +	DESIGN SURFACE LEVEL	EXISTING SURFACE LEVEL
0.00	-0.77	24.200	24.97
10.00	-1.00	23.900	24.90
20.00	-1.03	23.600	24.63
30.00	-1.13	23.300	24.43
40.00	-1.46	23.000	24.46
50.00	-1.49	22.700	24.19
60.00	-1.23	22.400	23.63
69.11	-1.17	22.127	23.29
70.00	-1.10	22.100	23.20
76.40	-1.00	21.908	22.91
80.00	-0.98	21.800	22.78
90.00	-0.74	21.500	22.24
100.00	-0.80	21.200	22.00
104.00	-0.83	21.080	21.91
109.83	-0.81	20.978	21.79
118.16	-0.84	20.832	21.67
120.00	-0.86	20.800	21.66
130.00	-0.87	20.625	21.50
140.00	-1.12	20.450	21.57
150.00	-1.25	20.275	21.53
160.00	-1.16	20.100	21.26
170.00	-1.31	19.925	21.24
180.00	-1.08	19.750	20.83
190.00	-1.10	19.575	20.67
200.00	-0.93	19.400	20.33
210.00	-0.97	19.225	20.19
220.00	-0.91	19.050	19.96
230.00	-0.78	18.875	19.65
240.00	-0.85	18.700	19.55
244.65	-0.75	18.619	19.37
250.00	-0.72	18.565	19.29
257.50	-0.77	18.490	19.26
260.00	-0.83	18.465	19.29
265.63	-0.89	18.409	19.30
270.00	-0.97	18.365	19.34
280.00	-1.16	18.265	19.43
290.00	-1.13	18.165	19.29
300.00	-0.99	18.065	19.06
301.84	-1.02	18.047	19.07
309.57	-1.28	17.969	19.25
313.95	-1.46	17.926	19.39
320.00	-1.27	17.865	19.13
330.00	-1.00	17.765	18.77
340.00	-0.63	17.665	18.29
341.51	-0.57	17.650	18.22

LONGITUDINAL SECTION - SWALE 06

SCALE HOR. 1:500 VERT. 1:100

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HORIZONTAL 1:500 AT ORIGINAL SIZE 0 5 10 15 20 25m

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E centralcoastmail@ghd.com W www.ghd.com

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Drafting Check P. PRASAD | Design Check A. ROBERTS
Approved (Project Director) I. GREGSON*
Date 26.09.19
Scale AS SHOWN
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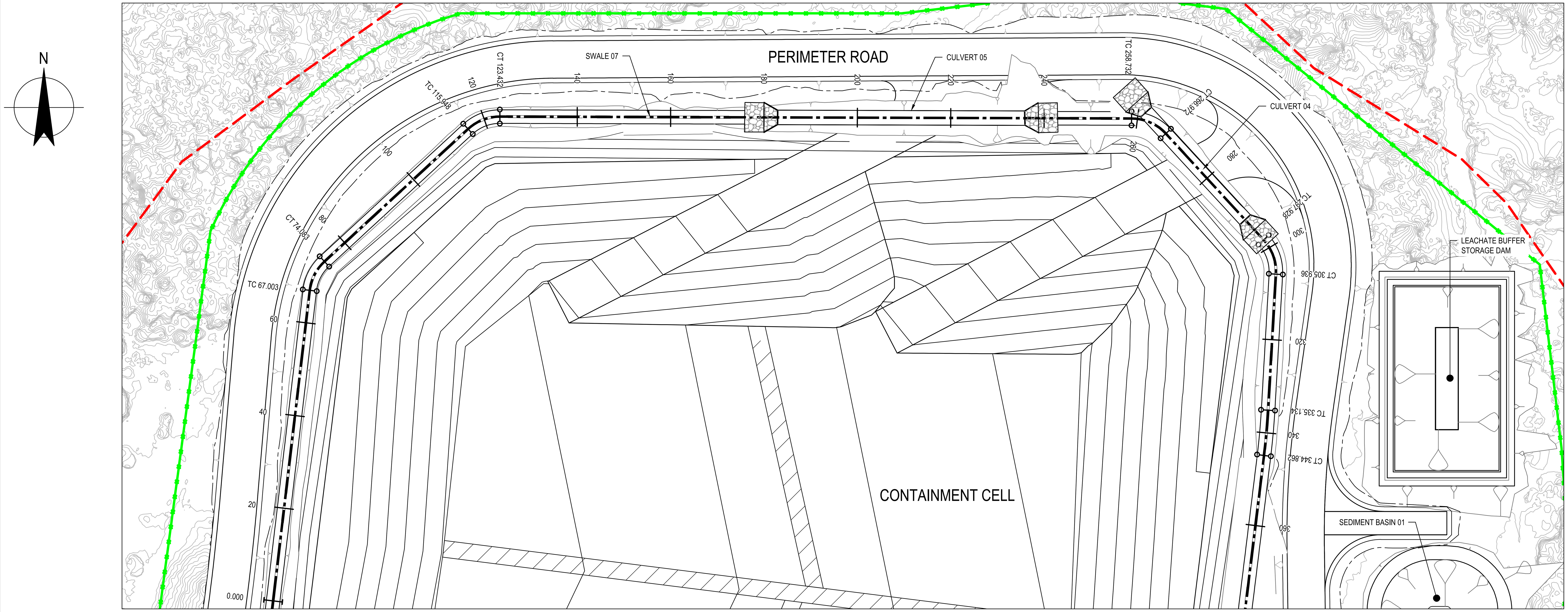
Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **SWALE LONGITUDINAL SECTION SHEET 6 OF 8**

Original Size A1 **Drawing No: 22-18015-C156** Rev: 0

Plot Date: 27 September 2019 - 10:05 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C156.dwg



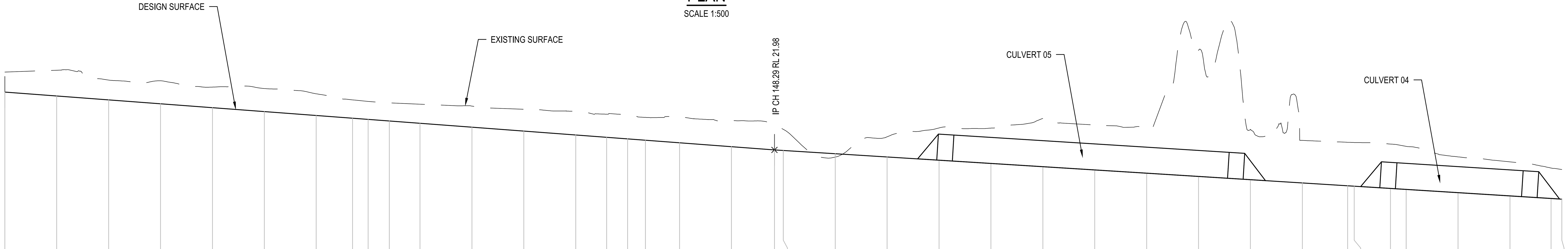
PLAN

SCALE 1:500

SWALE 07 SETOUT POINTS			
CHAINAGE	EASTING	NORTHING	HEIGHT
0.000	356944.680	6371452.538	24.200
67.003	356952.525	6371519.080	23.195
70.543	356952.958	6371522.751	23.142
74.083	356955.673	6371525.257	23.089
115.948	356986.436	6371553.653	22.461
119.690	356989.322	6371556.317	22.405
123.432	356993.249	6371556.305	22.349
258.732	357128.548	6371555.898	20.595
262.852	357132.918	6371555.885	20.544
266.972	357135.877	6371552.669	20.492
297.928	357156.835	6371529.887	20.105
301.932	357159.700	6371526.772	20.055
305.936	357159.459	6371522.546	20.005
335.134	357157.794	6371493.395	19.640
339.998	357157.516	6371488.537	19.579
344.862	357156.924	6371483.708	19.519
385.428	357151.991	6371443.443	19.011
388.633	357151.489	6371439.345	18.971
391.838	357155.601	6371438.973	18.931
418.343	357181.998	6371436.586	18.600

NOTE:

1. REFER DRAWING 22-18015-C111 FOR SWALE DETAILS.
3. REFER DRAWING 22-18015-C023 FOR PLAN LOCATION.



DATUM RL. 18.00

VERTICAL ALIGNMENT: L=148.29m G=-1.5%; L=270.06m G=-1.25%

HORIZONTAL ALIGNMENT: L=67.00m; L=7.08m R=10.00m; L=41.86m; L=7.48m R=10.00m; L=135.30m; L=8.24m R=10.00m; L=30.96m; L=8.01m R=10.00m

CHAINAGE	EXISTING SURFACE LEVEL	DESIGN SURFACE LEVEL	LEVEL DIFFERENCE CUT - / FILL +
0.00	24.97	24.200	-0.77
10.00	25.04	24.050	-0.99
20.00	24.66	23.900	-0.76
30.00	24.64	23.750	-0.89
40.00	24.39	23.600	-0.79
50.00	24.34	23.450	-0.89
60.00	24.13	23.300	-0.83
67.00	23.90	23.195	-0.71
70.00	23.84	23.150	-0.69
74.08	23.79	23.089	-0.70
80.00	23.74	23.000	-0.74
90.00	23.66	22.850	-0.81
100.00	23.55	22.700	-0.85
110.00	23.46	22.550	-0.91
115.95	23.35	22.461	-0.89
120.00	23.30	22.400	-0.90
123.43	23.23	22.349	-0.88
130.00	23.26	22.250	-1.01
140.00	23.11	22.100	-1.01
148.29	22.94	21.976	-0.96
150.00	22.77	21.954	-0.81
160.00	21.70	21.829	0.13
170.00	22.48	21.704	-0.77
180.00	22.82	21.579	-1.24
190.00	22.81	21.454	-1.36
200.00	23.18	21.329	-1.86
210.00	22.93	21.204	-1.73
220.00	22.79	21.079	-1.71
230.00	25.81	20.954	-4.86
240.00	22.76	20.829	-1.93
250.00	22.34	20.704	-1.64
258.73	22.27	20.595	-1.67
260.00	22.26	20.579	-1.68
266.97	22.20	20.492	-1.71
270.00	22.11	20.454	-1.66
280.00	21.71	20.329	-1.38
290.00	21.52	20.204	-1.31
297.93	21.28	20.105	-1.17
300.00	21.22	20.079	-1.14

LONGITUDINAL SECTION - SWALE 07

SCALE HOR. 1:500 VERT. 1:100

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No	Revision	Drawn	Job Manager	Project Director	Date
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HORIZONTAL 1:500 AT ORIGINAL SIZE 0 5 10 15 20 25m

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Drafting Check P. PRASAD | Design Check A. ROBERTS
Approved (Project Director) I. GREGSON*
Date 26.09.19
Scale AS SHOWN
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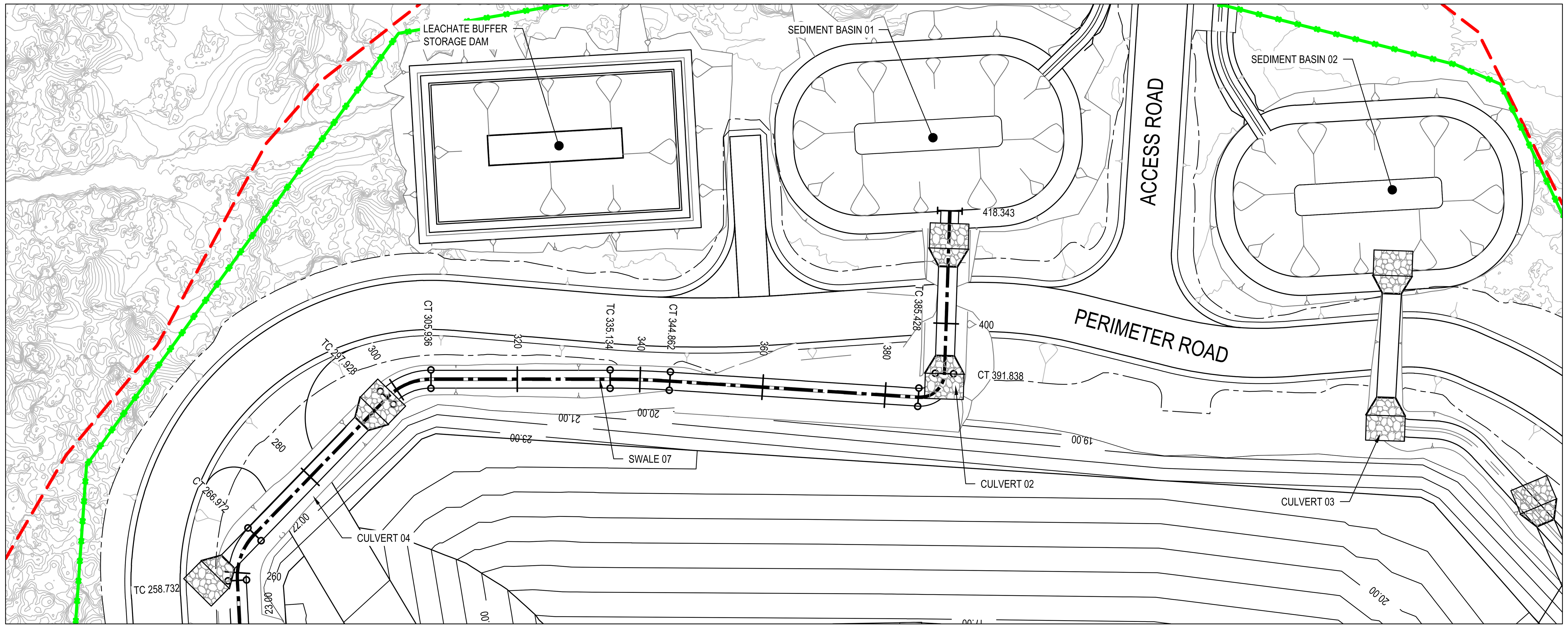
Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **SWALE LONGITUDINAL SECTION SHEET 7 OF 8**

Original Size A1 Drawing No: **22-18015-C157** Rev: 0

Plot Date: 27 September 2019 - 10:05 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C157.dwg

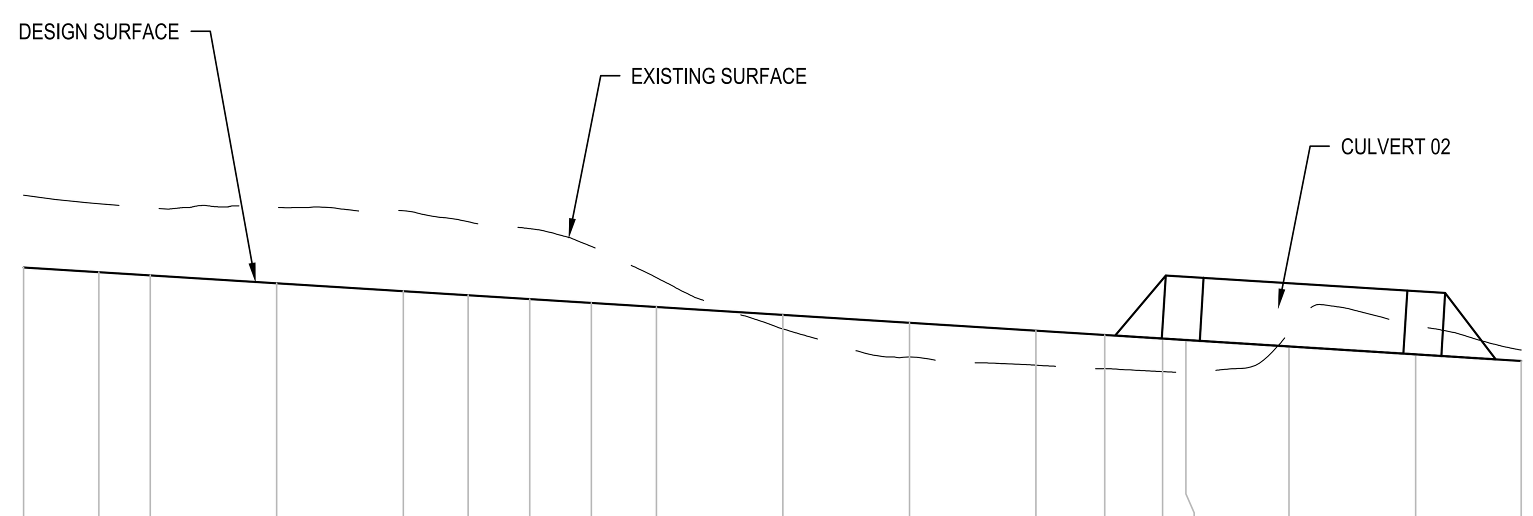
NOTES:

1. REFER DRAWING 22-18015-C157 FOR SETOUT TABLE.
2. REFER DRAWING 22-18015-C111 FOR SWALE DETAILS.
3. REFER DRAWING 22-18015-C023 FOR PLAN LOCATION



PLAN

SCALE 1:500



DATUM RL. 16.00

VERTICAL ALIGNMENT: L=270.06m, G=-1.25%

HORIZONTAL ALIGNMENT: L=8.01m R=10.00m | L=29.20m | L=9.73m R=150.00m | L=40.57m | L=6.41m R=-4.00m | L=26.50m

LEVEL DIFFERENCE CUT - / FILL +	DESIGN SURFACE LEVEL	EXISTING SURFACE LEVEL	CHAINAGE
-1.14	20.079	21.22	300.00
-1.08	20.005	21.09	305.94
-1.07	19.954	21.02	310.00
-1.20	19.829	21.03	320.00
-1.27	19.704	20.98	330.00
-1.16	19.640	20.80	335.13
-1.11	19.579	20.69	340.00
-0.89	19.519	20.41	344.86
-0.47	19.454	19.92	350.00
0.22	19.329	19.11	360.00
0.54	19.204	18.66	370.00
0.55	19.079	18.53	380.00
0.53	19.011	18.48	385.43
0.52	18.954	18.43	390.00
0.51	18.931	18.43	391.84
-0.22	18.829	19.05	400.00
-0.45	18.704	19.16	410.00
-0.17	18.600	18.77	418.34

LONGITUDINAL SECTION - SWALE 07 CONTINUED

SCALE HOR. 1:500 VERT. 1:100

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
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HORIZONTAL 1:500 AT ORIGINAL SIZE — 0 5 10 15 20 25m

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Drafting Check P. PRASAD — Design Check A. ROBERTS

Approved (Project Director) I. GREGSON*

Date 26.09.19

Scale AS SHOWN

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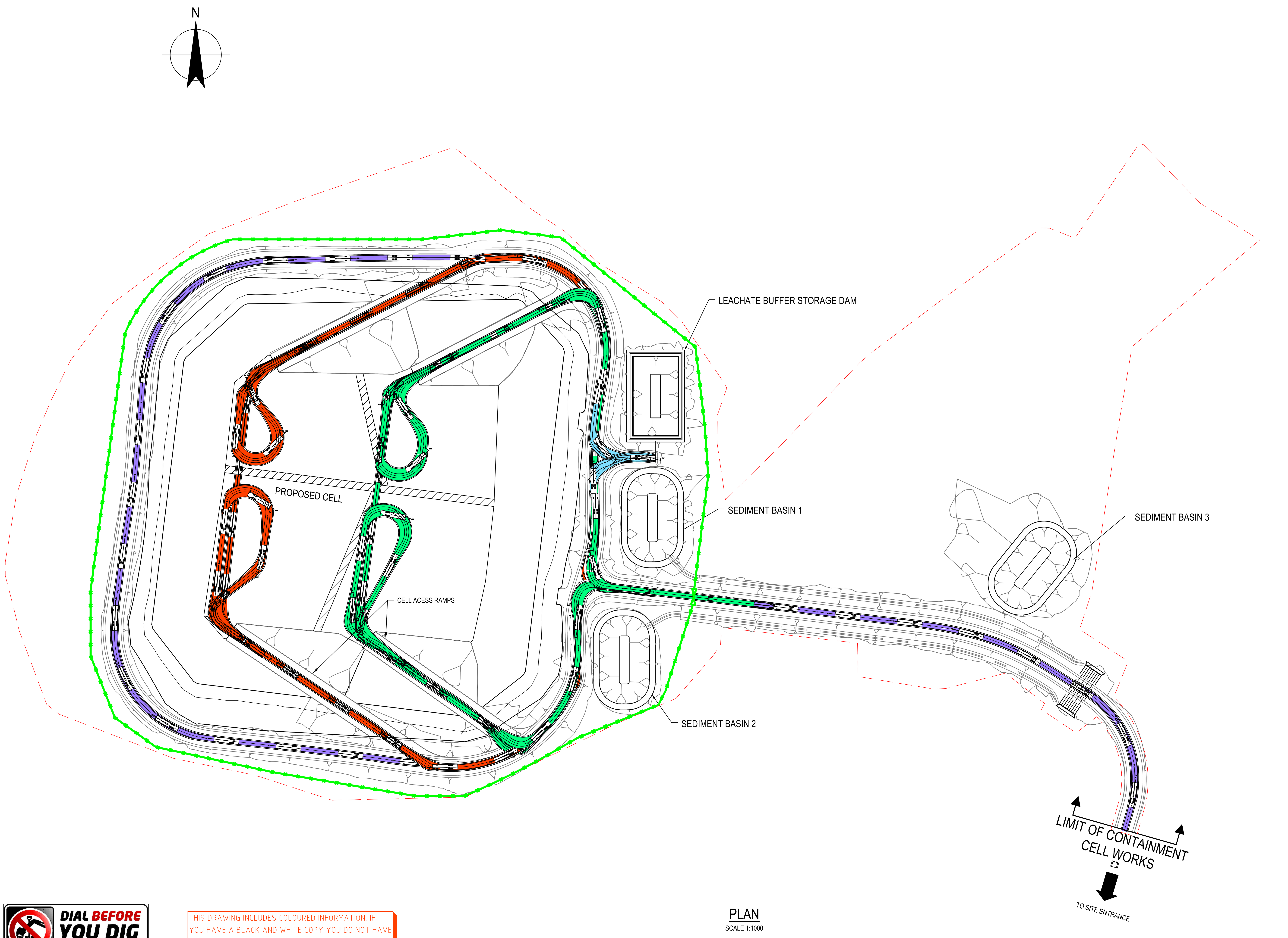
Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**

Project **CONTAINMENT CELL DETAILED DESIGN**

Title **SWALE LONGITUDINAL SECTION SHEET 8 OF 8**

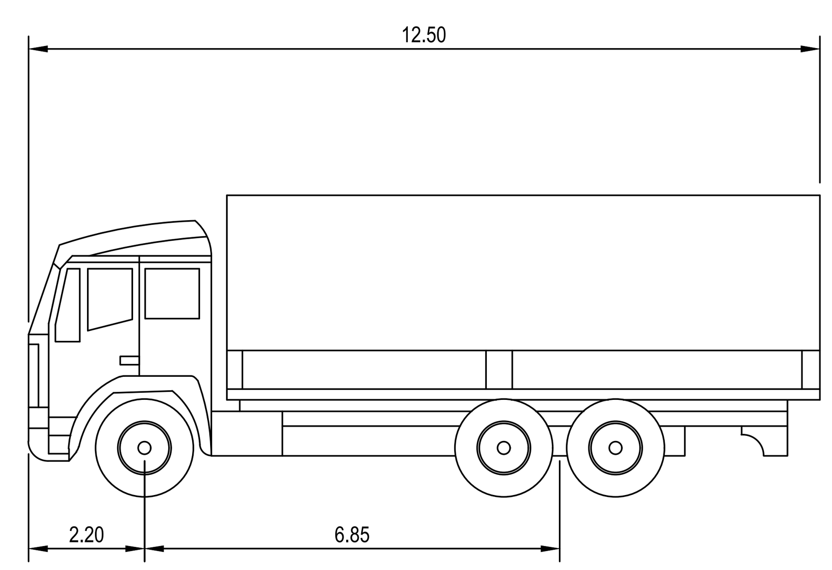
Original Size A1 — Drawing No: **22-18015-C158** — Rev: 0

Plot Date: 27 September 2019 - 10:05 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C158.dwg



LEGEND:

- CONTAINMENT CELL WORKS AREA
- EXISTING CONTOURS
- VEHICLE TURN PATH 01
- VEHICLE TURN PATH 02
- VEHICLE TURN PATH 03
- VEHICLE TURN PATH 04



SU TRUCK

WIDTH	: 2.5m
TRACK	: 2.5m
LOCK TO LOCK TIME	: 6.0
STEERING ANGLE	: 36.6m

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PLAN

SCALE 1:1000

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
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Note: * indicates signatures on original issue of drawing or last revision of drawing

0 10 20 30 40 50m
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Designer P. ETCHELLS
Drafting Check P. PRASAD
Design Check A. ROBERTS
Approved (Project Director) I. GREGSON*
Date 26.09.19
Scale 1:1000
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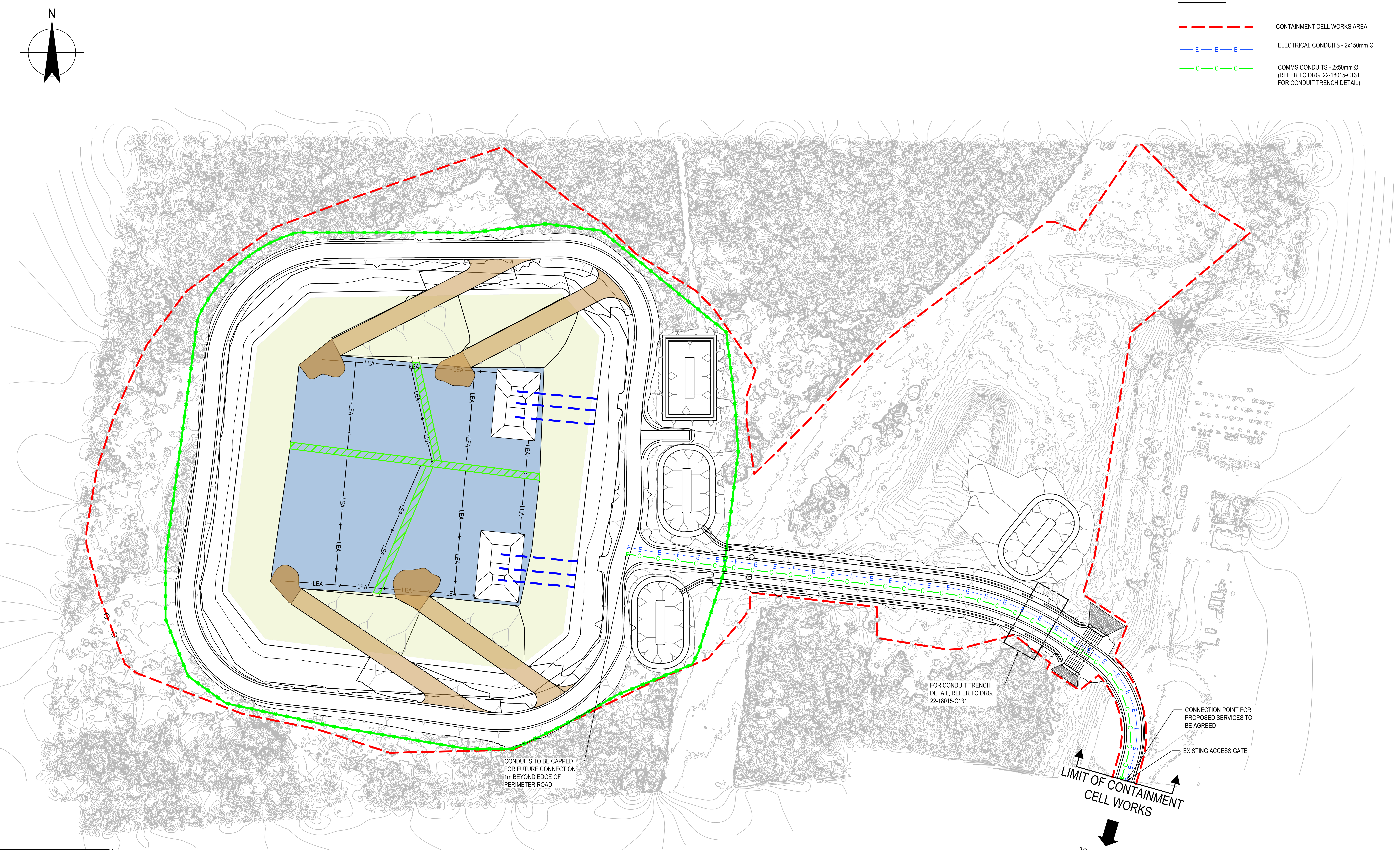
Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **VEHICLE TRACKING PLAN**

Original Size **A1**
Drawing No: **22-18015-C161**
Rev: **0**

Plot Date: 27 September 2019 - 10:06 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C161.dwg



PLAN
SCALE 1:1000

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Drafting Check P. PRASAD
Design Check A. ROBERTS
Approved (Project Director) I. GREGSON*
Date 26.09.19
Scale 1:1000
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Client **HYDRO ALUMINIUM KURRI KURRI PTY LTD**
Project **CONTAINMENT CELL DETAILED DESIGN**
Title **SECURITY AND UTILITIES PLAN**

Original Size A1
Drawing No: **22-18015-C162**
Rev: 0

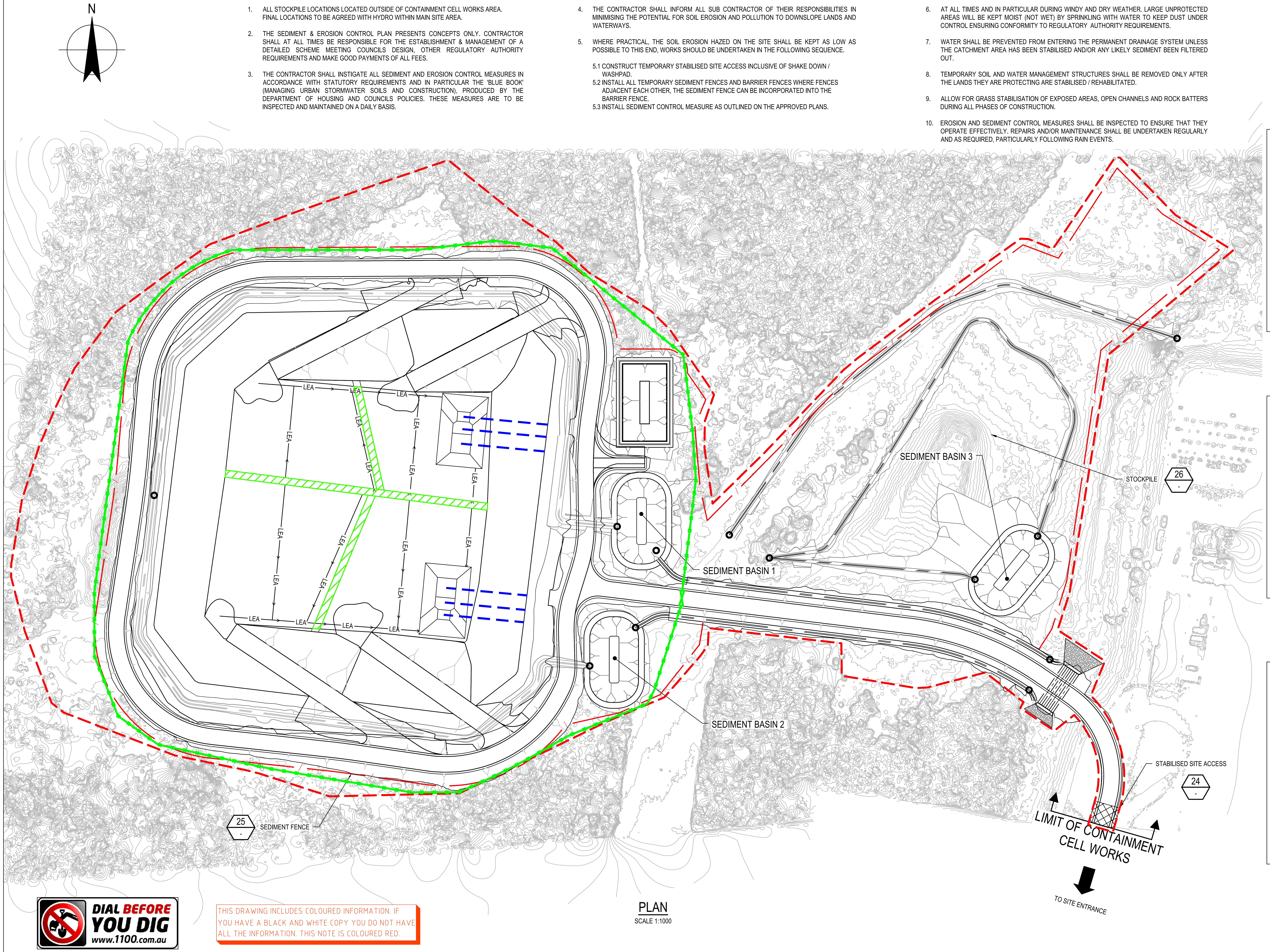
Plot Date: 27 September 2019 - 10:06 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C162.dwg

NOTES:

1. ALL STOCKPILE LOCATIONS LOCATED OUTSIDE OF CONTAINMENT CELL WORKS AREA. FINAL LOCATIONS TO BE AGREED WITH HYDRO WITHIN MAIN SITE AREA.
2. THE SEDIMENT & EROSION CONTROL PLAN PRESENTS CONCEPTS ONLY. CONTRACTOR SHALL AT ALL TIMES BE RESPONSIBLE FOR THE ESTABLISHMENT & MANAGEMENT OF A DETAILED SCHEME MEETING COUNCILS DESIGN, OTHER REGULATORY AUTHORITY REQUIREMENTS AND MAKE GOOD PAYMENTS OF ALL FEES.
3. THE CONTRACTOR SHALL INSTIGATE ALL SEDIMENT AND EROSION CONTROL MEASURES IN ACCORDANCE WITH STATUTORY REQUIREMENTS AND IN PARTICULAR THE 'BLUE BOOK' (MANAGING URBAN STORMWATER SOILS AND CONSTRUCTION), PRODUCED BY THE DEPARTMENT OF HOUSING AND COUNCILS POLICIES. THESE MEASURES ARE TO BE INSPECTED AND MAINTAINED ON A DAILY BASIS.
4. THE CONTRACTOR SHALL INFORM ALL SUB CONTRACTOR OF THEIR RESPONSIBILITIES IN MINIMISING THE POTENTIAL FOR SOIL EROSION AND POLLUTION TO DOWNSLOPE LANDS AND WATERWAYS.
5. WHERE PRACTICAL, THE SOIL EROSION HAZED ON THE SITE SHALL BE KEPT AS LOW AS POSSIBLE TO THIS END, WORKS SHOULD BE UNDERTAKEN IN THE FOLLOWING SEQUENCE.
   - 5.1 CONSTRUCT TEMPORARY STABILISED SITE ACCESS INCLUSIVE OF SHAKE DOWN / WASHPAD.
   - 5.2 INSTALL ALL TEMPORARY SEDIMENT FENCES AND BARRIER FENCES WHERE FENCES ADJACENT EACH OTHER, THE SEDIMENT FENCE CAN BE INCORPORATED INTO THE BARRIER FENCE.
   - 5.3 INSTALL SEDIMENT CONTROL MEASURE AS OUTLINED ON THE APPROVED PLANS.
6. AT ALL TIMES AND IN PARTICULAR DURING WINDY AND DRY WEATHER. LARGE UNPROTECTED AREAS WILL BE KEPT MOIST (NOT WET) BY SPRINKLING WITH WATER TO KEEP DUST UNDER CONTROL ENSURING CONFORMITY TO REGULATORY AUTHORITY REQUIREMENTS.
7. WATER SHALL BE PREVENTED FROM ENTERING THE PERMANENT DRAINAGE SYSTEM UNLESS THE CATCHMENT AREA HAS BEEN STABILISED AND/OR ANY LIKELY SEDIMENT BEEN FILTERED OUT.
8. TEMPORARY SOIL AND WATER MANAGEMENT STRUCTURES SHALL BE REMOVED ONLY AFTER THE LANDS THEY ARE PROTECTING ARE STABILISED / REHABILITATED.
9. ALLOW FOR GRASS STABILISATION OF EXPOSED AREAS, OPEN CHANNELS AND ROCK BATTERS DURING ALL PHASES OF CONSTRUCTION.
10. EROSION AND SEDIMENT CONTROL MEASURES SHALL BE INSPECTED TO ENSURE THAT THEY OPERATE EFFECTIVELY. REPAIRS AND/OR MAINTENANCE SHALL BE UNDERTAKEN REGULARLY AND AS REQUIRED, PARTICULARLY FOLLOWING RAIN EVENTS.

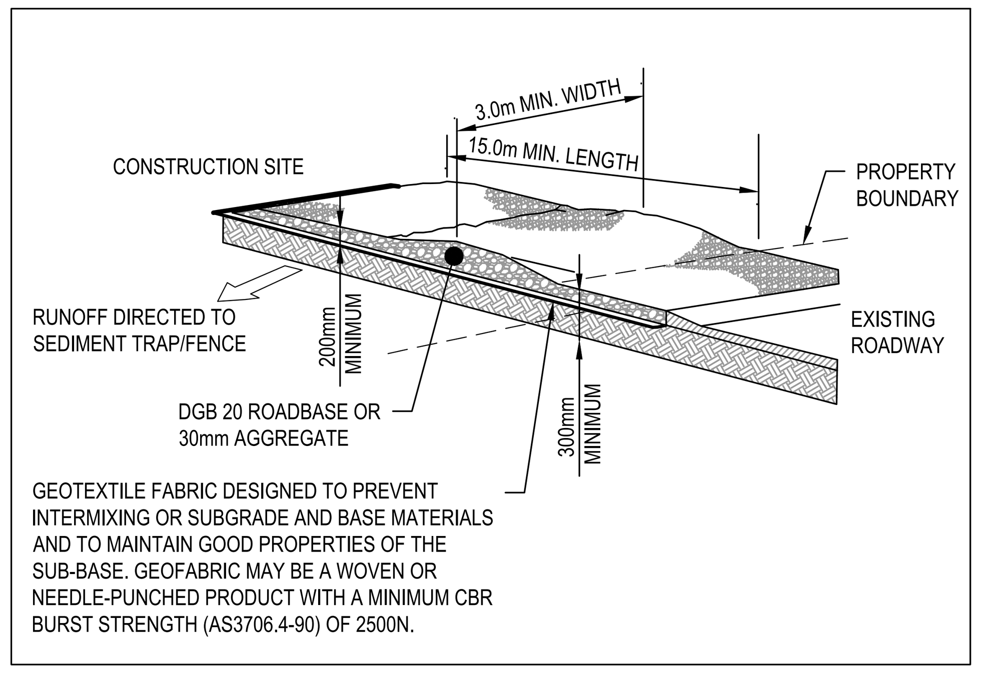
LEGEND:

- CONTAINMENT CELL WORKS AREA
- LEA — LEACHATE COLLECTION TRENCH
- GROUNDWATER, LEAK DETECTION AND LEACHATE RISER PIPEWORK
- SEDIMENT FENCING
- DISCHARGE POINT



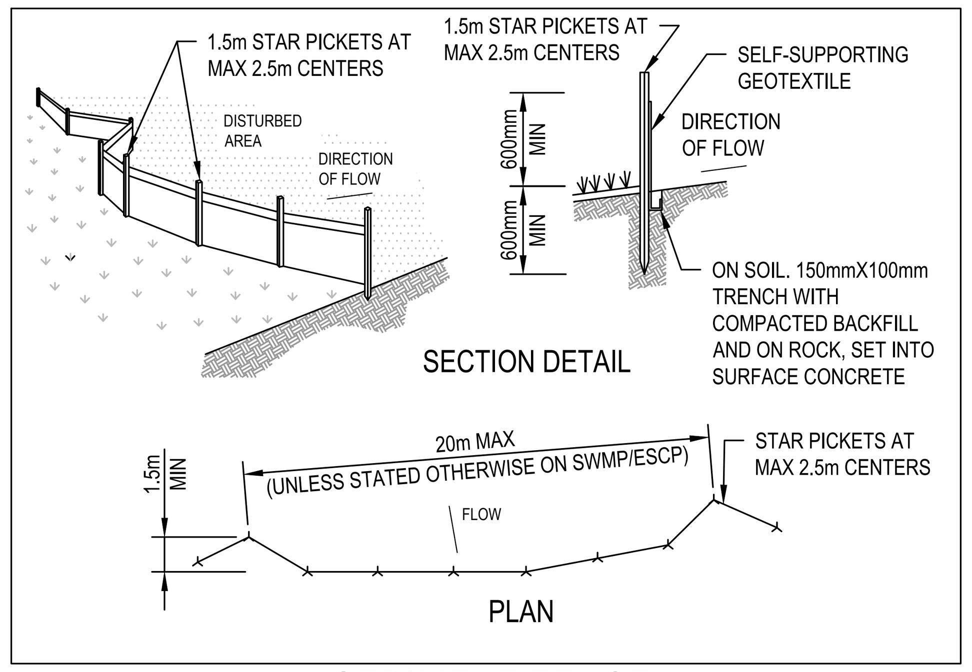
PLAN

SCALE 1:1000



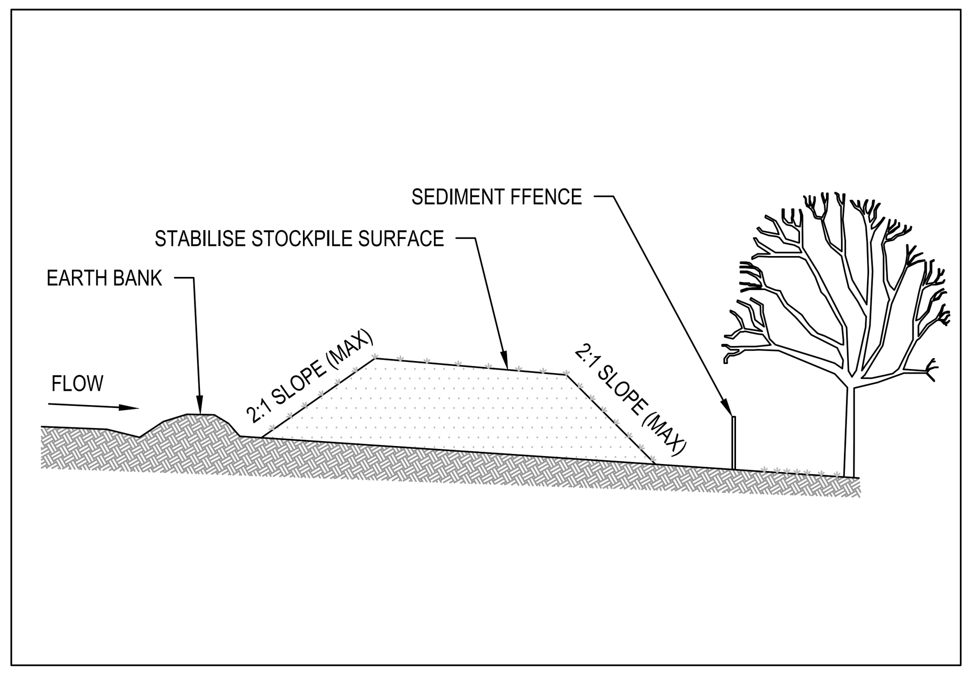
STABILISED SITE ACCESS

24 DETAIL
NTS



SEDIMENT FENCE

25 DETAIL
NTS



STOCKPILES

26 DETAIL
NTS

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Note: * indicates signatures on original issue of drawing or last revision of drawing

0 10 20 30 40 50m
SCALE 1:1000 AT ORIGINAL SIZE

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Drafting Check	P. PRASAD	Design Check	A. ROBERTS
Approved (Project Director)	I. GREGSON*		
Date	26.09.19		
Scale	AS SHOWN	This Drawing must not be used for Construction unless signed as Approved	

Client: HYDRO ALUMINIUM KURRI KURRI PTY LTD
Project: CONTAINMENT CELL DETAILED DESIGN
Title: EROSION AND SEDIMENT CONTROL PLANS AND DETAILS

Original Size A1 | Drawing No: 22-18015-C163 | Rev: 0

Plot Date: 27 September 2019 - 10:06 AM Plotted by: Renzel Keena Ignacio Cad File No: G:\22\18015\CADD\Drawings\22-18015-C163.dwg

APPENDIX 2
CONSTRUCTABILITY ASSESSMENT

Hydro Aluminium Kurri Kurri Pty Ltd

Containment Cell Detailed Design

Constructability Assessment

August 2018

Table of contents

Table index

Figure index

Appendices

1. Introduction

1.1 Project overview

GHD Pty Ltd (GHD) has been engaged by Hydro Aluminium Kurri Kurri Pty Ltd (herein referred to as 'Hydro') to prepare a detailed engineering design and supporting documentation for a proposed Containment Cell for the Hydro Demolition and Remediation Project (the Project). GHD's Scope of Services covers the detailed design, constructability review (this report), quality specifications, project cost estimate, schedule and other related requirements. The future Containment Cell will be an engineered facility for the purpose of immobilising and managing various waste streams generated by the Capped Waste Stockpile and the demolition and remediation of the Smelter.

1.2 Purpose and scope of report

The purpose of the report is to integrate constructability principles into the design process and conduct constructability reviews of the design at key stages of the design development.

It should be noted that the intent of this assessment is not to determine how a contractor should construct or stage the works but provide assistance and guidance in the process.

Within the scope of works, Hydro identified some constructability considerations and these include:

- Integration of the cell construction with the greater site works, in particular the demolition activities that may be occurring concurrently.
- Determining quantities of site work low permeability clay (intended for use in lining/capping layers) including clays currently being used as capping versus imported material
- Assessment of available stockpile locations from various materials during construction
- Management of the existing capped waste stockpile during construction/relocation to the new cell, as well as other material sources
- Construction innovations including options to manage existing leachate (capped waste stockpile) stormwater and minimising the exposure of smelter waste to wet weather during the material placement phase
- Flexibility in the design to avoid significant revamps should the need arise to cater for reductions or increases in material volumes encountered during construction
- Placement of certain material which would allow ease of future reclamation if a feasible market for reuse was determined
- Recycling on-site materials (such as crushed concrete and bricks) for possible utilisation in the proposed cell
- Minimising the disturbance and contamination of the surrounding environment
- Minimising settlement risk by crushing of materials

In addition to these additional constructability considerations includes:

- Review of the construction facilities required for the project and any constraints around programme and months of working
- Estimate of traffic movements around site for the movement of earthworks and the stockpile materials (including the capped waste stockpile)

1.3 Related documents

The following documents were considered in the preparation of this report:

- Containment Cell Design – Design Report, GHD
- Detailed Design Drawings, GHD
- Capped Waste Stockpile Assessment, Ramboll Environ, April 2016
- Draft Demolition Phase Diagrams – Environ, January 2015

1.4 Limitations

This report:

1. Has been prepared by GHD for Hydro Aluminium Kurri Kurri Pty Ltd
2. May be used and relied on by Hydro Aluminium Kurri Kurri Pty Ltd
3. May be copied to relevant consultants carrying out approval works for information purposes;
4. Must not be copied to, used by, or relied on (as relevant) by any person other than those listed in 1-3 above without prior written consent of those listed in 1 above;
5. May only be used for the purpose specifically detailed in section 1.2 of this report (and must not be used for any other purpose).

GHD otherwise disclaims responsibility to any person other than Hydro Aluminium Kurri Kurri Pty Ltd arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Hydro Aluminium Kurri Kurri Pty Ltd and others who provided information to GHD, which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

2. Project background

2.1 Introduction

Background to the project can be found fully detailed with the design report and design drawings. SK001 provides an overview of the proposed works. Overall site plans can be found within the design drawings

2.2 Site Inspection

To understand the constraints around the site a site visit was undertaken by David Morrison (GHD) on 15th December 2016, which involved a walkthrough of the site with Hydro personnel. Photographs taken allowing an appreciation of the site are below. The site visit covered all areas within the Hydro site however did not include visits to the external material sites namely the formal municipal landfill site and Dickson road landfill. In terms of the overall constructability assessment visits to these two areas was deemed not to be important.

2.3 Capped waste stockpile

The Capped waste stockpile is an on-site stockpile comprising mixed smelter wastes that was capped, see Figure 1 and Figure 2 Further information on this stockpile are contained within the Capped Waste Stockpile report prepared by Ramboll Environ.

Figure 1 View from top of capped waste stockpile (looking west)

Figure 2 Birdseye view of capped waste stockpile

2.4 Containment cell site

The containment cell is proposed to be located in an area in the north west of the site, see Figure 3 and Figure 4 below.

Figure 3 View of Containment Cell site looking east

Figure 4 View to south of containment cell site – from Stockpile 1

2.5 Stockpile and laydown area

During the site visit, it was evident that the nominated stockpile and laydown area, see Figure 5 and Figure 6 was not suitable for the works due to the presence of existing M15 stockpiles material, an existing electrical easement and the proximity to the watercourse.

This area would only be suitable if this existing material were removed however, this would involve a greater effort than defining an alternative area for stockpiling material.

Figure 5 View from M15 stockpile and laydown area towards containment cell site

Figure 6 View to north of M15 stockpile and laydown area

2.6 Other stockpiles

Demolition material around the site are currently contained in a combination of states from stored inside existing sheds, stored outside with covers and stored inside sheds in storage bags. The nature of this material is highly variable and the figures below provide an indication of the type of materials around the site. Methodology around the transportation and disposal of these stockpiles will require to be considered, see Figure 7 to Figure 10.

Figure 7 Typical bagged material within rodding shop in carbon plant

Figure 8 Typical External Stockpile – asbestos contaminated material

Figure 9 Typical view of waste material from processing

Figure 10 Typical smelter waste stripped, sorted and stored around site

2.7 Site features

The following site features are important in considering the constraints around the site.

- Watercourse crossing at containment cell site entry (Figure 11)
- Hydro switchyard (Figure 12)
- Portion of 2 pot rooms that will be retained for future development (Figure 11)

Figure 11 View of existing culvert crossing from stockpile area and pot rooms to be retained

Figure 12 Hydro switchyard and transformer yard to north of site

3. Construction staging

3.1 Introduction

This section discusses the potential stages required to construct the works, where stockpiles can potentially be created (including indicative sizes) and constraints identified with each of the stages.

This staging assumes that the site demolition work is underway and the containment cell contractor will require to co-ordinate activities with the demolition contractor. However for the purposes of this assessment is assumed that co-ordination will not cause further delays to the construction or impact on the methodology adopted.

The construction staging and sketches have been developed on the assumption that 250 m of Pot rooms 2 and 3 will be retained for the future development of the site as per Hydro discussions. Pot room 1 shall be demolished.

For the purposes of the staging, it has been assumed that stockpiles will be separated and individually stockpiled within the site.

3.2 Overall staging

The following stages are proposed for the works.

Table 1 Proposed construction stages

Stage No.	Stage description
1	Construct containment cell access road, temporary haul roads and erosion control.
2	Relocate stockpiles within containment cell site
3	Excavation and stockpiling of containment cell site to subgrade level
4	Construction of containment cell liner
5a	Placement of demolition and external stockpiles within containment cell. *Noting that the asbestos contaminated soils should be placed first, before the demolition material to protect the liner materials from damage.*
5b	Placement of materials within areas on site requiring remediation. These include the 5A greenmix area, the 60C carbon bake scrubber footprint and the waste anode stockpile.
6	Removal and stockpiling of capped waste stockpile capping material
7	Placement of capped waste stockpile within containment cell
8	Placement of relocated stockpiles from containment cell site
9	Placement of final cap for containment cell including capped waste stockpile capping material
10	Removal of haul roads and surfacing of access roads

3.3 Stage 1 – Construct containment cell access roads and temporary haul roads

Stage 1 provides access to the containment cell site during the works, refer to SK010. The following components will be required:

- Establishment of site offices
- Establishment of erosion and sediment control measures, fauna exclusion fence and site security fencing
- Site clearance – including clearance through site for temporary access road
- Construction of culvert crossing, including removal of existing crossing
- Construction of access road and haul roads

Key considerations for the stage include:

- Ensuring adequate width of access and haul roads for two way operation of construction vehicles
- Ensuring sediment control measures are in place for stockpile locations

3.4 Stage 2 – Relocate stockpiles located within containment cell site

Stage 2 will clear the containment cell site of the existing stockpiled material and allow the containment cell to be constructed, refer to SK020.

The existing stockpiled material will be relocated to an agreed location prior to replacement back within the containment cell site if it cannot be re-used elsewhere. Table 2 below provides a summary of this volume.

Table 2 Extract from Table 1 – Waste Volumes (Rennie-Golledge survey Enviropacific Services)

Waste Type	m^3
Stockpiled Hydro Land Soils	33,751 m^3 Stockpile 15 at 27,856 m^3 and; Stockpile 42 at 5,895 m^3.

Based on these volumes Table 3 provides an estimate of the stockpile area required.

Table 3 Stage 2 – Approximate stockpile extents

Length (m)	Width (m)	Height (m)	Side Slopes (1 in)
50	50	5.5	3

This relocated stockpile will require to be retained within the overall site in a location agreed with Hydro. However we have assumed that this would be near the haul road, within the confines of the demolition works, refer to SK020.

Key considerations for the stage include:

- Contractor to be satisfied that there is adequate space available to accommodate stockpiles
- Stockpiles to be protected to prevent degradation of material and runoff

3.5 Stage 3 – Excavation of containment cell to subgrade level

Stage 3 includes the excavation of the containment cell to subgrade level see SK030.

This excavated material shall be relocated to a location agreed with Hydro. The contractor is recommended to look at using this material (potentially as general fill) as part of the construction works.

Table 5 Stage 2 – Approximate containment cell excavation stockpile extents outlines the assumed excavated volumes.

Table 4 Extract from Table 2 – Summary of key parameters (GHD Design Report)

Waste Type	m^3
Total excavation to subgrade level	70,610
Excavation of extremely weathered rock	6,500

Based on these volumes Table 5 provides an estimate of the stockpile area required.

Table 5 Stage 2 – Approximate containment cell excavation stockpile extents

Length (m)	Width (m)	Height (m)	Side Slopes (1 in)
150	150	6	3

This relocated stockpile will require to be retained within the overall site in a location agreed with Hydro. However we have assumed that this would be near the haul road, within the confines of the demolition works, adjacent to the stage 2 stockpile, refer to SK030.

Key considerations for this stage include:

- Stockpiles protected to prevent degradation of material and runoff.
- Prevention of stormwater runoff into containment cell excavation through construction of bunds where appropriate.
- Installation of pump out pit within cell to prevent build-up of stormwater.

3.6 Stage 4 – Construction of containment cell liner

Stage 4 includes the construction of the containment cell liner, see SK040.

The construction of the containment cell liner is described fully within Section 4.6 of the design report. However, in terms of staging the following will be constructed:

- Groundwater diversion system
- Secondary liner system
- Primary leak detection and extraction system
- Primary liner system
- Primary liner protection system
- Primary leachate collection and extraction system

The majority of the material will require to be imported from off the site and therefore the contractor should ensure works is sequenced in such as a way as to limit the amount of material required to be stored on site.

Key considerations for this stage include:

- Construction access into the cell
- Protection of liner materials from construction activities, weather, fauna (kangaroos) prior to placement of next layer
- Construction of internal bunds and impact on stormwater flow prior to placement
- Protection of installed pipework from construction loading

3.7 Stage 5 – Placement of demolition stockpiles within containment cell

Stage 5 involves the placement of the various demolition stockpiles within the containment cell, see SK050.

The placement of these shall be sequenced in a way that the material with low risk of damaging the liner system will be placed into the cell first. It is anticipated at this stage that the material will form the first layer to be placed along the slope and floor. The material along the slope will be free draining in nature to facilitate leachate flow. The contractor shall be required to satisfy themselves of the make-up of each of the demolition stockpiles.

The following waste types as summarised from Table 6 which are obtain from the design report.

Table 6 Summary of stockpiled material

Waste Type	m^3
Process wastes	26,330
Smelter Containment Soils	34,328
Hydro Land Contaminated Soils	
Dickson Road Landfill	14,150
Former Municipal Landfill	8,400
Asbestos Contaminated Material	6,700
Kline Street Wastes and Soils	3,074
Non-Recyclable Demolition and Smelter Wastes	21,000
Non-Leachable/Non Hazardous	9,000

3.8 Stage 6 – Removal and stockpiling of capped waste stockpile topsoil and capping material

Stage 6 involves the removal and stockpiling of the topsoil and capping material currently located on top of the capped waste stockpile, see Figure 13.

Figure 13 Construction of capping over capped waste stockpile (photo courtesy of Hydro)

The capped waste stockpile assessment report outlines that the capped waste stockpile is covered by approximately 0.5 m topsoil and 1.1 m of clay material – 1.6 m total thickness.

To access the site this material would require to be stripped progressively and stockpiled for re-use within the containment cell cap.

Waste Type	m^3
Capped waste stockpile capping material	48,000

Based on these volumes the following is an estimate of the stockpile area required.

Table 7 Stage 2 – Approximate containment cell excavation stockpile extents

Length (m)	Width (m)	Height (m)	Side Slopes (1 in)
125	125	4	3

This relocated stockpile will require to be retained within the overall site in a location agreed with Hydro. However we have assumed that this would be adjacent to the capped waste stockpile, refer to SK060.

This material must be readily accessible, as the capped waste capping material will be progressively removed as the capped waste stockpile material is accessed.

3.9 Stage 7 – Placement of capped waste stockpile within containment cell

Stage 7 involves the transfer of the material from the capped waste stockpile into the containment cell, see SK070.

Waste Type	m³
Capped Waste Stockpile	183,491

The material will be excavated, and then transported via the haul road and placed directly into the containment cell.

Photos from the capped waste stockpile and the material within it are contained below in Figure 14 and Figure 15. The stockpile contains full cathode assemblies with collector bars which will potentially need downsizing at the capped waste stockpile prior to transporting into the containment cell to ensure they are transportable.

Figure 14 View of typical material within capped waste stockpile. (Photo: courtesy of Hydro)

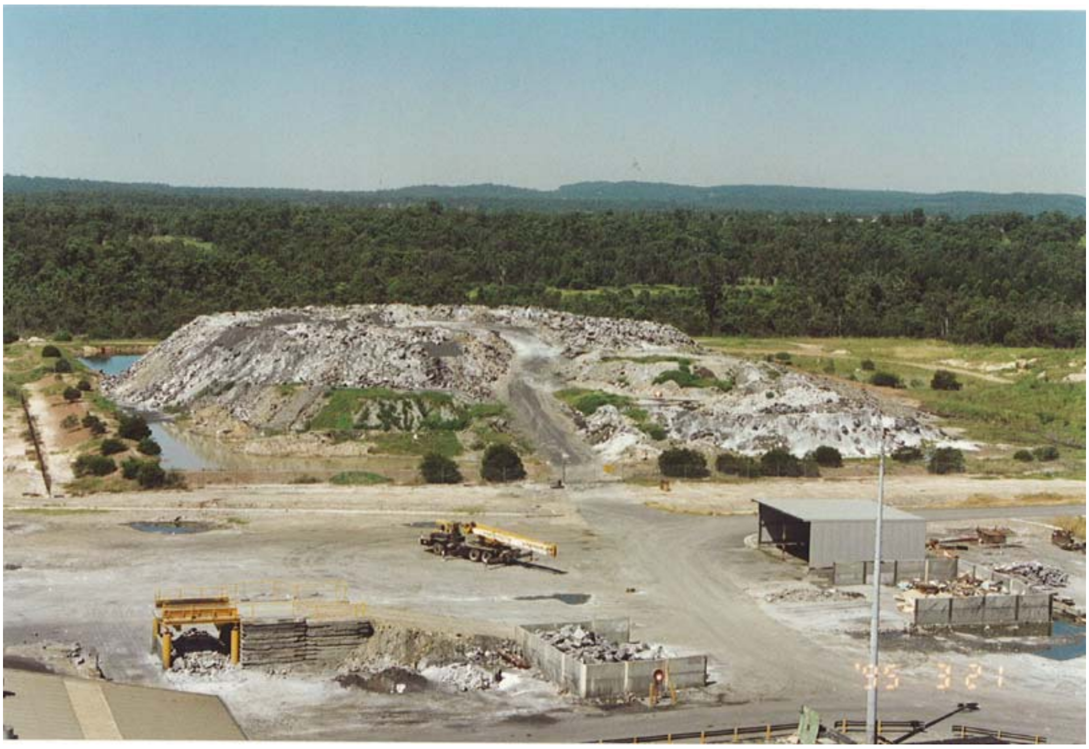


Figure 15 View of capped waste stockpile prior to capping (photo courtesy Hydro)

The material will be placed into the containment cell by using spotters around the perimeter of the cell. The spotters will be used during the first 3 to 4 m of waste placement. The larger items of material will require to be placed once this 3 to 4 m layer of more granular material is placed to ensure that the liner is not pierced.

3.9.1 Gypsum Application

With regards to gypsum application, the following process is anticipated however this process would require to be developed by the contractor appointed to undertake the work.

- Waste will be loaded to trucks and driven over a weighbridge to ascertain total weight

  The existing weighbridge at the southwest gatehouse would be relocated to a position on the Haul Road west of the Capped Waste Stockpile. Once the truck has passed through the weighbridge and the required quantity of gypsum based on a 10% application rate has been calculated, the truck would then progress to the gypsum application station to the west of the weighbridge.

- Gypsum will be added to the loaded waste at the pre-determined w/w percentage using a front end loader with weighing system attached within a specified tolerance
- The truck will be driven to the containment cell and the waste end deposited at the filling face
- The waste will be pushed out by bull dozer and compacted in accordance with the cell filling requirements

Mixing of the waste with gypsum will occur through this process. When considering the waste mass as a whole, the proposed containment will incorporate approximately 8,500 individual 40T truck loads of waste each with the addition of gypsum. Through this method of placement the gypsum addition is considered to be mixed on a macro scale. This level of mixing is sufficient when considering that the waste itself is variable in concentration and highly heterogeneous and that any pathway of leachate through the cell will inevitably pass through gypsum when designed in this manner.

3.10 Stage 8 – Placement of relocated stockpiles from containment cell site

Stage 8 involves the replacement of the stockpiles, which were relocated from the containment cell site within Stage 2, see SK080. These may be used as general fill around the site and have been tested to confirm this.

Haul road surface to be scraped/graded to remove any spilled waste material and deposited within containment cell.

3.11 Stage 9 – Placement of final cap for containment cell

Stage 9 involves the placement of the final cap to the containment cell, see SK090.

The construction of the containment cell liner is described fully within Section 4.6 of the design report. However, in terms of sequencing the following will be constructed

- Separation geotextile
- Geosynthetic clay Liner
- 300 mm seal bearing layer (utilising existing capping material from capped waste stockpile)
- LLDPE geomembrane
- Protection geotextile
- 300 mm recycled drainage aggregate
- Separation geotextile
- 1300 mm soil subsoil layer
- 150 mm soil topsoil layer to be revegetated

The clay material for the cap shall be taken from the clay material recovered from any capping material left from the containment cell

3.12 Stage 10 – Removal of haul roads and finalising of access road (surfacing)

Stage 10 involves the completion of the works, see SK010 including:

- Completion of access road surfacing
- Removal of haul roads
- Removal of erosion and sediment control measures

4. Waste removal / filling practices

4.1 Introduction

This section describes the practices to be considered by the Contractor in the preparation of their construction management plans relating to the removal, transfer and placement of waste materials at both the capped waste stockpile and the containment cell and associated leachate management.

Handling /treatment of waste and leachate will be required at both the capped waste stockpile and containment cell.

4.2 Active waste area requirements

The capped waste stockpile is where activities related to cap removal, waste removal / treatment and leachate treatment are undertaken.

The containment cell is where activities relating to waste deposition and leachate treatment will occur.

4.2.1 General

The active area changes constantly, as waste removal / placement progresses, but usually comprises the following:

- Access tracks/roads and temporary haul roads
- Manoeuvring areas
- Unloading area
- Working face (for excavation and/or deposition)
- Stockpiles
- Mobile amenities, if applicable

The key features include:

- Haul track runs from the capped waste stockpile to the containment cell
- Access
  - Existing vegetated access ramp onto the capped waste stockpile
  - Containment cell includes four designed access ramps
- Leachate management - Capped waste stockpile
  - Temporary works – Area for 2.5 Ml leachate pond provided (to be designed if necessary)
- Leachate management – Containment cell
  - Temporary in-cell storage
  - 1 Ml designed leachate pond
- Nearby transportable amenities and first aid shed
- Stockpile areas to sort waste
- Area for trucks to turn and be loaded with waste material (and be covered if required)
- Excavator sorting and moving material and depositing in trucks

While the circumstances and available space for establishing and maintaining the individual areas of an active area constantly change, it shall be prioritised to always consider health and safety of staff and contractors when setting up the active area. In particular the potential interference between mobile plant and trucks removing/placing waste from the stockpile shall be considered during the development of each stage.

It would be advisable to allocate a staff member to undertaking supervisory duties in the manoeuvring areas in order to minimise the risk of vehicle accidents, particularly when reversing.

4.2.2 Roads and manoeuvring areas

Haul roads and manoeuvring areas for waste trucks shall be aligned and established at a sufficient distance from the operating area for mobile plant, which always includes the area where trucks load their waste consignments. Depending on the available space, this distance may be in excess of 30 metres to allow for safe reversing of trucks into the loading area.

4.2.3 Loading / unloading area

These areas should be established in close proximity to the working face, ideally terminating at the lower level of the working face, The closer the loading area is located to the working face, the easier it usually is to maintain the area.

The surface should be prepared from materials providing good bearing capacity for trucks, particularly during periods of adverse weather with strong rainfall.

4.2.4 Working face

4.2.4.1 Capped waste stockpile

The working face is the area where waste is to be removed, sorted and loaded onto trucks for transfer to the containment cell.

Dependant on the machinery proposed by the contractor, the working face should be maintained at a safe slope with a gradient no steeper than 1 in 1 (Safe slope gradient to be assessed and proposed by Contractor based on existing conditions).

It is anticipated that the working face should extend out horizontally by no more than 20-30 metres.

The width of the working face can often vary, depending on the geometry of the cell area to be excavated and the types and numbers of equipment in operation, however, it is anticipated to span ca. 30-50 metres.

4.2.4.2 Containment cell

The working face is the area where waste is to be deposited and compacted.

In order to ensure the effectiveness of the placement and compaction equipment, the working face should be maintained at a slope with a gradient of ca. 1 in 3. Based on this gradient, the working face would therefore extend out horizontally by between 30 to 40 metres.

While the width of the working face can often vary, depending on the geometry of the cell area to be filled and the types and numbers of compaction equipment in operation, it would roughly span around 30-50 metres.

The proposed placement method is the onion skin method which is typically used for the compaction of waste.

The onion skin method requires the compactor to operate solely on the gradient of the shallower face during placement of layers of waste.

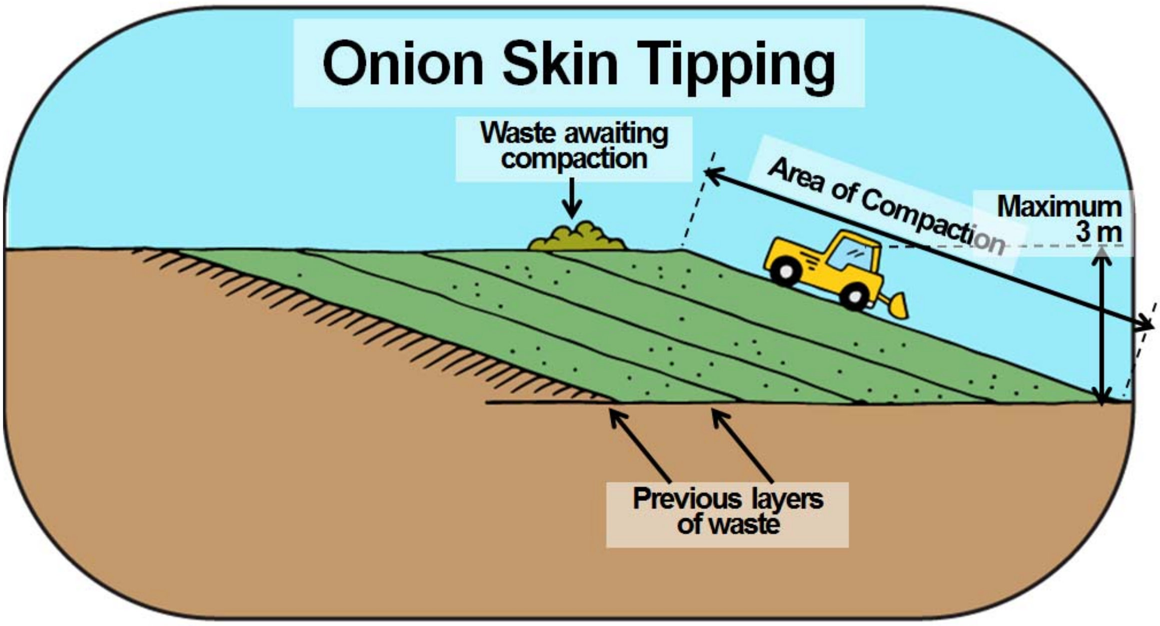


Figure 4-1 Onion skin placement

4.2.5 Stockpiles

One or more stockpiles with cover material for daily and intermediate cover should be maintained in the vicinity of both working faces, without interfering with manoeuvring areas for trucks and mobile plant.

This material can be utilised for daily cover if required and / or emergency cover in preparation for upcoming storm events.

It should be stressed that limiting the open stages to a minimum will reduce the amount of leachate management required to be undertaken by reducing the potential volume.

Temporary bunds shall be used to facilitate storm water controls preventing unnecessary ingress of surface water to the leachate system.

4.2.6 Leachate management

Reference should be made to the GHD Leachate Management Options Assessment Report for further information and guidance.

4.2.6.1 Capped waste stockpile (CWS)

The removal of waste and remediation of the CWS will subsequently result in an improvement in groundwater quality over time. Therefore, it is no longer considered necessary to extract and treat the contaminated groundwater plume extending out from the CWS.

During excavation of waste from the CWS, a layer of contaminated natural ground under the waste material will also be removed. During this activity it is expected that there will be some contaminated groundwater ingress into the excavation.

A capped waste stockpile leachate system is therefore required to manage the following water sources:

- stormwater that falls on the CWS and becomes contaminated during excavation

- residual leachate in the waste material and contaminated groundwater that enters the capped waste stockpile excavation during the extraction of waste material and the underlying contaminated natural ground

Figure 2 below provide an indication of the staged approach potentially required to the opening up of the capped waste stockpile to manage leachate generation. The staging being in line with the stages identified within the leachate management options report.

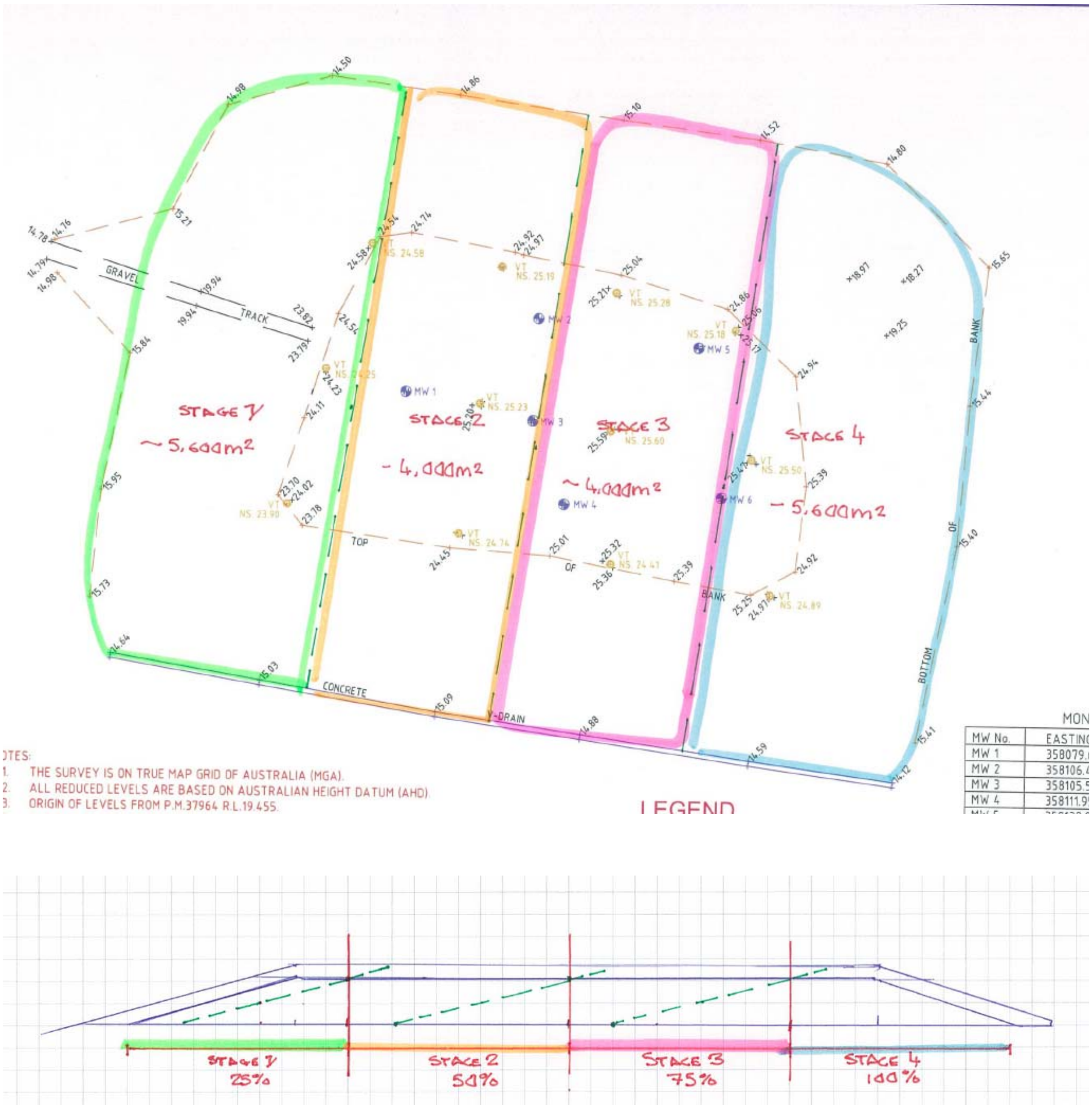


Figure 2 Capped Waste Stockpile Staging

A 2.5 ML leachate buffer dam adjacent to the capped waste stockpile may be required to be designed and constructed. This could be located at the current location of the ‘Ahead of schedule Anode Pile’, see Figure 3.

A leachate sump would be required in the lowest point of the capped waste stockpile. This sump shall be utilised for leachate management. Leachate can then be pumped to the leachate buffer dam, trucked to the leachate pond at the containment cell site or trucked directly off-site for treatment at a treatment facility.

The sump will require to be sized based on containing an agreed duration of rainfall and contractor proposed extraction methods, i.e. trucking to leachate pond versus piping to leachate pond.

Figure 3 Potential location for 2.5 ML Capped Waste Stockpile Leachate Buffer Dam

4.2.6.2 Containment cell

The designed leachate treatment system located at the containment cell, accounts for

- Stormwater that falls within waste containing sub-cells in the containment cell and becomes contaminated during the placement of waste
- Residual leachate generated from the containment cell following capping of the sub-cells

The leachate system designed includes

- Temporary in-cell storage (during storm events)
- 1 ML Leachate Buffer Dam adjacent to the containment cell.

4.2.6.3 Leachate management plans

Management plans required under the contract to manage leachate during and after rainfall events must consider:

- Compliance with the relevant State legislations, regulations and approvals
- Outline measures to minimise the potential for leachate migration from the capped waste stockpile
- Outline measures to minimise potential leachate migration from storage dams
- Detail a suitable monitoring program for characterising leachate quality
- Detail contingency measures to lower leachate levels
- Wet weather protocols to be implemented by Contractor to include (as a minimum):
  - Daily cover placement

- Sediment laden water run-off treatment
- Cessation of waste removal/placement activities

Mitigation measures that may be able to be incorporated to minimise the risk and consequences associated with the leachate management are summarised below

- Construction of leachate barrier systems
- Control of the leachate within the capped waste stockpile
- Maintaining sufficient freeboard in leachate storage dams
- Treatment of leachate extracted
- Treatment of excess leachate
- Diversion of stormwater into surface water capture systems
- Implementation of contingency leachate management measures, where needed

4.3 Waste materials including asbestos

Work involving cut and fill of waste materials is assumed to contain ACM, and therefore will be conducted by a licensed asbestos removal contractor.

A comprehensive asbestos management plan shall require to be developed for the works. The asbestos management plan is to be developed in accordance with the below Codes of Practice, which provide practical guidance on achieving the standards of health, safety and welfare required under the WHS Act and Regulation in relation to management of asbestos:

- SafeWork NSW 2016. *Code of Practice: How to manage and control asbestos in the workplace* (approved under Clause 274 of the Work Health and Safety Act 2011 NSW).
- SafeWork NSW 2016. *Code of Practice: How to safely remove asbestos* (approved under Clause 274 of the Work Health and Safety Act 2011 NSW).

The asbestos management plan would include but is not limited to the following:

- The identification, location, nature and extent of ACM at the site.
- Legislative and guidance framework.
- Management of asbestos at the site – signage, asbestos in soil management/removal methodologies, capping methodologies, air monitoring, clearance inspection.
- Plant, tools and equipment.
- PPE.
- Decontamination of personnel, plant and equipment, including wetting down of truckloads
- Waste disposal.
- Procedures for emergencies, incidents involving ACM.
- Unexpected finds protocol.
- Consultation, information, training responsibilities to workers carrying out asbestos work.
- Roles and responsibilities of workers.
- Health surveillance requirements.
- Air monitoring and removal procedures.
- PPE requirements and usage (decontamination procedures).
- ACM risk control measures.

- Timetable for managing risks of exposure.

Other control measures for working with waste materials include:

- Minimise the amount of exposed waste at any one time.
- No stockpiling of excavated waste materials is allowed.
- Exposed waste materials must be covered at the end of each working day or sooner if possible.

Control air monitoring is to be conducted by an independent SafeWork NSW Licensed Asbestos Assessor. The contractor is to determine whether exposure monitoring is also required. Air monitoring should be carried out in accordance with the National Occupational Health and Safety Commission *Guidance Note on the Membrane Filter Method of Estimating Airborne Asbestos Fibres, 2nd edition* [NOHSC:3003 (2005)] and the results should be reported by a NATA accredited laboratory.

5. Project interfaces

5.1 Introduction

This section outlines the interfaces require to be considered around the site.

5.2 Site access

The site is accessed via Hart Road in Loxford, which is reached via the Hunter Expressway in the south-western edge of Hydro Land. The Hunter Expressway is a large freeway within the Lower Hunter Region that connects to the Pacific Motorway and Newcastle Link Road in the south and New England Highway in the north.

No issues with access to the site for delivery of materials and construction materials are anticipated.

All site access will be through the Hydro security gates at the main entrance using the main weighbridge.

Figure 4 View of Hydro site access gates

5.3 Demolition works

The demolition works will be partially completed prior to the commencement of the containment cell to ensure that all material to be placed within the containment cell is clearly stockpiled. Some existing sheds may be retained to protect these stockpiles and this will be subject to finalising details with the demolition contractor. If the demolition contractor remains on site during part of the cell works the following will require to be considered.

- Compound locations – an additional compound location will be required for the containment cell contractor if the demolition contractor remains on site. Indicative compound locations are shown in the construction staging sketches within Appendix A.
- Access across the haul road – this will essentially cut the site in two and we would propose that this be fenced off and a formal crossing point controlled by the containment cell contractor to ensure the safe operation of trucks through the site.
- Stockpile locations – locations will require to be secured where demolition contractor has completed works.

- SPL movements as well as planned activities by the Developer will need to be considered.

5.4 Hydro switchyard

The Hydro switchyard to the north of the site, is understood to remain operational during the duration of the works. Access to this will require crossing the site (including the temporary haul road).

The location of the switchyard limits the availability to access the containment cell from the north of the pot rooms.

Ausgrid access to the site must be retained during the works and arrangements must be agreed to maintain this, including access to the easement for feeder 96 W which crosses the main access road to the containment cell and connects into the western end of the switchyard.

Figure 5 Hydro switchyard and transformer yard to north of site

5.5 Adjacent development work

Development work is anticipated to be undertaken after the completion of the containment cell works and therefore have not been considered further at this stage, it should be noted that this may work in parallel and co-ordination may be required.

6. Construction facilities

6.1 Introduction

This section is to provide an indication of where the contractor would set up and likely constraints around working hours, programme etc. This is to feed into Section 7 on traffic movements.

6.2 Construction compound

A construction compound will be required by the containment cell contractor to allow for the following (however two may be required one at the capped waste stockpile and one at the containment cell):

- Contractor facilities
- Contractor parking
- Storage and delivery of materials

These can either be a single area preferably at the entrance to the site, however to reduce the requirement for double handling a material storage area could be nominated adjacent to the containment cell for the delivery of materials specific to the containment cell.

6.3 Compound services

Services required to be supplied to the construction compound will include:

- Water supply
- Sewerage
- Comms
- Power

The availability of these will require to be confirmed by Hydro for the nominated compound. Where these are not available, the contractor will require to provide their own temporary supplies.

7. Traffic movements

7.1 Introduction

This section outlines an estimate of the earthworks traffic movements around the site for each stage based on a number of assumptions outlined below.

7.2 Key assumptions

- Truck Capacity – 40 tonnes capacity (Figure 6)
- Truck Width – 3.43 m

Figure 6 Typical Earthworks Vehicle

- Hours of Operation to be as per Cessnock Council's approval for Stage 1 – 7 am to 6 pm (Monday to Friday), 7am to 1 pm (Saturday). No work on Sundays or Public Holidays unless agreed to by the Statutory Approval Authority.
- Two way operation on all roads and turnaround areas.

7.3 Summary of truck movements

The construction staging plans summarises the calculations for the movement of trucks around the site. This includes the assumptions around time to fill. Table 8 outlines the stages where movements have been estimated. The stages which have not been estimated will all include construction vehicles including trucks, graders and excavators.

Table 8 Heavy Vehicle Movements

Construction Stage	Stage Description	No. of Heavy Vehicle Movements estimated
Stage 1	Construct containment cell access road, temporary construction haul roads to proposed stockpile areas, erosion, and sediment control measures.	No
Stage 2	**Relocate stockpiles within containment cell site to nominated stockpile area**	**Yes**
Stage 3	**Excavation and stockpiling of containment cell site to design level subgrade**	**Yes**
Stage 4	Construction of containment cell liner to allow placement of material	No
Stage 5	**Placement of demolition and external stockpiles within containment cell**	**Yes**
Stage 6	**Removal and stockpiling of capped waste stockpile capping material**	**Yes**
Stage 7	**Placement of capped waste stockpile within containment cell**	**Yes**
Stage 8	**Placement of relocated stockpiles from containment cell site**	**Yes**
Stage 9	Placement of final cap for containment cell	Yes
Stage 10	Removal of haul roads and finalising of access road (surfacing)	No

Table 9 summarises the estimates of movements around the site for each stage.

Table 9 Summary of Truck Movements and Durations

Construction Stage	Total No. of Truck Movements (one way)	Estimated Duration to move material	
		4 trucks	6 trucks
2	1,519	5 weeks	3 weeks
3	2,824	10 weeks	7 weeks
5	4,078	20 weeks	13 weeks
6	1,920	6 weeks	4 weeks
7	8,170	30 weeks	20 weeks
8	315	1 week	1 week
9	1,920	6 weeks	4 weeks
TOTAL	**20,746**	**78 weeks (18 months)**	**52 weeks (12 months)**

Please note that this only includes estimates for moving of earthworks and does not include the time for elements particularly around the construction and testing of the liner, approvals and final capping system for the cell.

8. Materials

8.1 Introduction

This section summarises the materials required for the construction of the containment cell and identifies if any materials within the site would be suitable for use for this purpose. It also summarises if not able to be recycled where in the cell the different material should be placed.

8.2 Construction Materials

Table 10 below summarises the materials nominated for use within the design and identifies if potentially they could be sourced from site won material. This would be subject to further testing to confirm suitability and to identify the volumes required and available for the works.

Table 10 Site Won Material Re-use

Description	Potential for site won material	Potential Source
Sediment Detention Basin		
D50 100 mm Rip Rap	Yes	Crushed Demolition Material
Select Fill	Yes	Crushed Demolition Material
Leachate Buffer Storage Dam		
Clay Rich Fill	Yes	Capped Waste Stockpile Capping
Protection Geotextile	No	
2 mm HDPE Textured Geomembrane	No	
Select Fill	Yes	Crushed Demolition Material
Containment Cell Base and Sidewall Liner		
Groundwater Drainage Geocomposite	No	
Sand Drainage Layer	No	
Geosynthetic Clay Liner	No	
2 mm HDPE Geomembrane	No	
Protection Geotextile	No	
Drainage Aggregate	Yes	Crushed Demolition Material
Separation Geotextile	No	
Perimeter Bund		
Select Fill	Yes	Crushed Demolition Material

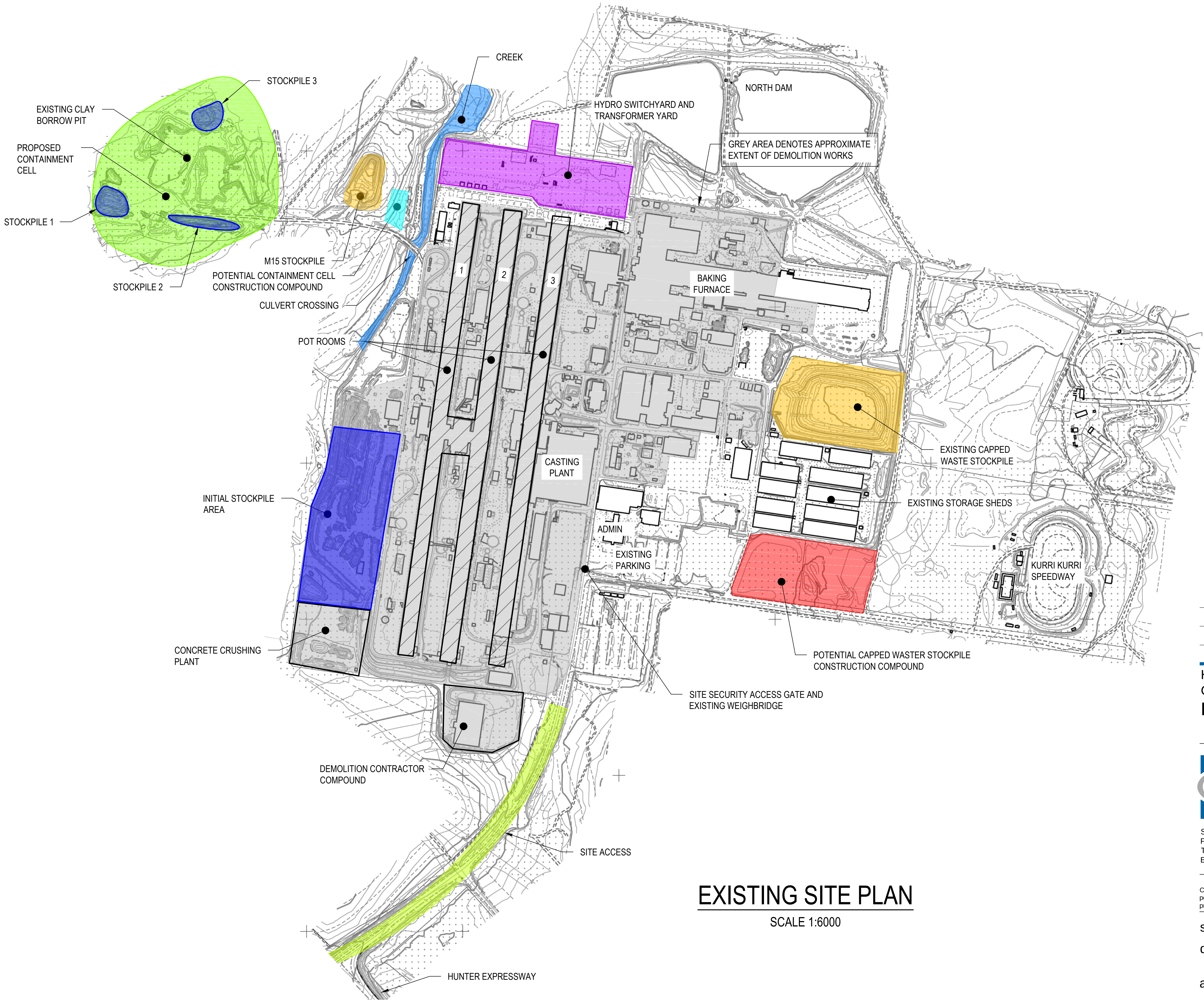
Description	Potential for site won material	Potential Source
Geogrid Geotextile Composite	No	
Geosynthetic Clay Liner	No	
Containment Cell Cap		
Geosynthetic Clay Liner	No	
Seal Bearing Layer	Yes	Capped Waste Stockpile Capping and Clay material below Capped Waste Stockpile
LLDPE Geomembrane	No	
Protective Geotextile	No	
Drainage Aggregate	Yes	Crushed Demolition Material
Separation Geotextile	No	
Subsoil Layer	Yes	Excavated Material from Containment Cell site.
Revegetation and Topsoil Layer	Yes	Excavated material from site – containment cell site or nominated location
Culvert Crossing		
Embankment Fill	Yes	Crushed demolition material
D20 300 mm Rip Rap	Yes	Crushed demolition material
Separation Geotextile	No	
Containment Cell Access Road		
Gravel Wearing Course	No	
Base Course – DGB20	Yes	Crushed demolition material
Select Fill Material	Yes	Crushed demolition material
Temporary Haul Roads		
Road Base – DGB20	Yes	Crushed demolition material

9. Constructability assessment

Appendix B outlines the risk register created to manage the constructability risks discussed as part of this report and within the design meetings on the project.

Appendices

Appendix A – Constructability Sketches



EXISTING SITE PLAN

SCALE 1:6000

PRELIMINARY

rev	description	app'd	date
C	UPDATED WITH COMMENTS	DB	27/07/18
B	FINAL ISSUE	DB	19/10/17

HYDRO ALUMINIUM KURRI KURRI PTY LTD
CONSTRUCTABILITY REVIEW
EXISTING SITE OVERVIEW

GHD

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PO Box 3220 Tuggerah NSW 2259
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E centralcoastmail@ghd.com W www.ghd.com

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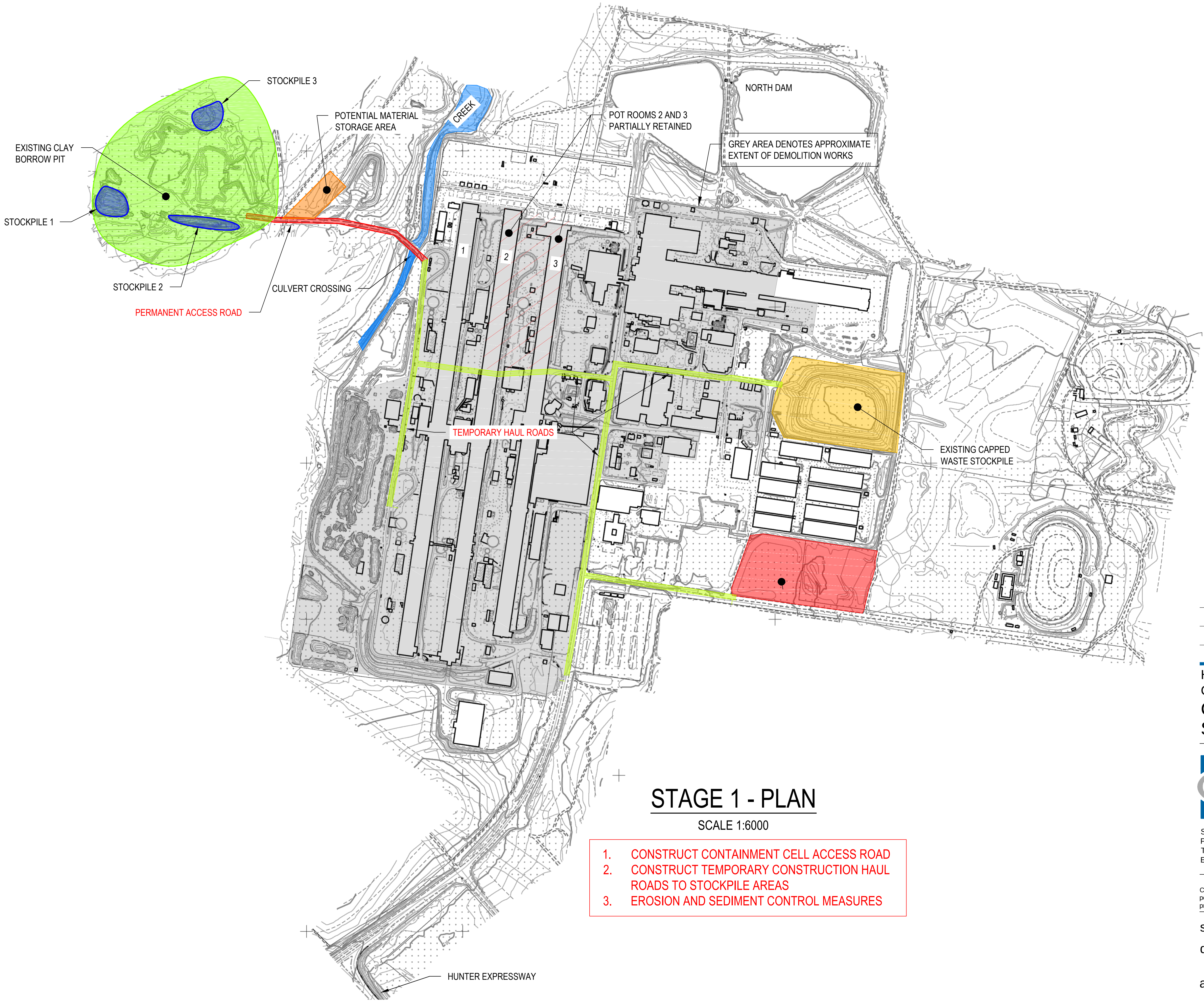
approved (PD) SK001



STAGE 1 - PLAN

SCALE 1:6000

1. CONSTRUCT CONTAINMENT CELL ACCESS ROAD
2. CONSTRUCT TEMPORARY CONSTRUCTION HAUL ROADS TO STOCKPILE AREAS
3. EROSION AND SEDIMENT CONTROL MEASURES

PRELIMINARY

rev	description	app'd	date
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CONSTRUCTABILITY REVIEW

CONSTRUCTION STAGING
STAGE 1

GHD

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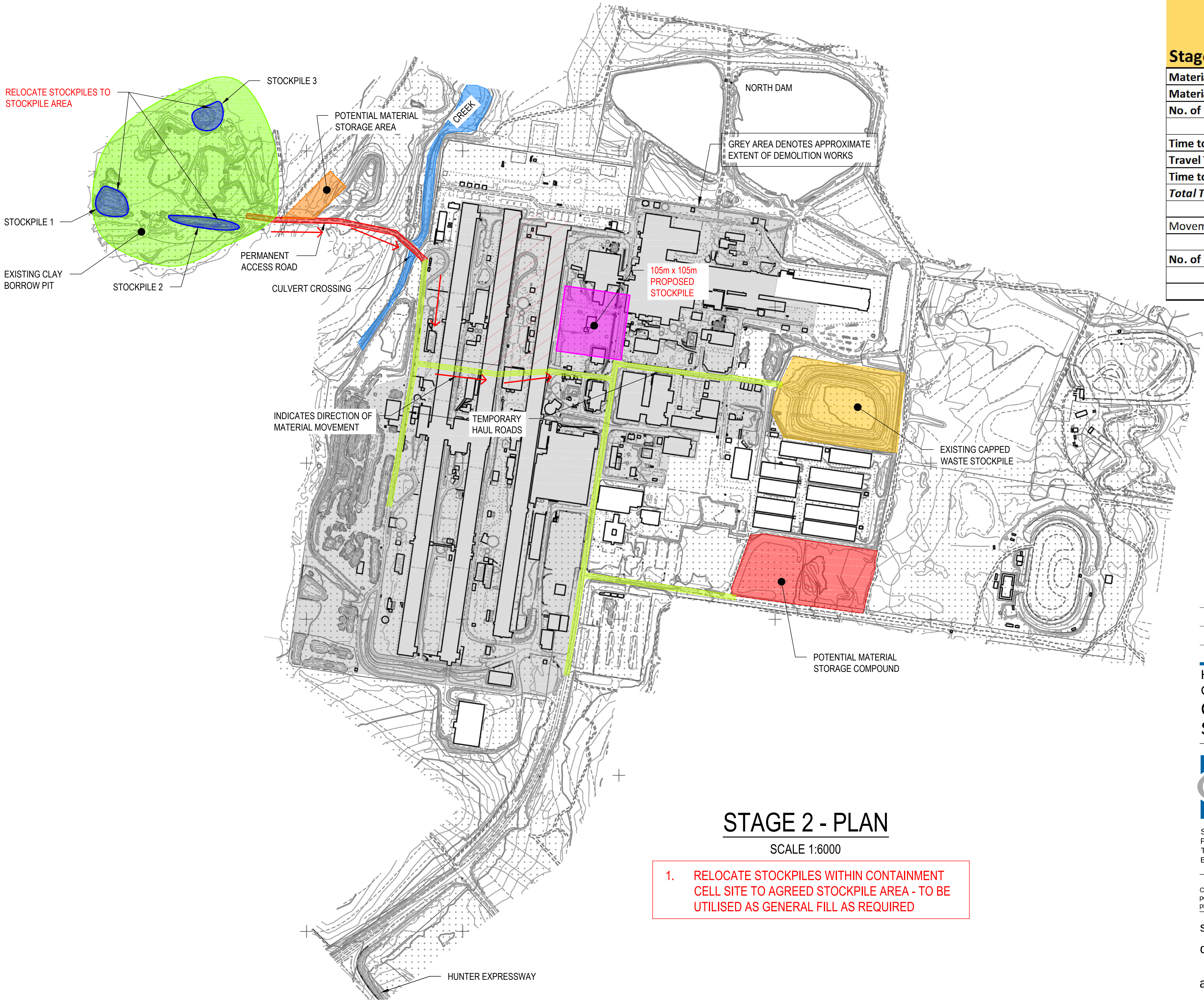

Stage 2	Relocate Stockpiles within Containment Cell Site to Nominated Stockpile	
Material Volume	33,751	m3
Material Weight	60,752	Tonnes
No. of Trucks	1,519	Trucks
Time to Fill	15	minutes
Travel Time	5	minutes
Time to Empty	10	minutes
Total Time	*30*	*minutes*
Movements per day	16	
No. of Trucks	Duration to move material	
4	5	weeks
6	3	weeks

STAGE 2 - PLAN

SCALE 1:6000

1. RELOCATE STOCKPILES WITHIN CONTAINMENT CELL SITE TO AGREED STOCKPILE AREA - TO BE UTILISED AS GENERAL FILL AS REQUIRED

PRELIMINARY

C	UPDATED WITH COMMENTS	DB	27/07/18
B	FINAL ISSUE	DB	19/10/17
rev	description	app'd	date

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CONSTRUCTABILITY REVIEW

CONSTRUCTION STAGING
STAGE 2

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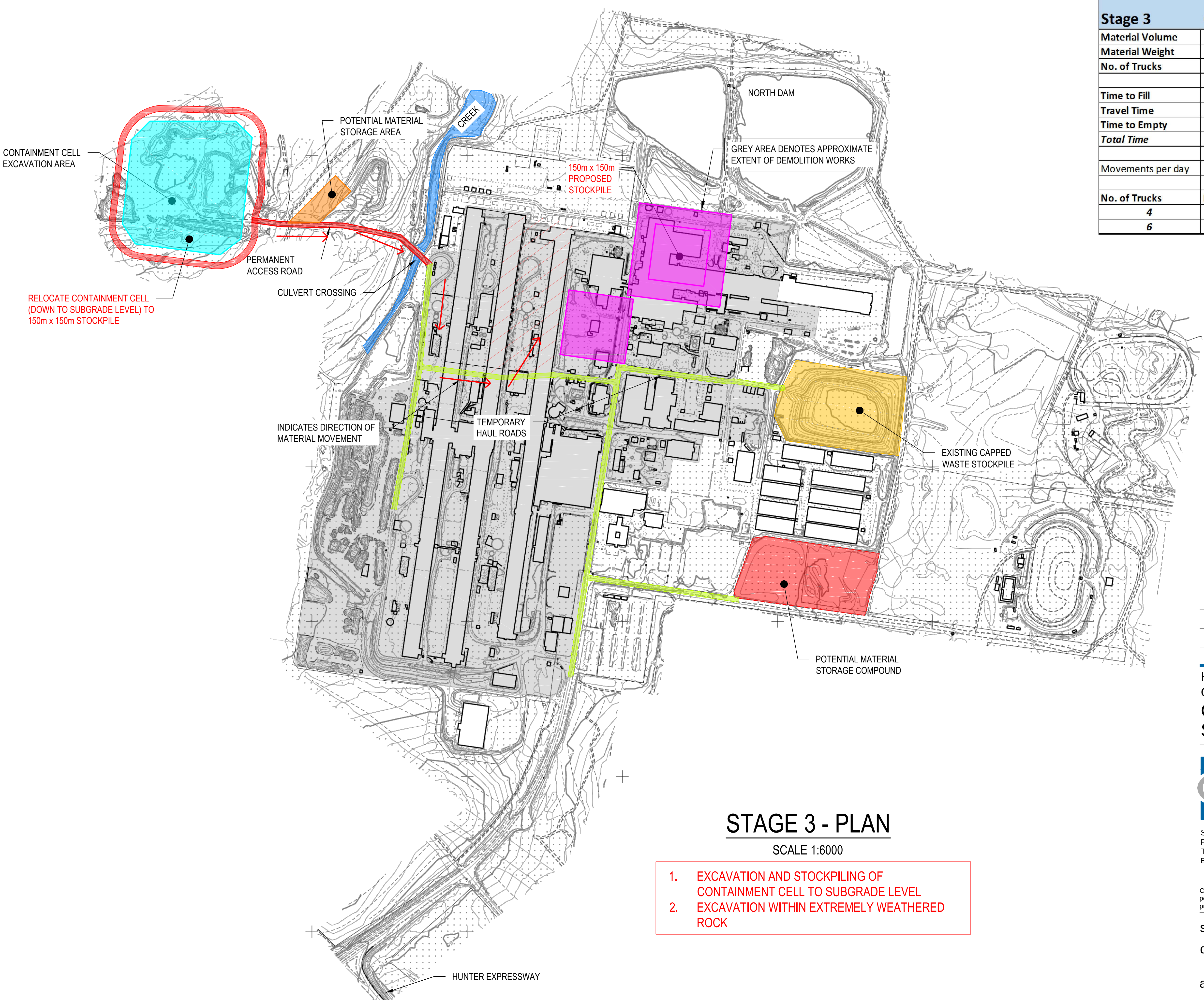
Stage 3	Excavation and Stockpiling of Containment Cell to Subgrade Level	
Material Volume	70,610	m3
Material Weight	112,976	Tonnes
No. of Trucks	2,824	Trucks
Time to Fill	20	minutes
Travel Time	5	minutes
Time to Empty	10	minutes
Total Time	*35*	*minutes*
Movements per day	13.7142857	
No. of Trucks	**Duration to move material**	
4	**10**	weeks
6	**7**	weeks



STAGE 3 - PLAN

SCALE 1:6000

1. EXCAVATION AND STOCKPILING OF CONTAINMENT CELL TO SUBGRADE LEVEL
2. EXCAVATION WITHIN EXTREMELY WEATHERED ROCK

PRELIMINARY

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C	UPDATED WITH COMMENTS	DB	27/07/18
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HYDRO ALUMINIUM KURRI KURRI PTY LTD
CONSTRUCTABILITY REVIEW

CONSTRUCTION STAGING STAGE 3

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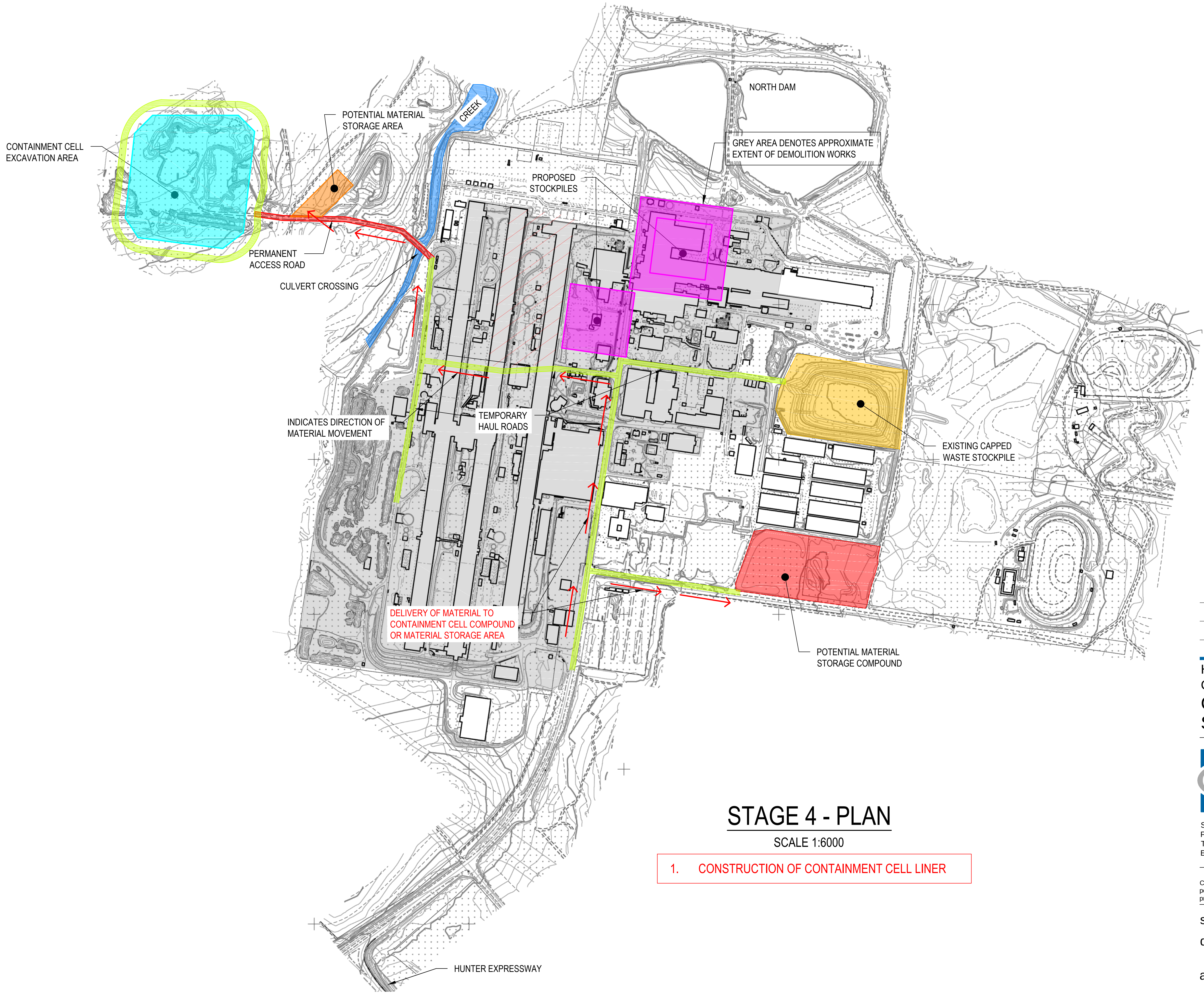

STAGE 4 - PLAN

SCALE 1:6000

1. CONSTRUCTION OF CONTAINMENT CELL LINER

N

PRELIMINARY

rev	description	app'd	date
C	UPDATED WITH COMMENTS	DB	27/07/18
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HYDRO ALUMINIUM KURRI KURRI PTY LTD
CONSTRUCTABILITY REVIEW

CONSTRUCTION STAGING STAGE 4

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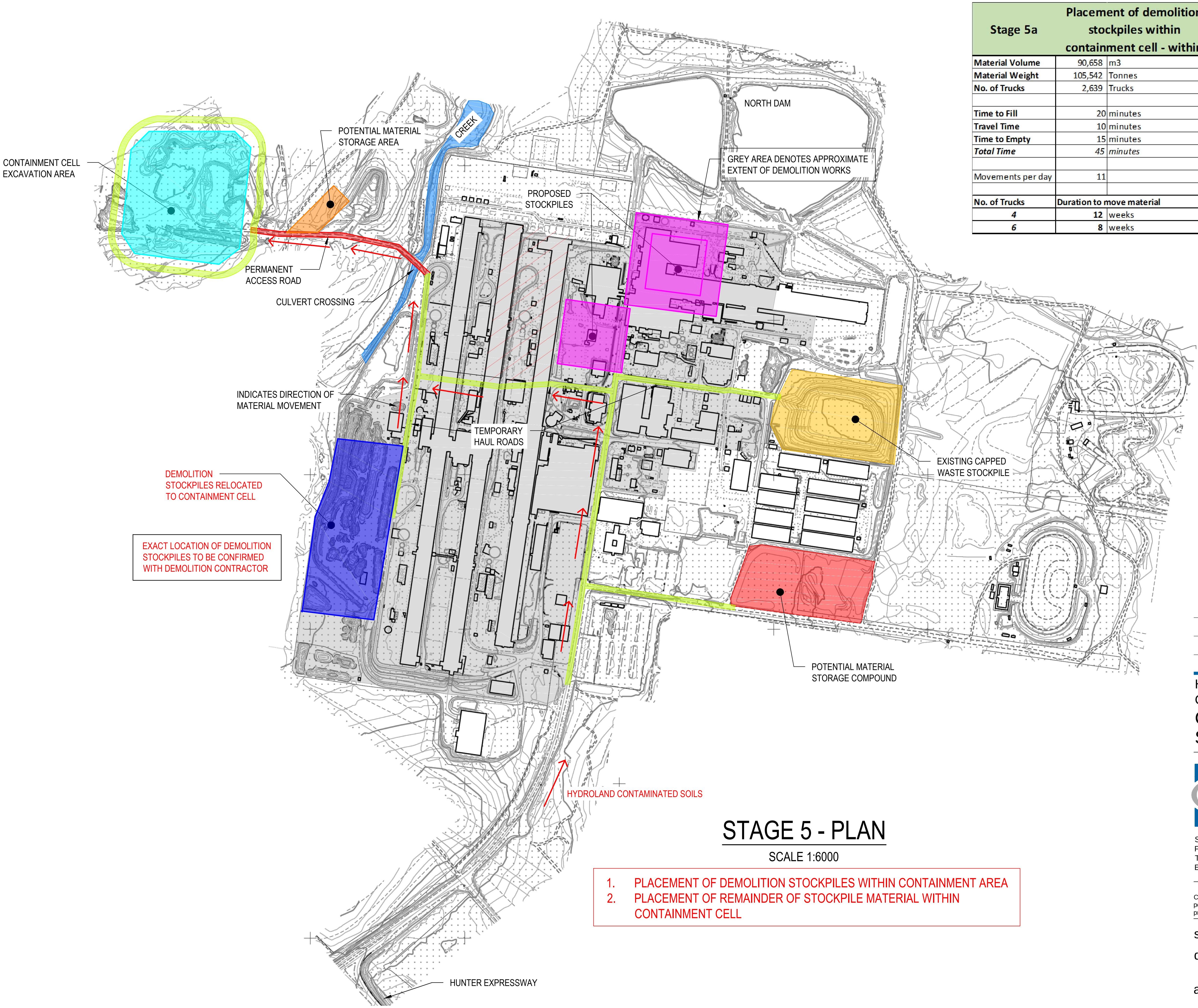
Stage 5a	Placement of demolition stockpiles within containment cell - within		Stage 5b	Placement of stockpiles external to site	
Material Volume	90,658	m3	Material Volume	32,324	m3
Material Weight	105,542	Tonnes	Material Weight	57,574	Tonnes
No. of Trucks	2,639	Trucks	No. of Trucks	1,439	Trucks
Time to Fill	20	minutes	Time to Fill	20	minutes
Travel Time	10	minutes	Travel Time	20	minutes
Time to Empty	15	minutes	Time to Empty	15	minutes
Total Time	*45*	*minutes*	*Total Time*	*55*	*minutes*
Movements per day	11		Movements per day	9	
No. of Trucks	Duration to move material		No. of Trucks	Duration to move material	
4	12	weeks	*4*	8	weeks
6	8	weeks	*6*	5	weeks



STAGE 5 - PLAN

SCALE 1:6000

1. PLACEMENT OF DEMOLITION STOCKPILES WITHIN CONTAINMENT AREA
2. PLACEMENT OF REMAINDER OF STOCKPILE MATERIAL WITHIN CONTAINMENT CELL

PRELIMINARY

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HYDRO ALUMINIUM KURRI KURRI PTY LTD
CONSTRUCTABILITY REVIEW
CONSTRUCTION STAGING
STAGE 5

GHD

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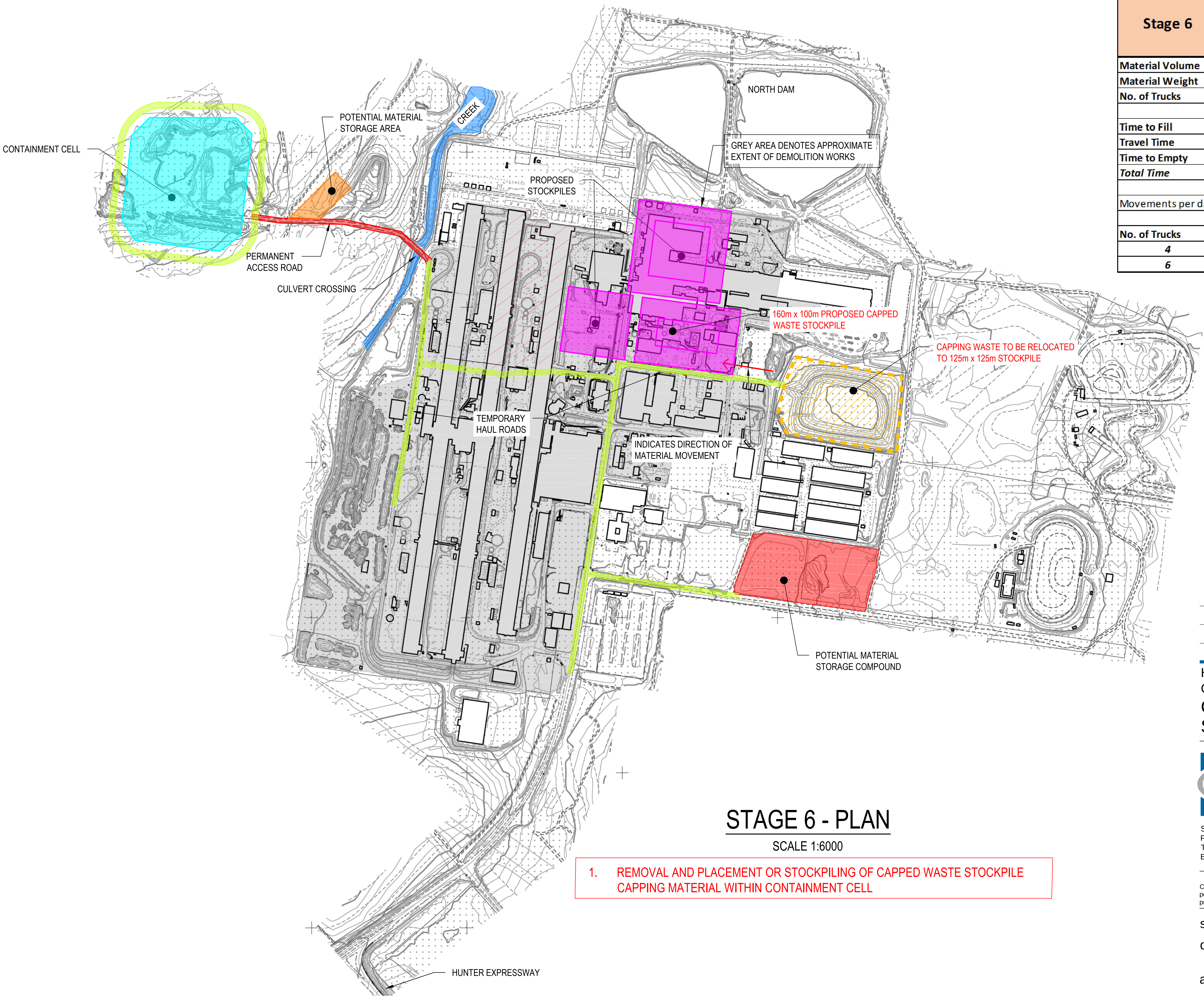
Stage 6	Removal and Stockpiling of Capped Waste Stockpile Capping Material	
Material Volume	48,000	m3
Material Weight	76,800	Tonnes
No. of Trucks	1,920	Trucks
Time to Fill	15	minutes
Travel Time	5	minutes
Time to Empty	10	minutes
Total Time	*30*	*minutes*
Movements per day	16	
No. of Trucks	**Duration to move material**	
4	**6**	weeks
6	**4**	weeks



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PRELIMINARY

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B	FINAL ISSUE	DB	19/10/17

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CONSTRUCTABILITY REVIEW

CONSTRUCTION STAGING STAGE 6

STAGE 6 - PLAN

SCALE 1:6000

1. REMOVAL AND PLACEMENT OR STOCKPILING OF CAPPED WASTE STOCKPILE CAPPING MATERIAL WITHIN CONTAINMENT CELL

GHD
Suite 10, 6 Reliance Drive Tuggerah Business Park
PO Box 3220 Tuggerah NSW 2259
T 61 2 4350 4100 F 61 2 4350 4101
E centralcoastmail@ghd.com W www.ghd.com

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date	JULY 2018		rev no.	C

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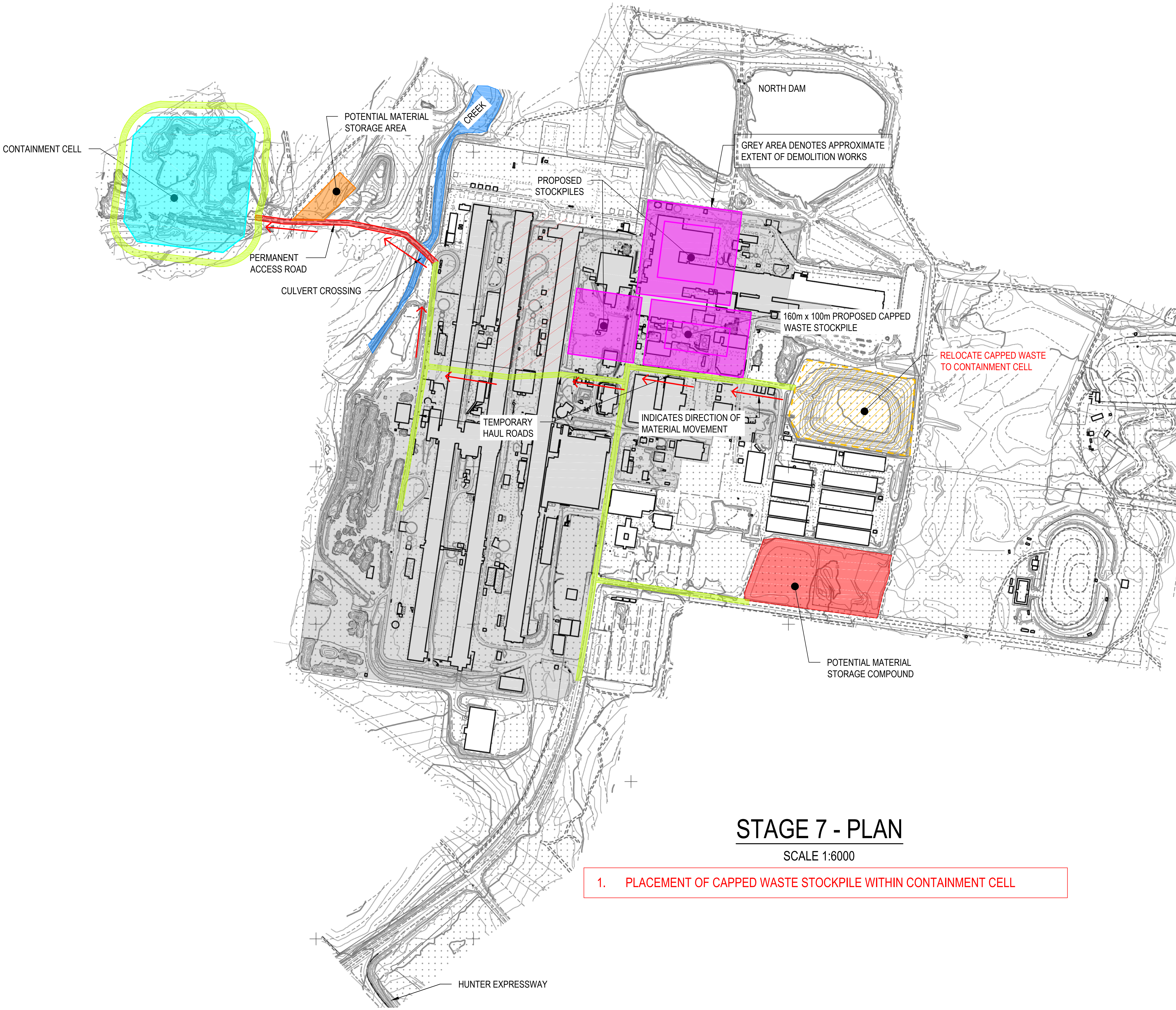
Stage 7	Placement of Capped Waste Stockpile within Containment Cell	
Material Volume	183,491	m3
Material Weight	326,816	Tonnes
No. of Trucks	8,170	Trucks
Time to Fill	10	minutes
Travel Time	10	minutes
Time to Empty	15	minutes
Total Time	*35*	*minutes*
Movements per day	13.7142857	
No. of Trucks	**Duration to move material**	
4	**30**	weeks
6	**20**	weeks



STAGE 7 - PLAN

SCALE 1:6000

1. PLACEMENT OF CAPPED WASTE STOCKPILE WITHIN CONTAINMENT CELL

PRELIMINARY

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C	UPDATED WITH COMMENTS	DB	27/07/18
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HYDRO ALUMINIUM KURRI KURRI PTY LTD
CONSTRUCTABILITY REVIEW

CONSTRUCTION STAGING STAGE 7

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E centralcoastmail@ghd.com W www.ghd.com

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approved (PD) SK070

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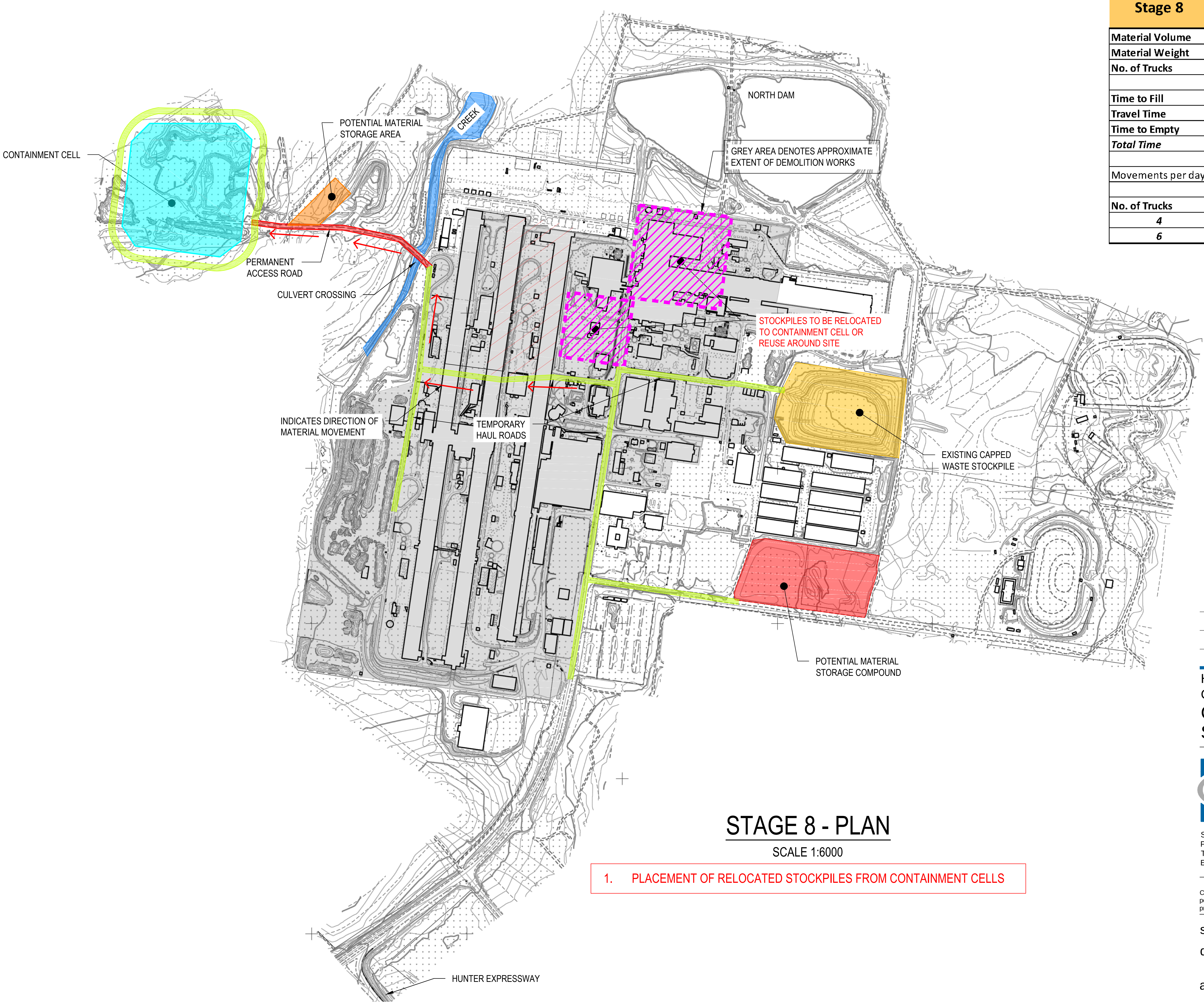
Stage 8	Placement of Relocated Stockpiles from Containment Cells	
Material Volume	6,622	m3
Material Weight	12,611	Tonnes
No. of Trucks	315	Trucks
Time to Fill	15	minutes
Travel Time	5	minutes
Time to Empty	15	minutes
Total Time	*35*	*minutes*
Movements per day	14	
No. of Trucks	Duration to move material	
4	1	weeks
6	1	weeks



STAGE 8 - PLAN

SCALE 1:6000

1. PLACEMENT OF RELOCATED STOCKPILES FROM CONTAINMENT CELLS

PRELIMINARY

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C	UPDATED WITH COMMENTS	DB	27/07/18
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CONSTRUCTABILITY REVIEW
CONSTRUCTION STAGING
STAGE 8

GHD
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PO Box 3220 Tuggerah NSW 2259
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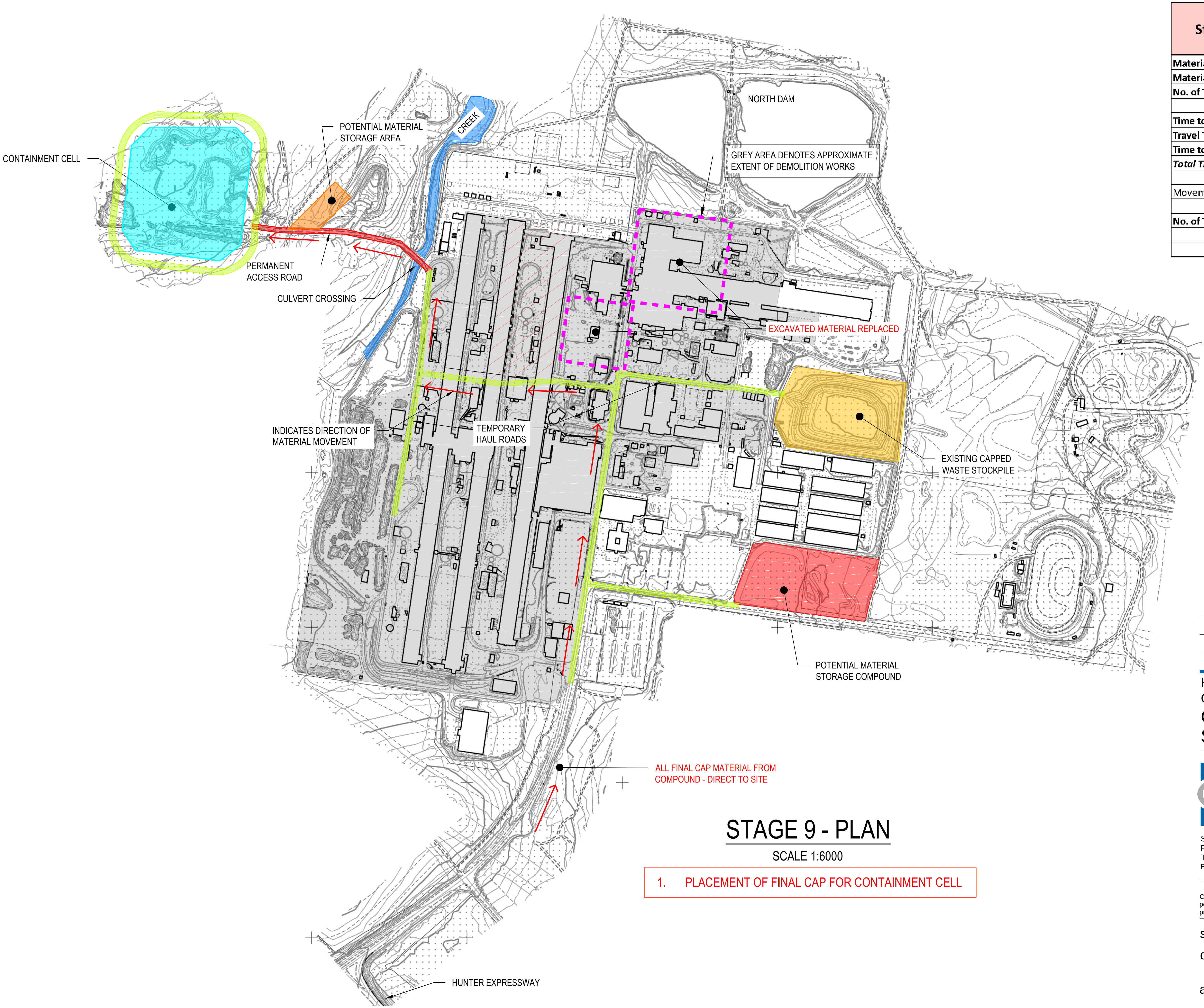
Stage 9	Movement of Capping Material	
Material Volume	48,000	m3
Material Weight	76,800	Tonnes
No. of Trucks	1,920	Trucks
Time to Fill	15	minutes
Travel Time	5	minutes
Time to Empty	10	minutes
Total Time	*30*	*minutes*
Movements per day	16	
No. of Trucks	Duration to move material	
4	6	weeks
6	4	weeks



STAGE 9 - PLAN

SCALE 1:6000

1. PLACEMENT OF FINAL CAP FOR CONTAINMENT CELL

PRELIMINARY

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HYDRO ALUMINIUM KURRI KURRI PTY LTD
CONSTRUCTABILITY REVIEW

CONSTRUCTION STAGING STAGE 9

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date JULY 2018 rev no. C

approved (PD) SK090

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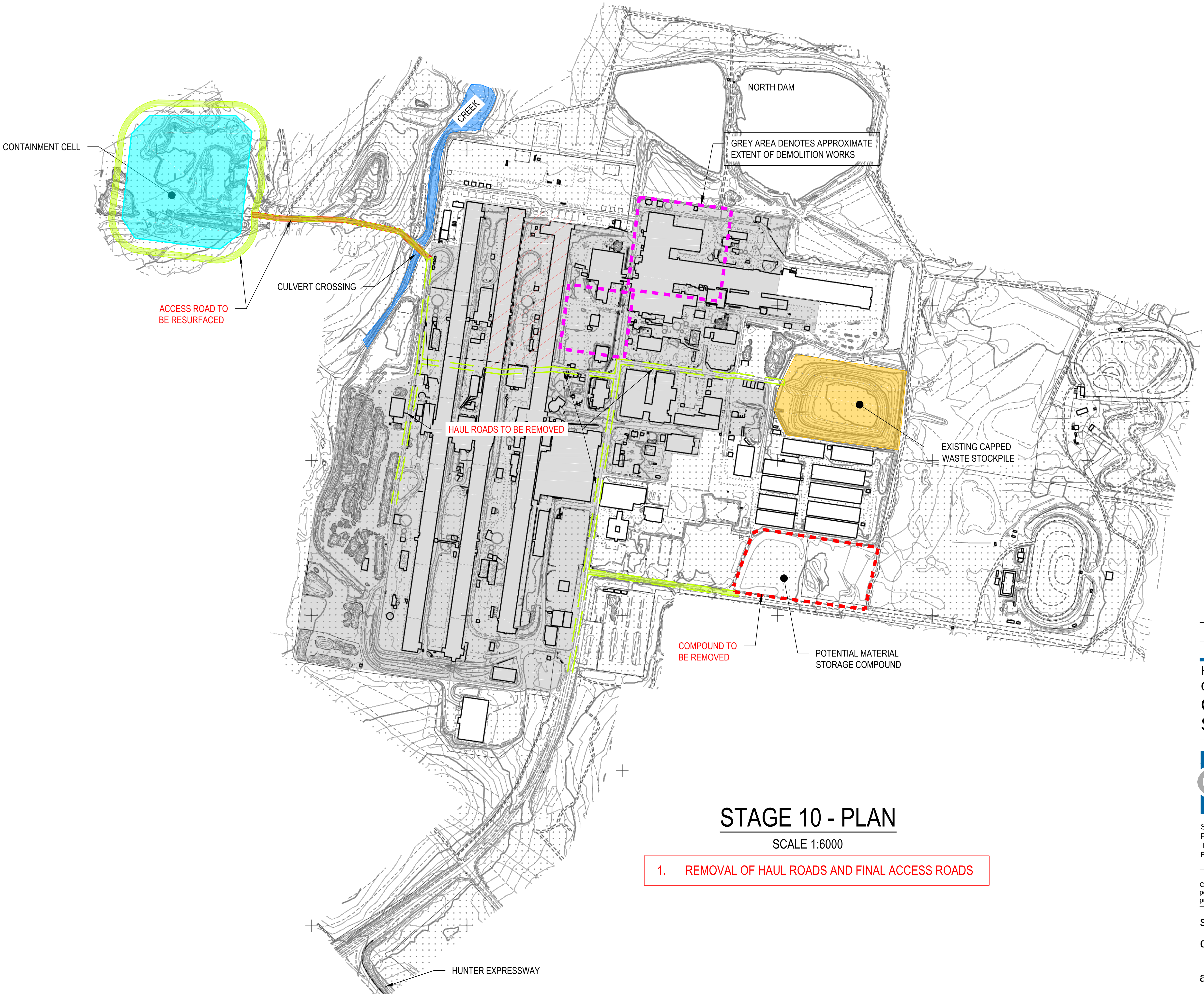

STAGE 10 - PLAN

SCALE 1:6000

1. REMOVAL OF HAUL ROADS AND FINAL ACCESS ROADS

PRELIMINARY

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C	UPDATED WITH COMMENTS	DB	27/07/18
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HYDRO ALUMINIUM KURRI KURRI PTY LTD
CONSTRUCTABILITY REVIEW

CONSTRUCTION STAGING
STAGE 10

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APPENDIX 3
TECHNICAL SPECIFICATION

Hydro Aluminium Kurri Kurri Pty Ltd

Containment Cell Design

Technical Specification

November 2018

Table of contents

Table index

Figure index

Appendices

1. Introduction

1.1 General

This Specification contains the technical requirements for materials and procedures to be implemented for the construction of the containment cell (the Works) at Hydro Aluminium Kurri Kurri (the site) and must be read in conjunction with the other Contract Documents.

Where the Specification and any other Contract Documents do not agree, the Contractor shall seek clarification from the Superintendent.

1.2 Definitions

The following additional terms used in this Specification shall have the meanings ascribed to them below unless the context otherwise requires:

‘Contract’ – The agreement between the Superintendent and Contractor.

‘Contract Drawings’ – The construction drawings which form part of the Contract Documents.

‘Contract Documents’ – The documents which form the Contract.

‘Contractor’ – The person bound to execute the work under the Contract.

‘Contractor’s Independent Testing Firm’ – Independent testing firm(s) engaged by the Contractor to conduct construction quality control (CQC) testing.

‘Construction Quality Assurance (CQA) Engineer’ – Suitably qualified professional responsible for administering the CQA requirements for the Works.

‘Construction Quality Assurance (CQA) Engineer’s Independent Testing Firm’ – Independent testing firm(s) engaged by the CQA Engineer to conduct construction quality assurance testing.

‘Construction Quality Assurance (CQA) Plan’ – Plan forming part of the Contract Documents, describing the construction quality assurance requirements for the Works.

‘ENM’ – Excavated natural material. As defined in the NSW EPA excavated natural material exemption 2014 (http://www.epa.nsw.gov.au/resources/waste/rre14-excavated-natural-material.pdf).

‘Field Crew Foreman’ – Foreman for the Geosynthetic Installer’s field crew, as defined by the Contractor.

‘Geosynthetic’ – Synthetic material (man-made plastic and fabric) used in geotechnical and construction applications.

‘Geosynthetic Installer’ – Firm subcontracted by the Contractor to complete the installation of geosynthetic for the Works.

‘MARV’ – Minimum average roll value.

‘MaxARV’ – Maximum average roll value.

‘PE’ – Polyethylene.

‘Regulatory Authority’ – Authority responsible for licencing the Works.

SBS Bitumen mix -- Styrene-butadiene-styrene: a polymer modifier added to improve the mechanical properties of the bitumen.

‘Seaming Crew’ – Crew responsible for the seaming activities performed by the Geosynthetic Installer, as defined by the Contractor.

‘Seaming Foreman’ – Foreman for the seaming activities performed by the Geosynthetic Installer, as defined by the Contractor.

‘Specification’ – This document.

‘Superintendent’ – As defined in the Conditions of Contract.

‘VENM’ – Virgin excavated natural material. As defined in Schedule 1 of the *Protection of the Environment Operations Act 1997.*

‘Waste’ – Material identified by the Superintendent to be placed in the containment cell.

‘Work under the Contract' – The work which the Contractor is or may be required to execute under the Contract and includes variations, remedial work, constructional plant and temporary works.

‘Works’ – The whole of the work to be executed in accordance with the Contract, including variations provided for by the Contract, which by the Contract is to be handed over to the Superintendent.

‘Works Area’ – As shown on the Contract Drawings.

1.3 Lines of communication

The Superintendent shall be the main point of liaison between the Contractor and the CQA Engineer, as well as the Client.

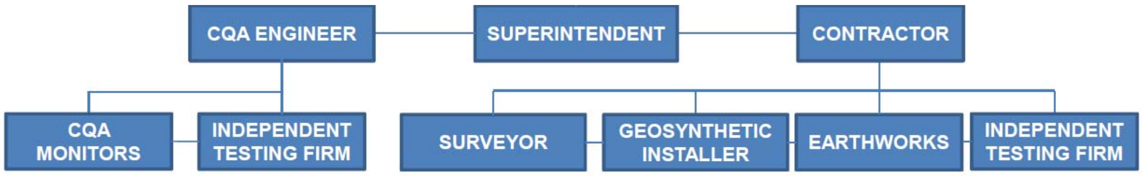

Figure 1 Lines of communication

1.4 Materials

The Contractor shall be responsible for the sourcing, delivery, storage, preparation, handling and installation of all materials, except as modified in individual sections of this Specification.

Material and installation specifications are included in the individual sections of this Specification for each material type.

1.5 Sequencing and scheduling

The Contractor shall be responsible for sequencing the installation of all materials, including surveys, testing and field trials.

In general, installation sequencing shall proceed from higher elevations to lower elevations to prevent precipitation runoff from flowing into and/or below installed products.

Individual components shall not be covered with the subsequent component until the underlying component has been accepted by the Superintendent.

1.6 Construction program

The Contractor shall prepare a program for the Works.

1.7 Submittals

Submittals for each material are included in the individual chapters of this Specification. Each submittal shall be submitted alongside the relevant submittal forms found in Appendix B.

The following pre-qualification submittals are required to be submitted by the Contractor for approval by the Superintendent.

Note: This technical specification only covers some of the technical submittals required under the Contract.

1.7.1 Pre-qualification of the Geosynthetic Installer

Prior to construction, the Contractor shall provide a list documenting completed facilities for which the Geosynthetic Installer has completed the installation of a geosynthetic systems similar to this Specification. For each facility, the following information shall be provided:

- The name and purpose of the facility, its location, and the date of installation
- The name of the owner, project manager, designer, manufacturer, and fabricator (if any)
- If requested, the name and telephone number of a reference contact at the facility who can discuss the project
- The name and qualifications of the supervisor(s) of the installer's crew(s)
- The type(s) of seaming, patching, and tacking equipment
- Any available information on the performance of the geosynthetic systems at the facility

The Contractor shall also provide:

- Certification indicating an approval or licence from the proposed geosynthetic manufacturers for the Contractor to install the manufacturer's materials.
- Certification that the Geosynthetic Installer's Field Crew Foreman has a minimum of 200 hectares of actual geosynthetic installation experience and a minimum of 100 hectares of supervisory experience for geosynthetic installation on a minimum of 10 different projects.
- Certification that the Geosynthetic Installer's Seaming Foreman is an International Association of Geosynthetic Installer's Certified Welding Technician and has a minimum of 100 hectares of actual geosynthetic seaming experience and a minimum of 50 hectares of supervisory experience during the seaming of geosynthetic materials.
- Certification that each individual on the Geosynthetic Installer's Seaming Crew has a minimum of 10 hectares of geosynthetic seaming experience and a minimum of 5 hectares of seaming experience with geosynthetics similar to this Specification. This condition may be relaxed at the discretion of the Superintendent to allow training of installation staff.

1.7.2 Pre-qualification of the Contractor's Independent Testing Firm

Prior to construction, the Contractor shall provide a listing of qualifications for the proposed Contractor's Independent Testing Firms(s) and its key personnel who shall perform the work described in this Specification. The Contractor's Independent Testing Firms(s) shall be National Association Testing Authorities (NATA) accredited and proof of accreditation shall be maintained throughout the duration of the Works. All site subcontractors and key suppliers (quarry material, HDPE, Bix culverts) will require to be approved by the Superintendent prior to engagement.

A listing of testing apparatus and testing standards typically performed by the testing firm shall be provided along with a letter stating that the testing firm is independent and has no financial interest in the Contractor, the Geosynthetic Installer or any of the manufacturers/suppliers that are providing materials for the Works.

1.7.3 Construction program

Refer Section 1.6.

1.7.4 Construction quality control plan

Refer Section 1.8.

1.8 Construction quality control

All construction quality control (CQC) testing shall be arranged by the Contractor and shall be carried out by the Contractor's Independent Testing Firm. Unless noted otherwise, copies of all test results shall be sent to the Superintendent as soon as available. The minimum testing frequencies shall be as nominated within this Specification.

1.9 Construction quality assurance

1.9.1 General

A Contractor's Quality Assurance plan is to be developed by the Contractor, and approved by the Superintendent and the CQA Engineer, and shall be the SOLE document for QA guidance and conformance. The Quality Assurance (QA) Plan is to be developed in conjunction with this Specification and shall be implemented by the Contractor to verify that the Works are undertaken in a manner that meets the requirements of the Contract Documents.

The Superintendent shall engage an independent organisation (the CQA Engineer), under contract to the Superintendent, who shall oversee the requirements of quality assurance for the Project.

The Contractor shall cooperate fully with the Superintendent and the CQA Engineer during any sampling, testing, and certification.

1.9.2 Independent conformance testing

The CQA Engineer may arrange for independent conformance testing of the materials used in the Works. Samples shall be collected at locations designated by the CQA Engineer and all independent conformance sampling shall be witnessed by the CQA Engineer. Where sampling of geosynthetics is necessary, the sampling shall be undertaken by the Geosynthetic Installer from the relevant materials for the independent conformance testing of the material. The Contractor shall make a suitable allowance for this testing within their construction program.

The sample frequency shall be in accordance with Table 1-1 . The table also identifies the indicative sample size. The sample sizes shall be confirmed by the CQA Engineer prior to construction. Sampling shall include the first and last roll. The specified frequency assumes all rolls are from a single manufacturing run. If rolls are from different manufacturing runs then the frequency shall be applied to each manufacturing run. The test frequency for all rolls where, in the opinion of the CQA Engineer, the manufacturing run cannot be identified shall be every roll for all test types. Samples shall not be taken from the outer wrap of the roll.

Table 1-1 Independent sample size and frequency schedule

Material	Indicative size	Frequency
Geonet drainage composite	1 metre by roll width	TBC
Sand drainage layer	20 kg bucket	TBC
Geosynthetic clay liner	1 metre by roll width	TBC
PE geomembrane	1 metre by roll width	TBC
Geotextile	1 metre by roll width	TBC
Drainage aggregate	20 kg bucket	TBC

If a sample records a non-conforming test result, it may be re-tested. If it passes this retest, both results shall be provided in the laboratory report from the relevant independent testing firm. If the retest produces a non-conforming test result, the Contractor shall remove and replace all rolls between the sampled roll and the nearest conforming rolls either side (based on the production order of the rolls). The Contractor may, by testing and verification of these intermediate rolls, reduce the range of rolls to be removed in this way. Such additional testing shall be for the full range of specified tests, not just the test or property which yielded a failure.

In the event of discrepancies between the CQA Engineer's test results and the Contractor's test results, the Contractor shall be responsible for arranging a third independent testing firm to verify the test results.

Any replacement material shall receive the independent conformance testing, in accordance with the CQA Plan.

1.10 Work method statements for the Containment Cell works

Prior to the commencement of each type of work, the Contractor shall submit to the Superintendent work method statements that detail how the work is to be carried out and the plant and equipment proposed.

Appendix A contains a schedule of activities for which the Contractor shall produce work method statements for the Containment Cell works.

1.11 Survey requirements

Prior to commencing construction, the Contractor shall establish a survey grid over the Works footprint. The survey grid shall be a maximum 10 m spacing over the Works footprint, as well as any locations at which there is a change or break in grade and set out points identified on the Contract Drawings. The elevation of excavated surfaces and placed materials shall be recorded at these grid locations.

Survey data shall be provided to the Superintendent in graphical and tabular formats. All survey shall be to MGA and levels shall be based on Australian Height Datum (AHD).

Table 1-2 contains a schedule of survey requirements for the Works.

Table 1-2 Survey requirements

Component	Survey requirements
Bulk earthworks	Following completion of clearing and grubbing works, survey the elevation of the completed surface at all grid locations and at any changes in grade.
Access roads	Following completion of the works, survey the levels and alignments at maximum 10 m spacing and at any changes in grade.
Containment cell excavated surface	Following completion of excavation works, survey the elevation of the completed surface at all grid locations and at any changes in grade.
Containment cell subgrade surface (including external bunds)	Following completion of filling works, survey the elevation of the completed surface at all grid locations and at any changes in grade.
Clay rich fill layer	Following placement of the clay rich fill layer, survey the elevation of the completed layer at all grid locations and at any changes in grade. A conformance survey shall also be provided (with consideration to the surveyed elevations of the underlying surface) showing conforming layer thickness within the allowable tolerances.
Sand drainage layer	Following installation of the sand drainage layer, survey the elevation of the completed surface at all grid locations and at any changes in grade. A conformance survey shall also be provided (with consideration to the surveyed elevations of the underlying surface) showing conforming layer thickness within the allowable tolerances.
Internal bunds	Following installation of the internal bunds, survey the elevation of the completed surface at all grid locations and at any changes in grade.
Drainage aggregate layer	Following installation of the drainage aggregate layer in the base of the containment cell, survey the elevation of the completed surface at all grid locations and at any changes in grade. A conformance survey shall also be provided (with consideration to the surveyed elevations of the underlying surface) showing conforming layer thickness within the allowable tolerances.
Soil confining layer	Following installation of the soil confining layer on the sidewalls of the containment cell, survey the elevation of the completed surface at all grid locations and at any changes in grade. A conformance survey shall also be provided (with consideration to the surveyed elevations of the underlying surface) showing conforming layer thickness within the allowable tolerances.
Leachate drainage pipes	Following installation of the leachate drainage pipes, survey the levels and alignments of all pipework at maximum 10 m spacing and at any changes in grade.
Leachate storage pond subgrade	Following completion of excavation and filling works, survey the elevation of the completed surface at all grid locations and at any changes in grade.
Progressive waste heights	On a weekly basis, survey the elevation of the waste material at all grid locations and at any changes in grade.
Sediment detention basins subgrade	Following completion of excavation and filling works, survey the elevation of the completed surface at all grid locations and at any changes in grade.
Surface water drains	Following completion of the surface water drains, survey the levels and alignments of drain inverts at maximum 10 m spacing and at any changes in grade or structure type.

Component	Survey requirements
Completed waste surface	Following completion of landfilling works, survey the elevation of the completed surface at all grid locations and at any changes in grade.
Recycled drainage aggregate layer	Following placement of the layer, survey the elevation of the completed layer at all grid locations and at any changes in grade. A conformance survey shall also be provided (with consideration to the surveyed elevations of the underlying surface) showing conforming layer thickness within the allowable tolerances.
Subsoil	Following placement of the layer, survey the elevation of the completed layer at all grid locations and at any changes in grade. A conformance survey shall also be provided (with consideration to the surveyed elevations of the underlying surface) showing conforming layer thickness within the allowable tolerances.
Topsoil	Following placement of the layer, survey the elevation of the completed layer at all grid locations and at any changes in grade. A conformance survey shall also be provided (with consideration to the surveyed elevations of the underlying surface) showing conforming layer thickness within the allowable tolerances.
Landfill gas system trenches	Following completion of the landfill gas system trenches, survey the levels and alignments of the invert at maximum 10 m spacing and at any changes in grade.
Landfill gas system bores and landfill gas monitoring bores	Following completion of the landfill gas system bores and landfill gas monitoring bores , survey the locations.

1.12 Witness and hold points

The following information applies to witness and hold points for the Works:

- A hold point is a defined position in the Works beyond which work shall not proceed without mandatory verification and acceptance by the Superintendent
- A witness point is a nominated position in the Works where the option of attendance may be exercised by the Superintendent, after notification of the requirement
- It shall be the Contractor's responsibility to ensure that all obligations are fulfilled in regards to the witness and hold points within the Contract
- The Contractor shall give the Superintendent a minimum 2 days notice prior to the required inspection
- Where the witness or hold point relates to the condition of a surface or installed material, the Contractor shall verify that the completed surface has achieved full conformance with the Contract Documents
- Witness or hold points may be released for part of the Works Area only, as defined by the Superintendent, so that the Works can be completed in a sequenced manner. The Superintendent's approval of the completed items is required prior to the release of each witness or hold point.

Table 1-3 contains a list of activities to which witness and hold points apply.

Table 1-3 Witness and hold points

Item	Description	Witness	Hold
1	General		
	Provision of required pre-construction submittals, including general work method statements, management plans and details of proposed testing firm(s)		✓
2	Bulk earthworks		
	Provision of required submittals prior to delivery and placement of fill materials		✓
	Survey following completion of clearing and grubbing works		✓
	Inspection of finished surface		✓
2	Subgrade		
	Provision of required submittals prior to delivery and placement of fill materials		✓
	Survey following completion of clearing and grubbing works		✓
	Results of CQC results	✓	
	Inspection of finished surface		✓
3	Clay rich fill		
	Provision of required submittals prior to placement of clay rich fill		✓
	Results of CQC results	✓	
	Inspection of finished surface		✓
3	Geonet drainage composite		
	Provision of required submittals prior to delivery and placement		✓
	Results of CQC results	✓	
	Inspection of finished surface	✓	
4	Sand drainage layer		
	Provision of required submittals prior to delivery and placement		✓
	Results of CQC results	✓	
	Inspection of finished surface		✓
5	Geosynthetic clay liner		
	Provision of required submittals prior to delivery and placement		✓
	Results of CQC results	✓	
	Inspection of finished surface	✓	
6	PE geomembrane		
	Provision of required submittals prior to delivery and placement		✓
	Results of CQC results	✓	
	Inspection of finished surface		✓
7	Geotextile		
	Provision of required submittals prior to delivery and placement		✓
	Results of CQC results	✓	
	Inspection of finished surface	✓	
8	Drainage aggregate		

Item	Description	Witness	Hold
	Provision of required submittals prior to delivery and placement of materials		✓
	Results of CQC results	✓	
	Inspection of finished surface	✓	
9	PE pipework		
	Provision of required submittals prior to delivery and placement of materials		✓
	Results of CQC results	✓	
10	Soil confining layer		
	Provision of required submittals prior to delivery and placement of materials		✓
	Results of CQC results	✓	
	Inspection of finished surface	✓	
11	Waste placement		
	Survey following completion of clearing and grubbing works		✓
	Placement of waste fill	✓	
	Inspection of finished surface		✓
12	Seal bearing layer		
	Provision of required submittals prior to delivery and placement of fill materials		✓
	Survey following completion of seal bearing layer		✓
	Results of CQC results	✓	
	Inspection of finished surface		✓
13	Revegetation layer		
	Provision of required submittals prior to delivery and placement of fill materials		✓
	Survey following completion of seal bearing layer		✓
	Results of CQC results	✓	
	Inspection of finished surface		✓
14	Field Trials		
	Prior to conducting field trials, provision of submittals identified in Section 16.2.1 and Section 17.2.1		✓
	Field trial being undertaken	✓	
	Following completion of the field trials, provision of submittals identified in Section 16.2.2 and Section 17.2.2		✓
15	Stormwater Drainage		
	Completion of trench excavation, before placing Bed Zone material		✓
	Completion of laying and jointing, before placing Haunch Zone material		✓
	Inspection of trench prior to back filling	✓	
	Completion of formwork and reinforcement in stormwater drainage structures, before placing concrete		✓
16	Concrete		
	Completion of excavation and prior to placement of formwork and reinforcement		✓
	Completion of formwork, reinforcement and other embedded items, before placing concrete		✓
	At Completion of formwork Stripping	✓	

Item	Description	Witness	Hold
17	Pavements		
	Proof rolling of subgrade	✓	
	Placement of subbase course		✓
	Placement of base course		✓
	Placement of wearing course		✓
18	Rock Mattresses and / or Rock Fill		
	Completion of trimming area before placing geotextile and rock fill		✓
	Inspection of completed Rock Mattresses and / or rock fill		✓
21	Landfill gas system		
	Provision of required submittals prior to delivery and placement		✓
	As built-survey of landfill gas system		✓
	Inspection of finished system		✓
22	*Services*		
	Completion of trench excavation, before placing bed zone material		✓
	Installation of electrical and communications cable pits, before laying conduits	✓	
	Completion of laying each layer of electrical and communications conduits, before refilling	✓	

1.13 Works as Executed Drawings

The Contractor shall provide one (1) set of Works as Executed Drawings, which shall include all corrections and as-constructed information done in a professional draftsman-like manner. All Works as Executed Drawings shall be certified by a Registered Surveyor.

The following Works as Executed Drawings shall be prepared as a minimum:

- Surface contours following clearing and grubbing
- Surface contour following construction of access roads
- Surface contours of the completed subgrade
- Surface contours of the completed sand drainage layer
- Surface contours of the completed drainage aggregate layer
- Surface contours of the completed soil confining layer
- Surface contours of the completed clay rich fill layer
- Plans detailing the progression of the containment cell as per survey requirements.
- Alignment and levels of all pipework, drains and culverts
- Final contours of landfilled waste
- Surface contours of completed recycled aggregate layer
- Surface contours of completed seal bearing layer
- Surface contours of completed revegetation layers
- Alignment, locations and levels of all gas management system infrastructure including gas monitoring bores including logs

All Works as Executed Drawings shall include test locations, showing as a minimum the approximate location, identification number, date sampled and type of testing completed.

2. Earthworks

2.1 General

This section contains the technical requirements for earthworks.

The Superintendent may reject any earthworks that do not meet or exceed the requirements of this section.

Any earthworks rejected by the Superintendent shall be remediated by the Contractor.

2.2 Standards

2.2.1 Australian standards

Relevant Australian standards are as follows but not limited to:

- 1152 Specification for test sieves
- 1289 Methods of testing soils for engineering purposes
- 1289.2.1.1 Determination of the moisture content of a soil - oven drying method
- 1289.3.1.1 Soil classification tests - Calculation of the plasticity index of a soil
- 1289.3.6.1 Soil classification tests - Determination of the particle size distribution of a soil - Standard method of analysis by sieving
- 1289.3.6.3 Soil classification tests - Determination of the particle size distribution of a soil - Standard method of fine analysis using a hydrometer
- 1289.3.8.1 Soil classification tests - Dispersion - Determination of emerson class number of a soil
- 1289.5.1.1 Soil compaction and density tests - Determination of the dry density/moisture content relation of a soil using standard compactive effort
- 1289.5.6.1 Soil compaction and density tests - Compaction control test - Density index method for a cohesionless material
- 1289.5.7.1 Soil compaction and density tests - Compaction control test - Hilf density ratio and Hilf moisture variation (rapid method)
- 1289.5.8.1 Soil compaction and density tests - Determination of field density and field moisture content of a soil using a nuclear surface moisture density gauge
- 1289.6.7.2 Determination of the permeability of a soil - Falling head method for a remoulded specimen
- 1289.6.7.3 Determination of the permeability of a soil - Constant head method using a flexible wall permeameter
- 1726 Geotechnical site investigations
- 2868 Classification of machinery for earthmoving, construction, surface mining and agricultural purposes
- 3798 Guidelines on earthworks for commercial and residential developments
- 4419 Soil for landscaping and garden use

2.3 Submittals

2.3.1 Prior to delivery and placement of fill material

The Contractor shall submit the following to the Superintendent for review and approval prior to placement of each type of fill material:

- Certification that the material is VENM or ENM or NSW EPA Resource Recovery Exemption appropriate for use as fill material
- Pre-qualification test results/reports demonstrating that the material complies with the relevant material property requirements of this Specification
- Survey of the underlying surface in accordance with Section 1.11
- Work method statement(s) for the placement of the fill material, including testing and repair procedures (refer Appendix A)

Note: This technical specification only covers some of the technical submittals required under the Contract.

2.3.2 Following completion of earthworks

The Contractor shall submit the following to the Superintendent for review and approval following completion of earthworks (per layer and/or segment):

- As-built survey of the completed surface/s showing conforming layer thickness within the allowable tolerances
- CQA testing results/reports showing compliance with the requirements of this Specification
- Defect and repairs log, showing details of all defects identified and any repairs completed

2.4 Materials

2.4.1 Unsuitable material

Fill material shall not contain any of the following:

- Organic soils, such as top soils, severely root-affected subsoils and peat, except where used for revegetation layers
- Materials contaminated through past site usage which may contain toxic substances or soluble compounds harmful to water supply or agriculture
- Materials containing substances that can be dissolved or leached out in the presence of moisture, or which undergo volume change or loss of strength when disturbed and exposed to moisture
- Materials which may be detrimental to the lining material
- Silts or materials that have the deleterious engineering properties of silt
- Materials containing fire ant infestation/s
- Fill that contains wood, metal, plastic, boulders or other deleterious material
- Actual or potential acid sulphate soils (ASS)
- High plasticity clays
- Material susceptible to combustion

2.4.2 Select fill

Select fill material shall:

- Be selectively sourced material from on-site
- Not contain any unsuitable materials identified in Section 2.4.1 unless accepted by the Superintendent
- Be well graded in accordance with AS 1726
- Comply with the acceptance criteria specified in Table 2-1.

The Contractor shall supply pre-qualification testing results in accordance with the testing frequencies identified in Table 2-1 showing that the proposed material meets the requirements of this table. Samples taken shall be representative of the whole material source and shall be evenly distributed across the material source.

If required by the Superintendent, a sample of the material shall be provided (per source) and the Superintendent and/or CQA Engineer may undertake an inspection of the material source.

Table 2-1 Acceptance criteria – select fill

Property	Test method	Acceptance criteria	Minimum test frequency
Particle size distribution: - Passing 19 mm - Passing 0.075 mm	AS 1141.11,12,13 or AS 1289.3.6.1, 3.6.3	100% > 25%	Greater of: 1 per 5,000 m^3 of material or 3 per source
Atterberg limits: - Plasticity index - Liquid limit	AS 1289.3.1.1, 3.2.1 & 3.3.1	8 – 35 ≤ 50	Greater of: 1 per 5,000 m^3 of material or 3 per source
California Bearing Ratio (CBR)	AS1289.5.7.1	≥ 5	Greater of: 1 per 5,000 m^3 of material or 3 per source
Emerson class	AS 1289.3.8.1	> 3	Greater of: 1 per 5,000 m^3 of material or 3 per source

2.5 Lines and levels

All earthworks shall be to the lines and levels shown in the Contract Drawings.

Earthworks shall be trimmed to line and level by machine and/or hand as necessary to produce profiles to the tolerances required.

2.6 Clearing and grubbing

The Contractor shall undertake all clearing and grubbing necessary to execute the Works including all vegetation, both living and dead, all minor man-made structures (such as fences and livestock yards), all rubbish and other materials which, in the opinion of the Superintendent, are unsuitable for use in the Works, the chipping of the crowns of trees and the branches of shrubs, and the grubbing of trees and stumps from the Works Area.

2.7 Excavation

Excavation shall consist of all excavation required to complete the Works unless separately designated.

Material that is unsuitable for use shall be excavated and disposed by the Contractor as directed by the Superintendent.

2.8 Filling

Filling includes all operations associated with the preparation of the Works on which fill material to be placed and the placing and compacting of approved fill material to the alignment, grading and dimensions shown on the Contract Drawings, including any pre-treatment such as breaking down, blending or drying out material containing excess moisture.

All fill shall be placed, spread, mixed, watered and compacted in accordance with the Specification.

The ground surface prepared to receive fill shall be firm and unyielding. This shall be determined by undertaking compaction testing and roll testing.

Prior to filling, the ground surface shall be scarified, disked, or bladed until it is uniform and free from uneven features which may prevent uniform compaction. The scarified ground surface shall then be brought to appropriate moisture content, mixed as required and compacted. If the scarified zone is greater than 300 mm in depth, the excess shall be removed and placed in compacted lifts not greater than 200 mm compacted thickness, unless otherwise specified.

Unless otherwise specified, fill material shall be placed in thin lifts with a maximum compacted lift thickness of 200 mm. Each lift shall be spread evenly and thoroughly mixed to obtain a near uniform condition in each lift. In areas of excess lift thickness, regrading of the surface to the maximum lift thickness shall be completed prior to construction of additional lifts.

Handling and spreading of all fill material shall produce a gradation of the materials when compacted to comply with this Specification.

All fill materials shall be placed in such a manner that the distribution and gradation of the materials throughout will be such that the fill will be free from lenses, pockets, streaks, or layers of material differing substantially in texture or gradation from the surrounding material within the zone.

Where work is interrupted by rain, fill operations shall not be resumed until observations and field tests by the Contractor indicate that the moisture content and density of the in-place fill materials and/or materials intended for placement are within the limits identified in this Specification. This requirement does not preclude the Contractor from disking or aerating excessively wet areas to enhance drying.

2.9 Compaction

Unless stated otherwise, all fill shall be compacted at a moisture content of -2 to +2% of optimum moisture content (OMC) in accordance with Table 2-2.

Table 2-2 Minimum relative compaction

Application	Minimum relative compaction (%)	
	Minimum density ratio (cohesive soils)	Minimum density index (cohesionless soils)
Subgrade materials, embankments/bunds and trench backfill	98 std	60
Select fill	98 std	-
Sand fill	-	70 - 75
Clay rich fill	95 std	-
Soil confining material	90 std	-
Seal bearing material	98 std	-
Subsoil material	Refer Section 15.4.1	-

2.10 Construction quality control testing

Unless stated otherwise, the Contractor shall undertake CQC testing of all fill in accordance with Table 2-3 (general filling works) and Table 2-4 (trench filling works) as a minimum. Sampling locations for testing shall be agreed with the Superintendent and CQA Engineer.

The Superintendent may request additional tests at any time, where in the opinion of the Superintendent, a deficiency is suspected.

CQC testing for all earthworks shall be carried out by the Contractor's Independent Testing Firm who shall supply reports identifying the material type, the Specification requirements, and associated results.

The Contractor shall maintain a register of in-situ test results, which shall record the following details:

- Test number
- Description of the fill material
- Location/Grids or co-ordinates of the tests
- Lift tested
- Density ratio
- Moisture content
- Method of testing in accordance with AS 1289

Where tests do not conform to the Specification requirements, retests shall be undertaken and these shall be clearly identified in the register.

Table 2-3 Construction quality control testing – earthworks (general)

Property	Test method	Minimum test frequency
Moisture content	AS 1289.5.1.1 or AS 1289.5.7.1	Greater of: 1 per layer per 2,500 m^2 or 1 per 500 m^3 or 3 per lift
Dry density	AS 1289.5.8.1 AS 1289.5.1.1 or AS 1289.5.7.1	Greater of: 1 per layer per 2,500 m^2 or 1 per 500 m^3 or 3 per lift

Table 2-4 Construction quality testing – earthworks (trenches)

Property	Test method	Minimum test frequency
Moisture content	AS 1289.5.1.1 or AS 1289.5.7.1	1 per 2 layers per 40 linear metres
Dry density	AS 1289.5.8.1 AS 1289.5.1.1 or AS 1289.5.7.1	1 per 2 layers per 40 linear metres

2.11 Tolerances

Unless specified otherwise, tolerances shall meet the acceptance criteria in Table 2-5.

The Contractor may excavate and re-compact the existing material if necessary to assist in achieving this tolerance.

Notwithstanding these allowable tolerances, the Contractor shall be responsible for meeting grading requirements across the surfaces of earthworks materials as shown on the Contract Drawings.

Plus (+) refers to the following:

- Elevation: Plus (+) is higher than design
- Layer thickness: Plus (+) is thicker than design
- Depth: Plus (+) is deeper than design
- Width: Plus (+) is wider than design

Minus (-) refers to the following:

- Elevation: Minus (-) is lower than design
- Layer thickness: Minus (-) is thinner than design
- Depth: Minus (-) is shallower than design
- Width: Minus (-) is narrower than design

Table 2-5 Tolerances

Element	Measurement	Acceptance criteria
General excavation	Elevation	±100 mm
Subgrade	Elevation	+0, -100 mm
Sidewalls: At the toe of the batter 2 m above toe of batter and higher Between toe of batter and 2 m above toe of batter	Elevation	 +0, -100 mm ± 100 mm pro rata basis
Embankments/bunds	Elevation	+100, -0 mm
All trenches	Depth Width	+100, -0 mm +100, -0 mm
Clay rich fill layer	Layer thickness	+50, -0 mm
Sand drainage layer	Layer thickness	+50, -0 mm
Leachate drainage aggregate layer	Layer thickness	+50, -0 mm
Soil confining layer	Layer thickness	+50, -0 mm
Recycled aggregate layer	Layer thickness	+50, -0 mm
Seal bearing layer	Layer thickness	+100, -0 mm
Revegetation layer	Layer thickness	+100, -0 mm

Element	Measurement	Acceptance criteria
Capping layer	Elevation	+0 mm

2.12 Anchoring of geosynthetics

Anchor trench excavation, backfill, and compaction shall be completed to the line and grades shown on the Contract Drawings. A work method statement shall be prepared for the excavation and backfill of anchor trenches during the Works with consideration to the guidance below.

Anchor trenches shall be prepared with slightly rounded corners where the geosynthetics adjoin the trench so as to avoid sharp bends in the geosynthetic material. The base of the anchor trench must be a smooth uniform surface that is free of defects and loose material.

The geosynthetic layers shall be placed in the trench as per the Contract Drawings to ensure effective anchorage. Fill material shall be placed in maximum 100 mm loose lifts if compacted with hand-operated compaction equipment, or maximum 200 mm loose lifts if compacted with a self-propelled compactor.

The Contractor shall repair or replace any geosynthetics damaged as a result of placement or compaction of backfill to the satisfaction of the superintendent.

2.13 Stockpiles

The Contractor shall be responsible for managing stockpiles of fill materials for the Works. It is the Contractor’s responsibility to prevent the fill material stockpiles to become contaminated with unsuitable material (refer Section 2.4.1) or by other methods (such as fines contamination) which may result in the fill material no longer meeting the relevant acceptance criteria in this Specification. The Superintendent may organise independent inspections and/or testing of the fill material stockpiles to verify conformance with these requirements. In the Superintendent’s opinion, if remediation of any contaminated fill materials is not viable then the fill shall be rejected by the Superintendent and removed from the site by the Contractor.

All stockpiles shall be located so that drainage from the stockpile flows into the site or to the proposed sedimentation basins. Where a stockpile cannot be located such that drainage flows into the site, the stockpile shall have a drainage swale placed on the uphill side of the stockpile to divert surface water from the stockpile area and sediment traps at its base to capture sediment running off the stockpile.

All stockpiles shall:

- Have maximum slopes not exceeding 1(V):2(H)
- Have rounded shoulders and base of batters to minimise wind and water erosion
- Be surrounded by filter fence

2.14 Defects and repairs

Compacted fill material with non-conforming CQC test results shall be remediated as Table 2-6. This includes non-conformances resulting from independent testing commissioned by the Superintendent or CQA Engineer.

Material with non-conforming CQC test results after remedial work has been implemented (that is, tested for a second time) shall be removed and replaced.

The Contractor shall submit to the Superintendent for review a log containing details of any defects identified and repairs carried out.

Table 2-6 Remedial actions for compacted fill

Category	Density ratio result	Density index result	Moisture result	Remedial action[2]
A	Non-conforming by less than 1%	Non-conforming by less than 3%	Conforming	Re-compact (maximum of three passes)
B	Non-conforming by 1% or more	Non-conforming by less than 5%	Conforming, but not more than 1.0% wet of OMC	Rip, re-water, re-compact and re-test
C	Non-conforming by 1% or more	N/A	Pass, but 1.0% or more wet of OMC	Rip, re-compact and re-test
D	Conforming	N/A	Non-conforming	Rip, re-water, re-compact and re-test
E	Non-conforming	Non-conforming by more than 5%	Non-conforming	Remove fill, replace, compact and re-test

[2] Should the Superintendent deem the depth of insufficiently compacted material to be greater than can be effectively compacted from the surface, material shall be removed to a depth at which compaction is satisfactory and replaced and compacted in layers

3. Subgrade

3.1 General

This section contains the technical requirements for the subgrade preparation. The relevant requirements for the subgrade in Section 2 shall be considered alongside guidance provided in this section.

The Superintendent may reject any component of the subgrade that does not meet or exceed the requirements of this section.

Any subgrade rejected by the Superintendent shall be remediated by the Contractor.

3.2 Standards

3.2.1 Australian standards

Relevant Australian standards are as follows but not limited to:

- 1152 Specification for test sieves
- 1289 Methods of testing soils for engineering purposes
- 1289.2.1.1 Determination of the moisture content of a soil - oven drying method
- 1289.3.1.1 Soil classification tests - Calculation of the plasticity index of a soil
- 1289.3.6.1 Soil classification tests - Determination of the particle size distribution of a soil - Standard method of analysis by sieving
- 1289.3.6.3 Soil classification tests - Determination of the particle size distribution of a soil - Standard method of fine analysis using a hydrometer
- 1289.3.8.1 Soil classification tests - Dispersion - Determination of emerson class number of a soil
- 1289.5.1.1 Soil compaction and density tests - Determination of the dry density/moisture content relation of a soil using standard compactive effort
- 1289.5.6.1 Soil compaction and density tests - Compaction control test - Density index method for a cohesionless material
- 1289.5.7.1 Soil compaction and density tests - Compaction control test - Hilf density ratio and Hilf moisture variation (rapid method)
- 1289.5.8.1 Soil compaction and density tests - Determination of field density and field moisture content of a soil using a nuclear surface moisture density gauge
- 1289.6.7.3 Methods of testing soils for engineering purposes - Soil strength and consolidation tests - Determination of permeability of a soil - Constant head method using a flexible wall permeameter
- 1726 Geotechnical site investigations
- 2868 Classification of machinery for earthmoving, construction, surface mining and agricultural purposes
- 3798 Guidelines on earthworks for commercial and residential developments
- 4419 Soil for landscaping and garden use

3.3 Submittals

3.3.1 Prior to delivery and placement of fill material

Refer Section 2.3.1

3.3.2 Prior to subgrade preparation

The Contractor shall submit the following to the Superintendent for review and approval prior to subgrade preparation:

- Work method statement for the subgrade preparation, including testing, proof rolling and repair procedures (refer Appendix A).

3.3.3 Following completion of subgrade preparation

The Contractor shall submit the following to the Superintendent for review and approval following completion of subgrade preparation:

- As-built survey of the completed surface showing conforming layer thickness within the allowable tolerances
- CQC testing results/reports showing compliance with the requirements of this Specification
- Defect and repairs log, showing details of all defects identified and any repairs completed

3.4 Preparation

The Contractor shall prepare a work method statement for subgrade preparation outlining the preparation methodology and proposed construction plant to be used (refer Appendix A). The work method statement shall be submitted to the Superintendent for review and comment prior to placement.

The work method statement and construction methodology for the subgrade shall be developed in accordance with the guidance provided below:

- Where unsuitable material is found (refer Section 2.4.1), such material shall be removed to the extent directed by the Superintendent It should be noted that some remaining smelter refactory may be encountered in the subgrade that were left from previous works.
- Select fill (refer Section 2.4.2) shall be used to achieve the required lines and levels where the subgrade has been over-excavated or unsuitable material has been removed.
- Soil berms and undulations shall be graded out on site to provide a smooth and unyielding surface.
- Proof-rolling operations shall be carried out as necessary to determine the soundness and suitability of the prepared subgrade (refer Section 3.8).
- The surface shall be sealed (by smooth drum rolling) at the end of each day to minimise the penetration of water, with erosion protection measures provided and drainage systems (permanent and temporary) maintained.
- The Contractor shall match compaction methods to the material and location, with consideration of the following guidelines:
  - Rubber-tired rollers are preferable to prevent bridging of softer materials
  - Double smooth drum rolling may be used provided that careful inspection is undertaken to monitor and prevent bridging

  - Proof-rolling equipment should, in general, provide more compaction effort than backfill compaction equipment, to assure integrity
  - Hand compaction equipment such as impact rammers or plate or small drum vibrators should be used to sound material
- Any desiccations, cracks, or inconsistencies in the subgrade shall be remediated as directed by the Superintendent.

3.5 Compaction

All subgrade material shall be placed and compacted to the requirements of Section 2.9.

3.6 Construction quality control testing

The Contractor shall undertake CQC testing of the subgrade material in accordance with Section 2.10.

3.7 Tolerances

The completed subgrade shall be within the tolerances provided in Section 2.11.

3.8 Proof rolling

Proof rolling shall be used throughout preparation of the subgrade to assist in identifying soft spots and unsuitable material.

The prepared subgrade shall be proof rolled by a mechanical self-propelled smooth drum roller (or equivalent) in the presence of the Superintendent to assess the soundness and suitability of the subgrade.

Proof rolling shall be conducted upon the full width and length of the subgrade. A final proof roll shall be conducted over the finished surface prior to acceptance.

To show conformance with the requirements of the Specification, during final proof rolling of the prepared subgrade the surface shall not exhibit visible deformation, rutting, yielding and/or show signs of distress or instability.

3.9 Finished surface

The finished surface of the subgrade shall exhibit the following characteristics:

- The surface shall be smooth, flat, firm and unyielding to the satisfaction of the Superintendent.
- The surface shall not exhibit visible deformation, rutting, yielding and/or show signs of distress or instability during final proof rolling.
- The surface shall be free of debris, roots, angular material (such as sharp rocks), desiccation cracks, abrupt breaks, indentations, sudden changes in grade, defects and/or imperfections that may result in damage to the overlying materials.
- No loose, coarse-grained material shall remain on the surface. If required, the surface shall be raked or graded to remove any material penetrating out of the surface.
- The surface shall promote drainage and excessive water shall not be allowed to pond on the surface.
- The surface shall not be pebbly, tracked, rutted or otherwise disturbed by the equipment deploying overlying materials or other traffic. Pockets, holes, or discontinuities shall be repaired.

- All construction stakes, hubs, or other items used for grade control shall be removed and any voids filled. Any unsuitable material shall be over-excavated to a depth of 100 mm and replaced with accepted material.
- The surface shall be maintained at sufficient moisture content to prevent desiccation during the Works.

3.10 Defects and repairs

Any areas of prepared subgrade that does not conform to the required compaction and moisture content testing criteria shall be repaired by the Contractor in accordance with Section 2.14. This includes non-conformances resulting from independent testing commissioned by the Superintendent or CQA Engineer.

The Contractor shall submit to the Superintendent for review a log containing details of any defects identified and repairs carried out.

4. Clay rich fill

4.1 General

This section contains the technical requirements for the clay rich fill. The relevant requirements for the clay rich fill in Section 2 shall be considered alongside guidance provided in this section.

The Superintendent may reject any component of the clay rich fill that do not meet or exceed the requirements of this section.

Any component of the clay rich fill rejected by the Superintendent shall be remediated by the Contractor.

4.2 Standards

4.2.1 Australian standards

Relevant Australian standards are as follows but not limited to:

- 1152 Specification for test sieves
- 1289 Methods of testing soils for engineering purposes
- 1289.2.1.1 Determination of the moisture content of a soil - oven drying method
- 1289.3.1.1 Soil classification tests - Calculation of the plasticity index of a soil
- 1289.3.6.1 Soil classification tests - Determination of the particle size distribution of a soil - Standard method of analysis by sieving
- 1289.3.6.3 Soil classification tests - Determination of the particle size distribution of a soil - Standard method of fine analysis using a hydrometer
- 1289.3.8.1 Soil classification tests - Dispersion - Determination of emerson class number of a soil
- 1289.5.1.1 Soil compaction and density tests - Determination of the dry density/moisture content relation of a soil using standard compactive effort
- 1289.5.6.1 Soil compaction and density tests - Compaction control test - Density index method for a cohesionless material
- 1289.5.7.1 Soil compaction and density tests - Compaction control test - Hilf density ratio and Hilf moisture variation (rapid method)
- 1289.5.8.1 Soil compaction and density tests - Determination of field density and field moisture content of a soil using a nuclear surface moisture density gauge
- 1289.6.7.3 Methods of testing soils for engineering purposes - Soil strength and consolidation tests - Determination of permeability of a soil - Constant head method using a flexible wall permeameter
- 1726 Geotechnical site investigations
- 2868 Classification of machinery for earthmoving, construction, surface mining and agricultural purposes
- 3798 Guidelines on earthworks for commercial and residential developments
- 4419 Soil for landscaping and garden use

4.3 Submittals

4.3.1 Prior to placement of clay rich fill

The Contractor shall submit the following to the Superintendent for review and approval prior to placement of the clay rich fill:

- Survey of the underlying surface in accordance with Section 1.11.
- Work method statement for placement of the clay rich fill, including testing and repair procedures (refer Appendix A).
- Pre-qualification test results/reports demonstrating that the proposed material complies with the material property requirements of this section of the Specification (refer Section 4.4).
- Estimated quantity of material which is represented by the pre-qualification test results/reports.

4.3.2 Following placement of clay rich fill

The Contractor shall submit the following to the Superintendent for review and approval following placement of clay rich fill:

- As-built survey of the completed surface showing conforming layer thickness within the allowable tolerances
- CQC testing results/reports showing compliance with the requirements of this Specification
- Defect and repairs log, showing details of all defects identified and any repairs completed

4.4 Material

Clay rich fill shall:

- Be selectively sourced material from on-site
- Not contain any unsuitable materials identified in Section 2.4.1 unless accepted by the Superintendent
- Be well graded in accordance with AS 1726
- Comply with the acceptance criteria specified in Table 4-1

The Contractor shall supply pre-qualification testing results in accordance with the testing frequencies identified in Table 4-1 showing that the proposed material meets the requirements of this table. Samples taken shall be representative of the whole material source and shall be evenly distributed across the material source.

If required by the Superintendent, a sample of the material shall be provided (per source) and the Superintendent and/or CQA Engineer may undertake an inspection of the material source.

Table 4-1 Acceptance criteria – clay rich fill

Property	Test method	Acceptance criteria	Minimum test frequency
Standard compaction	AS 1289.5.1.1	N/A	Greater of: 1 per 5,000 m^3 of material or 3 per source
Moisture content	AS 1289.2.1.1	N/A	Greater of: 1 per 5,000 m^3 of material or 3 per source
Atterberg limits: - Plasticity index - Liquid limit	AS 1289.3.1.1, 3.2.1 & 3.3.1	 ≥ 10 ≤ 50	Greater of: 1 per 5,000 m^3 of material or 3 per source
Particle size distribution: - Passing 50 mm - Passing 19 mm - Passing 0.075 mm - Passing 0.002 mm	AS 1141.11,12,13 or AS 1289.3.6.1, 3.6.3	 100% > 70% > 30% > 15%	Greater of: 1 per 5,000 m^3 of material or 3 per source

4.5 Preparation of receiving surface

Prior to placement of the clay rich fill, the receiving surface shall exhibit the following characteristics:

- The surface shall be smooth, flat, firm and unyielding to the satisfaction of the Superintendent.
- The surface shall not exhibit visible deformation, rutting, yielding and/or show signs of distress or instability during final proof rolling (if required).
- The surface shall be free of debris, roots, angular material (such as sharp rocks), desiccation cracks, abrupt breaks, indentations, sudden changes in grade, defects and/or imperfections that may result in damage to the overlying materials.
- No loose, coarse-grained material shall remain on the surface. If required, the surface shall be raked or graded to remove any material penetrating out of the surface.
- The surface shall promote drainage and excessive water shall not be allowed to pond on the surface.
- The surface shall not be pebbly, tracked, rutted or otherwise disturbed by the equipment deploying overlying materials or other traffic. Pockets, holes, or discontinuities shall be repaired.
- All construction stakes, hubs, or other items used for grade control shall be removed and any voids filled. Any unsuitable material shall be over-excavated to a depth of 100 mm and replaced with approved material.
- The surface shall be maintained at sufficient moisture content to prevent desiccation during the Works.

The receiving surface shall be surveyed as per the requirements of Section 1.11

Placement of the clay rich fill shall not proceed until the receiving surface has been inspected and approved by the Superintendent.

4.6 Installation

The Contractor shall prepare a work method statement for placement of the clay rich fill outlining the measures taken to moisture condition the clay rich fill prior to placement, placement methodology and proposed construction plant to be used (refer Appendix A). The work method statement shall be submitted to the Superintendent for review and approval.

The work method statement and construction methodology for the clay rich fill shall be developed in accordance with the guidance provided below:

- The clay rich fill shall be moisture conditioned uniformly throughout the material prior to placement.
- If the clay rich fill requires significant moisture content adjustment, the Contractor shall use a moisture conditioning area to allow hydration or dehydration of material to meet moisture content requirements.
- Should the clay rich fill be too wet to permit proper compaction, all work on the portions of the clay rich fill affected shall be delayed until the material has dried to the required moisture content.
- Prior to placement, the clay rich fill shall be mixed and processed to ensure no clods greater than 50 mm diameter are present.
- The material shall be constructed with a maximum compacted thickness of 150 mm.
- The material shall be placed to the required compaction and moisture content using a sheepsfoot roller, with feet/pads that penetrate the full depth of the placed loose lift of clay rich fill.
- Prior to placement of the overlying lift, the surface of the underlying lift shall be scarified as necessary to allow sufficient bonding of the lifts and prevent a lateral zone of higher permeability to be formed.
- The surface of the clay rich fill lifts shall be maintained as necessary prior to placement of the overlying lifts or overlying materials to prevent any moisture variations outside the requirements of the Specification. The Contractor shall be required to rework areas which do not meet this requirement.
- The Contractor shall seal surfaces (by smooth drum rolling) at the end of each day to minimise the penetration of water, provide erosion protection measures and ensure drainage systems (permanent and temporary) are maintained.
- Should joints be required between adjacent lift layers or to tie-in to existing clay rich fill, the existing edge/face shall be trimmed back to remove any desiccated material such that the material exposed in the face complies with the Specification. The clay rich fill to be placed shall be benched into the existing face/edge such that no continuous alignment of the vertical joints occurs.

4.7 Compaction

All compacted clay rich fill shall be placed in compacted lifts not exceeding 150 mm at a moisture content of 0 to +3% of the optimum moisture content, to a minimum density ratio of 95% SDD. The Superintendent may modify these compaction and moisture content requirements based on the results of the material testing submitted prior to placement. Fill is to be placed to at least half of the width of the roller beyond the finished surface of the clay rich fill shown on the Contract Drawings, such that when it is trimmed back to the finished surface, all of the cut face is compacted.

4.8 Construction quality control testing

The Contractor shall undertake testing of the compacted clay in accordance with Table 4-2 as a minimum. Sampling locations for testing shall be agreed with the Superintendent and CQA Engineer. Each compacted lift is required to be individually tested prior to the construction of subsequent lifts.

Table 4-2 Construction quality control testing – compacted clay

Property	Test method	Minimum test frequency
Moisture content	AS 1289.5.1.1 or AS 1289.5.7.1	Greater of: 3 per 500 m^3 or 3 per lift
Dry density	AS 1289.5.8.1 AS 1289.5.1.1 or AS 1289.5.7.1	Greater of: 3 per 500 m^3 or 3 per lift

4.9 Tolerances

The Contractor shall place the clay rich fill within the tolerances provided in Section 2.11.

4.10 Finished surface of clay rich fill

The finished surface of the clay rich fill shall exhibit the following characteristics:

- The surface shall be smooth, flat, firm and unyielding to the satisfaction of the Superintendent. The surface shall be proof rolled by the Contractor using a mechanical self-propelled smooth drum roller (or equivalent) in the presence of the Superintendent to assess the soundness and suitability of the finished surface. The surface shall not exhibit visible deformation, rutting, yielding and/or show signs of distress or instability during final proof rolling.
- The surface shall be free of debris, roots, angular material (such as sharp rocks), desiccation cracks and sudden changes in grade. If required, the surface shall be raked or graded to remove any material penetrating out of the surface greater than 10 mm.
- The surface shall promote drainage and excessive water shall not be allowed to pond on the surface.
- The surface shall not be rutted or otherwise disturbed by the equipment deploying overlying materials or other traffic.
- The surface shall be maintained at sufficient moisture content to prevent desiccation during the Works.
- Any voids resulting in the compacted clay due to extraction from tube samples (testing requirements) shall be filled with water, and then backfilled with sodium bentonite pellets, hand rammed into the void.

It is essential that the compacted clay not dry out after compaction otherwise severe desiccation can occur in which case shrinkage cracks will appear in the compacted clay and act as conduits for flow. At the discretion of the Superintendent, clay rich fill shall be removed and re-compacted after conditioning with additional moisture if shrinkage cracks appear prior to the placement of overlying material.

4.11 Defects and repairs

Any areas of placed clay rich fill that do not conform to the required compaction and moisture content testing criteria shall be repaired by the Contractor in accordance with Section 2.14 This includes non-conformances resulting from independent testing commissioned by the Superintendent or CQA Engineer.

The Contractor shall submit to the Superintendent for review details of any defects identified and repairs carried out.

5. Geonet drainage composite

5.1 General

This section contains the technical requirements for geonet drainage composite.

The Superintendent may reject any geonet drainage composite that does not meet or exceed the requirements of this section.

All geonet drainage composite rejected by the Superintendent shall be removed from the site by the Contractor.

5.2 Standards

5.2.1 American Society for Testing and Materials Standards

Relevant American Society for Testing and Material (ASTM) standards are as follows:

- D1505 Standard Test Method for Density of Plastics by the Density-Gradient Technique
- D1603 Standard Test Method for Carbon Black in Olefin Plastics
- D4218 Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique
- D4354 Standard Practice for Sampling of Geosynthetics and Rolled Erosion Control Products (RECPs) for Testing
- D4355 Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus
- D4439 Standard Terminology for Geosynthetics
- D4491 Standard Test Methods for Water Permeability of Geotextiles by Permittivity
- D4533 Standard Test Method for Trapezoid Tearing Strength of Geotextiles
- D4632 Standard Test Method for Grab Breaking Load and Elongation of Geotextiles
- D4716 Standard Test Method for Determining the (In-Plane) Flow Rate Per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head
- D4751 Standard Test Method for Determining Apparent Opening Size of a Geotextile
- D4833 Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products
- D4873 Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples
- D5199 Standard Test Method for Measuring the Nominal Thickness of Geosynthetics
- D7005 Determining The Bond Strength (Ply-Adhesion) of Composites
- D7179 Standard Test Method for Determining Geonet Bearing Force

5.2.2 Geosynthetic Research Institute Standards

Relevant Geosynthetic Research Institute (GRI) standards are as follows:

- GC8 Standard Guide for Determination of the Allowable Flow Rate of a Drainage Composite

- GN2 and GC13 Standard Guide for Jointing and Attaching Geonets and Drainage Composites

5.3 Submittals

The Contractor shall be responsible for the submission of all submittals required for geonet drainage composite by this Specification.

5.3.1 Prior to delivery of geonet drainage composite to site

The Contractor shall submit the following to the Superintendent for review and approval prior to delivery of geonet drainage composite to site:

- Material properties of the proposed geonet drainage composite
- Manufacturer’s certificate of compliance stating conformance with the requirements of this Specification
- Manufacturer’s quality control and assurance procedures
- Manufacturer’s quality control and assurance test results
- Complete description of the manufacturer’s shipping, handling and storage procedures
- Manufacturer’s installation procedures and requirements
- Delivery, storage and handling log for all composite rolls to be used in the Works, including delivery dockets, roll number and identification, delivery inspection checklist, details of storage and handling and quality control and assurance certificates

5.3.2 Prior to installation of geonet drainage composite

The Contractor shall submit the following to the Superintendent for review and approval prior to installation of the geonet drainage composite:

- Work method statement for geonet drainage composite installation, including seaming and jointing, procedures for testing and repairing and other information that shall promote proper use
- Proposed panel placement drawing, showing the location and reference number of all panels, expected seams, connections and penetrations, and panel dimensions and layout and the order of panel installation

5.3.3 Following installation of geonet drainage composite

The Contractor shall submit the following to the Superintendent for review and approval following installation of the geonet drainage composite:

- Panel placement and seaming log, providing details on date and time placed, date and time seamed, condition of receiving surface, weather conditions and precipitation events, quality assurance (QA) checks performed, and all other relevant information
- Finalised panel placement drawing showing the as-built location of all panels, seams, connections and penetrations
- Defect and repairs log, showing details of all defects identified and any repairs completed

5.4 Manufacturers Quality Control

The manufacturer shall follow a quality control program throughout the manufacturing of all geonet drainage composite approved by the Superintendent.

The frequency of sampling and testing shall be in accordance with Table 5-1.

The Superintendent may reject any geonet drainage composite rolls that have not been sampled and/or tested in accordance with this section.

All geonet drainage composite rolls rejected by the Superintendent shall be removed from the site by the Contractor.

5.5 Manufacturers Quality Assurance

The manufacturer shall follow a QA program throughout the manufacturing of all geonet drainage composite accepted by the Superintendent.

The frequency of sampling and testing shall be in accordance with ASTM D4354.

The Superintendent may reject any geonet drainage composite rolls that have not been sampled and/or tested in accordance with this section.

All geonet drainage composite rolls rejected by the Superintendent shall be removed from the site by the Contractor.

5.6 Material

All geonet drainage composite shall be new, first quality products manufactured for the Works.

The geotextile component shall be a non-woven, needle-punched, polypropylene geotextile heat bonded to the geonet during manufacture.

The resin shall be new, first quality, compounded polyethylene resin.

Geonet drainage composite shall meet or exceed the acceptance criteria specified in Table 5-1.

Table 5-1 Acceptance criteria – geonet drainage composite

Property (qualifier)	Test Method (ASTM) or AS.	Acceptance Criteria	Minimum Testing Frequency
Geotextile (before lamination)			
Mass per unit area (MARV)	D5261	270 g/m^2	every 10,000 m^2
Grab tensile strength (MARV)	D4632	900 N	every 10,000 m^2
Grab elongation (MARV)	D4632	50%	every 10,000 m^2
CBR puncture strength (MARV)	D6241	2,000 N	every 10,000 m^2
Trapezoidal tear strength (MARV)	D4533	350 N	every 10,000 m^2
Permittivity (MARV)	D4491	0.5 s^{-1}	every 50,000 m^2
Apparent opening size (MaxARV)	D4751	430 μm	every 50,000 m^2
UV stability (typical) [3]	D4355	50%	per formulation
Geonet (before lamination)			

[3] strength retained after 500 hours

Property (qualifier)	Test Method (ASTM) or AS.	Acceptance Criteria	Minimum Testing Frequency
Thickness at 200 kPa (min.)	D5199	8 mm	every 5,000 m^2
Density [4] (min.)	D1505 or D792	0.94 g/cm^3	every 5,000 m^2
Melt flow index (max.)	D1238	1.0 g/10 min	every 5,000 m^2
Carbon black content (range)	D4218 (5)	2.0 to 3.0%	every 5,000 m^2
Tensile strength (machine direction) (MARV)	D1682	7.5 kN/m	every 5,000 m^2
Transmissivity [6] (MARV)	D4716	1 x 10^{-3} m^2/s	every 50,000 m^2
Compressive strength (MARV)	D1621	460 kPa	every 10,000 m^2
Geonet drainage composite			
Configuration (top to bottom)		Geotextile - geonet - geotextile	
Ply adhesion (MARV)	D7005	90 N/m	every 5,000 m^2

5.7 Roll and Sample Identification

All geonet drainage composite rolls and samples shall be identified in accordance with ASTM D4873.

The Superintendent may reject any geonet drainage composite roll or sample that has not been identified in accordance with this section.

Any geonet drainage composite roll or sample rejected by the Superintendent shall be removed from the site by the Contractor.

5.8 Delivery, Storage and Handling

The delivery, storage and handling of all geonet drainage composite rolls and samples shall be undertaken in accordance with the manufacturer's instructions and ASTM D4873 as a minimum.

The Contractor shall inspect all geonet drainage composite rolls for defects and damage upon delivery.

The Superintendent may reject any geonet drainage composite roll or sample that has not been stored or handled in accordance with this section.

Any geonet drainage composite roll or sample rejected by the Superintendent shall be removed from the site by the Contractor.

[4] Base resin density without carbon black added

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

[6] Hydraulic gradient (1 m/m), Confining stress (>230 kPa), Seating time (100 hours)

5.9 Preparation of Surface to Receive Geonet Drainage Composite

The surface to receive the geonet drainage composite shall provide a dry, smooth, uniform surface that is free of defects or imperfections that may result in damage to the geonet drainage composite. The surface shall be free from abrupt breaks, sharp objects, or other foreign material that may inhibit placement of the geonet drainage composite.

All construction stakes, hubs, or other items used for grade control shall be removed and any void filled with processed material.

The surface shall not be pebbly, or tracked and rutted by equipment. Pockets, holes, or discontinuities shall be repaired. No loose, coarse-grained material shall remain on the surface.

Placement shall not proceed until the surface has been approved by the Superintendent.

5.10 Installation

The Contractor shall undertake installation in accordance with the manufacturer's instructions, the approved work method statement, GRI-GN2 and GRI-GC13, this Specification and the Contract Drawings. Any contradictions shall be clarified with the Superintendent.

The work method statement shall be developed based on the guidance provided below:

- Prior to incorporation into the works, each roll shall be inspected for damage and/or defects. If damage or defects are identified, the roll shall be inspected by the Superintendent and approved or rejected
- The protective wrapping on geonet drainage composite rolls shall be maintained at all times prior to installation
- The Contractor shall verify that the material is free from dust and dirt immediately prior to installation. Washing operations may be implemented at the discretion of the Superintendent
- Geonet drainage composite shall not be placed or seamed:
  - If moisture prevents proper subgrade preparation, panel placement or panel seaming
  - During precipitation, during periods of fog, or in the presence of excess moisture (e.g. dew, ponded water)
  - During periods of excessive winds (>30 km/h) or when gusting wind conditions interfere with handling operations
- Geonet drainage composite shall be protected from damage due to exposure to sunlight, dirt, dust and other hazards
- Equipment used shall not damage the geonet drainage composite by handling, trafficking, leakage of hydrocarbons, or by other means
- No vehicle shall be allowed to travel directly on the geonet drainage composite unless approved by the Superintendent. Prior to approval, the Contractor shall provide the Superintendent the following information:
  - Guidance from the manufacturer on suitable plant for trafficking for the proposed geonet drainage composite and confirmation that the Contractor shall only use this plant
  - Guidance from the manufacturer on suitable trafficking method for the proposed geonet drainage composite and confirmation that the Contractor shall only use this trafficking method

- Certification from the manufacturer that the above trafficking method and plant shall not void the warranty for the proposed geonet drainage composite

- Geonet drainage composite shall not be allowed to 'bridge over' voids or low areas in the subgrade. The geonet drainage composite shall be placed to allow intimate contact with the subgrade or underlying geosynthetic
- Geonet drainage composite shall not be dragged across an unprepared surface. If the geonet drainage composite is dragged across an unprepared surface, it shall be inspected by the Superintendent and repaired or rejected if necessary
- Geonet drainage composite rolls shall be freely suspended during placement
- Where there is a geosynthetic layer below, the installation of the geonet drainage composite shall be undertaken in a manner so as not to damage the underlying layer
- Metallic ties shall not be used
- Geonet drainage composite shall not be welded to the geomembrane
- The machine direction of materials shall be placed parallel to the slope
- Strands of one layer shall not penetrate the channels of another layer
- The geotextiles above and below the geonet drainage composite shall be continuously inspected for broken needles remaining from needle-punching operations
- Sandbags or equivalent ballast shall be used as necessary to temporarily hold the geonet drainage composite in position under the foreseeable and reasonably expected wind conditions. Sandbag material shall be sufficiently close-knit to prevent soil fines from working through the bags and discharging on the geonet drainage composite
- After placement, the geonet drainage composite shall be free of irregular stressing, folds and wrinkles
- Contractor to address management of materials after placement and prior to placement to limit excessive exposure to construction plant, sun, wind and rain etc.
- The geonet drainage composite shall be covered after installation within a 10 day period

5.11 Defects and Repairs

All repairs shall be undertaken in accordance with the manufacturer's instructions and the approved work method statement. All repairs shall be verified by the Superintendent.

6. Sand drainage layer

6.1 General

This section contains the technical requirements for the sand drainage layer. The relevant requirements for the sand drainage layer in Section 2 shall be considered alongside guidance provided in this section.

The Superintendent may reject any component of the sand drainage layer that do not meet or exceed the requirements of this section.

Any component of the sand drainage layer rejected by the Superintendent shall be remediated by the Contractor.

6.2 Standards

6.2.1 Australian standards

Relevant Australian standards are as follows but not limited to:

- 1152 Specification for test sieves
- 1289 Methods of testing soils for engineering purposes
- 1289.2.1.1 Determination of the moisture content of a soil - oven drying method
- 1289.3.1.1 Soil classification tests - Calculation of the plasticity index of a soil
- 1289.3.6.1 Soil classification tests - Determination of the particle size distribution of a soil - Standard method of analysis by sieving
- 1289.3.6.3 Soil classification tests - Determination of the particle size distribution of a soil - Standard method of fine analysis using a hydrometer
- 1289.3.8.1 Soil classification tests - Dispersion - Determination of emerson class number of a soil
- 1289.5.1.1 Soil compaction and density tests - Determination of the dry density/moisture content relation of a soil using standard compactive effort
- 1289.5.6.1 Soil compaction and density tests - Compaction control test - Density index method for a cohesionless material
- 1289.5.7.1 Soil compaction and density tests - Compaction control test - Hilf density ratio and Hilf moisture variation (rapid method)
- 1289.5.8.1 Soil compaction and density tests - Determination of field density and field moisture content of a soil using a nuclear surface moisture density gauge
- 1289.6.7.3 Methods of testing soils for engineering purposes - Soil strength and consolidation tests - Determination of permeability of a soil - Constant head method using a flexible wall permeameter
- 1726 Geotechnical site investigations
- 2868 Classification of machinery for earthmoving, construction, surface mining and agricultural purposes
- 3798 Guidelines on earthworks for commercial and residential developments
- 4419 Soil for landscaping and garden use

6.3 Submittals

6.3.1 Prior to delivery of sand drainage material to site

The Contractor shall submit the following to the Superintendent for review and approval prior to delivery of the sand drainage material to site (per material source):

- Confirm that there are no suitable material sources available on site
- Material source
- Certification that the material is VENM, ENM or material covered under the resource recovery exception.
- Pre-qualification test results/reports demonstrating that the proposed material complies with the material property requirements of this section of the Specification (refer Section 6.4)
- Estimated quantity of material which is represented by the pre-qualification test results/reports

6.3.2 Prior to placement of sand drainage layer

The Contractor shall submit the following to the Superintendent for review and approval prior to placement of the sand drainage layer:

- Survey of the underlying surface in accordance with Section 1.11
- Work method statement for placement of the sand drainage layer, including repair procedures (refer Appendix A).

6.3.3 Following placement of sand drainage layer

The Contractor shall submit the following to the Superintendent for review and approval following placement of sand drainage layer:

- As-built survey of the completed surface showing conforming layer thickness within the allowable tolerances
- CQC testing results/reports showing compliance with the requirements of this Specification
- Defect and repairs log, showing details of all defects identified and any repairs completed.

6.4 Material

Sand drainage material shall:

- Be selectively sourced material from on-site or imported from an approved source. Imported material shall be classed as VENM or ENM or NSW EPA Resource Recovery Exemption
- Not contain any unsuitable materials identified in Section 2.4.1 unless approved by the Superintendent
- Be non-plastic, sound, durable and free-draining
- Be well graded in accordance with AS 1726
- Comply with the acceptance criteria specified in Table 6-1

The Contractor shall supply pre-qualification testing results in accordance with the testing frequencies identified in Table 6-1 showing that the proposed material meets the requirements of this table. Samples taken shall be representative of the whole material source and shall be evenly distributed across the material source.

If required by the Superintendent, a sample of the material shall be provided (per source) and the Superintendent and/or CQA Engineer may undertake an inspection of the material source. The Contractor shall cooperate fully with the Superintendent and CQA Engineer to allow this inspection to occur.

The Contractor shall confirm the source and parent geology of the sand fill material. Any sources with deleterious mineralogy shall be rejected as sand fill material. The Superintendent may conduct a mineralogical assessment of the sand sources at their discretion.

Table 6-1 Acceptance criteria – sand drainage material

Property	Test method	Acceptance criteria	Minimum testing frequency
Particle size distribution - Passing 4.75 mm - Passing 0.075 mm	AS 1141.11,12,13 or AS 1289.3.6.1, 3.6.3	 100% < 5%	1 per source
Sodium sulphate soundness	AS 1141.24	Maximum loss of 15%	1 per source
Constant head permeability	AS 1289.6.7.1	> 1 x 10^{-4} m/s	1 per source

6.5 Preparation of receiving surface

Prior to placement of the sand drainage layer, the underlying geosynthetic shall be free of:

- Any of debris, roots, angular material (such as sharp rocks), or loose, coarse-grained material on or immediately below the geosynthetic
- Excessive wrinkles preventing intimate contact between the underlying geosynthetics and/or foundation materials.

Placement of the sand drainage layer shall not proceed until the underlying geosynthetic has been inspected and approved by the Superintendent.

The Superintendent may reject any underlying geosynthetic or underlying foundation material which does not meet these requirements. Any geosynthetic rejected by the Superintendent shall be removed from the site by the Contractor. Any rejected foundation material shall be removed and/or remediated to the satisfaction of the Superintendent.

6.6 Installation

The Contractor shall prepare a work method statement for placement of the sand drainage layer outlining the placement methodology and proposed construction plant to be used (refer Appendix A). The work method statement shall be submitted to the Superintendent for review and approval prior to placement.

The work method statement and construction methodology for the sand drainage layer shall be developed in accordance with the guidance provided below:

- The sand drainage layer shall be placed with a uniform particle size distribution to prevent concentration of fines. This can be achieved through conditioning of the material prior to placement

- The sand drainage layer shall be constructed in one lift with a minimum thickness of 300 mm. Plant shall not be allowed to traffic the underlying surface unless a minimum 300 mm thick sand drainage layer is present. Sand drainage layer shall be placed in areas without placed sand drainage material by unloading the material from a pad of previously placed sand drainage material
- The maximum allowable ground pressure for plant trafficking the minimum 300 mm thick sand drainage layer is 35 kPa
- Plant exceeding the allowable ground pressure requirements shall be allowed providing they work from elevated pads with a minimum thickness from the underlying surface of 1 m. These elevated pads shall be removed following completion of sand drainage material placement
- Sand drainage material shall be placed directly on the underlying geosynthetic rather than pushing in place to avoid the formation of excessive wrinkles or 'waves'
- Sand drainage material shall be placed carefully around any pipework to ensure the pipework has sufficient and uniform support
- No sand drainage material shall be placed in areas where the underlying geosynthetic is not in contact with the supporting subgrade
- Sand drainage material shall not be placed closer than 2 m from the edge of geosynthetic panels where seaming of additional geosynthetics to the edge is yet to be performed. Temporary access across such edges shall be subject to approval by the Superintendent.

6.7 Construction quality control testing

The Contractor shall undertake CQC testing of the sand drainage layer in accordance with Table 6-2 as a minimum and the relevant requirements of Section 2.10. Sampling locations for testing shall be agreed with the Superintendent and CQA Engineer.

Table 6-2 Construction quality control testing – sand drainage layer

Property	Test method	Minimum test frequency
Particle size distribution	AS 1141.3.1, AS 1141.11.1	1 per 1,000 m^3

6.8 Tolerances

The Contractor shall place the sand drainage layer within the tolerances provided in Section 2.11.

6.9 Defects and repairs

The Superintendent may direct the Contractor to remove a section of the sand drainage layer to inspect underlying materials for damage. The Contractor shall repair any damage that occurs to the underlying materials as a consequence of the placement of sand drainage layer in accordance with this Specification.

Any areas of placed sand drainage material that do not conform to the required CQC testing criteria shall be repaired by the Contractor to the satisfaction of the Superintendent. This includes non-conformances resulting from independent testing commissioned by the Superintendent or CQA Engineer.

The Contractor shall submit to the Superintendent for review details of any defects identified and repairs carried out.

7. Geosynthetic clay liner

7.1 General

This section contains the technical requirements for geosynthetic clay liner (GCL).

The Superintendent may reject any GCL that does not meet or exceed the requirements of this section.

Any GCL rejected by the Superintendent shall be removed from the site and replaced by the Contractor.

7.2 Standards

7.2.1 Australian standards

Relevant Australian standards are as follows but not limited to:

- 1289 Methods of testing soils for engineering purposes
- 1289.3.6.2 Soil classification tests—Determination of the particle size distribution of a soil – Analysis by sieving in combination with hydrometer analysis (subsidiary method)
- 3706.1 Geotextiles - Methods of test - General requirements, sampling, conditioning, basic physical properties and statistical analysis
- 3706.4 Geotextiles - Methods of test - Determination of burst strength - California bearing ratio (CBR) - Plunger method

7.2.2 American Society for Testing and Materials standards

Relevant American Society for Testing and Material (ASTM) standards are as follows:

- D4354 Sampling of Geosynthetics and Rolled Erosion Control Products (RECPs) for Testing
- D4873 Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples
- D5888 Standard Guide for Storage and Handling of Geosynthetic Clay Liners
- D5889 Standard Practice for Quality Control of Geosynthetic Clay Liners
- D6072 Standard Practice for Obtaining Samples of Geosynthetic Clay Liners
- D6102 Standard Guide for Installation of Geosynthetic Clay Liners
- D6495 Guide for Acceptance Testing Requirements for Geosynthetic Clay Liners

7.2.3 Geosynthetic Research Institute standards

Relevant Geosynthetic Research Institute (GRI) standards are as follows:

- GCL3 Specification for Test Methods, Required Properties, and Testing Frequencies of Geosynthetic Clay Liners

7.3 Submittals

7.3.1 Prior to selection of the geosynthetic clay liner manufacturer

The Contractor shall submit the following to the Superintendent for review and approval prior to selection of a GCL manufacturer (per manufacturer and product):

- Product manufacturer

- Product name
- Material data sheet showing the material properties of the proposed GCL
- A list documenting at least 40 completed facilities totalling a minimum of 200 hectares for which the manufacturer has manufactured GCL similar to this Specification. For each facility the following information shall be provided:
  - Name and purpose of the facility, its location and the date of installation
  - The name of the owner, the project manager, designer, fabricator (if any), and the installer
  - If requested, the name and telephone number of a reference contact at the facility who can discuss the project
  - The GCL type and total square metres of the installation surface
- Manufacturer's quality control and assurance procedures (including the geotextile components).

7.3.2 Prior to delivery of geosynthetic clay liner to site

The Contractor shall submit the following to the Superintendent for review and approval prior to delivery of GCL to site (per GCL product):

- Manufacturer's certificate of compliance stating conformance with the requirements of this Specification
- Manufacturer's quality control and assurance test results
- Certification that the GCL supplied for this work was manufactured as consecutive rolls from a single lot or from consecutive lots. If the GCL is not manufactured from consecutive lots, the manufacturer shall provide certification of quality and consistency of the product characteristics
- Statement on the origin of the bentonite, bentonite supplier's name and production plant, and bentonite brand name and type
- Copies of quality control certificates issued by the bentonite supplier to verify conformance with Table 7-1
- Manufacturer's certification (per 50 tonnes of product) that the bentonite form is natural sodium bentonite powder(7)
- Complete description of the manufacturer's shipping, handling and storage procedures
- Manufacturer's installation procedures and requirements
- Work method statement for GCL delivery, storage, handling and installation. This shall include seaming and jointing, procedures for testing and repairing, proposed handling equipment and restraining methods, and other information that shall promote proper use

7.3.3 Prior to installation of geosynthetic clay liner

The Contractor shall submit the following to the Superintendent for review and approval prior to installation of GCL:

[7] Bentonite powder consisting of > 80 wt% sodium as activated bentonite may be used with approval from the Superintendent. Approval shall be sought prior to construction and prior to selection of GCL manufacturer

- Delivery, storage and handling log for all GCL rolls to be used in the Works, including delivery dockets, roll number and identification, delivery inspection checklist, details of storage and handling
- Proposed panel placement drawing, showing the location and reference number of all panels and expected seams, connections and penetrations, panel dimensions and layout, and the order of panel installation
- Survey of the underlying surface in accordance with Section 1.11

7.3.4 Following installation of geosynthetic clay liner

The Contractor shall submit the following to the Superintendent for review and approval following installation of GCL:

- Panel placement and seaming log, providing details on panel number and associated roll number, date and time placed, date and time seamed, condition of receiving surface, weather conditions and precipitation events, QA checks performed, and all other relevant information
- Finalised panel placement drawing conforming to Hydro drawing standards showing the as-built location of all panels, seams, connections and penetrations
- Defect and repairs log, showing details of all defects identified and any repairs completed.

7.4 Manufacturer's quality control

The manufacturer shall follow a quality control program, approved by the Superintendent, throughout the manufacturing of all GCL for the Works.

Manufacturer's quality control submissions shall include:

- Date of manufacture
- Lot number, roll number, length and width
- Bentonite manufacturer quality control documentation for the particular lot of clay used in the production of the rolls delivered
- Geotextile manufacturer quality control documentation for the particular lots of geotextiles used in the production of the rolls delivered
- Cross-referencing list delineating the corresponding geotextile and bentonite lots for the materials used in the production of the rolls delivered
- Quality control program laboratory-certified reports
- The manufacturer's approved quality assurance stamp and the technician's signature.

The frequency of sampling and testing shall be in accordance with Table 7-1.

The Superintendent may reject any GCL rolls that have not been sampled and/or tested in accordance with this section.

All GCL rolls rejected by the Superintendent shall be removed from the site and replaced by the Contractor.

7.5 Manufacturer's quality assurance

The manufacturer shall follow a quality assurance program, approved by the Superintendent, throughout the manufacturing of all GCL for the Works.

The frequency of sampling and testing shall be in accordance with ASTM D4354.

The Superintendent may reject any GCL rolls that have not been sampled and/or tested in accordance with this section.

All GCL rolls rejected by the Superintendent shall be removed from the site and replaced by the Contractor.

7.6 Material

The GCL shall:

- Be new, first quality products manufactured for the Works
- Be a proprietary product comprising a layer of natural sodium bentonite powder (8) of uniform thickness and consistency, reinforced by stitch-bonding or needle-punching to fully integrate the cover and carrier geotextile/s and constrained by thermally locking
- Certified as needle-free by the manufacturer
- Comply with the acceptance criteria specified in Table 7-1.

The Contractor shall supply manufacturer's quality control and assurance testing results in accordance with the testing frequencies identified in Table 7-1 showing that the proposed material meets the requirements of this table. Samples taken shall be representative of the whole material source and shall be evenly distributed across the roll lots. In addition to this, manufacturer's certification (per 50 tonnes of product) that the bentonite form is natural sodium bentonite powder shall be provided for all the GCL rolls supplied.

If required by the Superintendent, a sample of the GCL shall be provided (per product) and the Superintendent and/or CQA Engineer may undertake an inspection of the manufacturer's facility.

[8] Bentonite powder consisting of > 80 wt% sodium as activated bentonite may be used with approval from the Superintendent. Approval shall be sought prior to selection of GCL manufacturer

Table 7-1 Acceptance criteria – GCL

Property	Test method	Acceptance criteria	Minimum testing frequency
Bentonite clay			
Bentonite clay – particle size (min.)	AS 1289.3.6.2	80% passing 75 micron sieve (powdered)	every 50 tonnes
Bentonite clay – free swell index (min.)	ASTM D5890	24 mL/2g or $cm^3/2g$	every 50 tonnes
Bentonite clay – fluid loss (max.)	ASTM D5891	18 mL	every 50 tonnes
Bentonite clay – montmorillonite content (min.)	CSIRO x-ray diffraction	70%	every 50 tonnes
Bentonite clay – carbonate content (max.)	CSIRO x-ray diffraction	2 wt%	every 50 tonnes
Bentonite clay – cation exchange capacity (min.)	Methylene blue method	70 meq/100g or cmol/kg	every 50 tonnes
Geotextile			
Cover geotextile - mass (MARV) Non-woven	AS 3706.1	200 g/m^2	every 20,000 m^2
Carrier geotextile - mass (MARV) Non-woven AND woven	AS 3706.1	200/100 g/m^2	every 20,000 m^2
Durability of geotextile and reinforcing yarns (min.) [9]	Section 5.6.2 of GRI-GCL3	65%	yearly
Geosynthetic clay liner			
GCL mass per unit area @ 0% moisture (MARV) [10]	ASTM D5993	4,000 g/m^2	every 4,000 m^2
Bentonite clay mass per unit area @ 0% moisture (MARV) [4]	ASTM D5993	3,700 g/m^2	every 4,000 m^2
Bentonite clay moisture content (max.)	ASTM D5993	15%	every 4,000 m^2
California bearing ratio (CBR) burst strength (MARV)	AS 3706.4	1,500 N	every 5,000 m^2
Strip tensile strength (MARV) Machine direction	ASTM D6768	10 kN/m	every 20,000 m^2
Peel strength (MARV)	ASTM D6496	600 N/m [11]	every 4,000 m^2
Hydraulic conductivity (max.)	ASTM D5887	5×10^{-11} m/s	every 25,000 m^2

7.7 Roll and sample identification

All GCL rolls and samples shall be identified in accordance with ASTM D4873.

Each roll or panel shall carry a label which identifies, as a minimum:

- Product name, grade and name of manufacturer
- Date of manufacture, batch number
- Roll number
- Roll length
- Roll weight

[9] Value represents the minimum percent strength retained from the as-manufactured value after oven aging at 60°C for 50 days

[10] Mass of the GCL and bentonite clay shall be measured after oven drying per the stated test method

[11] Peel strength of 360 N/m may be accepted for GCL for the base of the cell only.

- Roll width
- Handling guidelines
- Reference numbers to raw material batch and laboratory certified reports
- The manufacturer's approved quality assurance stamp and the technician's signature

The Superintendent may reject any GCL rolls or samples that have not been identified in accordance with this section.

All GCL rolls rejected by the Superintendent shall be removed from the site and replaced by the Contractor.

7.8 Delivery, storage and handling

The Contractor shall prepare a work method statement for delivery, storage, handling and installation of GCL, including repair methods (refer Appendix A). The work method statement shall be submitted to the Superintendent for review and approval prior to delivery of the GCL to site.

The delivery, storage and handling components of the work method statement shall be developed in accordance with the guidance provided below:

- Delivery, storage and handling of all GCL rolls and samples shall be undertaken in accordance with the manufacturer's instructions and ASTM D5888 as a minimum.
- The Contractor shall inspect all GCL rolls for defects and damage upon delivery.
- Rolls shall be delivered to site, handled and stored in such a manner that no damage occurs to the rolls.
- Rolls shall be wrapped with weather and moisture-proof wrapping to prevent any contact with water prior to installation. In the event that it is suspected that roll/s may have come into contact with water, the Superintendent shall inspect the moisture content of the bentonite of the effected roll/s and reject the roll/s if they are damaged beyond use. All GCL rolls rejected by the Superintendent shall be removed from the site and replaced by the Contractor.
- Roll cores shall be sufficiently strong to ensure that they do not deflect by more than half their diameter during delivery, storage and handling.
- Rolls shall be stored in a location away from construction traffic but sufficiently close to the installation area to minimise handling. The storage area shall be level, dry, well-drained and stable, and shall protect the product from precipitation, chemicals, excessive heat, UV radiation, standing water, vandalism and animals.
- GCL roll stacks shall be limited to the height at which installation personnel can safely manoeuvre the handling equipment. The recommended maximum stack height is three rolls.
- Rolls shall be handled using a spreader stinger bar. The bar shall be capable of supporting the full weight of the rolls without significant bending. Under no circumstances shall the rolls be dragged, lifted from one end, lifted in the middle of the roll, lifted with the forks of a forklift or pushed to the ground from the delivery vehicle. The Contractor may nominate alternate handling equipment and plant for approval by the Superintendent as part of their work method statement.

The Superintendent may reject any GCL rolls that have not been delivered, stored or handled in accordance with this section.

All GCL rolls rejected by the Superintendent shall be removed from the site and replaced by the Contractor.

7.9 Preparation of receiving surface

Prior to placement of GCL, the receiving surface shall exhibit the following characteristics:

- The surface shall be smooth, flat, firm and unyielding to the satisfaction of the Superintendent
- The surface shall not exhibit visible deformation, rutting, yielding and/or show signs of distress or instability during final proof rolling (if required)
- The surface shall be free of debris, roots, angular material (such as sharp rocks), desiccation cracks, abrupt breaks, indentations, sudden changes in grade, defects and/or imperfections that may result in damage to the overlying materials
- No loose, coarse-grained material shall remain on the surface. If required, the surface shall be raked or graded to remove any material penetrating out of the surface greater than 10 mm
- The surface shall promote drainage and excessive water shall not be allowed to pond on the surface
- The surface shall not be pebbly, tracked, rutted or otherwise disturbed by the equipment deploying overlying materials or other traffic. Pockets, holes, or discontinuities shall be repaired
- All construction stakes, hubs, or other items used for grade control shall be removed and any voids filled. Any unsuitable material shall be over-excavated to a depth of 100 mm and replaced with approved material
- The surface shall be maintained at sufficient moisture content to prevent desiccation during the Works.

The receiving surface shall be surveyed as per the requirements of Section 1.11.

Placement of GCL shall not proceed until the receiving surface has been inspected and approved by the Superintendent.

7.10 Installation

7.10.1 General

The Contractor shall prepare a work method statement for delivery, storage, handling and installation of GCL (refer Appendix A). The work method statement shall be submitted to the Superintendent for review and approval prior to delivery of the GCL to site.

The installation component of the work method statement shall be developed in accordance with the guidance provided below.

The Superintendent may reject any GCL rolls that have not been installed in accordance with this section.

All GCL rolls rejected by the Superintendent shall be removed from the site and replaced by the Contractor.

7.10.2 Weather conditions

The Contractor shall consider the weather conditions on a daily basis to confirm they are suitable for placement of GCL.

GCL shall not be placed or seamed:

- If moisture prevents proper subgrade preparation, panel placement and/or panel seaming.
- During precipitation, during hail, during periods of excessive fog, in standing water, on excessively wet surfaces, in the presence of excess moisture (such as dew and/or ponded water) and/or under any other conditions which may cause premature hydration of the GCL.
- During periods of excessive winds (>30 km/h) or when gusting wind conditions interfere with handling operations.

7.10.3 Traffic

Equipment used shall not damage the GCL by handling, trafficking, leakage of hydrocarbons, or by other means.

No vehicle shall be allowed to traffic directly on the GCL unless approved by the Superintendent. Prior to approval, the Contractor shall provide the Superintendent the following information:

- Guidance from the manufacturer on suitable plant for trafficking for the proposed GCL and confirmation that the Contractor shall only use this plant
- Guidance from the manufacturer on suitable trafficking method for the proposed GCL and confirmation that the Contractor shall only use this trafficking method
- Certification from the manufacturer that the above trafficking method and plant shall not void the warranty for the proposed GCL

7.10.4 Placement

GCL shall be placed in accordance with the following:

- The GCL shall be placed and seamed in accordance with this Specification, the Contract Drawings, the approved work method statement, the manufacturer's instructions and ASTM D6102. Any contradictions shall be clarified with the Superintendent.
- Prior to placement, each roll shall be inspected by the Contractor for damage and/or defects. If damage or defects are identified, the roll shall be inspected by the Superintendent and approved or rejected.
- The protective wrapping on the rolls shall be maintained at all times prior to installation.
- GCL shall be protected at all times from damage due to exposure to sunlight, dirt, dust, moisture and other hazards.
- GCL shall be placed such that the panels are anchored at the crest of the slope and form a continuous layer down the side walls and slopes and across the base.
- The arrangement of the GCL panels shall be in accordance with the approved panel placement drawing and any changes approved by the Superintendent.
- Installation shall progress from the highest elevations to the lowest.
- GCL shall not be allowed to ‘bridge over’ voids or low areas. The GCL shall be placed to allow intimate contact with the subgrade or underlying geosynthetic.
- GCL shall be installed without undergoing excessive buckling, wrinkling or tensioning.

- GCL shall not be dragged across an unprepared surface. If the GCL is dragged across an unprepared surface, it shall be inspected by the Superintendent and/or CQA Engineer for defects and repaired or rejected if necessary.
- Where there is a geosynthetic layer below, the installation of the GCL shall be undertaken in a matter so as not to damage the underlying layer.
- Sandbags or equivalent ballast shall be used as necessary to temporarily hold the GCL in position and prevent uplift by wind. In case of high winds, continuous loading shall be placed along edges of panels to minimise wind flow under the panels. Sandbag material shall be sufficiently close-knit to prevent soil fines from working through the bags and discharging on the GCL.
- Care should be taken to avoid contaminating the upper surface of the GCL with bentonite powder from the within the GCL.
- GCL installed on slopes shall be fixed in anchor trenches as shown on the Contract Drawings and Section 2.12. GCL panels shall be anchored as soon as possible.
- Personnel working on the GCL shall not smoke, wear damaging shoes, excessively traffic or engage in other activities which may damage the GCL. GCL in heavy traffic areas shall be protected by a geosynthetic overlay.
- GCL rolls shall be freely suspended during placement.
- The method used to unroll the GCL shall not cause bridging or excessive wrinkles.
- After placement, the GCL shall be free of excessive buckles, wrinkles, ripples, creases, folds and irregular stressing before the overlying cover material or geosynthetic is placed.

7.10.5 Seaming

GCL shall be seamed in accordance with the following:

- All seams shall be overlapped and sealed with bentonite paste.
- All seams shall be ‘shingled’ down-slope to promote runoff (roof tile fashion).
- End seams shall be overlapped a minimum of 500 mm and side seams shall be overlapped a minimum of 300 mm.
- For batters with a 10% grade or steeper, transverse (cross-slope) seams shall be minimised. If required, transverse seams shall be overlapped a minimum of 1,500 mm. Transverse overlaps shall be immediately anchored.
- The overlap zone shall be kept clean and shall not be contaminated with loose soil or other debris. There shall be no folds or wrinkles in the overlap zone and no plant traffic or foot traffic shall occur over the finished overlap.
- Bentonite paste shall be applied continuously across the overlap zone at a rate of 400 grams per metre.
- Bentonite used for seaming shall comply with the relevant bentonite acceptance criteria in Table 7-1.
- Care shall be undertaken to avoid contaminating the upper surface of the GCL with bentonite paste.

7.11 Protection and covering

The GCL shall be protected from damage and premature hydration due to precipitation, wind and other environmental conditions.

Covering and confinement activities shall be coordinated to ensure the following:

- On a daily basis, only those areas of GCL which can be covered to within 3 m of all edges shall be installed. All edges which are not completely covered shall be protected with anchored tarpaulins.
- The overlying polyethylene geomembrane shall be placed immediately following placement and acceptance of the GCL panels.
- The overlying confinement layer (300 mm thick drainage aggregate on the base and 300 mm thick soil confinement layer on the sidewalls) shall be placed as soon as practicable, in accordance with the GCL manufacturer's instructions or as approved by the Superintendent. Notwithstanding these requirements, the overlying confinement layer shall be placed no longer than 2 weeks following GCL placement. The 300 mm thick drainage aggregate shall be installed in accordance with the approved work method statement (refer Section 10.6).
- No vehicle shall be allowed to traffic directly on the GCL during placement of the overlying confining layer unless approved by the Superintendent (refer Section 7.10.3). The overlying confinement layer shall not be pushed or graded in a direction that may cause damage to the GCL overlaps.

If the placed GCL panels have hydrated prematurely without confinement, then the effected GCL panels shall be removed and replaced by the Contractor at their own expense.

7.12 Pipe penetrations

The GCL shall be cut in a pie-shaped configuration at pipe penetrations.

A second GCL layer shall be installed over the first GCL, made using a new piece of GCL of the same material type and thickness with a minimum 500 mm overlap beyond the penetration area in each direction.

Bentonite paste shall be applied across the overlap zone around the penetration area at a rate of 400 grams per metre. Bentonite used for repairs shall comply with the relevant bentonite acceptance criteria in Table 7-1.

7.13 Defects and repairs

The Contractor shall be responsible for inspecting the placed GCL to identify any damage or faults in the material. The Superintendent and/or CQA Engineer may also undertake inspections of the placed GCL to identify any damage or faults in the material. Any areas of GCL damaged during installation shall be repaired in accordance with the manufacturer's instructions and the approved work method statement. All repairs shall be verified by the Superintendent.

Repairs shall be made using a new piece of GCL of the same material type and thickness with a minimum 500 mm overlap beyond the repair area in each direction.

Bentonite paste shall be applied across the overlap zone around the repair area at a rate of 400 grams per metre. Bentonite used for repairs shall comply with the relevant bentonite acceptance criteria in Table 7-1.

The Contractor shall submit to the Superintendent for review a log containing details of any defects identified and repairs carried out.

8. PE geomembrane

8.1 General

This section contains the technical requirements for all polyethylene (PE) products including HDPE and LLPDE.

The Superintendent may reject any PE geomembrane that does not meet or exceed the requirements of this section.

Any PE geomembrane rejected by the Superintendent shall be removed from the site and replaced by the Contractor.

8.2 Standards

8.2.1 American Society for Testing and Materials Standards

Relevant American Society for Testing and Material (ASTM) standards are as follows:

- D792 Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
- D1004 Standard Test Method for Initial Tear Resistance of Plastic Film and Sheeting
- D1204 Standard Test Method for Linear Dimensional Changes of Non-rigid Thermoplastic Sheeting or Film at Elevated Temperature
- D1238 Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer
- D1505 Standard Test Method for Density of Plastics by the Density Gradient Technique
- D1603 Standard Test Method for Carbon Black in Olefin Plastics
- D3895 Standard Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry
- D4218 Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique
- D4354 Standard Practice for Sampling of Geosynthetics and Rolled Erosion Control Products(RECPs) for Testing
- D4437 Standard Practice for Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Sheet Geomembranes
- D4439 Standard Terminology for Geosynthetics
- D4833 Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products
- D4873 Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples
- D5199 Standard Test Method for Measuring the Nominal Thickness of Geosynthetics
- D5397 Standard Test Method for Evaluation of Stress Crack Resistance of Polyolefin Geomembranes Using Notched Constant Tensile Load Test
- D5596 Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics
- D5641 Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber

- D5721 Standard Practice for Air-Oven Aging of Polyolefin Geomembranes
- D5820 Standard Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes
- D5885 Standard Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by High Pressure Differential Scanning Calorimetry
- D5994 Standard Test Method for Measuring the Core Thickness of Textured Geomembranes
- D6370 Standard Test Method for Rubber-Compositional Analysis by Thermogravimetry (TGA)
- D6392 Standard Test Method for Determining the Integrity of Non-Reinforced Geomembrane Seams Produced Using Thermo-Fusion Methods
- D6395 Standard Practice for Non-destructive testing of Geomembrane Seams using Spark Test
- D6693 Standard Test Method for Determining Tensile Properties of Non-Reinforced Polyethylene and Non-Reinforced Flexible Polypropylene Geomembranes
- D7238 Test Method for Effect of Exposure of Unreinforced Polyolefin Geomembrane Using Fluorescent UV Condensation Apparatus
- D7466 Standard Test Method for Measuring Asperity Height of Textured Geomembranes

8.2.2 Geosynthetic Research Institute Standards

Relevant Geosynthetic Research Institute (GRI) standards are as follows:

- GM9 Standard Practice for Cold Weather Seaming of Geomembranes
- GM10 Specification for the Stress Crack Resistance of Geomembrane Sheet
- GM13 Standard Specification for Test Methods, Test Properties, and Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes
- GM14 Standard Guide for Selecting Variable Intervals for Taking Geomembrane Destructive Seam Samples Using the Method of Attributes
- GM17 Standard Specification for Test Methods, Test Properties, and Testing Frequency for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes
- GM19 Standard Specification for Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes
- GM20 Standard Guide for Selecting Variable Intervals for Taking Geomembrane Destructive Seam Samples Using Control Charts
- GM29 Standard Practice for Field Integrity Evaluation of Geomembrane Seams (and Sheet) Using Destructive and/or Non-destructive Testing

8.3 Submittals

8.3.1 Prior to selection of the polyethylene geomembrane manufacturer

The Contractor shall submit the following to the Superintendent for review and approval prior to selection of a PE geomembrane manufacturer (per manufacturer and product):

- Product manufacturer
- Product name

- Material data sheet showing the material properties of the proposed PE geomembrane
- A list documenting no less than 40 completed facilities totalling a minimum of 200 hectares for which the manufacturer has manufactured PE geomembrane similar to this Specification. For each facility the following information shall be provided:
  - Name and purpose of the facility
  - The location and date of installation
  - The name of the owner, the project manager, designer, fabricator (if any), and the installer
  - If requested, the name and telephone number of the contact at the facility who can discuss the project
  - The PE geomembrane type, thickness, and total square metres of the installation surface
- Documentation indicating that the polymer supplier has previously produced a minimum of 1,000 tonne of polymer of the same composition as that proposed for use in the manufacture of the PE geomembrane for the Works
- Manufacturer's quality control and assurance procedures

8.3.2 Prior to delivery of polyethylene geomembrane to site

The Contractor shall submit the following to the Superintendent for review and approval prior to delivery of PE geomembrane to site (per PE geomembrane product):

- Manufacturer's certificate of compliance outlining conformance with the requirements of this Specification
- Manufacturer's quality control and assurance test results
- Certification that the PE geomembrane supplied for this work was manufactured as consecutive rolls from a single lot or from consecutive lots. If the PE geomembrane is not manufactured from consecutive lots, the resin manufacturer shall provide certification of quality and consistency of the resin characteristics
- Statement on the origin of the resin, its identification (type and lot number), resin supplier's name and production plant, resin brand name and type, and the maximum amount of recycling polymer material added to the raw resin
- Copies of quality control certificates issued by the resin supplier which shall include testing conducted to verify conformance with Table 9-1
- Certifications that the PE geomembrane and extrudate produced for the Works have the same properties and are of the same resin
- Complete description of the manufacturer's shipping, handling and storage procedures
- Manufacturer's installation procedures and requirements
- Work method statement for PE geomembrane delivery, storage, handling and installation. This shall include seaming and jointing, welding, procedures for testing and repairing, proposed handling equipment and restraining methods, and other information that shall promote proper use

8.3.3 Prior to installation of polyethylene geomembrane

The Contractor shall submit the following to the Superintendent for review and approval prior to installation of the PE geomembrane:

- Delivery, storage and handling log for all PE geomembrane rolls to be used in the Works, including delivery dockets, roll number and identification, delivery inspection checklist, details of storage and handling.
- Proposed panel placement drawing, showing the location and reference number of all panels and expected seams, connections and penetrations, panel dimensions and layout, and the order of panel installation.
- Survey of the underlying surface in accordance with Section 1.11.

8.3.4 Following installation of polyethylene geomembrane

The Contractor shall submit the following to the Superintendent for review and approval following installation of the PE geomembrane:

- Panel placement log, providing details on panel number and associated roll number, date and time placed, condition of receiving surface, weather conditions and precipitation events, QA checks performed, and all other relevant information
- Trial weld log, recording all trial welds and testing undertaken
- Field welding log providing details of all field welding undertaken, including:
  - Weld type
  - Weld ID number
  - ID numbers of panels to be joined
  - Name of welder
  - Details of equipment used
  - Ambient air temperature
  - Time of day
  - Geomembrane surface temperature
  - Weld temperature
  - Any problems or issues arising during welding.
- Field sampling and testing results, including non-destructive and destructive tests
- Results of electrical leak location survey as provided by the Contractor's Leak Detection Survey Contractor (refer Section 8.13)
- Finalised panel placement drawing showing the as-built location of all panels, seams, connections and penetrations
- Defects and repairs log, showing details of all defects identified and repairs completed

8.4 Manufacturer’s quality control

The manufacturer shall follow a quality control program, approved by the Superintendent, throughout the manufacturing of all PE geomembrane for the Works.

Manufacturer’s quality control submissions shall include:

- Date of manufacture
- Lot number, roll number, length and width

- Manufacturer quality control documentation for the particular lot of resin used in the production of the rolls delivered
- Cross-referencing list delineating the corresponding resin used in the production of the rolls delivered
- Quality control program laboratory-certified reports
- The manufacturer's approved quality assurance stamp and the technician's signature

The frequency of sampling and testing shall be in accordance with Table 9-1.

The Superintendent may reject any PE geomembrane rolls that have not been sampled and/or tested in accordance with this section.

All PE geomembrane rolls rejected by the Superintendent shall be removed from the site and replaced by the Contractor.

8.5 Manufacturer's quality assurance

The manufacturer shall follow a quality assurance program, approved by the Superintendent, throughout the manufacturing of all PE geomembrane for the Works.

The frequency of sampling and testing shall be in accordance with ASTM D4354.

The Superintendent may reject any PE geomembrane rolls that have not been sampled and/or tested in accordance with this section.

All PE geomembrane rolls rejected by the Superintendent shall be removed from the site and replaced by the Contractor.

8.6 Material

The PE geomembrane shall:

- Be manufactured of new, first-quality resin and shall be compounded and continuously manufactured specifically for the Works. The resin manufacturer shall certify each batch for the acceptance criteria listed in Table 8-1
- Comply with the acceptance criteria specified in Table 8-1
- Not contain more than 1 percent non-volatile pigment or fillers other than carbon black
- Not be factory seamed

The Contractor shall supply manufacturer's quality control and assurance testing results in accordance with the testing frequencies identified in Table 8-1 showing that the proposed material meets the requirements of this table. Samples taken shall be representative of the whole material source and shall be evenly distributed across the roll lots.

If required by the Superintendent, a sample of the PE geomembrane shall be provided (per product) and the Superintendent and/or CQA Engineer may undertake an inspection of the manufacturer's facility.

Table 8-1 Acceptance criteria – PE geomembrane

Property	Test method	Acceptance criteria			Minimum testing frequency
		Base and sidewall liner Pond liner	Cap geomembrane	Sacrificial geomembrane	
		2 mm HDPE (double side textured)	2 mm LLDPE double side textured)	1 mm LLDPE (Smooth)	
Resin [12]					
Density (HDPE min., LLDPE max.)	ASTM D1505 or D792 (method B)	0.932 g/cm^3	0.926 g/cm^3	0.926 g/cm^3	per resin lot
Melt index (maximum) [13]	ASTM D1238	1.0 g/10 min	1.0 g/10 min	1.0 g/10 min	per resin lot
Sheet					
Thickness (min. average)	ASTM D5199 (smooth) ASTM D5994 (textured)	1.9 mm	1.9 mm	1.0 mm	every roll
Thickness (min.) - Lowest individual of 10 readings - Lowest individual of 10 readings	ASTM D5199 (smooth) ASTM D5994 (textured)	- 1.8 mm	- 1.7 mm	0.9 mm -	every roll
Asperity height (min. average) [14] [15]	ASTM D7466	0.45 mm	0.25 mm	-	every 2nd roll
Density (HDPE min., LLDPE max.)	ASTM D1505 or D792 (method B)	0.94 g/cm^3	0.939 g/cm^3	0.939 g/cm^3	90,000 kg
Tensile properties (min. average) [16] - yield strength - break strength - yield elongation - break elongation	ASTM D6693	31 N/mm 27 N/mm 13% 200%	- 21 N/mm - 250%	- 27 N/mm - 800%	9,000 kg
2% modulus (max.)	ASTM D5323	-	840 N/mm	420 N/mm	per each formulation
Tear resistance (min. average)	ASTM D1004	266 N	200 N	100 N	20,000 kg
Puncture resistance (min. average)	ASTM D4833	711 N	400 N	250 N	20,000 kg
Multi-axial break resistance	ASTM D5617	15%	-	-	per each formulation

[12] Base resin density without carbon black or additives added

[13] Conducted at 190 °C with 2.16 kg mass applied

[14] Alternate the measurement side for double sided textured sheet

[15] Of 10 readings; 8 out of 10 must be $\geq$ 0.29 mm, and lowest individual reading must be $\geq$ 0.21 mm

[16] Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of five test specimens each direction:

- HDPE yield elongation is calculated using a gauge length of 33 mm
- HDPE break elongation is calculated using a gauge length of 50 mm
- LLDPE break elongation is calculated using a gauge length of 50 mm at 50 mm/min

Property	Test method	Acceptance criteria			Minimum testing frequency
		Base and sidewall liner Pond liner	Cap geomembrane	Sacrificial geomembrane	
		2 mm HDPE (double side textured)	2 mm LLDPE double side textured)	1 mm LLDPE (Smooth)	
Notched Constant tensile load [17]	ASTM D5397	1000 hours	-	-	90,000 kg
Axi-symmetric break resistance (min.)	ASTM D5617	-	30%	30%	per each formulation
Dimensional stability	ASTM D1204	±2%	±2%	±2%	90,000 kg
Carbon black content (range)	ASTM D4218 [18]	2 to 3%	2 to 3%	2 to 3%	9,000 kg (HDPE) or 20,000 kg (LLDPE)
Carbon black dispersion (category) [20]	ASTM D5596	Note 20	Note 20	Note 20	20,000 kg
Oxidative induction time (OIT) (min. average) [21] - standard OIT AND - high pressure OIT	ASTM D3895 ASTM D5885	>160 min >800 min	100 min 400 min	100 min 400 min	90,000 kg
Oven aging at 85°C (min. average) - standard OIT AND - high pressure OIT	ASTM D5721 ASTM D3895 ASTM D5885	- 80% retained at 90 days	35% retained at 90 days 60% retained at 90 days	35% retained at 90 days 60% retained at 90 days	per each formulation
UV resistance (min. average) [22] - high pressure OIT [23]	ASTM D7238 ASTM D5885	80% retained after 1600 hours	35% retained after 1600 hours	35% retained after 1600 hours	per each formulation

[17] The SP-NCTL test is not appropriate for testing geomembranes with textured or irregular rough surfaces. Test should be conducted on smooth edges of textured rolls or on smooth sheets made from the same formulation as being used for the textured sheet materials. The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing

[18] Other methods such as ASTM D1603 (tube furnace) or ASTM D6370 (TGA) are acceptable if an appropriate correlation to ASTM D4218 (muffle furnace) can be established

[20] Dispersion only applies to near spherical agglomerates. 9 of 10 views shall be Category 1 or 2. No more than 1 view from Category 3.

[21] Samples to be evaluated at 30 and 60 days to compare with the 90 day response

[22] The condition of the test should be 20 hour UV cycle at 75 ºC followed by 4 hour condensation at 60 ºC

[23] UV resistance is based on percent retained value regardless of the original high pressure OIT value

8.7 Roll and sample identification

All PE geomembrane rolls and samples shall be identified in accordance with ASTM D4873.

Each roll or panel shall carry a label which identifies, as a minimum:

- Product name, grade and name of manufacturer
- Date of manufacture, batch number
- Material thickness
- Roll number
- Roll length
- Roll weight
- Roll width
- Handling guidelines
- Reference numbers to raw material batch and laboratory certified reports
- The manufacturer’s approved quality assurance stamp and the technician’s signature

The Superintendent may reject any PE geomembrane rolls or samples that have not been identified in accordance with this section.

All PE geomembrane rolls rejected by the Superintendent shall be removed from the site and replaced by the Contractor.

8.8 Delivery, storage and handling

The Contractor shall prepare a work method statement for delivery, storage, handling and installation of PE geomembrane, including repair methods (refer Appendix A). The work method statement shall be submitted to the Superintendent for review and comment prior to delivery of the PE geomembrane to site.

The delivery, storage and handling components of the work method statement shall be developed in accordance with the manufacturer's written recommendations and the guidance provided below:

- Delivery, storage and handling of all PE geomembrane rolls and samples shall be undertaken in accordance with the manufacturer’s instructions and ASTM D4873 as a minimum.
- Rolls shall be delivered to site, handled and stored in such a manner that no damage occurs to the rolls.
- Roll cores shall be sufficiently strong to ensure that they do not deflect by more than half their diameter during delivery, storage and handling.
- Rolls shall be stored in a location away from construction traffic but sufficiently close to the installation area to minimise handling. The storage area shall be level, dry, well-drained and stable, and shall protect the product from precipitation, chemicals, excessive heat, UV radiation, standing water, vandalism and animals.
- PE geomembrane roll stacks shall be limited to the height at which installation personnel can safely manoeuvre the handling equipment. The recommended maximum stack height is three rolls.

- Rolls shall be handled using a spreader stinger bar. The bar shall be capable of supporting the full weight of the rolls without significant bending. Under no circumstances shall the rolls be dragged, lifted from one end, lifted in the middle of the roll, lifted with the forks of a forklift or pushed to the ground from the delivery vehicle. The Contractor may nominate alternate handling equipment and plant for approval by the Superintendent as part of their work method statement.
- The Contractor shall inspect all PE geomembrane rolls for defects and damage upon delivery.

The Superintendent may reject any PE geomembrane rolls that have not been delivered, stored or handled in accordance with this section.

All PE geomembrane rolls rejected by the Superintendent shall be removed from the site and replaced by the Contractor.

8.9 Preparation of receiving surface

8.9.1 For soil receiving surface

Prior to placement of PE geomembrane, the receiving surface shall exhibit the following characteristics:

- The surface shall be smooth, flat, firm and unyielding to the satisfaction of the Superintendent.
- The surface shall not exhibit visible deformation, rutting, yielding and/or show signs of distress or instability during final proof rolling (if required).
- The surface shall be free of debris, roots, angular material (such as sharp rocks), desiccation cracks, abrupt breaks, indentations, sudden changes in grade, defects and/or imperfections that may result in damage to the overlying materials.
- No loose, coarse-grained material shall remain on the surface. If required, the surface shall be raked or graded to remove any material penetrating out of the surface greater than 10 mm.
- The surface shall promote drainage and excessive water shall not be allowed to pond on the surface.
- The surface shall not be pebbly, tracked, rutted or otherwise disturbed by the equipment deploying overlying materials or other traffic. Pockets, holes, or discontinuities shall be repaired.
- All construction stakes, hubs, or other items used for grade control shall be removed and any voids filled. Any unsuitable material shall be over-excavated to a depth of 100 mm and replaced with approved material.
- The surface shall be maintained at sufficient moisture content to prevent desiccation during the Works.

The receiving surface shall be surveyed as per the requirements of Section 1.11.

Placement of PE geomembrane shall not proceed until the receiving surface has been inspected and approved by the Superintendent.

8.9.2 For geosynthetic receiving surface

Prior to placement of PE geomembrane, the underlying geosynthetic shall be free of:

- Any of debris, roots, angular material (such as sharp rocks), or loose, coarse-grained material on or immediately below the geosynthetic
- Excessive wrinkles preventing intimate contact between the geosynthetic and PE geomembrane
- Any GCL panels that have hydrated prematurely without confinement
- For GCL receiving surfaces, excessive bentonite powder and/or paste on the surface

The foundation material underlying the geosynthetic shall:

- Be smooth, flat, firm and unyielding to the satisfaction of the Superintendent
- Be free of abrupt breaks, indentations and/or sudden changes in grade
- Promote drainage and excessive water shall not be allowed to pond on the surface of the geosynthetic

Placement of PE geomembrane shall not proceed until the underlying geosynthetic has been inspected and approved by the Superintendent. The overlying PE geomembrane shall be placed immediately following acceptance of the geosynthetic panels to protect the underlying geosynthetic.

The Superintendent may reject any underlying geosynthetic or underlying foundation material which does not meet these requirements. Any geosynthetic rejected by the Superintendent shall be removed from the site by the Contractor. Any rejected foundation material shall be removed and/or remediated to the satisfaction of the Superintendent.

8.10 Installation

8.10.1 General

The Contractor shall prepare a work method statement for delivery, storage, handling and installation of PE geomembrane (refer Appendix A). The work method statement shall be submitted to the Superintendent for review and comment prior to delivery of the PE geomembrane to site.

The installation component of the work method statement shall be developed in accordance with the manufacturer's written recommendations.

The Superintendent may reject any PE geomembrane rolls that have not been installed in accordance with this section.

All PE geomembrane rolls rejected by the Superintendent shall be removed from the site and replaced by the Contractor.

8.10.2 Weather conditions

The Contractor shall consider the weather conditions on a daily basis to confirm they are suitable for placement of PE geomembrane.

PE geomembrane shall not be placed or seamed:

- If moisture prevents proper subgrade preparation, panel placement and/or panel seaming
- During precipitation, during hail, during periods of excessive fog, during periods of excessive dust, in standing water, on excessively wet surfaces, in the presence of excess moisture (such as dew and/or ponded water)

- During periods of excessive winds (>30 kph) or when gusting wind conditions interfere with handling operations
- When sheet temperatures are lower than 0° or higher than 65° as measured by a calibrated infrared thermometer or surface thermocouple

8.10.3 Traffic

Equipment used shall not damage the PE geomembrane by handling, trafficking, leakage of hydrocarbons, or by other means.

No vehicle shall be allowed to travel directly on the PE geomembrane unless approved by the Superintendent. Prior to approval, the Contractor shall provide the Superintendent the following information:

- Guidance from the manufacturer on suitable plant for trafficking for the proposed PE geomembrane and confirmation that the Contractor shall only use this plant
- Guidance from the manufacturer on suitable trafficking method for the proposed PE geomembrane and confirmation that the Contractor shall only use this trafficking method
- Certification from the manufacturer that the above trafficking method and plant shall not void the warranty for the proposed PE geomembrane

8.10.4 Placement

PE geomembrane shall be placed in accordance with the following:

- The PE geomembrane shall be placed and seamed in accordance with this Specification, the Contract Drawings, the approved work method statement and the manufacturer's written recommendations. Any contradictions shall be clarified by the Superintendent.
- Prior to placement, each roll shall be inspected by the Contractor for damage and/or defects, including tears, abrasion, indentation, cracks, thin spots or any other faults or defects. If damage or defects are identified, the roll shall be inspected by the Superintendent and approved or rejected.
- PE geomembrane shall be protected from damage due to exposure to sunlight, dirt, dust and other hazards.
- PE geomembrane shall be placed such that the panels are anchored at the crest of the slope and form a continuous layer down the side walls and slopes and across the base.
- The arrangement of the PE geomembrane panels shall be in accordance with the approved panel placement drawing and any changes approved by the Superintendent.
- Installation shall progress from the highest elevations to the lowest.
- PE geomembrane rolls shall be placed in an orderly fashion which shall minimise or prevent surface water from flowing below previously installed PE geomembrane.
- PE geomembrane shall not be allowed to ‘bridge over’ voids or low areas. The PE geomembrane shall be placed to allow intimate contact with the subgrade or underlying geosynthetic.
- PE geomembrane shall be installed without undergoing excessive buckling, wrinkling or tensioning.
- PE geomembrane shall not be dragged across an unprepared surface. If the PE geomembrane is dragged across an unprepared surface, it shall be inspected for defects and repaired or rejected if necessary.

- Where there is a geosynthetic layer below, the installation of the PE geomembrane shall be undertaken in a matter so as not to damage the underlying layer.
- Sandbags or equivalent ballast shall be used as necessary to temporarily hold the PE geomembrane in position and prevent uplift by wind. In case of high winds, continuous loading shall be placed along edges of panels to minimise wind flow under the panels. Sandbag material shall be sufficiently close-knit to prevent soil fines from working through the bags and discharging on the PE geomembrane.
- Only those PE geomembrane rolls which can be seamed or permanently anchored on at least two sides on the same day shall be placed on a daily basis. All other sides shall be temporarily anchored.
- PE geomembrane installed on slopes shall be fixed in anchor trenches as shown on the Contract Drawings and Section 2.12. PE geomembrane panels shall be anchored as soon as possible. The Geosynthetic Installer shall program anchor trenches backfilling when the temperature is coolest to minimise effects of material expansion.
- Personnel working on the PE geomembrane shall not smoke, wear damaging shoes, excessively traffic or engage in other activities which may damage the PE geomembrane. PE geomembrane in heavy traffic areas shall be protected by a geosynthetic overlay.
- PE geomembrane shall be cut from each roll with an approved hook blade knife with flat zones on each end.
- PE geomembrane rolls shall be freely suspended during placement.
- The method used to unroll the PE geomembrane shall not cause bridging, excessive wrinkles, scores, scratches and/or crimps.
- Folds and wrinkles caused by PE geomembrane panel placement or thermal expansion shall be minimised.
- After placement, the PE geomembrane shall be free of excessive buckles, wrinkles, ripples, creases, folds and irregular stressing before the overlying cover material or geosynthetic is placed.

8.10.5 Seaming

PE geomembrane shall be seamed in accordance with the following guidance.

General

- The PE geomembrane shall be field seamed into a continuous sheet across the Works by using either dual hot wedge fusion welding or extrusion welding seams.
- Dual hot wedge fusion welding shall be the preferred method of welding and shall be used for primary welds between adjacent PE geomembrane panels. Extrusion welding shall only be used for detailed work, repair work, or in areas inaccessible for dual hot wedge fusion welding (where approved by the Superintendent).
- PE geomembrane placement shall be limited to that which can be seamed in one day.
- Trial seams shall be completed each day as per Section 8.11.
- All seams shall be ‘shingled’ down-slope to promote runoff (roof tile fashion).
- All field seaming operations shall be supervised by the Seaming Foreman and no field seams shall be made without the Seaming Foreman present.

- Prior to welding, the prepared weld surfaces shall be free of dust, dirt, debris, markings foreign material and any other potential contaminants that would inhibit welding. Where contamination does occur, the prepared surfaces shall be thoroughly cleaned and the weld completed.
- There shall be no free moisture in the weld area during welding. If free moisture is located in the weld area, mitigation measures during seaming shall be employed as approved by the Superintendent.
- The Geosynthetic Installer shall have an independently calibrated handheld temperature measuring device to confirm the temperatures of each and every welding machine prior to the commencement of any test or field welds. All information regarding the results gained from the temperature device shall be recorded for each welding machine.
- Any electric generators used in welding shall be placed on a smooth base such that no damage occurs to the underlying PE geomembrane.
- Adjacent to anchor trenches, seaming shall extend up the panels a minimum of 300 mm past the crest of the anchor trench.

Weld locations

PE geomembrane panel placement shall take into consideration the site geometry including:

- Field seams shall be orientated parallel to the line of maximum slope.
- For batters with a 10% grade or steeper, transverse (cross-slope) seams shall not be permitted.
- No cross seams shall be allowed within 1,500 mm of the toe of any slope.
- In corners and odd shaped geometric locations, the number and total length of field seams shall be minimised.
- Seams shall not be located at low points.
- All cross seams shall be offset at least 600 mm from the cross seam of the adjacent panel and be extrusion or wedge welded where they intersect.
- All primary welds used to connect panel ends to sheets shall form T-joins (tees). These T-connections shall have a distance of at least 500 mm. The welding seams of the PE geomembrane cannot cross (no cruciform connections).

Dual hot wedge fusion welding

- The dual hot wedge fusion welding shall be conducted using the split head wedge fusion weld method, fusing the upper and lower overlapped PE geomembrane panels.
- The welding equipment shall be capable of continuously monitoring and controlling the temperature in the zone of contact where the machine is actually fusing the PE geomembrane so as to ensure that changes to environmental conditions shall not adversely affect the integrity of the weld.
- Seams shall have a finished overlap of a minimum of 150 mm for dual hot wedge fusion welding but in any event, sufficient overlap shall be provided to allow peel tests to be performed on the seam.
- The dual hot wedge fusion welding shall form two contact fusion areas of a minimum width of 15 mm and a 5 mm minimum wide void between each of the separate parallel weld zones.

Extrusion welding

- The extruder may be a combination sheet pre-heat and extruder type or a combination dynamic mixing assembly and extruder type.
- The extrudate shall be manufactured from the same resin type used in the manufacture of the relevant PE geomembrane being welded. All physical properties shall be identical to those possessed by the raw PE geomembrane material. The Geosynthetic Installer shall provide certification from the manufacturer that the relevant PE geomembrane and extrudate produced for the Works have the same properties and are of the same resin for each batch.
- During welding, the Geosynthetic Installer shall be responsible for regularly checking, calibrating and recording of:
  - Preheat air flow and temperature at the nozzle
  - Extrudate flow and temperature at the barrel outlet
- Seams shall have a finished overlap of a minimum of 75 mm for extrusion welding but in any event, sufficient overlap shall be provided to allow peel tests to be performed on the seam.
- The minimum width of the surface extruded bead shall be 30 mm.
- Prior to welding, oxidation by-products shall be removed from the weld area by grinding or buffing. Grind marks shall not be deeper than 10% of the PE geomembrane thickness. Seam grinding shall be been completed less than one hour before seam welding. The end of welds more than five minutes old shall be ground to expose new material before restarting a weld.
- Prior to welding, the extruder shall be purged until all the heat-degraded extrudate is removed.
- Welding shall be undertaken in one direction only.
- A smooth insulating plate or fabric shall be placed beneath the hot welding apparatus after use.

Pipe boots

- Pipe boots may be constructed in the factory or in the field in accordance with the detail shown on the Contract Drawings from relevant PE geomembrane conforming to this Specification.

8.11 Trial seams

Trial seams shall be performed on fragment pieces of PE geomembrane to verify that seaming conditions are satisfactory and to supply test specimens for the CQA program.

Trial seams shall be conducted at the beginning of each seaming period and at least once each four hours for each seaming apparatus used that day. Trial seams shall be repeated if any welding stoppage exceeds one hour and if weather conditions change. Trial seams shall be made under the identical conditions as the actual seams.

Each seamer shall make at least one trial seam each day for each seam method for each seaming equipment apparatus to be used that day.

Trial seams shall be a minimum of 1,350 mm by 300 mm with seam centred.

The trial seam sample shall be cut into three subsamples (450 mm by 300 mm with seam centred).

The two subsamples from each end shall immediately be tested onsite for peel and shear strength.

If either specimen does not meet the acceptance criteria, the seamer and seaming apparatus and/or methods shall not be accepted and shall not be used for seaming until the deficiencies are corrected and two consecutive trial seams are successful.

The central portion of the trial seam sample shall be labelled and provided to the CQA Engineer for destructive testing at the Superintendent's Independent Testing Firm. A minimum one trial seam sample per day shall be subjected to destructive testing. The Superintendent may reduce the frequency of trial seam destructive testing, if the field tensiometer appears adequate for assuring trial seam quality.

If a trial seam sample records a non-conforming result, a destructive test seam sample shall be taken by the Contractor from the seams completed by the seamer during the shift related to the considered trial seam. These samples shall be forwarded to the CQA Engineer's Independent Testing Firm by the Contractor and, if they recording non-conforming test results, the length of seam represented by the test sample shall be rejected.

The conditions of this section are considered as met for a given seam if a destructive seam test sample has already been taken from the considered seam(s).

8.12 Field seam sampling and testing

8.12.1 General

Testing parameters, requirements and anticipated schedules shall be continuously reviewed by the Contractor to ensure that adequate personnel and proper equipment shall be available.

Field seam sampling and testing shall be performed after seaming to verify that the mechanical characteristics of the seams do not compromise the PE geomembrane integrity.

Test results shall be provided to the Superintendent in accordance with Section 1.8.

8.12.2 Destructive seam testing

Destructive seam samples shall be taken and tested in accordance with Table 8-2.

Repair patches shall be extrusion welded over the areas where destructive seam samples have been taken and shall be subjected to non-destructive testing.

The location of each destructive seam sample shall be up to the discretion of the Superintendent and CQA Engineer and designated on a copy of the panel placement drawing, along with the date and time of sampling and the sample number.

Destructive test samples shall be a minimum of 1350 mm by 300 mm with seam centred.

The destructive seam sample shall be cut into 3 subsamples (450 mm by 300 mm with seam centred).

The two subsamples from each end shall be taken and tested on-site for peel and shear strength.

If both on-site subsamples meet the acceptance criteria of Table 8-2, the central portion of the test sample shall be labelled and provided to the CQA Engineer for destructive testing at the CQA Engineer's Independent Testing Firm.

If either on-site or off-site test results do not meet the acceptance criteria listed in Table 8-2, the length of seam represented by the test sample shall be rejected.

Table 8-2 Destructive seam testing requirements

Test description	Test method	Minimum test frequency	Acceptance criteria (24,25)
Peel strength (26)	ASTM D6392	1 test per 150 m (27) (or part thereof)	As per GM19
Shear strength	ASTM D6392	1 test per 150 m (or part thereof)	As per GM19

8.12.3 Non-destructive seam testing

All seams shall be non-destructively tested over the entire length of seam by at least one of the methods in Table 8-3. The tests shall be undertaken no earlier than one hour after welding. In addition to the above tests, the welds shall be visually inspected to assess the quality of the workmanship and the appearance of the welded seam.

Table 8-3 Non-destructive seam testing requirements

Test description	Test method	Minimum test frequency	Acceptance criteria
Vacuum box	ASTM D5641	All seams shall be tested by at least one of these three test methods as appropriate	No imperfections
Air pressure (28)	ASTM D5820		Refer Table 8-4
Spark test	ASTM D6365		No spark

Table 8-4 Air pressure test schedule

Geomembrane thickness	Minimum pressure	Maximum pressure	Maximum pressure differential (29)
1.0 mm	170 kPa	210 kPa	25 kPa
1.5 mm	190 kPa	250 kPa	20 kPa
2.0 mm	210 kPa	250 kPa	10 kPa
2.5 mm	210 kPa	250 kPa	10 kPa
3.0 mm	210 kPa	250 kPa	10 kPa

8.12.4 Pipe boot seam testing

All pipe boot seams shall be spark tested with acceptable pipe boots showing no spark.

Alternative testing methods may be allowed at the discretion of the Superintendent.

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[24] All destructive test results shall be based on Film-Tear Bond (FTB) criteria. All samples which produce seam failures shall be considered unacceptable

[25] A minimum of one series of destructive tests shall be performed each day that seaming is performed

[26] Peel strength testing shall be performed on both Weld A and Weld B

[27] When ambient air temperatures during seaming operations are less than 10 °C, testing frequency shall be increased to one test per 75 linear meters

[28] All hypodermic needle punctures shall be repaired as per the requirements of this Specification

[29] Observe and record the pressure 5 min after the initial reading. If the loss of pressure exceeds that shown, or if the pressure does not stabilize, the faulty area should be located and repaired

8.12.5 Non-conforming test results

If any test specimen does not meet the acceptance criteria listed, the test series shall be considered unacceptable and all material or length of seam represented by the test series shall be rejected. The Geosynthetic Installer may take additional samples for quality control testing in an attempt to minimise the amount of material represented by the non-conforming test result.

In the event of discrepancies between the CQA Engineer's test results and the Contractor's test results, the Contractor shall be responsible for arranging a third independent testing firm to verify test results.

An acceptable length of seam shall be defined as a length of seam which lies between conforming destructive test locations and has passed non-destructive seam testing.

8.12.6 Field testing summary

The Geosynthetic Installer shall prepare a field testing summary for all installed PE geomembrane. For each PE geomembrane layer, a separate copy of the panel placement drawing shall be utilised for this summary and shall indicate the PE geomembrane layer represented. On each sheet, the following information shall be recorded:

- The location, date, sample number and test result (conforming/non-conforming) of each destructive test series.
- The location, identification number and date of each non-destructive air pressure seam test including the length of the tested seam and the result of the test (conforming/non-conforming).
- The location, date and lengths of non-destructive vacuum box testing performed on a daily basis and the result of the tests (conforming/non-conforming).
- The location, identification number and date of each non-destructive spark test including the length of the tested seam and the result of the test (conforming/non-conforming).

8.13 Liner Integrity survey

8.13.1 General

Following the installation of each PE geomembrane layer, the Leak Location Contractor engaged by the Contractor shall conduct a liner integrity survey to detect leaks in the PE geomembrane. The surveys must also account for liner integrity following placement of subsequent sand and stone layers.

8.13.2 Preparation and support

The Contractor shall be responsible for preparing the survey area for the leak location survey. The Contractor shall be responsible for completing installation work around the edge of each PE geomembrane layer that provides electrical isolation of the PE geomembrane for the electrical leak location surveys. The Contractor is to develop installation procedures with the Leak Location Contractor and the Contractor's PE Liner Installation Work Method Statement, incorporating the Leak Detection Survey and shall be issued to the Superintendent for approval.

The Contractor shall ensure the PE geomembrane surface is clean and dry prior to the survey.

8.13.3 Repairs

The Geosynthetic Installer shall be responsible for repairing any leaks found. Repairs shall be undertaken in accordance with Section 9.13.

After the leak is repaired, the Leak Location Contractor shall retest the area to ensure the leak was repaired and that there are no other leaks in the vicinity of the repair.

8.14 Defects and repairs

The Contractor shall be responsible for inspecting the placed PE geomembrane to identify any damage or faults in the material. The Superintendent and/or CQA Engineer may also undertake inspections of the placed PE geomembrane to identify any damage or faults in the material. Any areas of PE geomembrane damaged during installation shall be repaired by the Contractor. All repairs shall be verified by the Superintendent.

The Contractor shall prepare a work method statement for delivery, storage, handling, installation and testing of PE geomembrane (refer Appendix A). The work method statement shall be submitted to the Superintendent for review and comment prior to delivery of the geomembrane to site.

The installation component of the work method statement shall include work methods for testing, defects and repairs, developed in accordance with the guidance provided below:

- All repairs shall be undertaken in accordance with this Specification, the approved work method statement and the manufacturer's instructions. Any contradictions shall be clarified with the Superintendent. All repairs shall be verified by the Superintendent.
- Patches and cap strips shall have rounded edges (minimum radius of 75 mm), shall be made of the same geomembrane and shall extend a minimum of 150 mm beyond the edge of defects. All patches shall be of the same compound and thickness as the PE geomembrane being patched over. Patches shall be seamed using extrusion (fusion) welding.
- Punctures, pin holes, blisters, small tears and localised imperfections shall be repaired using a patch.
- Large tears and lengths of seam shall be repaired using a cap strip. No re-seaming over existing seams shall be permitted.
- Tears which lie on slopes greater than 5% or which lie in areas of stress and have sharp ends shall have all sharp ends rounded prior to repair.
- The PE geomembrane below large patches and cap strips shall be cut as necessary to prevent moisture or gas collection between sheets.
- Excessive wrinkles which exist at the end of seaming operations and which may become creased during backfilling shall be cut and re-seamed. Excessive wrinkles shall be defined as a wrinkle which at the time of covering, and in the opinion of the Superintendent, meets any of the following criteria:
  - Is nominally >200 mm in height
  - May fold during backfilling
  - May adversely impede the flow along the surface of the geomembrane
- ‘Fishmouths’ or wrinkles at the seam overlaps shall be cut along the ridge of the wrinkle in order to achieve a flat overlap. The cut ‘fishmouths’ or wrinkles shall be seamed and any portion where the overlap is inadequate shall then be patched with an oval or round patch of the same geomembrane extending a minimum of 150 mm beyond the cut in all directions. All corners of the patch shall be rounded with a 25 mm minimum radius.
- All repair seams shall be made in accordance with the requirements of Section 8.10.5.

- Each repair shall be required to pass non-destructive tests (refer Section 8.12.3). Large cap strips may require destructive testing (refer Section 8.12.2), as directed by the Superintendent.

The Contractor shall submit to the Superintendent for review a log containing details of any defects identified and repairs carried out.

9. Geotextile

9.1 General

This section contains the technical requirements for geotextile.

The Superintendent may reject any geotextile that does not meet or exceed the requirements of this section.

Any geotextile rejected by the Superintendent shall be removed from the site and replaced by the Contractor.

9.2 Standards

9.2.1 Australian Standards

Relevant Australian standards are as follows but not limited to:

- 2001.2.3 Methods of test for textiles - Physical tests - Determination of breaking force and extension of textile fabrics
- 3704 Geosynthetics-Glossary of Terms
- 3705 Geotextiles-Identification, marking and general data
- 3706.3 Determination of tearing strength - Trapezoidal method
- 3706.4 Determination of burst strength - California bearing ratio (CBR) - Plunger method
- 3706.7 Determination of pore-size distribution - Dry-sieving method
- 3706.9 Determination of permittivity, permeability and flow rate

9.2.2 American Society for Testing and Materials Standards

Relevant American Society for Testing and Material (ASTM) standards are as follows:

- D4354 Standard Practice for Sampling of Geosynthetics and Rolled Erosion Control Products (RECPs) for Testing
- D4355 Standard Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water
- D4439 Standard Terminology for Geosynthetics
- D4491 Standard Test Methods for Water Permeability of Geotextiles by Permittivity
- D4533 Standard Test Method for Trapezoid Tearing Strength of Geotextiles
- D4632 Standard Test Method for Grab Breaking Load and Elongation of Geotextiles
- D4751 Standard Test Method for Determining Apparent Opening Size of a Geotextile
- D4833 Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products
- D4873 Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples
- D5199 Standard Test Method for Measuring the Nominal Thickness of Geosynthetics
- D5514 Standard Test Method for Large Scale Hydrostatic Puncture Testing of Geosynthetics

- D6767 Standard Test Method for Pore Size Characteristics of Geotextiles by Capillary Flow Test

9.2.3 Geosynthetic Research Institute Standards

Relevant Geosynthetic Research Institute (GRI) standards are as follows:

- GT12(a) Test Methods and Properties for Nonwoven Geotextiles Used as Protection (or Cushioning) Materials
- GT13(a) Test Methods and Properties for Geotextiles Used as Separation Between Subgrade Soil and Aggregate

9.3 Submittals

9.3.1 Prior to selection of the geotextile manufacturer

The Contractor shall submit the following to the Superintendent for review and approval prior to selection of a geotextile manufacturer (per manufacturer and product):

- Product manufacturer
- Product name
- Material data sheet showing the material properties of the proposed geotextile
- Manufacturer's quality control and assurance procedures

9.3.2 Prior to delivery of geotextile to site

The Contractor shall submit the following to the Superintendent for review and approval prior to delivery of geotextile to site (per geotextile product):

- Manufacturer's certificate of compliance outlining conformance with the requirements of this Specification.
- Manufacturer's quality control and assurance test results.
- Certification that the geotextile supplied for this work was manufactured as consecutive rolls from a single lot or from consecutive lots. If geotextile is not manufactured from consecutive lots, the manufacturer shall provide certification of quality and consistency of the product characteristics.
- Statement on the origin and identification of the fibres and polymers, including the supplier's name and production plant.
- Complete description of the manufacturer's shipping, handling and storage procedures.
- Manufacturer's installation procedures and requirements.
- Work method statement for geotextile delivery, storage, handling and installation. This shall include seaming and jointing, procedures for testing and repairing, proposed handling equipment and restraining methods, and other information that shall promote proper use.
- Results of compression testing (refer Section 9.7).

9.3.3 Prior to installation of geotextile

The Contractor shall submit the following to the Superintendent for review and approval prior to installation of the geotextile:

- Delivery, storage and handling log for all geotextile rolls to be used in the Works, including delivery dockets, roll number and identification, delivery inspection checklist, details of storage and handling.
- Proposed panel placement drawing, showing the location and reference number of all panels and expected seams, connections and penetrations, panel dimensions and layout, and the order of panel installation.
- Results of independent material conformance testing.

9.3.4 Following installation of geotextile

The Contractor shall submit the following to the Superintendent for review and approval following installation of the geotextile:

- Panel placement log, providing details on panel number and associated roll number, date and time placed, condition of receiving surface, weather conditions and precipitation events, QA checks performed, and all other relevant information.
- Finalised panel placement drawing showing the as-built location of all panels, seams, connections and penetrations.
- Defects and repairs log, showing details of all defects identified and repairs completed.

9.4 Manufacturer’s quality control

The manufacturer shall follow a quality control program, approved by the Superintendent, throughout the manufacturing of all geotextile for the Works.

Manufacturer’s quality control submissions shall include:

- Date of manufacture
- Lot number, roll number, length and width
- Polymer quality control documentation used in the production of the rolls delivered
- Fibre quality control documentation used in the production of the rolls delivered
- Geotextile manufacturer quality control documentation for the particular lots of geotextiles used in the production of the rolls delivered
- Quality control program laboratory-certified reports
- The manufacturer’s approved quality assurance stamp and the technician’s signature

The frequency of sampling and testing shall be in accordance with Table 9-1.

The Superintendent may reject any geotextile rolls that have not been sampled and/or tested in accordance with this section.

All geotextile rolls rejected by the Superintendent shall be removed from the site and replaced by the Contractor.

9.5 Manufacturer’s quality assurance

The manufacturer shall follow a quality assurance program, approved by the Superintendent, throughout the manufacturing of all geotextile for the Works.

The frequency of sampling and testing shall be in accordance with ASTM D4354.

The Superintendent may reject any geotextile rolls that have not been sampled and/or tested in accordance with this section.

All geotextile rolls rejected by the Superintendent shall be removed from the site and replaced by the Contractor.

9.6 Material

The geotextile shall:

- Be manufactured of new, first-quality products manufactured for the Works
- Certified as needle-free by the manufacturer
- Comply with the acceptance criteria specified in Table 9-1.

The Contractor shall supply manufacturer's quality control and assurance testing results in accordance with the testing frequencies identified in Table 9-1 showing that the proposed material meets the requirements of this table. Samples taken shall be representative of the whole material source and shall be evenly distributed across the roll lots.

If required by the Superintendent, a sample of the geotextile shall be provided (per product) and the Superintendent and/or CQA Engineer may undertake an inspection of the manufacturer's facility.

Table 9-1 Acceptance criteria – geotextile

Property	Test method	Acceptance criteria			Minimum testing frequency
		Separation geotextile	Protection geotextile [30]	Drainage geotextile	
Woven/Non-woven	-	Non-woven	Non-woven	Non-woven	-
Polymer	-	Polyester	Polyester	Polyester	-
Formation	-	Needle punched	Needle punched	Needle punched	-
Mass per unit area (MARV)	AS 3706.4	-	1,080 g/m^2	1,080 g/m^2	every 2,500 m^2
Grab tensile strength (MARV)	AS 3706.2b	1,100 N	2,250 N	2,250 N	every 5,000 m^2
Grab elongation (MARV)	AS 3706.2b	50%	50%	50%	every 5,000 m^2
Trapezoidal tear strength (MARV)	AS 3706.3	400 N	960 N	960 N	every 5,000 m^2
CBR burst strength (MARV)	AS 3706.4	2,250 N	7,560 N	7,560 N	every 5,000 m^2
Permittivity (MARV)	AS 3706.9	0.5 s^{-1}	-	-	every 5,000 m^2
Pore size (MaxARV)	ASTM D6767	120 µm	-	-	every 5,000 m^2

[30] Preliminary specification only. Refer Section 9.7

Property	Test method	Acceptance criteria			Minimum testing frequency
		Separation geotextile	Protection geotextile (30)	Drainage geotextile	
UV stability (typical) [31]	ASTM D4355	50%	50%	50%	per each formulation

9.7 Compression testing

The protection geotextile shall be capable of limiting strain within the underlying PE geomembrane to less than 6%.

The proposed protection geotextile shall be assessed by the Contractor by undertaking compression testing in accordance ASTM D5514 at 230 kPa, with the proposed overlying drainage aggregate and proposed underlying PE geomembrane(s). The results of the compression testing shall be provided to the Superintendent to verify the proposed protection geotextile can meet the PE geomembrane strain acceptance criteria.

The Contractor shall provide manufacturer's quality control and assurance test results for the protection geotextile material used in compression testing (tested for all the parameters identified in Table 9-1) to confirm the material properties of the geotextile. In addition to this requirement, the Superintendent may organise independent testing of this protection geotextile to verify the material properties of the geotextile. The Contractor shall provide sufficient samples of the material to allow this testing to occur.

If requested by the Contractor, alternate protection arrangements may be considered at the discretion of the Superintendent.

A preliminary specification for the protection geotextile is included in Table 9-1 for undertaking bidding purposes only.

9.8 Roll and sample identification

All geotextile rolls and samples shall be identified in accordance with AS 3705.

Each roll or panel shall carry a label which identifies, as a minimum:

- Product name, grade and name of manufacturer
- Date of manufacture, batch number
- Material thickness
- Roll number
- Roll length
- Roll weight
- Roll width
- Handling guidelines
- Reference numbers to raw material batch and laboratory certified reports
- The manufacturer's approved quality assurance stamp and the technician's signature

[31] Strength retained after 500 hours

The Superintendent may reject any geotextile rolls or samples that have not been identified in accordance with this section.

All geotextile rolls rejected by the Superintendent shall be removed from the site and replaced by the Contractor.

9.9 Delivery, storage and handling

The Contractor shall prepare a work method statement for delivery, storage, handling and installation of geotextile, including repair methods (refer Appendix A). The work method statement shall be submitted to the Superintendent for review and comment prior to delivery of the geotextile to site.

The delivery, storage and handling components of the work method statement shall be developed in accordance with the Manufacturer's written recommendations and the guidance provided below:

- Delivery, storage and handling of all geotextile rolls and samples shall be undertaken in accordance with the manufacturer’s instructions and ASTM D4873 as a minimum.
- Rolls shall be delivered to site, handled and stored in such a manner that no damage occurs to the rolls.
- Rolls shall be wrapped with weather and moisture-proof wrapping to prevent any contact with water prior to installation. In the event that it is suspected that roll/s may have come into contact with water, the Superintendent shall inspect the moisture content of the effected roll/s and reject the roll/s if they are damaged beyond use. All geotextile rolls rejected by the Superintendent shall be removed from the site and replaced by the Contractor.
- Roll cores shall be sufficiently strong to ensure that they do not deflect by more than half their diameter during delivery, storage and handling.
- Rolls shall be stored in a location away from construction traffic but sufficiently close to the installation area to minimise handling. The storage area shall be level, dry, well-drained and stable, and shall protect the product from precipitation, chemicals, excessive heat, UV radiation, standing water, vandalism and animals.
- Geotextile roll stacks shall be limited to the height at which installation personnel can safely manoeuvre the handling equipment. The recommended maximum stack height is three rolls.
- Rolls shall be handled using a spreader stinger bar. The bar shall be capable of supporting the full weight of the rolls without significant bending. Under no circumstances shall the rolls be dragged, lifted from one end, lifted in the middle of the roll, lifted with the forks of a forklift or pushed to the ground from the delivery vehicle. The Contractor may nominate alternate handling equipment and plant for approval by the Superintendent as part of their work method statement.
- The Contractor shall inspect all geotextile rolls for defects and damage upon delivery.

The Superintendent may reject any geotextile rolls that have not been delivered, stored or handled in accordance with this section.

All geotextile rolls rejected by the Superintendent shall be removed from the site and replaced by the Contractor.

9.10 Preparation of receiving surface

Prior to placement of geotextile, the receiving surface shall exhibit the following characteristics:

- The surface shall be smooth, flat, firm and unyielding to the satisfaction of the Superintendent.
- The surface shall not exhibit visible deformation, rutting, yielding and/or show signs of distress or instability during final proof rolling (if required).
- The surface shall be free of debris, roots, angular material (such as sharp rocks), desiccation cracks, abrupt breaks, indentations, sudden changes in grade, defects and/or imperfections that may result in damage to the overlying materials.
- No loose, coarse-grained material shall remain on the surface. If required, the surface shall be raked or graded to remove any material penetrating out of the surface greater than 10 mm.
- The surface shall promote drainage and excessive water shall not be allowed to pond on the surface.
- The surface shall not be pebbly, tracked, rutted or otherwise disturbed by the equipment deploying overlying materials or other traffic. Pockets, holes, or discontinuities shall be repaired.
- All construction stakes, hubs, or other items used for grade control shall be removed and any voids filled. Any unsuitable material shall be over-excavated to a depth of 100 mm and replaced with approved material.
- The surface shall be maintained at sufficient moisture content to prevent desiccation during the Works.

Where geotextile is being placed over a geosynthetic material, the underlying geosynthetic shall be free of excessive wrinkles preventing intimate contact between the underlying geosynthetics and/or foundation materials.

The receiving surface shall be surveyed as per the requirements of Section 1.11.

Placement of geotextile shall not proceed until the receiving surface has been inspected and approved by the Superintendent.

The Superintendent may reject any underlying geosynthetic or underlying foundation material which does not meet these requirements. Any geosynthetic rejected by the Superintendent shall be removed from the site by the Contractor. Any rejected foundation material shall be removed and/or remediated to the satisfaction of the Superintendent.

9.11 Installation

9.11.1 General

The Contractor shall prepare a work method statement for delivery, storage, handling and installation of geotextile (refer Appendix A). The work method statement shall be submitted to the Superintendent for review and comment prior to delivery of the geotextile to site.

The installation component of the work method statement shall be developed in accordance with the guidance provided below.

The Superintendent may reject any geotextile rolls that have not been installed in accordance with this section.

All geotextile rolls rejected by the Superintendent shall be removed from the site and replaced by the Contractor.

9.11.2 Weather conditions

The Contractor shall consider the weather conditions on a daily basis to confirm they are suitable for placement of geotextile.

Geotextile shall not be placed or seamed:

- If moisture prevents proper subgrade preparation, panel placement and/or panel seaming.
- During precipitation, during hail, during periods of excessive fog, during periods of excessive dust, in standing water, on excessively wet surfaces, in the presence of excess moisture (such as dew and/or ponded water).
- During periods of excessive winds (>30 kph) or when gusting wind conditions interfere with handling operations.

9.11.3 Traffic

Equipment used shall not damage the geotextile by handling, trafficking, leakage of hydrocarbons, or by other means.

No vehicle shall be allowed to travel directly on the geotextile unless approved by the Superintendent. Prior to approval, the Contractor shall provide the Superintendent the following information:

- Guidance from the manufacturer on suitable plant for trafficking for the proposed geotextile and confirmation that the Contractor shall only use this plant
- Guidance from the manufacturer on suitable trafficking method for the proposed geotextile and confirmation that the Contractor shall only use this trafficking method
- Certification from the manufacturer that the above trafficking method and plant shall not void the warranty for the proposed geotextile

9.11.4 Placement

Geotextile shall be placed in accordance with the following:

- The geotextile shall be placed and seamed in accordance with this Specification, the Contract Drawings, the approved work method statement and the manufacturer's instructions. Any contradictions shall be clarified with the Superintendent.
- Prior to placement, each roll shall be inspected by the Contractor for damage and/or defects, including tears, abrasion, indentation, cracks, thin spots or any other faults or defects. If damage or defects are identified, the roll shall be inspected by the Superintendent and approved or rejected.
- Geotextile shall be protected from damage due to exposure to sunlight, dirt, dust and other hazards.
- Geotextile shall be placed such that the panels are anchored at the crest of the slope and form a continuous layer down the side walls and slopes and across the base.
- The arrangement of the geotextile panels shall be in accordance with the approved panel placement drawing and any changes approved by the Superintendent.
- Installation shall progress from the highest elevations to the lowest.
- Geotextile rolls shall be placed in an orderly fashion which shall minimise or prevent surface water from flowing below previously installed geotextile.

- Geotextile shall not be allowed to 'bridge over' voids or low areas. The geotextile shall be placed to allow intimate contact with the subgrade or underlying geosynthetic.
- Geotextile shall be installed without undergoing excessive buckling, wrinkling or tensioning.
- Geotextile shall not be dragged across an unprepared surface. If the geotextile is dragged across an unprepared surface, it shall be inspected for defects and repaired or rejected if necessary.
- Where there is a geosynthetic layer below, the installation of the geotextile shall be undertaken in a manner so as not to damage the underlying layer.
- Sandbags or equivalent ballast shall be used as necessary to hold the geotextile in position and prevent uplift by wind. In case of high winds, continuous loading shall be placed along edges of panels to minimise wind flow under the panels. Sandbag material shall be sufficiently close-knit to prevent soil fines from working through the bags and discharging on the geotextile.
- Only those geotextile rolls which can be seamed or permanently anchored on at least two sides on the same day shall be placed on a daily basis. All other sides shall be temporarily anchored.
- Geotextile installed on slopes shall be fixed in anchor trenches as shown on the Contract Drawings and Section 2.12. Geotextile panels shall be anchored as soon as possible.
- Personnel working on the geotextile shall not smoke, wear damaging shoes, excessively traffic or engage in other activities which may damage the geotextile. Geotextile in heavy traffic areas shall be protected by a geosynthetic overlay.
- Geotextile rolls shall be freely suspended during placement.
- The method used to unroll the geotextile shall not cause bridging, excessive wrinkles, scores, scratches and/or crimps.
- After placement, the geotextile shall be free of excessive buckles, wrinkles, ripples, creases, folds and irregular stressing.

9.11.5 Seaming

Geotextile shall be seamed in accordance with the following:

- Geotextile seams shall be formed by overlapping the edges of the geotextile panels by a minimum of 200 mm and thermally bonding the seam or sewing the seam together with continuous stitches located a minimum of 100 mm from the overlapped edges. A two-thread, double-locked stitch shall be used. The proposed seaming method shall be in accordance with the manufacturer's instructions.
- Equipment used for thermal bonding and/or sewing shall be inspected and approved by the Superintendent prior to use. If requested by the Superintendent, the Geosynthetic Installer shall prepare a trial seam for inspection and/or testing prior to approval.
- The Contractor shall ensure that the seaming method does not result in damage to the underlying geosynthetics.
- Sewing procedures shall conform to the manufacturer's instructions. Spot sewing shall not be allowed.
- Thread used to sew panels of geotextile together shall be polymeric thread with physical and chemical-resistance properties that equal or exceed those of the geotextile. The

thread colour shall contrast with the geotextile colour and shall be approved for use by the manufacturer.

- Adhesive may be used to seam the geotextile subject to approval from the Superintendent. The adhesive shall be approved by the manufacturer for use in seaming their product. If requested by the Superintendent, the Geosynthetic Installer shall prepare a trial seam for inspection and/or testing prior to approval.
- Seams shall provide seam strength which equals or exceeds 75% of parent material strength when tested in accordance with AS 3706.2 (parent material strength) and AS 3706.6 (seam strength). The Superintendent may organise independent testing of the completed seams to verify conformance with this requirement. The Geosynthetic Installer shall repair any locations where samples are taken in accordance with Section 9.13.

9.12 Protection and covering

The protection geotextile shall be protected from damage due to overexposure to UV radiation. Covering activities shall be coordinated to ensure the following:

- The overlying confinement layer (300 mm thick drainage aggregate on the base and in the cap, and 300 mm thick soil confining layer on the sidewalls) shall be placed as soon as practicable, in accordance with the protection geotextile instructions or as approved by the Superintendent. Notwithstanding these requirements, the overlying confinement layer shall be placed no longer than 2 weeks following protection geotextile placement. The 300 mm thick drainage aggregate shall be installed in accordance with the approved work method statement (refer Section Appendix A).
- No vehicle shall be allowed to traffic directly on the protection geotextile during placement of the overlying confining layer unless approved by the Superintendent (refer Section 7.10.3). The overlying confinement layer shall not be pushed or graded in a direction that may cause damage to the protection geotextile seams.

In the opinion of the Superintendent, if the placed protection geotextile panels are damaged extensively due to overexposure to UV radiation, then the effected protection geotextile panels shall be removed and replaced by the Contractor at their own expense.

9.13 Defects and repairs

The Contractor and shall be responsible for inspecting the placed geotextile to identify any damage or faults in the material. The Superintendent and/or CQA Engineer may also undertake inspections of the placed geotextile to identify any damage or faults in the material. Any areas of geotextile damaged during installation shall be repaired by the Contractor. All repairs shall be verified by the Superintendent.

Any geotextile that has been damaged (by tears, holes or otherwise) during installation shall be repaired by patching a new piece of geotextile of the same material type and thickness with a minimum 300 mm overlap beyond the repair area in each direction. Any soil or other foreign material that may have penetrated the damaged geotextile onto the surface of the underlying layer or within the underlying layer shall first be removed to the satisfaction of the Superintendent before any repair work is undertaken.

Seaming of geotextile repair patches shall be undertaken in accordance with Section 9.11.3.

The Contractor shall submit to the Superintendent for review a log containing details of any defects identified and repairs carried out.

10. Drainage aggregate

10.1 General

This section contains the technical requirements for the drainage aggregate. The relevant requirements for the drainage aggregate in Section 2 shall be considered alongside guidance provided in this section.

The Superintendent may reject any component of the drainage aggregate that do not meet or exceed the requirements of this section.

Any component of the drainage aggregate rejected by the Superintendent shall be remediated by the Contractor.

10.2 Standards

10.2.1 Australian standards

Relevant Australian standards are as follows but not limited to:

- 1141.3.1 Methods for Sampling and Testing Aggregates – Sampling of aggregates and rock
- 1141.11 Methods for Sampling and Testing Aggregates – Particle size distribution/dry sieve
- 1289.6.7.1 Methods for Testing Soils for Engineering Purposes – Determination of the permeability of a soil

10.3 Submittals

10.3.1 Prior to delivery of drainage aggregate to site

The Contractor shall submit the following to the Superintendent for review and approval prior to delivery of the drainage aggregate to site (per material source):

- Material source
- Certification that the material is VENM or ENM or NSW EPA Resource Recovery Exemption appropriate for use as drainage aggregate
- Pre-qualification test results/reports demonstrating that the proposed material complies with the material property requirements of this section of the Specification (refer Section 10.4)
- Estimated quantity of material which is represented by the pre-qualification test results/reports
- Information on the parent geology of the material

10.3.2 Prior to placement of drainage aggregate

The Contractor shall submit the following to the Superintendent for review and approval prior to placement of the drainage aggregate:

- Survey of the underlying surface in accordance with Section 1.11
- Work method statement for placement of the clay rich fill layer, including testing and repair procedures (refer Appendix A)

10.3.3 Following placement of drainage aggregate

The Contractor shall submit the following to the Superintendent for review and approval following placement of drainage aggregate:

- As-built survey of the completed surface showing conforming layer thickness within the allowable tolerances
- CQC testing results/reports showing compliance with the requirements of this Specification
- Defect and repairs log, showing details of all defects identified and any repairs completed

10.4 Material

10.4.1 Drainage aggregate

Drainage aggregate shall:

- Be selectively sourced material from on-site or imported from an approved source. Imported material shall be classed as VENM or ENM or NSW EPA Resource Recovery Exemption
- Not contain any unsuitable materials identified in Section 2.4.1 unless approved by the Superintendent
- Be rounded to sub-rounded
- Be clean, hard, sound and durable material that will maintain the required performance under the maximum loads likely to be imposed on it in service
- Be non-reactive in mildly acidic conditions
- Have a calcium carbonate content of less than 8.5% by mass
- Have an effective angle of internal friction of greater than 35 degrees
- Be relatively uniform in grain size
- Comply with the acceptance criteria specified in Table 10-1

The Contractor shall supply pre-qualification testing results in accordance with the testing frequencies identified in Table 10-1 showing that the proposed material meets the requirements of this table. Samples taken shall be representative of the whole material source and shall be evenly distributed across the material source.

If required by the Superintendent, a sample of the material shall be provided (per source) and the Superintendent and/or CQA Engineer may undertake an inspection of the material source. The Contractor shall cooperate fully with the Superintendent and CQA Engineer to allow this inspection to occur.

The Superintendent may organise independent testing of the material to verify conformance with the requirements of this section.

Table 10-1 Acceptance criteria – drainage aggregate

Property	Test method	Acceptance criteria	Minimum test frequency
Constant head permeability	AS 1289.6.7.1[32]	> 10^{-3} m/s	Greater of: 1 per 10,000 m^3 of material or 3 per source
Particle size distribution: - Passing 50 mm - Passing 19 mm - Passing 0.075 mm	AS 1141.11,12,13 or AS 1289.3.6.1, 3.6.3	100% ≤ 10% ≤ 3%	Greater of: 1 per 1,000 m^3 of material or 3 per source

10.4.2 Recycled drainage aggregate

Recycled drainage aggregate shall:

- Be selectively sourced material from on-site or imported from an approved source. Imported material shall be asbestos free and be tested for the presence of other materials in accordance with RTA test method T276.
- Not contain any unsuitable materials identified in Section 2.4.1 unless approved by the Superintendent
- Be clean, hard, sound and durable material that will maintain the required performance under the maximum loads likely to be imposed on it in service
- Have an effective angle of internal friction of greater than 35 degrees
- Comply with the acceptance criteria specified in Table 10-1

The Contractor shall supply pre-qualification testing results in accordance with the testing frequencies identified in Table 10-1 showing that the proposed material meets the requirements of this table. Samples taken shall be representative of the whole material source and shall be evenly distributed across the material source.

If required by the Superintendent, a sample of the material shall be provided (per source) and the Superintendent and/or CQA Engineer may undertake an inspection of the material source. The Contractor shall cooperate fully with the Superintendent and CQA Engineer to allow this inspection to occur.

The Superintendent may organise independent testing of the material to verify conformance with the requirements of this section.

Table 10-2 Acceptance criteria – drainage aggregate

Property	Test method	Acceptance criteria	Minimum test frequency
Particle size distribution: - Passing 50 mm - Passing 19 mm - Passing 0.075 mm	AS 1141.11,12,13 or AS 1289.3.6.1, 3.6.3	100% ≤ 10% ≤ 3%	Greater of: 1 per 1,000 m^3 of material or 3 per source

[32] The intrinsic permeability of the testing apparatus shall be established prior to testing the drainage aggregate and reported with the test results to verify the testing apparatus is suitable for this test

10.5 Preparation of receiving surface

Prior to placement of drainage aggregate, the underlying geosynthetic shall be free of:

- Any of debris, roots, angular material (such as sharp rocks), or loose, coarse-grained material on or immediately below the geosynthetic
- Excessive wrinkles preventing intimate contact between the underlying geosynthetics and/or foundation materials

The foundation material underlying the geosynthetic shall:

- Be smooth, flat, firm and unyielding to the satisfaction of the Superintendent
- Be free of abrupt breaks, indentations and/or sudden changes in grade
- Promote drainage and excessive water shall not be allowed to pond on the surface of the geosynthetic

Placement of drainage aggregate shall not proceed until the underlying geosynthetic has been inspected and approved by the Superintendent.

The Superintendent may reject any underlying geosynthetic or underlying foundation material which does not meet these requirements. Any geosynthetic rejected by the Superintendent shall be removed from the site by the Contractor. Any rejected foundation material shall be removed and/or remediated to the satisfaction of the Superintendent.

10.6 Installation

The Contractor shall prepare a work method statement for placement of the drainage aggregate outlining the placement methodology and proposed construction plant to be used (refer Appendix A). The work method statement shall be submitted to the Superintendent for review and approval prior to commencement of the required field trial.

A field trial shall be undertaken by the Contractor to verify the Contractor's proposed construction methodology for the drainage aggregate, in accordance with Section 16. The Contractor shall adjust the placement method as necessary based on the results of the field trial.

The work method statement and construction methodology for the drainage aggregate shall be developed in accordance with the guidance provided below:

- The drainage aggregate shall be placed with a uniform particle size distribution to prevent concentration of fines. This can be achieved through conditioning of the material prior to placement.
- The drainage aggregate shall be constructed in one lift with a minimum thickness of 300 mm. Plant shall not be allowed to traffic the underlying surface unless a minimum 300 mm thick drainage aggregate layer is present. Drainage aggregate shall be placed in areas without placed drainage aggregate by unloading the material from a pad of previously placed drainage aggregate.
- The maximum allowable ground pressure for plant trafficking the minimum 300 mm thick drainage aggregate layer is 35 kPa.
- Plant exceeding the allowable ground pressure requirements shall be allowed providing they work from elevated pads with a minimum thickness from the underlying surface of 1 m. These elevated pads shall be removed following completion of drainage aggregate placement.

- Aggregate shall be placed directly on the underlying geosynthetic rather than pushing in place to avoid the formation of excessive wrinkles or 'waves'.
- Drainage aggregate shall be placed in a manner which does not result in excessive particle breakdown or crushing.
- Drainage aggregate shall be placed carefully around any pipework to ensure the pipework has sufficient and uniform support.
- No aggregate shall be placed in areas where the underlying geosynthetic is not in contact with the supporting subgrade.
- Drainage aggregate shall not be placed closer than 2 m from the edge of geosynthetic panels where seaming of additional geosynthetics to the edge is yet to be performed. Temporary access across such edges shall be subject to approval by the Superintendent.

10.7 Construction quality control testing

The Contractor shall undertake CQC testing of the drainage aggregate in accordance with Table 10-3 as a minimum and the relevant requirements of Section 2.10. Sampling locations for testing shall be agreed with the Superintendent and CQA Engineer.

Table 10-3 Construction quality control testing – drainage aggregate

Property	Test method	Minimum test frequency
Particle size distribution	AS 1141.3.1, AS 1141.11.1	1 per 1,000 m^3

10.8 Tolerances

The Contractor shall place the drainage aggregate within the tolerances provided in Section 2.11.

10.9 Defects and repairs

The Superintendent may direct the Contractor to remove a section of the aggregate to inspect underlying materials for damage. The Contractor shall repair any damage that occurs to the underlying materials as a consequence of the placement of drainage aggregate in accordance with this Specification.

Any areas of placed drainage aggregate that do not conform to the required CQC testing criteria shall be repaired by the Contractor to the satisfaction of the Superintendent. This includes non-conformances resulting from independent testing commissioned by the Superintendent or CQA Engineer.

The Contractor shall submit to the Superintendent for review details of any defects identified and repairs carried out.

11. PE pipework

11.1 General

This section contains the technical requirements for polyethylene (PE) pipework and fittings.

The Superintendent may reject any PE pipework and fittings that does not meet or exceed the requirements of this section.

Any PE pipework and fittings rejected by the Superintendent shall be removed from the site and replaced by the Contractor.

11.2 Standards

11.2.1 Australian Standards

Relevant Australian standards are as follows but not limited to:

- 1463 Polyethylene Pipe Extrusion Compounds
- 1646 Elastomeric Seals for Water Works Purposes
- 2033 Installation of Polyethylene Pipe Systems
- 2698.2 Plastic Pipes and Fittings for Irrigation and Rural Applications Polyethylene Rural Pipes
- 2700 Colour Standards for General Purposes
- 4129 Fittings for Polyethylene Pipes for Pressure Applications
- 4130 Polyethylene Pipes for Pressure Applications
- 4131 Polyethylene Compounds for Pressure Pipes and Fittings

11.2.2 Water Services Association of Australia

Relevant Water Services Association of Australia standards are as follows:

- 02-2002
- 03-2002

11.3 Submittals

11.3.1 Prior to delivery of PE pipework to site

The Contractor shall submit the following to the Superintendent for review and approval prior to delivery of PE pipework to site (per PE pipework product):

- Product manufacturer.
- Product name.
- Manufacturer’s certificate of compliance outlining conformance with the requirements of this Specification.
- Manufacturer’s quality control and assurance procedures.
- Manufacturer’s quality control and assurance test results.
- Complete description of the manufacturer’s shipping, handling and storage procedures.
- Manufacturer’s installation procedures and requirements.

- Work method statement for PE pipework delivery, storage, handling and installation. This shall include jointing, procedures for testing and repairing, proposed handling equipment and restraining methods, and other information that shall promote proper use.

11.3.2 Prior to installation of PE pipework

The Contractor shall submit the following to the Superintendent for review and approval prior to installation of the PE pipework:

- Delivery, storage and handling log for all PE pipework to be used in the Works, including delivery dockets, pipework identification, details of storage and handling.

11.3.3 Following installation of PE pipework

The Contractor shall submit the following to the Superintendent for review and approval following installation of the PE pipework:

- As-built survey of all pipework showing conforming lines and levels
- Defects and repairs log, showing details of all defects identified and repairs completed

11.4 Material

The materials used for the PE pipework and fittings shall be in accordance with the Contract Drawings.

If required by the Superintendent, a sample of the PE pipework shall be provided (per product) and the Superintendent and/or CQA Engineer may undertake an inspection of the manufacturer's facility. The Contractor shall cooperate fully with the Superintendent and CQA Engineer to allow this inspection to occur.

11.5 Delivery, storage and handling

The Contractor shall prepare a work method statement for delivery, storage, handling and installation of PE pipework and fittings, including repair methods (refer Appendix A). The work method statement shall be submitted to the Superintendent for review and comment prior to delivery of the PE pipework to site.

The delivery, storage and handling components of the work method statement shall be developed in accordance with the guidance provided below:

- Delivery, storage and handling of all PE pipework and fittings shall be undertaken in accordance with the manufacturer's instructions.
- PE pipework shall be delivered to site, handled and stored in such a manner that no damage occurs to the PE pipework.
- PE pipework shall be stored in a location away from construction traffic but sufficiently close to the installation area to minimise handling. The storage area shall be level, dry, well-drained and stable, and shall protect the product from chemicals, excessive heat, UV radiation, vandalism and animals.
- The Contractor shall inspect all PE pipework and fittings for defects and damage upon delivery.

The Superintendent may reject any PE pipework and fittings that have not been delivered, stored or handled in accordance with this section.

All PE pipework and fittings rejected by the Superintendent shall be removed from the site and replaced by the Contractor.

11.6 Installation

11.6.1 General

The Contractor shall prepare a work method statement for delivery, storage, handling and installation of PE pipework and fittings (refer Appendix A). The work method statement shall be submitted to the Superintendent for review and comment prior to delivery of the PE pipework to site.

The installation component of the work method statement shall be developed in accordance with the guidance provided below:

- The PE pipework and fittings shall be placed and seamed in accordance with this Specification, the Contract Drawings, AS 2033, the approved work method statement and the manufacturer's instructions. Any contradictions shall be clarified with the Superintendent.
- Prior to placement, each pipe/fitting shall be inspected by the Contractor for damage and/or defects. If damage or defects are identified, the PE pipework shall be inspected by the Superintendent and approved or rejected.
- Perforations shall be drilled to the size, number and location indicated on the Contract Drawings. Perforated pipework shall be thoroughly cleaned of drilling wastes or other foreign matter and any hanging beads removed before installation.
- PE pipework shall be installed in a manner so as to provide for expansion and contraction as recommended by the manufacturer.
- PE pipework shall be placed on an even bed of supporting material in accordance with the Contract Drawings.
- PE pipework shall lay free on the base with no induced strain. Where there is evidence of induced pipe strain, the Contractor shall be required to eliminate the strain. The Contractor shall also remove and replace any fitting, which induces a torque or strain to the pipe.
- PE pipework shall be cut in a manner so as to ensure square ends. Burrs at cut ends shall be removed prior to installation so that a smooth unobstructed flow be obtained.
- Pipe joints shall be butt-fusion welded in accordance with the manufacturer’s instructions.
- PE pipework and fittings shall be held firmly in position and protected from damage while drainage aggregate or other backfilling material is being placed.
- All pipe and fittings shall be clean upon installation and kept so during the progress of the Works.
- Any PE pipework that becomes either partially or fully clogged and/or damaged before final acceptance shall be cleaned/repaired to the satisfaction of the Superintendent, and/or replaced.

11.7 Defects and repairs

The Contractor and shall be responsible for inspecting the placed PE pipework and fittings to identify any damage or faults in the material. The Superintendent and/or CQA Engineer may also undertake inspections of the placed PE pipework and fittings to identify any damage or faults in the material. Any areas of PE pipework damaged during installation shall be repaired by the Contractor in accordance with the manufacturer’s instructions. All repairs shall be verified by the Superintendent.

The Contractor shall submit to the Superintendent for review a log containing details of any defects identified and repairs carried out.

12. Soil confining layer

12.1 General

This section contains the technical requirements for the soil confining layer. The relevant requirements for earthworks in Section 2 shall be considered alongside guidance provided in this section.

The Superintendent may reject any component of the soil confining layer that does not meet or exceed the requirements of this section.

Any component of the soil confining layer rejected by the Superintendent shall be remediated by the Contractor.

12.2 Standards

12.2.1 Australian Standards

Relevant Australian standards are as follows :

- 1141.3 Methods for Sampling and Testing Aggregates – Sampling of aggregates and rock.
- 1141.11 Methods for Sampling and Testing Aggregates – Particle size distribution/dry sieve
- 1289.6.7.1 Methods for Testing Soils for Engineering Purposes – Determination of the permeability of a soil

12.3 Submittals

12.3.1 Prior to placement of soil confining layer

The Contractor shall submit the following to the Superintendent for review and approval prior to placement of the soil-confining layer:

- A 20 kg sample of the proposed material.
- Pre-qualification test results/reports demonstrating that the proposed fill material complies with the material property requirements of this Specification
- Estimated quantity of material which is represented by the pre-qualification test results/reports (per source)
- Survey of the underlying surface in accordance with Section 1.11
- Work method statement for the placement of soil confining layer, including testing and repair procedures
- Completion and acceptance of the soil confining layer field trial, in accordance with Section 17

12.3.2 Following placement of soil confining layer

The Contractor shall submit the following to the Superintendent for review and approval following placement of the soil confining layer:

- As-built survey of the completed surface showing conforming layer thickness within the allowable tolerances
- Defect and repairs log, showing details of all defects identified and any repairs completed.

12.4 Material

Soil confining layer material shall comprise of select fill.

12.5 Delivery, storage and handling

If sand fill is to be stockpiled, it shall be stored and handled to prevent debris, pockets of clay and other deleterious or organic materials from being mixed into it.

The Contractor shall be responsible for storage and handling of the sand fill once delivered to site. The sand fill shall not become contaminated with soil and/or fines. Contaminated sand fill shall be rejected by the Superintendent and removed from the site by the Contractor.

12.6 Preparation of surface to receive soil confining layer

Placement of the soil confining layer shall not be undertaken until placement, installation and testing of the layers below are complete and accepted by the Superintendent.

Prior to placement of the soil confining layer, the receiving surface shall be cleared of any debris and/or foreign material.

The receiving surface shall be surveyed as per the requirements of Section 1.11.

Placement of the soil confining layer shall not proceed until the receiving surface has been approved by the Superintendent.

12.7 Installation

The Contractor shall prepare a work method statement for placement of the soil confining layer outlining the measures taken to prevent damage to the underlying lining system.

The protection aggregate shall be placed in a manner and with appropriate equipment such that damage does not occur to the previously installed liner layers.

The work method statement shall be developed based on the guidance provided below:

- The maximum allowable ground pressure for plant trafficking the soil confining layer is 35 kPa and in accordance with the outcome of the field trial.
- Plant exceeding the allowable ground pressure requirements shall be allowed providing they work from elevated pads with a minimum thickness from the liner of 1 m.
- Trafficking with heavy machinery shall be avoided after placement.
- Soil confining layer material shall be placed from the bottom of the slopes and pushed upward.
- No soil confining layer material shall be placed in areas where the geosynthetics are not in contact with the supporting subgrade.
- Soil confining layer material shall be placed parallel to the direction of the geosynthetic lapped seams.
- Soil confining layer material shall not be placed closer than 2 m from the edge of geosynthetic sheets where seaming of additional geosynthetics to the edge is yet to be performed. Temporary access across such edges shall be subject to Superintendent approval.

12.8 Defects and repairs

The Superintendent may direct the Contractor to remove a section of the soil confining layer to inspect underlying layers for damage.

The Contractor shall repair any damage that occurs to the underlying layers as a consequence of the placement of sand fill in accordance with the provisions of this Specification.

The Contractor shall submit to the Superintendent for review details of any defects identified and repairs carried out.

13. Waste placement

13.1 General

This section contains the technical requirements for waste placement.

13.2 Submittals

Prior to waste placement, the Contractor shall submit a work method statement for waste placement with consideration to the requirements outlined in this Specification, including though not necessarily limited to:

- Scheduling
- Supply
- Numbers, types, and sizes of equipment proposed to perform hauling and placement
- Anticipated challenges and mitigation measures
- Methods for maintaining adequate survey control during placement operations
- Method of material placement and compaction
- Trimming and final surface preparation
- Contaminated water management procedures detailing: methods and equipment to handle contaminated water during placement operations as specified herein and washing/decontamination methods, disposal methods, all with reference to relevant regulations

13.3 Waste material

The Contractor shall excavate and transport designated waste materials to achieve the final lines and levels as shown on the Contract Drawings. The Contractor shall note that waste materials vary substantially in composition, type, size, hazard, and compactibility, which will impact waste placement method and effectiveness. The Contractor shall perform waste placement for all designated waste materials to the requirements of this specification.

The Contractor shall separate any clean cover material from waste material, taking care not to contaminate the clean cover material or imported materials with waste material. The separated clean cover material shall be transported to the approved stockpile area and stockpiled separate from other materials. The clean cover material may be reused as part of the Works, subject to approval by the Superintendent. The Superintendent shall inspect and approve any clean cover material stockpiles prior to reuse.

All excavated waste material shall be transported to a nominated location as directed by Superintendent. All excavated waste materials will be immediately relocated to the nominated locations.

All exposed waste materials or waste materials used as select waste (fill) are to be covered with suitable material by the end of each working day. This includes waste materials relocated to locations nominated by the Superintendent.

The Contractor shall manage waste material placement such that no waste materials are deposited in areas not designated for waste materials.

13.4 Placement

13.4.1 General

Filling shall be undertaken in accordance with the Contract Drawings. Waste placement shall commence at the high end of each sub-cell and progress eastward.

Waste shall be placed to minimise the entrainment of leachate or surface water within the waste and the formation of void spaces. The placement of waste shall be undertaken to ensure ponding is minimised.

The amount of waste exposed during operations shall be minimised.

All waste batters shall be no steeper than 1 (vertical) in 3 (horizontal).

Waste placement shall be undertaken such that pre-capping contours are suitable for placement of the final capping layer.

13.4.2 Protection of lining system

Waste shall be placed in near horizontal layers across the entire area of the cell in horizontal lifts over the entire footprint.

Placement of the waste against the basal and sidewall liner system shall be undertaken so as to avoid damage to the lining systems. Specifically, no landfill compactor shall be allowed within 6 horizontal metres of the sidewall lining system at any time.

Waste placed against the sidewall shall be placed on existing waste and pushed against the sidewall. All pushing shall be towards the slope. No waste or other materials shall be pushed down the slope of the sidewall.

The liner protection layer across the sidewall lining system shall be maintained through operations. Inspections of the protection layer shall be undertaken following any rainfall event or periods of high wind speeds greater than 30 km/hr and any scouring or other damage to the layer shall be rectified.

No traffic is permitted on the separation geotextile over the leachate collection system, with the first layer of waste to be end tipped from the previously placed waste layer.

13.4.3 Compaction and lift thickness

Compaction of the waste shall be undertaken to ensure a minimum global in-situ waste density of 1.6 tonnes of waste per cubic metre of landfill airspace consumed. Based on the equipment utilised, the moisture condition and type of waste the maximum uncompacted waste layer shall be adjusted by the operator to ensure this requirement is met.

In-situ compaction shall be confirmed by weekly surveys of the previously filled areas as a minimum.

Test filling

The Contractor shall perform test filling, with adherence to the initial waste lift requirements of this specification, to determine acceptable placement and compaction methods to produce completed treated sediment fill that satisfies the requirements of this section.

The test fill will be constructed on a horizontal surface within the limits of the waste containment cell at a location agreed upon by the Contractor and the Superintendent.

To ensure the test fill will accurately represent the performance during full-scale production, the following guidelines will be followed:

1. Construction of the test fill will use a variety of the waste materials, equipment, and procedures as proposed for waste placement
2. The test fill will be constructed at least four times wider than the construction compactor drum width to be used for the waste placement or 15 metres minimum (whichever is greater).
3. The test fill will be long enough to allow construction equipment to achieve normal operating speed before reaching the test area or 25 metres minimum (whichever is greater).
4. The test fill will be constructed with at least compactible three lifts to evaluate the methodology used to tie lifts together such that the minimum global in-situ waste density of 1.6 tonnes of waste per cubic metre is achieved.

The Contractor shall conduct a survey of the test fill and record the following for Superintendent review and approval during the test filling: compaction equipment type, configuration and weight, the speed of compaction equipment travelling over the test filling area, the lift thicknesses, compaction procedures, and number of passes for compaction equipment, in-situ waste density achieved with any calculations and survey results.

13.4.4 Initial waste lift requirements

The initial lift of waste (the ‘fluffy layer’) shall be:

- Mixed with dry construction and demolition waste (ideally fines or other non-protruding materials) to provide a suitable protective layer
- Placed by tracked plant, such as a bulldozer, to avoid high point loads that could potentially damage the base liner
- A minimum of 1.5 metre for a Cat 826 Series Compactor (or similar) and 2 metres for an Cat 836 Series Compactor (or similar) to allow for placement of subsequent lifts by a landfill compactor
- Free from protruding objects that can pierce the liner
- Placed in a manner to ensure the separation geotextile overlying the drainage aggregate remains fit for purpose.

As soon as is feasible, a working platform should be established with or on top of the first waste lift, sufficient in size to allow for truck and plant manoeuvring.

13.4.5 Sidewall sacrificial geomembrane

The sidewall liner sacrificial geomembrane shall be maintained to prevent erosion of the soil confining layer. The sidewall liner to be placed per geomembrane placement requirements of this report. Any damage to the layer during operations which allows water to enter the soil confining layer shall be repaired as outlined in Section 11.7.

The sidewall liner sacrificial geomembrane shall be progressively removed as waste filling progresses.

13.4.6 Covering

Daily cover shall be placed progressively over areas of exposed waste. All waste shall be covered at the end of the working day. Intermediate cover shall be placed in areas where waste is to be exposed for periods of generally 90 days or longer.

Where possible daily and intermediate cover shall be stripped back for reuse before the waste is placed over the previously filled areas. Recovered cover material that is contaminated with waste may only be used for internal bunds to delineate the working face, or other engineering purposes where it is not exposed.

13.4.7 Setback from key-in locations

Where the internal bund requires later removal to facilitate extension of operations to new areas (at pipe penetrations), waste (including any required cover) shall not be placed within 1.5 metres of the termination of the liner at the toe of the bund.

13.4.8 Surface water diversion

As far as practicable, surface water shall be excluded from the landfilled waste.

13.4.9 Leachate collection system

The operation depth of leachate in the cell shall be limited to no more than 300 mm except during large storm events. Where the level of leachate exceeds 300 mm it shall be lowered to 300 mm as soon as is practicable.

13.4.10 Groundwater collection system

The groundwater collection system shall be effectively operated, checked and maintained during waste placement.

13.4.11 Contaminated water management

The Contractor shall conduct contaminated water management in accordance with the approved work method statement procedures of this specification. The methods, procedures and equipment required to conduct contaminated water management are the responsibility of the Contractor.

13.5 Access ramp

The surfaces of the access ramps shall be monitored for wear and any damage shall be repaired.

A smooth transition shall be maintained at the interface at the access ramp and the landfilled waste. These will remain in the cell and not removed.

13.6 Internal bund at pipe penetration

At the time of connection of each eastern sub-cell to the adjacent western sub-cell the leachate pipe and collection layer shall be made continuous to allow leachate to pass through to the leachate collection sumps.

The connection shall be made by:

- Removal of any stormwater and deleterious material within the sump area
- Repair of any damage to the protection geotextile in the base of the sump area
- Removal of the pipe end cap at the pipe penetration

- Removal of the geomembrane and protection geotextile layers over the staging bund at the pipe penetration to expose drainage aggregate within the staging bund
- Connection of the upstream and downstream pipes by moving the installed pipe sleeve
- Removal of the sandbags
- Backfilling of the sump area with the additional drainage aggregate
- Installation of separation geotextile to fully enclose the drainage aggregate layer

14. Seal bearing layer

14.1 General

This section contains the technical requirements for the seal bearing layer. The relevant requirements for the seal bearing layer in Section 2 shall be considered alongside guidance provided in this section.

The Superintendent may reject any component of the seal bearing layer that do not meet or exceed the requirements of this section.

Any component of the seal bearing layer rejected by the Superintendent shall be remediated by the Contractor.

14.2 Standards

14.2.1 Australian standards

Relevant Australian standards are as follows but not limited to :

- 1152 Specification for test sieves
- 1289 Methods of testing soils for engineering purposes
- 1289.2.1.1 Determination of the moisture content of a soil - oven drying method
- 1289.3.1.1 Soil classification tests - Calculation of the plasticity index of a soil
- 1289.3.6.1 Soil classification tests - Determination of the particle size distribution of a soil - Standard method of analysis by sieving
- 1289.3.6.3 Soil classification tests - Determination of the particle size distribution of a soil - Standard method of fine analysis using a hydrometer
- 1289.3.8.1 Soil classification tests - Dispersion - Determination of emerson class number of a soil
- 1289.5.1.1 Soil compaction and density tests - Determination of the dry density/moisture content relation of a soil using standard compactive effort
- 1289.5.6.1 Soil compaction and density tests - Compaction control test - Density index method for a cohesionless material
- 1289.5.7.1 Soil compaction and density tests - Compaction control test - Hilf density ratio and Hilf moisture variation (rapid method)
- 1289.5.8.1 Soil compaction and density tests - Determination of field density and field moisture content of a soil using a nuclear surface moisture density gauge
- 1289.6.7.3 Methods of testing soils for engineering purposes - Soil strength and consolidation tests - Determination of permeability of a soil - Constant head method using a flexible wall permeameter
- 1726 Geotechnical site investigations
- 2868 Classification of machinery for earthmoving, construction, surface mining and agricultural purposes
- 3798 Guidelines on earthworks for commercial and residential developments
- 4419 Soil for landscaping and garden use

14.3 Submittals

14.3.1 Prior to placement of seal bearing layer

The Contractor shall submit the following to the Superintendent for review and approval prior to placement of the seal bearing layer:

- Pre-qualification test results/reports demonstrating that the proposed material complies with the material property requirements of this section of the Specification (refer Section 10.4)
- Estimated quantity of material which is represented by the pre-qualification test results/reports
- Survey of the underlying surface in accordance with Section 1.11
- Work method statement for placement of the seal bearing layer, including testing and repair procedures (refer Appendix A)

14.3.2 Following placement of seal bearing layer

The Contractor shall submit the following to the Superintendent for review and approval following placement of seal bearing layer:

- As-built survey of the completed surface showing conforming layer thickness within the allowable tolerances
- CQC testing results/reports showing compliance with the requirements of this Specification
- Defect and repairs log, showing details of all defects identified and any repairs completed

14.4 Material

Seal bearing material shall:

- Be selectively sourced material from on-site or imported from an approved source. Imported material shall be classed as VENM or ENM or NSW EPA Resource Recovery Exemption appropriate for use as seal bearing material
- Not contain any unsuitable materials identified in Section 2.4.1 unless approved by the Superintendent
- Be well graded in accordance with AS 1726
- Comply with the acceptance criteria specified in Table 14-1

The Contractor shall supply pre-qualification testing results in accordance with the testing frequencies identified in Table 14-1 showing that the proposed material meets the requirements of this table. Samples taken shall be representative of the whole material source and shall be evenly distributed across the material source.

If required by the Superintendent, a sample of the material shall be provided (per source) and the Superintendent and/or CQA Engineer may undertake an inspection of the material source.

Table 14-1 Acceptance criteria – seal bearing material

Property	Test method	Acceptance criteria	Minimum test frequency
Particle size distribution: - Passing 19 mm - Passing 0.075 mm	AS 1141.11,12,13 or AS 1289.3.6.1, 3.6.3	100% > 25%	Greater of: 1 per 5,000 m^3 of material or 3 per source
Atterberg limits: - Plasticity index - Liquid limit	AS 1289.3.1.1, 3.2.1 & 3.3.1	8 – 35 ≤ 50	Greater of: 1 per 5,000 m^3 of material or 3 per source
California Bearing Ratio (CBR)	AS1289.5.7.1	≥ 5	Greater of: 1 per 5,000 m^3 of material or 3 per source
Emerson class	AS 1289.3.8.1	> 3	Greater of: 1 per 5,000 m^3 of material or 3 per source
% Organic content	AS 1289.4.1.1 or Walkley Black method	< 2%	1 per source
pH	AS 1289.4.3.1 or USEPA 9045 (1:5 solution)	4.5 – 8.5	1 per source
Ratio of Monovalent to Divalent Cations (RMD) (33)	ASTM 6141 and Rayment and Lyons 2011 15A1 (34)	> 0.15 $M^{0.5}$	1 per source

14.5 Preparation of receiving surface

Prior to placement of the seal bearing layer, the underlying geosynthetic shall be free of:

- Any of debris, roots, angular material (such as sharp rocks), or loose, coarse-grained material on or immediately below the geosynthetic
- Excessive wrinkles preventing intimate contact between the geosynthetic and the seal bearing layer

The foundation material underlying the geosynthetic shall:

- Be smooth, flat, firm and unyielding to the satisfaction of the Superintendent
- Be free of abrupt breaks, indentations and/or sudden changes in grade
- Promote drainage and excessive water shall not be allowed to pond on the surface of the geosynthetic

Placement of seal bearing layer shall not proceed until the underlying geosynthetic has been inspected and approved by the Superintendent. The seal bearing layer shall be placed immediately following acceptance of the geosynthetic panels to protect the underlying geosynthetic.

[33] RMD shall be calculated using exchangeable cation test results for material with respect to procedure outlined in Kolstad, D. C., Benson, C. H., and Edil, T. D. (2004). 'Hydraulic conductivity and swell of nonprehydrated GCLs permeated with multispecies inorganic solutions.' *J. Geotech. Geoenviron. Eng.*, 130(12), 1236–1249

[34] Methods for conducting exchangeable cation testing

The Superintendent may reject any underlying geosynthetic or underlying foundation material which does not meet these requirements. Any geosynthetic rejected by the Superintendent shall be removed from the site by the Contractor. Any rejected foundation material shall be removed and/or remediated to the satisfaction of the Superintendent.

14.6 Installation

The Contractor shall prepare a work method statement for placement of the seal bearing layer outlining the measures taken to moisture condition the seal bearing material prior to placement, placement methodology and proposed construction plant to be used (refer Appendix A). The work method statement shall be submitted to the Superintendent for review and approval prior to placement.

The work method statement and construction methodology for the seal bearing layer shall be developed in accordance with the guidance provided below:

- The seal bearing material shall be moisture conditioned uniformly throughout the material prior to placement.
- If the seal bearing material requires significant moisture content adjustment, the Contractor shall use a moisture conditioning area to allow hydration or dehydration of material to meet moisture content requirements.
- Should the seal bearing material be too wet to permit proper compaction, all work on the portions of the seal bearing material affected shall be delayed until the material has dried to the required moisture content.
- The material shall be constructed in one layer or 300 mm maximum lifts where the depth is insufficient, to the lines and grades indicated.
- The surface of the seal bearing material lifts shall be maintained as necessary prior to placement of the overlying lifts or overlying materials to prevent any moisture variations outside the requirements of the Specification. The Contractor shall be required to rework areas which do not meet this requirement.
- The Contractor shall seal surfaces (by smooth drum rolling) at the end of each day to minimise the penetration of water, provide erosion protection measures and ensure drainage systems (permanent and temporary) are maintained.

14.7 Compaction

All seal bearing material shall be placed and compacted to the requirements of Section 2.9.

14.8 Construction quality control testing

The Contractor shall undertake CQC testing for the seal bearing layer in accordance with Section 2.10.

14.9 Tolerances

The Contractor shall place the seal bearing layer within the tolerances provided in Section 2.11.

14.10 Finished surface

The finished surface of the seal bearing layer shall exhibit the following characteristics:

- The surface shall be smooth, flat, firm and unyielding to the satisfaction of the Superintendent. The surface shall be proof rolled by the Contractor using a mechanical self-propelled smooth drum roller (or equivalent) in the presence of the Superintendent to assess the soundness and suitability of the finished surface. The surface shall not exhibit visible deformation, rutting, yielding and/or show signs of distress or instability during final proof rolling.
- The surface shall be free of debris, roots, angular material (such as sharp rocks), desiccation cracks and sudden changes in grade. If required, the surface shall be raked or graded to remove any material penetrating out of the surface greater than 10 mm.
- The surface shall promote drainage and excessive water shall not be allowed to pond on the surface.
- The surface shall not be rutted or otherwise disturbed by the equipment deploying overlying materials or other traffic.
- The surface shall be maintained at sufficient moisture content to prevent desiccation during the Works.

14.11 Defects and repairs

Any areas of placed seal bearing layer that do not conform to the required compaction and moisture content testing criteria shall be repaired by the Contractor in accordance with Section 2.14. This includes non-conformances resulting from independent testing commissioned by the Superintendent or CQA Engineer.

The Contractor shall submit to the Superintendent for review details of any defects identified and repairs carried out.

15. Revegetation layer

15.1 General

This section contains the technical requirements for the revegetation layer. The relevant requirements for the revegetation layer in Section 2 shall be considered alongside guidance provided in this section.

The Superintendent may reject any component of the revegetation layer that do not meet or exceed the requirements of this section.

Any component of the revegetation layer rejected by the Superintendent shall be remediated at the expense of the Contractor.

All revegetation layer materials will be selectively sourced material from on-site (as agreed with the Superintendent). Where the import of earthworks materials is required, the Contractor shall import materials as directed by the Superintendent and CQA Engineer.

15.2 Standards

15.2.1 Australian standards

Relevant Australian standards are as follows but not limited to:

- 1289 Methods of Testing Soils for Engineering Purposes
- 4419 Soils for Landscaping and Garden Use

15.3 Submittals

15.3.1 Prior to placement of subsoil and topsoil

The Contractor shall submit the following to the Superintendent for review and approval prior to placement of the subsoil and topsoil materials:

- Survey of the underlying surface in accordance with Section 1.11
- Work method statement for placement of the revegetation layer, including testing and repair procedures (refer Appendix A)

15.3.2 Prior to seeding and sowing

The Contractor shall submit the following to the Superintendent for review and approval following placement of seal bearing layer:

- Proposed seed mix
- As-built survey of the completed soil layers showing conforming layer thickness within the allowable tolerances
- CQC testing results/reports for the completed soil layers showing compliance with the requirements of this Specification
- Defect and repairs log for the soil layers, showing details of all defects identified and any repairs completed
- Statement from the supplier/s showing conformance of the seed mixes with the requirements of the Technical Specification

15.4 Material

15.4.1 Subsoil

Subsoil material shall:

- Be selectively sourced material from on-site or imported.
- Not contain any unsuitable materials identified in Section 2.4.1 unless approved by the Superintendent
- Be well graded in accordance with AS 1726
- Comply with the acceptance criteria specified in Table 15-1

Subsoil shall be a low organic matter material that is well balanced chemically and is not saline, sodic, excessively acidic, calcium deficient or dispersive. The subsoil material is intended to provide improved rooting depth and reduce the likelihood of water logging.

The Contractor shall supply pre-qualification testing results in accordance with the testing frequencies identified in Table 15-1 showing that the proposed material meets the requirements of this table. Samples taken shall be representative of the whole material source and shall be evenly distributed across the material source.

If required by the Superintendent, a sample of the material shall be provided (per source) and the Superintendent and/or CQA Engineer may undertake an inspection of the material source.

Table 15-1 Acceptance criteria – subsoil

Property	Test method	Acceptance criteria	Minimum testing frequency
Particle size distribution: - Passing 37.5 mm - Passing 13.2 mm - Passing 2.36 mm - Passing 0.075 mm - Passing 0.002 mm	AS1141.11,12,13 or AS1289.3.6.1, 3.6.3	100% 95 – 100% 80 – 100% 20 – 50% 10 – 30%	Greater of: 1 per 5,000 m^3 of material or 3 per source
Atterberg limits: - Plasticity index - Liquid limit	AS1289.3.1.1, 3.2.1 & 3.3.1	8 – 35 < 50	Greater of: 1 per 5,000 m^3 of material or 3 per source
Emerson class	AS1289.3.8.1	> 4	Greater of: 1 per 5,000 m^3 of material or 3 per source
% Organic content	AS 1289.4.1.1 or Walkley Black method	Nominally 2-3%	Greater of: 1 per 10,000 m^3 of material or 3 per source
pH	AS 1289.4.3.1 or USEPA 9045 (1:5 solution)	5.5 – 6.8	Greater of: 1 per 10,000 m^3 of material or 1 per source

15.4.2 Topsoil

Topsoil shall be selectively sourced from onsite-qualification test results from a NATA Accredited Laboratory to show the proposed material meets these requirements.

If required by the Superintendent, a sample of the material shall be provided (per source) and the Superintendent and/or CQA Engineer may undertake an inspection of the material source.

15.4.3 Seed mix

The Contractor shall submit their proposed seed mix to the Superintendent for approval prior to use.

15.5 Preparation of surface to receive revegetation layer

Prior to placement of the revegetation layer, the receiving surface shall be cleared of any debris and/or foreign material.

The receiving surface shall be surveyed as per the requirements of Section 1.11.

Placement of the revegetation layer shall not proceed until the receiving surface has been approved by the Superintendent.

15.6 Installation

15.6.1 Subsoil

The subsoil shall be placed and installed following placement of the geonet drainage geocomposite. Placement of the material will proceed from the toe to the crest of the slope. A minimum cover of 450 mm should be maintained between construction equipment and the underlying geosynthetic layers at all time. Subsoil shall be spread evenly in one layer over the designated areas. The initial lift will consist of a lift with a maximum compacted layer thickness of 500 mm in accordance with the, compaction and moisture content requirements

Surface water shall not be permitted to drain into the geonet drainage geocomposite beneath placed subsoil.

Compaction of the lift will be accomplished after spreading using either a pneumatic or vibratory roller. Sheepsfoot rollers will not be used for initial compaction.

15.6.2 Topsoil

The Contractor shall cover trucks transporting the topsoil material to prevent loss of material during transport. The Contractor shall ensure trucks do not allow loss of material through tailgates or other parts of the truck body.

The Contractor shall take responsibility for the placing procedures adopted whether those nominated or its own.

Topsoil shall be spread evenly in one layer over the designated areas and compacted lightly and uniformly so that the finished surface is smooth and free of stones or other lumps, weeds, rubbish and other deleterious material brought to the surface. Excessive compaction shall be avoided.

Once placed, the topsoil surface shall be thoroughly watered. Regular watering shall be conducted by the Contractor to minimise establishment time for the vegetation and mitigate any erosion risks. Watering shall continue to be conducted until the vegetation has been established to the satisfaction of the Superintendent.

The equipment used for placing and spreading of materials shall be suitable for the purpose. Low pressure tyred vehicles shall be used. Graders and other high pressure tyred vehicles equipment shall not be used. The Contractor shall vary the routes of vehicles and other plant passing over completed areas of each soil profile layer to avoid areas of excess compaction.

The Contractor shall prevent areas of excess compaction from being caused by constructional plant. Compact lightly and uniformly. The Contractor shall avoid differential subsidence and produce a finished topsoil surface which is:

- At design levels
- Smooth and free from stones or lumps of soil
- Graded to drain freely, without ponding
- Graded evenly into adjoining ground surfaces
- Ready for planting

15.7 Seeding and sowing

Seeding and sowing shall be completed in accordance with the Landscape Management Plan and the following guidance (as a minimum):

- Grass seed will be sown in accordance with the supplier's requirements and/or achieve a minimum 80% cover per square meter (whichever is greater)
- Seeding outside of the specified areas must be prevented
- After sowing the topsoil surface will be lightly raked to cover the surface and the area watered immediately
- Watering will continue throughout the establishment period in accordance with the supplier's requirements
- This area shall be protected from pedestrians or animals until the grass has established, and from vehicles or heavy plant at all times

16. Field trial – drainage aggregate

16.1 General

This section contains the technical requirements for undertaking the field trial for the drainage aggregate. The relevant requirements in Section 2 shall be considered alongside guidance provided in this section.

All materials used for test sections shall be removed upon completion of the field trial and disposed of by the Contractor unless otherwise approved by the Superintendent.

16.2 Submittals

16.2.1 Prior to conducting the field trial

The Contractor shall submit the following to the Superintendent for review and approval prior to conducting the field trial:

- Work method statement for field trial methodology, including proposed location of the field trial
- Work method statement for installation of the drainage aggregate

16.2.2 Following completion of the field trial

The Contractor shall submit the following to the Superintendent for review and approval following completion of the field trial:

- A report containing the methods, details and results of the field trial
- Updated work method statement for installation of the drainage aggregate based on the results of the field trail

16.3 Method

The Contractor shall conduct a field trial of the drainage aggregate for each source of drainage aggregate material and protection geotextile arrangement. The purpose of the field trial is to evaluate the impact to the PE from the Contractor's proposed drainage aggregate placement method and performance of the protection geotextile.

16.3.1 Proposed placement method

The Contractor shall submit a work method statement outlining the proposed placement method of the drainage aggregate to the Superintendent prior to undertaking the field trial.

The work method statement shall include details of the following as a minimum:

- Method of transportation of drainage aggregate to placement location
- Method of spreading drainage aggregate
- Method of lift thickness control
- Details of plant and equipment to be used during placement, including calculation of ground pressure and proposed drainage aggregate thickness limits during trafficking
- Details of temporary pads or access tracks for plant exceeding allowable ground pressure limits
- Approximate number of passes for each item of plant on the drainage aggregate layer

16.3.2 Field trial of placement method

The field trial shall be supervised by the following personnel as a minimum:

- Contractor
- Geosynthetic Installer
- Superintendent
- CQA Engineer

The field trial may be constructed within the proposed layer area, or in an area approved by the Superintendent. The Contractor shall nominate the proposed location of the field trial for approval prior to undertaking the trial.

The field trial shall measure approximately 10 m by 20 m, unless otherwise approved by the Superintendent. Should the Superintendent approve construction of the field trial outside of the proposed drainage aggregate layer area, the Contractor shall construct the field trial on an area consistent with those represented on the Contract Drawings, and the areas of drainage aggregate shall be constructed using the methods, materials and equipment to be used during construction of the permanent drainage aggregate layer.

The complete underlying material profile shall be installed for the field trial to provide meaningful and complete results. The underlying materials for the field trial shall be installed as per the methods used to install the permanent underlying materials.

The drainage aggregate shall be placed as per the work method statement outlined in Section 16.3.1. The field trial shall mimic the actual placement method and real-world conditions. Any variations from this work method statement shall result in a non-conforming field trial unless approved by the Superintendent.

The Superintendent may direct additional passes or turning manoeuvres to be performed at their discretion to fully test the effectiveness of the protection geotextile.

16.3.3 Exhumation and inspection of the underlying geosynthetics

Prior to removal of the drainage aggregate, the layer thickness shall be recorded in order to compare the degree of damage to the thickness of the drainage aggregate.

Following completion of the field trial, the underlying PE geomembrane shall be exposed.

Most of the material may be removed using an excavator; however, care shall be taken to avoid doing any further damage to the underlying geosynthetics. Within 100 mm of the PE geomembrane, the material shall be removed by hand excavation to avoid damage to the PE geomembrane.

Once the material has been removed, the PE geomembrane shall be inspected for damage. The PE geomembrane shall be inspected over the length of the field trial test area.

Damage to the PE geomembrane shall include any holes, creases, indentations or scratches. Undamaged geomembrane shall be unblemished.

The location of the damage shall be recorded and compared to the drainage aggregate thickness at that point.

Where it is clear that there is no damage to any layers of the underlying geosynthetics as agreed with the Superintendent, the thickness of the drainage aggregate and associated plant and equipment used at that point shall be recorded.

16.3.4 Reporting and update of the proposed placement method

The Contractor shall submit a report to the Superintendent outlining the major findings from the field trial. The Contractor shall update the proposed placement method to reflect the findings of the field trial.

The Superintendent shall review and approve the updated placement method prior to placement of the permanent drainage aggregate layer. The report and updated placement method shall be provided to the Superintendent 10 working days prior to placement of the drainage aggregate.

17. Field trial – soil confining layer

17.1 General

This section contains the technical requirements for undertaking the field trial for the soil confining layer. The relevant requirements in Section 2 shall be considered alongside guidance provided in this section.

All materials used for test sections shall be removed upon completion of the field trial and disposed of by the Contractor unless otherwise approved by the Superintendent.

17.2 Submittals

17.2.1 Prior to conducting the field trial

The Contractor shall submit the following to the Superintendent for review and approval prior to conducting the field trial:

- Work method statement for field trial methodology, including proposed location of the field trial
- Work method statement for installation of the soil confining layer

17.2.2 Following completion of the field trial

The Contractor shall submit the following to the Superintendent for review and approval following completion of the field trial:

- A report containing the methods, details and results of the field trial
- Updated work method statement for installation of the soil confining layer based on the results of the field trail

17.3 Method

The Contractor shall conduct a field trial of the soil confining layer for each source of material and underlying material arrangement. The purpose of the field trial is to evaluate the Contractor’s proposed soil confining layer placement method and performance of the protection measures on the PE.

17.3.1 Proposed placement method

The Contractor shall submit a work method statement outlining the proposed placement method of the soil confining layer to the Superintendent prior to undertaking the field trial.

The work method statement shall include details of the following as a minimum:

- Method of transportation of soil confining layer material to placement location
- Method of spreading soil confining layer material
- Method of lift thickness control
- Details of plant and equipment to be used during placement, including calculation of ground pressure and proposed soil confining layer material thickness limits during trafficking
- Details of temporary pads or access tracks for plant exceeding allowable ground pressure limits

- Approximate number of passes for each item of plant on the soil confining layer, including consideration for trafficking required for placement of layers above

17.3.2 Field trial of placement method

The field trial shall be supervised by the following personnel as a minimum:

- Contractor
- Geosynthetic Installer
- Superintendent
- CQA Engineer

The field trial may be constructed within the proposed layer area, or in an area approved by the Superintendent. The Contractor shall nominate the proposed location of the field trial for approval prior to undertaking the trial.

The field trial shall measure approximately 10 m by 20 m, unless otherwise approved by the Superintendent. Should the Superintendent approve construction of the field trial outside of the proposed layer area, the Contractor shall construct the field trial on an area consistent with those represented on the Contract Drawings, and the areas of soil confining layer material shall be constructed using the methods, materials and equipment to be used during construction of the permanent soil confining layer.

The soil confining layer material shall be placed from the bottom of any slope and pushed upward.

The complete underlying material profile shall be installed for the field trial to provide meaningful and complete results. The underlying materials for the field trial shall be installed as per the methods used to install the permanent underlying materials.

The soil confining layer shall be placed as per the work method statement outlined in Section 17.3.1. The field trial shall mimic the actual placement method and real-world conditions. Any variations from this work method statement shall result in a non-conforming field trial unless approved by the Superintendent.

The Superintendent may direct additional passes or turning manoeuvres to be performed at their discretion to fully test the effectiveness of the protection geotextile.

17.3.3 Exhumation and inspection of the underlying geosynthetics

Prior to removal of the soil confining layer material, the layer thickness shall be recorded in order to compare the degree of damage to the thickness of the soil confining layer.

Following completion of the field trial, the underlying PE geomembrane shall be exposed.

Most of the material may be removed using an excavator; however, care shall be taken to avoid doing any further damage to the underlying geosynthetics. Within 100 mm of the PE geomembrane, the material shall be removed by hand excavation to avoid damage to the PE geomembrane.

Once the material has been removed, the PE geomembrane shall be inspected for damage. The PE geomembrane shall be inspected over the length of the field trial test area.

Damage to the PE geomembrane shall include any holes, creases, indentations or scratches. Undamaged geomembrane shall be unblemished.

The location of the damage shall be recorded and compared to the soil confining layer thickness at that point.

Where it is clear that there is no damage to any layers of the underlying geosynthetics as agreed with the Superintendent, the thickness of the soil confining layer and associated plant and equipment used at that point shall be recorded.

17.3.4 Reporting and update of the proposed placement method

The Contractor shall submit a report to the Superintendent outlining the major findings from the field trial. The Contractor shall update the proposed placement method to reflect the findings of the field trial.

The Superintendent shall review and approve the updated placement method prior to placement of the permanent soil confining layer. The report and updated placement method shall be provided to the Superintendent 10 working days prior to placement of the soil confining layer.

18. Stormwater drainage

18.1 General

This section contains the technical requirements for drainage elements including open drainage channels and underground culverts.

All drainage provided is to maintain the cross-sectional flow areas, slopes and lining types indicated in the design drawings to allow for the design flow conveyance and resistance to scour.

18.2 Standards

Relevant Australian standards are as follows but not limited to:

- AS3500 – Plumbing and Drainage
- AS3725 –Design and Installation of buried concrete pipes
- AS3725 Supplement 1
- AS2758.1 – Concrete aggregates
- AS1141 – Methods for Sampling and Testing Aggregates
- Australian Rainfall and Runoff A Guide to Flood Estimation

18.3 Submittals

18.3.1 Prior to delivery of materials

The Contractor shall submit the following to the Superintendent for review and approval prior to delivery of drainage materials to site:

- Product details, information and certificates for any culverts to be installed
- Details of any bedding and haunch material for stormwater drainage
- Details including particle size distribution curve and specific gravity for placed rock.
- A work method statement including details of the following as a minimum: scheduling, supply and quality control, method of installation, surface preparation, trimming and final surface preparation, defects and repairs, and quality control testing

18.4 Materials and Installation

18.4.1 Erosion Control Matting

Erosion control matting is to be provided in locations specified in design drawings. Matting to be “Grassroots” product supplied by Geofabrics Australasia or equivalent. Hydroseeding to be provided underneath matting Erosion control matting to be installed in accordance with manufacturers guidelines including Matting Installation Guide available from the supplier.

18.4.2 Topsoil

Topsoil in drainage channels is to be supplied and installed in accordance with general topsoil requirements detailed in Sections 15.4.2 and 15.6.2

18.4.3 Placed Rock

Rock is to be provided in channels as specified in the design drawings. Rock selection and installation is to maximise stability of channel under high velocities and must include the following:

- Selection of rock sizing, mass and grading as specified in design drawings
- Selection of rocks with an angular shape (not round) to maximise interlocking
- Selection of hard, dense and durable rocks with a specific gravity of approximately 2.65
- Placement of rocks in layers with large rocks placed first and smaller rocks fitted tightly in-between larger rocks to maximise interlocking

18.4.4 Crushed rock bedding

All bedding and haunch material used in rock lined channels shall be crushed rock material complying with the requirements of AS2758.1 and AS1141.

All proposed bedding and haunch material for stormwater drainage shall be subject to approval by the Superintendent.

Standard bedding and haunch material shall be of 10.0 mm nominal size.

In wet or unstable ground conditions where the trench bottom requires further stabilizing, additional bedding of 20 mm and/or 30 mm nominal size (as directed by the Superintendent), shall be placed below the standard bedding to a depth determined by the Superintendent. Where ordered by the Superintendent an approved filter fabric shall be used in conjunction with the additional bedding.

The bed and haunch material shall be compacted for the full width of the trench by two passes of a vibrating plate or hand tamping method to the satisfaction of the Superintendent.

18.4.5 Culverts

Delivery & Handling

Pipes shall be delivered, stacked and handled in accordance with the manufacturer’s recommendations. Any box culvert which is damaged during installation or during compaction of fill shall be replaced by the Contractor at the Contractor’s cost.

Jointing & Assembly

Pipes and fittings shall be installed and joined in accordance with the manufacturer’s recommendations. Pipes shall be laid with the female end placed upstream.

Joints in box culvert segments shall be made using cement mortar to provide as thin a joint as possible. The external faces of the units shall be bandaged with ‘Denso Tape 600’ or approved equivalent 200 mm wide lapped by at least 100 mm.

Lifting holes in pipes and culverts shall be plugged with mortar, precast tapered plugs mortar or tape surrounded, or other approved means prior to backfill material being placed.

Cutting operations for concrete pipe and box culverts shall provide neat end surfaces. The cut surfaces shall be given two coats of a tar epoxy paint.

Joints shall not be made under water. The trench shall be de-watered to facilitate joint making and inspection. Precautions shall be taken to prevent erosion of joint material by moving currents of water.

Completed cement mortar joints shall be kept damp and protected from the direct rays of the sun until backfilling takes place.

Installation Condition and Support

Installation shall be in accordance with AS 3725 and AS 3725 Supplement 1 with Type HS3 support. Unless specifically noted otherwise, all pipes shall be installed in trench condition (either negative projection or induced trench). For trench installation condition in an embankment, the embankment must be completed to the underside of the sub-grade prior to the commencement of the excavation for the pipe unless the Superintendent's Representative directs a change to embankment installation condition and the pipe class is amended accordingly.

Where the prior placement of embankment fill is required to provide for Type HS3 Support, the fill shall be placed and compacted as part of earthworks construction specified in Section 2.3.

In water charged soil or made up ground, drainage shall be bedded on reinforced concrete lintels at least 150 mm thick supported on piers or piles as specified and located at intervals not exceeding 3 m or suspended from slabs.

Minimum cover to box culverts shall be 500 mm under trafficable areas and 450 mm elsewhere UNO.

Precast components

Pre-cast concrete headwalls to box culverts shall be supplied and installed in accordance with the manufacturer's specification. Quality certification to the appropriate Australian Standards must be supplied by the manufacturer and submitted to the Superintendent's Representative prior to incorporation into the works.

Fill Construction

Lifting holes on all units shall be sealed by the Contractor to a standard of full structural integrity and durability before commencement of backfilling.

All box culverts shall be bedded on a continuous underlay of sand, not less than 75 mm thick in other than rock and 200 mm thick in rock after compaction. The sand shall be graded in accordance with AS3500 (latest edition) and compacted to at least 90% of the maximum dry density and shall be graded evenly to the required gradient of the pipeline.

In wet or unstable ground conditions where the trench bottom requires further stabilising, additional bedding of 20 mm and/or 30 mm nominal size aggregate (as directed by the Superintendent's Representative), shall be placed below the standard bedding to a depth determined by the Superintendent's Representative. Where ordered by the Superintendent's Representative an approved filter fabric shall be used in conjunction with the additional bedding.

The bed material shall be compacted for the full width of the trench by a minimum of two passes of a vibrating plate or hand tamping method to the satisfaction of the Superintendent's Representative.

Chases shall be formed where necessary to prevent sockets, flanges or the like from bearing on the trench bottom or the underlay.

Fill construction includes all operations associated with the preparation of the foundation areas on which fill material is to be placed, the placing and compacting of approved material within areas from which Unsuitable Material has been removed, the placing and compacting of fill material and of materials of specified quality in nominated zones and all other activities required to produce filled areas as specified to the alignment, grading, levels and dimensions shown on the Contract drawings. The Superintendent's Representative may order the removal of any Unsuitable Material prior to commencing construction operations.

General Fill Material

General fill material shall be inorganic, non-perishable well graded material with a maximum particle size of 75 mm and particle size not exceeding two-thirds of the compacted layer thickness, plasticity index □ 55%. General fill excludes material containing a sulphur content exceeding 0.5%.

Where excavated material is to be used for filling, the material shall be tested according to this Section 5. Test results must be approved by the Superintendent's Representative, following a visual inspection, prior to use of fill material.

Select/Engineered Fill:

Select/Engineered fill shall be granular material complying with the following:

- Particle size: 75 mm maximum
- Proportion passing 0.075 mm sieve: 25% maximum
- Plasticity index: > 2%, < 15%
- Hardcore: Graded hard material capable of being compacted to an even stable surface
- Particle size: 120 mm maximum
- Proportion exceeding particle size of 50 mm: 75% minimum

Selected/Engineered filling materials shall be free from:

- Organic soils
- Materials contaminated through past site usage
- Materials which contain substances which can be dissolved or leached out, or which undergo volume change or loss of strength when disturbed and exposed to moisture
- Silts or silt-like materials
- Fill containing wood, metal, plastic, boulders or other deleterious material
- Clays of high plasticity
- Material containing large particles after compaction
- Over-wet materials
- Gravels or rock fill which leave voids
- Saline soils
- Carbonate soils
- Demolition rubble

Unsuitable Material

Unsuitable Material, defined as material below sub-grade in excavations, below structures in excavations and below natural surface under embankments with fill liable to subsidence, ground containing cavities, faults or fissures, ground contaminated by harmful substances or ground which is or becomes soft, wet or unstable, might be encountered beneath proposed structures such as footings, slabs and roads which the Superintendent's Representative considers to be unsuitable for embankment or pavement support in its present position and likely to remain so despite dewatering or drying out of the subject area.

Unsuitable Material can be identified visually or through proof rolling.

It shall be the responsibility of the Contractor to notify the Superintendent's Representative, of areas where treatment of Unsuitable Material may be required and to demonstrate to the satisfaction of the Superintendent's Representative the unsuitability of that material.

Unsuitable Material does not include that which:

- Has become saturated due to the Contractor having neglected to protect the work by providing adequate drainage; or.
- Otherwise suitable material in a wet condition which can be removed, dried out and reused.

Material, which is deemed to be unsuitable shall be excavated and disposed of in suitable areas onsite or removed from site. Seek the Superintendent's Representatives instruction.

Material deemed unsuitable for pavement construction may include:

- Alluvium (soft silts with some organics)
- Organic soils, severely root-affected subsoils and peat
- Material with a particle size greater than 300 mm
- Fill which contains wood, metal, plastics, boulders or other deleterious material

After removal of the Unsuitable Material, the floor of the excavation shall be inspected by the Superintendent's Representative to determine whether a sufficient depth of Unsuitable Material has been removed, prior to backfilling with replacement material.

18.5 Maintenance

The Contractor shall be responsible for monitoring and maintaining the drainage network for a period of 12 months, in particular with relation to revegetation of channels, scour and the condition of the network after significant rainfall events. A maintenance program shall be undertaken by the Contractor and should be submitted to the Superintendent for approval.

18.6 Defects and Repairs

All repairs shall be undertaken in accordance with the manufacturer's instructions and the approved work method statement. All repairs shall be verified by the Superintendent. The drainage system was designed to convey a minimum of the 20-year ARI peak flow rate, with the exception of the rock lined channels where rock sizing was sized based on the 10-year ARI peak flow rate. For storm events in excess of these erosion or other related damage may result to channels and surrounding areas. An inspection of all drainage lines is to be undertaken during major events which could have possibly exceeded design storm events. The inspection should include observation for any signs of overflow from the system and any resulting damage. Repairs should be undertaken as required.

19. Minor concrete works

19.1 General

This section applies to minor plain and reinforced concrete work. Concrete workmanship and materials must be in accordance with AS 3600 – Concrete Structures Code.

19.2 Standards

19.2.1 Australian standards

Relevant Australian standards are as follows but not limited to:

- AS 1012 Methods of testing concrete
- AS 1275 Metal screw threads for fasteners
- AS 1379 Specification and supply of concrete
- AS 1478 Chemical admixtures for concrete, mortar and grout – Admixtures for concrete
- AS/NZS 1554.3 Structural steel welding – Welding of reinforcing steel
- AS 2350 Methods of Testing Portland and Blended Cements
- AS 2758.1 Aggregates and rock for engineering purposes – Concrete aggregates
- AS 3582.1 Supplementary cementitious materials for use with Portland and blended cement - Fly-ash
- AS 3582.2 Supplementary cementitious materials for use with Portland and blended cement - Slag - Ground granulated iron blast-furnace
- AS 3583 Methods of test for supplementary cementitious materials for use with Portland and blended cement
- AS 3600 Concrete structures
- AS 3610 Formwork for concrete
- AS 3735 Concrete structures retaining liquids
- AS 3799 Liquid membrane-forming curing compounds for concrete
- AS 4100 Steel Structures
- AS/NZS 4671 Steel reinforcing materials
- AS/NZS 4680 Hot-dip galvanised (zinc) coatings on fabricated ferrous articles

19.3 Submittals

19.3.1 Prior to selection of concrete mix

The Contractor shall submit the following to the Superintendent for review and approval prior to the selection of a concrete mix:

- Concrete mix designs and material supply
- Concrete trial mix testing program
- Manufacturers' or suppliers' recommendations

19.3.2 Prior to delivery of materials to site

The Contractor shall submit the following to the Superintendent for review and approval prior to the delivery of materials to site:

- Product data
- Material source
- Pre-qualification test results/reports demonstrating that the proposed material complies with the material property requirements of this section of the Specification (refer)
- Estimated quantity of material which is represented by the pre-qualification test results/reports
- Delivery Docket for each batch of concrete containing the following information:
  - Method of placement and climate conditions during pour
  - Name of concrete delivery supervisor
  - Project assessment carried out each day
  - The amount of water, if any, added at the Site
  - The concrete element or part of the Work for which the concrete was ordered, and where it was placed
  - The total amount of water added at the plant and the maximum amount permitted to be added at the Site

Table 19-1 Material certification requirements

Material	Document Type	Minimum Requirement
Cement (including supplementary cementitious materials)	NATA accredited Test Certificates	Information in accordance with the requirements of Section 0 and AS 3972. Na2O equivalence of cement
Fly ash	NATA accredited Test Certificates	Information in accordance with Appendix C of AS 3582.1
Slag	NATA accredited Test Certificates	Information in accordance with Appendix C of AS 3582.2
Aggregates	NATA accredited Test Certificates	Aggregate properties shall be in accordance with the relevant Australian Standards and shall comply with the requirements of AS 2758.1 except where noted below:
	Report	Petrographic examination in accordance with ASTM C295 with particular reference to the likelihood of alkali reactive aggregates.
Water	Report	Justification for acceptance in accordance with Section 2.4 of AS 1379
Admixtures	Product Data Sheets	Product Name Active Ingredients Approved dose rates Certificates of compliance to the requirements of AS 1478
Curing Compounds	Product Data Sheets	Product name Approved dose rates Certificate of compliance with the requirements of Section 3 of AS 3799
Concrete	NATA accredited Test Certificates	Sulphate and chloride ion content (AS 1012 Method 20)
Site Drilled Anchors	Product Data Sheet	Compliance with Drawings and durability requirements

19.3.3 Prior to installation of concrete structure

The Contractor shall submit the following to the Superintendent for review and approval prior to the installation of concrete structures:

- Contractors Work Method Statement
- Product/design substitution or modification

19.3.4 Following installation of concrete structure

The Contractor shall submit the following to the Superintendent for review and approval after the installation of concrete structures:

- Contractors' Inspection and Test Records

19.4 Formwork

The materials, design and construction of formwork must comply with AS 3610 and Section 19 of AS 3600.

The Contractor must design, fabricate, erect and strip formwork. Refer to Section 2 of AS 3610.

19.4.1 Types of Formwork

General

The types of formwork must be determined by the Contractor to achieve the surface finishes and the shapes, lines, levels and dimensions of the concrete work required by the drawings and this Specification.

Unless shown otherwise on the Drawings, forms must be filleted for corners. The face of the bevel in each case must be 20 mm and must form a straight line at 45 degrees to the faces of the forms. Drip grooves must be provided continuously around soffit edges to the dimensions and locations as detailed on the Drawings.

All materials to be used in the formwork must comply with the appropriate Australian Standards or in their absence the appropriate American or British Standards.

Void Formers

The material and construction used for the forming of voids, blockouts and the like must be of sufficient strength to prevent deformation or destruction under the load of wet concrete and construction loads and such as to prevent leakage of wet concrete or water into the voids. The formers must be so positioned and secured that they will not be dislodged during the concreting and will produce the required void within the tolerances stipulated in this specification. Care must be taken to resist the buoyancy effects of the wet concrete on the formwork.

If the void former is to remain in place it must be of lightweight construction not heavier than allowed for in the design of the element and unless fully surrounded and protected by concrete or the ground, it must also be incombustible.

Void formers used to form a space to allow for differential movement between structural elements must be of adequate strength to support the weight of the wet concrete and must have sufficient plasticity to permit the movement specified. Void formers must not be manufactured from absorbent material.

Void formers must be removed from the poured concrete by the Contractor leaving a clean penetration as shown on the Drawings and in accordance with the deviances nominated by this Specification. After the removal of void formers the concrete, which forms the extent of the void, must be within 10 mm of its theoretical position.

Permanent or Lost Formwork

Where it is not possible or practicable to remove formwork from formed surfaces, permanent or lost formwork must be used. Such formwork must be of sufficient strength and rigidity to support the weight of the wet concrete and construction loads and must be incombustible.

Permanent formers containing Calcium Chloride must not be used.

Where such formwork is also acting as a part of a construction joint it must be capable of transmitting any shear at the joint by indentation, penetration or the like.

The Superintendent must agree to the use of permanent or lost formwork.

19.4.2 Minimum Formwork Stripping Times

Refer to Section 5 of AS 3610 and Section 19 of AS 3600.

The requirements for minimum formwork stripping times are as set out in AS 3610 and Section 19 of AS 3600 where these are more stringent than the relevant requirements of AS 3610.

19.4.3 Stacked Materials

Materials must not be stacked on formwork or on concrete work supported by formwork.

19.4.4 Restraint of Formwork

Formwork must not be braced against previously cast concrete. Framed bracing must be constructed between formwork supports.

19.4.5 Sequence of Pours

The proposed sequence of pours must be submitted to the Superintendent for approval.

19.4.6 Inserts and Penetrations

Inserts or penetrations not specifically detailed on the Drawings must not be located without the approval of the Superintendent.

19.4.7 Permanent Formwork

Formwork that is required to remain permanently in the structure must be incombustible and must be free from calcium chloride.

19.4.8 Critical Face of Elements

The critical face must be the surface exposed to view.

19.4.9 Surface Finishes

Refer to Section 3 of AS 3610. The following surface finishes must be achieved:

Area	Surface Finish
Areas viewed as a whole (e.g. exposed external walls and internal walls of sewerage and stormwater drainage structures)	3
Areas concealed from view (e.g. hidden external walls, backs of sewerage and stormwater drainage structures)	4
Totally concealed areas where the only requirement is structural adequacy (i.e. footings etc.)	5

19.4.10 Construction

Refer to Section 5 of AS 3610.

19.4.11 Tolerances for Structures and Formwork

Refer to Section 19.5 of AS 3600 and Section 5 of AS 3610.

For formed surfaces the tolerances given in AS 3610 take precedence, unless those in Section 19.5 of AS 3600 are more stringent. For unformed plane surfaces, the flatness tolerances must not be greater than the relevant values in Clause 19.5.2 of AS 3600 and the methods for measuring them must be in accordance with AS 3610.

19.5 Reinforcement

Refer to Section 19 of AS 3600.

19.5.1 Samples

The Contractor must supply samples of materials when requested by the Superintendent and after agreement, subsequent work must be identical in appearance and quality to the reviewed sample.

19.5.2 Materials

Reinforcing Bar, Wire or Fabric

Reinforcing bar, wire or fabric must conform to the requirements of AS/NZS4671 as appropriate to the particular type and grade of reinforcement.

Identification and Testing of Reinforcement

Reinforcement must be readily identifiable as to grade and origin.

Copies of Manufacturer's test certificates as required by and in accordance with AS/NZS4671 as appropriate to the type and grade of reinforcement must be provided, if requested.

Reinforcement, which does not conform to this Specification, shall be rejected.

Incidental Materials – Bar Chairs etc. and Tie Wire

Bar chairs, spacers or stools must be made of plastic, concrete or of welded hard-drawn steel wire provided with plastic tips.

Tie wire must be black annealed 1.25 mm diameter wire, or alternatively approved clips may be used.

Sufficient quantities of the above must be supplied by the Contractor and delivered with the reinforcement, as directed by the Superintendent.

19.5.3 Fabrication

Bending, Splicing and Welding of Reinforcement

Reinforcement must be bent or straightened in a manner that will not damage it and to the requirements of Clause 19.2.3 of AS 3600.

The dimensions of splices, hooks and bends must conform to Clause 19.2.3.2 of AS 3600.

When splices not already shown on the Drawings are found necessary, the details of the proposed splices must be submitted for review by the Superintendent before use.

A lapped splice for welded mesh in tension shall be made so the two outermost cross-bars spaced at not less than 100 mm or 50 mm apart for plain or deformed bars, respectively, of one sheet of mesh overlap the two outermost cross-bars of the sheet being lapped as shown in the figure below. The minimum length of the overlap shall equal 100 mm.

(a) $S_1 = S_2$ (b) $S_1 < S_2$

Reinforcement must not be welded nor shall the use of tack welding be permitted in the manufacture of reinforcement cages without the specific agreement for use by the Superintendent. This Clause 0 does not apply to welding during manufacture of the wire fabric.

Reinforcing bar which has been supplied bent must not be subject to further cutting or bending without approval of the Superintendent. The use of heat for bending or rebending of galvanised reinforcement will not be permitted.

Heating or welding of reinforcement must be carried out only if agreed to by the Superintendent. Welding of reinforcing bars must satisfy the requirements of AS1554.3.

Where reinforcement is shown staggered no more than 50% of the reinforcement must be lapped at any one section unless otherwise specified.

Fabrication Tolerances

Reinforcement must be fabricated to the shape and dimensions shown on the Drawings and within the tolerances specified in Clause 19.2.2 of AS 3600.

Surface Condition

The surface condition of reinforcement must be supplied free from loose mill scale, loose rust, clay, mud, oil, grease and other coatings, which would reduce the bond between the concrete and the reinforcement.

Protective Coated Reinforcement

Unless otherwise shown on the Drawings, if an element is specified to contain protective coated reinforcement, the same coating type must be applied to all that elements' reinforcement and embedded ferrous metal items, including tie wires, stools, spacers, plates, ferrules and the like and other embedded metals must be protected by a suitable coating.

Galvanised Reinforcement

Where shown on the Drawings, reinforcement must be hot dipped galvanised in accordance with AS 4680. Reinforcement to be galvanised must be passivated in a 0.2% sodium dichromate solution applied by the galvaniser or alternatively chromium trioxide must be added to the concrete mix in the ratio of 300 ppm by weight of mixing water (0.3 grams per litre).

The galvanised coating must conform to AS 4680 and must have a minimum coating of 700 grams/square metre. Where galvanised reinforcement is welded, it is to be descaled and regalvanised following the recommendation contained in Appendix F of AS4680.

The use of heat for bending or re-bending of galvanised reinforcement will not be permitted.

19.5.4 Delivery, Unloading and Storage

Delivery

Fabricated reinforcing steel must be bundled and securely tied to ensure that it does not sustain damage during delivery or unloading.

Each bundle or piece must be identified by a wired-on metallic tag showing the 'mark' of that bundle. The 'mark' must refer to the bending schedule.

A different coloured tag must be used to identify each of the separate modules on the project.

Reinforcement must be delivered to the Site by the Contractor.

Unloading & Storage on Site

Fabricated reinforcing steel must be unloaded and stored on site in such a manner that it does not sustain damage or become contaminated by material liable to influence its effectiveness as reinforcing in concrete.

19.5.5 Bending Schedules

Bending schedules must be prepared by the Contractor, indicating shapes, dimensions and details of bar reinforcement.

19.5.6 Reinforcement Development Lengths

Unless noted otherwise on Drawings, the reinforcement development and cog lengths must be as below:

Bar Size	Development of Lap Length (mm)	Cog Length (mm)
N12	400	200
N16	500	250
N20	650	300
N24	850	350
N28	1150	400
N32	1400	450
N36	1700	550

19.5.7 Placing of Reinforcement Steel

Tolerances

Reinforcement must be placed within the tolerances specified in Clause 17.5.3 of AS 3600, the Drawings and this Specification.

Alignment

Reinforcement must be free from bends not required on the Drawings, kinks and similar defects and must be securely fastened and maintained in position.

Support of Reinforcement

Reinforcement must be securely held in position by using spacers or stools made of plastic or plastic tipped metal, by metal hangers or by other agreed means with the Superintendent. Reinforcement must not be held in position by bare steel supports which extend to the surface of the concrete. Reinforcement must not be supported on pieces of wood, brick, aggregate or like material.

Sufficient means of support must be provided to ensure that the reinforcement does not sag between supports and to allow the reinforcement to be walked upon without damage.

The concrete cover to reinforcement nominated on the Drawings and this Specification must be maintained at all times.

Reinforcement must be tied at intersections with black annealed 1.25 mm diameter iron wire. The free ends of the wire must be bent inwards toward the centre of the section of the concrete.

Reinforcement in suspended slabs and in concrete pavements must be supported by bar chairs etc. at a maximum spacing of 750 mm.

Reinforcement for concrete slabs poured on ground in conjunction with a vapour barrier must be supported on bar chairs which are supported on spreader plates sufficient to prevent the bar chair puncturing the vapour barrier.

In reinforcement in the form of a mat, each bar must be secured at alternate intersections and at other points as required.

Each beam ligature must be secured to a bar in each corner of the ligature and all longitudinal column reinforcement secured to all ligatures at every intersection.

Lifting of reinforcement through wet concrete will not in any circumstances be permitted.

19.5.8 Cores and Embedments

The supply and fixing of cores and embedments is included in other sections of this Specification. Reinforcement must not be cut to provide space for core holes or embedments. Reinforcement may be moved slightly to allow fitting of cores. Agreement from the Superintendent must be obtained.

19.5.9 Protection of Other Works

The Contractor is responsible at all times for the protection of work completed by others throughout the duration of the Works.

19.5.10 Inspections

The Contractor must give a minimum 24 hours' notice to the superintendent of the reinforcement, forms and embedment being completed and ready for inspection prior to pouring of concrete.

The inspection of the reinforcement does not relieve the Contractor of its responsibility to carry out its own inspection and to ensure compliance with the Contract.

The Contractor must allow sufficient time for these inspections and time to complete any necessary rectification work and subsequent re-inspection.

19.6 Concrete

The following Clause must be read in conjunction with the Drawings and the applicable specifications and relevant Australian Standards.

19.6.1 Schedule of Concrete Mixes

Unless otherwise noted on Drawings, concrete mixes must be as below:

Element/Location	Class/Grade	f'c at 28 days (Mpa)	Aggregate size (mm)	Slump (mm)
All reinforced concrete	N40	40	20	80 +/- 15

19.6.2 Concrete Supply and Placement

The Contractor must select materials and design concrete mixes. The Contractor must design and produce finished concrete and concrete work that is in accordance with this Specification.

19.6.3 Materials

Cement

Cement must be Type GP - General Purpose Portland Cement complying with AS 3972.

Fly Ash

Fly ash must not be used as an additive to cement, unless it can be established to the satisfaction of the Superintendent that aggregates for the concrete mix are unlikely to have the potential to create an environment for an aggregate/alkali reaction.

The proportion of fly ash must be 25% by weight of the total combined weight of fly ash and cement.

Fly ash must satisfy the requirements of AS 3582.1 and AS 3583.

Fine and Coarse Aggregates

Fine and coarse aggregates must satisfy the requirements of AS1141 and AS2758.1. The maximum coarse aggregate size must be 20 mm.

Water

The water used in mixing concrete must be clean and free from injurious amounts of oil, acid, alkali, organic matter or other deleterious substances and must be of potable quality.

Admixtures

Chemical admixtures in concrete may be used only with the written acceptance of the Superintendent. Admixtures may satisfy the requirements of AS1478. Fly ash is not considered an admixture under the terms of this Clause.

19.6.4 Concrete Mix Design

The concrete mix design including details of the materials must be submitted to and agreed by the Superintendent prior to pouring of any concrete.

Certificate of Tests of Materials

The following certificates from a laboratory registered with NATA must be produced by the Contractor, upon request by the Superintendent.

- Cement - certificates as in Appendix A of AS1315. Certificates of results of Autoclave Expansion Test as in ASTM C151.
- Aggregates - certificates of results of tests set out in AS2758 Part 1.
- Admixtures and fly ash - Certificates that the admixture or fly ash complies with the requirements of AS1478 or AS3582, respectively for acceptance testing and uniformity.

Ready Mixed Concrete

Identification certificate as per Clause 1.7.3 of AS1379.

Certificates are required for:

- Characteristic compressive strength at 28 days
- Slump prior to addition of super plasticiser
- Shrinkage values after 56 days
- Values for modulus of rupture (if requested)
- Abrasion resistance - Chaplin Testing (if requested)

Water

If not from a town water supply evidence is required, supplied by the Contractor, that the water contains no matter harmful to concrete, reinforcement or other embedded items.

19.6.5 Ready Mixed Concrete and Pumped Concrete

Ready mixed concrete and pumped concrete may be used, provided that it satisfies the requirements of this Specification and of AS1379.

19.6.6 Site Mixed Concrete

Site mixed concrete must not be used.

19.6.7 Grout

Grout must consist of Portland cement and water or of Portland cement, sand and water.

An additive designed to produce fluidity and for expansion of the grout may be used, subject to the Superintendent agreement, provided that additives containing aluminium powder, chlorides or nitrates are not be used.

Sand, if used, must satisfy the requirements of AS2758 except that the grading may be modified to obtain increased workability. The water content must be the minimum necessary for proper placement.

19.6.8 Mixing and Delivery

Supervision

Concrete must be produced under the supervision of a qualified and experienced Engineer employed by the Contractor and deemed acceptable to the Superintendent. The mix designs must conform to the requirements set in Clause 19.6.1 in this Specification.

Concrete Quality

All concrete produced must conform to this Specification and to the referenced standards.

The characteristic compressive strengths at 28 days, and types of concrete, slump and maximum size of aggregates required for the various parts of the work must be as shown on the Drawings. The characteristic compressive strength at 28 days shall be denoted by the symbol f'c. Any required early age mean strength shall be shown on the Drawings and denoted by fcm.

All concrete mixes must be designed to achieve or exceed 45% of the 28 day characteristic compressive strength at 3 days and 75% of the 28 day characteristic compressive strength at 7 days.

The mass per unit volume of hardened concrete shall be in the range from 2400 kg/m^3 to 2500 kg/m^3 when determined in accordance with AS1012 Part 12.

The Contractor is wholly responsible for producing the concrete which will have the properties specified.

The proportions of aggregate and cement for the concrete must be such as will produce a mix which will work readily into corners and angles of the forms and around reinforcement with the method of placement employed on the work but without permitting the material to segregate, or excess free water to collect on the surface.

The proportioning must be such as to ensure that the resultant concrete will be sound, dense, durable and of the strength and other properties specified.

The Contractor must submit for agreement with the Superintendent, a minimum of 14 days prior to the placement of the concrete, the proposed mix proportions for each grade of concrete to be used in the project along with test results indicating that the proposed mix will satisfy the requirements of this Specification.

Information to be supplied for assessment must include:

- Source of supply of all materials including cement, aggregates, fly ash and any admixtures.
- Mix proportion by weight per cubic metre of all constitutes including water and water/cement ratio.
- Characteristic compressive strength at 28 days, f'c.
- Early age mean strength, fcm (if applicable).
- Slump.
- Shrinkage of concrete at 56 days.
- Assessment of maximum long term shrinkage values.
- Suitability of aggregates to meet specified abrasion resistance requirements (if required).
- Hardened concrete density values.
- Time available between mixing and placing concrete to ensure design parameters are met.
- Structural elements being poured.

After all ingredients of the concrete have been mixed no further water is to be added.

Sampling and Testing

All concrete will be subject to both production and project assessment in accordance with AS1379.

Sampling and testing of concrete for compliance must be in accordance with AS1379.

All sampling must be carried out in accordance with Section 5 and Appendix B of AS1379 by a person approved by NATA for this purpose.

Testing and curing of samples must be carried out in a laboratory registered with NATA for this purpose and agreed to by the Superintendent.

Slump tests must be undertaken in accordance with AS1379.

A slump cone and at least two test cylinder moulds and other necessary equipment must be maintained on Site.

Concrete must not be discharged into formwork whilst slump or other tests are being performed which could result in its rejection.

19.6.9 Concrete Placing

Conditions for Placement

Concrete placement must be carried out under the direct supervision of a capable foreman, employed by the Contractor and approved by Superintendent, experienced in reinforced concrete construction and familiar with the relevant Standard Codes and Specifications.

Concrete must not be placed when the following conditions occur:

- The temperature of the concrete is less than 10 °C or exceeds 35 °C.
- The outdoor shade temperature is likely to be greater than 35 °C during placement, or within 2 hours subsequent to placement, unless special precautions, to the approval of the Superintendent, are undertaken. Notwithstanding that such special precautions are taken, concrete must not be placed when the outdoor shade temperature exceeds 38 °C.
- Where the concrete temperature is less than 32 °C, concrete must reach its final position in the forms within 30 minutes after the introduction of water to the cement and aggregate, or the cement to the aggregate, except in the case of concrete which is continuously agitated in a truck mixer, when 1.5 hours may elapse between introduction of water and final placing. In hot weather where the concrete temperature is greater than 32 °C the above times must be reduced to 15 minutes and 45 minutes respectively.

Notwithstanding the above, the Superintendent may direct other times.

The concrete slump must be 80 ± 15 mm at the construction Site unless noted otherwise.

The Contractor must not cover up formwork and reinforcement by placing concrete without the prior approval of the Superintendent.

Concrete must not be placed except in the presence of the Superintendent.

Concrete must not be placed unless materials for curing unformed surfaces are at the Site and ready for use.

Before concrete is placed, the formwork and the space into which the concrete is to be placed must be free of contaminants and free of water.

Concrete is to be brought to the forms and placed in such a manner that there is to be no segregation of the concrete mix. Internal vibrators must not be used to move concrete within the forms.

Concrete must not be exposed to rain during mixing, transport or placing, until it has set.

Equipment

Hoppers, skips, barrows and the like must be of such design that concrete does not segregate in them. Sufficient numbers of such equipment must be available to ensure a satisfactory rate of placing concrete.

Chutes must be so designed that concrete flows readily and does not segregate.

Barrow runs and pump lines must be supported off the formwork, not the reinforcement and must be agreed to by the Superintendent. The Contractor is responsible for the design and installation of high-rise pump lines. All fixings must be removed and the structure made good after detachment of the pump lines.

Except for slabs on ground compaction must be achieved by the use of high frequency immersion type vibrators.

One spare vibrator which is in full operating condition must be on hand during concrete placement.

Vibrators mounted on screed boards must be used for the compaction of slabs on ground when the width of pour permits. Vibrating screeds must be supplemented by immersion vibrators.

Cleaning

All items of equipment used for carrying, holding and working with concrete must have dry mortar, mud and other deleterious matter removed from them.

Water puddles which may form by whatever means must be removed before pouring concrete all to the agreement of the Superintendent. All slab, beams and column forms must be cleaned of foreign material. The cleanliness of formwork must be inspected and accepted by the Superintendent prior to placement of concrete. The Contractor must ensure that the release agent does not puddle due to excessive application and so cause staining or retardation of the concrete surface. No part of the reinforcement or construction joints shall be coated with the release agent.

Reinforcement, including starter bars, which have become contaminated by oil, mud, mortar or other coatings other than a firm rust layer must be cleaned to the acceptance of the Superintendent prior to placing concrete.

Transport of Concrete

Concrete must be transported in such a manner that it is not caused to segregate or spill, or be contaminated.

Concrete Placement

Immediately prior to placement of concrete the forms must be wetted. Excess water from this process must be removed before commencing concrete placement to the agreement of the Superintendent.

The concrete must not be placed if the specified slump as measured in accordance with this Specification is not within the required limits.

The specified slumps refer to on-site delivery slumps. For pumping and placement purposes the specified slump is to be a maximum of 80 mm ± 15 mm using a super plasticiser which conforms and is added in accordance with AS1478. At no stage from the time of mixing must water or admixture be added to the concrete to increase workability.

Where concrete is to be placed by pumping all excess slurry used to prime equipment and all material surplus must be discharged to waste, not into forms, and must be removed from the Site by the Contractor.

Pumping equipment must be arranged so that no vibrations that may damage freshly placed concrete shall result.

Concrete must be deposited as near as practicable to its final position. It must not be dumped away from its final position and worked along the forms.

Where concrete is to be pumped, line stools must be used. Provide bases to stools to prevent damage to formwork, post-tensioning ducts, reinforcement, cast-ins and other associated items.

Concrete must be placed at a rate that will permit proper compaction and must not be placed to a depth greater than 300 mm before compaction of the concrete below. Carry out placing in such a manner as will ensure that concrete which is partially set is not subsequently disturbed.

The concrete shall be placed in such a manner as to avoid segregation or loss of materials. To achieve this in the placing of concrete in thin walls and columns in excess of 1.5 m in height it may be necessary to pour the concrete through enclosed chutes or access hatches. These chutes must be kept as vertical as possible during the placing operation.

Where it is proposed that concrete be placed from a height in excess of 3.5 m, the Contractor must submit for acceptance details of the proposed placing procedure by the Superintendent. Such procedures may only be proposed for use where forms have been designed to be adequate to resist all consequent forces.

The concrete placing must be carried out continuously between the construction joints and in such a manner that a plastic edge is maintained, at all times.

Columns and walls must be poured first and allowed to cure for a minimum of 8 hours prior to pouring of the suspended structure.

Compaction

All concrete must be fully compacted by mechanical vibration using internal vibrators and/or vibrating screeds and/or vibrators fixed to the formwork. The vibration method used by the Contractor must minimise segregation of the concrete.

The Contractor must have available for immediate use at least one standby vibrator.

Joints

In general, concrete must be placed and compacted against unset previously-placed concrete such that the finished work is monolithic and uniform in strength and appearance.

Construction joints may be made only where indicated on the Drawings and otherwise in such locations and in such a manner as may be accepted by the Superintendent, who may direct the Contractor to scabble or otherwise remove laitance and provide for bond and to provide keys, steps and other means of load transfer. Any such provision, whether indicated on the Drawings or directed by the Superintendent, is at the Contractor's expense.

Concrete poured on Natural Ground

All slabs cast on ground require a minimum 50 mm thick N20 concrete blinding.

Concrete Poured on Rock

Surfaces of rock that will be in contact with concrete must be free of loose materials. Except where concrete is placed on a vapour barrier, the rock must be thoroughly wetted prior to pouring of concrete. Water used for cleaning such excavations must not lie in puddles at the time of placing concrete.

Concrete Poured on Fill or Other Porous Material

Except where concrete is placed on a vapour barrier, formed surfaces of earth, fill, roadbase or hardcore must be thoroughly wetted to a depth of at least 75 mm prior to pouring concrete. Water must not lie in puddles on the surface at the time of pouring concrete.

Where shown, a vapour barrier consisting of a 0.3 mm thick layer of polythene sheeting must be supplied and laid on the sub-grade or fill by the Contractor. Adjoining sheets must be lapped 250 mm at the sides and ends and taped for the full length of the lap. The sheeting must be taped to pipes and other embedments. The vapour barrier must be turned up the full thickness of the slab at free edges, walls, columns and the like. Further treatment of the vapour barrier must be as detailed.

Finish at Edges of Slabs on Ground

Finishes at edges of slabs on ground include:

At edges of slabs - unless specifically shown otherwise on the Drawings, concrete must be finished flush with the top of the formwork with square corners.

Where slabs are poured against existing slabs - concrete must be poured and screeded flush with existing concrete and the corners left square.

Joints - generally the treatment of joints for slabs on ground must be as specified on the Drawings.

19.6.10 Unformed Surface Finishes

Unformed surfaces must be constructed to a smooth even surface and finished with a wooden float.

Finish unformed surfaces, unless otherwise specified, by hand or power driven equipment.

Commence finishing operations as soon as the screeded surface has stiffened sufficiently and produce a surface that is free from screed marks and uniform texture.

19.6.11 Curing

All concrete work must be cured.

For unformed surfaces curing must be commenced immediately finishing is complete.

The curing period from the time of placing concrete is to be continuous and must be not less than the following:

- Portland cement concrete - 7 days
- Cements with fly ash or pozzolanic materials - 10 days

The curing method must include one or a combination of the following methods:

- Ponding or continuous sprinkling with water
- Use of a curing compound that is in accordance with the recommendations of AS3799
- Use of an absorptive cover kept continuously wet
- Use of an impermeable membrane

The Superintendent may direct that any curing method not be used.

The concrete shall be protected from damage during the curing period.

Protection

Load application on newly poured surfaces shall comply with AS3610.

The concrete must be protected from damage due to overload, heavy shocks and excessive vibration particularly during the curing period.

All finished concrete surfaces must be protected from damage caused by construction equipment, materials, or methods and by rain or running water.

Self-supporting structures must not be loaded in such a way as to overstress the concrete.

Rejection of Concrete

Plastic and hardened concrete that does not meet the requirements of this Specification and of AS3600, AS3610 or AS1379 is not in accordance with the Contract.

Repairs of Concrete

Where repair of concrete is necessary and permitted, such repairs must be performed by skilled workers and must be completed within 24 hours after removal of formwork or, in the case of unformed concrete, within 24 hours after placing of concrete. All repair of concrete work must be in accordance with AS3600.

The materials and techniques of repair that the Contractor proposes to use must be notified to the Superintendent prior to commencement and are subject to agreement of the Superintendent.

The repairs will be at no cost to the Superintendent.

20. Granular pavements

20.1 General

All granular pavements shall be constructed in accordance with Cessnock Council construction specification requirements unless stated otherwise in this specification or drawings. This section provides for the granular pavement works.

20.2 Standards

- *Standard*: To AS 1348
- RMS QA Specification R71
- Austroads Guide to Pavement Technology Part 6: Unsealed Pavements, 2009

20.3 Pavement base and sub-base

20.3.1 Aims

Provide base and sub-base courses that are as follows:

- In conformance with the level tolerances specified
- Tested by a NATA registered geotechnical testing authority
- In conformance with the compaction requirements supplied

20.3.2 Definitions

For the purposes of this section the definitions given below apply.

- Absolute level tolerance means maximum deviation from design levels
- Relative level tolerance means maximum deviation from a 3 m straight edge laid on the surface

20.3.3 Tests

All testing shall be carried out in accordance with Cessnock Councils Construction specification and AS 1289.5.4.1 and AS 1289.5.4.2.

20.3.4 Submissions

General: Not less than the following (whichever requires the most tests):

- Two tests per road
- One test per 50 metres of road

Standard: To Table 8.1 in AS 3798.

Source of material: State the supplier name, nature of material (for example, crushed rock, natural gravel, recycled) and source quarry or recycling site.

Compliance of material: Provide certification and test results from a NATA registered laboratory confirming that the material complies with the requirements of the Specification.

Execution

General: Submit proposals for the methods and equipment to be used for the roadworks, including the following:

- Staging of the work, access and traffic control methods
- Disposal of surface water, control of erosion, contamination and sedimentation of the site, surrounding areas and drainage systems
- Methods and equipment for each operation
- Sources of materials
- Material stockpiles

Compaction: If it is proposed that a layer is to exceed 150 mm in thickness, submit evidence demonstrating that the proposed compaction equipment can achieve the required density throughout the layer.

20.4 Products

20.4.1 Base and sub-base material

Base and sub-base materials shall comply with Table 3.5 Austroads Guide to Pavement Technology, Part 6 (2009) and Table 20-1.

Table 20-1 Particle size and soaked CBR

Item	Maximum particle size (mm)	Soaked CBR (%)
Sub-base	55	30
Wearing course	20	40

20.5 Execution

20.5.1 Subgrade preparation

Subgrade preparation to be undertaken in accordance with Section 3.3.3.

20.5.2 Tolerances

Provide a finished surface that is free draining and evenly graded between level points.

Edges abutting gutters/drains shall be within -0 + 10 mm of the level of the actual gutter/drain edge.

The tolerances apply to the finished level of each layer, unless overridden by the requirements (including tolerances) for the finished level and thickness of the wearing course.

Table 20-2 Surface Level Tolerances

Item	Level tolerance	
	Absolute	Relative
Sub-base surface	- 15 to +25 mm	12 mm
Base surface	- 15 to +25 mm	6 mm

20.5.3 Sub base and base compaction

Compact each layer of fill to the required depth and density, as a systematic construction operation and to conform to.

Table 20-3 Minimum Relative Compaction

Item description	Minimum dry density ratio (standard compaction) to AS 1289.5.2.1
Sub-base	98%
Base	98%

Any unstable areas that develop during rolling or are identified by proof rolling shall be removed for the full depth of the layer and disposed of and replaced with fresh material. Material used as replacement material shall comply with the requirements of the Specification. The placing and compaction of the replacement materials shall also comply with the requirements of the Specification.

Compaction requirements

General: Apply uniform and sufficient compactive effort over the whole area to be compacted. Use rollers appropriate to the materials and compaction requirements.

Moisture content

During spreading and compaction, maintain materials at the moisture content (modified compaction) not exceeding the optimum moisture content or less than –3% of OMC.

Maintain moisture content. Use water-spraying equipment capable of distributing water uniformly in controlled quantities over uniform lane widths.

Rectification

If a section of pavement material fails to meet the required density or moisture content after compaction remove the non-complying material, replace with fresh material, and recompact.

Level corrections

General: Rectify incorrect levels as follows:

- *High areas*: Grade off
- *Low areas*: Remove layers to a minimum depth of 75 mm, replace with new material and recompact

20.5.4 Placing base and sub base

General

Weak surfaces: Do not place material on a surface that has been so weakened by moisture that it will not support, without damage, the constructional plant required to perform the work.

Spreading: Spread material in uniform layers without segregation.

Moisture content: Maintain wet mixed materials at the required moisture content before and during spreading. Add water to dry mixed materials through fine sprays to the entire surface of the layer after spreading, to bring the material to the required moisture content.

Layer thickness: 150 mm maximum and 75 mm minimum (after compaction). Provide equal layers in multilayer courses.

Joints

General: Plan spreading and delivery to minimise the number of joints. Offset joints in successive layers by at least 300 mm.

Final trimming

General: Trim and grade the base course to produce a tight even surface without loose stones or a slurry of fines.

21. Gabions and gabion mattresses

21.1 General

This section contains the technical requirements for the gabions and gabion mattresses.

The Superintendent may reject any component of the gabions and gabion mattresses that do not meet or exceed the requirements of this section.

Any component of the gabions and gabion mattresses rejected by the Superintendent shall be remediated by the Contractor.

21.2 Standards

21.2.1 Australian standards

Relevant Australian standards are as follows but not limited to:

- 1141.3.1 Methods for Sampling and Testing Aggregates – Sampling of aggregates/rock
- RTA R63 – Geotextiles (Separation and Filtration)
- AUSTROADS – Guide to Geotextiles
- AS 1141.22 – Wet / dry strength variation
- AS 1289.5.4.1 – Compaction control test – Dry density ratio, moisture variation and moisture ratio
- AS 1289.5.7.1 – Compaction control test (Rapid method)
- AS 1650 – Hot-dipped galvanised coatings on ferrous articles

21.3 Definitions

Gabions: Galvanised-steel, wire-mesh box-shaped baskets of various sizes, filled on site.

Diaphragms: Internal wire-mesh partitions that divide the gabion into cells.

Lacing or Binding Wire: The wire used to assemble and join the gabion unit.

Heavily galvanised: To the coating mass requirements of type A wire per AS 1650.

21.4 Products

The Contractor shall provide documentation that the materials specified below conform to this specification for approval by the Superintendent.

21.4.1 Wire mattresses

The wire mattresses shall be flexible woven wire mesh boxes with dimensions of 6m x 2m in plan or as specified in the Drawings. The mattresses shall be divided by diaphragms into cells at not more than 1.0 m centres or as specified in the Drawings. Unless otherwise specified, they shall be fabricated of woven heavily galvanised wire and PVC coated.

Mattresses shall have a mesh size of 60 mm x 80 mm and body wire shall be a minimum diameter of 2.0 mm heavily galvanised with an additional minimum thickness of 0.4 mm PVC coating. The minimum core diameters of heavily galvanised selvedge wire and lacing wire shall be 2.7 mm and 2.2 mm respectively.

21.4.2 Gabions

The gabions shall be of the sizes shown on the Drawings and fabricated of woven heavily galvanised wire mesh and PVC coated. Each gabion shall be divided by diaphragms into cells whose length shall not be greater than the width of the gabions plus 100 mm.

Gabions shall have a nominal mesh size of 80 mm x 100 mm and body wire shall be a minimum diameter of 2.7 mm heavily galvanised with an additional thickness of 0.4 mm PVC coating. The minimum core diameters of heavily galvanised selvedge wire and lacing wire shall be 3.4 mm and 2.2 mm respectively.

21.4.3 Geotextiles

Before laying out gabions and mattresses, a non-woven filter fabric as shown on the Drawings shall be placed between the wire cages and the material being protected or retained. Filter fabric shall be supplied and installed in accordance with RTA R63.

A chemically and biologically stable geotextile with a minimum strength rating (G) of 1350 and minimum mass of 180 grams per square metre, in accordance with AUSTROADS Guide to Geotextiles, shall be used.

Samples, manufacturer's specification and instructions on installation shall be submitted to the Superintendent for review and approval seven days before the intended use of geotextile.

21.4.4 Rock fill material

The rock fill shall consist of clean hard rock with a minimum wet strength of 100 kilonewtons and a maximum wet/dry strength variation not greater than 35 percent as determined by AS 1141.22.

Rock fill for wire mattresses shall have particle sizes between 80 mm and 0.66 dmm where d is the mattress depth. The maximum rock size should not exceed 200 mm. Not more than 5% shall pass through a 75 mm aperture sieve opening.

Rock fill for gabions shall have particle sizes between 100 mm and 250 mm with not more than 5% passing a 75 mm aperture sieve opening. Rock fill material may be placed by hand or suitable mechanical device to ensure fill is tightly packed with a minimum of voids. Fill material shall be levelled off 25 mm to 50 mm above the top of the mesh to allow for settlement.

Details regarding the properties and source of rock fill shall be submitted to the Superintendent for approval. When the mattress is on a slope, rock fill material shall be placed into the units starting from the low end. Units shall be filled slightly overfull to allow for settlement and to provide an even, tight and smooth surface of the required contour.

21.4.5 Select backfill

Select Granular Fill material shall be placed behind the gabions as indicated on the Drawings.

Compaction adjacent to the gabions should be done using hand operated rollers, plate compactors or rammers.

Before installation of rock filled wire mattresses, the foundation material shall be excavated such that the final surface levels of the Drawings are achieved. The foundation material supporting mattresses and gabions shall be shaped free of humps, hollow and defined channels (unless shown on the Drawings) and compacted, and in accordance with AS 1289.5.4.1 the dry density ratio shall not be less than 95 per cent for standard compactive effort.

21.5 Execution

21.5.1 Gabion installation

Unless directed otherwise by the Superintendent, multi-layered gabion baskets shall be placed in a horizontal plane, rather than following the grade of the ground surface. Where necessary, individual boxes shall be cut down to the required shape to allow horizontal placement, or to otherwise fit in with the overall shape of the gabion structure.

Assembly

Prior to assembly, the gabions material shall be opened out flat on the ground and stretched to remove all kinks and bends.

The gabion boxes shall be assembled individually, by raising the sides, ends and diaphragms, ensuring that all creases are in the correct position and that the tops of all four sides and the diaphragms are even.

The four corner edges of the Gabion boxes shall be laced first, followed by the edges of internal diaphragms to the sides.

In all cases, lacing shall commence by twisting the end of the lacing wire tightly around the selvedge/s. It shall then pass round the two edges being joined using alternate single and double loops at 100 mm intervals and be securely tied off at the bottom. The ends of all lacing wires shall be turned to the inside of the box on completion of each lacing operation. Each loop shall be pulled tight to prevent the joint opening during filling. Tightness of the lacing is essential.

As an alternative to the continuous lacing wire system for securing gabions, an approved mechanical system using heavily galvanised clips (or Stainless Steel for plastic specification units) may be used. Spacing of clips shall be to the gabion manufacturer’s recommendations.

Erection

Only assembled boxes, or groups of boxes, shall be positioned in the structure. The side, or end, from which work is to proceed, shall be secured either to the completed work or by rods or stakes driven into the ground at the corner. These stakes must be secure and reach at least to the top of the gabion box.

Further gabion boxes shall be positioned in the structure as required, each being securely laced to the preceding one along all common corners and diaphragms using the lacing technique described above.

The constructed gabion boxes shall be inspected for approval by the Superintendent.

Stretching

Final stretching of the gabion boxes shall be carried out using a pull-lift of at least one tonne capacity, firmly secured to the free end of the assembled gabion boxes.

Whilst under tension, the gabion boxes shall be securely laced along the edges (top, bottom and sides) and at diaphragm points, to all adjacent boxes.

Filling

Filling shall be carried out whilst gabion boxes are under tension.

The front face and all other faces which will be exposed in the completed structure shall be “hand packed” with the stones placed so as to produce a neat face free from excessive bulges, depressions and voids.

Internal bracing wires shall be provided on the exposed faces at the rate of 4/ cm.m at 330 mm centres to prevent distortion of the gabion units during filling and in the completed structure. Additional bracing wires shall be provided on exposed ends at a rate of 4/ sq.m of face.

Tension on the gabion boxes shall be released only when fully laced and sufficiently full to prevent the mesh from slackening.

All gabions shall be overfilled by 25 mm using flat stone to allow for minor settlement and to provide a level surface for subsequent layers.

The filled gabions shall be inspected for approval by the Superintendent.

Final Lacing

Closing and lacing down of lids shall proceed as soon as practicable after filling operations especially if exposed to the likelihood of a storm or flood during construction.

Lids shall be stretched tight over the filling with suitably designed closing tools and laced down securely through each mesh along all edges, ends and diaphragms before commencing work on the next layer of gabion. The ends of all tying and bracing wires shall be turned into the gabion box on completion of each lacing operation.

The filled gabions shall be inspected for approval by the Superintendent.

21.5.2 Mattress installation

Assembly

To assemble, the mattress base shall be opened out on the ground and all unnecessary creases removed. The lid is opened separately and all folds and creases should be removed.

Mattresses shall be assembled individually by raising the sides and stamping the mesh to create the diaphragm folds. Care must be taken to ensure that the folded diaphragms and sides are vertical and of the correct height (as identified in the Drawings).

The edges of the folded diaphragms shall be laced to the side panels using the lacing technique described in above.

Shortening of the double diaphragm standard units to create smaller mattress lengths may be affected by cutting along the apex of any diaphragm fold ensuring a neat and integral end remains.

In all cases, lacing shall commence by twisting the end of the lacing wire around the selvedge/s. It shall then pass round the two edges being joined using alternative single and double loops at 100 mm centres and be securely tied off at the bottom. Tightness of the mesh and wiring is essential.

As an alternative to the continuous lacing wire system for securing gabions, an approved mechanical system using heavily galvanised clips (or Stainless Steel for plastic specification units) may be used. Spacing of clips shall be to the gabion manufacturer’s recommendations.

Erection

Only assembled mattress or groups of mattresses shall be positioned in the structure, with each mattress being securely laced to the surrounding ones along the perimeter. When the mattress is laid on a slope steeper than 1 in 1.5, it should be secured by hardwood stakes or star pickets driven into the ground just below the upper end panel, at 2 m centres or as approved. It is essential that the mattress remain free to flex and accommodate any settlement or scour.

The constructed mattresses shall be inspected for approval by the Superintendent.

Filling

Mechanical filling equipment shall be used with the approval of the Superintendent and providing adequate precautions are taken to protect the plastic coating from abrasion during filling operations.

Filling materials shall be hand packed to ensure all diaphragm compartments are fully filled and to produce a neat and level top surface. Mattress units shall be overfilled by 25-50 mm above to allow for subsequent settlement to prevent excessive stone movement under hydraulic conditions.

Where suitably sized filling materials cannot be obtained, the Superintendent may approve insertion of a second mesh panel consisting of the same specifications as the mattress below the top and front face of the mattress to contain the smaller sized rock filling within the mattress. The second woven wire mesh panel can be laced to the structure and offset by one half mesh.

The filled mattresses shall be inspected for approval by the Superintendent.

Final Lacing

Closing and lacing down of lids shall proceed as soon as practicable after filling operations especially if exposed to the likelihood of a storm or flood during construction.

Lids shall be stretched tight over the filling with suitably designed closing tools and laced down securely through each mesh along all edges, ends and diaphragms using the lacing method described above. The ends of all tying and bracing wires shall be turned into the mattress box on completion of each lacing operation.

The filled mattresses shall be inspected for approval by the Superintendent.

22. Rip rap

This section contains the technical requirements for the rip rap. The relevant requirements for the rip rap in Section 2 shall be considered alongside guidance provided in this section.

The Superintendent may reject any component of the rip rap that do not meet or exceed the requirements of this section.

Any component of the rip rap rejected by the Superintendent shall be remediated by the Contractor.

22.1 Standards

22.1.1 Australian standards

Relevant Australian standards are as follows but not limited to:

- 1141.3.1 Methods for Sampling and Testing Aggregates – Sampling of aggregates and rock
- 1141.11 Methods for Sampling and Testing Aggregates – Particle size distribution/dry sieve
- 2758 Aggregates and rock for engineering purposes.

22.2 Submittals

22.2.1 Prior to delivery of rip rap to site

The Contractor shall submit the following to the Superintendent for review and approval prior to delivery of the rip rap to site (per material source):

- Material source
- Certification that the material is VENM or ENM or NSW EPA Resource Recovery Exemption appropriate for use a rip rap
- Pre-qualification test results/reports demonstrating that the proposed material complies with the material property requirements of this section of the Specification (refer Section 22.3)
- Estimated quantity of material which is represented by the pre-qualification test results/reports
- Information on the parent geology of the material.

22.2.2 Prior to placement of rip rap

The Contractor shall submit the following to the Superintendent for review and approval prior to placement of the rip rap:

- Survey of the underlying surface in accordance with Section 1.11
- Work method statement for placement of the rip rap, including repair procedures (refer Appendix A).

22.2.3 Following placement of rip rap

The Contractor shall submit the following to the Superintendent for review and approval following placement of rip rap:

- As-built survey of the completed surface showing conforming layer thickness within the allowable tolerances
- Defect and repairs log, showing details of all defects identified and any repairs completed.

22.3 Material

Rip rap shall:

- Be selectively sourced material from on-site or imported from an approved source. Imported material shall be classed as VENM or ENM or NSW EPA Resource Recovery Exemption.
- Not contain any unsuitable materials identified in Section 2.4.1 unless approved by the Superintendent.
- Be clean, hard, sound and durable material that will maintain the required performance under the maximum loads likely to be imposed on it in service.
- Shall not be single sized, but shall be a well graded mixture designed to ensure that all interstices between larger rocks are filled with rock of progressively smaller size. Rock gradation shall be as per the Contract Drawings.

The Contractor shall supply pre-qualification testing results showing that the proposed material meets the requirements of this Specification and the Contract Drawings. Samples taken shall be representative of the whole material source and shall be evenly distributed across the material source.

22.4 Installation

The Contractor shall prepare a work method statement for placement of the rip rap outlining the placement methodology and proposed construction plant to be used (refer Appendix A). The work method statement shall be submitted to the Superintendent for review and approval prior to placement.

The work method statement and construction methodology for the rip rap shall be developed in accordance with the guidance provided below:

- Rip-rap shall be placed in a uniform manner which ensures that larger rocks are uniformly distributed, and smaller rocks effectively fill the spaces between the larger rocks without leaving any large voids.
- All rip rap is to be underlain by a geotextile. Rip rap shall be placed in a manner to prevent damage to the underlying geotextile. Hand placement shall be required to the extent necessary to prevent any punching, cutting, or tearing of the separation geotextile.
- Laying shall commence at the toe of the slope and shall progress upwards, with each rock being firmly embedded into the slope and against the adjoining rocks. The rip rap shall be thoroughly packed as construction progresses, so that the finished surface is tight and uniform and conforms to the design slope. Larger rocks shall be placed at the bottom of the slope.
- Rip rap shall be placed in a manner which does not result in excessive particle breakdown or crushing.

- Rip rap shall be placed carefully around any pipework to ensure the pipework is sufficiently protected.

22.5 Tolerances

The Contractor shall place the rip rap within the tolerances provided in Section 2.11.

22.6 Defects and repairs

The Superintendent may direct the Contractor to remove a section of the rip rap to inspect underlying materials for damage. The Contractor shall repair any damage that occurs to the underlying materials as a consequence of the placement of rip rap in accordance with this Specification.

Any areas of placed rip rap that do not conform to the Specification shall be repaired by the Contractor to the satisfaction of the Superintendent.

The Contractor shall submit to the Superintendent for review details of any defects identified and repairs carried out.

23. Landfill gas system

23.1 General

This section contains the technical requirements for the landfill gas system. The relevant requirements for sequencing and scheduling in Section 1.5 and Earthworks in Section 2 shall be considered alongside guidance provided in this section.

The Superintendent may reject any component of the landfill gas system that does not meet or exceed the requirements of this section.

Any component of the landfill gas system rejected by the Superintendent shall be remediated by the Contractor.

23.2 Submittals

23.2.1 Prior to installation of landfill gas system

The Contractor shall submit the following to the Superintendent for review and approval prior to installation of the landfill gas system:

- Work method statement for installation of the landfill gas system, including sequencing and with other works and repair procedures (Appendix A).

23.2.2 Following installation of landfill gas system

The Contractor shall submit the following to the Superintendent for review and approval following placement of seal bearing layer:

- As-built survey of trenches, bore locations and vent location
- As-built survey of perimeter landfill gas monitoring bore network, borehole drilling and installation logs for each of the landfill gas monitoring bores

23.3 Installation

The Contractor shall install the landfill gas system in accordance with the Contract Drawings.

The Contractor shall prepare a work method statement for installation of the landfill gas system outlining installation methodology and proposed construction plant to be used (refer Appendix A). The work method statement shall be submitted to the Superintendent for review and comment prior to placement.

The landfill gas system trench and bore locations are approximate only and shall be confirmed with the Superintendent prior to drilling. The landfill gas system is installed directly into landfilled waste materials. Bores shall be installed using suitable drilling rigs and equipment.

The landfill gas system includes a single penetration without pipe boot through the cap for the ventilation shaft as part of the central landfill gas vent.

All drilling cuttings and other waste generated by the works are the responsibility of the Contractor. They shall be considered waste materials to be incorporated into the containment cell as directed by the Superintendent and in accordance with the requirements of these works (e.g., waste placement Section 13).

24. Appurtenances

24.1 Sandbags

Unless otherwise instructed by the Superintendent, sand bags or approved equivalent shall have a minimum weight of 10 kilograms. Sandbags are to be placed at 2 m centres. The material used for the bags shall be non-degradable, UV stabilised material with a 5 year exposure rating.

24.2 Bentonite fill

Bentonite fill shall consist of nominal 6 mm bentonite pellets. Pellets shall be adequately hydrated during installation to provide a suitable seal around the installed pipe.

The Contractor shall provide manufacturer documentation for the bentonite fill shall be submitted to the Superintendent for approval prior to installation.

24.3 Recycled aggregate

The recycled aggregate will consist of clean, sound, rock or crushed/broken brick and tile of nominally 20-40 mm in size. It is to be free from metals, organic material and other contaminants. This material should be free flowing and achieve a hydraulic conductivity of greater than 1×10^{-4} m/s.

Where possible, the material supplier should provide a copy of the grading and hydraulic conductivity results for this material. At commencement of the works, one load of recycled aggregate will be delivered to site for a visual inspection by the Superintendent. The Contractor will be required to source an alternative recycled aggregate if approval is not granted by the Superintendent (the Superintendent will be required to provide details of the non-conformance in writing). Once the material has been approved, the Superintendent will continue to carry out visual inspections and reject any future loads, which are not considered to conform.

24.4 Gabions and gabion mattresses

The following standards should be adhered to:

Standard	Title
RMS R55	Rock filled gabions and mattresses Include PVC coating for all reno mattresses

24.5 Leachate transfer system

The contractor is to provide a leachate transfer system that has the following key components:

- Two leachate transfer pipelines, nominally one for each side of the containment cell that conveys flows to the leachate pond
- Portable pump set that can be relocated around site by the operators to utilise at the other cells in the facility

Provide details of the nominate pumps and any other associated equipment to the Superintendent for approval prior to procurement. The Superintendent shall review the information and provide feedback as required. The contractor shall provide details of the nominated pump, maintenance requirements and items with a long lead-time.

24.5.1 Pump requirements

The contractor is to nominate a pump that can access the leachate sump as shown in the drawings. A surface operated pump is preferred. The pump shall be diesel-powered and should be able to be operated by a single operator safely utilising a small truck or ute for transport. The pump shall be readily serviceable with spares and consumables available from Australian suppliers.

The pump is to be compatible with the nominated Leachate Collection System The Contractor may modify the Leachate Collection System to accommodate the nominate pump subject to approval from the Superintendent.

The pump is to operate over a range of duties to accommodate the flows at various cells:

Note that the operating heads may vary considerably based on pipeline temperature.

The pump is to be suitable to handle leachate from the landfill, and it is likely that there may be small fines and solids in the leachate up to say 10 mm size.

24.5.2 Transfer pipeline

The transfer pipelines shall be constructed of a nominal 90 mm diameter HDPE PE 100 SDR 21

The transfer pipeline shall be located above ground, except as noted below:

- Provide a mass concrete surround to the pipeline adjacent to the Leachate Pond nominally 1 m long and 250 mm thick on all sides. Location is to be confirmed by the Superintendent. Extend the pipeline down the bank and nominally 1 m beyond the lined crest.
- At the start of the pipeline, provide a mass concrete surround nominally 1 m long and 250 mm thick on all sides. Provide a short vertical section within the concrete and provide a camlock fitting and cap as approved by the Superintendent.

The alignment of the transfer pipelines is generally as shown on the drawings. The final alignment shall be confirmed onsite by the Superintendent. Ensure that the pipe is founded on even ground free of any deleterious material that may damage the pipeline.

Provide warning signage at nominally 50 m intervals along the pipelines. The signs shall have the following wording:

- WARNING LEACHATE PIPELINE.
- If damaged, urgently contact XXXXXXXX on XXXXXXXXX. Details to be confirmed by Superintendent.

Where the pipeline is likely to be trafficked (even intermittently) bury the pipeline for nominally 3 m length to prevent damage. Details to be agreed with the superintendent. During construction protect the pipeline from damage. Any temporary crossing shall be removed prior to Practical Completion as directed by the Superintendent.

24.5.3 Commissioning

Advise the Superintendent at least 10 working days prior to commissioning to allow for their attendance. At this time submit a Commissioning Plan outlining procedures and checklists and details of precommissioning activities (pipeline welding details, etc.). Commissioning shall be conducted in a logical sequence.

All materials, equipment, installation and workmanship shall be tested and/or inspected to prove compliance with the Specification requirements. Tests and inspections shall comply with current relevant Australian Standards.

Throughout commissioning the Contractor shall be responsible for the test program.

Provide continuous supervision by personnel experienced in the operation of the equipment and have qualified personnel in attendance to carry out all necessary adjustments and/or remedial work during the commissioning tests.

24.5.4 Operation and maintenance information

Provide Operation and Maintenance Information in digital PDF format following commissioning. The package shall include:

- Contents page
- Description of the work under the contract
- Operational requirements, settings and constraints for the work (refer below)
- Listing of installed components, including pumps, motors, valves, flowmeters
- Draft Maintenance Schedules for all components of the work
- Copies of test certificates for components of the work
- Copies of performance curves or capability statements for components (particularly pump curves)
- Proposed Spare Parts list
- Work-As-Constructed drawings
- Supplier documentation and warranties

Appendices

Appendix A – Schedule of work method statements for the Containment Cell works

Component	Work method statement requirements
General	The Contractor shall prepare the following general work method statements for review approval by the Superintendent: • Scheduling • Site access and traffic control • Survey control • Surface water management • Erosion and sediment control
Earthworks	The Contractor shall prepare an earthworks work method statement for review approval by the Superintendent with consideration to the following: • Scheduling • Removal of vegetation • Excavation of earthwork materials • Filling of earthwork materials • Supply and quality control • Stockpile management and control measures • Method of moisture conditioning, material placement and compaction for earthworks materials • Earthworks material layer thickness control and survey • Trimming and final surface preparation • Anchor trench excavation and backfilling • Defects and repairs • Quality control testing
Subgrade	The Contractor shall prepare a subgrade work method statement for review approval by the Superintendent with consideration to the following: • Scheduling • Supply and quality control • Method of moisture conditioning, material placement and compaction • Surface preparation • Material layer thickness control and survey • Trimming and final surface preparation • Defects and repairs • Quality control testing
Clay rich fill layer	The Contractor shall prepare a clay rich fill layer work method statement for review approval by the Superintendent with consideration to the following: • Scheduling • Supply and quality control • Method of moisture conditioning, material placement and compaction • Surface preparation • Material layer thickness control and survey • Trimming and final surface preparation • Defects and repairs • Quality control testing

Component	Work method statement requirements
Geonet drainage composite	The Contractor shall prepare a geonet drainage composite work method statement for review approval by the Superintendent with consideration to the following: • Scheduling • Supply and quality control • Method of material placement • Surface preparation • Defects and repairs • Quality control testing
Sand drainage layer	The Contractor shall prepare a sand drainage work method statement for review approval by the Superintendent with consideration to the following: • Scheduling • Supply and quality control • Method of material placement and compaction • Surface preparation • Material layer thickness control and survey • Trimming and final surface preparation • Defects and repairs • Quality control testing
Geosynthetic clay liner	The Contractor shall prepare a geosynthetic clay liner work method statement for review approval by the Superintendent with consideration to the following: • Scheduling • Supply and quality control • Method of material placement • Surface preparation • Defects and repairs • Quality control testing
PE geomembrane	The Contractor shall prepare a PE geomembrane work method statement for review approval by the Superintendent with consideration to the following: • Scheduling • Supply and quality control • Method of material placement • Surface preparation • Defects and repairs • Quality control testing
Geotextile	The Contractor shall prepare a geotextile work method statement for review approval by the Superintendent with consideration to the following: • Scheduling • Supply and quality control • Method of material placement • Surface preparation • Defects and repairs • Quality control testing

Component	Work method statement requirements
Drainage aggregate	The Contractor shall prepare a drainage aggregate work method statement for review approval by the Superintendent with consideration to the following: • Scheduling • Supply and quality control • Method of material placement and compaction • Surface preparation • Material layer thickness control and survey • Trimming and final surface preparation • Defects and repairs • Quality control testing
PE pipework	The Contractor shall prepare a PE pipework method statement for review approval by the Superintendent with consideration to the following: • Scheduling • Supply and quality control • Method of material placement • Defects and repairs • Quality control testing
Soil confining layer	The Contractor shall prepare a soil confining layer work method statement for review approval by the Superintendent with consideration to the following: • Scheduling • Supply and quality control • Method of moisture conditioning, material placement and compaction • Surface preparation • Material layer thickness control and survey • Trimming and final surface preparation • Defects and repairs • Quality control testing
Waste placement	The Contractor shall prepare a waste placement work method statement for review approval by the Superintendent with consideration to the following: • Scheduling • Supply • Numbers, types, and sizes of equipment proposed to perform hauling and placement • Anticipated challenges and mitigation measures • Methods for maintaining adequate survey control during placement operations • Method of material placement and compaction • Trimming and final surface preparation • Contaminated water management procedures detailing: methods and equipment to handle contaminated water during placement operations as specified herein and washing/decontamination methods, disposal methods, all with reference to relevant regulations.

Component	Work method statement requirements
Seal bearing layer	The Contractor shall prepare a seal bearing layer work method statement for review approval by the Superintendent with consideration to the following: • Scheduling • Supply and quality control • Method of moisture conditioning, material placement and compaction • Surface preparation • Material layer thickness control and survey • Trimming and final surface preparation • Defects and repairs • Quality control testing
Revegetation layer	The Contractor shall prepare a revegetation layer work method statement for review approval by the Superintendent with consideration to the following: • Scheduling • Supply and quality control • Method of moisture conditioning, material placement and compaction • Surface preparation • Material layer thickness control and survey • Trimming and final surface preparation • Planting and sowing • Vegetation maintenance • Defects and repairs • Quality control testing
Field trials	The Contractor shall prepare a field trials work method statement for review approval by the Superintendent with consideration to the following: • Method of transportation of fill material to placement location • Method of moisture conditioning of material prior to placement • Method of mixing and processing of material for clod removal prior to placement • Method of spreading fill material • Method of lift thickness control • Method of compaction and moisture conditioning of material during placement • Details of plant and equipment to be used during placement • Approximate number of passes for each item of plant on the clay rich fill layer
Drainage and Stormwater infrastructure	The Contractor shall prepare a waste placement work method statement for review approval by the Superintendent with consideration to the following: • Scheduling • Supply and quality control • Method of installation • Defects and repairs • Quality control testing
Concrete	The Contractor shall prepare a concrete method statement for review and approval by the Superintendent with consideration of the following: • Scheduling • Supply and quality control • Method of installation • Defects and repairs • Quality control testing

Component	Work method statement requirements
Granular Pavements	The Contractor shall prepare a pavement method statement for review approval by the Superintendent with consideration of the following: • Scheduling • Supply and quality control • Method of installation • Defects and repairs • Quality control testing
Rip rap	The Contractor shall prepare a rip rap work method statement for review approval by the Superintendent with consideration to the following: • Scheduling • Supply and quality control • Method of installation • Defects and repairs • Quality control testing
Landfill gas system	The Contractor shall prepare a landfill gas monitoring bore work method statement for review approval by the Superintendent with consideration to the following: • Scheduling • Supply and quality control • Method of drilling, material placement and pipework installation • Defects and repairs.

Appendix B – Example submittal forms

Delivery submittal form – earthworks materials

Submission data	
Project name and location:	
Submittal number:	
Material designation (as per the Specification):	
Reference section of Specification:	
Material source (including certificates):	
Proposed placement location:	
Estimated quantity:	
Material sample provided:	☐ Yes ☐ No (provide reason below) ☐ N/A (provide reason below)
Material inspected by CQA Engineer:	☐ Yes ☐ No (provide reason below) ☐ N/A (provide reason below)
Material certificates/documentation for VENM, ENM and/or Resource Recovery Exemption:	
Additional comments (including other information provided as required):	

Attachments	
VENM/ENM certification:	☐ Yes ☐ No (provide reason below) ☐ N/A (provide reason below)
Pre-qualification test results/reports:	☐ Yes ☐ No (provide reason below) ☐ N/A (provide reason below)
Additional comments (including other information provided as required):	
Submitted by: (include title and signature)	Date:

Installation submittal form – earthworks materials

Submission data	
Project name and location:	
Submittal number:	
Material designation (as per the Specification):	
Reference section of Specification:	
Material source (including certificate:	
Proposed placement location:	
Estimated quantity:	
Material sample provided:	☐ Yes ☐ No (provide reason below) ☐ N/A (provide reason below)
Material inspected by CQA Engineer:	☐ Yes ☐ No (provide reason below) ☐ N/A (provide reason below)
Additional comments (including other information provided as required):	

Attachments	
Work method statement for material use:	☐ Yes ☐ No (provide reason below) ☐ N/A (provide reason below)
Survey of underlying surface:	☐ Yes ☐ No (provide reason below) ☐ N/A (provide reason below)
Additional comments (including other information provided as required):	
Submitted by: (include title and signature)	Date:

Pre-selection submittal form – geosynthetics

Submission data	
Project name and location:	
Submittal number:	
Material designation (as per the Specification):	
Reference section of Specification:	
Product manufacturer:	
Product name:	
Proposed placement location:	
Estimated quantity:	
Material sample provided:	☐ Yes ☐ No (provide reason below) ☐ N/A (provide reason below)
Additional comments (including other information provided as required):	

Attachments	
Material data sheet:	☐ Yes ☐ No (provide reason below) ☐ N/A (provide reason below)
Manufacturer’s quality control and assurance procedures:	☐ Yes ☐ No (provide reason below) ☐ N/A (provide reason below)
Additional comments (including other information provided as required):	
Submitted by: (include title and signature)	Date:

Delivery submittal form – geosynthetics

Submission data	
Project name and location:	
Submittal number:	
Material designation (as per the Specification):	
Reference section of Specification:	
Product manufacturer:	
Product name:	
Proposed placement location:	
Estimated quantity:	
Material sample provided:	☐ Yes ☐ No (provide reason below) ☐ N/A (provide reason below)
Additional comments (including other information provided as required):	

Attachments	
Manufacturer’s certificate of compliance:	☐ Yes ☐ No (provide reason below) ☐ N/A (provide reason below)
Manufacturer’s quality control and assurance test results/reports:	☐ Yes ☐ No (provide reason below) ☐ N/A (provide reason below)
Manufacturer’s shipping, handling and storage procedures:	☐ Yes ☐ No (provide reason below) ☐ N/A (provide reason below)
Manufacturer’s installation procedures and requirements:	☐ Yes ☐ No (provide reason below) ☐ N/A (provide reason below)
Work method statement for material delivery, storage, handling and installation:	☐ Yes ☐ No (provide reason below) ☐ N/A (provide reason below)
Additional comments (including other information provided as required):	
Submitted by: (include title and signature)	Date:

Installation submittal form – geosynthetics

Submission data	
Project name and location:	
Submittal number:	
Material designation (as per the Specification):	
Reference section of Specification:	
Product manufacturer:	
Product name:	
Proposed placement location:	
Estimated quantity:	
Material sample provided:	☐ Yes ☐ No (provide reason below) ☐ N/A (provide reason below)
Material inspected by CQA Engineer:	☐ Yes ☐ No (provide reason below) ☐ N/A (provide reason below)
Additional comments (including other information provided as required):	

Attachments	
Delivery, storage and handling log (including roll numbers):	☐ Yes ☐ No (provide reason below) ☐ N/A (provide reason below)
Proposed panel placement drawing:	☐ Yes ☐ No (provide reason below) ☐ N/A (provide reason below)
Survey of underlying surface:	☐ Yes ☐ No (provide reason below) ☐ N/A (provide reason below)
Independent conformance test results/reports (provided by CQA Engineer)	☐ Yes ☐ No (provide reason below) ☐ N/A (provide reason below)
Additional comments (including other information provided as required):	
Submitted by: (include title and signature)	Date:

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Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
2	A Roberts, D Morrison	D Barrett		Ian Gregson		08/11/2018

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APPENDIX 4
CONSTRUCTION QUALITY ASSURANCE (CQA) PLAN

Hydro Aluminium Kurri Kurri Pty Ltd

Containment Cell Design

Construction Quality Assurance (CQA) Plan

October 2017

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1. Introduction

This plan presents the Construction Quality Assurance (CQA) requirements for the construction of the Works (refer section 1.3) at the former Hydro Aluminium Kurri Kurri Aluminium Smelter (the site), and must be read in conjunction with the Works Documents.

1.1 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.

1.2 Purpose

The purpose of this CQA Plan is to define, for the landfill barrier system and leachate collection and conveyance system, construction quality assurance procedures and requirements necessary to demonstrate compliance with the requirements of the Works Documents.

1.3 Scope of Works

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

- Protect the Works Area to prevent unauthorised pedestrian and vehicular access and damage to existing infrastructure and works proposed under this contract. This shall include, but not be limited to, locate and protect existing environmental monitoring wells, gas infrastructure and services to the satisfaction of the Superintendent and other authorities, providing site and traffic management such as temporary signage, fencing, gates, lighting (if necessary) and protection barriers.
- Set out the Works including all associated survey work.

- Install and maintain during construction all necessary erosion and sedimentation control measures.
- Supply and construct all necessary temporary works to facilitate the construction of the works.
- Excavate, fill, compact and grade as necessary to develop the finished surfaces.
- Supply and install the leachate barrier system (including sidewall liner system)
- Supply and install leachate collection and conveyance system.
- Supply and construction all necessary access roads and infrastructure.
- Supply and install the surface water drainage works.
- Supply and install the gas extraction system
- Supply and install the final cap
- Supply record drawings in both digital and hardcopy format.

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:

<u>Superintendent</u>

……………………………………………………………………………………………..

Contact: ……………………………………………………………………………………..

Phone: ...…………………………………………………………………………………….

<u>Superintendents Representative</u>

……………………………………………………………………………………………..

Contact: ……………………………………………………………………………………..

Phone: ...…………………………………………………………………………………….

<u>Contractor</u>

……………………………………………………………………………………………..

Contact: ……………………………………………………………………………………..

Phone: ...…………………………………………………………………………………….

<u>CQA Engineer</u>

……………………………………………………………………………………………..

Contact: ……………………………………………………………………………………..

Phone: ...…………………………………………………………………………………….

<u>Regulatory Authority</u>

……………………………………………………………………………………………..

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.

The Superintendent shall be the main point of liaison between the Contractor and the CQA Engineer, as well as the Client.

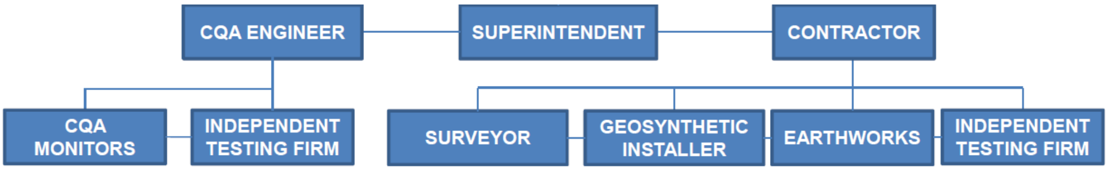

Figure 1 Lines of communication

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 3.4) 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.

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; 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 (eg. 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 m^3 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 Subgrade preparation

During subgrade preparations verify the following:

- The subgrade is smooth, free of voids, and composed of satisfactory materials;
- The subgrade is compacted as specified;
- The lines and levels of the top surface of the subgrade is correct; and
- The subgrade surface is scarified as specified prior to placement of the first lift of fill.

3.12 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; and
- Fill is placed to the lines and levels shown in the Works Documents.

3.13 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.

3.14 Conformance testing

3.14.1 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.

3.14.2 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; and
- The Contractor uses nuclear gauges in the direct transmission mode to measure density.

3.15 Tolerances

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

3.16 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.

3.17 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.

3.18 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; and
- Ensure the Contractor repairs damaged areas and re-establishes grades.

3.19 Weather conditions

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

3.20 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.

3.21 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.

4. Subgrade

4.1 General

The CQA Engineer shall verify the following during subgrade preparation.

The relevant requirements for subgrade preparation in Section 3.11 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 m^3 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.

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 fillshall have provided CQA inspection during installation soil layers for at least three major earthworks projects totalling a minimum of 50,000 m^3 of protective 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. Geonet drainage composite

6.1 General

All individuals' assigned CQA responsibilities for the geonet and geonet drainage composite shall have be 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 m^2 of geosynthetics.

6.2 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.

6.3 Manufacturers 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.

6.4 Manufacturers 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.

6.5 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.

6.6 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 Table 1 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 1 Geonet and geonet drainage composite CQA testing

Test Type	Test Method	Frequency	Comments
Mass per unit area	D5261	1 test per 5 rolls	Laboratory measurement
Thickness	D5199	1 test per 5 rolls	
Tensile strength (machine direction)	D1682	1 test per 10 rolls	Laboratory measurement
Transmissivity (1)	D4716	1 test per 10 rolls	Laboratory measurement
Compressive strength	D1621	1 test per 10 rolls	Laboratory measurement
Apparent opening size of geotextile		1 test per 5 rolls	
Ply adhesion (MARV)	D7005	1 test per 5 rolls	Laboratory measurement

6.7 Roll and sample identification

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

6.8 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.

6.9 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

[1] Hydraulic gradient (1 m/m), Confining stress (>230 kPa), Seating time (100 hours)

- 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.

6.10 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
- 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.

6.11 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 24.2).

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

6.12 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.

7. Sand Drainage Layer

7.1 General

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

All individuals assigned CQA responsibilities for the sand drainage layer shall have provided CQA inspection during installation soil layers for at least three major earthworks projects totalling a minimum of 50,000 m^3 of protective soil layer material.

7.2 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.

7.3 Materials

The CQA Engineer shall:

- Review all test results/reports provided by the Contractor for the proposed sand drainage 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 sand drainage material appear to have changed significantly
- Inspect sand drainage material stockpiles prior to use and advise the Superintendent of the presence of any unsuitable material.

7.4 Delivery, storage and handling

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

7.5 Preparation of surface to receive sand drainage layer

The receiving surface shall be inspected and approved by the CQA Engineer each day that sand drainage 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.

7.6 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 sand drainage material
- Sand drainage 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 sand drainage material is being spread over the underlying geosynthetics
- Wrinkles in underlying geosynthetics are not folding over onto themselves during sand drainage material placement
- Low ground pressure equipment is being used where specified
- Placement of sand drainage material proceeds from a stable working area adjacent to the deployed geosynthetic materials and gradually progresses outward. For slopes, sand drainage 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 sand drainage material is occurring
- Large stockpiles of sand drainage material are not placed on top of in-place geosynthetics
- Thin areas of sand drainage material which could allow underlying geosynthetics to be punctured or torn by construction equipment are repaired immediately.

7.7 Defects and repairs

The CQA Engineer shall visually inspect the sand drainage 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.

7.8 Acceptance

Prior to the final acceptance of the sand drainage 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.

8. Geosynthetic Clay Liner

8.1 General

The CQA Engineer shall verify the following during geosynthetic clay liner (GCL) installation.

8.2 Qualifications

The CQA Engineer assigned CQA responsibilities for the GCL shall have be accredited by the Geosynthetic Certification Institute-Inspectors Certification Program for installation of geosynthetic materials or have provided CQA inspection during installation of GCL for at least three projects totalling a minimum of 100,000 m^2.

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.

8.4 Manufacturers Quality Control

The CQA Engineer shall review the manufacturer's quality control procedures and test results prior to delivery of GCL 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 geosynthetic clay liner, the geotextile and the bentonite meet the Specification.

8.5 Manufacturers Quality Assurance

The CQA Engineer shall review the manufacturer's quality assurance procedures and test results prior to delivery of GCL 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.

8.6 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.

8.7 Independent Conformance Testing

The CQA Engineer shall supervise collection of CQA samples by the Geosynthetic Installer for GCL at the rate specified in Table 2 and forward the samples to the CQA Engineers Independent Testing Firm for testing. The testing frequencies shall apply to all GCL products provided as part of the Works.

Each product supplied shall be treated as a separate GCL 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.

Samples shall be cut on a flat surface and the edges taped closed to limit loss of bentonite.

Table 2 lists the independent conformance testing that shall be performed on the GCL prior to installation.

Table 2 GCL independent conformance testing

Test Type	Test Method	Frequency	Comments
Bentonite Clay – Mass @ 0% moisture	ASTM D5993	1 test per 2,500 m^2	Laboratory
Bentonite Clay – Fluid Loss	ASTM D5891	1 test per roll or per 1,250 m^2 (whichever is greater)	Laboratory
Bentonite Clay – Free Swell Index	ASTM D5890	1 test per roll or per 2,500 m^2 (whichever is greater)	Laboratory
Bentonite Clay – Montmorrillonite Content	CSIRO method	1 test per 10,000 m^2	Laboratory
Bentonite Clay – Moisture Content	ASTM D5993	1 test per roll or per 2,500 m^2 (whichever is greater)	Laboratory
Bentonite Clay – Cation exchange capacity	Methylene blue method	1 test per roll or per 2,500 m^2 (whichever is greater)	Laboratory
Strip tensile strength – machine direction	ASTM D6768	1 test per 5,000 m^2	Laboratory
Peel strength	ASTM D6496	1 test per roll or per 1,250 m^2 (whichever is greater)	Laboratory
Hydraulic conductivity	ASTM D5887	1 test per 10,000 m^2	Laboratory

In addition to this testing, GCL thickness and apparent variations in the as placed moisture distribution shall be assessed on-site for each roll during placement. If thickness appears to be variable a check of the variability of the mass per unit area shall be conducted.

8.8 Roll and Sample Identification

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

8.9 Delivery, Storage and Handling

The CQA Engineer shall fill out a receiving inspection report (Section 23.3 and Appendix A) for each delivery of GCL. 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 GCL
- Rolls are shipped, handled and stored in accordance with the approved work method statement and the manufacturer’s instructions

- GCL rolls are packaged in opaque, waterproof, protective coverings. GCL rolls delivered without complete packaging, labelling and documentation shall be either rejected or quarantined based on inspections by the CQA Engineer
- Each roll is labelled in accordance with the Specification
- Rolls which are damaged beyond use are removed from the site.

If the CQA Engineer determines any damaged GCL rolls or partial rolls are suitable for use, written justification for doing so shall be provided.

8.10 Preparation of Surface to Receive Geosynthetic Clay Liner

The receiving surface shall be inspected and approved each day that GCL 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 GCL
- Excessive moisture is not present which may inhibit GCL installation
- 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.

The CQA Engineer shall sign a certificate of subgrade acceptance shall be signed each day GCL materials are placed.

8.11 Installation

The CQA Engineer shall verify the following during installation:

- Installation and movement of GCL 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
- Any visible or suspected damage is recorded and reported, and relevant rolls are tagged and segregated for further investigation
- 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 GCL when they are covered
- There are no tensile stresses in the deployed GCL
- Construction personnel are not smoking or wearing shoes that could damage the GCL
- GCL which has been hydrated prior to being covered is removed and replaced. Hydrated GCL is defined as material, which has become soft as determined by squeezing the material with finger pressure or material that has exhibited swelling.
- 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
- Overlaps are constructed in accordance with the requirements of the Specification
- Bentonite paste is placed along the entire overlap width at the rate as per manufacturer's instructions
- Adhesives or other approved seaming methods recommended by the manufacturer are used if horizontal seams are allowed on slopes
- Rolls are not dragged across the receiving surface or other deployed GCL. This can result in damage to the GCL. A sacrificial rub sheet may be used to alleviate this problem
- Rolls are not being damaged during placement or covering
- GCL is not hydrated prior to covering.

8.12 Protection

The CQA Engineer shall visually inspect and verify that only those GCL panels which can be anchored and covered before the end of the day are removed from the packaging. If exposed GCL cannot be covered before the end of the day, the CQA Engineer shall verify it is covered with a plastic cover material and ballasted until construction can resume.

8.13 Penetrations

The CQA Engineer shall verify the following:

- Penetrations are located as shown on the plans
- Penetrations are constructed and tested as per the Specification and the manufacturer's instructions.

8.14 Defects and Repairs

The CQA Engineer shall visually inspect GCL 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.

8.15 Acceptance

Prior to the final acceptance of the GCL 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 GCL deployment
- Review of CQA test results
- Relevant monitoring and inspections undertaken.

9. PE Geomembrane

9.1 General

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

9.2 Qualifications

The CQA Engineer assigned CQA responsibilities for the PE geomembrane shall have be 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 m^2.

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

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.

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

9.4 Manufacturers 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.

9.5 Manufacturers 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.

9.6 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.

9.7 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 3 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 3 lists the independent conformance testing that shall be performed on the PE geomembrane prior to installation.

Table 3 PE geomembrane independent conformance testing

Test Type	Test Method	Frequency	Comments
Thickness (average)	ASTM D5994	One test per 5 rolls or 5,000 m^2 (whichever is greater).	Laboratory measurement
Minimum thickness	ASTM D5994	One test per 5 rolls or 5,000 m^2 (whichever is greater).	Laboratory measurement
Asperity height (min)	ASTM D7466	One test per 5 rolls or 5,000 m^2 (whichever is greater).	Laboratory measurement
Density	ASTM D1505 or D792 (method B)	One test per 5 rolls or 5,000 m^2 (whichever is greater).	Laboratory measurement
Tensile properties (each direction) • Strength at break • Elongation at break • Strength at yield • Elongation at yield	ASTM D6693	One test per 5 rolls or 5,000 m^2 (whichever is greater).	Laboratory measurement
Tear resistance	ASTM D1004	One test per 5 rolls or 5,000 m^2 (whichever is greater).	Laboratory measurement
Puncture resistance	ASTM D4833	One test per 5 rolls or 5,000 m^2 (whichever is greater).	Laboratory measurement
Carbon black content	ASTM D4218	One test per 5 rolls or 5,000 m^2 (whichever is greater).	Laboratory measurement

Test Type	Test Method	Frequency	Comments
Carbon black dispersion	ASTM D5596	One test per 5 rolls or 5,000 m^2 (whichever is greater).	Laboratory measurement
Oxidative Induction Time (OIT) • 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

9.8 Roll and Sample Identification

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

9.9 Delivery, Storage and Handling

The CQA Engineer shall fill out a receiving inspection report (Section 23.3 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.

9.10 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.

9.11 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.

9.12 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.

9.13 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.

9.14 Field Sampling and Testing

9.14.1 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 23.9 and Appendix A)
- Verify seams which fail CQA and/or CQC destructive seam testing are repaired in accordance with the Specification.

9.14.2 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.

9.15 Electrical Leak Location Survey

The CQA Engineer shall be responsible for engaging a Leak Location Contractor on behalf of the Principal to undertake electrical leak location surveys following the installation of all PE geomembranes layers. Electrical leak location surveys shall be undertaken in accordance with Section 14.

9.16 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.

9.17 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.

10. Electrical Leak Location Survey

10.1 General

This section contains the requirements for undertaking electrical leak location surveys. The Principal shall be responsible for engaging a Leak Location Contractor to undertake an electrical leak location surveys required for the Works.

The CQA Engineer may be the Leak Location Contractor.

Two types of leak location surveys shall be undertaken:

- Arc testing leak location survey (following installation of each PE geomembrane layer)
- Dipole leak location survey (following installation of the soil confining layer).

10.2 Standards

Relevant American Society for Testing and Material (ASTM) standards are as follows:

- D6747 – Standard Guide for Selection of Techniques for Electrical Detection of Potential Leak Paths in Geomembranes
- D7007 – Standard Practices for Locating Leak in Geomembranes Covered withWater or Earth Materials
- D7953 Standard Practice for Electrical Leak Location on Exposed Geomembranes Using the Arc Testing Method

Alternate test methods may be considered by the CQA Engineer in consultation with the Principal when requested in writing by the Contractor.

10.3 Submittals

10.3.1 Pre-qualification of Leak Location Contractor

The CQA Engineer shall submit to the Superintendent the following for review and approval prior to selection of a PE geomembrane manufacturer.

- Qualifications of the proposed Leak Location Contractor including the number of years the Leak Location Contractor has performed the proposed survey methods
- Certification that the Leak Location Contractor has previously tested a minimum of 90 ha of geomembrane liner and a minimum of 45 ha of the proposed survey method on at least five projects
- Certification that the leak location surveys shall be supervised by a professional or technician with a minimum of 18 ha of liner testing experience using the proposed method on at least three projects.

10.3.2 Prior to Conducting the Leak Location Surveys

The Contractor shall submit the following to the Superintendent for review and approval prior to conducting the leak location surveys:

- Work method statement for leak location surveys, including any information on any permanent electrodes and wires required during construction, and any installation instructions to be provide to the Contractor prior to the installation of the geomembrane and soil confining layer.

10.3.3 Following Completion of the Leak Location Surveys

The Contractor shall submit the following to the Superintendent for review and approval following completion of each of the leak location surveys:

- A report containing the methods, details and results of the leak location surveys, including a list of leak locations and rectification works undertaken by the Contractor.

10.4 Preparation and Support

Prior to the survey being conducted, the CQA Engineer, in consultation with the Leak Location Contractor, shall verify the Contractor has suitably prepared the PE geomembrane layer for the survey.

10.5 Execution

10.5.1 Arc Testing Leak Location Survey

The arc testing leak location survey shall be performed after the installation of each PE geomembrane layer in accordance with ASTM D7953.

The Leak Location Contractor shall be responsible for calibrating equipment utilised to achieve optimum data quality and sensitivity for the site conditions.

The survey works best when the geomembrane is in intimate contact with the subgrade. Wrinkles are an impediment to conducting a good survey and defects on wrinkles may not be detected.

Therefore, it is usually in the interest of the project to conduct the survey when the liner system is cool and flat, such as in the morning or during the night.

Working on slopes can create safety hazards with slippery surfaces, and may require additional harnessing and slower production rates. The Leak Location Contractor shall account for this in their work method statement.

Leak locations shall be logged, visibly marked, and reported to the CQA Engineer and Superintendent for repair.

10.6 Dipole Leak Location Survey

The dipole leak location survey shall be performed after the placement of the soil confining layer in accordance with ASTM D7007.

The Leak Location Contractor shall be responsible for calibrating equipment utilised to achieve optimum data quality and sensitivity for the site conditions.

Manual measurements shall be made to verify leak signals and to pinpoint the leak positions on top of the soil confining layer for excavation while the survey personnel are on site. Within 300 mm of the liner, the Contractor’s labourers shall hand excavate possible leak locations to expose the liner.

Additional manual measurements shall be made to guide the Contractor’s personnel while they excavate the leak, if required.

After the identification and excavation of a leak, the soil around the leak location shall be tested while the leak is uncovered and cleaned to check for adjacent leaks.

Leak locations shall be logged, visibly marked, and reported to the CQA Engineer and Superintendent for repair.

10.7 Reporting

The Leak Location Contractor shall report the general results of the survey to the CQA Engineer and Superintendent during the daily progress of the field work.

Prior to the demobilisation of the survey personnel from the site, the Leak Location Contractor shall submit a list of locations of the leaks detected to the CQA Engineer and Superintendent.

The Leak Location Contractor shall submit a report documenting the field work and results of the surveys to the CQA Engineer and Superintendent following completion of the field work. The report shall be certified by the CQA Engineer.

11. Geotextile

11.1 General

The CQA Engineer shall verify the following during geotextile installation.

11.2 Qualifications

The CQA Engineer assigned CQA responsibilities for the geotextile shall have be 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 m^2 of geosynthetics.

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

11.3 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.

11.4 Manufacturers 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.

11.5 Manufacturers 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.

11.6 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.

11.7 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 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 4 lists the independent conformance testing that shall be performed on the geotextile prior to installation.

Table 4 Geotextile independent conformance testing

Test Type	Test Method	Frequency	Comments
Mass per unit area	ASTM D5261	1 test per 2,500 m^2	All geotextiles
Grab Tensile strength	ASTM D4632	1 test per 5,000 m^2	All geotextiles
CBR Puncture Strength	ASTM D6241	1 test per 5,000 m^2	All geotextiles
Trapezoidal Tear Strength	ASTM D4533	1 test per 5,000 m^2	All geotextiles
Apparent Opening Size	ASTM D4751	1 test per 5,000 m^2	Separation geotextiles only
Permittivity	ASTM D4491	1 test per 5,000 m^2	Separation geotextiles only

11.8 Roll and Sample Identification

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

11.9 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.

11.10 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.

11.11 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.

11.12 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.

11.13 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.

12. Drainage aggregate

12.1 General

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

12.2 Qualifications

The CQA Engineer assigned CQA responsibilities for the drainage aggregate installation shall have be 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 m^2.

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

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, including any updates made based on the results of the field trial.

12.4 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.

12.5 Independent Conformance Testing

The CQA Engineer shall supervise collection of CQA samples for drainage aggregate at a rate specified in Table 5 and forward the samples to the CQA Engineers Independent Testing Firm for testing.

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

Table 5 Drainage aggregate independent conformance testing

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

12.6 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.

12.7 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.

12.8 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.

12.9 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.

12.10 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.

12.11 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.

13. PE 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 6 lists the independent conformance testing shall be performed on the plastic pipework prior to installation.

Table 6 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;

- 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.

14. Soil confining layer

14.1 General

The CQA Engineer shall verify the following during placement of the Soil confining layer.

All individuals assigned CQA responsibilities for the Soil confining layer shall have provided CQA inspection during installation soil layers for at least three major earthworks projects totalling a minimum of 50,000 m^3 of protective soil layer material.

14.2 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.

14.3 Materials

The CQA Engineer shall:

- Review all test results/reports provided by the Contractor for the proposed soil confining 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 soil confining material appear to have changed significantly
- Inspect material stockpiles prior to use and advise the Superintendent of the presence of any unsuitable material.

14.4 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.

14.5 Preparation of surface to receive Soil confining layer

The receiving surface shall be inspected and approved by the CQA Engineer each day that Soil confining 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.

14.6 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 soil confining material
- Soil confining 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 soil confining material is being spread over the underlying geosynthetics
- Wrinkles in underlying geosynthetics are not folding over onto themselves during soil confining material placement
- Low ground pressure equipment is being used where specified
- Placement of soil confining material proceeds from a stable working area adjacent to the deployed geosynthetic materials and gradually progresses outward. For slopes, soil confining 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 soil confining material is occurring
- Large stockpiles of soil confining material are not placed on top of in-place geosynthetics
- Thin areas of soil confining material which could allow underlying geosynthetics to be punctured or torn by construction equipment are repaired immediately.

14.7 Defects and repairs

The CQA Engineer shall visually inspect the Soil confining 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.

14.8 Acceptance

Prior to the final acceptance of the Soil confining 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.

15. Waste placement

15.1 General

The CQA Engineer shall verify the following during placement of waste.

15.2 Qualifications

The CQA Engineer assigned CQA responsibilities for earthworks shall have provided CQA inspection during placement of waste for at least three major waste projects totalling a minimum of 50,000 m^3 of waste placement activities.

15.3 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.

15.4 Equipment

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

15.5 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.

15.6 Independent Conformance Testing

The CQA Engineer shall supervise CQA tests for waste placement at a rate specified in Table 7.

Table 7 Waste placement independent conformance testing

Test Type	Test Method	Frequency	Comments
Compaction	ASTM D 698	1 per 7,600 m^3	Prior to placement
Density	ASTM D 1556 ASTM D 2922	1 per 20 CQC tests	In-place soils

15.7 Weather conditions

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

15.8 Execution

The CQA Engineer shall verify the following during waste placement:

- Verify stockpiles containing contaminated material are bermed, lined, and covered. Also verify a means of managing leachate is provided.
- Verify waste material is placed so that large void spaces do not exist.
- Compaction of waste is usually specified by requiring several passes of a compactor over all areas of the waste instead of requiring that a specific density criteria be achieved. At least 3 times per 8-hour period, spot-check to make sure the contractor is making the minimum required number of passes for each lift of waste placed.
- For landfill liner systems, verify the contractor’s method of placement does not damage the liner.
- Immediately notify the superintendent if unexpected hazardous materials are discovered during waste regrading or placement.
- Verify the contractor minimizes the amount of waste exposed during regrading operations to reduce odour problems.
- Notify the superintendent if odour or volatilization of contaminants becomes a problem. Daily cover may need to be placed over areas of exposed waste.
- When waste is being regraded, look for leachate seeps that present unsuitable conditions for fill placement. Report such seeps to the superintendent
- For landfill liner systems, verify the contractor implements measures to remove runoff which collects in the landfill.
- Check for areas where additional fill needs to be placed due to settlement.
- For landfill liner systems, check interim surveys to verify adequate space is available within the landfill to store all contaminated material.
- Verify final lines and grades of the regraded and in-place waste are correct.

16. Seal bearing layer

16.1 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 m^3 of protective soil layer material.

16.2 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.

16.3 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.

16.4 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.

16.5 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.

16.6 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.

16.7 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.

16.8 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.

17. Revegetation layer

17.1 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.

17.2 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.

17.3 Material

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 conform to 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.

17.4 Preparation of surface to receive revegetation 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.

17.5 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.

17.6 Seeding and 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.

17.7 Compaction

As per Section 3.13.

17.8 Construction quality control testing

As per Section 2.9

17.9 Tolerances

As per Section 3.15.

17.10 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.

17.11 Revegetation

The CQA Engineer shall regularly inspect revegetation works completed by the Contractor and recommend rejection or approval to the Superintendent.

17.12 Maintenance

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

17.13 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.

18. Field Trials

18.1 General

The CQA Engineer shall verify the following during the field trials.

18.2 Qualifications

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

18.3 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.

18.4 Field trial placement

During the field trials, 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.

19. Drainage and stormwater infrastructure

19.1 General

The CQA Engineer shall verify the following during drainage and stormwater infrastructure construction.

19.2 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.

19.3 Material

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

19.4 Equipment

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

19.5 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.

19.6 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.

19.7 Excavation

The CQA Engineer shall verify the excavation for drainage and stormwater infrastructure subgrade is in accordance to Section 3.

19.8 Filling

The CQA Engineer shall verify the filling for drainage and stormwater infrastructure subgrade is in accordance to Section 3.

19.9 Compaction

The CQA Engineer shall verify the compaction for drainage and stormwater infrastructure subgrade is in accordance to Section 3.

19.10 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
- Trafficking with heavy machinery is avoided after construction or placement
- Oversize and angular material which could damage geosynthetics (if any) has been removed prior to placement
- Underlying geosynthetics (if any) 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 (if any) are not folding over onto themselves during aggregate placement
- Low ground pressure equipment is being used where specified.
- Visually inspect for dips and reverse grades along swales and channel bottoms.
- Verify inlets and outlets are not obstructed or damaged during construction.

19.11 Tolerances

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

19.12 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.

19.13 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.

19.14 Acceptance

Prior to the final acceptance of construction and installation all drainage and stormwater infrastructure 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

20. Concrete structures

20.1 General

The CQA Engineer shall verify the following during concrete structures construction.

20.2 Qualifications

The CQA Engineer assigned CQA responsibilities for earthworks shall have provided CQA inspection during construction of concrete structures for at least three documented projects including concrete structure construction.

20.3 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.

20.4 Materials

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

20.5 Equipment

Verify equipment used to handle, place, compact, finish and cure concrete is in accordance with the Works Documents and the manufacturer's recommendations.

20.6 Delivery, storage and handling

Be present during delivery and unloading and verify the following:

- Concrete materials are not damaged during shipping, storage, and handling;
- Deliveries are properly recorded;
- The correct material type, strength, and sizes have been delivered;

20.7 Manufacturer Quality Control testing

Verify that material 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 material.

20.8 Preparation of surface to receive concrete

The receiving surface shall be inspected and approved by the CQA Enginee on each occasion that concrete is constructed r. 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 concrete once hardened
- The receiving surface is free from abrupt breaks, sharp objects, or other foreign material
- The receiving surface has not been damaged by inclement weather

20.9 Placing, compaction and finishing

Verify the following during concrete handling, placing and compaction:

- Segregation or loss of materials are minimised
- Premature stiffening is minimised
- Production of monolithic mass between planned joined or the extremities of structure
- Formwork is completely filled to intended level, expel entrap air and closely surround all reinforcement, tendons, ducts, anchorages, embedment and fixings
- Provide the specified finish to the formed surfaces of the structure
- Finish surface to achieve specified dimensions, falls, tolerances or similar details relating to the shape and uniformity of surfaces, cover from surface to reinforcement, tendons ducts and texture of the surface

21. Landfill gas system

21.1 General

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

21.2 Equipment

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

21.3 Delivery, storage and handling

Be present during delivery and unloading and verify the following:

- Landfill gas system materials and 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.

21.4 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.

21.5 Independent Conformance Testing

Table 8 lists the independent conformance testing shall be performed on the components of the landfill gas system prior to installation.

Table 8 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

21.6 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;
- 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

21.7 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.

21.8 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

22. Roads infrastructure

22.1 General

The CQA Engineer shall verify the following during construction of roads infrastructure.

22.2 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.

22.3 Material

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

22.4 Equipment

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

22.5 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.

22.6 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.

22.7 Excavation

The CQA Engineer shall verify the excavation for roads infrastructure subgrade is in accordance to Section 3.

22.8 Compaction

The CQA Engineer shall verify the compaction for roads infrastructure subgrade is in accordance to Section 3.

22.9 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
- Trafficking with heavy machinery is avoided after construction or placement of bitumen (if any)
- Low ground pressure equipment is being used where specified.

22.10 Tolerances

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

22.11 Weather conditions

Verify that roads infrastructure construction does not occur during periods of excessive rain, or if other detrimental weather conditions exist.

22.12 Defects and Repairs

If a road material 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.

22.13 Acceptance

Prior to the final acceptance of construction all road infrastructures 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

23. Appurtenances

23.1 Temporary access ramps

The CQA Engineer shall verify the following:

- That the construction Contractor complies with requirements concerning vehicle speeds and number of vehicles on the access ramp
- That construction equipment is not braking sharply while on the ramp
- Inspect the access ramp daily for cracks and slippage of the protective soil layer. Also verify the protective soil layer is not thinning due to traffic or erosion.

23.2 Sumps

Sumps are very labour intensive and difficult to construct. Continuous visual inspection during construction activities shall be performed in sump areas by the CQA Engineer. The CQA Engineer shall verify the following:

- Carefully inspect placement of sand and aggregate to confirm underlying geosynthetics are not being damaged
- Confirm pipe perforations meet specified requirements and are placed at the correct locations
- Pumps and other mechanical equipment are in accordance with the Specification and manufacturer’s instructions
- That test operation of pumps, level alarms, valves, switches and controls have been performed in accordance with manufacturer’s recommendations and all equipment is operational.

23.3 Trenches

The CQA Engineer shall verify the following:

- That trenches are constructed at the proper depth and alignment
- That any pipes in the trenches are placed at the proper lines and grades
- If geosynthetics are included in trenches, ensure that subgrade/sidewall protrusions or backfill placement does not damage the geosynthetics.

23.4 Swales and channels

- Visually inspect for dips and reverse grades along swales and channel bottoms.
- Verify inlets and outlets are not obstructed or damaged during construction.

24. CQA documentation

24.1 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.

24.2 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
- CQC and 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

24.3 Receiving Inspection Report

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

24.4 Certificate of Subgrade Acceptance

A certificate of subgrade acceptance shall be signed each day geomembrane or GCL materials are placed. Each certificate shall be signed by the Geosynthetic Installer, the Contractor and CQA Engineer prior to installation of the geomembrane or GCL. The area being accepted must be described on the certificate.

24.5 Geomembrane Panel Deployment Log

This data sheet shall be used to record geomembrane panel numbers as they are placed in the field and to cross-reference assigned panel numbers with roll numbers. The weather conditions, time and temperature at placement shall be recorded on the log. Measured dimensions of the geomembrane shall also be recorded on the log.

24.6 Geomembrane Trial Seam Data Sheet

Test results for each trial seam shall be recorded on the geomembrane trial seam data sheet.

24.7 Geomembrane Seam Log

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

24.8 Geomembrane Defects and Repairs

Each geomembrane defect and repair shall be recorded on a geomembrane repair log.

24.9 Non-destructive and Destructive Geomembrane Seam Testing Data Sheets

These data sheets shall be used to record test results for all non-destructive and destructive geomembrane seam tests.

24.10 Field Moisture and Density Test Result Data Sheet

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

24.11 Test Report

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

24.12 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.

24.13 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.

24.14 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
- A reviewed copy of all CQC reports undertaken, including earthworks, geosynthetics and other works aforementioned in this CQA Plan
- 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 and CQC reports
- Record Drawings which include the final geomembrane panel placement layout and all survey conformance data:
  - Plan view of the perimeter of the cell;
  - The installed alignments and grades of the groundwater drainage system within the cell;
  - Finished installed contours of the prepared subgrade within the cell (determined prior to placement of the geosynthetics);
  - The installed alignments and grades of the leachate collection pipework within the cell (all determined prior to placement of the leachate drainage layer);

  - Finished installed contours of the leachate drainage layer and covering geotextile within the cell; and
  - All test locations, showing as a minimum: approximate location, identification number, date sampled and type of testing completed.
- 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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Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	A Roberts	D Barrett		D Barrett		20/10/2017

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APPENDIX 5
QUALITY ASSURANCE EXTRACTION FROM DARACON IPMP

HAKK - Containment Cell Construction & Site Remediation

Integrated Project Management Plan

1640

INTEGRATED WHS ENVIRONMENT & QUALITY MANAGEMENT PLAN

Plan Details	
Type of Document:	Integrated Project Management Plan
Issue Nº.	2.0
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Plan Developed By:	James Towns

Project Details	
Project Name:	HAKK Containment Cell Construction & Site Remediation
Project Number:	1640
Address of Project:	Hart Road Loxford, NSW, Australia
Principal Contractor:	Daracon Contractors Pty Ltd
Principal Contractor Address:	20 Kullara Close, Beresfield NSW 2322, Australia
Project Client:	Hydro Aluminium Kurri Kurri Pty Ltd

Plan Review Control - Project

Issue Nº.	Description of Changes to the Plan	Date
1.0	Initial Draft and Submission for Use on the Project	20/12/2019
2.0	Revised Issue	11/02/2020

Document Template Revision Control - Corporate

Issue Nº.	Description of Changes to the Template	Date
6.0	Update to reflect RMS Learnings & include new Design Control Clause (12.8), update to 8.2 reporting requirements in training under RMS, Update to Table 3	24/10/2018
7.0	Update to Quality & WHS Aspects to meet RMS requirements for the template, inclusion of SiD, changes to wording, removal of repealed documents.	26/11/2018
8.0	Removal of expired documents and incorrect references.	06/12/2018
9.0	Insertion of Potential Emergency Situation Table in Section 5.6.2	23/01/2019
10.0	Amendments to Clauses 1, 4, 5, and 6.	26/03/2019
11.0	Amendments to document references throughout the IPMP. OWI Update.	05/08/2019
11.1	Removed reference to old DMS link to reference new DMS link.	09/08/2019
11.2	Removed reference to ALARP and updated to SFAIRP.	17/10/2019
11.3	Amendments to Clauses 6.2.1, 6.3.1, 6.6, 7.8, 7.9, 8.1.5, 11.5, 12.7	06/11/2019

Plan **Approval**	Name	Position	Signature
Document Owner:	Cheslyn Africa	Project Manager	
Document Approver:	Michael Rummery	Divisional Manager	

Plan Issue Control	
Insert document-controlled copy number if printed and/or issued externally:	**001**

12 CONSTRUCTION QUALTIY ASSURANCE

In accordance with the Daracon Quality Management Policy, Daracon's Quality objectives are:

- To provide a conforming product in line with the Clients specifications and drawings to the Clients satisfaction and
- To minimise the potential re-work of non-conforming products; to reduce the cost and time to the client.

The Project Quality Manager (PQM) and Project Quality Representative (PQR) for the project will be have been nominated within **APPENDIX 1** of this IPMP; the role and responsibilities are further addressed within **APPENDIX 2** of this IPMP.

12.1 TRACEABILITY

Conformance of construction to design and specification may be recorded for traceability by using one or more of the methods shown below in this section where required by the contract.

Tracking of materials moved onsite will be as per the Materials Management Plan provided in **Appendix 07.**

12.1.1 LOT TRACEABILITY

Where required works will be divided into separate lots for the purpose of controlling production and recording conformance details. Lots should consist of a continuous, homogeneous portion of end product that has been produced under constant conditions and should be structured in such a way that all material inspection and test results can be traced back to the source or supplier and into which lot it was incorporated.

Lots shall be recorded to follow the progress of each lot, ensuring the location and quantities are recorded using the project specific Lot Status Register ***IM-REG-1401-001***.

The Quality Manager and/or PQR Delegate shall ensure an activity numbering system is agreed to by the project team in relation to giving each lot a unique lot number when being recorded in the lot status register and other file locations within project records.

The intended lot numbering system to be used will compatible with the project specific client approved construction program using the following methods and numbering systems:

- Lots will be separated and numbered using;
  - Project Number as a prefix (i.e. **1563**);
  - Disciplines will be broken into discipline number and discipline type which typically ties back to relevant specifications
    - Discipline No. (*e.g. **25** for South Street*) and
    - Discipline (*e.g. **EW-SMZ** for Earthworks – SMZ*)

  - Overarching lot numbers and sub-lot numbers where applicable (*e.g. Lot **002** and sub-lots **001**, **002** and so on*).
    - Example of a Lot Number for Demolition (DE) would be ***1593-DE-002***
    - Example of the first sub-lot in that lot sequence would be ***1593-DE-002-001.***
- Continuous layers for earthworks (cuttings and fill), SMZ pavement and asphalt etc. will be managed by describing the three-dimensional location of each lot.
- Embankment earthworks where there are multiple layers may be treated as a lot and each layer as a sub-lot ensuring that three-dimensional locations have been established for each sub-lot.
- Lots are to be managed in accordance with relevant process control plans or ITPs relevant to the discipline being completed.
- Where contract drawings call up discrete work areas these may be used to identify these areas as lots.

Before closing each lot, the Project Manager shall ensure the inspection and test results for the lot are reviewed making sure that all hold points have been released. All lot associated NCRs are to be closed to ensure that evidence of conformance exists for all aspects of the work. This is particularly important for those lots that will be covered by further work.

12.1.2 PRODUCT TRACEABILITY

Daracon require the following specific records for material that is considered significant in the construction of a quality product:

Product	Record
Geomembrane & Geotextile	MQA certificate Pre-installation conformance testing On-site conformance testing Placement information, panel layout and certification of surface preparation Jointing methods / Field welds Certification of installationAll materials shall be tracked and traced – origin, description, final cell location
Imported materials used in the construction - Gravels & Sand - Pavement Materials - Culverts	MQA certificates On-site conformance testing (where required) Materials shall be tracked and traced – origin, description, final cell location
For the material transferred into the Cell and from Stockpiles onsite	All materials shall be tracked and traced – origin, description, final cell location

Daracon will be responsible for establishing traceability requirements and setting out of work required under the contract. This will only be different whereby the contract conditions state otherwise.

12.2 PROCESS CONTROL DOCUMENTS

Process controls for this project will be based on Inspection and Test Plans, Inspection Checklist Reports, Process Control Plans and Work Method Statements, developed by the Project Manager or their delegate based on the tasks and activities outlined in the client approved construction program.

When preparing process control documentation and planning works, the following shall be considered and identified where applicable:

- What is the sequence of construction or operations on the project;
- Identify Plant and/or Equipment needed for the works;
  - Are there any specific maintenance or calibration requirements to ensure WHS, Environmental and Quality aspects are complied with?
- Where are the works located and what potential is there to impact on the Environment;
- Is there any specific training, skills, competency and/or qualification required for tasks;
- Define the preferred work methods and proposed materials to be used;
  - Based on the above identify product characteristics, allowable tolerances and workmanship standards to be met as applicable.
- Develop or identify process controls charts applicable to the works that need to be followed where specified;
- Review and document intended and/or required inspection, test and control points;
- Confirm the processes that will be adopted to monitor, validate and verify the process control documents suitability for ongoing use and/or currency;
- Determine the records that will be kept as evidence to maintain traceability that work process controls remain effective and
- Identify responsible persons / project positions for implementing, monitoring and rectification of any identified deficiencies in stated work process controls.

Where work processes are to be undertaken by Subcontractors; Engineers responsible for specific packages shall ensure that the subcontractor has suitable resources to manage and complete works in accordance with specifications as part of the qualification process outlined in Clause 6.5 of the IPMP. In addition, any required process control documents and supporting work methods will be reviewed for adequacy against specifications and any other relevant guidance materials prior to works commencing.

The Project Manager has the overall responsibility to ensure the process control plans are adequately implemented and monitored to ensure effectiveness and rectification of any deficiencies on this project. This responsibility may be delegated by the Project Manager to other Management and Engineering support staff within the project team for packages being managed.

12.2.1 INSPECTION & TEST PLANS

Process controls will be based on Inspection and Test Plans, Lot Status Registers, Other Process Control Plans / Flowcharts and Work Method Statements that will be developed by the Project Manager or their delegate based on the tasks and activities outlined in the client approved construction program.

Inspection and Test Plans (ITPs) are developed for each technical specification to ensure relevant work processes are identified and delivered as specified. Process Control Pans will be included within ITPs and will be submitted to the Superintendent for approval prior to use where required by the contract. ITPs will assist in ensuring works are undertaken and controlled in such a way as to meet the requirements set out by the Client in the contract specifications.

Inspection and testing is to be carried out by NATA registered laboratories where applicable and in accordance with all frequencies nominated in the ITP.

The list of proposed ITP's is provided **APPENDIX 15**.

12.2.1.1 LOT STATUS REGISTER

A Lot Status Register using ***IM-REG-1401-001*** shall be developed to record conformance data for each lot of work to be completed on the project. Lot conformance data should include information from the ITP that requires confirmation of works completed on site.

The following criteria should be addressed at a minimum:

- What activity is being identified that needs to be verified;
- Identify the ITP step number;
- Validation of conformance relating to the ITP step and
- List any Hold Point, Witness Point, Surveillance requirement, Non-conformance and/or Test report number relevant to the step.

Any non-conformance raised must be managed in accordance with the Corrective and Preventive Action procedure ***IM-PRO-1407-002.***

12.2.2 MATERIAL TESTING

Where material testing is nominated within the project specifications, the Project Manager must ensure all testing is completed and submitted to the relevant Laboratory within the required timeframe for the project using **IM-LET-1403-001** *Geotechnical Test Instruction*.

Records of material testing should detail the following information at a minimum:

- Project Name and Number;
- Name of person requesting the test;
- Description of the tests required (i.e. chainage, GPS or other coordinates);

- Lot identification number;
- Lot layer, offset, level and any other relevant description;
- Material type to be tested;
- Time and Date the test was requested;
- Identification of how many tests are required and
- Clarify the required range or acceptance criteria.

Results must be analysed by a competent person for adherence to the testing requirements and accuracy. Where there is a discrepancy this shall be brought to the attention of the consultant engaged for the works for rectification.

Where works are identified as nonconforming by the test reports, works shall be identified and delineated from further works. All non-conformances shall be raised be raised in accordance with **Clause 12.6**.

Verification that all quality related testing and inspections are occurring at the required testing frequencies shall be completed as part of Second Party and Internal Audit processes onsite as needed. This will occur in accordance with the approved audit schedule for the project which will include subcontractors and suppliers as part of this process as required.

Engineers responsible for lots must complete a final review of all inspection and test results to confirm that all inspections and tests have been carried out to completely verify conformity for each Lot.

12.2.3 HOLD POINTS

Hold points (HPs) may be raised internally to mitigate risk associated with works or they may be required by contract specifications. HPs raised under a specification requirement are a point in a process where works are not to proceed without authorisation from the Superintendent or delegated representative.

Where HPs are nominated in the contract specifications a schedule of hold points should be prepared at the commencement of the project. Each process identifies a HP must also be recorded within the ITP generated for the work lot.

Hold points are to be raised using **IM-FOR-1411-002** *Hold Point Notification Form* and recorded on *Hold Point Register* **IM-REG-1411-001**.

12.2.4 WITNESS POINTS

Witness points (WPs) may be raised internally to mitigate risk associated with works or they may be required by contract specifications. Where WPs are nominated in the contract specifications each process identifying a WP must be recorded within the ITP generated for the work lot.

Witness points are to be raised using **IM-FOR-1411-003** *Witness Point Notification Form* and recorded on *Hold Point Register* **IM-REG-1411-001**.

12.2.5 WORK METHOD STATEMENTS

Work Method Statements (WMS) will be developed for all nominated works required under the contract. The list of WMS documents nominated in the technical specification to provide additional guidance outside of the ITPs are shown in **Appendix 15**

12.3 SURVEY

Surveying is a critical activity on this project and must be done in a consistent and systematic manner by competent persons in accordance with Daracon Survey Control procedures and work process control plans established for the project.

Daracon use only qualified surveyors to direct and take responsibility for all surveys. The survey control network for this project shall be verified by the Project Manager with the Surveyor prior to commencing works with the agreed values of the primary control marks being recorded. The Superintendent shall be promptly notified of any discrepancies.

The Control Mark Register shall be kept current by adding new control marks where placed and noting those that may be destroyed or disturbed so that they are no longer used.

Critical aspects of Survey and associated control procedures are identified below, suitable controls must be incorporated into process control documents as required and followed to ensure conformity of works to drawings, specifications and design.

Key survey procedures and a summary of content that apply to this project are as follows:

- Survey Job Control ***IM-PRO-1300-010***
    - Setting up a Survey Job File;
    - Recording client instructions and
    - Keeping necessary records.
- Set out for Clearing ***IM-PRO-1300-011***
    - Work processes to ensure that only the necessary and sufficient area is cleared using calculation methods, field methods and specific verification and acceptance criteria.
- Set out for Drainage Structures ***IM-PRO-1300-013***
    - Establishes of order of accuracy, type of equipment used and calculation methods, field methods and specific verification and acceptance criteria for setting out of drainage structures.
- Set out of Pavement Layers ***IM-PRO-1300-014***
    - States how horizontal and vertical positions of pavements is controlled by formation pegs that are placed at short intervals (approx. 15m) along each side of the pavement and are marked with the “Finished Level” height.

- Includes information on techniques, equipment, calculation methods and verification processes.

- Trigonometrical Levelling ***IM-PRO-1300-008***
  - Details how trigonometrical levels may be used for new instrument stations, setting out work or conformance checks and appropriate techniques for application.
- Radiations (or Polar Calculation) ***IM-PRO-1300-006***
  - Details information on technique used to coordinate points by one-way observations from a known mark.
- Traverse ***IM-PRO-1300-005***
  - Details surveying technique that is used to locate successive points so that their coordinate values can be reliably determined to a predefined standard of accuracy.
- Differential Levelling ***IM-PRO-1300-007***
  - Details survey technique used to determine the height of points.
- Volume Determination ***IM-PRO-1300-019***
  - Provides information on the use of Type 3 precision for volume determination except where the height component of the feature being measured is critical (e.g. pavement layers) and a higher precision may be required for heights.
- Resection ***IM-PRO-1300-009***
  - Details how coordinates and level of an eccentric instrument station can be used on Daracon projects.
- Conformance of Batters ***IM-PRO-1300-016***
  - Identifies process control and equipment used in verifying the position of cut and fill batters against the designed and constructed surfaces at random points
- Conformance of Structures ***IM-PRO-1300-017***
  - Identifies process control and equipment used in verifying the position of structures against the designed and constructed elements.
- Conformance of Pavement ***IM-PRO-1300-018***
  - Identifies process control and equipment used in verifying the position of a pavement.
- Machine Guidance Systems ***IM-PRO-1300-020***
  - Details how MGS complements onsite surveyors and outlines correct applications and use of Machine Guidance Systems (MGS) within the Daracon Group.
- Calibration Technique ***IM-PRO-1302-003***
  - Details the calibration requirements and suggested periods of relevant survey instruments and equipment used in Daracon.

In the event that joint surveys are required they should be identified and included within the ITP relevant to the works.

In the event that joint surveys are required they should be identified and included within the ITP relevant to the works.

12.4 MEASURING & TEST EQUIPMENT

The Project Manager shall ensure equipment used for inspection, measurement or testing of the work is in good working order and where required to verify compliance, have a current calibration record as per requirements outlined in Control of Inspection, Measuring and Test Equipment ***IM-PRO-1302-001*** and Calibration Technique ***IM-PRO-1302-003.***

Inspection, measuring and test equipment must be handled carefully to preserve accuracy and reliability. Where results or equipment indicate uncertainty, other equipment may be used for validation and/or the specific item in question shall be re-calibrated and previous inspection and test results validated for accuracy.

Equipment requiring calibration on this project has been identified to be any of the following but is not limited to:

- Survey Equipment (Internal and External);
- Laboratory Equipment (Offsite Consultant that is NATA accredited);
- Geotechnical Equipment (Subcontractor);
- WHS Monitoring Equipment (Alcolizer, Anemometer, Gas Detector / Meter) and
- Environmental Monitoring Equipment (Water, Noise and Vibration).

On this project Daracon will ensure measuring and test equipment at a minimum is managed using the following strategies:

- Determining measurements and accuracy required and selecting equipment capable of necessary accuracy and precision for intended applications;
- Engaging certified external calibration services or establishing suitable methods to check calibration against internationally or nationally recognised standards and describing actions if results are unsatisfactory;
- Confirming calibration status of measuring and test equipment used by subcontractors through subcontractor engagement and onsite monitoring / review processes;
- Providing suitable containers for storage of equipment and instructing personnel on handling and use of equipment to prevent abuse, misuse or damage and
- Ensure validity of previous inspection and test results occurs if equipment is damaged or out of calibration.

In most cases, a NATA accredited business relevant to the item being calibrated shall be engaged to provide records of conformance. A copy of their current accreditation shall be kept in site records. Where calibration of equipment is completed onsite, equipment being used for validation and accuracy of calibration shall be recognised or have a suitable mechanism for ensuring accurate results.

12.5 INCOMING MATERIAL & PRODUCT CONFORMANCE

The Project Manager has the overall responsibility to ensure that all goods and materials that are to be incorporated into the project are inspected for conformance as follows:

- WHS Safeguards;
- Product Damage and/or
- Material & Product conformance.

This can be done by visually inspecting the material for obvious defects and/or reviewing supporting documentation provided with the material / product to verify conformance to the project specification.

The Project Manager or delegate shall ensure materials and/or products inspected are marked with a date and time where practicable. Incoming Inspection Forms using ***IM-REP-1410-001*** shall be used for all supplied products except for the following:

- Concrete
    - Concrete Test Report Forms (**IM-REP-1409-001)** shall be used.

All products that are delivered to site are to be securely stored and handled as per the manufacturer's recommendations; and/or the relevant specifications. Where this is not provided, best practice is to be used to store products based on the type of material.

Defective and/or non-conforming materials identified through incoming inspections shall be marked clearly and kept separate from conforming products and materials. Such materials and products must then be processed as per the Control of Non-Conforming Product Procedure ***IM-PRO-1407-001.***

Where an incoming product does not match the order, the order will not be received on the project by Daracon. If material and/or products are delivered that results in an incident an Immediate Incident Notification using ***IM-FOR-0306-001*** will be completed.

All incoming products and materials will be stored according to manufacturer's requirements to prevent deterioration and to preserve the integrity of the material and/or product.

12.5.1 VERIFICATION OF PURCHASED PRODUCT AT PREMISES

In addition to onsite verification of purchased product at time of delivery, the Project Manager will ensure suitable surveillance and monitoring of critical Manufactured components occurs onsite at the Subcontractor / Supplier's premises to assess the process control methods and documented processes completed during manufacturing.

Geosynthetics shown below have been identified as critical for this project:

- Geomembrane
- Geotextile
- GCL

The Quality Manager and/or delegate will ensure all required documentation is submitted, reviewed and approved as required for each component.

12.6 NON-CONFORMANCE & CORRECTIVE ACTION

Managing non-conformances and associated corrective actions are essential to the project in its delivery and shall be done so in accordance with the Corrective and Preventive Action procedure ***IM-PRO-1407-002***. A non-conformance may be defined as something that has the potential to or has affected the service provided and/or the life of a product. It could pertain to per any of the following but is not limited to:

- Quality Non-Conformance
    - Where materials and/or products do not meet project specifications and
    - Where project procedures both internal and Client are not met
- WHS Non-Conformance
    - Where works are carried out that do not comply with safety specifications, this plan or other procedures, risk assessments and regulatory requirements.
- Environmental Non-Conformance
    - Where works are carried out that do not comply with environmental specifications, this plan or other procedures, risk assessments and regulatory requirements.

Any non-conformance must be promptly documented, evaluated and corrected in a timely manner as approved by the SR2018-001 CQA Engineer. Rework or repaired product shall be inspected or tested as defined in the relevant ITP and to the satisfaction of the SR2018-001 CQA Engineer. Corrective action shall be monitored to ensure that it has been implemented effectively.

The Project Manager has overall responsibility and authority for control of non-conforming product. The Project Manager must ensure suitable resources are allocated to allow for detection of deficiencies, investigation of causes, authorisation and application of controls to ensure corrective action is effective.

In addition, all project management personnel have a responsibility and authority to ensure the following processes occur where quality related issues are identified on the project that relate to their works or activities:

- Quality problems where identified are recorded appropriately;
- Initiation and/or recommendation of suitable solutions occurs through designated channels;
- Corrective actions are implemented and verified for effectiveness and
- Where quality related issues relate to non-conforming product, controls are established to prevent any further processing / delivery and/or installation of nonconforming product until deficiency or unsatisfactory condition is corrected;
- Identify, notify and segregate nonconforming and untested product to prevent unintended use;

- Determine corrective actions needed immediately to prevent repetition, and long term to eliminate cause) which are appropriate to the magnitude of the problem and commensurate with the risk encountered
- Evaluate nonconformities, determine appropriate dispositions, analyse and record the cause of nonconformities;
  - Determine corrective actions needed to prevent long term issues and to eliminate the cause.
  - Determine actions which are appropriate to the magnitude of the problem and commensurate with the risk encountered.
- Ensure suitable processes are implemented to address and manage customer complaints;
- Ensure that reworked and repaired products are re-inspected and re-tested;
- Maintain records which trace the resolution of the nonconformity and identify actual condition of product when resolution has been completed, including register which summarises status of nonconformity rectification and
- Monitor and review outcomes to confirm that corrective action is effective.

12.7 DESIGN, CHANGE AND CONTRACT VARIATION

The Project Manager or delegate shall review any changes required that are applicable to the products or services being provided under the contract for works. Where a Scope change occurs, the Project Manager and/or delegate shall ensure facilitation of a risk assessment occurs with competent persons.

This risk assessment process provides an opportunity to identify hazards and to ensure assessment and control of health and safety risks are considered specifically addressing safety in design~~,~~ the contract and applicable buildability / constructability issues. Risk assessments should be documented on the Global Risk Assessment template using *IM-FOR-0301-002* or other site accepted equivalent (*i.e. Lining subcontractor design documents where engaged for design work*).

Throughout this process the Project Manager should review if there are any significant impacts to existing contract works. If potential changes are identified, the Project Manager must consider if the changes relate to a variation of the agreed scope of works in accordance with the conditions of contract.

Potential impacts from significant changes to works may include, but will not necessarily be limited to, the following Additional WHS Risk;

- Potential Impact to the Environment outside of current assessment area;
- Process control change required;
- Additional Materials needed;
- Additional Resources required and/or
- Impacts to the client approved construction program / budget.

Where there is a variance or discrepancy in the Scope change (*i.e. contract drawings*), the Project Manager must seek clarification from the Superintendent prior to undertaking any further works.

Discrepancies may be as a result of any of the following:

- Changes to management plans, specifications and/or construction drawings;
- Interpretation of specified requirements and/or
- Variations to the original contract for works.

To obtain clarification or to propose an alternative process relating to Scope changes, the Project Manager shall address concerns and queries via a Request for Information (RFI) ***IM-FOR-1000-001.*** The RFI shall be forwarded to the Superintendent seeking their response (*or disposition*); correspondence must be recorded on the Request for Information Register ***IM-REG-1004-001*** or other similar means accepted for the project.

The Project Manager or delegate shall also record any identified issues and/or opportunities within **IM-FOR-0906-003** *Monthly Project Report* in order to track potential opportunities or impacts to the project.

12.8 DESIGN & DEVELOPMENT CONTROL

Design & design development needs will be identified as per the requirements of the contract for works. Additional design & development or changes identified during the course of a project may relate to either permanent and/or temporary design activities which will be managed as detailed below, taking into consideration the following:

- Internal design controls, inputs and outputs;
- Externally provided design controls and quality management processes related to design.

12.8.1 PERMANENT STRUCTURE OR STRUCTURAL COMPONENT DESIGN

Daracon is not required to undertake '*engineering design services*' for permanent structures or structural components

Where there is a request for information raised about permanent design in a construct only contract, Daracon will typically be requested to conduct any one of the following:

- Wait until the Superintendent and their designer engineer a solution to respond to the RFI and then re-issue revised construction drawings or similar documents; or
- The Superintendent may request Daracon to engage with the Clients designer directly to prepare an engineering solution; or
- Daracon may be requested to engage with our own subcontracted design consultant to prepare an engineering solution that will require approval from the Superintendent and their designer.

Examples of permanent design aspects undertaken by Daracon in the delivery of our projects that may require additional, or, have an impact on approved engineering design could include:

- Use of alternative materials and/or concrete and asphalt mixes and/or
- Lifting devices for manufactured materials (*i.e. pre-cast concrete pits, bridge girders*).

Where Daracon are requested by the Superintendent to undertake a design process directly, or, where design is nominated in the contract, applicable design and other specialist subcontracted consultants shall be managed in accordance with **IM-PRO-0703-001** *Subcontractor & Supplier Management.*

Permanent design solutions being developed by Daracon where nominated in the contract and/or where alternate permanent structures or structural components are being proposed, should be completed as per the requirements of **IM-PRO-1900-001** *Design Control*.

12.8.2 TEMPORARY WORKS DESIGN

Daracon may undertake design of temporary structures where we require an element of design or specification to aid in supporting our selected temporary works construction methodology, and, delivery of our project works. The design may be conducted by Project staff or by a structural design professional where required.

Some temporary design aspects undertaken by Daracon in the delivery of our projects that may require approved engineering design could include:

- Change in Construction methodology;
- New or alternate proposals for temporary structures (*i.e. Crane pads for construction loadings, Sheet piling, formwork or falsework*);
- Alternate proposals for the Staging of works, alternative processes;
- Temporary structures, including the checking of construction loadings (e.g. Sediment Basins) and/or
- Traffic Control, temporary roadways and detours (typically managed through the *Traffic Management Plan – TMP for temporary works*).

The above temporary design solutions should be managed as per **IM-PRO-1900-001** *Design Control*.

12.9 DESIGN ASSESSMENTS

Permanent and/or temporary designs provided by Daracon would normally take into account implementation and consideration of the following systematic process inputs for design work. This should all be completed by the Project Manager and/or delegate prior to issuing a design plan / brief and subsequent information to the Superintendent, Designer and/or Subcontractor engaged for design works.

Design process inputs and outputs to be considered should be as follows at a minimum depending on the design activity being assessed:

- Any '*Change or Risk Management*' processes needed as identified under **IM-PRO-0301-001** *Risk Management*;
- Buildability and/or Constructability issues dependant on contract type and stage of the design;
- Identify who is responsible for the design (internal / external);
- Identify what tasks are required and any constraints, complexities of design on construction methods;
- Determine responsibilities for activities & approvals to be completed;
- Assess what professional services and skilled disciplines are needed to complete the design and associated works;
- Outline the design review, verification and validation process as needed depending on the type of design proposal;
- Identify any necessary Milestones where applicable;
- Review applicable legislative requirements;
- Assess Work Health and Safety aspects to determine Safety in Design (SiD) issues;
- Identify any Industrial Relations requirements;
- State applicable Standards and Engineering Design Guidelines (e.g. AS/NZS, ISO and Engineering Guidelines from the Superintendent or Asset Owner);
- State applicable Codes of Practice and/or
- List relevant contract documentation applicable to the design activity such as approved drawings, specifications.

12.10 DESIGN CONTROL RECORDS

Communication & management of design control records generated as a result of design processes should be managed by using the following processes where applicable to the design activity:

- As per requirements of **IM-PRO-1000-002** *Document and Data Control*;
- As per requirements of **IM-PRO-1900-001** *Design Control*;
- Emails using MS Outlook or other project specific correspondence platform;
- Design Plans, Briefs and Design Validation / Verification;
- Project meeting minutes and/or
- Requests for Information (RFIs).

13 RECORDS MANAGEMENT & DOCUMENT CONTROL

13.1 DOCUMENT CONTROL

The receipt and distribution of critical documents used for the Project shall be controlled utilising Daracons Document and Drawing Register ***IM-REG-1000-002.*** This tool will help ensure that only current construction drawings and other critical project documents are being used. The Project Manager shall ensure that project documentation is maintained as follows:

- In a legible condition;
- Labelled with its title and revision number;
- Authorised and current and
- Readily available in either hard copy or electronically at the point of use.

Project personnel shall ensure that document and data control of quality, environmental and WHS related information is managed in accordance with ***IM-PRO-1000-002*** Document & Data Control and project specifics outlined within **Appendix 8** *Records Management Plan*.

This will ensure all personnel have ready access to current documents required to perform their work onsite; and that only the current, up-to-date versions of each document are available to users. All project personnel shall ensure superseded documents are repealed effectively, withdrawn from all points of use and stored in relevant project records for traceability.

The Daracon DMS maintains all corporate related management system information that outlines revision status and document records and is readily accessible online by the project.

13.2 MANAGEMENT OF PROJECT RECORDS

Project records will be filed in accordance with File Index ***IM-FOR-1000-006*****.** Some hard copies of records will be maintained onsite within clearly labelled folders.

Where hard copies are not kept, electronic copies of all records will be maintained in a file structure that mirrors that of the hard copy records. The Project Manager is to consult with the Daracon IT Representative to ensure project specific electronic records are backed up on a regular basis.

IM-FOR-1000-006 shall be displayed in a prominent location in the Daracon site office.

13.2.1 PROJECT ARCHIVING

At the completion of this project in accordance with **IM-PRO-1004-001** *Archive Procedure*, project records generated shall be archived and retained for future reference where required.

13.3 CLIENT ISSUED DOCUMENTS

Client issued documents, such as drawings or updated specifications must be controlled as part of the projects document control and records management process. Upon receipt, these documents are to be clearly marked as controlled and be recorded using ***IM-REG-1000-002***.

13.4 PROJECT COMPLETION

The Project Manager will ensure that all relevant quality plans and records detailed in the contract documents are collated at the completion of the project. A copy of these records shall be submitted to the Superintendent as required titled *Works as Executed* (WAE).

13.5 PROJECT DATA REPORT

The format of the Project Data Report ("PDR") shall be developed by Daracon and approved by the Superintendent prior to the performance of any Permanent Works being carried out. Data shall be progressively added to the PDR as works progress.

At the end of each distinct part of the Scope of Works the PDR shall be reviewed by the Superintendent to ensure it is up to date with the progress of the Works.

Practical Completion of the whole of the Works includes the provision of the complete Project Data Report that shall provide, but not be limited to, the following:

- A complete set of As-Built drawings
- Original test certificates
- Completed Inspection and Test Plans
- Original Area Clearance Certificates
- Copies of Asbestos Works Completion Certificates
- Original Warranties, Guarantees and Installation Certificates from Manufacturers and Suppliers

14 ACCOUNTABILITY

All Workers and Officers listed below have a responsibility to take reasonable care of their own health and safety, and that of others. In addition, all positions shall ensure they carry out Environmental due diligence which will allow for site opportunities and constraints to be identified across the project.

14.1 MANAGING DIRECTOR

The Managing Director shall ensure that all resources needed to fulfil the requirements outlined within this plan are made available. The Managing Director shall hold all relevant managers accountable to implement and monitor all applicable requirements within this plan.

14.2 MANAGER RESPONSIBLE FOR DARACON GROUP SYSTEMS

The Manager responsible for Daracon Group Systems shall ensure that the requirements of this plan are effectively implemented across the group and subsidiary companies that they may apply to from time to time. This shall be completed by implementing adequate review and monitoring processes to ensure compliance with this plan.

As the Manager responsible for quality management at a corporate level throughout the group, this position shall ensure the quality policy and any initiatives are communicated effectively to the project team along with suitable training as needed. In addition, all project related issues that have the potential to affect the wider business shall be reviewed and actioned as required at the corporate level by this position in consultation with other business managers.

14.3 GENERAL AND DIVISIONAL MANAGERS

Senior Management (*General and Divisional Managers*) are required to have a strong understanding of the requirements of this Plan applicable to their projects. They are to ensure requirements outlined within are effectively implemented and monitored across all their responsible operational areas of the business.

14.4 SITE MANAGEMENT PERSONNEL

Site Management Personnel are required to have a strong understanding of the requirements in this Plan to ensure effective implementation on the project. Site Management must hold all workers on this project accountable to follow and work in accordance with this plan.

14.5 ENVIRONMENTAL MANAGEMENT REPRESENTATIVE

The Environmental Management Representative (EMR) will be located offsite for the duration of the project however will have the overall responsibility to ensure that the Environmental Site Representative is held accountable to ensure the onsite matters relating to Environmental Management are implemented effectively and as per regulatory requirements and the Specification.

The EMR will attend site from time to time to assist the project team relating to Environmental Management on the project and will be available via phone and email.

14.6 ENVIRONMENTAL SITE REPRESENTATIVE (ESR)

The Full-time Environmental Site Representative (ESR) nominated in the Organisation Chart in **APPENDIX 1** of this IPMP will be suitably qualified and is responsible for, and has the authority to ensure that onsite matters relating to Environmental Management are implemented effectively and as per regulatory requirements and the Specification.

14.7 PROJECT QUALITY REPRESENTATIVE (PQR)

The Project Quality Representative nominated in the Project Organisation Chart in **APPENDIX 1** of this IPMP will be suitably qualified as per the requirements of the SR2018-001 Contract and is responsible to ensure the onsite matters relating to Quality Management system procedures are implemented on the project.

The PQR must ensure all project related issues that have the potential to affect the wider business are communicated to the HSEQ Manager for review and action as required.

14.8 DARACON WORKERS

All Daracon workers shall fully comply with the requirements of this plan.

14.9 SUBCONTRACTORS

Where Subcontractors are working under the Daracon Management System on this project, all Subcontractors and their workers shall fully comply with the requirements of this plan.

15 DEFINITIONS

All terms referenced within this plan are included within **REG.00001** *Definitions & Glossary of Terms Register.*

16 ASSOCIATED DOCUMENTS AND PROCEDURES

Approved Forms, Process Flowcharts, Registers and/or other documents referenced within the body of, or those that are associated with this plan, are accessible and made available for all Daracon personnel via the following link: **https://dms.daracon.com.au/.**

APPENDIX 6
CONTAINMENT CELL SAMPLING AND QUALITY PLAN

Intended for
Hydro Aluminium Kurri Kurri Pty Ltd

Document type
Report

Date
August 2020

CONTAINMENT CELL VALIDATION PLAN
HYDRO ALUMINIUM KURRI KURRI, NSW

Bright ideas. Sustainable change.

CONTAINMENT CELL VALIDATION PLAN
HYDRO ALUMINIUM KURRI KURRI, NSW

Project name	**Validation Sampling and Analysis Quality Plan**
Project no.	**318000301**
Recipient	**Hydro Aluminium Kurri Kurri Pty Ltd**
Document type	**Report**
Version	**Draft**
Date	**26/08/2020**
Prepared by	**Kirsty Greenfield**
Checked by	**Fiona Robinson**
Approved by	**Fiona Robinson**
Description	**This report outlines the Validation Sampling and Analysis Quality Plan for the remediation of the capped waste stockpile and construction and filling of a Containment Cell at the Hydro Aluminium Kurri Kurri Smelter, located in Loxford, NSW. The Containment Cell is a whole-of-site remediation strategy that will contain smelter wastes in perpetuity.**

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ABBREVIATIONS

Measures	Description
%	per cent
µg/L	Micrograms per Litre
µg/m^3	Micrograms per Cubic Metre
ha	Hectare
km	Kilometres
m	Metre
mAHD	Metres Australian Height Datum
mbgs	Metres below ground surface
mg/kg	Milligrams per Kilogram
mg/L	Milligrams per Litre
mg/m^3	Milligrams per Cubic Metre
mm	Millimetre
ng/L	Nanograms per Litre
ppm	Parts Per Million
ABC	Added Background Concentrations
ACL	Added Contaminant Limit
ACM	Asbestos Containing Material
ADWG	Australian Drinking Water Guidelines
AEC	Area of environmental concern
AF	Asbestos Fines
AHD	Australian Height Datum
ALS	Australian Laboratory Services
ASET	Australian Safer Environment and Technology Pty Ltd. (Laboratory)
AST	Aboveground Storage Tank
ANZECC	Australian and New Zealand Environment and Conservation Council
BaP	Benzo(a)pyrene
BTEX	Benzene, Toluene, Ethylbenzene & Xylenes (Monocyclic Aromatic Hydrocarbons)
CLM Act	NSW Contaminated Land Management Act 1997
COC	Chain of Custody
CoC	Contaminants of Concern
Council	Cessnock City Council
CT	Certificate of Title
DP	Deposited Plan
DQI	Data Quality Indicator
DQO	Data Quality Objective
EIL	Ecological Investigation Level
EMP	Environmental Management Plan
Envirolab	Envirolab Services Pty Ltd
EPA	Environment Protection Authority (NSW)
ESL	Ecological Screening Level
GIL	Groundwater Investigation Level
GME	Groundwater Monitoring Event
HIL	Health Investigation Level
HSL	Health Screening Level

LCS	Laboratory Control Sample
LEP	Local Environment Plan
LOR	Limit of Reporting
MAH	Monocyclic Aromatic Hydrocarbons
Mercury	Inorganic mercury unless noted otherwise
Metals	As: Arsenic, Cd: Cadmium, Cr: Chromium, Cu: Copper, Ni: Nickel, Pb: Lead, Zn: Zinc, Hg: Mercury
ML	Management Limits
NATA	National Association of Testing Authorities
NC	Not Calculated
ND	Not Detected
NEHF	National Environmental Health Forum
NEPM	National Environment Protection Measure
NHMRC	National Health and Medical Research Council
NL	Non-Limiting
n	Number of Samples
OCPs	Organochlorine Pesticides
OEH	Office of Environment and Heritage
OH&S	Occupational Health & Safety
OPPs	Organophosphorus Pesticides
PAEC	Potential Areas of Concern
PAHs	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
pH	A measure of acidity, hydrogen ion activity
PID	Photoionisation Detector
PQL	Practical Quantitation Limit
QA/QC	Quality Assurance/Quality Control
RAP	Remediation Action Plan
RPD	Relative Percent Difference
SAQP	Sampling Analysis and Quality Plan
SAR	Site Audit Report
SAS	Site Audit Statement
SILs	Soil Investigation Levels
SWL	Standing Water Level
TCLP	Toxicity Characteristic Leaching Procedure
TPHs	Total Petroleum Hydrocarbons
TRHs	Total Recoverable Hydrocarbons
TV	Trigger Value
UCL	Upper Confidence Limit
VSAQP	Validation Sampling and Analysis Quality Plan
VENM	virgin excavated natural material
-	On tables is "not calculated", "no criteria" or "not applicable"

EXECUTIVE SUMMARY

Ramboll Australia Pty Ltd (Ramboll) was engaged by Hydro Aluminium Kurri Kurri Pty Ltd (Hydro) to prepare a Validation Sampling and Analysis Quality Plan (VSAQP) for the validation of the construction of a Containment Cell, to be completed as part of remediation works across approximately 180 ha, comprising the Hydro Aluminium Kurri Kurri Smelter Site and an area known as the Clay Borrow Pit (herein referred to as the “Smelter Site”).

Hydro suspended aluminium smelting operations at the smelter in 2012 and following a two-year period of care and maintenance, closure was announced in May 2014. A Masterplan has been developed that identifies land proposed for future commercial/ industrial and environmental conservation land use at the Smelter Site.

Environmental investigations undertaken since 2012 have identified a number of Areas of Environmental Concern (AECs) that require remediation. A Remedial Action Plan (RAP) was prepared in 2018. The RAP included a Validation Plan, which incorporated validation data quality objectives, validation criteria and validation requirements for the Smelter Site.

This VSAQP details the validation data to be collected to demonstrate remediation of:

- AEC 1 comprising the Capped Waste Stockpile and associated leachate plume
- Construction of the containment cell including construction, filling with site wastes and capping.

In relation to AEC 1: Capped Waste Stockpile and associated leachate plume, validation works are required to confirm that:

- Capping removed from the Capped Waste Stockpile is suitable for on-site reuse
- All wastes and contaminated soil have been removed from the Capped Waste Stockpile
- The capped waste stockpile excavation is backfilled with soil suitable for the proposed land use
- A short-term environmental management plan is developed for monitoring of the residual leachate plume.

In relation to the Containment Cell validation is to demonstrate:

- The Containment Cell has been constructed in accordance with the design
- All wastes stored at other areas of the Smelter Site are appropriately relocated to the Containment Cell including treatment with gypsum where required
- Materials imported for the construction of the Containment Cell are suitable
- Materials used to backfill or landscape the Capped Waste Stockpile following removal of wastes are suitable
- Contaminated materials were appropriately treated (where required) and compatibly placed within the Containment Cell
- Leachate from the containment cell was appropriately managed during cell construction
- The Containment Cell is capped according to the design
- The Containment Cell is performing as required in relation to gas and leachate generation following construction
- An environmental management plan has been developed for the long term management of the cell.

Validation data quality objectives (DQOs) have been developed for each validation task in the Sections below. Validation works listed above have been grouped into the following elements:

- Materials Suitability
- Materials Tracking
- Materials Treatment
- Containment Cell Construction
- Leachate Management
- Long Term Performance – Containment Cell
- Long Term Performance – Leachate Plume

Reporting requirements at the completion of the remedial works are also provided here-in.

1. INTRODUCTION

Ramboll Australia Pty Ltd (Ramboll) was engaged by Hydro Aluminium Kurri Kurri Pty Ltd (Hydro) to prepare this Validation Sampling and Analysis Quality Plan (VSAQP) for the validation of remediation works across approximately 80 ha, comprising the Hydro Aluminium Kurri Kurri Smelter Site and an area known as the Clay Borrow Pit (herein referred to as the "Smelter Site").

The Smelter Site is located at Hart Road, Loxford, New South Wales (NSW) as shown in **Figure 1, Appendix 1.** Details of the site conditions and requirements for remediation of the Smelter Site are reported in Ramboll (2018) Remedial Action Plan, Hydro Aluminium Smelter Kurri Kurri.

In accordance with NSW Environment Protection Agency (NSW EPA 2020) Guidelines for Consultants reporting on Contaminated Land, the objective of an SAQP is 'to provide the context, justification and details of the selected sampling and analysis approach. The 'sampling and analysis quality plan' has a critical role in ensuring that the data collected is representative and provides a robust basis for site assessment decisions'.

1.1 Background

The Hydro Aluminium Kurri Kurri Smelter commenced production in 1969 with a single pot line. A second pot line was commissioned in 1979 and a third added in 1985. In 2002, Hydro undertook an upgrade program, which increased production capacity to 180,000 tonnes of aluminium metal per annum. The Smelter Site is surrounded by a 2000 ha buffer zone (Hydro Land), part of which is used for agricultural purposes.

Hydro suspended operations at the smelter in 2012 and following a two-year period of care and maintenance, closure was announced in May 2014. A Masterplan has been developed that identifies land proposed for future commercial/ industrial and environmental conservation land use at the Smelter Site.

Environmental investigations which contribute to definition of remedial requirements within this report include:

- 'Phase 2 Environmental Site Assessment, Kurri Kurri Aluminium Smelter', dated November 2012 by Environ Australia Pty Ltd (Environ, now Ramboll)
- 'Phase 1 ESA, Hydro Kurri Kurri Aluminium Smelter', dated October 2013 by Environ
- 'Hydro Aluminium Kurri Kurri Smelter, Sampling, Analysis and Quality Plan', dated June 2014 by Environ
- 'Phase 2 Environmental Site Assessment, Smelter Site, Additional Investigations', dated January 2015 by Environ
- 'Remedial Action Plan, Hydro Aluminium Smelter Kurri Kurri', dated July 2018 by Ramboll Environ, now Ramboll

These investigations have identified a number of Areas of Environmental Concern (AECs) that require remediation. The AEC that is driving the remediation project is AEC 1: Capped Waste Stockpile, a stockpile of aluminium smelting wastes and associated wastes that is located in a low-lying area of the Smelter Site in contact with shallow groundwater. Prior to it being capped in the mid-1990s, infiltration and groundwater flow through this waste stockpile resulted in the development of a leachate plume downgradient of the stockpile.

A Remedial Action Plan (RAP) was prepared in 2018. The RAP identified the preferred remedial option for AEC 1: Capped Waste Stockpile and other AECs at the Smelter Site requiring remediation, to be a whole-of-site strategy involving the construction of a purpose-built Containment Cell to store smelter wastes in perpetuity.

The RAP included a Validation Plan, which incorporated validation data quality objectives, validation criteria and validation requirements for remedial works at the Smelter Site.

Demolition of the site commenced in 2017 and included remediation of some AECs identified in the RAP. This VSAQP has been developed for the remediation of the Capped Waste Stockpile and leachate plume (AEC 1) and the Containment Cell Construction, filling and closure.

1.2 Objectives

The objective of this VSAQP is to outline Data Quality Objectives (DQOs) and Data Quality Indicators (DQIs) for the following elements of the remediation project:

- Remediation of AEC 1: Capped Waste Stockpile and associated leachate plume
- Construction of the Containment Cell.

1.3 Scope of Work

To meet the objectives, Ramboll has completed the following works:

- Review of previous environmental investigation reports prepared for the Smelter Site
- Establish DQOs and DQIs for the remediation of AEC 1 and the construction of the Containment Cell
- Outline sampling requirements, including field quality assurance/ quality control (QA/QC) requirements
- Establish laboratory analytical methods and QA/QC requirements
- Outline reporting requirements for remediation of AEC 1 and construction of the Containment Cell.

1.4 Regulatory Framework and Guidelines

This document has been prepared in reference to the following regulations:

- *Contaminated Land Management Act 1997*
- *Protection of the Environment Operations Act 1997*
- *Environmental Planning and Assessment Act 1979*.

This document has been prepared with regard for the following guidelines:

- 'Guidelines for Consultants Reporting on Contaminated Land' 2020 NSW EPA
- 'Guidelines for the NSW Site Auditor Scheme (3rd Edition)' 2017 NSW EPA
- 'National Environment Protection (Assessment of Site Contamination) Amendment Measure 2013 (No. 1)' 2013 National Environment Protection Council (NEPC).

2. SITE IDENTIFICATION

2.1 Site Location

The Smelter Site is located approximately 30 km west of the town of Newcastle and 150 km north of Sydney in New South Wales, Australia. Site details are presented in **Table 2-1.**

For the purpose of the VSAQP, the Smelter Site comprises the whole of the lots that comprise the smelter footprint and the Clay Borrow Pit. The site layout and locality are shown in **Figure 1, Appendix 1.** The layout of the smelter and location of the Capped Waste Stockpile and associated leachate plume is shown in **Figure 2, Appendix 1**.

Table 2-1: Site Identification

Information	Description
Street Address:	Off Hart Road, Loxford, NSW 2326
Identifier:	Lots 318, 319, 411, 412, 413, 414, 769 in DP 755231, Lots 1, 2, 3 in DP 456769 and part Lot 16 in DP 1082775
Site Area:	Approximately 180 ha
Local Government:	Cessnock City Council
County and Parish:	Heddon, Northumberland
Owner:	Hydro Aluminium Kurri Kurri Pty Ltd (subject to Deed of Company Arrangement)
Current Zoning:	Rural Landscape (RU2)
Current Site Use:	Aluminium smelter (closed)
Proposed Zoning:	General Industrial (IN1), Heavy Industrial (IN3) and Environmental Conservation (E2)
Proposed Site Use:	Industrial subdivision

2.2 Site Details

Ramboll (formerly Environ) completed a site history review in Environ (October 2013) Phase 1 ESA, Hydro Kurri Kurri Aluminium Smelter. A summary of the history of the smelter is provided below.

The aluminium smelter was built on previously undeveloped agricultural land. A buffer zone of land was purchased around the planned smelter as required in the planning approval. The smelter was developed in 1969 by Alcan Australia Ltd, later Capral Aluminium, with pot lines commissioned in 1969 (Pot Line 1 – 120 cells) and expanded in 1973; in 1979 (Pot Line 2 – 120 cells); and in 1985 (Pot Line 3 – 120 cells) for a final capacity of 180,000 tonnes per annum. The Smelter was purchased by VAW Aluminium in 2000 and became part of Hydro with their purchase of VAW Aluminium in 2001.

The overall process of aluminium smelting comprises four main operational areas:

- Pot Lines, where alumina is reduced to molten aluminium in individual pots using the Hall-Herault process
- Casthouse, where molten metal is cast into ingots and billots
- Carbon Plant, where ring furnaces are used to bake anodes. The Anode Plant is included in the Carbon Plant
- Anode Plant, where carbon anodes are manufactured. The anode plant included the Greenmix Plant, the Baking Furnaces and the Rodding Plant.

Ancillary facilities comprise the storage of raw materials, including alumina, petroleum coke, tar pitch, diesel; dry air scrubbers; compressed air supply; process water treatment; support services and maintenance installations. A transformer yard is located in the north western corner of the Smelter and numerous electrical substations are located around the Smelter Site to distribute electricity as required.

2.3 Current and Proposed Land Use

The smelter ceased production of aluminium in 2012 and was formerly closed in 2014. Demolition of the smelter commenced in 2017 and is due to be completed in late 2020. Remediation works have been on-going during the demolition works to ensure the Smelter Site is suitable for the future proposed commercial/industrial land use.

A Rezoning Masterplan has been prepared for the Smelter Site, which identifies future land use zonings for different land parcels. The Smelter Site has been designated as one Land Parcel within the Master Plan and planned land use zonings within the Smelter Site include:

- Heavy Industrial (IN3): Clay Borrow Pit, which is the planned location of the Containment Cell, and portion of the smelter footprint directly east of the Clay Borrow Pit
- General Industrial (IN1): Southern portion of the smelter footprint
- Environmental Conservation (E2): Undeveloped bushland to the west, south and north of the smelter footprint.

2.4 Site Boundaries

The Smelter Site is located within the following boundaries:

- East: Bushland within the Buffer Zone owned by Hydro (herewith described as the Hydro Land)
- North: Bushland within the Hydro Land
- West: The former Bishops Bridge Road (now an internal access road only due to the construction of the new Hunter Expressway) and bushland within the Hydro Land
- South: The Hunter Expressway then bushland within the Hydro Land.

The boundary of the Smelter Site is shown on **Figure 2, Appendix 1**.

3. SITE CONDITION AND SURROUNDING ENVIRONMENT

Site characterisation information has been summarised from the following reports in conjunction with recent observations at the time of preparing this report (August 2020):

- 'Phase 2 Environmental Site Assessment, Kurri Kurri Aluminium Smelter' November 2012 Environ (now Ramboll)
- 'Phase 1 ESA, Hydro Kurri Kurri Aluminium Smelter' October 2013 Environ
- 'Phase 2 Environmental Site Assessment, Smelter Site, Additional Investigations' January 2015 Environ

3.1 Site Conditions

A summary of the site conditions and surrounding environment is included in **Table 3-1**.

Table 3-1: Summary of Site Conditions and Surrounding Environment

Item	Description
Topography	The Smelter Site is located between low residual hills to the west and low-lying swampy land to the north and east. The Smelter is relatively flat with a gentle slope from west to east, from the plant area towards the surrounding water courses in the east and northeast. Low lying areas were filled to create a flat, elevated platform at approximately 14 m AHD for construction. The Smelter Site increases in elevation to the west in the vicinity of the Clay Borrow Pit, which is at an elevation of 25 m AHD.
Boundary Conditions	The boundary of the Smelter Site is shown in **Figure 2, Appendix 1**. The western, northern and southern boundaries are identifiable by roads or tracks, including the recently completed Hunter Expressway on the southern boundary of the Smelter Site. The majority of the eastern boundary is within bushland and is not easily identifiable on the ground.
Visible Signs of Contamination	During site visits conducted by Ramboll on 6 and 15 May 2014, visible signs of contamination were noted in the following areas: - The garden bed at the south-western corner of the Carbon Plant (soils discoloured black). - Staining surrounding the hydraulic rooms of the Carbon Plant and Casting Plant. - Staining surrounding the Heating Transfer Medium (HTM) electric heater room and gas heater room in the Carbon Plant. - Hydraulic oil on the floor of the Butt Crushing Plant. These areas with visible staining and discolouration have been remediated as part of the demolition and remediation works completed at the Smelter Site between 2017 and the present day.
Visible Signs of Plant Stress	During site visits conducted by Ramboll throughout 2012, 2013 and 2014, visible signs of plant stress were observed down gradient of the Capped Waste Stockpile within the area of the leachate plume.
Presence of Drums, Wastes and Fill Material	During the Phase 2 ESAs, the following were observed at the Smelter Site: • Some 44 gallon drums of Castrol oil were observed by Ramboll at the drum store in the eastern portion of the Smelter Site on 15 May 2014. • Smelter wastes were observed at the Anode Waste Pile, where Ahead of Schedule anodes are stockpiled prior to disposal or reuse and at the Clay Borrow Pit, where refractory bricks and concrete were stockpiled. Remedial works were completed to remove stockpiled materials from the Clay Borrow Pit in 2015. A second anode waste pile was also observed immediately east of Pot Line 1, where excess anodes have been stockpiled prior to disposal offsite since the closure of the Smelter. • Stockpiles of various waste streams were observed on the storage area west of Pot Line 3 during the 2012 site walkover. It is noted that these stockpiles were recycled or disposed of and were not present during the 2014 investigations. During the demolition and remediation works completed between 2020 and the present day, oil drums have been recycled, most waste stockpiles have been recycled or appropriately disposed of. These works have been reported separately to this report.
Odours	No odours were noted at the Smelter Site during the investigations conducted between 23 June and 2 July 2014. Odours have been observed during the remediation of hydrocarbon impacted

Item	Description
	soils at the Carbon Plant in 2020. Completed remediation and validation works have been reported separately to this report.
Conditions of Buildings and Roads	Roads at the Smelter Site were noted to be in good condition during the investigations undertaken between 23 June and 2 July 2014. Since operations ceased in 2012 and the Smelter was put on a care and maintenance mode, rust has developed on the surface of scrubbers and other plant associated with the pot lines. Office buildings remain in good condition. Demolition of buildings and milling of roads has been completed during the demolition and remediation works undertaken between 2017 and the present day.
Quality of Surface Water	There are five storage ponds located at the Smelter Site as shown on **Figure 2, Appendix 1**. Surface water from the Smelter Site is directed to these storage ponds via open channels and some concrete subsurface drainage lines. Surface water ponds known as 'East', 'West' and 'South' are pumped to two North dams where excess surface water is discharged to an irrigation area under license from NSW Office of Environment and Heritage (EPL 1548). Surface water dams were constructed by excavation into the residual underlying extremely weathered bedrock. Surface water quality at the East Surge Pond and North Dams are monitored and fluoride concentrations are elevated compared to background levels. This is likely due to flow from site sources such as the anode waste pile which was not covered for some time.
Flood Potential	The majority of the Smelter Site is located on low lying swampy ground that has been filled. Low lying areas of the Site remain susceptible to flooding. The western portion of the Smelter Site is located on ground at a higher elevation and is less likely to flood.
Local Sensitive Environment	Sensitive environments including two creeks and a wetland swamp are located in the vicinity of the Smelter Site. Swamp Creek is located approximately 400 m to the south and east of the Smelter Site, flowing in a northerly direction. Swamp Creek flows north into Wentworth Swamp, a large wetland located approximately 1.6km north of the Site. Swamp Creek is the receptor for groundwater from the eastern portion of the Site. The location of Swamp Creek is shown on **Figure 2, Appendix 1.** An unnamed creek passes through the Site between the Smelter site and the Clay Borrow Pit. This creek originally passed through the Smelter site and was relocated during Smelter construction. Black Waterholes Creek is located approximately 700 m to the north of the Site, flowing in a northerly direction. Black Waterholes Creek flows north into the western portion of Wentworth Swamp. Black Waterholes Creek is the receptor for groundwater from the western portion of the Site.

3.2 Geology and Hydrogeology

A summary of the site conditions and surrounding environment is provided in **Table 3-2**.

Table 3-2: Summary of Geology and Hydrogeology

Item	Description
Geology	According to the review of the regional geology described on the Sydney Basin Geological Sheet, the Smelter Site and Hydro Land are underlain by siltstone, marl and minor sandstone from the Permian aged Rutherford Formation (Dalwood Group) in the Sydney Basin.
Location and Extent of Fill	The Smelter is located in low lying land that was filled to create a level area for the construction of the Smelter. The fill material is generally understood to comprise locally derived fill. During the Phase 2 ESA investigations, crushed refractory brick fill was observed within fill material underlying the Carbon Plant and the Pot Lines. A portion of the Smelter Site between the north-western fence line and the Clay Borrow Pit was also filled with material likely to include refractory bricks and concrete waste. This area was recently filled with excess Excavated Natural Material (ENM) from the construction of the Hunter Expressway immediately south of the Smelter Site. A classification of this material was completed by Environ (Classification for Stockpiled Soil, Grahams Lane, dated 8 April 2014) under the Excavated Natural Material Exemption 2012.
Borehole Logs	During the Phase 2 ESA, Ramboll supervised the drilling of 52 boreholes across the Smelter Site. These boreholes extended to a maximum depth of 16 m bgs. The subsurface conditions varied across the Smelter Site, but generally comprised fill material overlying estuarine sediments. The fill material, where encountered, generally comprised clayey

Item	Description
	gravelly sand and included gravel brick fragments. The estuarine sediments generally comprised fine grained sand, with high plasticity clay encountered in some boreholes.
On-site Wells	During the Phase 2 ESA, Ramboll supervised the installation of 21 monitoring wells at the Site. The wells were installed at AECs, including the Carbon Plant, the Diesel Spray Area, the Refuelling Area and the Anode Waste Pile. Prior to the Phase 2 ESA, a pair of shallow and deep nested wells were installed at the Carbon Plant as part of the geotechnical investigations for the bake furnace reconstructions.
Depth to Groundwater Table	Groundwater in the east of the Smelter Site was identified at shallow depths within the estuarine sands, between 1 m and 5 m bgs during the Phase 2 ESA. At the Clay Borrow Pit in the west of the Smelter Site, groundwater was identified within residual clay at depths ranging between 8 m and 9 m bgs.
Aquifers present	Two aquifer systems are present at the Smelter Site, one shallow aquifer within alluvium and one deeper aquifer within the underlying bedrock/ residual clay. The shallow aquifer system is limited in extent due to the nature of the alluvium (interbedded sands and clays, with groundwater limited to the sands). There are a number of licensed groundwater bores located within the shallow alluvium immediately east of the Site, which are used for monitoring of the leachate plume from the Capped Waste Stockpile. Groundwater bores licensed for uses such as domestic, recreation, irrigation and stock watering are located at distances of greater than 3km from the Smelter Site.
Direction and Rate of Groundwater Flow	During the Phase 2 ESA, groundwater was identified flowing north to north east across the Smelter Site. At the Clay Borrow Pit, groundwater is expected to flow towards the north east following topography.
Direction of Surface Water Runoff	Stormwater runoff is managed at the Smelter Site via a series of drainage channels and three surge ponds. Surge ponds discharge to the two North Dams, from which excess stormwater is spray irrigated over an adjacent paddock in accordance with EPL1548. There are no other surface water bodies located on the Site.
Background Water Quality	A background monitoring well was installed as part of the Phase 2 assessment. The well was installed approximately 60 m west of the Smelter in bushland within the Smelter Site. This well was installed in an upgradient location. Analysis of water from the background well in 2012 was completed and the results were below the adopted criteria, including ANZECC (2000) 95% protection of fresh water species, irrigation and stock watering criteria for heavy metals aside from zinc, fluoride, free cyanide, PAHs, Semi Volatile Organic Compounds (SVOCs). The zinc concentration (78 µg/L) marginally exceeded the ANZECC (2000) hardness modified trigger value of 70 µg/L.
Preferential Water Courses	The 1951 historical aerial photograph shows a former water course extending in a northeast/ southwest direction towards Wentworth Swamp in the west of the Smelter Site. It is understood this water course was filled in and relocated to the west to provide a level platform on which to construct Pot Lines 2 and 3. The water course is now an ephemeral unnamed creek situated on the sites western boundary.
Summary of Local Meteorology	Median, daily highest and lowest hourly average temperatures have been collected over the past 20 years. Meteorological information was provided in Hydro's Annual Environmental Monitoring Report (AECOM 2013) and indicated that the 2012 temperatures were above average for summer days and nights; annual rainfall in 2012 was 515 mm, which is below the 20 year average of 619mm and quarterly wind roses show the usual pattern of strongest winds from the northwest in winter, moderate winds from the south and southwest in spring and autumn and moderate to strong southeast winds in summer.

4. PREVIOUS INVESTIGATIONS

Ramboll has completed a number of environmental investigations at the Smelter Site since operations were suspended in 2012. These investigations included Phase 1 and Phase 2 contamination assessments, a health risk assessment, ecological risk assessments, hazardous materials audits and preparation of the RAP.

Investigations completed by Ramboll that are relevant to this Validation Plan are outlined below.

- Stage 1 Phase 2 Environmental Site Assessment, Hydro Kurri Kurri Aluminium Smelter (ENVIRON 2012a)
- Environmental Site Assessment, Capped Waste Stockpile, Kurri Kurri Aluminium Smelter (ENVIRON 2012b)
- Tier 2 Ecological Risk Assessment Hydro Kurri Kurri Aluminium Smelter (ENVIRON 2013a)
- Preliminary Screening Level for Human Health Risk Assessment Hydro Kurri Kurri Aluminium Smelter (ENVIRON 2013b)
- Phase 1 Environmental Site Assessment, Hydro Kurri Kurri Aluminium Smelter (ENVIRON 2013c)
- Hazardous Materials Assessments Hydro Kurri Kurri Aluminium Smelter
  - Stage 1 - Maintenance Workshops and Storage Sheds (ENVIRON 2014a)
  - Stage 2 - Administration, Personal Training Centre, Gatehouse, Medical Centre and Personnel, Bathhouse and EOHS (ENVIRON 2014b)
  - Stage 3 - Cast House and Associated Buildings (ENVIRON 2014c)
  - Stage 4 - Pot Rooms and Associated Structures (ENVIRON 2014d)
  - Stage 5 – Carbon Plant and Associated Structures (ENVIRON 2014e)
  - Stage 6 - Transformer Yard, Substations and Miscellaneous Areas (ENVIRON 2014f)
- Phase 2 Environmental Site Assessment, Smelter Site, Additional Investigations (ENVIRON 2015a)
- Environmental Site Assessment, Diesel Spray Area, Hydro Aluminium Smelter (Ramboll Environ 2016a)
- Capped Waste Stockpile Assessment (Ramboll Environ 2016c)
- Remedial Action Plan, Hydro Aluminium Smelter Kurri Kurri (Ramboll 2018).

5. NATURE AND EXTENT OF CONTAMINATION

5.1 Soil

During the previous environmental investigations, a total of 32 Areas of Concern (AECs) and Potential Areas of Concern (PAECs) were identified for assessment. Assessment of potential soil contamination was completed during the 2012 and 2014 Phase 2 ESAs and during a Data Gap Assessment, completed in 2020 as previously inaccessible AECs became accessible during the demolition of the smelter between 2017 and 2020.

Soil impacts at the Smelter Site were identified at 32 AECs of which eight require remediation. primarily associated with the following activities:

- Waste stockpiling – leaching of contaminants of concern into surface soils
- Burial of wastes - leaching of contaminants of concern into surface soils
- Site operations – aerial deposition of contaminants of concern onto surface soils
- Use of fill – impacted fill used to level a portion of the Smelter Site
- Impact to sediments in drainage lines and dam – accumulation of contaminated sediments

A summary of the 32 identified AECs and PAECs and their current status is included in **Table 5-1**. The location of remediated AECs and remaining AECs requiring remediation are shown on **Figure 3, Appendix 1**.

Table 5-1: Summary of Identified AECs and PAECs

Reference	Site Area	Description	Identified Soil Contamination	Current Status
AEC 1	Capped Waste Stockpile	Long term stockpiling of spent pot lining and other wastes.	Asbestos, PAHs and TRHs identified in soil at concentrations exceeding site criteria	AEC 1 is to be remediated in 2021/2022 and is included in this VSAQP
AEC 2	Anode Waste Pile	Long term stockpiling of 'ahead-of-schedule' anodes.	PAHs identified in shallow soil at concentrations exceeding site criteria	AEC 2 is to be remediated in 2021
AEC 3	Refuelling Area	Refuelling of vehicles from diesel aboveground storage tank (AST). Location of former fuel oil AST and underground fuel oil distribution lines.	No widespread soil contamination identified, AEC to be visually assessed during removal of infrastructure	AEC 3 was remediated in August 2020, no further works required
AEC 4	Diesel Spray Area	Diesel was used to treat rust coatings from cathode rods prior to reuse. Impacted fill material was used to level this portion of the site.	PAHs identified in fill at concentrations exceeding site criteria	AEC 4 was remediated in 2019, no further works required
AEC 5	Drainage Lines	Surface water flow and movement of sediments along drainage lines next to Capped Waste Stockpile and Anode Waste Pile	PAHs identified in sediment at concentrations exceeding site criteria	AEC 5 is to be remediated in 2021
AEC 6	East Surge pond	Receives surface wate and sediment from drainage lines next to Capped Waste Stockpile and Anode Waste Pile	PAHs identified in sediment at concentrations exceeding site criteria	AEC 6 is to be remediated in 2021
AEC 7	North Dams 1 and 2	Receiving water bodies for surface water from the northern portion of the Smelter Site	None identified	No further works required

Reference	Site Area	Description	Identified Soil Contamination	Current Status
AEC 8	Carbon Plant	Manufacturing of anodes. The Carbon Plant includes the Anode Plant, Bake Furnaces, the Rodding Plant and Greenmix. Use of pitch and coke in anode production. Previous use of heavy fuel oil.	PAHs identified in shallow soil at concentrations exceeding site criteria. Areas of staining beneath concrete slabs in buildings required assessment following demolition.	Remediation of soil contamination completed during demolition between 2017 and August 2020, no further works required
AEC 9	Cathode Bar Washdown Area	High pressure spray trial for cathode bars	None identified	No further works required
AEC 10	Flammable Liquids Store	Storage of hazardous substances	None identified	No further works required
AEC 11	Washdown Bay	Used for cleaning cathode bars	None identified	No further works required
AEC 12	Pot Lines 1, 2 and 3	Lines of pots in which alumina was reduced through electrolysis to molten aluminium.	None identified	No further works required
AEC 13	SPL Storage Sheds	Storage of spent pot linings in six sheds constructed from 2006.	None identified	No further works required
AEC 14	South Surge Pond	Receiving body for surface water from the southern portion of the Smelter Site.	None identified	No further works required
AEC 15	West Surge Pond	Receiving body for surface water from the western portion of the Smelter Site.	None identified	No further works required
AEC 16	Switchyard	Receipt of high voltage electricity feeders and conversion for site use.	Not able to be assessed due to health and safety concerns. Will also remain live in the future.	No further works required
AEC 17	Contractors Storage Compound	Use of degreasers, paint, oil and greases	None identified	No further works required

Reference	Site Area	Description	Identified Soil Contamination	Current Status
AEC 18	Pot Rebuild Area	Historical workshop area for melting and rebuilding pots.	None identified	No further works required
AEC 19	Clay Borrow Pit	Area historically filled with inert materials following extract of clay to cap Capped Waste Stockpile	Aesthetic impacts from buried wastes, no chemical contamination	Remedial works completed in 2015, no further works required
AEC 20	Glen Ayr Drift Infilling	Located in the Buffer Zone, filling of mine subsidence area with illegally dumped wastes	PAHs identified in fill at concentrations exceeding site criteria	Remedial works completed in 2015, no further works required
AEC 21	Irrigation Area	Located in the Buffer Zone, irrigation of Smelter Site stormwater	None identified	No further works required
AEC 22	General Buffer Zone	Not on the Smelter Site, works completed separately	Not applicable	Not applicable
AEC 23	Background Well	A background well located immediately upgradient of the Smelter Site	None identified	No further works required
AEC 24	Not used	Not applicable	Not applicable	Not applicable
AEC 25	Pot Line Dry Scrubbers	Scrub fluoride from the three pot lines	None identified	No further works required
AEC 26	Ring Furnace Scrubber	Scrub PAHs from the Carbon Plant	PAHs identified in shallow soil at concentrations exceeding site criteria	AEC 26 is to be remediated in late 2020
AEC 27	Substations	Each substation facilitates the distribution of electricity across the Smelter Site	Stained soils indicating leaking of transformer oils with hydrocarbons and polychlorinated biphenyls (PCBs)	Remedial works completed during demolition and remediation between 2017 and present day, no further works required
AEC 28	Playing Fields	Level fields, potentially filled	None identified	No further works required

Reference	Site Area	Description	Identified Soil Contamination	Current Status
AEC 29	Area East of the Playing Fields	Burial of waste materials	Aesthetic impacts and PAH impacts to shallow soil in south east corner	Remedial works completed in 2019, no further works required
AEC 30	Area East of Clay Borrow Pit	Potentially filled area	None identified	No further works required
AEC 31	Storage Area West of Pot Line 3	Potential impacts to surface soils from stockpiling of materials	None identified	No further works required
AEC 32	Garden Beds	Potential aerial deposition of fluoride and PAHs	Limited investigation completed prior to demolition	Garden beds removed during demolition and remediation between 2017 and present day, no further works required

5.2 Groundwater

Groundwater beneath the Smelter Site has been assessed at specific AECs and a background well has also been installed to assess background water quality. Twenty-one groundwater wells were initially installed and sampled during the 2012 Phase 2 ESA. An additional seven wells were installed at three AECs during the 2014 Phase 2 ESA and sampling was undertaken at the existing and new wells. These wells were subsequently sampled in 2018. Aluminium and fluoride were consistently detected at concentrations exceeding the site criteria within the wells beneath the Smelter Site.

In 2016, six groundwater wells were installed directly into AEC 1: Capped Waste Stockpile and sampled to assess the nature of groundwater within and below the stockpile. One well, MW201, was installed within the waste pile, while the remaining wells were installed in natural material below the base of the waste. Groundwater was analysed for a wide range of contaminants. Soluble fluoride, aluminium, TRH C6-C36, benzene, ethyl benzene, fluoranthene, phenanthrene and naphthalene were detected at concentrations exceeding the site criteria.

The location and identity of groundwater wells installed by Ramboll is outlined in **Table 5-2**. Groundwater wells locations are shown in **Figure 4, Appendix 1**.

Table 5-2: Groundwater Well Locations across the Smelter Site

Ref.	Site Area	Wells Installed in 2012	Wells Installed in 2014	Wells Installed in 2016	Groundwater Monitoring Events
AEC 1	Capped Waste Stockpile	None	None	MW201 to MW206	2016
AEC 2	Anode Waste Pile	MW12, MW13	MW103, MW104	None	2012, 2014, 2018
AEC 3	Refuelling Area	MW07, MW08	MW101, MW102	None	2012, 2014, 2018
AEC 4	Diesel Spray Area	MW19, MW20	None	None	2012, 2014, 2018
AEC 8	Carbon Plant	MW14, MW15, MW16, MW17, MW18	MW105, MW106, MW107	None	2012, 2014, 2018
AEC 9	Washdown Area	MW11	None	None	2012, 2014, 2018
AEC 10	Flammable Liquids Store	MW09, MW10	None	None	2012, 2014, 2018
AEC 18	Pot Rebuild Area	MW21	None	None	2012, 2014, 2018
AEC 19	Clay Borrow Pit	MW01, MW02, MW03, MW04, MW05, MW06	None	None	2012, 2014, 2018

Extensive groundwater sampling has been completed at a leachate plume located down gradient of AEC 1: Capped Waste Stockpile. The network of existing wells was rationalised by Ramboll in 2013 and an additional seven shallow and deep monitoring well pairs were installed to monitor the leachate plume. Since 2013, monitoring of the leachate plume has been undertaken on a quarterly basis at a network of 25 wells on five sections located at increasing distance from the source (Capped Waste Stockpile). The leachate plume is characterised by a basic pH (>9), brown coloured leachate and elevated concentrations of sodium, fluoride, sulphate and cyanide. Analysis for soluble fluoride, aluminium and total and free cyanide is completed during groundwater monitoring events.

A summary of the 25 groundwater wells analysed as part of the quarterly groundwater monitoring at the leachate plume is included in **Table 5-3**.

Table 5-3: Groundwater Well Locations within the Leachate Plume

Section	Distance from Source (CWS)	Existing Wells	Wells Installed in 2013	Maximum Fluoride Concentration
1	0 m	E5	W2S, W2D, PUMP, W7M, W7S, E5D	1700 mg/L (W2D, March 2017)
2	75 m	E4	W1S, W1D	699 mg/L (E4, July 2013)
3	175 m	A7	W3S, W3SA, W3D, W4S, W4D	600 mg/L (A7, March 2019)
4	250 m	E11, N2	W5S, W5D	230 mg/L (E11, March 2017)
5	325 m	G2, N8, N9	W6S, W6D	210 mg/L (N9, November 2014)

5.3 Conceptual Site Model

A Conceptual Site Model (CSM) was completed based on known source(s) of contamination, the pathway(s) by which contaminants may migrate through the environmental media and the populations (human or ecological) that may potentially be exposed. This relationship is commonly known as a Source-Pathway-Receptor (SPR) linkage. Where one or more elements of the SPR linkage are missing, the exposure pathway is considered to be incomplete and no further assessment is required.

The CSM presented in this report is specific to the Capped Waste Stockpile and associated leachate plume, the subject of this VSAQP, as presented in **Table 5-4**.

Table 5-4: Exposure Pathway Assessment

Pathways	Potentially Complete Source-Pathway-Receptor Link ? (Y/N/P/NA)				Justification
	Current and future onsite employees (non-intrusive)	**Current and future onsite Intrusive Maintenance and Construction Workers**	**Recreational users of Kurri Kurri Speedway**	**Hydro Land Ecological Receptors**	
Capped Waste Stockpile – Soil					
Dermal contact with soil and dust	N	N	N	N	In its current condition, the Capped Waste Stockpile is capped with clay that provides a physical barrier between human and ecological receptors and the stockpiled wastes.
Incidental ingestion of dust/soil	N	N	N	N	
Dermal contact with dust only	N	N	N	N	
Outdoor dust inhalation	N	N	N	N	
Indoor dust inhalation	N	N	N	N	
Groundwater					
Dermal contact	N	**P**	N	N	Shallow (~0.5-5 m bgs) fluoride impacted groundwater detected on the Smelter Site in excess of the site specific recreational use. HHRA required to determine the potential risk to current and future intrusive maintenance and construction workers.
Incidental ingestion	N	**P**	N	N	
Plant Uptake	NA	NA	NA	N	Shallow (0.5-2.5 m bgs) leachate plume identified downgradient of Capped Waste Stockpile. During times of high rainfall, groundwater daylights to the surface in the Buffer Zone and can flow to surface water bodies. However, studies have shown that concentrations of fluoride and aluminium in surface waters in the Hydro Land have not impacted on ecology at the downgradient receptor, Swamp Creek (ENVIRON, 2013a and 2013e). On this basis, concentrations of fluoride and aluminium in groundwater at the site are not considered to represent an ecological risk under the current site use. Leachate from the stockpile may present an unacceptable risk to future development of the site for industrial land use.

Y Yes, N No, P Potential, NA Not applicable

6. REMEDIAL ACTION PLAN

A RAP was prepared by Ramboll (Ramboll Environ 2018) for the Smelter Site to outline remediation requirements for identified AECs and additional investigations required to assess data gaps. The objective of the RAP was to render the Smelter Site suitable for future commercial/ industrial land use.

6.1 Extent of Remediation

The approximate remediation volume included in the RAP for each AEC and PAEC is defined below in **Table 6-1**. The volume calculations were determined from an estimation of the lateral and vertical extent determined during site investigations, noting that further lateral delineation was completed recently at some AECs. Tonnages were calculated from the anticipated bulk density as shown for each material present. There is inherent uncertainty in the volume estimates.

Table 6-1: Predicted Remediation Volumes at each AEC and PAEC

Type	Volume estimate Range[1] (m^3)			Bulk Density (T/m^3)	Mass Estimates (T) Range	
	Estimate	Low	High		Low	High
AEC 1: Capped Waste Stockpile	159000	145000	206700	2	290000	413400
AEC 2: Anode Waste Pile	1500	1370	1950	1.8	2470	3510
AEC 4: Diesel Spray Area[2]	450	395	730	1.8	720	1320
AEC 5: Drainage Lines	220	200	290	1.8	360	530
AEC 6: East Surge Pond	2300	2100	2990	1.8	3780	5390
AEC 8: Carbon Plant	940	860	1230	1.8	1548	2220
AEC 15: West Surge Pond	2700	2460	3510	1.8	4430	6320
AEC 26: Bake Furnace Scrubber	510	470	670	1.8	850	1210
PAEC 27: Transformer Yard and Substations[3]	15500	14100	20150	1.8	25380	36270
AEC 28: Area East of Playing Fields	2600	2370	3380	1.8	4270	6090
PAEC 30: Area East of Clay Borrow Pit	2600	2370	3380	1.8	4270	6090

1. Low/high -10%, +30%
2. Low/high based on field observations
3. Revised plans for future land use include retention of the Transformer Yard. The Transformer Yard will not be remediated and so volume estimates are considered conservatively high

As indicated in **Section 5**, remedial works were completed during demolition of the Smelter at AEC 3: Refuelling Area, AEC 4: Diesel Spray Area, AEC 8: Carbon Plant, AEC 26: Bake Furnace Scrubber, PAEC 27: Substations and AEC 30: Area East of the Playing Fields. Contaminated soils from these AECs were stockpiled at two locations on the Smelter Site; the Dickson Road Stockpile or the 60C Contaminated Soil Stockpile.

In addition, data gaps were closed out at AEC 15: West Surge Pond and PAEC 30: Area East of Clay Borrow Pit in 2019 and 2020 and no remedial works are required at these AECs.

6.2 Remediation Options Assessment

6.2.1 Soil Contamination

Remedial options were identified for soil contamination. These remedial options were previously identified and assessed as part of a Remedial Options Study completed by ENVIRON in May 2014 (ENVIRON 2014g) and were reviewed and amended as part of the RAP (Ramboll 2018). Seven remedial options were assessed for soil and included the following:

1. Do Nothing
2. Encapsulate *in situ*
3. Move to specifically designed landfill adjacent to the capped waste stockpile
4. Encapsulate in purpose-built containment cell
5. Treat and encapsulate in purpose-built containment cell
6. Excavate, sort and dispose offsite
7. Onsite treatment to achieve complete destruction

The evaluation criteria identified in the Remedial Options Study were reviewed and a quantitative and qualitative assessment of the advantages and disadvantages of each option was completed. The evaluation criteria included approval likelihood, legacy management and costs; risk rating; sustainable analysis and project time.

The preferred strategy for contaminated soils was Option 4 - the relocation and consolidation of all contaminated soils and the contents of the Capped Waste Stockpile into one specifically designed Containment Cell. This option was considered most favourable when compared to other options in terms of cost, risk of failure, long term legacy and onsite management, corporate responsibility and sustainability. The Containment Cell will be constructed at the location of the Clay Borrow Pit and will be constructed using best demonstrated available technology to contain contaminated soils and smelter wastes in perpetuity. The Clay Borrow Pit has been identified as a suitable location based on a Preliminary Containment Cell Study (ENVIRON 2013c) which evaluated possible cell locations. The Clay Borrow Pit is situated more than three metres above the groundwater table level and within competent bedrock. The cell would be situated approximately 200 m from the closest ephemeral surface water body. A conceptual cell design was included in the RAP.

The cell design comprises a base liner combining compacted clay and with high density polyethylene liners. Leachate drainage layers and leachate collection capability is included in the liner. Materials placed within the cell are not putrescible and therefore leachate generation is expected to be minimal.

The cell cap design comprises a liner system comprising clay and geosynthetic liners. Gas venting, drainage layers, fauna protection and vegetation layers are included in the cap design.

Cap slopes are designed to promote surface water diversion and surface water runoff as well as ensure stability of the Containment Cell.

Detailed design of the Containment Cell is currently being prepared. The detailed design will be consistent with the performance standard of the concept design. The system will be designed to maximise infiltration reduction and will be evaluated in terms of long-term performance and compatibility with the leachate present.

The cell will be constructed to hold a volume of 266,000 m^3 over an area of approximately six hectares. The cell is designed to accommodate additional volume (if required) by increasing height.

PCB impacted soils will be segregated for off-site thermal treatment and disposal.

6.2.2 Groundwater Contamination Associated with the Capped Waste Stockpile

Six remedial options were assessed for groundwater contamination, where groundwater contamination is a secondary source comprising groundwater impacted by the Capped Waste Stockpile, and included the following:

8. Do Nothing
9. Leachate Interception
10. Source removal to the extent practicable
11. Reactive Barrier Wall
12. Monitored Natural Attenuation
13. Combination of source removal to the extent practicable, leachate removal and monitored natural attenuation

The preferred strategy for the leachate plume in groundwater at the Capped Waste Stockpile was Option 6 - a combination of leachate interception, source removal to the extent practicable and monitored natural attenuation. Leachate interception was employed in April 2014 with the installation of a leachate interception trench that collects leachate and pumps to the East Surge Pond. Source removal to the extent practicable will be achieved during the soil remediation works by the relocation of the Capped Waste Stockpile contents to the Containment Cell. At this time, leachate contained within the wastes will be drained to a sump within the Capped Waste Stockpile bund. Leachate will be extracted and treated through the water treatment plant to a level suitable for discharge to the North Dam, which is irrigated under the EPL.

The sump within the Capped Waste Stockpile will remain and groundwater will continue to be treated until visible signs of leachate are removed from the upper sand aquifer. The Capped Waste Stockpile footprint will then be backfilled and reshaped to above the groundwater table.

Monitored natural attenuation will be achieved via physical processes, such as dispersion, diffusion and sorption. On-going monitoring will be used to determine the success of leachate interception and source removal as a remedial strategy for the leachate plume.

6.3 Remedial Methodology

Detailed information on the remedial methodology for the remediation of soil contamination at the Smelter Site, construction of the Containment Cell and remediation of leachate-impacted groundwater at the Capped Waste Stockpile is included in the RAP. In general, the remedial methodology is as follows:

- Identify the extent of contaminated surface soils at each AEC using site plans and GPS information provided in the Phase 2 ESA reports
- Excavate contaminated surface soils from each AEC
- Transport contaminated soils to the designated stockpile area or directly to the Containment Cell
- Relocate contaminated soils from the stockpile area to the Containment Cell
- Validate soils remaining at each AEC.
- Where required, re-instate each AEC with validated crushed concrete or refractory brick to appropriate site levels.

6.4 Key Roles

Key project roles that are integral to the remediation and validation works and key stakeholders are outlined in **Table 6-2**.

Table 6-2: Key Personnel and Stakeholders

Stakeholder	Role	Focus
Hydro Aluminium Kurri Kurri Pty Ltd	Site owner	Overall management of the demolition, remediation and development works
Ramboll Australia Pty Ltd	Environmental Consultant	Completion of environmental assessments, RAP preparation, validation activities, compilation of validation information and validation reporting
Ross McFarland (AECOM)	Independent NSW EPA Accredited Site Auditor	Audit against NSW EPA guidelines
GHD Group Pty Ltd	Containment Cell engineering design	Design of the containment cell and preparation of quality assurance requirements
Daracon Group Pty Ltd	Civil Works Contractor	Remediation project works including construction of Containment Cell
Enviropacific Services Pty Ltd	Remediation Contractor	Remediation project works including leachate treatment works
Cessnock City Council	Local Council	Stakeholder
NSW EPA	Environmental Regulator	Stakeholder

7. BASIS FOR VALIDATION CRITERIA

7.1 Soil Validation Criteria

7.1.1 Contaminants of Concern

Contaminants of Concern (CoCs) are those contaminants that have been found to be present in AEC 1: Capped Waste Stockpile during previous investigations, as follows:

- Soluble fluoride
- Aluminium
- Polycyclic Aromatic Hydrocarbons (PAHs)
- Petroleum hydrocarbons (TRH)
- Asbestos

7.1.2 Soil Criteria

The guidelines proposed as the validation criteria at AEC 1: Capped Waste Stockpile are sourced from the following references:

- National Environmental Protection (Assessment of Site Contamination) Amendment Measure 2013 (No. 1) (NEPM) (NEPC 2013)

The variation to the National Environmental Protection (Assessment of Site Contamination) Measure (NEPM 2013) was approved in 2013 by the NSW EPA under the *Contaminated Land Management Act 1997*. NEPM (2013) provide revised health-based soil investigation levels (HILs) and ecological-based investigation levels (EILs) for various land uses.

Based on the planned commercial/ industrial zoning of the Capped Waste Stockpile, the validation criteria adopted from NEPM (2013) are as follows:

- HIL D – Health investigation level for commercial/industrial such as shops, offices, factories and industrial sites. The HILs are applicable for assessing human health risk via all relevant pathways of exposure. The HILs are generic to all soil types and apply generally to a depth of 3 m below the surface for industrial use.
- HSLs for commercial/industrial use - Health screening levels for soil vapour intrusion from petroleum hydrocarbons are guidelines that prevent accumulation of vapours at concentrations that may represent a health risk. The HSLs are derived for various depths and are for the same generic land uses as for the HILs. The guidelines are relevant were soils are beneath building or structures such as confined spaces.
- EIL for commercial/ industrial use – ecological investigations levels applicable for assessing risk to terrestrial ecosystems. EILs depend on specific soil physicochemical properties and generally apply to the top 2 m of soil.
- ESLs for commercial/ industrial use – ecological screening levels developed for selected petroleum hydrocarbon compounds and fractions and are applicable for assessing risk to terrestrial ecosystems. These are also generally applicable to the top 2 m of soil.
- Management Limits where concentrations above these limits may indicate poor aesthetics, high odour and potentially explosive vapour. Management limits are to be applied after consideration of relevant ESLs and HSLs.

NEPM (2013) do not provide criteria for fluoride and aluminium in soils in Australia. Ramboll (2013b) conducted a Human Health Risk Assessment (HHRA) specific to fluoride and aluminium in order to derive site-specific screening levels for the Smelter Site. The screening levels are protective of the range of human receptors.

The applicable validation criteria for soluble fluoride and PAHs in soil are presented in **Table 7-1.**

Table 7-1: Validation Criteria (mg/kg) – Health and Ecological Investigation Levels

Analyte	HIL D	EIL C&I
Fluoride (soluble)	17,000 (site-specific)[1]	-
Aluminium	Non-limiting (Site-specific)[1]	
Carcinogenic PAHs (as BaP TEQ)	40	-
Total PAHs	4000	-
Naphthalene	-	370

[1] Site-specific industrial values calculated in the Preliminary Screening Level Health Risk Assessment for Fluoride and Aluminium (ENVIRON 2013b)

The applicable remediation assessment criteria for petroleum hydrocarbons in soil are presented in **Table 7-2** and **Table 7-3.**

Table 7-2: Soil Assessment Criteria for Vapour Intrusion – HSL D (mg/kg) - Sand

Analyte	0 to <1 m	1 m to <2 m	2 m to <4 m	4 m+
Toluene	NL	NL	NL	NL
Ethylbenzene	NL	NL	NL	NL
Xylenes	230	NL	NL	NL
Naphthalene	NL	NL	NL	NL
Benzene	3	3	3	3
F1(4)	260	370	630	NL
F2(5)	NL	NL	NL	NL

[1] The soil saturation concentration (Csat) is defined as the soil concentration at which the porewater phase cannot dissolve any more of an individual chemical. The soil vapour that is in equilibrium with the porewater will be at its maximum. If the derived soil HSL exceeds Csat, a soil vapour source concentration for a petroleum mixture could not exceed a level that would result in the maximum allowable vapour risk for the given scenario. For these scenarios, no HSL is presented for these chemicals and the HSL is shown as 'not limiting' or 'NL'.

[2] (For soil texture classification undertaken in accord with AS 1726, the classifications of sand, silt and clay may be applied as coarse, fine with liquid limit <50% and fine with liquid limit>50% respectively, as the underlying properties to develop the HSLs may reasonably be selected to be similar. Where there is uncertainty, either a conservative approach may be adopted or laboratory analysis should be carried out.

[3] To obtain F1 subtract the sum of BTEX concentrations from the C6-C10 fraction.

[4] To obtain F2 subtract naphthalene from the >C10-C16 fraction.

Table 7-3: ESLs and Management Limits for Petroleum Hydrocarbons in Soil

TPH fraction	Soil texture	ESLs (mg/kg dry soil)	Management Limits (mg/kg dry soil)
F1 C6- C10	Coarse	215*	800
F2 >C10-C16	Coarse	170*	1000
F3 >C16-C34	Coarse	1700	5000
F4 >C34-C40	Coarse	3300	10 000
Benzene	Coarse	75	-
Toluene	Coarse	135	-
Ethylbenzene	Coarse	165	-
Xylenes	Coarse	180	-

TPH fraction	Soil texture	ESLs (mg/kg dry soil)	Management Limits (mg/kg dry soil)
Benzo(a)pyrene	Coarse	72**	-

Management limits are applied after consideration of relevant ESLs and HSLs.

Separate management limits for BTEX and naphthalene are not available hence these should not be subtracted from the relevant fractions to obtain F1 and F2.

To obtain F1, subtract the sum of BTEX from C6-C10 fraction.

*ESLs are of moderate reliability, all other ESL values are of low reliability.

**Benzo(a)pyrene ESL criteria from Canadian Council of Ministries of the Environment (2010) Canadian Soil Quality Guidelines Carcinogenic and Other Polycyclic Aromatic Hydrocarbons (PAHs) (Environmental and Human Health Effects) Scientific Criteria Document (revised)

NEPM (2013) includes a low reliability ecological screening criterion for benzo(a)pyrene of 1.4 mg/kg for commercial/industrial land use. This criterion has been adopted from Environment Canada (1999) benzo(a)pyrene soil quality guideline, which is based on toxicity data for a single invertebrate species (an earthworm). Environment Canada revised their benzo(a)pyrene soil quality guideline in 2010 using the Species Sensitivity Distribution method, which is the preferred method for the derivation of ecological investigation levels and can only be used where sufficient toxicity data are available that adhere to rigorous quality control requirements. Ramboll has elected to use the revised Environment Canada soil quality guideline of 72 mg/kg, for commercial/industrial land use, as the most relevant ecological investigation level for benzo(a)pyrene at the Site as this guideline has been derived from a larger and more up-to-date toxicity database than the NEPM (2013) low reliability criterion.

Asbestos has been identified in the wastes in the Capped Waste Stockpile. The HSLs for asbestos are applicable for assessing human health risk via the exposure pathway of inhalation of airborne asbestos and are presented in **Table 7-4**. The HSLs are generic to all soil types.

Table 7-4: Health Screening Levels for Asbestos Contamination in Soil (w/w)

Form of asbestos	Screening Level
Bonded ACM	0.05 %[1]
FA and AF[2] (friable asbestos)	0.001 %
All forms of asbestos	No visible asbestos for surface soil

Fibrous Asbestos (FA) is asbestos material that is in a degraded condition such that it can be broken or crumbled by hand pressure.

Asbestos Fines (AF) includes free fibres, small fibre bundles and also small fragments of bonded ACM that pass through a 7 mm x 7 mm sieve.

[1] Commercial/industrial D includes premises such as shops, offices, factories and industrial sites. Recommended measure for bonded ACM where FA and AF (derived from bonded ACM only) make up <10 % of the total amount of asbestos present.

[2] The screening level of 0.001% w/w asbestos in soil for FA and AF (i.e. non-bonded/ friable asbestos) only applies where the FA and FA are able to be quantified by gravimetric procedures. This screening level is not applicable to free fibres.

7.2 Groundwater and Surface Water Validation Criteria

7.2.1 Contaminants of Concern

Contaminants of Concern (CoCs) in groundwater and surface water at and downgradient of AEC 1: Capped Waste Stockpile and associated leachate plume are:

- Soluble fluoride
- Cyanide
- Elevated pH (>9)

7.2.2 Groundwater Criteria

The guidelines proposed for the assessment of groundwater contamination at the Capped Waste Stockpile and the Site are sourced from the following references:

- Guidelines for the Assessment and Management of Groundwater Contamination (Department of Environment and Conservation 2007)
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Australia and New Zealand Environment and Conservation Council (ANZECC) 2000 and 2018)
- Guidelines for Managing Risks in Recreational Water (National Health and Medical Research Council, National Resource Management Ministerial Council 2008)
- Australian Drinking Water Guidelines 6 (National Health and Medical Research Council, National Resource Management Ministerial Council 2015)
- Preliminary Screening Level for Human Health Risk Assessment Hydro Kurri Kurri Aluminium Smelter (ENVIRON 2013b).

7.2.3 Potential Beneficial Uses

NSW DEC (2007) indicates that for assessing groundwater quality, it is first necessary to assess the beneficial uses of groundwater and surface water down gradient of the site.

The closest surface water receptor to the site is a dam and then Swamp Creek located approximately 1.5 km to the north-east of the Smelter Site within an area of the Buffer Zone used for farming. This drainage area discharges into Wentworth Swamp, which in turn discharges to the Hunter River approximately 15 km north-east of the Smelter Site near Maitland.

Surface water within Swamp Creek is described generally neutral, ranging between pH 7.0 and 7.8 and conductivity was generally fresh, ranging from 626 µS/cm to 1520 µS/cm. This surface water body is considered to be a fresh water receptor and supports the following beneficial uses:

- Discharge into Swamp Creek, which supports aquatic ecosystems and potentially flows into the Hunter River.
- Recreational use of Swamp Creek for swimming and fishing.
- Abstraction of water from Swamp Creek may also be used for stock watering and/ or irrigation.

It is noted that drinking water has not been included as a potential beneficial use of water from Swamp Creek for the following reasons:

- Drinking water supply to the local communities is reticulated and originates from Chichester Dam on the Chichester River.
- The Kurri Waste Water Treatment Works is located up gradient of the site. The works has a licensed discharge point into Swamp Creek.

Groundwater is expected to follow the topography and flow north-east towards the dam and Swamp Creek. Water level gauging completed during previous investigations confirmed the groundwater flow direction to the north-east.

According to the Office of Industry and Investment, NSW, there are 17 licensed groundwater abstractions (bores) located within the Smelter Site, which are known to be associated with monitoring of groundwater impact at the Capped Waste Stockpile. There are no other licensed groundwater bores within 2 km of the Smelter Site.

The shallow estuarine aquifer beneath the Site is ephemeral in nature with a low yield and as such, this aquifer is not viable for beneficial uses such as drinking water, stock watering or irrigation.

7.2.4 Appropriate Criteria for Groundwater

The review of potential beneficial uses of the shallow estuarine groundwater aquifer did not identify any potential beneficial uses. As such, validation criteria for demonstrating successful source removal (excavation of stockpiled wastes and contaminated soil) and secondary removal (extraction and treatment of leachate within the footprint of the Capped Waste Stockpile) will be trend analysis following a minimum of 2 years of quarterly monitoring of those wells required to be monitored under the EPL. Wells are to show stable or reducing trends in the concentrations of soluble fluoride, cyanide and pH.

7.2.5 Appropriate Criteria for Surface Water

Based on the review of potential beneficial uses of surface water within the closest receptor, the criteria for protection of aquatic ecosystems, irrigation, stock watering and recreational use will be used for evaluating surface water quality.

The investigation levels presented in ANZECC and ARMCANZ (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality are considered applicable for the protection of aquatic ecosystems of receiving waters. ANZECC (2000) advocates a site-specific approach to developing guideline values based on such factors as local biological affects data and the current levels of disturbance of the ecosystem. The guidelines present 'low risk trigger values' which are defined as concentrations of key performance parameters below which there is a low risk of adverse biological effects. If these trigger values are exceeded, then further action is required which may include further site-specific investigations to assess potential contamination or management and remedial actions.

Low risk trigger values are presented in Table 3.4.1 of ANZECC (2000) for the protection of 80-99% of species in fresh and marine waters, with trigger values depending on the health of the receiving waters.

Surface water results will be compared against trigger values for the protection of 95% of freshwater species. A 95% protection of fresh water species was selected due to the indication from the Hunter Catchment Management Trust that declining stream water quality and a reduction in diversity of native plants and animals has occurred in the last ten years.

Guidelines for Managing Risks in Recreational Water (2008) indicates that a qualitative assessment of recreational use can be undertaken using 10 times the concentrations of chemicals stipulated in the Australian Drinking Water Guidelines (2015). This is based on an assumed contribution for swimming equivalent to 10% of drinking water consumption.

The ENVIRON (2013b) HHRA identified a preliminary screening criteria of 1.5 mg/L for fluoride for recreational use. This guideline value has been adopted in this evaluation, as Swamp Creek, the closest surface water body, is used recreationally. The guideline that is protective of aquatic ecosystems has not been developed.

A summary of the remediation acceptance criteria for surface water and groundwater are provided in **Table 7-5.**

Table 7-5: Surface Water Validation Criteria (mg/L)

Contaminant	95% Protection for	Irrigation	Stock	Recreational[4]
Aluminium	0.055	5	5	9[5]
Fluoride	No guideline	1	2	1.5[5]
Free Cyanide	0.007	No guideline	No guideline	0.8
pH	6.5 - 8[1]	No guideline	No guideline	5 - 9
Electrical conductivity (µS/cm)	No guideline	4500 - 7700[2], 12,200[3]	No guideline	No guideline

[1] Values for lowland rivers from Table 3.3.2 in ANZECC (2000)

[2] Values for tolerant crops from Table 4.2.4 in ANZECC (2000)

[3] Value from Table 4.2.4 in ANZECC (2000) for where electrical conductivity is 'generally too saline' for plant growth

[4] Recreational guidelines based on 10 times that stipulated in the drinking water guidelines may merit further consideration (NHMRC 2008)

[5] Site-specific: fluoride and aluminium recreational values are site-specific and were calculated in the Preliminary Screening

Level Health Risk Assessment for Fluoride and Aluminium (ENVIRON, 2013b)

8. VALIDATION SAMPLING AND ANALYSIS QUALITY PLAN

The RAP included an overview of the plan for validation of remedial works. In relation to AEC 1: Capped Waste Stockpile and associated leachate plume including construction of the Containment Cell. Validation works are required to confirm that:

- Capping removed from the Capped Waste Stockpile is suitable for on-site reuse
- All wastes and contaminated soil have been removed from the Capped Waste Stockpile
- All wastes stored at other areas of the Smelter Site were appropriately relocated to the Containment Cell
- The Containment Cell has been constructed in accordance with the design
- Materials imported for the construction of the Containment Cell are suitable
- Materials used to backfill or landscape the Capped Waste Stockpile following removal of wastes are suitable
- Contaminated materials were appropriately treated (where required) and compatibly placed within the Containment Cell
- Leachate from the containment cell was appropriately managed during cell construction
- The Containment Cell is performing as required in relation to gas and leachate generation following construction
- Groundwater is suitable for proposed land use following remediation.

Validation data quality objectives (DQOs) have been developed for each validation task in the Sections below. Validation works listed above have been grouped into the following elements:

- Materials Suitability
- Materials Tracking
- Materials Treatment
- Containment Cell Construction
- Leachate Management
- Long Term Performance – Containment Cell
- Long Term Performance – Leachate Plume

The DQO process is a systemic, seven step process that defines the criteria that the validation sampling should satisfy in accordance with the Guidelines for the NSW Site Auditor Scheme (3rd Edition) (NSW EPA 2017).

The seven step DQOs process comprises:

- Step 1: State the problem
- Step 2: Identify the decisions/ goal of the study
- Step 3: Identify the information inputs
- Step 4: Define the boundaries of the study
- Step 5: Develop the analytical approach
- Step 6: Specify the performance or acceptance criteria
- Step 7: Develop the plan for obtaining data

8.1 Definition of the Study Boundary (Step 4)

For the purpose of validation works at the Smelter Site, the boundaries of the study (Step 4) are defined below.

The cadastral boundary of the Smelter Site is outlined in **Section 2.1** and shown in **Figure 2, Appendix 1**. As AECs requiring remediation are limited to the developed area of the Smelter Site, the study boundary excludes surrounding bushland, as shown in **Figure 2, Appendix 1**.

For groundwater within the leachate plume downgradient of the Capped Waste Stockpile, the study boundary extends into bushland to the east of the developed portion of the smelter, as shown in **Figure 2, Appendix 1**.

The vertical study boundary for soil is 1.5 m bgs. Impacts to soil were observed to be shallow, within fill material and generally less than 0.6 m bgs. PAH contamination is limited in vertical extent and has not impacted underlying natural soils with the exception of the Capped Waste Stockpile.

9. DATA QUALITY OBJECTIVES – MATERIALS SUITABILITY

9.1 Step 1: State the Problem

Remediation of the Capped Waste Stockpile is to be completed via excavation and relocation of wastes from AEC 1: Capped Waste Stockpile, contaminated soil from remaining AECs to be remediated and stockpiled wastes from the demolition of the smelter to a purpose-built Containment Cell. These works will include the removal and re-use of the clay used to cap the Capped Waste Stockpile. Assessment of the clay is required to ensure it is suitable for on-site reuse.

The Containment Cell is to be constructed with materials to be imported to the Smelter Site. Validation is required to demonstrate that imported materials are suitable for their proposed use. Materials proposed to be imported for the Containment Cell construction include the following:

- Geotechnical materials that meet material specifications such as geofabrics and liners
- Natural and engineered soils and gravels and referred to as imported materials

9.2 Step 2: Identify the Decisions/Goal of the Study

Materials to be re-used on site and materials to be imported for the construction of the Containment Cell must be suitable for their proposed use. Material suitability will be assessed as follows:

- Clay capping: This material will be assessed as suitable for on-site reuse via the collection and analysis of sufficient soil samples to characterise the material, with analysis for Contaminants of Concern at the Smelter Site
- Imported materials: These materials are to be supplied with certification from the supplier of their suitability for use.

9.3 Step 3: Identify Inputs to the Decision

For the assessment of materials suitability, the following inputs into the decision-making process are required:

- Clay capping: Laboratory analytical results and assessment of these results against the site criteria
- Imported materials: Certification records from each supplier.

9.4 Step 4: Define the Study Boundary

The study boundary has been defined in **Section 8.1**.

9.5 Step 5: Development of Decision Rules or Analytical Approach

The decision rules can be defined as:

- If the results of the analytical data quality control assessment are acceptable, then the data will be deemed suitable for the purpose of assessing material suitability. In this regard, data will be assessed against completeness, comparability, representativeness, precision and accuracy.
- If the results of the analytical data quality control assessment are not acceptable, then additional data will be required.
- In relation to the importation of materials to the Smelter Site, if the supplier is unable to provide certification of the suitability of the materials for their use, Ramboll as Hydro's Environmental Representative, will make an assessment of material suitability.

9.6 Step 6: Specific Limits of Decision Error

There are two types of decision errors:

- Sampling errors occur when the sampling program does not adequately detect the variability of a contaminant from point to point across the site. That is, the samples collected are not representative of the site conditions (e.g. an appropriate number of representative samples have not been collected from each stratum to account for estimated variability).
- Measurement errors occur during sample collection, handling, preparation, analysis and data reduction.

If the data received is not in accordance with the defined acceptable limits outlined in Step 5, it may be considered to be an estimate or be rejected. Determination of whether this data may be used or if re-sampling is required will be based on the following tolerable limits on decision errors:

- Probability that 95% of data will satisfy the DQIs, therefore a limit on decision error will be 5% that a conclusive statement may be incorrect.
- Comparing individual concentrations against the validation criteria and if discrete samples are in excess of the validation criteria level then.
- Comparing the 95% upper confidence limit of mean against the validation criteria, also ensuring that:
  - the standard deviation of the results is less than 50% of the validation criteria.
  - no single value exceed 250% of the validation criteria.
  - Closeness of the result to the validation criteria.
  - Specific contaminant of concern (e.g. response to carcinogens may be more conservative).
  - The area of site in question and the potential lateral and vertical extent of questionable information.
  - Whether the uncertainty can be effectively managed by site management controls or plans.

The potential for significant decision errors will be minimised by:

- Ensuring the quality assurance/ quality control (QA/QC) are followed to assess that the data satisfies the DQIs.
- Assessment of whether appropriate sampling and analytical densities were completed for the purposes of the investigation and future site use.
- Ensuring that the validation criteria was appropriate for the proposed use of the Site.

If any of the validation procedures or criteria identified are not followed or met, this will constitute a non-conformance. The significance of the non-conformance will determine if rectification is required after discussion with the Site Auditor.

9.7 Step 7: Optimise the Design for Obtaining Data

In relation to suitability of materials for on-site reuse, the sampling plan for clay capping from the Capped Waste Stockpile is as follows:

- Soil sampling will be completed at a rate of one sample per 500 m^3, estimated to be 24 samples for 12,000 m^3 of capping (comprising a 900mm thick cap and 450mm of topsoil)
- Soil samples will be collected during the stripping of the clay from the Capped Waste Stockpile
- Quality assurance/ quality control (QA/QC) samples will be collected as follows:

  - Intra-laboratory duplicate samples will be collected at a rate of one sample per 10 primary samples
  - Inter-laboratory duplicate samples will be collected at a rate of one sample per 20 primary samples
  - Rinsate blank samples will be collected from reusable sampling equipment that requires decontamination during a sample event, with one rinsate blank per sampling event as required
- Soil samples will be analysed for Contaminants of Concern at the Smelter Site, those being soluble fluoride, TRH and PAH.
- Visual validation will be completed to assess for bonded asbestos containing materials (ACM) fragments.

In relation to imported materials, the supplier is to provide certification of the suitability of the materials supplied and this is to be kept on file for validation reporting.

10. DATA QUALITY OBJECTIVES – MATERIALS TRACKING

10.1 Step 1: State the Problem

Remedial works at the Smelter Site include the relocation of waste materials at the site from their current location to the newly constructed Containment Cell. Materials from the following locations require relocation:

- AEC 1: Capped Waste Stockpile
- AEC 2: Anode Waste Pile
- AEC 5: Drainage Lines
- AEC 6: East Surge Pond
- Dickson Road South
- Dickson Road Stockpile
- 60C Contaminated Soil Stockpile
- Materials stockpiled within 7A Bake Furnace Tubs
- Materials stockpiled within Building 68C
- Concrete impacted with bonded ACM materials stockpiled along the northern Smelter fenceline

Materials tracking is required to ensure that all required materials are relocated into the Containment Cell and that any materials requiring treatment by gypsum are adequately treated.

The construction of the Containment Cell requires relocation of clay capping and the importation of materials. Tracking of these materials is required.

10.2 Step 2: Identify the Decisions/Goal of the Study

Materials tracking is required to ensure that all required materials are relocated into the Containment Cell. Materials tracking is also required to track the importation and movement of materials associated with the construction of the Containment Cell.

Materials tracking will be deemed to be successful based on the following:

- A Materials Tracking Register is maintained for the duration of the project, with one spreadsheet tracking imported materials and one spreadsheet tracking on-site materials movements
- The Materials Tracking Register is populated with a date, a Source Reference, a Material Type, a Destination and an approximate tonnage
- The Materials Tracking Register is to be included in the Validation Report prepared at the completion of the remedial works.

10.3 Step 3: Identify Inputs to the Decision

For the tracking of materials, the following inputs into the decision-making process are required:

- The Material Type is required to allow an assessment of destination
- The Date of the material movement is required
- The Source Reference and Destination are required
- An approximate tonnage is required.

10.4 Step 4: Define the Study Boundary

The study boundary has been defined in **Section 8.1**.

10.5 Step 5: Development of Decision Rules or Analytical Approach

The decision rules can be defined as:

- If a Materials Tracking Register is maintained for the duration of the remedial works for on-site movement of materials into the Containment Cell and for the importation of materials to the Smelter Site for the construction of the Containment Cell, materials tracking will be considered to be verified.
- If a Materials Tracking Register is not maintained, verification of on-site material movements and importation of materials to site may not be able to be reported.

10.6 Step 6: Specific Limits of Decision Error

Decision errors in relation to materials tracking may occur due to incorrect recording of the Date, Source Reference, Material Type, Destination or Tonnage. Care shall be taken when recording entries into the Materials Tracking Spreadsheet to prevent incorrect recording of material movements.

Incorrect recording of information will constitute a non-conformance. The significance of the non-conformance will determine if rectification is required after discussion with the Site Auditor.

10.7 Step 7: Optimise the Design for Obtaining Data

The Materials Tracking Spreadsheet shall be updated on a regular basis (likely weekly) to ensure that correct records are maintained. Consistent reference will be made to locations for Source References and Destinations using Hydro Aluminium Kurri Kurri site plans as a reference.

11. DATA QUALITY OBJECTIVES – MATERIALS TREATMENT

11.1 Step 1: State the Problem

Waste materials from the Capped Waste Stockpiled are required to be treated with 10% gypsum to reduce the potential for the generation of leachate with high fluoride concentrations. The additional of gypsum is required to be monitored and recorded during the remedial works.

11.2 Step 2: Identify the Decisions/Goal of the Study

An addition of 10% gypsum is required to be added to each truck load of waste material removed from the Capped Waste Stockpile during transport to the Containment Cell. The addition of gypsum will be deemed to be successful when:

- A process is set up on the Smelter Site to automate the addition of 10% gypsum to each truck load of waste during transport between the Capped Waste Stockpile and the Containment Cell
- The addition of gypsum is recorded for inclusion in the Validation Report.

11.3 Step 3: Identify Inputs to the Decision

For materials treatment, the following inputs into the decision-making process are required:

- Recording of the addition of 10% gypsum per truck load of waste is required.

11.4 Step 4: Define the Study Boundary

The study boundary has been defined in **Section 8.1**.

11.5 Step 5: Development of Decision Rules or Analytical Approach

The decision rules can be defined as:

- If the addition of 10% gypsum is recorded for the duration of the remedial works, then materials treatment can be verified.
- If the addition of 10% gypsum is not recorded, materials treatment may not be able to be verified.

11.6 Step 6: Specific Limits of Decision Error

Decision errors in relation to materials treatment may occur due to incorrect recording of the addition of gypsum.

11.7 Step 7: Optimise the Design for Obtaining Data

The addition of 10% gypsum to each truck load of waste from the Capped Waste Stockpile will be set up as an automated process for ease of use. Recording of the addition of 10% gypsum per truck load of waste will be automatically recorded as part of the Materials Tracking Spreadsheet for on-site materials movements.

12. DATA QUALITY OBJECTIVES – CONTAINMENT CELL CONSTRUCTION

12.1 Step 1: State the Problem

A Containment Cell is required to be constructed at the Smelter Site so that aluminium smelter wastes can be placed for long-term storage. The construction of the Containment Cell needs to be verified via a Construction Quality Assurance (CQA) program. A CQA report has been prepared by GHD, who designed the Containment Cell. The requirements of the CQA program must be met as part of the remedial works. A copy of the CQA report is included in **Appendix 3**.

12.2 Step 2: Identify the Decisions/Goal of the Study

The containment cell is constructed in accordance with the design.

12.3 Step 3: Identify Inputs to the Decision

CQA report.

12.4 Step 4: Define the Study Boundary

The study boundary has been defined in **Section 8.1**.

12.5 Step 5: Development of Decision Rules or Analytical Approach

The decision rules can be defined as:

- If the CQA report confirms adequate compliance with the CQA objectives then the requirements are satisfied
- If the CQA report is unable to confirm compliance with the CQA objectives then the requirements are not satisfied.

12.6 Step 6: Specific Limits of Decision Error

The CQA outlines the tolerance for non conformances.

12.7 Step 7: Optimise the Design for Obtaining Data

Hydro will appoint an appropriately qualified person to oversee the quality assurance requirements for the cell construction in accordance with the CQA documentation. A report demonstrating compliance with the CQA requirements will be prepared to demonstrate the requirement is met.

13. DATA QUALITY OBJECTIVES – LEACHATE MANAGEMENT

13.1 Step 1: State the Problem

The remediation of AEC 1: Capped Waste Stockpile will require the management of leachate within the stockpile through a leachate treatment system. The leachate treatment system is required to be constructed and managed in accordance with the design.

13.2 Step 2: Identify the Decisions/Goal of the Study

A leachate treatment system is required to be constructed to manage leachate generated during the remediation of AEC 1: Capped Waste Stockpile. Management of leachate will be deemed to be successful when:

- The leachate management system has been constructed and is operating in accordance with the design
- Concentrations of Contaminants of Concern within treated leachate are below the site criteria

13.3 Step 3: Identify Inputs to the Decision

For leachate management, the following inputs into the decision-making process are required:

- Verification that the leachate treatment system has been constructed and is operating in accordance with the design
- Analytical results of treated leachate.

13.4 Step 4: Define the Study Boundary

The study boundary has been defined in **Section 8.1**.

13.5 Step 5: Development of Decision Rules or Analytical Approach

The decision rules can be defined as:

- If the results of the analytical data quality control assessment are acceptable, then the data will be deemed suitable for the purpose of the project. In this regard, data will be assessed against completeness, comparability, representativeness, precision and accuracy.

13.6 Step 6: Specific Limits of Decision Error

There are two types of decision errors:

- Sampling errors occur when the sampling program does not adequately detect the variability of a contaminant from point to point across the site. That is, the samples collected are not representative of the site conditions (e.g. an appropriate number of representative samples have not been collected from each stratum to account for estimated variability).
- Measurement errors occur during sample collection, handling, preparation, analysis and data reduction.

If the data received is not in accordance with the defined acceptable limits outlined in Step 5, it may be considered to be an estimate or be rejected. Determination of whether this data may be used or if re-sampling is required will be based on the following tolerable limits on decision errors:

- Probability that 95% of data will satisfy the DQIs, therefore a limit on decision error will be 5% that a conclusive statement may be incorrect.
- Comparing individual concentrations against the validation criteria and if discrete samples are in excess of the validation criteria level then.
- Comparing the 95% upper confidence limit of mean against the validation criteria, also ensuring that:

- the standard deviation of the results is less than 50% of the validation criteria.
- no single value exceed 250% of the validation criteria.
- Closeness of the result to the validation criteria.
- Specific contaminant of concern (e.g. response to carcinogens may be more conservative).
- The area of site in question and the potential lateral and vertical extent of questionable information.
- Whether the uncertainty can be effectively managed by site management controls or plans.

The potential for significant decision errors will be minimised by:

- Ensuring the quality assurance/ quality control (QA/QC) are followed to assess that the data satisfies the DQIs.
- Assessment of whether appropriate sampling and analytical densities were completed for the purposes of the investigation and future site use.
- Ensuring that the validation criteria was appropriate for the proposed use of the Site.

If any of the validation procedures or criteria identified are not followed or met, this will constitute a non-conformance. The significance of the non-conformance will determine if rectification is required after discussion with the Site Auditor.

13.7 Step 7: Optimise the Design for Obtaining Data

Data to validate the adequate management of the leachate treatment plant will be developed and implemented by the contractor responsible for the management of the leachate treatment plant.

14. DATA QUALITY OBJECTIVES – CONTAINMENT CELL LONG TERM PERFORMANCE

14.1 Step 1: State the Problem

Following the construction of the Containment Cell, verification of its performance is required over a two-year period.

14.2 Step 2: Identify the Decisions/Goal of the Study

The Containment Cell is monitoring in accordance with the design.

14.3 Step 3: Identify Inputs to the Decision

For the long-term performance of the Containment Cell, the following inputs into the decision-making process are required:

- Monitoring in accordance with the requirements outlined in the final Long Term Environmental Management Plan.

14.4 Step 4: Define the Study Boundary

The study boundary has been defined in **Section 8.1**.

14.5 Step 5: Development of Decision Rules or Analytical Approach

The decision rules can be defined as:

- If monitoring demonstrates that the Containment Cell is functioning in accordance with the design expectations outlined in the long term management plan then the Containment Cell is considered to be meeting the performance requirements and the long term environmental management plan remains a suitable document for the management of the cell
- If monitoring demonstrates that the Containment Cell is not function in accordance with the design expectations then contingency actions outlined in the long term management plan are required.

14.6 Step 6: Specific Limits of Decision Error

There are two types of decision errors:

- Sampling errors occur when the sampling program does not adequately detect the variability of a monitoring criteria. That is, the samples collected are not representative of the site conditions
- Measurement errors occur during sample collection, handling, preparation, analysis and data reduction.

If the data received is not in accordance with the defined acceptable limits outlined in Step 5, it may be considered to be an estimate or be rejected. Determination of whether this data may be used or if re-sampling is required will be based on the following tolerable limits on decision errors:

- Probability that 95% of data will satisfy the DQIs, therefore a limit on decision error will be 5% that a conclusive statement may be incorrect.
- Comparing individual concentrations against the validation criteria and if discrete samples are in excess of the validation criteria level then.
- Comparing the 95% upper confidence limit of mean against the validation criteria, also ensuring that:
  - the standard deviation of the results is less than 50% of the validation criteria.

- no single value exceed 250% of the validation criteria.
- Closeness of the result to the validation criteria.
- Specific contaminant of concern (e.g. response to carcinogens may be more conservative).
- The area of site in question and the potential lateral and vertical extent of questionable information.
- Whether the uncertainty can be effectively managed by site management controls or plans.

The potential for significant decision errors will be minimised by:

- Ensuring the quality assurance/ quality control (QA/QC) are followed to assess that the data satisfies the DQIs.
- Assessment of whether appropriate sampling and analytical densities were completed for the purposes of the investigation and future site use.
- Ensuring that the validation criteria was appropriate for the proposed use of the Site.

If any of the validation procedures or criteria identified are not followed or met, this will constitute a non-conformance. The significance of the non-conformance will determine if rectification is required after discussion with the Site Auditor.

14.7 Step 7: Optimise the Design for Obtaining Data

Monitoring is outlined in the Long Term Management Plan.

15. DATA QUALITY OBJECTIVES – LEACHATE PLUME LONG TERM PERFORMANCE

15.1 Step 1: State the Problem

Stockpiling of waste materials at AEC 1: Capped Waste Stockpile has resulted in a leachate plume that extends 350 m from the north eastern corner of the stockpile within shallow groundwater.

Remediation of AEC 1: Capped Waste Stockpile will remove the source of leachate plume.

Treatment of leachate located within AEC 1: Capped Waste Stockpile through the leachate treatment system will remove a secondary source of contamination.

Following source removal, monitoring of the long term performance of the leachate plume is required to demonstrate improvement of fluoride concentrations in the leachate plume.

15.2 Step 2: Identify the Decisions/Goal of the Study

Assessment of the long-term performance of the leachate plume is required following removal of the primary and secondary sources of contamination. The assessment will be deemed to be successful when:

- Groundwater monitoring of the leachate plume has been completed on a quarterly basis for a period of two years following removal of AEC 1: Capped Waste Stockpile
- Assessment of data collected during quarterly monitoring indicates that pH and concentrations of fluoride within the leachate plume show a decreasing trend using Mann-Kendall trend analysis

15.3 Step 3: Identify Inputs to the Decision

For the assessment of the long-term performance of the leachate plume, the following inputs into the decision-making process are required:

- Analytical results from quarterly groundwater monitoring events for a period of two years following removal of the Capped Waste Stockpile
- Mann-Kendall analysis of analytical data
- Relevant criteria for assessment

15.4 Step 4: Define the Study Boundary

The study boundary has been defined in **Section 9.1**.

15.5 Step 5: Development of Decision Rules or Analytical Approach

The decision rules can be defined as:

- If the results of the analytical data quality control assessment are acceptable, then the data will be deemed suitable for the purpose of the project. In this regard, data will be assessed against completeness, comparability, representativeness, precision and accuracy.

15.6 Step 6: Specific Limits of Decision Error

There are two types of decision errors:

- Sampling errors occur when the sampling program does not adequately detect the variability of a contaminant from point to point across the site. That is, the samples collected are not representative of the site conditions (e.g. an appropriate number of representative samples have not been collected from each stratum to account for estimated variability).
- Measurement errors occur during sample collection, handling, preparation, analysis and data reduction.

If the data received is not in accordance with the defined acceptable limits outlined in Step 5, it may be considered to be an estimate or be rejected. Determination of whether this data may be used or if re-sampling is required will be based on the following tolerable limits on decision errors:

- Probability that 95% of data will satisfy the DQIs, therefore a limit on decision error will be 5% that a conclusive statement may be incorrect.
- Comparing individual concentrations against the validation criteria and if discrete samples are in excess of the validation criteria level then.
- Comparing the 95% upper confidence limit of mean against the validation criteria, also ensuring that:
  - the standard deviation of the results is less than 50% of the validation criteria.
  - no single value exceed 250% of the validation criteria.
  - Closeness of the result to the validation criteria.
  - Specific contaminant of concern (e.g. response to carcinogens may be more conservative).
  - The area of site in question and the potential lateral and vertical extent of questionable information.
  - Whether the uncertainty can be effectively managed by site management controls or plans.

The potential for significant decision errors will be minimised by:

- Ensuring the quality assurance/ quality control (QA/QC) are followed to assess that the data satisfies the DQIs.
- Assessment of whether appropriate sampling and analytical densities were completed for the purposes of the investigation and future site use.
- Ensuring that the validation criteria was appropriate for the proposed use of the Site.

If any of the validation procedures or criteria identified are not followed or met, this will constitute a non-conformance. The significance of the non-conformance will determine if rectification is required after discussion with the Site Auditor.

15.7 Step 7: Optimise the Design for Obtaining Data

Since 2013, a network of 25 groundwater wells have been analysed on a quarterly basis to assess trends in pH, fluoride, cyanide and aluminium concentrations within the leachate plume. This network of wells will continue to be used to obtain groundwater data from the leachate plume for the two-year monitoring period following source removal.

16. REPORTING REQUIREMENTS

At the completion of the remedial works, validation reporting will be prepared documenting the remediation and validation works. The following Validation Reports are required based on the works outlined in this VSAQP:

- Report documenting the Containment Cell construction, including the CQA program, materials suitability, materials tracking and materials treatment
- Report documenting leachate management during the removal and relocation of wastes from the Capped Waste Stockpile and associated leachate treatment through the leachate management system
- Report documenting the long-term performance of the Containment Cell, to be prepared two years following construction completion
- Report documenting the long-term performance of the leachate plume, to be prepared two years following primary and secondary source removal

Each Validation Report shall include the following:

- Executive Summary
- Introduction, including Objectives and Scope of Work
- Site Description
- Site Condition and Surrounding Environment
- Geology and Hydrogeology
- Summary of this VSAQP
- Data Quality Objectives and Data Quality Indicators specific to the content of each report
- Reporting of remediation and validation activities specific to each report
- Reporting of QC/QC analysis specific to each report
- Reporting of regulatory requirements specific to each report
- Conclusions and recommendations specific to each report

17. LIMITATIONS

Ramboll Australia Pty Ltd prepared this report in accordance with the scope of work as outlined in our proposal to Hydro Aluminium Kurri Kurri Pty Ltd and in accordance with our understanding and interpretation of current regulatory standards.

A representative program of sampling and laboratory analyses was undertaken as part of this investigation, based on past and present known uses of the Site. While every care has been taken, concentrations of contaminants measured may not be representative of conditions between the locations sampled and investigated. We cannot therefore preclude the presence of materials that may be hazardous.

Site conditions may change over time. This report is based on conditions encountered at the Site at the time of the report and Ramboll disclaims responsibility for any changes that may have occurred after this time.

The conclusions presented in this report represent Ramboll's professional judgment based on information made available during the course of this assignment and are true and correct to the best of Ramboll's knowledge as at the date of the assessment.

Ramboll did not independently verify all of the written or oral information provided to Ramboll during the course of this investigation. While Ramboll has no reason to doubt the accuracy of the information provided to it, the report is complete and accurate only to the extent that the information provided to Ramboll was itself complete and accurate.

This report does not purport to give legal advice. This advice can only be given by qualified legal advisors.

User Reliance

This report has been prepared exclusively for Hydro Aluminium Kurri Kurri Pty Ltd and may not be relied upon by any other person or entity without Ramboll's express written permission.

18. REFERENCES

Australia and New Zealand Environment and Conservation Council (ANZECC) (2000 and 2018) Australian and New Zealand Guidelines for Fresh and Marine Water Quality

Environ (November 2012) Phase 2 Environmental Site Assessment, Kurri Kurri Aluminium Smelter

Environ (October 2013) Phase 1 ESA, Hydro Kurri Kurri Aluminium Smelter

Environ (2013) Preliminary Screening Level for Human Health Risk Assessment, Hydro Kurri Kurri Aluminium Smelter

Environ (June 2014) Hydro Aluminium Kurri Kurri Smelter, Sampling, Analysis and Quality Plan

Environ (January 2015) Phase 2 Environmental Site Assessment, Smelter Site, Additional Investigations

Ramboll Environ (now Ramboll) (July 2018) Remedial Action Plan, Hydro Aluminium Smelter Kurri Kurri

Hunter Catchment Management Trust (HCTM 2000) Wallis and Fishery Creeks Total Catchment Management Strategy

NEPC (1999) National Environmental Protection (Assessment of Site Contamination) Amendment Measure (NEPM) 2013

NHMRC (2008) Guidelines for Managing Risks in Recreational Water

NHMRC (2015) Australian Drinking Water Guidelines

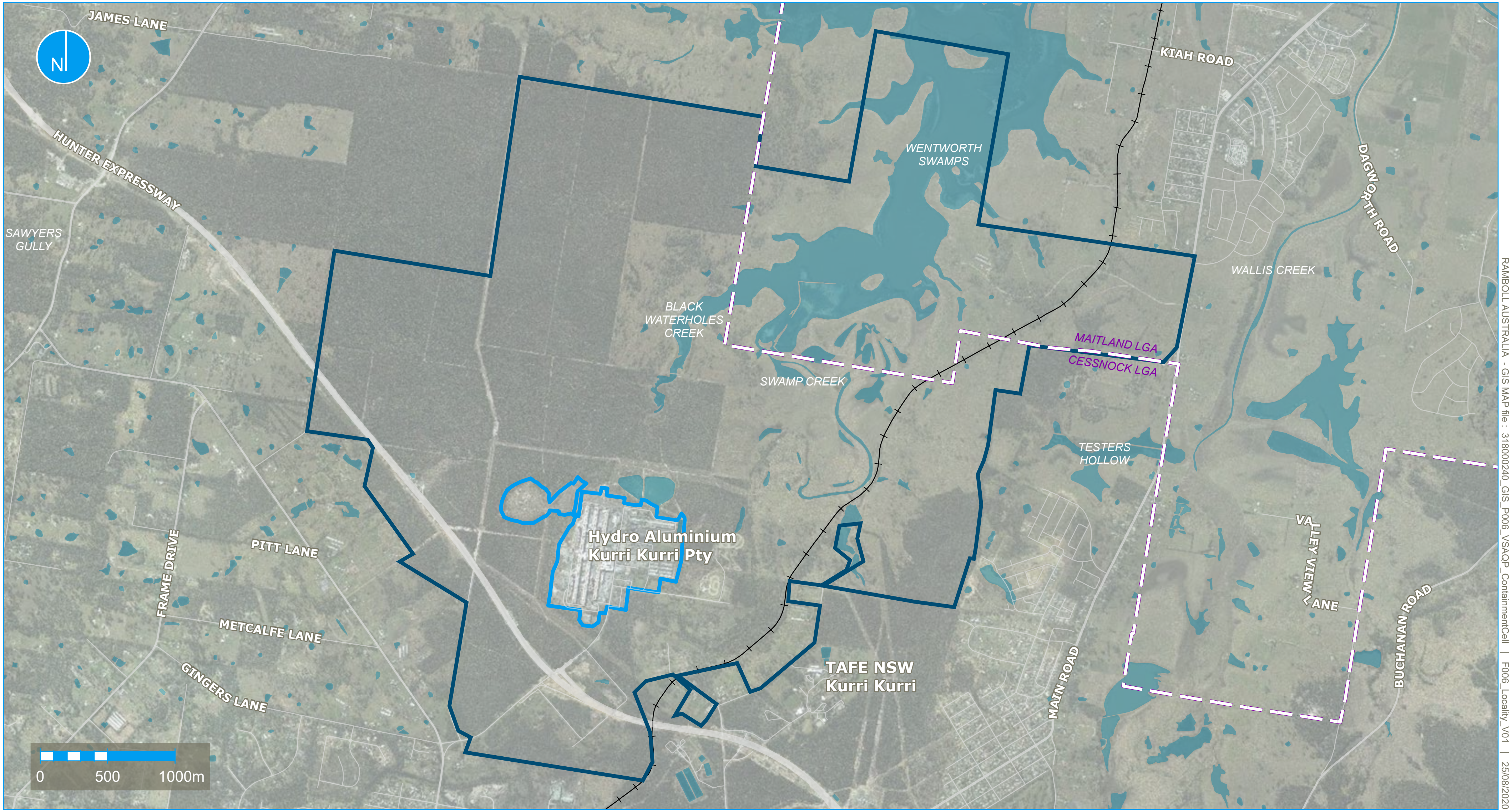
NSW DEC (2007) Guidelines for the Assessment and Management of Groundwater Contamination

NSW EPA (2017) Guidelines for the NSW Site Auditor Scheme (Third Edition)

NSW EPA (1994) Sampling Design Guidelines

NSW EPA (2020) Consultants Reporting on Contaminated Sites, Contaminated Land Guidelines

APPENDIX 1
FIGURES



Imagery © Department of Customer Service 2020

Legend

- Hydro owned land
- Project site
- LGA boundary

Figure 1 | Smelter and Hydro Land Locality Plan

RAMBOLL AUSTRALIA - GIS MAP file : 318000240_GIS_P006_VSAQP_ContainmentCell | F001_Smelter_V01 | 25/08/2020

Aerial photography by Nearmap, flown 15.06.2020

Legend

Project site

A4
1:8,000

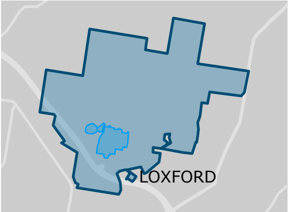


Figure 2 | Smelter Site Location Plan

Legend

- Project site
- Area of Ecological Concern (AEC) 1
- Leachate plume

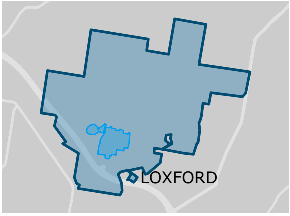


Figure 3 | Location of AEC 1: Capped Waste Stockpile and associated Leachate Plume

RAMBOLL AUSTRALIA - GIS MAP file : 318000240_GIS_P006_VSAQP_ContainmentCell | F003_AECremediation_V01 | 25/08/2020

Aerial photography by Nearmap, flown 15.06.2020

Legend

- Project site
- AEC remediated
- AEC to be remediated
- AEC 27: Substations (remediated)

AECs remediated

AEC 3: Refuelling Area
AEC 4: Diesel Spray Area
AEC 8: Carbon Plant
AEC 26: Bake Furnace Scrubber
AEC 27: Substations
AEC 29: Area East of the Playing Fields

AECs to be remediated

AEC 1: Capped Waste Stockpile
AEC 2: Anode Waste Pile
AEC 5: Drainage Lines
AEC 6: East Surge Pond

A4
1:8,000

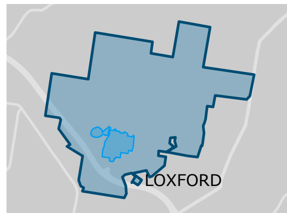


Figure 4 | Location of Remediated AECs and AECs Requiring Remediation

Aerial photography by Nearmap, flown 15.06.2020

Legend

Project site

Groundwater well

A4
1:8,000

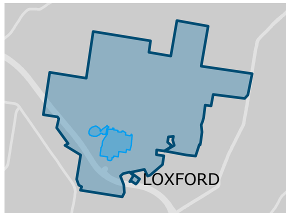
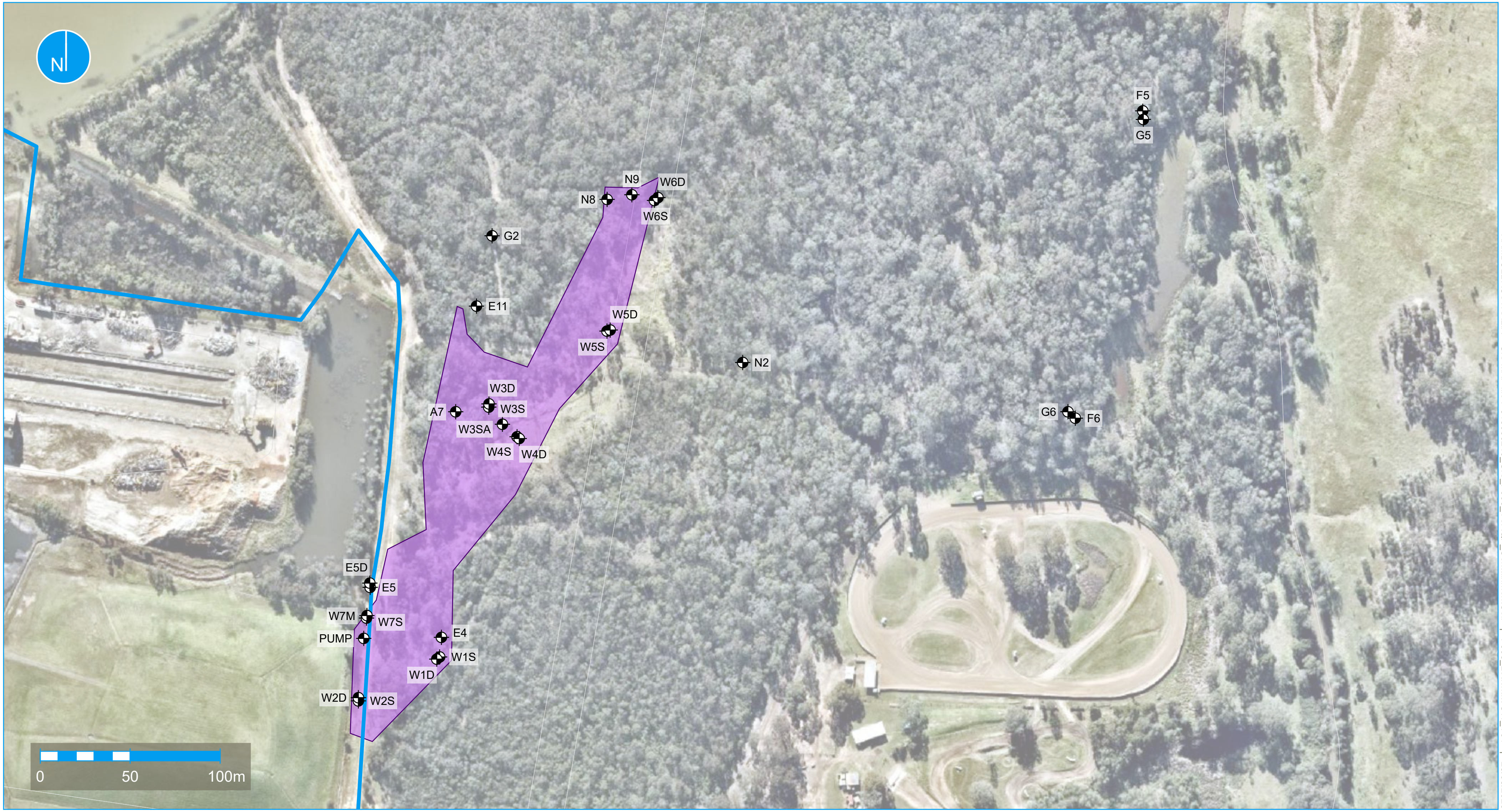


Figure 5 | Location of Smelter Site Groundwater Wells



RAMBOLL AUSTRALIA - GIS MAP file : 318000240_GIS_P006_VSAQP_ContainmentCell | F005_LeachateGW_V01 | 25/08/2020

Aerial photography by Nearmap, flown 15.06.2020

Legend

Project site

Groundwater well

Leachate plume

A4

1:3,000

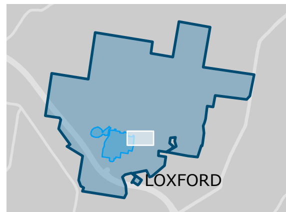


Figure 6 | Location of Groundwater Wells within the Leachate Plume

APPENDIX 2
CQA REPORT

Hydro Aluminium Kurri Kurri Pty Ltd

Containment Cell Design

Construction Quality Assurance (CQA) Plan

October 2017

WATER | ENERGY & RESOURCES | ENVIRONMENT | PROPERTY & BUILDINGS | TRANSPORTATION

Table of contents

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Figure index

1. Introduction

This plan presents the Construction Quality Assurance (CQA) requirements for the construction of the Works (refer section 1.3) at the former Hydro Aluminium Kurri Kurri Aluminium Smelter (the site), and must be read in conjunction with the Works Documents.

1.1 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.

1.2 Purpose

The purpose of this CQA Plan is to define, for the landfill barrier system and leachate collection and conveyance system, construction quality assurance procedures and requirements necessary to demonstrate compliance with the requirements of the Works Documents.

1.3 Scope of Works

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

- Protect the Works Area to prevent unauthorised pedestrian and vehicular access and damage to existing infrastructure and works proposed under this contract. This shall include, but not be limited to, locate and protect existing environmental monitoring wells, gas infrastructure and services to the satisfaction of the Superintendent and other authorities, providing site and traffic management such as temporary signage, fencing, gates, lighting (if necessary) and protection barriers.
- Set out the Works including all associated survey work.

- Install and maintain during construction all necessary erosion and sedimentation control measures.
- Supply and construct all necessary temporary works to facilitate the construction of the works.
- Excavate, fill, compact and grade as necessary to develop the finished surfaces.
- Supply and install the leachate barrier system (including sidewall liner system)
- Supply and install leachate collection and conveyance system.
- Supply and construction all necessary access roads and infrastructure.
- Supply and install the surface water drainage works.
- Supply and install the gas extraction system
- Supply and install the final cap
- Supply record drawings in both digital and hardcopy format.

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:

Superintendent

………………………………………………………………………………………………..

Contact: ………………………………………………………………………………..

Phone: ...…………………………………………………………………………………

Superintendents Representative

………………………………………………………………………………………………..

Contact: ………………………………………………………………………………..

Phone: ...…………………………………………………………………………………

Contractor

………………………………………………………………………………………………..

Contact: ………………………………………………………………………………..

Phone: ...…………………………………………………………………………………

CQA Engineer

………………………………………………………………………………………………..

Contact: ………………………………………………………………………………..

Phone: ...…………………………………………………………………………………

Regulatory Authority

………………………………………………………………………………………………..

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.

The Superintendent shall be the main point of liaison between the Contractor and the CQA Engineer, as well as the Client.

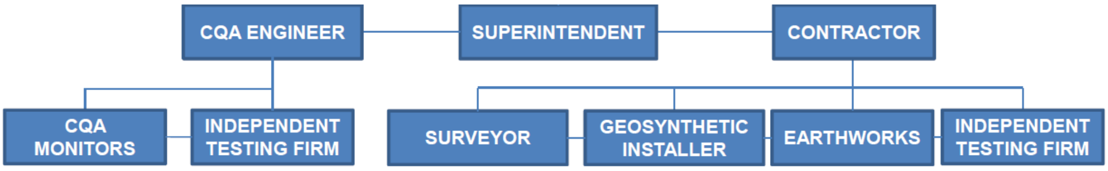

Figure 1 Lines of communication

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 3.4) 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.

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; 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 (eg. 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 m^3 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 Subgrade preparation

During subgrade preparations verify the following:

- The subgrade is smooth, free of voids, and composed of satisfactory materials;
- The subgrade is compacted as specified;
- The lines and levels of the top surface of the subgrade is correct; and
- The subgrade surface is scarified as specified prior to placement of the first lift of fill.

3.12 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; and
- Fill is placed to the lines and levels shown in the Works Documents.

3.13 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.

3.14 Conformance testing

3.14.1 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.

3.14.2 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; and
- The Contractor uses nuclear gauges in the direct transmission mode to measure density.

3.15 Tolerances

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

3.16 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.

3.17 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.

3.18 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; and
- Ensure the Contractor repairs damaged areas and re-establishes grades.

3.19 Weather conditions

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

3.20 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.

3.21 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.

4. Subgrade

4.1 General

The CQA Engineer shall verify the following during subgrade preparation.

The relevant requirements for subgrade preparation in Section 3.11 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 m^3 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.

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 fillshall have provided CQA inspection during installation soil layers for at least three major earthworks projects totalling a minimum of 50,000 m^3 of protective 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. Geonet drainage composite

6.1 General

All individuals' assigned CQA responsibilities for the geonet and geonet drainage composite shall have be 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 m^2 of geosynthetics.

6.2 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.

6.3 Manufacturers 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.

6.4 Manufacturers 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.

6.5 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.

6.6 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 Table 1 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 1 Geonet and geonet drainage composite CQA testing

Test Type	Test Method	Frequency	Comments
Mass per unit area	D5261	1 test per 5 rolls	Laboratory measurement
Thickness	D5199	1 test per 5 rolls	
Tensile strength (machine direction)	D1682	1 test per 10 rolls	Laboratory measurement
Transmissivity (1)	D4716	1 test per 10 rolls	Laboratory measurement
Compressive strength	D1621	1 test per 10 rolls	Laboratory measurement
Apparent opening size of geotextile		1 test per 5 rolls	
Ply adhesion (MARV)	D7005	1 test per 5 rolls	Laboratory measurement

6.7 Roll and sample identification

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

6.8 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.

6.9 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

[1] Hydraulic gradient (1 m/m), Confining stress (>230 kPa), Seating time (100 hours)

- 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.

6.10 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
- 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.

6.11 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 24.2).

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

6.12 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.

7. Sand Drainage Layer

7.1 General

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

All individuals assigned CQA responsibilities for the sand drainage layer shall have provided CQA inspection during installation soil layers for at least three major earthworks projects totalling a minimum of 50,000 m^3 of protective soil layer material.

7.2 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.

7.3 Materials

The CQA Engineer shall:

- Review all test results/reports provided by the Contractor for the proposed sand drainage 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 sand drainage material appear to have changed significantly
- Inspect sand drainage material stockpiles prior to use and advise the Superintendent of the presence of any unsuitable material.

7.4 Delivery, storage and handling

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

7.5 Preparation of surface to receive sand drainage layer

The receiving surface shall be inspected and approved by the CQA Engineer each day that sand drainage 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.

7.6 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 sand drainage material
- Sand drainage 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 sand drainage material is being spread over the underlying geosynthetics
- Wrinkles in underlying geosynthetics are not folding over onto themselves during sand drainage material placement
- Low ground pressure equipment is being used where specified
- Placement of sand drainage material proceeds from a stable working area adjacent to the deployed geosynthetic materials and gradually progresses outward. For slopes, sand drainage 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 sand drainage material is occurring
- Large stockpiles of sand drainage material are not placed on top of in-place geosynthetics
- Thin areas of sand drainage material which could allow underlying geosynthetics to be punctured or torn by construction equipment are repaired immediately.

7.7 Defects and repairs

The CQA Engineer shall visually inspect the sand drainage 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.

7.8 Acceptance

Prior to the final acceptance of the sand drainage 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.

8. Geosynthetic Clay Liner

8.1 General

The CQA Engineer shall verify the following during geosynthetic clay liner (GCL) installation.

8.2 Qualifications

The CQA Engineer assigned CQA responsibilities for the GCL shall have be accredited by the Geosynthetic Certification Institute-Inspectors Certification Program for installation of geosynthetic materials or have provided CQA inspection during installation of GCL for at least three projects totalling a minimum of 100,000 m^2.

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.

8.4 Manufacturers Quality Control

The CQA Engineer shall review the manufacturer’s quality control procedures and test results prior to delivery of GCL 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 geosynthetic clay liner, the geotextile and the bentonite meet the Specification.

8.5 Manufacturers Quality Assurance

The CQA Engineer shall review the manufacturer’s quality assurance procedures and test results prior to delivery of GCL 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.

8.6 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.

8.7 Independent Conformance Testing

The CQA Engineer shall supervise collection of CQA samples by the Geosynthetic Installer for GCL at the rate specified in Table 2 and forward the samples to the CQA Engineers Independent Testing Firm for testing. The testing frequencies shall apply to all GCL products provided as part of the Works.

Each product supplied shall be treated as a separate GCL 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.

Samples shall be cut on a flat surface and the edges taped closed to limit loss of bentonite.

Table 2 lists the independent conformance testing that shall be performed on the GCL prior to installation.

Table 2 GCL independent conformance testing

Test Type	Test Method	Frequency	Comments
Bentonite Clay – Mass @ 0% moisture	ASTM D5993	1 test per 2,500 m^2	Laboratory
Bentonite Clay – Fluid Loss	ASTM D5891	1 test per roll or per 1,250 m^2 (whichever is greater)	Laboratory
Bentonite Clay – Free Swell Index	ASTM D5890	1 test per roll or per 2,500 m^2 (whichever is greater)	Laboratory
Bentonite Clay – Montmorrillonite Content	CSIRO method	1 test per 10,000 m^2	Laboratory
Bentonite Clay – Moisture Content	ASTM D5993	1 test per roll or per 2,500 m^2 (whichever is greater)	Laboratory
Bentonite Clay – Cation exchange capacity	Methylene blue method	1 test per roll or per 2,500 m^2 (whichever is greater)	Laboratory
Strip tensile strength – machine direction	ASTM D6768	1 test per 5,000 m^2	Laboratory
Peel strength	ASTM D6496	1 test per roll or per 1,250 m^2 (whichever is greater)	Laboratory
Hydraulic conductivity	ASTM D5887	1 test per 10,000 m^2	Laboratory

In addition to this testing, GCL thickness and apparent variations in the as placed moisture distribution shall be assessed on-site for each roll during placement. If thickness appears to be variable a check of the variability of the mass per unit area shall be conducted.

8.8 Roll and Sample Identification

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

8.9 Delivery, Storage and Handling

The CQA Engineer shall fill out a receiving inspection report (Section 23.3 and Appendix A) for each delivery of GCL. 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 GCL
- Rolls are shipped, handled and stored in accordance with the approved work method statement and the manufacturer’s instructions

- GCL rolls are packaged in opaque, waterproof, protective coverings. GCL rolls delivered without complete packaging, labelling and documentation shall be either rejected or quarantined based on inspections by the CQA Engineer
- Each roll is labelled in accordance with the Specification
- Rolls which are damaged beyond use are removed from the site.

If the CQA Engineer determines any damaged GCL rolls or partial rolls are suitable for use, written justification for doing so shall be provided.

8.10 Preparation of Surface to Receive Geosynthetic Clay Liner

The receiving surface shall be inspected and approved each day that GCL 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 GCL
- Excessive moisture is not present which may inhibit GCL installation
- 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.

The CQA Engineer shall sign a certificate of subgrade acceptance shall be signed each day GCL materials are placed.

8.11 Installation

The CQA Engineer shall verify the following during installation:

- Installation and movement of GCL 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
- Any visible or suspected damage is recorded and reported, and relevant rolls are tagged and segregated for further investigation
- 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 GCL when they are covered
- There are no tensile stresses in the deployed GCL
- Construction personnel are not smoking or wearing shoes that could damage the GCL
- GCL which has been hydrated prior to being covered is removed and replaced. Hydrated GCL is defined as material, which has become soft as determined by squeezing the material with finger pressure or material that has exhibited swelling.
- 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
- Overlaps are constructed in accordance with the requirements of the Specification
- Bentonite paste is placed along the entire overlap width at the rate as per manufacturer’s instructions
- Adhesives or other approved seaming methods recommended by the manufacturer are used if horizontal seams are allowed on slopes
- Rolls are not dragged across the receiving surface or other deployed GCL. This can result in damage to the GCL. A sacrificial rub sheet may be used to alleviate this problem
- Rolls are not being damaged during placement or covering
- GCL is not hydrated prior to covering.

8.12 Protection

The CQA Engineer shall visually inspect and verify that only those GCL panels which can be anchored and covered before the end of the day are removed from the packaging. If exposed GCL cannot be covered before the end of the day, the CQA Engineer shall verify it is covered with a plastic cover material and ballasted until construction can resume.

8.13 Penetrations

The CQA Engineer shall verify the following:

- Penetrations are located as shown on the plans
- Penetrations are constructed and tested as per the Specification and the manufacturer’s instructions.

8.14 Defects and Repairs

The CQA Engineer shall visually inspect GCL 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.

8.15 Acceptance

Prior to the final acceptance of the GCL 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 GCL deployment
- Review of CQA test results
- Relevant monitoring and inspections undertaken.

9. PE Geomembrane

9.1 General

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

9.2 Qualifications

The CQA Engineer assigned CQA responsibilities for the PE geomembrane shall have be 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 m^2.

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

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.

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

9.4 Manufacturers 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.

9.5 Manufacturers 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.

9.6 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.

9.7 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 3 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 3 lists the independent conformance testing that shall be performed on the PE geomembrane prior to installation.

Table 3 PE geomembrane independent conformance testing

Test Type	Test Method	Frequency	Comments
Thickness (average)	ASTM D5994	One test per 5 rolls or 5,000 m^2 (whichever is greater).	Laboratory measurement
Minimum thickness	ASTM D5994	One test per 5 rolls or 5,000 m^2 (whichever is greater).	Laboratory measurement
Asperity height (min)	ASTM D7466	One test per 5 rolls or 5,000 m^2 (whichever is greater).	Laboratory measurement
Density	ASTM D1505 or D792 (method B)	One test per 5 rolls or 5,000 m^2 (whichever is greater).	Laboratory measurement
Tensile properties (each direction) • Strength at break • Elongation at break • Strength at yield • Elongation at yield	ASTM D6693	One test per 5 rolls or 5,000 m^2 (whichever is greater).	Laboratory measurement
Tear resistance	ASTM D1004	One test per 5 rolls or 5,000 m^2 (whichever is greater).	Laboratory measurement
Puncture resistance	ASTM D4833	One test per 5 rolls or 5,000 m^2 (whichever is greater).	Laboratory measurement
Carbon black content	ASTM D4218	One test per 5 rolls or 5,000 m^2 (whichever is greater).	Laboratory measurement

Test Type	Test Method	Frequency	Comments
Carbon black dispersion	ASTM D5596	One test per 5 rolls or 5,000 m^2 (whichever is greater).	Laboratory measurement
Oxidative Induction Time (OIT) • 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

9.8 Roll and Sample Identification

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

9.9 Delivery, Storage and Handling

The CQA Engineer shall fill out a receiving inspection report (Section 23.3 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.

9.10 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.

9.11 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.

9.12 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.

9.13 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.

9.14 Field Sampling and Testing

9.14.1 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 23.9 and Appendix A)
- Verify seams which fail CQA and/or CQC destructive seam testing are repaired in accordance with the Specification.

9.14.2 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.

9.15 Electrical Leak Location Survey

The CQA Engineer shall be responsible for engaging a Leak Location Contractor on behalf of the Principal to undertake electrical leak location surveys following the installation of all PE geomembranes layers. Electrical leak location surveys shall be undertaken in accordance with Section 14.

9.16 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.

9.17 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.

10. Electrical Leak Location Survey

10.1 General

This section contains the requirements for undertaking electrical leak location surveys. The Principal shall be responsible for engaging a Leak Location Contractor to undertake an electrical leak location surveys required for the Works.

The CQA Engineer may be the Leak Location Contractor.

Two types of leak location surveys shall be undertaken:

- Arc testing leak location survey (following installation of each PE geomembrane layer)
- Dipole leak location survey (following installation of the soil confining layer).

10.2 Standards

Relevant American Society for Testing and Material (ASTM) standards are as follows:

- D6747 – Standard Guide for Selection of Techniques for Electrical Detection of Potential Leak Paths in Geomembranes
- D7007 – Standard Practices for Locating Leak in Geomembranes Covered withWater or Earth Materials
- D7953 Standard Practice for Electrical Leak Location on Exposed Geomembranes Using the Arc Testing Method

Alternate test methods may be considered by the CQA Engineer in consultation with the Principal when requested in writing by the Contractor.

10.3 Submittals

10.3.1 Pre-qualification of Leak Location Contractor

The CQA Engineer shall submit to the Superintendent the following for review and approval prior to selection of a PE geomembrane manufacturer.

- Qualifications of the proposed Leak Location Contractor including the number of years the Leak Location Contractor has performed the proposed survey methods
- Certification that the Leak Location Contractor has previously tested a minimum of 90 ha of geomembrane liner and a minimum of 45 ha of the proposed survey method on at least five projects
- Certification that the leak location surveys shall be supervised by a professional or technician with a minimum of 18 ha of liner testing experience using the proposed method on at least three projects.

10.3.2 Prior to Conducting the Leak Location Surveys

The Contractor shall submit the following to the Superintendent for review and approval prior to conducting the leak location surveys:

- Work method statement for leak location surveys, including any information on any permanent electrodes and wires required during construction, and any installation instructions to be provide to the Contractor prior to the installation of the geomembrane and soil confining layer.

10.3.3 Following Completion of the Leak Location Surveys

The Contractor shall submit the following to the Superintendent for review and approval following completion of each of the leak location surveys:

- A report containing the methods, details and results of the leak location surveys, including a list of leak locations and rectification works undertaken by the Contractor.

10.4 Preparation and Support

Prior to the survey being conducted, the CQA Engineer, in consultation with the Leak Location Contractor, shall verify the Contractor has suitably prepared the PE geomembrane layer for the survey.

10.5 Execution

10.5.1 Arc Testing Leak Location Survey

The arc testing leak location survey shall be performed after the installation of each PE geomembrane layer in accordance with ASTM D7953.

The Leak Location Contractor shall be responsible for calibrating equipment utilised to achieve optimum data quality and sensitivity for the site conditions.

The survey works best when the geomembrane is in intimate contact with the subgrade. Wrinkles are an impediment to conducting a good survey and defects on wrinkles may not be detected.

Therefore, it is usually in the interest of the project to conduct the survey when the liner system is cool and flat, such as in the morning or during the night.

Working on slopes can create safety hazards with slippery surfaces, and may require additional harnessing and slower production rates. The Leak Location Contractor shall account for this in their work method statement.

Leak locations shall be logged, visibly marked, and reported to the CQA Engineer and Superintendent for repair.

10.6 Dipole Leak Location Survey

The dipole leak location survey shall be performed after the placement of the soil confining layer in accordance with ASTM D7007.

The Leak Location Contractor shall be responsible for calibrating equipment utilised to achieve optimum data quality and sensitivity for the site conditions.

Manual measurements shall be made to verify leak signals and to pinpoint the leak positions on top of the soil confining layer for excavation while the survey personnel are on site. Within 300 mm of the liner, the Contractor’s labourers shall hand excavate possible leak locations to expose the liner.

Additional manual measurements shall be made to guide the Contractor’s personnel while they excavate the leak, if required.

After the identification and excavation of a leak, the soil around the leak location shall be tested while the leak is uncovered and cleaned to check for adjacent leaks.

Leak locations shall be logged, visibly marked, and reported to the CQA Engineer and Superintendent for repair.

10.7 Reporting

The Leak Location Contractor shall report the general results of the survey to the CQA Engineer and Superintendent during the daily progress of the field work.

Prior to the demobilisation of the survey personnel from the site, the Leak Location Contractor shall submit a list of locations of the leaks detected to the CQA Engineer and Superintendent.

The Leak Location Contractor shall submit a report documenting the field work and results of the surveys to the CQA Engineer and Superintendent following completion of the field work. The report shall be certified by the CQA Engineer.

11. Geotextile

11.1 General

The CQA Engineer shall verify the following during geotextile installation.

11.2 Qualifications

The CQA Engineer assigned CQA responsibilities for the geotextile shall have be 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 m^2 of geosynthetics.

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

11.3 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.

11.4 Manufacturers 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.

11.5 Manufacturers 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.

11.6 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.

11.7 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 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 4 lists the independent conformance testing that shall be performed on the geotextile prior to installation.

Table 4 Geotextile independent conformance testing

Test Type	Test Method	Frequency	Comments
Mass per unit area	ASTM D5261	1 test per 2,500 m^2	All geotextiles
Grab Tensile strength	ASTM D4632	1 test per 5,000 m^2	All geotextiles
CBR Puncture Strength	ASTM D6241	1 test per 5,000 m^2	All geotextiles
Trapezoidal Tear Strength	ASTM D4533	1 test per 5,000 m^2	All geotextiles
Apparent Opening Size	ASTM D4751	1 test per 5,000 m^2	Separation geotextiles only
Permittivity	ASTM D4491	1 test per 5,000 m^2	Separation geotextiles only

11.8 Roll and Sample Identification

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

11.9 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.

11.10 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.

11.11 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.

11.12 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.

11.13 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.

12. Drainage aggregate

12.1 General

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

12.2 Qualifications

The CQA Engineer assigned CQA responsibilities for the drainage aggregate installation shall have be 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 m^2.

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

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, including any updates made based on the results of the field trial.

12.4 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.

12.5 Independent Conformance Testing

The CQA Engineer shall supervise collection of CQA samples for drainage aggregate at a rate specified in Table 5 and forward the samples to the CQA Engineers Independent Testing Firm for testing.

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

Table 5 Drainage aggregate independent conformance testing

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

12.6 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.

12.7 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.

12.8 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.

12.9 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.

12.10 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.

12.11 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.

13. PE 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 6 lists the independent conformance testing shall be performed on the plastic pipework prior to installation.

Table 6 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;

- 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.

14. Soil confining layer

14.1 General

The CQA Engineer shall verify the following during placement of the Soil confining layer.

All individuals assigned CQA responsibilities for the Soil confining layer shall have provided CQA inspection during installation soil layers for at least three major earthworks projects totalling a minimum of 50,000 m^3 of protective soil layer material.

14.2 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.

14.3 Materials

The CQA Engineer shall:

- Review all test results/reports provided by the Contractor for the proposed soil confining 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 soil confining material appear to have changed significantly
- Inspect material stockpiles prior to use and advise the Superintendent of the presence of any unsuitable material.

14.4 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.

14.5 Preparation of surface to receive Soil confining layer

The receiving surface shall be inspected and approved by the CQA Engineer each day that Soil confining 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.

14.6 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 soil confining material
- Soil confining 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 soil confining material is being spread over the underlying geosynthetics
- Wrinkles in underlying geosynthetics are not folding over onto themselves during soil confining material placement
- Low ground pressure equipment is being used where specified
- Placement of soil confining material proceeds from a stable working area adjacent to the deployed geosynthetic materials and gradually progresses outward. For slopes, soil confining 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 soil confining material is occurring
- Large stockpiles of soil confining material are not placed on top of in-place geosynthetics
- Thin areas of soil confining material which could allow underlying geosynthetics to be punctured or torn by construction equipment are repaired immediately.

14.7 Defects and repairs

The CQA Engineer shall visually inspect the Soil confining 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.

14.8 Acceptance

Prior to the final acceptance of the Soil confining 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.

15. Waste placement

15.1 General

The CQA Engineer shall verify the following during placement of waste.

15.2 Qualifications

The CQA Engineer assigned CQA responsibilities for earthworks shall have provided CQA inspection during placement of waste for at least three major waste projects totalling a minimum of 50,000 m^3 of waste placement activities.

15.3 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.

15.4 Equipment

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

15.5 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.

15.6 Independent Conformance Testing

The CQA Engineer shall supervise CQA tests for waste placement at a rate specified in Table 7.

Table 7 Waste placement independent conformance testing

Test Type	Test Method	Frequency	Comments
Compaction	ASTM D 698	1 per 7,600 m^3	Prior to placement
Density	ASTM D 1556 ASTM D 2922	1 per 20 CQC tests	In-place soils

15.7 Weather conditions

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

15.8 Execution

The CQA Engineer shall verify the following during waste placement:

- Verify stockpiles containing contaminated material are bermed, lined, and covered. Also verify a means of managing leachate is provided.
- Verify waste material is placed so that large void spaces do not exist.
- Compaction of waste is usually specified by requiring several passes of a compactor over all areas of the waste instead of requiring that a specific density criteria be achieved. At least 3 times per 8-hour period, spot-check to make sure the contractor is making the minimum required number of passes for each lift of waste placed.
- For landfill liner systems, verify the contractor's method of placement does not damage the liner.
- Immediately notify the superintendent if unexpected hazardous materials are discovered during waste regrading or placement.
- Verify the contractor minimizes the amount of waste exposed during regrading operations to reduce odour problems.
- Notify the superintendent if odour or volatilization of contaminants becomes a problem. Daily cover may need to be placed over areas of exposed waste.
- When waste is being regraded, look for leachate seeps that present unsuitable conditions for fill placement. Report such seeps to the superintendent
- For landfill liner systems, verify the contractor implements measures to remove runoff which collects in the landfill.
- Check for areas where additional fill needs to be placed due to settlement.
- For landfill liner systems, check interim surveys to verify adequate space is available within the landfill to store all contaminated material.
- Verify final lines and grades of the regraded and in-place waste are correct.

16. Seal bearing layer

16.1 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 m^3 of protective soil layer material.

16.2 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.

16.3 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.

16.4 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.

16.5 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.

16.6 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.

16.7 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.

16.8 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.

17. Revegetation layer

17.1 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.

17.2 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.

17.3 Material

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 conform to 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.

17.4 Preparation of surface to receive revegetation 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.

17.5 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.

17.6 Seeding and 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.

17.7 Compaction

As per Section 3.13.

17.8 Construction quality control testing

As per Section 2.9

17.9 Tolerances

As per Section 3.15.

17.10 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.

17.11 Revegetation

The CQA Engineer shall regularly inspect revegetation works completed by the Contractor and recommend rejection or approval to the Superintendent.

17.12 Maintenance

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

17.13 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.

18. Field Trials

18.1 General

The CQA Engineer shall verify the following during the field trials.

18.2 Qualifications

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

18.3 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.

18.4 Field trial placement

During the field trials, 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.

19. Drainage and stormwater infrastructure

19.1 General

The CQA Engineer shall verify the following during drainage and stormwater infrastructure construction.

19.2 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.

19.3 Material

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

19.4 Equipment

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

19.5 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.

19.6 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.

19.7 Excavation

The CQA Engineer shall verify the excavation for drainage and stormwater infrastructure subgrade is in accordance to Section 3.

19.8 Filling

The CQA Engineer shall verify the filling for drainage and stormwater infrastructure subgrade is in accordance to Section 3.

19.9 Compaction

The CQA Engineer shall verify the compaction for drainage and stormwater infrastructure subgrade is in accordance to Section 3.

19.10 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
- Trafficking with heavy machinery is avoided after construction or placement
- Oversize and angular material which could damage geosynthetics (if any) has been removed prior to placement
- Underlying geosynthetics (if any) 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 (if any) are not folding over onto themselves during aggregate placement
- Low ground pressure equipment is being used where specified.
- Visually inspect for dips and reverse grades along swales and channel bottoms.
- Verify inlets and outlets are not obstructed or damaged during construction.

19.11 Tolerances

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

19.12 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.

19.13 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.

19.14 Acceptance

Prior to the final acceptance of construction and installation all drainage and stormwater infrastructure 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

20. Concrete structures

20.1 General

The CQA Engineer shall verify the following during concrete structures construction.

20.2 Qualifications

The CQA Engineer assigned CQA responsibilities for earthworks shall have provided CQA inspection during construction of concrete structures for at least three documented projects including concrete structure construction.

20.3 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.

20.4 Materials

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

20.5 Equipment

Verify equipment used to handle, place, compact, finish and cure concrete is in accordance with the Works Documents and the manufacturer's recommendations.

20.6 Delivery, storage and handling

Be present during delivery and unloading and verify the following:

- Concrete materials are not damaged during shipping, storage, and handling;
- Deliveries are properly recorded;
- The correct material type, strength, and sizes have been delivered;

20.7 Manufacturer Quality Control testing

Verify that material 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 material.

20.8 Preparation of surface to receive concrete

The receiving surface shall be inspected and approved by the CQA Enginee on each occasion that concrete is constructed r. 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 concrete once hardened
- The receiving surface is free from abrupt breaks, sharp objects, or other foreign material
- The receiving surface has not been damaged by inclement weather

20.9 Placing, compaction and finishing

Verify the following during concrete handling, placing and compaction:

- Segregation or loss of materials are minimised
- Premature stiffening is minimised
- Production of monolithic mass between planned joined or the extremities of structure
- Formwork is completely filled to intended level, expel entrap air and closely surround all reinforcement, tendons, ducts, anchorages, embedment and fixings
- Provide the specified finish to the formed surfaces of the structure
- Finish surface to achieve specified dimensions, falls, tolerances or similar details relating to the shape and uniformity of surfaces, cover from surface to reinforcement, tendons ducts and texture of the surface

21. Landfill gas system

21.1 General

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

21.2 Equipment

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

21.3 Delivery, storage and handling

Be present during delivery and unloading and verify the following:

- Landfill gas system materials and 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.

21.4 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.

21.5 Independent Conformance Testing

Table 8 lists the independent conformance testing shall be performed on the components of the landfill gas system prior to installation.

Table 8 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

21.6 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;
- 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

21.7 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.

21.8 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

22. Roads infrastructure

22.1 General

The CQA Engineer shall verify the following during construction of roads infrastructure.

22.2 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.

22.3 Material

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

22.4 Equipment

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

22.5 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.

22.6 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.

22.7 Excavation

The CQA Engineer shall verify the excavation for roads infrastructure subgrade is in accordance to Section 3.

22.8 Compaction

The CQA Engineer shall verify the compaction for roads infrastructure subgrade is in accordance to Section 3.

22.9 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
- Trafficking with heavy machinery is avoided after construction or placement of bitumen (if any)
- Low ground pressure equipment is being used where specified.

22.10 Tolerances

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

22.11 Weather conditions

Verify that roads infrastructure construction does not occur during periods of excessive rain, or if other detrimental weather conditions exist.

22.12 Defects and Repairs

If a road material 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.

22.13 Acceptance

Prior to the final acceptance of construction all road infrastructures 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

23. Appurtenances

23.1 Temporary access ramps

The CQA Engineer shall verify the following:

- That the construction Contractor complies with requirements concerning vehicle speeds and number of vehicles on the access ramp
- That construction equipment is not braking sharply while on the ramp
- Inspect the access ramp daily for cracks and slippage of the protective soil layer. Also verify the protective soil layer is not thinning due to traffic or erosion.

23.2 Sumps

Sumps are very labour intensive and difficult to construct. Continuous visual inspection during construction activities shall be performed in sump areas by the CQA Engineer. The CQA Engineer shall verify the following:

- Carefully inspect placement of sand and aggregate to confirm underlying geosynthetics are not being damaged
- Confirm pipe perforations meet specified requirements and are placed at the correct locations
- Pumps and other mechanical equipment are in accordance with the Specification and manufacturer's instructions
- That test operation of pumps, level alarms, valves, switches and controls have been performed in accordance with manufacturer's recommendations and all equipment is operational.

23.3 Trenches

The CQA Engineer shall verify the following:

- That trenches are constructed at the proper depth and alignment
- That any pipes in the trenches are placed at the proper lines and grades
- If geosynthetics are included in trenches, ensure that subgrade/sidewall protrusions or backfill placement does not damage the geosynthetics.

23.4 Swales and channels

- Visually inspect for dips and reverse grades along swales and channel bottoms.
- Verify inlets and outlets are not obstructed or damaged during construction.

24. CQA documentation

24.1 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.

24.2 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
- CQC and 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

24.3 Receiving Inspection Report

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

24.4 Certificate of Subgrade Acceptance

A certificate of subgrade acceptance shall be signed each day geomembrane or GCL materials are placed. Each certificate shall be signed by the Geosynthetic Installer, the Contractor and CQA Engineer prior to installation of the geomembrane or GCL. The area being accepted must be described on the certificate.

24.5 Geomembrane Panel Deployment Log

This data sheet shall be used to record geomembrane panel numbers as they are placed in the field and to cross-reference assigned panel numbers with roll numbers. The weather conditions, time and temperature at placement shall be recorded on the log. Measured dimensions of the geomembrane shall also be recorded on the log.

24.6 Geomembrane Trial Seam Data Sheet

Test results for each trial seam shall be recorded on the geomembrane trial seam data sheet.

24.7 Geomembrane Seam Log

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

24.8 Geomembrane Defects and Repairs

Each geomembrane defect and repair shall be recorded on a geomembrane repair log.

24.9 Non-destructive and Destructive Geomembrane Seam Testing Data Sheets

These data sheets shall be used to record test results for all non-destructive and destructive geomembrane seam tests.

24.10 Field Moisture and Density Test Result Data Sheet

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

24.11 Test Report

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

24.12 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.

24.13 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.

24.14 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
- A reviewed copy of all CQC reports undertaken, including earthworks, geosynthetics and other works aforementioned in this CQA Plan
- 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 and CQC reports
- Record Drawings which include the final geomembrane panel placement layout and all survey conformance data:
  - Plan view of the perimeter of the cell;
  - The installed alignments and grades of the groundwater drainage system within the cell;
  - Finished installed contours of the prepared subgrade within the cell (determined prior to placement of the geosynthetics);
  - The installed alignments and grades of the leachate collection pipework within the cell (all determined prior to placement of the leachate drainage layer);

- Finished installed contours of the leachate drainage layer and covering geotextile within the cell; and
- All test locations, showing as a minimum: approximate location, identification number, date sampled and type of testing completed.

- 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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Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
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APPENDIX 7
CONTAINMENT CELL CONSTRUCTION ENVIRONMENTAL MANAGEMENT MEASURES (EXTRACTS FROM THE RWEMP)

Overarching Environmental Management Objectives, Controls and Responsibilities

Issue/ Objective	Environmental Management Control	Relevant Management Plan	Person/s Responsible	Remediation Contractor Documentation
Site Access				
Maintain safe and efficient access throughout the site during demolition and remediation activities	Implementation of the Demolition and Remediation Access Plan is provided in **Appendix B**.	Demolition and Remediation Access Plan (**Appendix B**)	Construction Manager Demolition Contractor Remediation Contractor	
Traffic and Access				
Minimise impacts on local traffic	Implementation of the Traffic Management Plan provided in **Appendix C**.	Traffic Management Plan (**Appendix C**)	Construction Manager / Project Manager Demolition Contractor Remediation Contractor	Remediation Traffic Management Plan
Air Quality				
Minimise dust generation and off-site air quality impacts	Implementation of the Air Quality Management Plan provided in **Appendix D**.	Air Quality Management Plan (**Appendix D**)	Construction Manager/ Project Manager Demolition Contractor Remediation Contractor	Remediation Air Quality Management Plan
Noise and Vibration				
Minimise noise and vibration impacts to off-site receptors	Implementation of the Noise and Vibration Management Plan provided in **Appendix E**.	Noise and Vibration Management Plan (**Appendix E**)	Construction Manager/ Project Manager Demolition Contractor Remediation Contractor	Remediation Noise and Vibration Management Plan
Soil and Water				
Protection of water quality and local hydrology	Implementation of the Soil and Water Management Plan provided in **Appendix F**.	Soil and Water Management Plan (**Appendix F**)	Construction Manager/ Project Manager Demolition Contractor Remediation Contractor	Remediation Soil and Water Management Plan

Issue/ Objective	Environmental Management Control	Relevant Management Plan	Person/s Responsible	Remediation Contractor Documentation
Minimise the potential impacts of soil erosion	Implementation of the Soil and Water Management Plan provided in **Appendix F**.	Soil and Water Management Plan (**Appendix F**)	Construction Manager/ Project Manager Demolition Contractor Remediation Contractor	Remediation Soil and Water Management Plan
Minimise the potential impacts from contaminated soil remediation	Implementation of the requirements of the applicable Remediation Action Plans, as described in the Contaminated Soils Management Plan and the Leachate Management Plan that form part of the Soil and Water Management Plan provided in **Appendix F**.	Soil and Water Management Plan (**Appendix F**)	Construction Manager/ Project Manager Remediation Contractors	Remediation Soil and Water Management Plan
Waste				
Minimise waste generation and the amount of waste requiring landfill disposal	Implementation of the Waste Management Plan provided in **Appendix G**.	Waste Management Plan (**Appendix G**)	Construction Manager/ Project Manager Demolition Contractor Remediation Contractor	Remediation Waste Management Plan
Energy Efficiency				
Maximise energy efficiency and minimise greenhouse gas generation	Implementation of the Energy Efficiency Management Plan provided in **Appendix H**.	Energy Efficiency Management Plan (**Appendix H**)	Construction Manager/ Project Manager Demolition Contractor Remediation Contractor	Remediation EMP
Biodiversity				
Minimise the potential impacts on Biodiversity	Implementation of the Biodiversity Management Plan provided in **Appendix I**.	Biodiversity Management Plan (**Appendix I**)	Project Manager Demolition Contractor Remediation Contractor	Remediation EMP

Issue/ Objective	Environmental Management Control	Relevant Management Plan	Person/s Responsible	Remediation Contractor Documentation
Aboriginal Heritage				
Minimise the potential impacts on Aboriginal heritage	Implementation of the Aboriginal Heritage Management Plan provided in **Appendix J**.	Aboriginal Heritage Management Plan (**Appendix J**)	Project Manager Demolition Contractor Remediation Contractor	Remediation EMP
Non-Indigenous Heritage				
Collect records of the Smelter buildings for future reference	In the event that a potential non-indigenous heritage item is unearthed during activities works would cease at that location and the Office of Environment and Heritage would be notified.	EMP	Construction Manager Demolition Contractor Remediation Contractor	Remediation EMP
	Photographs are to be taken of Smelter buildings prior to demolition.	EMP	Construction Manager Demolition Contractors	N/A
	Photographs are to be taken of Smelter buildings during demolition.	EMP	Construction Manager Demolition Contractors	N/A
	Photographs and drawings (from construction, operation and demolition) of the Smelter would be made available to interested historical societies or community groups.	Stakeholder Engagement Plan (**Appendix K**)	Construction Manager Demolition Contractors	N/A

Issue/ Objective	Environmental Management Control	Relevant Management Plan	Person/s Responsible	Remediation Contractor Documentation
Stakeholder Engagement				
Inform the community and other stakeholders of activities at the site	Implementation of the Stakeholder Engagement Plan provided in **Appendix K**.	Stakeholder Engagement Plan (**Appendix K**)	Managing Director Principal Communications Consultant	N/A
Provide mechanisms for the community to request information and to make enquiries or complaints about activities			Managing Director Principal Communications Consultant	N/A
Emergency Response				
Minimise the potential impacts in the event of an emergency	Implementation of the Emergency Services Cooperation Agreement provided in **Appendix M**.	Emergency Services Cooperation Agreement (**Appendix M**)	Construction Manager/ Site Services Manager Demolition Contractor Remediation Contractor WHS Manager	Remediation Emergency Response Management Plan
Health and Safety				
Minimise the potential impacts on site personnel, occupants of neighbouring properties and public road users	Implementation of this EMP and supporting sub-plans.	EMP	Construction Manager/ Site Services Manager Demolition Contractor Remediation Contractor WHS Manager	Remediation Integrated Project Management Plan
	Implementation of the Work Health and Safety Plan.	Health and Safety Plan		Remediation Integrated Project Management Plan
Hazardous Materials				
Minimise the potential health and environmental impacts associated with the removal and handling of hazardous materials	Prior to the commencement of decommissioning or demolition activities, the Hazardous Materials Register is to be inspected to determine if hazardous materials are present.	Hazardous Materials Register	Construction Manager/ Site Services Manager	N/A

Issue/ Objective	Environmental Management Control	Relevant Management Plan	Person/s Responsible	Remediation Contractor Documentation
	Hazardous materials are to be removed in accordance with a Hazardous Materials Management Plan reviewed and approved by the Hydro Project Manager.	EMP Hazardous Materials Register	Construction Manager/ Site Services Manager Demolition Contractor Remediation Contractor	Remediation Asbestos Removal Procedure
	Removed hazardous materials are to be stored and/ or disposed in accordance with the Waste Management Plan provided in **Appendix G**.	Waste Management Plan (**Appendix G**)	Construction Manager/ Site Services Manager Demolition Contractor Remediation Contractor	Remediation Asbestos Removal Procedure
	Demolition contractors are to prepare (prior to commencement of demolition) and implement (if required) an Unexpected Hazardous Materials Protocol.	EMP Hazardous Materials Register	Construction Manager/ Site Services Manager Demolition Contractors	Remediation Waste Management Plan

Specific Containment Cell Environmental Management Measures

Management Measures	Actions	Timing / Frequency	Responsibility	Further Detail
Site Access				
Establish internal access restrictions and alternative access routes for the Smelter prior to the commencement of remediation.	Implement the version of the Smelter Access Control Plan (included in Appendix A) at the commencement of remediation.	Prior to remediation activities	Project Manager	Site Access Plan
	Traffic controls (including the type and location of signage and safety barriers) will be installed in accordance with *Traffic Control at Work Sites Manual* (Roads and Traffic Authority, 2018).	Prior to and during activities	Project Manager	Site Access Plan
	Prohibit queuing on the public road network unless otherwise approved by Council.	Prior to and during activities	Project Manager	Site Access Plan
All personnel required to drive on the Smelter will be informed during the site induction of access restrictions and dynamic nature of changes to access restrictions.	The Smelter Access Control Plan is to be displayed in central locations (such as Site Office, kitchens and crib rooms).	Prior to and during activities	WHS Manager	Site Access Plan
	Vehicle manoeuvring areas will always be kept clear of any obstacles, including parked cars.	During activities	WHS Manager	Site Access Plan
The initial internal access restrictions and alternative access routes will be managed as required to reflect the status of remediation, demolition and decommissioning activities.	Undertake quarterly review of internal access restrictions and access routes to determine whether changes are required.	Prior to and during activities	Project Manager	Site Access Plan
	When access changes are required, update the Control Plan and communicate to all personnel via a toolbox talk and display in central locations (such as Site Office, kitchens and crib rooms).	During activities	WHS Manager	Site Access Plan

Management Measures	Actions	Timing / Frequency	Responsibility	Further Detail
A speed limit of 20 km/hr will be imposed on internal roads within parts of the Smelter (some parts would remain at 12 km/hr).	Install speed limit signage along access roads.	Prior to activities	Project Manager	Site Access Plan
	Communicate speed limit change to all personnel via a toolbox talk.	Prior to and during activities	WHS Manager	Site Access Plan
Air Quality				
All personnel will be informed during the site induction of their obligations to minimise potential air quality and dust and the need to take reasonable and practical measures to minimise impacts.	Air quality obligations and management measures to be communicated to personnel during the relevant site induction (Hydro or Contractor's site induction).	Prior to and during activities	WHS Manager Remediation Contractors	Air Quality Management Plan
	Personnel are to report to the Project Manager or Environment Officer any activities that are generating, or have the potential to generate, dust or other air emissions that could have an adverse impact on offsite sensitive receivers.	During activities	All personnel	Air Quality Management Plan
Dust suppression will be used during activities at the Smelter and the Hydro Land.	Watering of unsealed access roads during dusty conditions and if dust is noticed above the wheel height of vehicles.	During demolition As required	Project Manager Remediaiton Contractor Environmental Officer	Air Quality Management Plan
	Where possible, vehicles will use existing sealed roads to minimise dust generation.	During activities	Project Manager Remediation Contractor Site Services Manager	Air Quality Management Plan
	A speed limit of 20 km/hour will be imposed on internal roads.	During activities	Project Manager Remediation Contractor	Air Quality Management Plan
	Sealed roads at the Smelter will be cleaned of dirt and other deposited material that could generate dust.	As required	Project Manager Remediation Contractor	

Management Measures	Actions	Timing / Frequency	Responsibility	Further Detail
	Cutting, grinding or sawing equipment will be used with fitted or suitable dust suppression techniques such as water sprays or local extraction where reasonably practical.	During activities	Project Manager Remediation Contractors	
	Provide and maintain an adequate water supply on the site for effective dust/particulate matter suppression/mitigation. Water sources for dust suppression are: • Use of water from the Smelter water management system. • Potable water supply.	Prior to and during activities	Project Manager Remediation Contractor	Soil and Water Management Plan
	In the event that strong winds are forecast, the activities proposed are to be considered against the predicted wind direction and speed. Where required to avoid impacts on sensitive receivers, activities will be modified or suspended.	During activities	Project Manager Remediation Contractor Environmental Officer	Air Quality Management Plan
	Works will cease in the event that adverse meteorological conditions or extraordinary events lead to conditions that cause unacceptable dust generation.	During activities	Project Manager Remediation Contractor Environmental Officer	Air Quality Management Plan
	Where dust is observed moving in the direction of sensitive receivers and could adversely impact the receivers, dust suppression measures must be implemented.	During activities	Project Manager Remediation Contractor Environmental Officer	Air Quality Management Plan

Management Measures	Actions	Timing / Frequency	Responsibility	Further Detail
Vehicles will be operated and maintained to minimise exhaust emission impacts.	Where possible vehicles and machinery will be turned off or throttled down when not in use.	During activities	Project Manager Remediation Contractor Site Services Manager	Air Quality Management Plan
	Vehicles and machinery will be maintained in accordance with manufacturer's requirements to maximise operational efficiencies and associated exhaust emissions.	Prior to and during activities As per manufacturers requirements.	Project Manager Remediation Contractor Site Services Manager	
Haul routes will be inspected for integrity and, where required, instigate necessary repairs to the surface as soon as reasonably practicable.	Undertake integrity inspections of haul routes within the Smelter.	Prior to and during activities Monthly	Project Manager Remediation Contractor	RWEMP
Transportation, storage and placement of gypsum will be undertaken in a manner which reduces the potential to generate dust.	All vehicles transporting gypsum on public roads will have covered loads.	During remediation activities	Project Manager Remediation Contractor	
	Load levels will not exceed the height of the truck, reducing the material's potential wind and draft exposure.	During remediation activities	Project Manager Remediation Contractor Environmental Officer	
	The gypsum will be unloaded and stored within the specified enclosed shed.	During remediation activities	Project Manager Remediation Contractor Environmental Officer	
	A small daily quantity will be stockpiled at the gypsum application station. Where required due to weather conditions (such as wind) the amount would be reduced and more regularly transported from the stockpile within the shed.	During remediation activities	Remediation Contractor Environmental Officer	

Management Measures	Actions	Timing / Frequency	Responsibility	Further Detail
	Capped Waste Stockpile materials (including the placed gypsum) are to be subjected to mist spraying to suppress dust generation if required due to climatic conditions.	During remediation activities	Project Manager Remediation Contractor Environmental Officer	
	Mist spraying facilities are to be available at the Containment Cell if required due to climatic conditions to suppress dust generation.	During remediation activities	Project Manager Remediation Contractor Environmental Officer	
Noise and Vibration				
All personnel will be informed during the site induction of their obligations to minimise noise and the need to take reasonable and practical measures to minimise impacts.	Noise management obligations and control measures to be communicated to personnel during site induction.	Prior to and during activities	Project Manager Remediation Contractor	Remediation works EMP Noise and Vibration Management Plan
	Truck drivers are to be informed of site access routes, acceptable delivery hours and must minimise extended periods of engine idling.	Prior to and during activities	Project Manager Remediation Contractor Site Services Manager	Site Access Plan
	A Driver Code of Conduct and induction training will be developed and implemented for the remediation activities to minimise road traffic noise. The Driver Code of Conduct and induction training for must be reviewed and updated as applicable for the duration of remediation activities.	During remediation activities	Remediation Contractor	Remediation works EMP
Vehicles and machinery will be selected with consideration of noise emissions.	Undertake a review of vehicles and machinery so that plant are selected with consideration of noise emissions. Contractors and machinery suppliers are to consider the sound power level of equipment and plant and provide comparable equipment and machinery.	Prior to and during activities	Project Manager Remediation Contractor Site Services Manager	Noise and Vibration Management Plan

Management Measures	Actions	Timing / Frequency	Responsibility	Further Detail
	Equipment with effective mufflers, enclosures and low-noise tool bits and blades must be procured and utilised, where practicable.	Prior to and during activities	Project Manager	
Activities that will generate an audible noise at sensitive receivers will be limited to occur during specified timeframes.	Activities that will generate an audible noise at sensitive receivers will be undertaken between the hours of 7:00 am to 6:00 pm Mondays to Fridays and 7:00 am to 1:00 pm on Saturdays.	Prior to and during activities	Project Manager Remediation Contractor Site Services Manager	Noise and Vibration Management Plan
	If activities are to be undertaken outside of the standard activity hours, concurrently operating machinery are to be consistent with those described in the Noise and Vibration Management Plan.	Prior to and during activities	Project Manager Remediation Contractor Site Services Manager	Noise and Vibration Management Plan
Machines found to produce excessive noise compared to typical noise levels will be removed and replaced, or repaired or modified prior to recommencing works.	Undertake inspections of activities that may create unexpected excessive noise. If activities are found to produce excessive noise, remove or replace machinery, or modify activities prior to recommencing works.	During activities	Project Manager Remediation Contractor WHS Manager	Remediation Works EMP
	Where practicable vehicles and machinery will be turned off or throttled down when not in use.	Prior to and during activities	Project Manager Remediation Contractor	
	Equipment will be inspected and maintained in accordance with manufacturer's requirements.	Prior to and during activities	Project Manager Remediation Contractor	
If required mains power will be utilised for temporary traffic signals / work area lighting where possible. Where this is not feasible silenced generator sets are to be used instead.	Where required temporary traffic signals and lighting will be powered by mains power where possible. If this is not feasible, silenced generator sets will be procured for use.	Prior to and during activities	Project Manager Remediation Contractor	

Management Measures	Actions	Timing / Frequency	Responsibility	Further Detail
Soil and Water Management				
All personnel will be informed during the site induction of their obligations to minimise erosion and protect water quality.	Soil and water quality management obligations and control measures to be communicated to personnel during site induction.	Prior to and during activities	WHS Manager	Soil and Water Management Plan
Erosion and sediment controls will be installed prior to the commencement of activities.	Prior to any remediation activities (including the Capped Waste Stockpile removal) at the Smelter erosion, drainage and sediment controls will be installed as shown in the Containment Cell Erosion and Sediment Control Plan in Appendix 3. This plan would be updated by the Remediation Contractor throughout the remediation activities to reflect work activities as required.	Prior to and during remediation	Project Manager Remediation Contractor	Soil and Water Management Plan
	An Erosion and Sediment Control Plan is to be developed and implemented prior to any remediation activities in the Hydro Land. This plan would be updated by the Remediation Contractor throughout the remediation activities to reflect work activities as required.	Prior to and during remediation	Project Manager Remediation Contractor	Soil and Water Management Plan
	Prior to commencing the construction of the Containment Cell, erosion, drainage and sediment controls will be installed as shown in the Containment Cell Erosion and Sediment Control Plan in the . This plan would be updated by the Remediation Contractor throughout the remediation activities to reflect work activities as required	Prior to remediation	Project Manager Remediation Contractor	Soil and Water Management Plan

Management Measures	Actions	Timing / Frequency	Responsibility	Further Detail
Erosion and sediment controls are to be inspected and maintained.	Erosion and sediment controls will be inspected on a fortnightly basis and after a rain event (greater than 5mm in any one period up to 24 hours in duration).	During activities Fortnightly and after a rain event	WHS Manager Environmental Officer	Soil and Water Management Plan Remediation Works EMP
	Where an issue is identified during the inspection, the erosion and sediment controls will be maintained, repaired or improved.	During activities As required	WHS Manager Environmental Officer	Soil and Water Management Plan Remediation Works EMP
	A record is to be maintained of the inspections and any maintenance, repair or improvement works required.	During activities Fortnightly and after a rain event	WHS Manager Environmental Officer	Remediation Works EMP
	Inspection records are to be made available upon request of the Department and the EPA.	As required	WHS Manager Environmental Officer	
	The Erosion and Sediment Control Plans are to be reviewed and updated as required to reflect the dynamic nature of the activities to ensure adequate protection of surface water quality.	During remediation	Project Manager Remediation Contractor Environmental Officer	
A stormwater management system will be designed and installed for the Containment Cell prior to completion of remediation.	A stormwater management system will be designed: • By a suitably qualified expert • In consultation with Council • In accordance with relevant Australian Standards • Generally in accordance with the conceptual design in the EIS • In accordance with Australian Rainfall and Runoff (Engineers Australia, 2016) and Managing Urban Stormwater: Council Handbook (EPA, 1997) guidelines	Prior to completion of remediation	Project Manager	Appendix 1

Management Measures	Actions	Timing / Frequency	Responsibility	Further Detail
	Within two months of the completion of remediation works or within another timeframe agreed by the Planning Secretary, works-as-executed drawings signed by a registered surveyor will be submitted to the Site Auditor demonstrating that the stormwater drainage and finished ground levels have been constructed as detailed in the Containment Cell Detailed Design and the RAP.	Following completion of remediation	Project Manager	
As soon as practicable following completion of activities in an area, the surface will be treated to reduce the potential for erosion and sediment loss, which may include methods such as grass seeding, jute mesh or crushed concrete depending on the intended future use of the area.	Stabilise disturbed areas with grass seed or cover with appropriate material (such as jute mesh rolled crushed concrete) to prevent dust generation. Stabilisation method depends on the need for future activity in the area.	During demolition Following completion of activities within an area	Project Manager Remediation Contractor	Remediation Works EMP
	Undertake routine inspection and maintenance activities on stabilised areas to ensure stabilisation has occurred.	During and following activities	Project Manager Remediation Contractor	Soil and Water Management Plan
	Conduct maintenance on stabilised areas as required.	As required following stabilisation	Project Manager Remediation Contractor	
Use of chemicals and fuels will be managed to avoid spills and contamination of soil, surface water and groundwater	Vehicle refueling will be undertaken using mobile refueling vehicles equipped with spill containment equipment and a spill kit.	During activities	Project Manager Remediation Contractor	Remediation Works EMP
	All chemicals and fuels on site will be stored in accordance with the applicable Safety Data Sheet.	During activities	Project Manager Remediation Contractor	Remediation Works EMP

Management Measures	Actions	Timing / Frequency	Responsibility	Further Detail
	An appropriate spill kit is to be on site at all times and any spillage is to be immediately cleaned up. In the event of a large or hazardous spill, the fire brigade, police, ambulance and EPA will be contacted as appropriate, in accordance with Emergency Services Cooperation Agreement.	During activities	Project Manager Remediation Contractor	Remediation Works EMP
	Any spills will be contained and disposed of at a licensed facility.	As required	Project Manager Remediation Contractor	Soil and Water Management Plan
	Servicing of vehicles will only be undertaken within a sealed area with the appropriate environmental controls in place, including bunding where required.	During activities	Project Manager Remediation Contractor	Remediation Works EMP
Water encountering any waste fill will be classified as leachate and require collection and treatment.	Surface water will be diverted around active remediation areas to minimise the volume of leachate generated during remediation activities.	Prior to and during remediation	Project Manager Remediation Contractor	Appendix 1
	Perimeter bunds and diversion drains will be constructed around the Containment Cell to prevent stormwater entering the active remediation area.	Prior to and during remediation	Project Manager Remediation Contractor	Appendix 1
	Leachate generation will be minimised by reducing the area of exposed waste at any one time and covering of waste as soon as practicable.	During remediation	Project Manager Remediation Contractor	Appendix 1
Controlled capture of leachate within the Containment Cell	The Containment Cell will be subdivided into four sub-cells by intracell bunds. The sub-cells will be filled progressively, resulting in potential leachate generation occurring from only one cell at a time.	Prior to and during remediation	Project Manager Remediation Contractor	Appendix 1

Management Measures	Actions	Timing / Frequency	Responsibility	Further Detail
	Leachate will be drained to one of two leachate sumps, located at the eastern boundary of the containment cell.	During remediation	Project Manager Remediation Contractor	Appendix 1
	Leachate extraction pumps will be used to extract the leachate and pumped to the leachate buffer storage dam for temporary storage.	During remediation	Project Manager Remediation Contractor	Appendix 1
	The operation depth of leachate in the cell will be limited to no more than 300 mm except during large storm events. Where the level of leachate exceeds 300 mm it shall be lowered to 300 mm as soon as is practicable.	During remediation	Project Manager Remediation Contractor	Appendix 1
Contaminated Soils Management				
Record the removal, transportation, temporary stockpiling and disposal of contaminated soils.	The type, source location and estimated quantity of each truckload of removed contaminated soils would be recorded at the removal location.	During remediation and construction of the Containment Cell	Remediation Contractor	Contaminated Soils Management Plan
	The type, source location and estimated quantity of each truckload of each truckload of contaminated soils would be provided at the Containment Cell prior to deposition.	During remediation and construction of the Containment Cell	Remediation Contractor	Contaminated Soils Management Plan
	The type, placement location and estimated quantity would be recorded for each truckload of contaminated soils deposited within the Containment Cell.	During remediation and construction of the Containment Cell	Remediation Contractor	Contaminated Soils Management Plan

Management Measures	Actions	Timing / Frequency	Responsibility	Further Detail
Gypsum and materials imported for construction of the Containment Cell will be appropriately certified and managed to avoid contamination.	Only VENM, ENM, or other material approved in writing by the EPA or the Site Auditor is to be brought onto the site.	During construction of the containment cell	Remediation Contractor Project Manager	Contaminated Soils Management Plan
	Records will be kept of the volume and type of fill used on site. These records will be made available to the Planning Secretary if requested.	As required	Remediation Contractor Project Manager	Contaminated Soils Management Plan
Biodiversity				
The requirement to avoid native vegetation beyond the Smelter will be confirmed during site inductions.	Information on ecologically sensitive areas, the restrictions on entering these areas and approved vegetation clearance areas and methodologies will be presented in the site induction as appropriate.	Prior to and during activities	WHS Manager Remediation Contractor	Remediation Works EMP
Any clearance of native vegetation will be undertaken in accordance with the approval conditions and/regulatory requirements, as well as any ecologist recommendations.	The Project Site boundary will be clearly delineated to limit the extent of vegetation clearance to that described in the Biodiversity Management Plan, and to restrict access during the Works. This will include: • Survey and marking of the approved vegetation clearance areas. • Erection of fluorescent flagging with stakes at 20m along the boundary of the approved vegetation clearance prior to clearing. • Construction of security fencing around the perimeter of the Containment Cell vegetation clearance area/ construction site.	Prior to activities	Principal Environmental Consultant Environmental Officer Remediation Contractor	Biodiversity Management Plan Remediation Works EMP

Management Measures	Actions	Timing / Frequency	Responsibility	Further Detail
	• Maintaining the flagging along the vegetation clearance boundary in other locations in the Smelter. • Maintaining the security fencing around the Smelter Site.			
	Any machinery to be used for native vegetation clearance is to be cleaned of mud and any accumulated materials to avoid the importation of weed species seeds or propagules	Prior to vegetation clearance	Remediation Contractor	Remediation Works EMP

	Where native vegetation clearance is required, the following will be implemented prior to and during the vegetation clearing and tree felling:
	• A pre-clearance survey will be undertaken by an appropriately qualified ecologist for the presence of any hollow bearing trees, nests or burrows for native animals.
	• If no burrows or nests are identified, clearance of the understorey can occur without further management
	• If no tree hollow is present, the tree can be felled without further management.
	• If hollows, nest or burrows inhabited by native animals are present, the following procedures will be implemented:
	  • An ecologist or wildlife handler is to inspect the nest, burrow or tree and see if there are any markings or other signs indicating use.
	  • If there is no evidence of use clearing can proceed.
	  • If there is evidence of use:
		Prior to and during any native tree clearance	Environmental Officer
			Principal Environmental Consultant
				Remediation Works EMP

Management Measures	Actions	Timing / Frequency	Responsibility	Further Detail
	• Inspect the nest or burrow for the presence of animals. If present the animals are to be removed by an ecologist/ animal handler • For a tree, an excavator or similar is to shake the tree to alarm animals and encourage them to leave the tree. • Leave it one day (to allow any animals to leave). • On the clearing day (in the presence of the ecologist/ animal handler), the tree is to again be shaken before bringing the tree down a short time later. The animal handler is to check the hollow in the felled tree to see if animals are present. If there any animals still in the hollow, the ecologist is to determine if the felled tree is to be left 24 hours to allow the animal to escape. The handler can determine if it the animal can be released or if it needs to be taken to a shelter or a veterinarian.			
	Green waste from native vegetation clearance will be managed in accordance with the Waste Management Plan.	During activities	Remediation Contractor Environmental Officer	Waste Management Plan
Native animals encountered during activities are not to be harmed	Any native animals encountered during activities are to be avoided.	As required during vegetation clearance	Environmental Officer Remediation Contractor	Remediation Works EMP
	In the event that an injured native animal is encountered during activities: • Activities that could further harm the animal are to cease.	As required	Environmental Officer	

Management Measures	Actions	Timing / Frequency	Responsibility	Further Detail
	• The Environmental Officer is to be notified. The Environmental Officer will then notify the Native Animal Trust Fund (0418 628 483).			
Aboriginal Heritage				
The known artefact and the identified area of high archaeological sensitivity are to be collected or protected prior to undertaking remediation activities that would have a direct impact	Surface collection and relocation of the identified isolated artefact Hydro-IA35-15.	Prior to remediation	Project Manager/ Principal Environmental Consultant Qualified Archaeologist and/or RAP field representative	Aboriginal Heritage Management Plan
	Where possible, avoid the need to stockpile material in the area of high archaeological sensitivity. In the event that stockpiling in this area is required, geo-matting will be placed on the surface of the area prior to stockpiling.	Prior to activities	Environment Officer Remediation Contractor	Aboriginal Heritage Management Plan

APPENDIX 8
CONTAINMENT CELL CONSTRUCTION PROGRAM

1640 - Hydro Aluminium Site Remediation Separable Portion 2 Construction Program

ID	Task Mode	Task Name	Duration	Start	Finish
1		**1640 - Hydro Aluminium Site Remediation Separable Portion 2 Construction Program**	**476 days**	**Mon 18/01/21**	**Fri 25/11/22**
2					
3		**SEPARABLE PORTION 2 PART 1 - PROJECT INFRASTRUCTURE**	**110 days**	**Mon 18/01/2**	**Tue 29/06/21**
4		Daracon re-establishment to site	5 days	Mon 18/01/21	Fri 22/01/21
5		Temporary Works (Excluding East-West haul road)	20 days	Wed 27/01/21	Tue 23/02/21
6		Temporary Sediment Basin 1	6 days	Mon 18/01/21	Wed 27/01/21
7		Survey set out	1 day	Mon 18/01/21	Mon 18/01/21
8		Earthworks	3 days	Tue 19/01/21	Thu 21/01/21
9		200 thick D50 rip rap for Stormwater Inlet (Culvert 2) and Overflow to Swale 2	1 day	Fri 22/01/21	Fri 22/01/21
10		Separation geotextile	1 day	Wed 27/01/21	Wed 27/01/21
11		Temporary Sediment Basin 2	10 days	Tue 19/01/21	Wed 3/02/21
12		Survey set out	1 day	Tue 19/01/21	Tue 19/01/21
13		Earthworks	3 days	Thu 28/01/21	Mon 1/02/21
14		200 thick D50 rip rap for Stormwater Inlet (Culvert 3) and Overflow to Swale 01	1 day	Tue 2/02/21	Tue 2/02/21
15		Seperation geotextile	1 day	Wed 3/02/21	Wed 3/02/21
16		Temporary Sediment Basin 3	14 days	Tue 19/01/21	Tue 9/02/21
17		Survey set out	1 day	Tue 19/01/21	Tue 19/01/21
18		Earthworks	2 days	Thu 4/02/21	Fri 5/02/21
19		200 thick D50 rip rap for Stormwater Inlet (Culvert 3 and 4) and Overflow to surface	1 day	Mon 8/02/21	Mon 8/02/21
20		Seperation geotextile	1 day	Tue 9/02/21	Tue 9/02/21
21		Temporary Leachate Storage Basin (Earthworks)	18 days	Tue 19/01/21	Mon 15/02/21
22		Survey set out	1 day	Tue 19/01/21	Tue 19/01/21
23		Excavate, load, haul & place at stockpile for reuse	2 days	Wed 10/02/21	Thu 11/02/21
24		Excavate, load, haul, place& compact Clay Rich Fill	2 days	Fri 12/02/21	Mon 15/02/21
25		Excavation of Containment Cell	45 days	Tue 16/02/21	Thu 22/04/21
26		Survey set out	1 day	Tue 16/02/21	Tue 16/02/21
27		Cut to fill to form containment cell - haul, place& compact	12 days	Wed 17/02/21	Thu 4/03/21
28		Excavate and transport to stockpile for reuse - haul& place	24 days	Fri 5/03/21	Mon 12/04/21
29		Excavate and transport to stockpile extremely weathered rock strata - haul& place	7 days	Tue 13/04/21	Wed 21/04/21
30		Provide dewatering system for ECC area during construction, including pipes and pu	1 day	Thu 22/04/21	Thu 22/04/21
31		Leachate Liquid - Prevention, Mitigation & Treatment	110 days	Mon 18/01/21	Tue 29/06/21
32		Procure Temporary Water Treatment Plant	90 days	Mon 18/01/21	Fri 28/05/21
33		Install a Temporary Water Treatment Plant (TWTP) on Site at an approved location	20 days	Mon 31/05/21	Tue 29/06/21
34		Containment Cell Access Road	27 days	Tue 19/01/21	Fri 26/02/21
35		Survey set out	1 day	Tue 19/01/21	Tue 19/01/21
36		Earthworks	2 days	Tue 16/02/21	Wed 17/02/21
37		Place & Compact Pavement	7 days	Thu 18/02/21	Fri 26/02/21
38		Containment Cell Perimeter Road	56 days	Tue 19/01/21	Tue 13/04/21
39		Survey set out	1 day	Tue 19/01/21	Tue 19/01/21
40		Place& compact 150mm select fill	4 days	Mon 1/03/21	Thu 4/03/21
41		Install Road Culverts 02& 03	6 days	Fri 5/03/21	Fri 12/03/21
42		Place & Compact Pavement	12 days	Mon 15/03/21	Tue 30/03/21
43		Swale Drains	7 days	Wed 31/03/21	Tue 13/04/21
44		**SEPARABLE PORTION 2 PART 2 - CONTAINMENT CELL STAGE 1**	**115 days**	**Fri 23/04/21**	**Wed 6/10/21**
45		ECC Base, Sidewall & Anchor Trench Liner - Supply and installation	80 days	Fri 23/04/21	Mon 16/08/21
46		Leachate Transfer System, Collection Sumps & Pipe Risers	20 days	Tue 17/08/21	Mon 13/09/21
47		Temporary Basin at CWS	15 days	Tue 14/09/21	Wed 6/10/21
48		**SEPARABLE PORTION 2 PART 3 - SITE REMEDIATION & MATERIAL TRANSFER**	**145 days**	**Thu 7/10/21**	**Wed 27/04/22**
49		Miscellaneous Contaminated Materials	20 days	Thu 7/10/21	Wed 3/11/21
50		Anode Waste Pile (AEC 2)	30 days	Thu 21/10/21	Wed 1/12/21
51		Capped Waste Stockpile - Drainage and Cap	19 days	Thu 4/11/21	Tue 30/11/21
52		Area East of Clay Borrow Pit (AEC 30)	13 days	Thu 18/11/21	Mon 6/12/21
53		Process Waste - 7A Furnace North & South Tubs	10 days	Thu 2/12/21	Wed 15/12/21
54		East Surge Pond and Drainage Line (AEC5 and 6)	6 days	Thu 9/12/21	Thu 16/12/21
55		Asbestos Contaminated Material ("ACM")	59 days	Thu 16/12/21	Tue 8/03/22
56		Capped Waste Stockpile (AEC 1)	85 days	Thu 30/12/21	Wed 27/04/22
57		Dickson Road South Landfill	25 days	Thu 13/01/22	Wed 16/02/22
58		Area East of Playing Fields (AEC 29) - Dickson Rd North Stockpile	19 days	Thu 17/02/22	Tue 15/03/22
59		General Waste - Demolition Works	13 days	Wed 16/03/22	Fri 1/04/22
60		**SEPARABLE PORTION 2 PART 4 - CONTAINMENT CELL STAGE 2 & COMPLETION**	**170 days**	**Mon 4/04/22**	**Fri 25/11/22**
61		Placement of ECC Capping Layer	108 days	Mon 4/04/22	Wed 31/08/22
62		Gas Management System - Part 2 of 2	24 days	Thu 1/09/22	Tue 4/10/22
63		Decommissioning & Removal of the Leachate Buffer Storage Dam	4 days	Wed 5/10/22	Mon 10/10/22
64		Decommissioning & Removal of Sediment Basin 1, 2 & 3	1 day	Tue 11/10/22	Tue 11/10/22
65		QA Documentation	13 days	Wed 12/10/22	Fri 28/10/22
66		Removal of Temporary Works	20 days	Mon 31/10/22	Fri 25/11/22

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Date: Sun 3/01/21

Task | Split | Milestone | Summary | Project Summary | External Tasks | External Milestone | Inactive Task | Inactive Milestone | Inactive Summary | Manual Task | Duration-only | Manual Summary Rollup | Manual Summary | Start-only | Finish-only | Deadline | Progress | Manual Progress

APPENDIX 9
CCMP PREPARATION TEAM DETAILS

Name	Role in Preparation of CCMP	Qualifications and Years of Experience	Relevant Environmental and Construction Management Experience
Shaun Taylor	CCMP Collation	Bachelor of Applied Science (Environmental Assessment and Management) (Hons), > 22 years	Shaun has ore than 22 years of experience in environmental assessment, management plan documentation, and compliance auditing
Adrian Roberts	Detailed Design Drawings Technical Specification Author Construction Quality Assurance Plan Author	Bachelor of Environmental Engineering (Hons), >15 years	Adrian has worked as a specialist landfill design and remediation engineer for a period of more than 15 years. Adrian has extensive knowledge in the planning, design, procurement, construction quality assurance for geosynthetic materials and liner systems for waste projects.
David Barrett	Detailed Design Drawings Constructability Assessment Author Technical Specification Author Construction Quality Assurance Plan Author	Bachelor of Civil Engineering, CPEng, >18 years	David has extensive experience acting as the Clients Engineer, supervising construction contracts of Waste Facility development/remediation, sludge/tailings management facilities and earthmoving projects throughout Ireland, mainland Europe, and Australia.
David Morrison	Constructability Assessment Author	Master of Civil and Environmental Engineering, Chartered Engineer UK, >18 years	David is a senior civil engineer with more than 18 years experience in the design and management of civil infrastructure projects in Australia and Scotland. With a background in construction management, David has worked with multi disciplinary teams to optimise constructability for a range of projects
Jason Gorton	Daracon IPMP Author	Bachelor of Commerce; Master of Environment and Business Management, > 22 years	Jason is Daracon’s Divisional Manager – HSEQ and Training and has over 22 years of construction experience and mover 12 years of experience in HSEQ management.
Kirsty Greenfield	Containment Cell SAQP Author	Bachelor of Science (Hons) Environmental, > 15 years	Kirsty has more than 15 years of experience working in soil and groundwater contamination assessments and remediation projects