APPENDIX C

Remediation Action Plan: Kooragang Island Remediation Program

08 July 2016

ORICA KOORAGANG ISLAND: ARSENIC MANAGEMENT ORDER

Remediation Action Plan

Submitted to:
Orica Australia Pty Ltd
15 Greenleaf Road
Kooragang Island NSW 2034

REPORT

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Golder Associates

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APPENDIX B
Important Information Relating to this Report

1.0 INTRODUCTION

Golder Associates Pty Ltd (Golder) was engaged by Orica Australia Pty Ltd (Orica) to prepare this Remediation Action Plan (RAP) for the arsenic remediation program at the north-western portion of the Orica site at Greenleaf Road, Kooragang Island (KI), NSW (the site), **Figure 1**.

This RAP is required by Action 1(e) of a management order (MO) (Order Number 20131407) issued by NSW EPA under Section 14(1) of the Contaminated Land Management Act 1997 (the Act) on 28 July 2014. It presents a detailed design for the installation of an integrated cap and containment system to meet the objectives of the MO.

1.1 Management Order Overview

Orica is in the process of implementing an arsenic remediation project at the former arsenic sludge disposal pit in the north western portion of the site. The project has been initiated in response to the EPA MO identified above.

The MO presents requirements for identification of a preferred remediation approach for this area, followed by planning, investigation and groundwater modelling stages to support the identified approach and ultimately inform a detailed design stage. The process culminates in the preparation of a RAP, intended to capture the outputs from the earlier stages and document the design and performance metrics for the overall approach.

The requirements are set down in Action 1 of the MO:

1) *Implement works that will prevent, to the extent required by Action 1c, the further offsite migration of arsenic in groundwater. In planning the works, all necessary steps are to be taken to ensure the remedial work is implemented and commissioned by 31 December 2017.*

   a) *Prepare and submit a plan (workplan) to the EPA which clearly identifies the remedial method that will be implemented at the site and describes activities to:*

      i) *Undertake investigations and trials of remediation works to develop the design, construction and performance and specifications of a remediation system or process to meet the remedial outcome described in '1.' above. These investigations and trials may include aquifer pump tests and groundwater modelling.*

      ii) *As necessary, undertake treatability trials to confirm the design, construction and performance specifications to meet required treatment cirteria, and/or management of waste streams. These works may include bench scale and pilot scale testing of component parts of the works, and of any waste management.*

      iii) *Undertake investigations to support the development of performance specifications and remediation endpoints of the proposed works.*

      iv) *If necessary, undertake a field trial of the proposed remedial works based on the outcomes of tasks (i) and (ii), above.*

   b) *Identify performance criteria for the identified remedial method and submit the performance criteria to the EPA;*

   c) *Upon the agreement of the workplan and performance criteria by the EPA, implement the approved workplan and submit the required deliverables in accordance with the schedule in the approved workplan;*

   d) *As appropriate, formally request landowner consent for access to relevant off site areas required for proposed works. This may include in-principle agreement with finalisation of the agreement after detailed design of the proposed works is complete.*

e) *Prepare and submit to the EPA for approval a Remediation Action Plan (RAP) which is in accordance with the remedial method identified in the approved workplan and which documents the remediation strategy, system design, implementation approach, identification of regulatory licences, approvals and remediation end points.*

Actions 1 (a), (b) and (c) were largely addressed during late 2014 and 2015 through completion of a workplan document (the 'Workplan'), detailed soil and groundwater investigations (Report Modules A through E) together with an integrated groundwater modelling program.

The documents reporting the finding of these works are identified below:

- Golder (2014) *Orica Kooragang Island – Workplan – Arsenic Management Order* (147623010_017_R_Rev1 dated 22 December 2014);
- Golder (2016d) *Orica Kooragang Island: Arsenic Management Order – Remediation Investigations*:
  - Module A: *Background Information* (1418917_012_R_Rev0_ModA);
  - Module B: *Environment Investigation* (1418917_013_R_Rev0_ModB);
  - Module C: *Geotechnical Investigation* (1418917_014_Rev0_ModC);
  - Module D: *Hydrogeologic Conceptual Model* (1418917_015_Rev0_ModD); and
  - Module E: *Contaminant Distribution* (1418917_016_Rev0_ModE).
- A.D.Laase Hydrologic Consulting (Laase, 2016a) *Orica Kooragang Island – Steady-State Groundwater Flow Model* (Draft Report); and
- A.D.Laase Hydrologic Consulting (Laase, 2016b) *Design Evaluation of a Cap and Cut Off Wall for Orica Botany Kooragang Island, Former Sludge Disposal Pit* (Draft Report).

1.2 RAP Scope

This RAP documents a summary of the works completed to date in developing and planning the proposed remediation approach and outlines a methodology (detailed design) for implementation of the preferred remediation strategy (cap and contain).

More specifically, the scope of this RAP includes:

- Documentation of the remediation approach in accordance with the relevant NSW EPA endorsed guidance documents to ensure the information adequately meets the requirements of Action 1 of the MO;
- Identification of the regulatory and legislative framework for the remediation works as well as the necessary approvals and licences required by regulatory authorities in order to enable the remediation works to proceed;
- Establishing the necessary controls required to complete the remediation work in a safe and environmentally acceptable manner;
- Identification of suitable remediation validation protocols (as required) for the remediation;
- Identification of a framework for preparation of a long term site environmental management approach, including ongoing monitoring programs required by the MO;
- Documentation of the proposed program of community consultation, prior to, during and post remediation works; and
- Specification of a timeline of milestone goals and targets by which progress towards implementation of the RAP will be measured and reported in writing on a regular basis to the EPA.

2.0 SITE LOCATION AND IDENTIFICATION

2.1 Location and Identification

The site's main entrance is at 15 Greenleaf Road, Kooragang Island, NSW. The site is described as Lot 2 and Lot 3 in Deposited Plan 234288. The site covers an area of approximately 22 hectares. The site is located on the south eastern peninsula of Kooragang Island at the confluence of the North and South Arms of the Hunter River (**Figure 1**).

2.2 Site Setting

A detailed description of the site land use, surrounding areas, history of use and geology and hydrogeology is provided in the Conceptual Site Model (CSM) (Golder, 2013). A brief summary is provided below, however, if further detail is required the CSM should be referred to.

Kooragang Island was originally a series of smaller islands which formed part of the Hunter River Delta. The southern portion of Kooragang Island was subsequently reclaimed[1] in the late 1950s and early 1960s from the original landform of a series of tidal mud flats using dredged sand from the Hunter River. Since the reclamation, the southern portion of Kooragang Island, including the area occupied by the site, has been developed for heavy industrial use, including port facilities, chemical manufacturing and storage, waste recycling and hazardous waste treatment.

The Orica site is used for the manufacturing of ammonia and nitric acid as intermediate products in the production of ammonium nitrate for use in the mining sector. The Orica site is classified as a major hazard facility (MHF) as the site produces the scheduled materials ammonia and ammonium nitrate at rates that exceed threshold quantities specified in Schedule 15 of the *Work Health and Safety Regulation 2011*.

The southern portion of Kooragang Island, including the Orica site, is zoned 'Special Activities' under the New South Wales State Environmental Planning Policy (Major Projects) Amendment (Three Ports) 2009 under the Environmental Planning and Assessment Act 1979. The objective of this zoning is to facilitate development to maximise use of the port facility, particularly special land uses that are not allowed for in other zones as well as ensuring separation from residential areas and other sensitive land uses.

2.3 Geological Profile

A detailed summary of the inferred site hydrostratigraphy, based on the work reported in Module D of Golder 2016d, is provided in **Section 5.3**.

The site is underlain by appreciable thicknesses of sedimentary materials overlying bedrock at approximately 35 to 40 m below ground surface. Detailed investigations have allowed the unconsolidated materials to be divided into hydrostratigraphic 'units' which exhibit common hydrogeological characteristics.

- Unit 1: Fill and Reclaimed sands;
- Unit 2: Estuarine silt and clay;
- Unit 3: Alluvial sand;
- Unit 4: Coarse fluvial sand;
- Deeper sands and clays; and
- Permian Bedrock.

[1] Based on review of available historical aerial photographs

3.0 CONTAMINANT HISTORY AND CHARACTERISATION

A summary of arsenic contamination associated with the former sludge disposal pit is presented in the CSM (Golder, 2013). Provided below is a summary of arsenic contamination in the area to which the MO applies. In general this contamination is located in an approximately 4000 m^2 area in the north-western portion of the Orica site, bounded to the north by the Incitec Pivot Limited site and to the west by the Vue Australia Pty Ltd site (**Figure 1**).

3.1 Former Sludge Disposal Pit

The former sludge disposal pit (**Figure 2**) was used for the disposal of solids and liquid arsenic wastes from the Vetrocoke process used at the Ammonia Plant from late 1960s to 1994.

Although the primary source of contamination has been removed (ceased disposal), residual arsenic sorbed to soils beneath the former pit and in the surrounding subsurface represent an ongoing source of arsenic to groundwater. Removal of a secondary source of contamination occurred in 2005 with the remediation of contaminated soil beneath the former pit (to the depth of the groundwater table), the bund walls and soil surrounding the pit by excavation, treatment and off-site disposal.

3.2 Soil Contamination

Beneath the remediated extent of the former pit on site, residual arsenic soil concentrations average 170, 540 and 130 mg/kg in Units 1, 2 and 3, respectively. Maximum arsenic concentrations reported are of the order of 1,900 mg/kg.

The estimated mass of arsenic in soil on site is 8,200 kg (Appendix A of Orica, 2013).

Further assessment of the extent of soil contamination on the site has been undertaken during the development of the RAP.

3.3 Groundwater Contamination

Dissolved arsenic in groundwater is present below and down-gradient (west-northwest) of the former sludge disposal pit. Concentrations of arsenic in groundwater on site have ranged between 15 mg/L and 85 mg/L, with concentrations decreasing since the remediation of the former disposal pit in 2005 (**Section 3.1**).

The highest dissolved arsenic concentrations occur between 3 and 7 m below ground level (bgl). At depths greater than approximately 8 m bgl, dissolved arsenic concentrations are low (<1 mg/L).

The predominant arsenic species in groundwater is As (III) (arsenite) with a minor portion as As(V) (arsenate), which is consistent with the original arsenic source (arsenic trioxide) and the groundwater geochemistry (mildly reducing). Both As(III) and As(V) are inferred to be present predominantly as oxyanions (including their hydrogen substituted forms) in groundwater (Golder, 2013).

3.4 Fate and Transport of Arsenic

Despite a relatively high average groundwater velocity, the migration of arsenic is significantly attenuated within the aquifer. This is supported by the distribution of arsenic in soil and groundwater down-gradient of the former sludge disposal pit (Golder, 2013).

Transport

The arsenic (either as a release of arsenic trioxide solution during operation of the sludge disposal pit or as a result of the subsequent leaching of arsenic from the contaminated soils below the pit) has entered into the vadose zone below the former pit and then the saturated zone (groundwater). Dissolved arsenic then migrated with the groundwater flow. Arsenic has adsorbed to aquifer materials along the flow path until the attenuation capacity of the aquifer is exceeded such that the arsenic plume has migrated more slowly than the groundwater flow.

A portion of arsenic in groundwater migrating downward vertically from Unit 1 is inferred to have been partitioned onto the fine-grained (silts and clays) soils of Unit 2, which are inferred to represent a significant secondary source of arsenic. This inference is supported by generally higher arsenic concentrations within the silty/clayey sediments of Unit 2. Limited arsenic has continued to migrate into Unit 3.

Attenuation Mechanisms

Investigations have confirmed that the predominant process attenuating arsenic in the aquifer is adsorption onto naturally-occurring iron minerals (particularly hydrous ferric (oxy) hydroxides (HFO)) (Golder, 2013). The amount of HFO present in the aquifer was considered to provide substantial arsenic adsorption capacity, approximately 330 mg arsenic per kg of soil (CSIRO, 2007), though it is expected to be highly variable and it is noted that significantly higher soil concentrations (>1,000 mg/kg) have been reported[2].

Other mechanisms such as adsorption of arsenic to organic matter, sulfides, clays and other minerals are considered not to be the dominant factor in attenuating arsenic within the aquifer, however, may contribute directly or indirectly to fate and transport of arsenic, in particular within Unit 2 fine-grained sediments.

Although Unit 2 is inferred to have a high arsenic attenuation capacity due to the presence of a high portion of fine grained sediments, a portion of adsorbed arsenic is likely to be more weakly bound to clays, and organic matter. The combination of the higher arsenic attenuation capacity, and lower hydraulic conductivity, of Unit 2 sediments means that Unit 2 represents an ongoing, long-term source of arsenic groundwater contamination.

Changes in the geochemical condition of the aquifer may alter the presence or capacity of aquifer materials to provide adsorption sites for the attenuation of arsenic (i.e. dissolution of HFO) and/or cause desorption of arsenic.

[2] Reported soil concentrations of samples collected from the saturated zone contain pore water which will contribute to the apparent soil analytical result, particularly where there are elevated arsenic groundwater concentrations.

4.0 REMEDIATION OPTIONS REVIEW

In response to the MO, Golder prepared a Workplan (Golder, 2014) to identify the remediation method that was to be implemented to achieve the objectives of the MO, as well as outline the investigations and trials required to allow the development of the remediation design.

For completeness within this RAP, the review and selection of the remediation options, as previously presented within the Workplan (Golder, 2014) is summarised below. It is noted that the Workplan and the remediation option selection has been provided to the NSW EPA.

4.1 Background to Remediation Option Review

The review and consideration of remediation options for the identified arsenic contamination have been considered throughout Stages 1 to 4 of the Voluntary Remediation Agreements (VRA) and Voluntary Management Proposal (VMP) (see **Section 7.1**). This process has involved detailed literature reviews, assessment of the processes that naturally attenuate arsenic in the aquifer, bench scale remediation trials and field trials. At the end of the Stage 4 VMP a comprehensive Feasibility Assessment (Orica, 2013) was completed and considered five short-listed remediation options considered capable of meeting the remediation goals defined in the Feasibility Assessment.

The process adopted for the Feasibility Assessment was independently reviewed by Dr Peter Nadebaum, a former NSW EPA accredited auditor under the Contaminated Land Management Act, who indicated the following (GHD, 2014):

- The initial technology [remediation options] screening undertaken was considered to be appropriate and the selected remediation alternatives for detailed evaluation were appropriate;
- The overall process of detailed evaluation of remediation alternatives was considered to be appropriate; and
- The process for the assessment of each remediation alternative was considered to be appropriate and in accordance with good industry practice. It was evident that the assessment has been carried out by persons with a good understanding of the technologies and their application to this particular site; the commentaries provided give a good outline of relevant considerations.

A key objective of the Workplan was to identify the remediation method that will be implemented at the site to achieve the objective of the MO (noting that the objective of the MO differs to those considered in the Feasibility Assessment). Presented in this section of the RAP is the process undertaken to evaluate and select a preferred remediation option capable of meeting the objective of the MO. In summary, the process included two stages:

- Screening of all available remediation options to short-list those capable of meeting the objective of the MO; and
- Evaluation and ranking of the short-listed options to select a preferred remediation option.

4.2 Remediation Options Review

Screening of potential remediation technology alternatives for arsenic contaminated groundwater was undertaken in two workshops (July and September 2014). The two workshops were attended by Orica and consultants (Golder and URS Australia Pty Ltd) who have had long-term involvement with the investigations and remediation trials associated with the arsenic contamination at the site.

At both workshops, all available remediation options were screened against the remediation objectives including consideration of the advantages and disadvantages of each option in terms of:

- Potential ability to meet the remediation objective (noting that this was refined for the second workshop);
- Technical feasibility;

- Potential to impact on safety, health, environmental and community values;
- Uncertainties and data gaps which must be addressed; and
- Relative cost.

Based on the outcomes of the two workshops the feasible remediation alternatives retained for further evaluation were:

- **On-site excavation and off-site disposal ("dig and dump**"):

  Excavation and off-site disposal to a licensed landfill of approximately 30,000 m^3 (3,900 m^2 and 7 m deep) of contaminated soil. Soil may require treatment prior to disposal. Shoring and dewatering of the excavations would be required to facilitate the excavation of the soil. Extracted water would require treatment and disposal. The excavation would need to be validated and backfilled with validated fill materials.

- **On-site groundwater extraction with aboveground treatment ("pump and treat"):**

  Groundwater extraction and aboveground treatment to contain arsenic contaminated groundwater such that arsenic mass flux is reduced. Arsenic contaminated groundwater would be pumped from approximately 12 wells (8 shallow and 4 deeper wells) located in an L-shaped configuration along the northern and western boundaries (80 m) to contain the migration of dissolved arsenic. Extracted groundwater, approximately 70 m^3/day, would be treated in an aboveground treatment system by chemical precipitation and coagulation. Treated water would be disposed to the site effluent system. Iron-arsenic sludge would be dewatered as far as practicable, stabilised (on site or off site) and disposed of to an appropriately licensed waste facility.

- **On-site Cap and Containment ("cap and contain"):**

  Cap and containment would comprise the construction of "impermeable" barrier walls to enclose the on-site contamination on four sides. Currently, no underlying low-permeability founding layer (base layer) has been identified beneath the source area, effectively making it a "hanging" impermeable barrier with an uncontained base layer. A cap would be constructed to prevent rainfall infiltrating and mitigate the flow through the impacted soil and aquifer material.

- **On-site Permeable Reactive Barrier (PRB):**

  A PRB would be constructed in an L-shaped configuration along the northern and western boundaries with a total length of approximately 80 m to a depth of approximately 9 m. Based on arsenic concentrations in groundwater the thickness of the barrier may vary along its length ranging from 1 to 4 m. It is also likely that a low-permeability layer may be required to reduce vertical migration of groundwater within the PRB. The PRB would comprise granular Zero Valent Iron (ZVI) to create an in situ permeable treatment zone designed to intercept and treat the arsenic in the groundwater. Arsenic would be removed from the dissolved phase in the groundwater through adsorption on the iron surface and precipitation of stable, non-reactive minerals within the PRB.

On-site excavation and off-site disposal of contaminated soil, combined with the treatment/management of contaminated groundwater, would result in a significant reduction of arsenic mass. In addition, there would be a reduction in the off-site migration of arsenic in groundwater, however, it is considered that this option (implemented in isolation from other remediation options) would unlikely meet the MO objective of preventing off-site migration, as residual groundwater contamination is likely to persist and continue to migrate off site, albeit at reduced concentrations and mass flux (which would also be expected to decrease further over time due to the significant decrease in arsenic mass).

In addition to the concerns with respect to meeting the MO objective, this option would present significant difficulties with respect to its implementation. Excavation of soil to depths in the order of 6 to 7 m (noting the hydrogeological setting) would require significant dewatering (including management/treatment of the extracted and seepage water) whilst ensuring no adverse effects on surrounding infrastructure (particularly off-site) would present significant challenges and complexity.

Based on the impracticable nature of this remediation option, uncertainty with respect to meeting the objective of the MO and the relatively very high indicative costs, on-site excavation with off-site disposal is not considered further in the evaluation process described in **Section 4.3**.

The three remaining short-listed options were previously considered in the Feasibility Assessment (Orica, 2013), although Groundwater Extraction and Treatment and PRB were off-site options. In addition, these three remediation options have been previously discussed with the EPA and are noted in Point S of the background section of the MO.

4.3 Evaluation of Short-listed Remediation Options

The three short-listed remediation options were evaluated using the same independently reviewed process that was previously adopted for the Feasibility Assessment. As discussed above, all three options were considered in the Feasibility Assessment, however, two of the options were reconsidered as on-site implementation was required to meet the MO objective. In the evaluation undertaken herein, consideration was given to the Conceptual Designs documented in the Feasibility Assessment and how the remediation option may change with respect to an on-site implementation.

The three short-listed remedial technologies were further evaluated on the basis of:

- **Effectiveness** in meeting the remediation objective;
- **Implementability** – level of effort and complexity required to install the system;
- **Operability** – level of effort and complexity required to operate the system;
- **Safety, health, environment** and **community** (SHEC) – effort required to manage or mitigate potential impacts to SHEC values *during implementation of remediation*; and
- **Cost** – present day value of capital and operational and maintenance costs over the project period.

Evaluation of the remediation technologies against the above-mentioned key criteria were summarised. It should be noted that whilst to the extent possible, the evaluation of the shortlisted technologies was drawn from the design, investigations, trials and evaluation undertaken for the Feasibility Assessment report (Orica, 2013), no specific detailed investigation or design of the on-site remediation options were undertaken as part of the evaluation process.

4.4 Remediation Option Ranking and Selection

Ranking of the selected alternatives was undertaken against the assessment criteria based on the evaluation presented in **Tables B1-B3** (Golder, 2014), and quantified using a weighted ranking scale (**Appendix C**, Golder, 2014). Assessment criteria ranking factors are weighted by multiplying the rank by the weighting factor (**Appendix C**, Golder, 2014) to consider the relative importance of certain criteria over others. It is recognised that the weighting of criteria is subjective, but provides a transparent and systematic evaluation of the relative merits of the remediation technologies. The ranking process was consistent with that completed in the Feasibility Assessment.

The ranking outcome is presented in **Table 1.**

Table 1: Ranking Outcome.

Criteria	Ranking Weighting (%)	On-site Cap and Containment	On-site Groundwater Extraction and Treatment	On-site PRB
Effectiveness	25	200	177	136
Implementability	25	149	129	84
Operability	15	120	30	105
SHEC	10	60	30	44

Criteria	Ranking Weighting (%)	On-site Cap and Containment	On-site Groundwater Extraction and Treatment	On-site PRB
Cost	25	135	97	103
Total	**100**	**664**	**463**	**472**

As indicated in **Table 1**, on-site cap and containment is considered the most implementable, and operable remediation approach with the lowest cost and SHEC impacts with regard to achieving the MO objective. It is noted that if the options are ranked without consideration of the cost component, on-site containment remains as the preferred remediation option and that this option ranks highest in all 5 criteria.

4.5 Remediation Option – Cap and Containment

Based on the evaluation and ranking of the identified remediation options, cap and containment was selected as the preferred remediation option to meet the objective of the MO, and to be carried forward in this RAP.

In summary, it is envisaged cap and containment remediation technology will consist of the installation of an impermeable subsurface wall to prevent the flow of groundwater through the impacted soil in the on-site source area and a surface cap to reduce infiltration. The cap and containment approach provides isolation of arsenic located on the Orica site and prevents, to the extent practicable, the further off-site migration of arsenic in groundwater.

Although the cap and containment is a durable remediation option, ongoing maintenance and monitoring will be required and will be documented in the Long-Term Environment Management Plan and the Groundwater Monitoring Program.

It is noted that this type of remediation technology has been developed and successfully implemented at many sites in New South Wales, including the Newcastle area and on Kooragang Island.

5.0 REMEDIATION INVESTIGATIONS

As outlined in **Section 1.1**, the remediation investigations were largely completed between March and May 2015 and comprised the advancement of soil bores, installation of groundwater monitoring wells as well as development, gauging and sampling of the monitoring well suite, which comprised newly installed and existing monitoring wells.

Investigations centred on the former arsenic sludge disposal pit and its immediate environs, and the investigation design was based on a detailed review of previous investigations as well as historical aerial photographs and site plans showing the former infrastructure in the area. The key objectives of the remediation investigation were to:

- Define the lateral and vertical extents of the on-site arsenic contamination; and
- Develop an understanding of the groundwater characteristics – (for consideration in the groundwater modelling and cut-off wall design and construction).

The outcomes were documented in a modular format report (Golder, 2016d) in June 2015, comprising the following components:

- Module A: Project Background;
- Module B: Remediation Investigation;
- Module C: Geotechnical Investigation;
- Module D: Hydrogeological Investigation; and
- Module E: Delineation of arsenic contamination.

A summary of Modules B, D and E is provided below. Reference is made to Modules A and C as required.

5.1 Extent of Contamination – Arsenic in Soil

The works involved the drilling of twenty one (21) soil bores to a depth of 15 m bgl. The configuration of these bores was specific to the general boundary of the arsenic impacted area and was intended to better define the lateral extent of contamination and to enable vertical discretisation of arsenic impacts. The soil investigation locations are presented Module B of the remediation investigations report (Golder, 2016d).

Soil samples were collected, tested in the field using an X-Ray fluorescence (XRF) meter and submitted to a laboratory (ALS Environmental) that has been accredited by the National Association of Testing Authorities, Australia (NATA) for arsenic analysis.

The laboratory test results were presented in graphical format as an ‘inferred extent of arsenic impacts’, defined as arsenic concentrations that exceeded a nominated soil quality criterion. Initially, 100 mg/kg for individual samples and 45 mg/kg for the 95% UCL on the mean were adopted, based on previously completed bench-scale testing.

- Previous leach testing work, including column tests and sequential batch tests had indicated that desorption from significantly contaminated soils is in the order of 4 to 10 % after some 13 to 15 pore volumes.
- Leach assessments had also indicated that the arsenic is absorbed by the natural soil. Sequential batch tests indicated that water after leaching 15 pore volumes with soils containing 450 mg/kg had arsenic concentrations of approximately 1 mg/L.

As a conservative measure, a soil concentration of 45 mg/kg (an order of magnitude less than the contaminated soils test) was adopted to provide an indication of soil that will not act as a significant secondary source of arsenic (to groundwater) and was applied as a UCL on the mean concentration for soil in each bore. In addition to the UCL concentration, it was proposed that no individual sample should have a concentration exceeding 100 mg/kg.

In summary, the adoption of 45 mg/kg was therefore based on a preliminary statistical appraisal of the soil quality data set and its anticipated impact on groundwater quality, and was intended to facilitate a preliminary clarification of the inferred lateral and vertical extent of arsenic in soil.

It is noted that this 'extent of impact' was later refined in concert with the evolving detailed design process. The concentration adopted for assessment of remediation requirements was lowered to 40 mg/kg to reflect a more conservative approach. More information on the derivation of the design process with regard to the refinement of the cut-off wall alignment is provided in **Section 8.2**.

5.2 Groundwater

Seven of the soil bores were converted to groundwater monitoring wells, including two which were advanced to a depth of up to 35 m bgl. The wells were developed and surveyed and subsequently sampled. The acquired data were tabulated and form a baseline for groundwater monitoring as part of a groundwater monitoring plan (GMP) which is a requirement of the Workplan (Golder, 2014).

Data loggers were deployed across a range of existing and newly installed monitoring wells in the remediation area. The data acquired during this program informed the development of the Hydrogeological Conceptual Model (HCM) **(Section 5.3)** and the groundwater modelling program **(Section 5.4)**. Also included was a series of groundwater gauging events, which utilised all available wells to provide a site-wide perspective on flow direction in each of the individual hydrostratigraphic units.

5.3 Hydrogeological Assessment

The data collected during the course of the remediation investigations, as well as selected historical data from across the wider site, were collated and interpreted.

A detailed hydrostratigraphy for the area beneath the former disposal pit was developed and is summarised in the following table. A more detailed description of the lithologies characterised in each of the units is provided in the remediation investigations report (Golder, 2016d). The data were also represented as a series of hydrogeological cross sections.

Table 2: Summary of Hydrostratigraphic Units

Hydrostratigraphic Units	Description	Classification	Typical Hydraulic Conductivity
Unit 1 Fill and reclaimed sand	Various loose fill (including localised slag and ash) and reclaimed sand of coastal origin with shell fragments.	Aquifer, porous medium, unconfined.	3×10^{-5} m/s to 8×10^{-5} m/s
Unit 2 Estuarine silt and clay	Fine-grained estuarine sediments predominantly comprising of silts and clays, black in colour. The lower part becomes gradually coarser (i.e. sandier).	Aquitard, porous medium.	**Upper part:** likely two orders of magnitude lower than Unit 1 **Lower (sandier) part:** 10^{-5} m/s
Unit 3 Alluvial sand	Fine- to medium-grained alluvial sand, grey in colour, sub-rounded, occasionally interspersed with bands of clay and minor sandy silt.	Aquifer, porous medium, confined.	8×10^{-5} m/s to 2×10^{-4} m/s
Unit 4 Coarse fluvial sand	Dense medium- to coarse-grained fluvial sands, with rounded gravels and pebbles, pale brown in colour.	Aquifer, porous medium, confined.	Over 10^{-4} m/s
Deeper Sands and Clays	Interbedded strata comprising of: ■ **Upper part:** yellow brown uniform fine-grained sand (possibly of terrestrial origin),	Succession of thin aquifer zones and aquitards,	N/A

Hydrostratigraphic Units	Description	Classification	Typical Hydraulic Conductivity
	■ **Middle part:** grey fine- to medium-grained sand with rounded coal fragments, and ■ **Lower part:** interspersed black silty clay and sandy clay with minor bands of sand.	porous medium, confined.	
Permian Bedrock	Fine- to medium-grained weathered sandstone, green-blue in colour, dry (predominantly recovered as pulverulent material).	Aquifer, fractured rock medium.	N/A

N/A – Not Available

It concluded that the hydrostratigraphic units that have the most relevance to the understanding of arsenic distribution and movement are Unit 1 to Unit 4.

A review of the hydraulic data from the data loggers as well as from the site-wide ‘dip-round’ allowed interpretation of flow characteristics in each of the characterised units.

5.4 Groundwater Modelling

A calibrated groundwater model was developed for the Walsh Point Peninsula of Kooragang Island, which incorporates the Orica site. This calibrated groundwater model was subsequently used to refine the remediation design and enable consideration of potential design contingencies. The groundwater modelling is discussed in detail in **Section 8.1** and reports (Laase, 2016a and b).

5.5 Geotechnical Review

The geotechnical component of the Remediation Investigations (Module C) (Golder, 2016d) assessed subsurface conditions along the anticipated cut-off wall alignment that may influence wall constructability and durability, as well as provided preliminary considerations for the ‘constructability’ of a cut-off wall system.

The investigation included assessment of soil conditions (particle size distribution, Atterberg limits and cone penetrometer test (CPT) soundings) and groundwater conditions (quality assessment for indicators of incompatibility with cement or bentonite).

5.5.1 Excavatability and Groundwater Implications

Based on the results of the geotechnical testing and assessment as part of the Remediation Investigations (Golder, 2016d), it was considered that excavation to a depth of 15 m (a generalised maximum target depth based preliminary design considerations) is feasible for slurry wall or Cutter Soil Mixing wall construction options. However, some difficulty and lower excavation rate within the upper 4 m and lower 2 m (13 to 15 m depths) are anticipated due to the presence of very dense materials.

For slurry wall construction, it was considered that excavation to the envisaged depth of 15 m can be potentially undertaken using a long-reach excavator; however, the construction production rate and other site constraints, to be confirmed at a detailed design stage, may dictate use of other excavation plant such as a ‘clamshell’ for excavation deeper than a nominal depth of 10 to 12 m. For slurry wall construction to safely maintain stability of an excavated trench, the drilling mud/slurry level might need to be kept nominally 2 m above the groundwater level. It is noted that the groundwater level across the site varies between <1 and 3 m bgl. Therefore, in some areas, a bund could be required to adequately maintain the slurry level above the existing groundwater level during cut-off wall construction.

5.5.2 Base Soil (Host Material)

The particle size distribution results suggest that site substrata are generally dominated by fine-medium sand size particles, with little coarse sand and gravel content. The results also suggest that the overall fines content of the materials that would be encountered for wall construction would exceed 30%. These grain size characteristics are favourable for slurry trench stability. In addition, these grain size characteristics are favourable for use of excavated trench materials for wall construction (i.e., soil-bentonite wall construction) without the need for imported soil to supplement excavated materials. The general very low coarse sand and gravel content is not ideal but is considered to be a minor issue affecting wall construction. These initial comments are to be further considered in the mix design for the preferred cut-off wall option.

5.6 Geochemical Modelling

Given that the proposed cap and containment system will reduce oxygen from entering the aquifer, which may result in a decrease in the redox state (Eh) of the contained aquifer and consequently may affect the attenuation of arsenic within the cell, a geochemical model was developed to assess the potential geochemical effects associated with the installation of the cap and containment system at the site. Specifically, the geochemical model assists with the understanding of:

- potential changes in the aquifer geochemistry from the installation of the remediation system; and
- the associated effects on arsenic stability/mobility post construction of the remediation system.

The geochemical modelling approach and methodology, as well as the results of the modelling are presented in Technical Memoradum “Geochemical Modelling of Arsenic Attenuation and Release” (Golder, 2016e).

In summary, the geochemical modelling of the three aquifer layers within the cap and containment system revealed that arsenic outcompetes most other constituents for surface sorption sites and will only be released from iron oxide surfaces if arsenopyrite precipitates or the iron oxide surface is in contact with a solution with very low concentrations of arsenic. In the former case, arsenic released from the iron oxide is subsequently attenuated as an arsenic-sulphide mineral. In the latter case only small amounts of arsenic were observed to desorb and only in Unit 1. With the cap and containment system the groundwater flow rates will be very low and the mass of released arsenic is predicted to be negligible.

The cap and containment system will likely result in a reduction in oxygen ingress. Under these lower redox conditions adsorption onto iron oxides will remain a dominant mechanism for arsenic removal. Also, precipitation of arsenic as a sulphide mineral is predicted to be an important process for arsenic removal. While adsorption onto iron oxide surfaces is a finite process (sorption sites become saturated) removal of arsenic by sulphide precipitation is only limited by the amount of sulphur in the aquifer. Geochemical modelling revealed that the stable arsenic sulphide mineral under lower redox conditions is orpiment. However, pyrite is also predicted to form and has been shown to remove arsenic, either via adsorption or co-precipitation at similar sites (Wilkin, 2001). Removal of arsenic by pyrite precipitation was not modelled and represents a third mechanism for arsenic attenuation.

The cap and containment system should have a positive impact on the amount of arsenic currently leaving the site by substantially decreasing the flow to the aquifers underlying the site. Furthermore, the increased residence times under the cap and containment system are likely to promote a shift in equilibrium toward sulphide precipitation, an effective removal mechanism limited only by the amount of dissolved sulphur in groundwater.

6.0 REMEDIATION REQUIREMENTS

6.1 Remediation Objectives

The stated overall objective of the Management Order is to "Implement works that will prevent, to the extent required by Action 1c [of the Management Order], the further offsite migration of arsenic in groundwater. In planning the work, all necessary steps are to be taken to ensure the remedial work is implemented and commissioned by 31 December 2017".

To achieve the MO objectives and based on the selected cap and containment remediation option, the specific remediation objective is to install a cap and containment system designed within the practical constraints associated with the conditions at the site.

The cap and containment system will effectively segregate the residual source of arsenic from the surrounding groundwater system by significantly reducing the flux of groundwater through the identified arsenic contamination. The reduction in the groundwater flux through the source area will also reduce the contaminant mass flux of arsenic migrating off site.

6.2 Remediation Extent

The extent of the remediation was developed in consideration of the following:

- Remediation Objectives – **Section 6.1**.
- Consideration of the remediation option selected (Cap and Containment) – **Section 4.5**.
- Remediation investigations to delineate the on-site extent of arsenic contamination at the former arsenic sludge disposal pit – **Section 5.1** and Modules B and E (Golder, 2016d).
- Groundwater modelling to understand the reduction in the flow of groundwater through contaminated soil with the construction of the remediation system – **Section 5.4**.
- Practicable constraints associated with existing site infrastructure and boundary restrictions.

A detailed description of the considerations that have defined the extent of remediation incorporated into the remediation design is presented in **Section 8.0**. Provided below are the key elements which have defined the extent of remediation, and as such, the alignment and depth of the containment wall.

6.2.1 Contamination Assessment

The remediation investigations, as presented in Modules B and E (Golder, 2016d), considered the extent of arsenic contamination in the vicinity of the former sludge pit. For the eastern, southern and vertical 'extent' of contamination a qualitative assessment approach was taken, identifying 40 mg/kg as level of arsenic contamination in soil requiring isolation into the containment cell.

The 40 mg/kg criterion was derived from previous column and leach testing work undertaken on contaminated soils. It was estimated that leaching of arsenic from soils containing 40 mg/kg would be negligible and would be readily naturally attenuated by the residual soils. This was supported by ASTM distilled water leaching undertaken to delineate arsenic present in shallow soils (Golder, 2016f).

The eastern and southern extent of remediation is presented in Plate 4, **Section 8.2**. It is noted that there are surficial soils (< 1 m bgl) to the east and south of the proposed extent of remediation that contain arsenic concentrations greater than 40 mg/kg (nominally < 250 mg/kg). As part of the remediation it is proposed to excavate these soils and place them into the containment cell.

The vertical depth of the contamination is approximately 8 m bgl. The final wall target depth will be 12 m bgl. This depth was selected to provide a reasonable margin beyond the characterised depth of arsenic contamination and was also based on consideration of the hydrostratigraphy conceptual model and associated groundwater modelling outputs.

6.2.2 Practicable Constraints

The remediation investigations indicated that arsenic contamination was present up to the northern and western site boundaries. Based on the requirements of the MO, and subsequent Remediation Objectives, the extent of remediation along the northern and western boundaries is limited by the access limitations associated with the wall construction methodology. Notwithstanding this, the remediation design and associated groundwater modelling (**Section 8.0**) has indicated that further off-site migrations from the arsenic contaminated soils outside the containment cell will be reduced.

A practicable design constraint for the infiltration area and above ground site infrastructure is the alignment of the north-eastern and south-eastern corners of the containment wall. This design feature is discussed further in **Section 8.0**, however, it does affect the containment of arsenic contaminated soils (40 mg/kg).

The northern and western extent of remediation is presented in Plate 4.

7.0 REMEDIATION REGULATORY REQUIREMENTS

7.1 Contaminated Land Management Act 1997

In NSW, the management of contaminated land is shared by the NSW EPA, the Department of Planning and Environment (DPE) and planning consent authorities (usually local councils).

The NSW *Contaminated Land Management (CLM) Act 1997* is the primary Act under which contaminated land is regulated by the NSW EPA for land located in NSW. Under the CLM Act 1997 the NSW EPA regulates contaminated sites where the contamination is Significant Enough to Warrant Regulation (SEWR). Contaminated sites that are not regulated by the NSW EPA are managed by local councils through land use planning processes.

Orica has entered into agreements with the NSW EPA under the CLM Act 1997 to manage arsenic contamination identified on the western side of the site. Incitec Pty Ltd (the land owner at the time) notified the NSW EPA under Section 60 of the CLM Act 1997 of soil and groundwater contamination at the site. The NSW EPA (8 October 2001) determined that arsenic contamination in groundwater on the western part of the site and adjoining property (and other contamination present elsewhere on the site) represented a significant risk of harm [terminology prior to SEWR]. As such Incitec and then Orica entered into a number of Voluntary Remediation Agreements (VRA, Stages 1 to 3) and Voluntary Management Proposal (VMP, Stage 4). The NSW EPA declared the site (Lot 3 DP 234288) to be a remediation site under the “Contaminated Land Management Act (1997) – Declaration of Remediation Site No. 21089” on 16 November 2005. On 28 July 2014 the NSW EPA issued a Management Order (MO) (Order Number 20131407; Declaration Number 21089; Area Number 3183) to Orica under Section 14 of the CLM Act 1997, which included objectives, principal features, milestones and reporting requirements for the remediation of the identified arsenic contamination at the former arsenic sludge disposal pit.

Remediation of arsenic contamination at the former arsenic sludge disposal pit is therefore regulated under the CLM Act 1997.

7.2 Environmental Planning and Assessment Act 1979

The *Environmental Planning and Assessment Act (EP&A Act) 1979* and the *Environmental Planning and Assessment Regulation (EP&A Regulation) 2000* provide the framework for development and environmental assessment in NSW.

7.2.1 State Environmental Planning Policy 55

The *State Environmental Planning Policy No. 55 (SEPP 55) – Remediation of Land* under the *EP&A Act 1979* provides a state-wide planning approach for the remediation of contaminated land. In particular, *SEPP 55* provides for Category 1 and Category 2 remediation.

Projects classified as Category 1 remediation works are work requiring development consent, while projects classified as Category 2 do not require development consent. The following table (**Table 3**) provides an assessment of the proposed remediation works against the Category 1 remediation works triggers identified in clause 9 of *SEPP 55*.

Table 3: SEPP 55 Category 1 Remediation Work Triggers

SEPP 55 clause 9 'trigger'	Assessment against proposed remediation works
(a) Designated Development	**No**. The proposed remediation works are not considered to constitute "designated development" under Schedule 3 of the *EP&A Regulation 2000* as they do not currently propose the treatment or storage of more than 30,000 m^3 of contaminated soil and they do not involve the disturbance of an aggregate area of more than 3 hectares of contaminated soil.
(b) Carried out or to be carried out on land identified as critical habitat	**No**.
(c) likely to have a significant effect on a critical habitat or a threatened species, population or ecological community	**No**.
(d) Development for which another State environmental planning policy or a regional environmental plan requires development consent.	**Yes**. Refer to flow chart in **Plate 1**. Under the Three Ports SEPP, Orica KI site is zoned as SP1 'Special Activities'. 'Environmental Protection Works' are identified as being permitted **with** consent for the land use zone.
(e) carried out in an area or zone to which any classifications to the following effect apply under an environmental planning instrument: (i) coastal protection, (ii) conservation or heritage conservation, (iii) habitat area, habitat protection area, habitat or wildlife corridor, (iv) environment protection, (v) escarpment, escarpment protection or escarpment preservation, (vi) floodway, (vii) littoral rainforest, (viii) nature reserve, (ix) scenic area or scenic protection, or (x) wetland.	**Yes**. The proposed works are to be carried out within the area of SEPP 71 Coastal Protection and within the 'Special Activities' zone under the Major Development State Environmental Planning Policy (Major Projects) Amendment (Three Ports).
(f) carried out or to be carried out on any land in a manner that does not comply with a policy made under the contaminated land planning guidelines by the council for any local government area in which the land is situated (or if the land is within the unincorporated area, the Western Lands Commissioner).	**No**. Refer to Section 7.2.4 discussing the development control plan of Newcastle City Council.

'Environmental Protection Works' is identified as an activitiy that is permitted *with* consent for lands zoned as Zone SP1 Special Activities in the State Environmental Planning Policy (Three Ports) 2013. Accordingly, under clause 9(d) of SEPP 55, the proposed remediation action associated with the former arsenic sludge disposal pit are considered to constitute Category 1 remediation works (i.e. works requiring consent).

It is noted that SEPP 55 (Clause 14, Category 2 remediation work : work not needing consent) states: *For the purposes of this policy, a category 2 remediation work is (b) a remediation work (whether or not it is a* *work of a kind described in clause 9 (a)-(f) that: (ii) may be carried out without consent under another State environmental planning policy or a regional environmental plan (as referred to in clause 19(4)).* Other SEPPs, including the SEPP (Infrastructure) 2007, were reviewed in this context, however, were ultimately considered not to be applicable.

7.2.2 State Environmental Planning Policy (State and Regional Development) 2011

State Environmental Planning Policy (State and Regional Development) 2011 identifies development that is classified as State significant development and State significant infrastructure.

Schedule 1 State significant development – general identifies development that is classified as State significant development. Schedule 1, Clause 24 addresses Remediation of Contaminated Land and includes:

> *(1) Development for the purpose of remediation of land that is category 1 remediation works on significantly contaminated land if the work is required to be carried out under the Contaminated Lands Management Act 1997 by a management order that requires:*
>
> > *(a) the taking of action of the kind referred to in section 16 (d) or (g) of that Act, or*
> >
> > *(b) the preparation of a plan of management that provides for the taking of any such action.*

Therefore, given that the remediation action is classified as category 1 remediation works (refer to **Section 7.2.1**) in accordance with a MO issued under the CLM Act 1997, the remediation action is considered to be State significant development. As such, the remediation action requires development consent under Part 4 of the EP&A Act and the Department of Planning and Environment is the consent authority.

Refer to **Plate 1** that summarises the approval pathway for the remediation works.

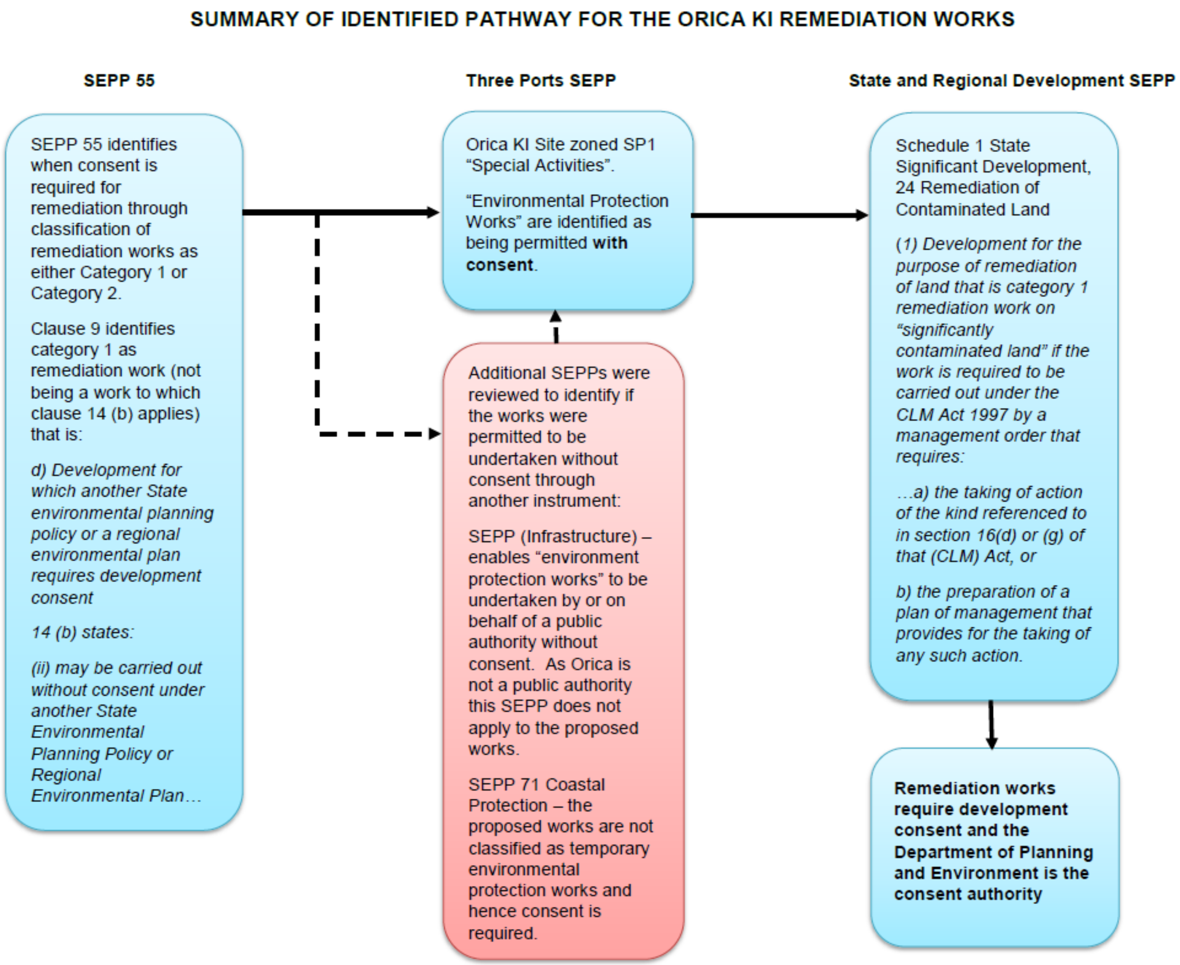

Plate 1: Planning Pathway

7.2.3 Part 5 (Environmental Assessment) of the EP&A Act

Part 5 of the EP&A Act provides for development that is permissible without development consent. As the pathway outlined above considers that the remediation action is Category 1 (remediation with consent) this part is not considered to apply and is not reviewed further herein.

7.2.4 Newcastle City Council – Development Control Plan 2012

Newcastle City Council has a Development Control Plan 2012 (DCP) (CoN, 2012). The DCP incorporates a number of Technical Manuals addressing specific issues, including one for Contaminated Land Management.

Under Section 5. Remediation Work, Category 1 remediation work is defined as a special category of remediation work defined by the State Environmental Planning Policy No. 55 – Remediation of Land (SEPP 55), noting category 1 remediation work can only be carried out with development consent. In so doing it refers to clauses 9 and 14 of SEPP55, consistent with the 'pathway' outlined above.

The manual provides guidance for Category 2 remediation work, which for the reasons outlined above, is not considered to apply.

7.3 Protection of the Environment Operations Act 1997

The *Protection of the Environment Operations (POEO) Act 1997* is the key piece of environment protection legislation administered by NSW EPA.

The *POEO Act 1997* provides a single integrated licensing arrangement to control the air, noise, water and waste impacts of an activity. The NSW EPA is the regulatory authority for the licensing of activities specified under Schedule 1 of the *POEO Act 1997* (scheduled activities) and in most cases councils are the regulatory authority for non-scheduled activities. Licences can also be issued to regulate water pollution from activities that are not in Schedule 1. Such licences can provide protection against prosecution for water pollution if the licence conditions are complied with.

The *POEO Act 1997* also provides the key mechanisms (including the issuing of three types of environment protection notices including: clean up, prevention and prohibition notices) for protecting the environment. It also provides the regulatory regime for waste management under the *Protection of the Environment Operations (Waste) Regulation 2005.*

All works completed as part of the remediation of the former arsenic sludge disposal pit should be conducted in compliance with the relevant requirements of the POEO Act and regulations.

7.3.1 Scheduled Remediation Activities

Section 48 of the *POEO Act 1997* requires a person to obtain a licence from the NSW EPA before carrying out any of the premises-based activities described in Schedule 1 of that Act. The site holds a licence, number 828, for activities at the Orica Kooragang Island site.

The EPA has indicated that the remediation activities will trigger Schedule 1: Contaminated Soil Treatment and that Orica will be required to submit an application to vary the licence to add it as an ancillary activity.

7.3.2 Environment Protection Licence

Orica currently has an Environment Protection Licence (EPL – No. 828), issued under Section 55 of the Protection of the Environment Operations Act 1997. There are currently no Special Conditions listed in the EPL which specifically relate to the contamination addressed within this RAP.

There are general conditions that will be managed through the incorporation of control measures in the Construction Environmental Management Plan. This includes:

- Prevention of pollution of waters
- Waste management

- Carrying out of activities in a competent manner
- Dust management

7.3.3 Protection of the Environment Operations (Waste) Regulation 2005

The remediation envisages that soil material from the wall excavations will be retained within the cap and containment system. The following outlines the documentation and approvals required for the handling, off-site transport and disposal of waste (including hazardous waste) during the remediation works. Although the proposed works are unlikely to involve significant quantities of waste being transported and disposed off-site the following summary of the regulatory provisions as presented in the *Protection of the Environment Operations (POEO) (Waste) Regulation 2005* and the *POEO Act 1997* has been included for contingency amounts of waste to be disposed of off-site as part of the proposed remediation works.

Waste Transporter Requirements

Under Schedule 1, Part 2 of the *POEO Act 1997* the transport of hazardous, restricted solid waste, liquid waste, clinical and related waste or friable asbestos waste (or any combination of them), in loads exceeding 200 kilograms is declared to be a scheduled activity for which a licence is required, but where no licence is required for the premises at which it is carried out (the activity is not premises based).

As such, if the transport of hazardous waste and restricted solid waste from the site to an off-site disposal facility is required to be carried out as part of the remediation, this will require the use of licensed transporters. It is noted that such transport is considered unlikely to be required based on the remediation proposed and would likely be part of a contingency measure.

Waste Tracking Requirements

The *POEO (Waste) Regulation 2005* specifies requirements for the tracking of waste both within NSW and interstate. The wastes that must be tracked are listed in the Schedule 1 of the Regulation (this Schedule includes arsenic or arsenic compounds wastes including soil contaminated with arsenic or arsenic compounds).

Wastes that need to be tracked need to be characterised in accordance with the NSW EPA *Waste Classification Guidelines, Part 1: Classifying Waste* (2014). A NSW EPA online tracking system is available to track waste that is transported within NSW or into NSW from other states or territories.

Waste producers (Orica) are responsible under the legislation for ensuring that wastes (defined under Schedule 1 of the Regulation) are transported only after all the necessary documents and checks have been completed. The management and tracking of waste can, however, be delegated to an “authorised agent”. An authorised agent must be approved by the NSW EPA and the waste producer (Orica) must have a written agreement with the authorised agent.

A consignment authorisation (CA) is issued to the waste consigner (either the waste producer or its authorised agent) by NSW EPA or by an approved receiving facility. This CA allows the transport of the specified waste to the receiving facility. This CA can cover multiple loads and remain valid for up to one year.

A separate transport certificate must accompany each load of waste that is being transported. A waste transport certificate is a document that includes information about the waste, the consigner, the transporter and the receiving facility. The NSW EPA online waste tracking system can be used to create a transport certificate.

Before wastes are transported from the site, Orica must:

- Ensure the waste has been correctly characterised; and
- Ensure the facility (e.g. landfill/ recycling facility) where the waste is being transported to is legally able to accept the waste.

If using an authorised agent Orica must:

- Request documentation from the agent to confirm they are approved by the NSW EPA; and
- Have an agreement in writing with the agent to permit them to consign the waste on Orica's behalf.

If not using an authorised agent Orica must:

- Obtain a CA by contacting the waste facility receiving the waste or NSW EPA;
- Ensure a waste transport certificate is completed for each load of waste;
- Provide the waste transport certificate (with Part 1 completed) to the waste transporter; and
- Ensure the waste transporter is licensed or legally allowed to transport the waste.

If not using an approved online tracking system, Orica must also keep copies of the waste transport certificates for at least four years. The use of the NSW EPA online tracking system removes the requirement to maintain these records.

Waste Immobilisation Approval

The wastes generated (if any) during the proposed remediation works may be classified as either restricted solid waste or hazardous waste in accordance with the NSW EPA *Waste Guidelines* (NSW EPA, 2014a). Hazardous wastes are generally not suitable for disposal to landfill in NSW without 'immobilisation' in order to avoid release of contaminants into landfill leachate. In order to facilitate the off-site disposal of the arsenic impacted hazardous wastes to a licensed landfill facility Orica would be required to apply for a specific immobilisation approval under Section 50 of the *Protection of the Environment Operations (Waste) Regulation 2005*. Immobilisation approvals will only be issued where it is not possible to reuse, recycle or reprocess the waste.

As part of the previous remediation program undertaken for the arsenic disposal pit in 2005, Orica applied for a specific immobilisation approval under Section 50 of the *Protection of the Environment Operations (Waste) Regulation 2005* in order to dispose of the arsenic impacted industrial and hazardous wastes to a licensed landfill facility. A Specific Immobilisation Approval was issued for the on-site treatment and off-site disposal to landfill.

8.0 REMEDIATION DESIGN DEVELOPMENT

This section presents the modelling and concept development components that informed the remediation design.

8.1 Groundwater Model

Using the HCM presented in Module D ((Golder, 2016d) (Refer **Section 5.3**)), A.D.Laase Hydrologic Consulting (Laase) completed a steady-state groundwater flow model for the remediation area and its immediate and downgradient environs, including the downgradient point of discharge into the South Arm of the Hunter River.

Details of the model design and calibration evaluation are presented in the report entitled '*Orica, Kooragang Island, Steady-State Groundwater Flow Model*' (Laase, 2016a).

8.1.1 Methodology

The report (Laase, 2016a) outlines the process involved in 'synthesising' the hydrogeological data into a conceptual model of groundwater flow and the formulation of a 'domain' for the numerical model and eventual design and configuration of the model grid.

The model was 'configured' by translating the Golder HCM onto a three dimensional grid based groundwater flow model. The model was discretised spatially and vertically into five units (Units 1 to 5) and consisted of 745 rows and 600 columns with a constant width of 2 m.

The model was temporarily discretised as three, one-day 'stress' periods representing water level collection periods in January, May and August 2015.

In terms of model boundary conditions, constant head cells were used to represent the North and South Arms of the Hunter River in Units 1 through 4 and were assigned values of 0 m Australian Height Datum (AHD) to represent "average" river stages. The constant head footprints were changed with depth to reflect the known bathymetry of the river on either side of the island. Unit 5 is not in direct contact with the Hunter River and did not require a constant head cell in the model.

Model parameters control the rate of water movement within the model domain. Model parameters included hydraulic conductivity, recharge zonation and evapotranspiration. Model-specific calibration targets were identified, including water level elevations, head differences, flux and trajectory targets.

On the basis of the calibration, the report concluded that the model matches water level elevations and head differences and other identified calibration targets. Based on particle trace analyses, the model was shown to reproduce the arsenic plume flow paths (see **Plate 2** below). It was concluded that the model reflected the conceptual site model and was suitable for use in remedial design evaluation.

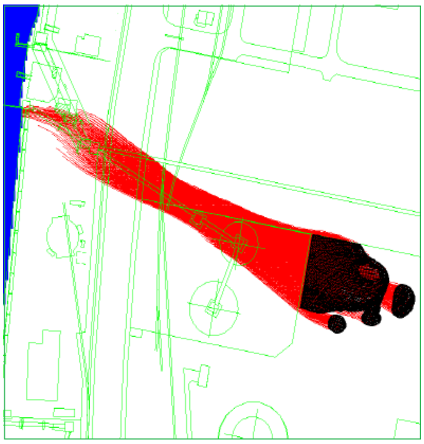

Plate 2: Model predicted arsenic plume particle paths (Lasse, 2016a)

8.1.2 Design Parameter Testing

The calibrated model was subsequently used to evaluate a series of design scenarios intended to inform the overall conceptualisation and eventual design of the cap and containment remediation system. The evaluation of these scenarios was presented in a separate report entitled: '*Design Evaluation of a Cap and Cut-Off Wall for Orica Kooragang Island, Former Sludge Disposal Pit'* (Laase, 2016b).

Overall, one 'ambient' and six 'design' scenarios were run. Five of the design scenarios considered variations in wall depth and cap infiltration rate and estimated a unit net outflow for each scenario as an evaluation of containment cell performance. The sixth scenario (Scenario 2D) also considered the inclusion of an infiltration basin on the eastern (up gradient) side of the containment cell. The evaluation also calculated a percentage reduction in groundwater flow through the arsenic source zone.

A summary table from the design evaluation report is represented below.

Design Scenario		Wall and Cap Specification		Unit Net Outflow, m^3/d				Percentage Reduction in Groundwater Flow Through Arsenic Source
Number	Description	Wall Depth, m bgs	Cap Infiltration Rate, mm/year	Unit 1	Unit 2	Unit 3	Total	
Design Evaluations								
0	Ambient	NA	NA	5.12	0.60	0.16	5.88	0
1	Cap and Walls	8	10	0.16	0.02	0.05	0.23	96
2A	Cap and Walls	12	10	0.16	0.02	0.04	0.22	96
2B	Cap and Walls	12	0	0.07	0.03	0.06	0.16	97
2C	Cap and Walls	12	41	0.42	0.02	0.00	0.44	93
2D	Cap, Walls and Infiltration Basin	12	10	0.16	0.03	0.05	0.24	96
3	Cap and Walls	16	10	0.16	0.02	0.04	0.22	96

8.1.3 Modelling Outcome

On the basis of the remediation investigations, development of the HCM and hydrogeological modelling process, it was concluded that a cut-off wall would need to extend from the ground surface through Units 1 and 2 and partially into Unit 3, a depth of approximately 12 m.

The wall would be a 'hanging wall' and would not have any 'key-in' requirements at its base. It would comprise a closed polygon, with a minimum thickness of 0.8 m and a maximum permeability of 1 x 10^{-9} m/s.

The wall will be integrated with a capping system. The capping system would prevent surface water run-on into the cap and contain area and would limit water infiltration to less than 1% of total annual rainfall.

8.2 Wall Alignment

Following completion of the remediation investigations, a rectangular polygon showing the 'Extent of Arsenic Contamination' (i.e. arsenic concentrations greater the 40 mg/kg) was presented on Figure E1 of the remediation investigations report (Golder, 2016d).

During the course of the modelling and design programs, the cut-off wall alignment was developed further based on the following facets.

8.2.1 Optimisation of Containment

Using the data gathered during the remediation investigations, a series of 3-dimensional representations of the spatial distribution of subsurface arsenic contamination were developed using a geographical information system. These were used as an aid in optimising the wall alignment. An example is presented below.

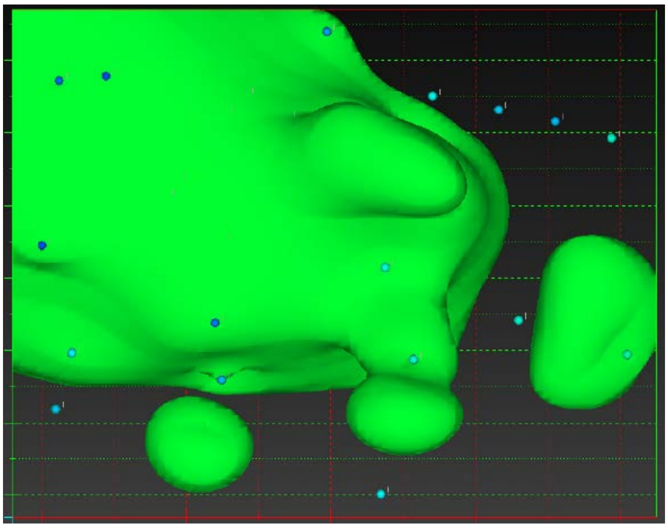

Plate 3: Example of 3-dimensional representation of the 40 mg/kg arsenic concentration 'surface' (plan view)

Additional hand auger sampling was undertaken in two areas to better delineate the extent and depth of shallow arsenic concentrations in soils on the eastern and southern margins of the rectangular polygon. These data are presented in the remediation investigations report (Golder, 2016d).

Plate 4: Further development of the wall alignment using plan view of the 3-D shape, showing additional hand auger locations to the south and east

On the basis of this information the shape of the closed polygon was progressively refined. It should be noted that areas of shallow contamination to the east and south will be excavated and placed inside the alignment before cut-off wall construction so they can also be encapsulated within the proposed system. These areas were subject to additional investigations (Golder, 2016d) to characterise soil quality and to inform volumetric assessment.

8.2.2 Site Features

Careful consideration with regard to minimising impacts on the existing site features, such as drainage structures and water supply infrastructure, was required in finalising an alignment design. Boundary 'off-sets' from the neighbouring properties (to the north and west) considering space required for cut-off wall and capping system construction methodologies were identified and incorporated. Similarly, providing sufficient space for reconstruction of the access road was a key consideration during design.

Due to the offset requirement between the existing ammonia plant flare and the proposed road realignment, the wall was 'chamfered' in the south eastern corner.

Based on the works and considerations outlined above, a final wall alignment was formulated. It is represented in the final design drawings presented in Appendix A and in the following plate.

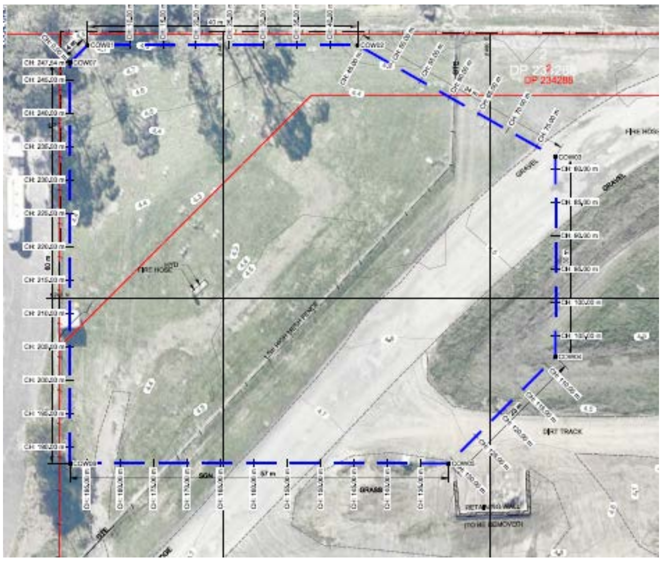

Plate 5: Final Wall Alignment (see Appendix A)

8.3 Wall Construction Method Selection

To assist Orica with the cut-off wall design and construction tendering process, Golder prepared a reference specification (Golder, 2016a).

The specification did not identify a preferred construction methodology, but provided broad preliminary design parameters including wall alignment, depth, thickness and required permeability (hydraulic conductivity).

The reference specification called for a range of design activities including:

- Preparation of mix designs;
- Cut-off wall detail designs;
- Spoil placement and other general design; and
- Design report.

The specification also called for the following construction activities:

- General;
- Work area establishment;
- Underground service clearance;
- Cut-off wall construction;
- Spoil and water management;

- Top of wall completion; and
- Quality Control and Reporting.

The document was issued to a shortlist of specialty contractors, and submissions were received based on three potential construction approaches being:

- **Soil bentonite (SB) Wall –** Wall excavation is carried out by hydraulic excavator with specialist long arm attachment and/or a cable-suspended clamshell depending upon the construction requirements. Throughout the excavation process, the stability of the excavated trench is maintained by flooding the open trench with controlled density bentonite slurry, which provides a positive hydraulic head across the walls of the trench to maintain trench wall stability. The excavated soil is then mixed with bentonite slurry and, if necessary, with imported clays and the mixture is used to backfill the trench. The amount of surplus spoil is anticipated to be 10% to 30% of the wall volume.
- **Cement-Bentonite (CB) Wall –** Wall excavation and trench stabilisation are done similarly to the SB wall, with cement included in the slurry. The wall is formed by hardening of the cement-bentonite slurry. None of the excavated soil is reused and therefore the amount of surplus spoil is equivalent to the wall volume.
- **Cutter Soil Mixing Wall –** The wall is constructed using a piling rig with an arm fitted with rotating blades. As the blades are lowered, the soil is slurried with bentonite and then cement grout is injected as the blades are withdrawn. The amount of surplus spoil is around 10% **–** essentially the volume that is displaced by bentonite and grout.

The submissions were reviewed by Orica, with technical support from Golder. The technical review considered a range of 17 weighted parameters. On the basis of a comparative assessment, the SB approach was considered to be the most suitable, primarily on the basis of it being the most likely candidate to achieve the low permeability requirements, the technical superiority and experience of the proponent, as well as the overall suitability of the approach to the site conditions and target depths. The SB wall approach was notably used in 2006 for construction of the deep cut-off wall at the nearby Mayfield Steelworks remediation site.

8.3.1 Mix Testing

The successful SB contractor has commenced their mix-design testing, using groundwater and soil core materials sourced from the site.

Golder has also undertaken independent mix testing on behalf of Orica, presenting the results and interpretation in a standalone report (Golder, 2016c). The program included laboratory preparation and testing of four SB backfill mixes with varying proportions of bentonite slurry added to site derived bulk soil samples. For each of the four SB mixes, testing included particle size distribution (PSD) as per AS1289.3.6.1 and triaxial permeability (as per AS1289.6.7.3). The permeability ranges recorded were in the order of 1 x 10^{-10} m/s.

Based on the results, the SB testing appeared suitable for cut-off wall construction at the site and would provide sufficiently low permeability material, subject to final design by the cut-off wall contractor.

8.3.2 Durability

SB cut-off walls have been used extensively at remediation sites since the 1980s and are generally considered to be extremely durable because their only consitutents are stable geological materials (i.e. soils and bentonite clay). The predominant constituent is excavated soil from the wall alignment at the site. This material has, by definition, already come to general geochemical equilibrium in the site subsurface conditions. Further, at the Orica KI site, subsurface conditions identified in the remediation investigations are considered non aggressive to SB walls - with potentially unfavourable charateristics such as low pH or significant sulfate, ammonia or volatile organic compound (VOC) concentrations not being detected in soil or water. The predominant site contaminant, arsenic, is not known to influence long-term SB wall performance.

The mix design testing in progress by the successful SB contractor will address durability through permeability testing using site-sourced groundwater and soil core materials. The testing will include extended-duration permeation testing (minimum 30 days' duration) to simulate long-term exposure and allow assessment of the potential for unfavourable chemical interaction between the SB wall material and groundwater. The testing will be consistent with ASTM D7100 - Standard Test Method for Hydraulic Conductivity Compatibility Testing of Soils with Aqueous Solutions, which is considered to be best practice for evaluation of long-term cut-off wall durability. Similar extended-duration permeation testing is required to be performed on samples of material recovered from the constructed wall, as part of the construction quality control process (refer **Section 9.2.1.2**), to confirm as-constructed properties.

8.4 Capping System Design Process

The primary purpose of the capping system is to limit surface infiltration within the footprint of the wall alignment. The design was initially informed by the outcome of the groundwater modelling program and consideration of landform requirements for the site. The overall concept comprised a layered capping system with a composite liner system comprising a linear low-density polyethylene (LLDPE) geomembrane underlain by a geosynthetic clay liner (GCL) integrated into a landform design.

8.4.1 Capping System

The groundwater model identified that a capping system that would reduce infiltration to less than 1% of total annual rainfall is required to achieve the cap and containment performance. The capping system is designed as follows from bottom to top:

- Bearing layer: formed by selected on-site materials (California Bearing Ratio (CBR) >8), to provide support for the geosynthetic liner system.
- GCL: placing the GCL underneath the LLDPE geomembrane will improve performance as it can minimise the leakage through any defects in the geomembrane.
- LLDPE geomembrane: the primary liner layer. With strict Construction Quality Assurance (CQA) processes, the layer would be a reliable barrier minimising water infiltration.
- A subsurface drainage system comprising a drainage sand layer and drainage pipes at maximum 25 m intervals to significantly reduce infiltration through the liner. The sand layer will also minimise the risk of damaging the LLDPE geomembrane during construction of overlying layers.
- A separation geotextile layer to prevent fines entering the sand layer; and
- A surface layer comprising a 400 mm thickness of revegation soil and grass, and/or road base with spray seal.

8.4.2 Landform design

The landform design was developed based on the following assumptions:

- Capacity to contain approximately 1,500 m^3 of soil comprising cut-off wall construction spoil and pre-remediation excavated materials
- Minimum 2% (1-in-50) slope for surface water drainage
- 1-in-3 batter slope with a 9 m wide ramp to provide access to the platform area.

8.5 Remediation Design

On the basis of the modelling and testing processes outlined above, the design for an on-site integrated cap and containment system has been developed.

The final wall alignment and the detailed design for the integrated capping system are presented in Appendix A. It is noted that the details of the design may be subject to minor adjustment during implementation by the cut-off wall and capping system contractors.

9.0 REMEDIATION VALIDATION

This sections presents the overall approach for assessing the performance of remediation against a series of criteria and metrics identified and developed in the following sections.

9.1 Performance Criteria Overview

Remediation is to be achieved through design and construction of engineered solutions comprising a containment (cut-off) wall to isolate a potential continuing source of arsenic impact to groundwater and an integrated capping system to minimise infiltration of rainwater and surface run-off.

Therefore, validation of these measures will be achieved through a combination of Construction Quality Control (CQC) and Assurance (CQA) programs during the installation of the system, in concert with validation through assessment of hydraulic performance post construction including:

- Preparation of a design report by the system designer for review by regulator(s) and project stakeholders;
- Implementation of an agreed CQC program by the appointed construction contractor(s). It is noted these programs are outlined in:
  - Orica KI: Cut-Off Wall – Reference Specification (Golder, 2016a); and
  - Orica KI: Capping System – Reference Specification (Golder, 2016b).
- The CQC programs will culminate in the production of a Construction Report by the Remediation Contractor.
- The Validation Consultant will perform an adequacy review of the CQC outputs and will also implement an independent CQA program during the installation of the cap and containment system.

The other aspects of the validation will include design and implementation of a network of nested monitoring wells (inside and outside the wall) to assess the response in the local hydraulic regime to implementation of the remediation system and performance of the cut-off wall design.

The validation approach for each of these components is developed further in the following sections.

9.2 Cut-Off Wall System

This section elaborates on the general outline of CQC and CQA requirements presented in **Section 9.1**. It provides a summary of the information detailed in the Reference Specification (Golder, 2016a).

9.2.1 Construction Quality Control (CQC)

The cut-off wall construction quality control approach comprises three main elements.

9.2.1.1 Before Construction

The mix testing and any other pre-implementation testing, as required in the specification (Golder, 2016a), will form part of the validation review.

9.2.1.2 During Construction

Section 5.6 of the Reference Specification (Golder, 2016a) outlines tests and measurements to be carried out by the Contractor during construction of the cut-off wall.

The requirements can be summarised as follows to outline the validation requirements, however, the Reference Specification should be referred to directly for implementation. The final target wall properties (other than the permeability acceptability criteria, refer **Section 9.2.1.3**) will be presented in the finalised Design Report.

Table 4: Summary of CQC Testing Requirements

Material / Medium	Stage	General Requirements
Slurry Materials	As-mixed	Sampling of the slurry after mixing and hydration, before introduction into the trench Testing to be conducted for density, viscosity and any other properties identified in the Design Report Testing to be conducted at least 3 times per day.
	In-trench	Sampling of the slurry in the trench, from a depth of approximately 2 m above the trench bottom. Testing to be conducted for density, viscosity and any other properties identified in the Design Report Testing to be conducted at least 3 times per day.
Cut-off Wall Materials	Wall Materials (During Placement)	The wall material will be sampled at the surface, during placement into the trench, 3 times per day.
	Backfill Slope Measurement	Soundings within the trench at approximate 5 m horizontal intervals to establish the depth of the wall backfill material and therefore the overall wall material slope angle
	Sampling In-Trench	Samples of wall materials for confirmation of permeability to be obtained from their as–constructed position within the wall immediately after final placement.

9.2.1.3 Permeability Acceptance Criteria

The permeability requirement will be satisfied if measured values for at least 85% of test specimens are no more than $1x10^{-9}$ m/s, no measured value is greater than $5x10^{-9}$ m/s, and no two measured values between $1x10^{-9}$ m/s and $5x10^{-9}$ m/s are from specimens obtained with 30 m horizontal distance of each other. .

9.2.1.4 Post Construction

The Contractor shall prepare a preliminary Construction Report within 14 days of the end of construction for the cut-off wall to demonstrate that the constructed cut-off wall satisfies specification requirements. A final report including all laboratory test results outstanding at the time of issue of the preliminary report shall be issued within one week after receipt of all outstanding laboratory test certificates.

9.2.2 Construction Quality Assurance (CQA)

The Validation Consultant shall perform inspections and review requirements during the cut-off construction program as follows. These requirements, as well as the various assessment ‘outputs’, are summarised in the table below. Orica (and the Validation Consultant) will have discretion to conduct independent testing or inspection of materials or construction methods at any time.

Table 5: CQA Review Outputs (Validation Consultant)

Work Stage	Component	Action	Interim Output / Reporting Location
Pre-Works	Design Report Mix Testing	Technical Review	Interim advice to Orica / collated into Remediation Validation Report (RVR)
During Works	CQC Testing Program	Oversight of Construction Works Audit of CQC Testing Results Discretionary independent duplicate testing	Validation Consultant Daily Field Activity Logs / Ongoing advice to Orica and stakeholders / collated into the RVR
Post-Works	Construction Report	Technical Review	Close Out Memo / collated into the RVR

9.3 Capping System CQC

The Technical Specification (Golder, 2016b) outlines requirements for a Construction Quality Management System. This aspect of the QC system establishes a preferred construction sequence.

9.3.1 Construction

The main elements can be summarized as:

- Contractor requirements (CQC) including: preparation of Management Plans and Work Method Statements, material testing, compaction testing, surveying, notifying for Inspection Points, and preparing Hold Point documentation and works-as-executed (WAE) documentation.
- Third party inspection actions including: review and approval of Contractor submittals and documentation, inspecting construction works, conducting audit testing, attending Inspection Points, and releasing Hold Points.
- A description of the approach for quality management of material properties is also provided including approval of material sources, confirmation of as-delivered material properties and audit testing.
- A list of Hold Points, Inspection Points and requirement for fulltime inspection of the works is provided in the Technical Specification (Golder, 2016b).

9.3.2 Reporting

The Contractor shall prepare a preliminary Construction Report within 14 days of the end of installation to demonstrate that the constructed capping system satisfies the Technical Specification (Golder, 2016b) requirements. A final report including all laboratory test results outstanding at the time of issue of the preliminary report shall be issued within one week after receipt of all outstanding laboratory test certificates.

9.4 Capping System CQA

The components of the capping system Quality Assurance program that are relevant to the validation of the remedial action to be performed by the Validation Consultant, as well as the assessment outputs, are summarised as follows.

Table 6: CQA Review Outputs

Work Stage	Component (Contractor)	Action (Principal's Representative)	Interim Output / Reporting Location
During Works	Quality Testing / Inspection Programs	Oversight of Installation Works Audit of CQC Testing Results Discretionary independent duplicate testing	Daily Reports / ongoing advice to Orica and stakeholders / incorporated into RVR
Post-Works	Completion Report	Technical Review	Close Out Memo / RVR

Review of the report by the Validation Consultant will form part of the RVR for the remediation works. The RVR will be submitted to the NSW EPA and the Independent Reviewer for review.

9.5 Hydraulic Validation

Hydraulic performance of the containment system will form a key component of the overall remediation validation assessment.

This section discusses the approach for design and installation of a monitoring well network to assess the efficacy of system performance. The design is guided by the hydrogeological information presented in the HCM (Golder, 2016d) as well as the predicted responses presented in the groundwater model (Laase, 2016b).

Interpretation of the HCM has elucidated a containment approach targeting groundwater in Units 1, 2 and the uppermost portion of Unit 3. Hydrostratigraphic conditions in each of these three units have been characterised to be largely distinct, with some connectivity between Units 2 and 3. On this basis, it is expected that the piezometric heads in monitoring wells installed into each unit may respond differently to the effects of system installation.

Similarly, as described in **Section 8.1** above, the calibrated groundwater model (Laase, 2016a) was used to evaluate a series of design scenarios, chiefly intended to inform the overall conceptualisation and eventual design of the cap and containment remediation system. Overall, one ambient and six design scenarios were run. The six scenarios considered variations in wall depth and cap infiltration rate and estimated a unit net outflow for each scenario as an evaluation of containment cell performance. In addition, the model considered the effect on each scenario on water table elevations in several hypothetical paired head observation locations, presenting water table and groundwater levels through the containment cell in a series of model run outputs (Figures 9 through 13 in Laase, 2016b).

It is noted that it is not the intent of the validation program to attempt to recreate the outcomes of the modelling outlined above, but rather to use them as an approximate guide to the types of reponses likely to be observed. In addition to the modelled responses, it is expected that water levels in the monitoring wells located outside the wall will respond to temporal effects, such as rain events, far more obviously than those inside the system.

9.5.1 Methodology

The proposed validation approach is to install a series of nested well suites at strategic locations on either side of the completed cut-off wall, such that the internal and external 'piezometric' water levels can be compared.

The proposed monitoring well network is shown in Drawing 004 in Appendix A. It comprises three sets of paired monitoring wells (a total of six nested well suites) located around the cut-off wall alignment. It is noted that selection of the proposed locations is somewhat constrained by the site characteristics and design features of the cell, however, the wells are best placed to observe the expected effects of design implementation.

At each of the six well suite locations, three separate piezometers will be installed to target Units 1, 2 and 3 individually. This is considered to be an appropriate level of assessment and also reflects the considerations presented in the groundwater model (Laase 2016b), which advocated such an approach.

The monitoring well design will be appropriate to sample the water contained in each of the three units identified in the HCM (Golder, 2016d) and summarised in **Section 5.3**.

9.5.2 Hydraulic Monitoring Approach

The new wells will be installed and developed shortly after cut-off wall installation to ensure that they are functioning appropriately in the context of the expected local conditions. The well heads will be surveyed and dedicated water level loggers installed in each.

The following presents a series of potential effects on the local hydrogeology that may be observed following installation of the containment cell. These include the effects predicted by the groundwater model (Laase, 2016b). It is stressed that validation of system installation is not dependent on observation of *all* of these potential effects. Rather, the validation will consider an holistic assessment of hydraulic effects observed at the monitoring points.

Identified potential effects include:

- The detection of responses to rainfall events that may be recorded in the external wells, but which would be expected to be less prevalent in the data collected from inside the wall. It is noted that the timing of installation of the capping system is a key factor in this assessment as rainfall events prior to cap installation could affect conditions either side of the wall.
- A flattening of the groundwater table(s) inside the cell relative to external conditions;
- An increase in the external hydraulic gradient across the cell (in the direction of groundwater flow); and/or potential increase in gradients around the perimeter of the cell.

Effects predicted in the groundwater model (Laase, 2016b) are described in a series of model run outputs, which were primarily intended to inform the cell design, but which also described hydrostatic conditions in theoretical monitoring points post installation. There is some variability in the predicted outcomes, depending on the various input parameters, including for example wall depth and wall permeability. The modelling run that is closest to the proposed conceptual design is Scenario 2A, which includes a small infiltration basin to the east of the cell.

- Modelling of the identified scenario indicates that water levels in Units 1 and 2 will be lower inside the cell walls by an order of 1 to 2 m, while water in Unit 3 will be slightly higher on the inside.

It is noted that small changes to the overall design have occurred since the model was completed and that further minor changes may occur as the wall contractor's design and construct package progresses. Nonetheless, it is considered that the modelling outputs provide a useful backgound to the assessment of measured effects. At this stage it is proposed that the effects on the local hydraulic regime will be monitored through hydraulic measurements made inside and outside the integrated system. The interpretation of these comparative assessments will be also be considered in the context of the modelled outputs to assist in the primary assessment of wall performance.

It is also noted that barometric pressure inside containment cells has been documented as potentially affecting internal water levels, thereby confounding the comparison with external water levels. To understand these potential effects, an electronic barometric logging device will be deployed in the unsaturated zone (above the water table) beneath the capping system. This will provide real-time monitoring of barometric pressures inside the cell and allow 'normalisation' of the interal water level data, if required. An additional monitoring point (refer Drawing 004 in Appendix A) has been incorporated into the design for this purpose. This will be of similar design to the groundwater monitoring wells, but will not intercept the water table and will be be appropriately designed to prevent air ingress into the space where the logger is located (i.e. air-sealed)..

9.5.3 Hydraulic Monitoring Timeframes

The monitoring well network would be installed immediately after cut-off wall completion. It is noted that the system design has allowed for installation of the monitoring wells after completion of the wall but before installation of the integrated capping system, with eventual completion of permanent well heads being incorporated into the capping system. Data loggers would be deployed following well development and survey.

A data downloading program will be developed and as a minimum will allow for monthly downloads during the first six months of monitoring. Instantaneous measurements using a dip-meter will also be recorded during each download event to allow continuous calibration and checking of the data logger outputs.

The downloaded data will be assessed in the context of the parameters outlined above following the first month of data recording, with monthly downloads thereafter for a minimum of six months, at which point a review of the download frequency may be performed. Overall, it is envisaged that such verification monitoring will be performed for one year following installation as a minimum, but the overall timeframe will be subject to review at that stage.

10.0 BULK MATERIAL VALIDATION

10.1 Background

The primary focus of the remediation validation program is the assessment of the engineered solution and hydraulic performance of the proposed system. These aspects of the validation are discussed separately in **Section 9.0**.

However, the capping system also requires construction of a designed landform into which the capping system will be integrated. This will be mainly be achieved through placement of cut-off wall spoil as well as other bulk materials generated through excavations associated with ground treatments and construction of the infiltration basins etc.

It is therefore proposed to use materials already available on site to meet the land form requirements, with the shortfall (if required) to be made up with imported materials. It is likely that imported materials would form a minor component of the total materials required. All such materials are referred to as bulk materials hereafter.

The Construction Environmental Management Plan (CEMP) will give due consideration to the staging of works to allow appropriate bulk materials tracking measures to be put in place to track and record on-site material movements.

It is also noted that construction of the upper portions of the capping structure, such as bedding layers and batters, will also require importation onto site of other bulk construction materials such as quarry-derived sand and gravels etc.

This section identifies the categories of the likely site-derived and imported bulk materials requiring validation and provides methodologies and assessment criteria where required.

10.2 Bulk Materials Identification and Approach

This section identifies candidate materials that are to be placed inside the cut-off wall and beneath the capping system.

Cut-off Wall Construction Spoils: The proposed construction approach is a Soil Bentonite (SB) cut-off wall. It is estimated that installation of the SB wall will generate spoil in the order of 20 to 30% of the overall wall volume. A conservative estimate of spoil volume would be in the order of 1,500 m^3.

It is intended that this material will be placed inside the cut-off wall perimeter during construction. Noting that this material hardens significantly after placement, geotechnical guidance on the optimal placement, aimed at avoiding density contrasts in the structural base, will be required.

It is considered that chemical characterisation of these materials is not required. A general record of the placement locations (such as photographic logs and 'mud-maps') would be sufficient.

Other Site Materials: Materials generated through excavation and/or surface shaping prior to land forming, may be placed within the containment system. Such materials do not warrant chemical characterisation but will be recorded in the same manner as that outlined for construction spoils as described above. It is noted that this material will include relatively low-level arsenic contaminated soils (refer **Section 5.1**), to be excavated from contiguous areas of shallow soil impacts currently located outside the cut-off wall alignment intended for emplacement inside the containment system. These materials have been pre-characterised (refer **Section 8.2.1** and Golder (2016f)) but their final emplacement will be documented spatialy.

Additional Imported Materials: In the event that imported materials are required they should be validated as either Virgin Excavated Natural Materials (VENM) or Excavated Natural Materials (ENM) as defined under the *POEO Act 1997* and the *POEO (Waste) Regulation 2005*. Validation requirements are specified below.

10.3 Imported Materials Validation

Any other materials proposed for importation should be validated as suitable using sampling and analysis in accordance with the requirements of the NSW EPA (1995) Sampling Design Guidelines.

10.3.1 Assessment Criteria

Consistent with the requirements of the Guidelines for the NSW Site Auditor Scheme (DEC NSW, 2006), it is not appropriate to validate imported materials using soil investigation or screening levels.

Potential contaminant concentrations for VENM or ENM materials proposed for importation must meet the validation criteria listed in Table 2 of the POEO (Waste) Regulation 2005 – General Exemption under Part 6, Clause 51 and 51A – The excavated natural material exemption 2014 (NSW EPA, 2014b).

The following table details a summary of the adopted remediation validation guidelines for imported materials.

Table 7: Validation Criteria for Imported Materials

Analyte	ENM Exemption (NSW EPA, 2014b) (mg/kg)
Arsenic	$20^{a}/40^{b}$
Cadmium	$0.5^{a}/1.0^{b}$
Lead	$50^{a}/100^{b}$
Nickel	$30^{a}/60^{b}$
Mercury	$0.5^{a}/1.0^{b}$
Chromium	$75^{a}/150$ (Total)^{b}
Copper	$100^{a}/200^{b}$
Zinc	$150^{a}/300^{b}$
Electrical conductivity	1.5 dS/m^{a} / 3 dS/m^{b}
pH*	5 to 9^{a}/4.5 to 10^{b}
Total polycyclic aromatic hydrocarbons (PAHs)	$20^{a}/40^{b}$
Benzo[a]pyrene	$0.5^{a}/1^{b}$
Total petroleum hydrocarbons (TPH)	$250^{a}/500^{b}$
Benzene	0.5^{b}
Toluene	65^{b}
Ethyl Benzene	25^{b}
Xylenes	15^{b}
Rubber, plastic, bitumen, paper, cloth, paint and wood	0.05%^{a}/0.10%^{b}

Notes:

a = Maximum average concentration for characterisation

b = Absolute maximum concentration

* = The ranges given for pH are for the minimum and maximum acceptable pH values in the excavated natural material.

All other chemicals of potential concern (COPC) analysed for source characterisation and site verification should be below the respective laboratory detection limits.

Any deviations from this protocol (such as trace level concentrations of petroleum hydrocarbons due to, for instance, naturally occurring hydrocarbon substances) would require justification in the Validation Report.

10.3.2 Sampling Methodology

Imported VENM or ENM will be assessed in accordance with the Sampling Design Guidelines (NSW EPA, 1995). Prior to importation, the source site of the imported materials will be investigated. The site history will be reviewed to ensure previous activities undertaken on the source site have not caused contamination of the imported materials. For VENM, the materials being excavated are visually assessed to confirm that no sign of contamination is present and that the materials are undisturbed.

Imported materials would be sampled at the source site and on delivery to achieve a total sampling density of 1 per 100 m^3 for VENM in accordance with the excavated natural material exemption (NSW EPA, 2012) for ENM and/or manufactured products (e.g. road base).

The proposed soil sampling and analytical program is summarised in **Table 8** below.

Table 8: Proposed Validation Sampling and Analytical Program

Sample Type	Sampling Method	Sampling Frequency	Records/Analytes
Imported Fill (VENM/ENM).	Sampling Trowel	1 per 100 m^3 (Minimum 5 samples per source)	Inorganic suite (As, Cd, Cr, Cu, Hg, Pb & Zn), OCP[1], PCB[2], PAH[3], TPH/BTEX[4]

Notes: 1 Organochlorine pesticides; 2 Polychlorinated biphenyls; 3 Polycyclic aromatic hydrocarbons; 4 Total petroleum hydrocarbons and benzene, toluene, ethyl benzene and xylene compounds

11.0 VALIDATION REPORTING

11.1 Overview

As described in the sections above, validation of the proposed remedial system is to be achieved through assessment of:

- Measured parameters relating to hydraulic responses to the installation of the containment system; and
- A review of key Quality Assurance outputs relating to the construction.

A suitably qualified and experienced Validation Consultant will be engaged by Orica to undertake validation of the remedial action. Given the range of skills required to fulfil the validation assessment, it may be that the Validation Consultant is in fact a team comprising expertise in the following areas will be required:

- Environmental science, including:
  - Hydrogeology; and
  - Bulk materials sampling and validation.
- Construction oversight and verification; and
- Construction Quality Assurance review.

It is envisaged that the Validation Consultant shall report directly to Orica and will liaise with other stakeholders, as required.

11.2 Validation Assessment Inputs

The Validation Consultant shall collect the following to inform the validation assessments:

- Field samples and laboratory testing results to support assessment of suitability of materials for importation and use on site.
- Water table elevation (level logger) data from the identified monitoring wells to inform assessment of local hydraulic response to containment system installation

The Validation Consultant shall oversee the construction process. The consultant shall perform the following audit and testing roles, the outputs from which will inform the overall assessment of construction quality:

- Technical review of preliminary documentation and submissions;
- Ongoing audit of contractor's CQC outputs;
- Oversight and logging of construction activities;
- Discretionary independent 'duplicate' or additional QC testing to assess and/or support the contractor's testing regimes; and
- Technical review of Contractor's Completion Reports.

11.3 Remediation Validation Report

The identified data outputs and information collected during the process outlined above will be collated on an ongoing basis and presented in a Remediation Validation Report (RVR).

The environmental assessment components of the RVR will be prepared in general accordance with Guidelines for Consultants Reporting on Contaminated Sites (NSW EPA, 1997).

The report will present the following results of the validation assessments:

- Confirmation that the cap and containment system has been constructed in accordance with:

- The remediation design presented herein for the capping system; and
- The remediation design to be developed by the cut-off wall contractor for the SB wall system.

- The identified hydraulic responses to the containment system through hydraulic measurements in the proposed monitoring well suite.

The report will present a conclusion which establishes:

- An overall assessment of the effectiveness of the implementation of the remedial system;
- What contingent actions might be required if the assessment concludes that certain aspects of the remedial system have not achieved their objectives; and
- Identified requirements for inclusion in the Long Term Environmental Management Plan (LTEMP) (**Section 15.0**).

12.0 CONTINGENCIES

The proposed remediation approach comprises two engineered solutions aimed at (to the extent practicable) isolating the inferred ongoing source of groundwater impact and minimising downward infiltration of rain water or surface runoff through the system.

Should either of the engineered solutions prove ineffective in meeting the remediation objectives (due to design as opposed to implementation), it is unlikely that improvement of the engineered solutions would be practicable. It is considered more likely that alternate engineered designs would need to be tabled for consideration and construction to achieve the remediation objectives.

Notwithstanding, this section briefly explains the contingent approach that will be adopted in the event that, after reviewing the balance of evidence, it is concluded that some or all of the remediation objectives have not been met.

12.1 Construction Quality

CQC documentation will be provided by the construction contractor during the construction program and will be reviewed by the Validation Consultant on an ongoing basis.

If inspections or laboratory analysis reveal inconsistencies with the construction quality requirements, these may be able to be addressed during the construction phase through, for example, amendment of the SB mix, rate of emplacement, etc.

Otherwise, if review of testing results collected after construction indicates that permeability or alignment are not in accordance with the specification, it is unlikely that improvement will be achievable and, as stated above, alternate engineering designs would need to be considered.

12.2 Hydraulic Performance

The hydraulic performance of the integrated capping and containment system will be assessed by measuring the groundwater elevations inside and outside the containment wall. The data will allow an assessment within the context of several potential hydraulic effects.

Should the measured water levels indicate effects that are contrary to those generally predicted, and further assessment through additional measures (such as installation of targeted monitoring wells outside the cut-off wall) fail to provide sufficient evidence that the remediation objective is being achieved, then management through low-flow extraction of groundwater using one or more of the groundwater monitoring wells inside the containment wall would be a possible contingency. Extracted water would be collected and tested to enable implementation of the appropriate method of treatment and disposal. It is also noted that such targeted pumping measures may also assist in better understanding the nature of the problem.

Once the capping system has been installed, it will be very difficult to effect repairs on the containment wall. Groundwater level management is likely to be the most practicable means of addressing this.

13.0 ENVIRONMENTAL MANAGEMENT

13.1 Approach and Objectives

Orica will commission the preparation of a Construction Environmental Management Plan (CEMP) to document the proposed environmental control measures and monitoring programs to be implemented during the remediation works. The CEMP will be prepared in accordance with the framework provided in this RAP and guidance provided in DIPNR (2004) Guideline for the Preparation of Environmental Management Plans.

The principal objectives of the CEMP will be to:

- Ensure that there will be no detrimental effects on the environment caused by potential discharges or emissions from the remediation works;
- Identify relevant environmental statutory requirements to ensure the works comply with all requirements of law, including the *Protection of the Environment Operations Act 1997* and relevant licences (including EPL 828), the MO and the requirements of City of Newcastle Development Control Plan (2012); and
- Identify requirements for an operational structure that allows:
  - Identification and reporting of incidents and non-conformances such that corrective actions can be completed in a timely manner; and
  - Response to changes in environmental conditions through review of the monitoring and control programs.

The CEMP will be required to be prepared in conjunction with a Site Specific Health and Safety Plan (SSHSP, see **Section 14.0**) and be developed, and approved by Orica, prior to mobilisation to commence works. In addition to the requirements outlined above, the CEMP will be prepared with regard to the aspects outlined below.

13.2 Environmental Aspects

The following sections of the RAP outline the environmental controls to be adopted to protect the environment both on the site and in the surrounding area for the duration of the proposed remediation works.

The controls aim to protect surface water, groundwater and air quality by preventing the release of dusts, contaminated soils, and contaminated water to the extent practicable, and to control noise and vibration levels. Where monitoring indicates unsatisfactory performance, then work methods and/or controls will be modified.

Elements of the proposed remediation works that can interact with the environment are identified as broadly including the following:

- Dust emissions;
- Surface water discharge;
- Noise emission and vibration;
- Spillage of contaminated soil in the event of off-site disposal;
- Fuel/oil leaks/spills; and
- Handling of contaminated materials (soil and groundwater).

Odours and vapour generation have not been considered as a significant environmental aspect given the absence of odours and vapours during previous investigations and work programs.

13.3 Meteorological Conditions

As part of the remediation methodology and the specific job safety analysis, the CEMP shall consider contingency measures for unexpected conditions which could affect environmental performance, such as increases in dry conditions resulting in increased risk of dust, or prolonged rainfall affecting surface water quality, particularly if such an event or events occur over an extended period such as several days.

13.4 Dust Control

The remediation works must be completed in a manner that minimises or prevents dust emissions from the remediation activities including wind-blown, excavation and wheel-generated dust.

The CEMP will identify the techniques to be implemented during the remediation program to mitigate dust from the works. A suite of controls will be implemented within the Remediation Area to manage potential dust generating sources or activities. For remediation works these controls could include:

- Minimisation of open excavation areas;
- Expeditious reinstatement of excavations and exposed surfaces;
- Covering of all loads being transported off-site;
- Minimisation of the number of stockpiles and implementation of dust minimisation controls for stockpiled materials; and
- Minimisation of dust generation from haulage areas.

Minimisation of dust emissions may include covering of areas, use of water sprays or other appropriate techniques.

13.5 Surface Water Management

The CEMP will include a plan for erosion and sediment control for the works. As required by the CoN Council DCP (2012), the plan should be in accordance with the "Managing Urban Stormwater: Soils and Construction. 4th Edition – Vol1." (the Blue Book) (Landcom, 2004).

The surface water management measures to be implemented during remediation works should include, but not be limited to, perimeter drainage control measures (which may include straw bales, diversion drains, ditches and silt fences) to prevent clean water from entering the work areas. The diverted water will be directed away from (and/or around) the work area, through a series of sediment and erosion control devices..

Drainage in the construction area will also be managed to minimise discharge of potentially contaminated surface water from the area.

Spill control equipment will be available in the event of a fuel or oil spill in the remediation area.

13.6 Contaminated Wastewater Management

The CEMP will include a plan for excavation water management.

If wastewater is generated during the proposed remediation works, it will be collected and contained on site in tanks to be provided and maintained by Orica and may be discharged to the site effluent system, subject to confirmation of compliance with the discharge limits. If the wastewater is not suitable for on-site management it will be disposed of to a licensed waste facility.

13.7 Noise and Vibration Management

The CEMP will identify the noise management protocols to be implemented during remediation works to address noise and vibration and include:

- All plant and equipment should be designed and operated with the objective of achieving noise targets set out in the CoN DCP (2012); and

- The use of any plant and/or machinery shall not cause vibrations in excess of relevant NSW State Government guidelines and Australian Standards (CoN, 2012).

The construction contractor will be responsible for implementation of the noise and vibration compliance monitoring, if required. The monitoring program will be conducted by a qualified and experienced noise monitoring specialist. Monitoring will be conducted as appropriate should there be any noise complaints and during remediation works identified as a potential noise hazard.

13.8 Solid Waste Management

The CEMP will outline procedures for the management of waste.

The proposed remediation approach is substantially based on site capping and containment of impacted soils and materials. Spoils generated during the wall construction process will also be placed within the cut-off wall system. The potential for substantial volumes of solid waste to be generated is relatively low. Off-site disposal of such waste (if generated as a surplus of spoil for example) would be the most likely option.

Any such surplus materials which cannot be contained, or otherwise re-used, on site and for which off-site disposal is deemed appropriate will be classified and managed in accordance with the NSW EPA Waste Classification Guidelines Part 1: Classifying Waste (NSW EPA, 2014a).

13.9 Traffic Management

The CEMP will include a plan for managing traffic associated with the works with regard to the safety and welfare of the general public and to alleviate the impact of additional traffic volumes on other activities at the site. This would include traffic control measures such as establishment of designated haul routes on and off site.

All truck drivers carting materials from the site will be given a safety instruction briefing. The briefing will detail the procedures to be followed by the truck driver should an incident occur. These will include, but not necessarily be limited to:

- Vehicle accident;
- Mechanical breakdown;
- Rain commencing during transportation; and
- Payload (or other) loss.

13.10 Emergency Response

The CEMP will include a plan for emergency response. The emergency response plan (ERP) will identify possible emergency situations that might occur throughout the works program both on and off the site. The ERP should be consistent and integrated with the site ERP, and as a minimum, include the following:

- Assignment of responsibilities to nominated key personnel;
- Assessment of the potential on- and off-site impacts of hazards;
- Emergency reporting procedures, including on-site reporting lines of communication and procedures for reporting relevant issues to appropriate authorities; and
- Emergency response procedures for the remediation area including:
  - Fires;
  - Spill and leaks of arsenic impacted hazardous material;
  - Traffic accidents involving the transportation of arsenic impacted hazardous material;
  - Rupture of buried services;

- Earth moving machine roll-over;
- First aid for injured personnel;
- Evacuation of on-site personnel; and
- Incident investigation procedures.

13.11 Contingency Management

A procedure to address conditions which may be reasonably expected to be encountered and a plan of how to manage these issues should be developed, and include:

- The assignment of responsibilities to nominated key personnel;
- The assessment of the potential on- and off-site hazards associated with such situations;
- Contingency responses; and
- Procedures for reporting relevant issues to regulatory authorities.

The following events have been identified to date as having the potential to occur during the remediation works for which contingency plans should be developed:

- Variation of contaminant characteristics or identification of unanticipated contaminants and materials;
- Generation of unacceptable levels of dust during remediation works;
- Generation of unacceptable noise levels during remediation works;
- Generation of unacceptable vibration levels during remediation works; and
- Generation of unexpected quality or quantity of wastewater.

14.0 OCCUPATIONAL HEALTH AND SAFETY

14.1 Site Specific Health & Safety Plan

A Site Specific Health and Safety Plan (SSHSP) will be developed by Orica or its nominated subcontractor/ sub consultant prior to commencement of remediation works. The objective of the SSHSP will be the protection of the health and safety of workers in the Remediation Area as well as the general safety of occupiers of surrounding areas on and off site. The SSHSP will be prepared in accordance with the *Work Health and Safety Act 2011,* the *Work Health and Safety Regulation 2012* WorkCover, NSW and any additional governing regulations.

The document will provide details of the chemical and physical hazards associated with the proposed remediation works and a range of controls. It will also specify requirements for personnel inductions and medical surveillance.

The SSHSP shall include:

- Details of an induction process for all personnel working on the remediation site;
- Where applicable, detailed safe work method statements (SWMS) and Job Safety Analysis (JSA) developed by appointed sub-contractors prior to the commencement of any work;
- Emergency phone numbers;
- A map showing the shortest route to nearby hospitals or health centres;
- Daily toolbox meeting content and procedures;
- Definition of roles and responsibilities of personnel, including staff and other contractors;
- Hazard identification procedures and control measures;
- Safety data sheets;
- Soil, water and material handling procedures;
- Personal protective equipment requirements (all the safety equipment shall meet all applicable Australian Standards);
- Decontamination procedures for leaving the remediation area prior to breaking for eating, drinking, smoking, using the toilet and before leaving the each day;
- Work zones, traffic routes and stockpile areas; and
- Incident management and reporting plans.

Site workers and visitors will be trained on the contents of the SSHSP prior to mobilisation to the works area.

14.2 Site Mobilisation

Prior to commencement of remediation activities, the following activities will be undertaken:

- Establishment of equipment, amenities and work area(s);
- Installation of decontamination facilities;
- Establishment of exclusion zones;
- Installation of safety equipment;
- Establishment of area fencing/bunding and impacted area exclusion zones; and
- Project signage.

14.3 Exclusion Zones

As part of the work health and safety requirements, access within the Remediation Area shall be controlled. Orica or its nominated subcontractor/ sub consultant will be expected to implement varying controls depending on the personnel and whether the proposed work area is in an Exclusion Zone.

Exclusion Zones are areas of the Remediation Area that either require additional protective measures or may require the adoption of additional health and safety requirements and work practices. The Exclusion Zone may incorporate a buffer area along the boundary of the zone.

Access of personnel into and out of Exclusion Zones will be controlled, with these controls varying depending on the personnel classification.

The boundary of all Exclusion Zones will be defined by construction of hazard tape fences/barricade. Safety signs shall also be erected at regular intervals around each Exclusion Zone warning on-site personnel of the boundary of the Exclusion Zone, the nature of the hazard associated with it and access restrictions that apply to entry into the Zone. Maintenance of the Exclusion Zones will be the responsibility of Orica or its nominated subcontractor/ sub consultant.

14.4 Decontamination Procedures

The SSHSP will outline the procedure for decontamination of personnel leaving the Exclusion Zone(s) prior to breaking for eating, drinking, smoking, use of ablution facilities and before leaving the site.

All tools, vehicles or equipment which have been in contact with contaminated materials will be decontaminated after leaving the Exclusion Zone(s).

15.0 LONG-TERM ENVIRONMENTAL MANAGEMENT PLAN

Orica has been implementing an Environmental Management Plan (EMP) since 2008, to provide a framework to minimise risk to either human health or the environment from the identified arsenic contamination. This EMP has been regularly revised since its initial implementation. The current version (Revision 3) was updated in February 2015 (Golder, 2015). This EMP is appropriate for the site conditions prior to the proposed remediation. A CEMP (**Section 13.0**) will be developed and implemented for the remediation works.

The MO requires the development of a Long-Term Environment Management Plan (LTEMP) for implementation following completion of the remediation works. The LTEMP is to fulfil the following requirements of the MO:

- Action 2 c). *Prepare a LTEMP for any operational phase of the proposed works and provide a copy to the EPA. The LTEMP will incorporate any long-term requirements for operation and maintenance, monitoring and restrictions on site activities in the vicinity of the system or process. The LTEMP should be revised based on systems or process operation and monitoring results on a periodic basis with EPA approval*.
- Action 2 d). *Operate and maintain the installed system or process in a manner to achieve the remediation objective and in accordance with the LTEMP.*
- Action 4). *Update the Arsenic EMP*.

The LTEMP is to be developed to address the above actions nominated within the MO, specifically:

- Describe any restrictions associated with activities or land use on or around the Containment Cell area.
- Maintenance and inspections associated with the Containment Cell.
- Groundwater monitoring requirements. The Groundwater Monitoring Plan (GMP, which forms a requirement of the Workplan (Golder, 2014)) currently being implemented will be revised and form part of the LTEMP to allow the collection of the required groundwater data to facilitate assessment of the performance of the Containment Cell against the assessment approach nominated in **Section 9.5**.
- Provide the framework to minimise risk to either human health or the environment from the identified arsenic contamination post the construction of the Containment Cell, noting that arsenic contamination will be present outside the cell and on adjacent land.
- Provide a program for revision of the LTEMP.

The LTEMP is to be developed two months prior to the completion date for the installation of the Containment Cell. The completion of the LTEMP is document in the Remediation Schedule presented in **Section 17.0**.

16.0 COMMUNICATION STRATEGY

In harmony with the existing EMP (Golder, 2015), Orica developed and has been implementing a Communication Plan since 2008 (Orica, 2015). The Communication Plan has been regularly reviewed to allow provision of update information to stakeholder based on the progression of investigation and remediation works.

The Communication Plan outlines the objectives, the stakeholders, and the communication requirements.

Action 5 of the MO requires:

Prepare and provide to the EPA a communication strategy to ensure key stakeholders are kept informed on the progress of the remedial work under this Management Order. The Communications Strategy must include:

- *a) Identification of key stakeholders, including the Orica Kooragang Island Community Reference Group (CRG), industrial neighbours, Newcastle City Council (NCC) and neighbouring communities.*
- *b) Utilisation of a range of different communication measures to maximise access to information; and*
- *c) Schedule communication activities to update stakeholders of progress at regular intervals.*

As noted above, the communication strategy is already in place and being implemented. It is envisaged that the communication strategy will be revised, together with the preparation of the LTEMP, nearing completion of the Containment Cell.

17.0 REMEDIATION MILESTONES

The remediation milestones are those set down in the Management Order. They include:

- LTEMP (and revision of the Communication Strategy) – 2 months prior to completion of the containment cell
- Remediation to be completed by 31 December 2017.
- LTEMP and Communication Strategy to be implemented as described within.

18.0 REFERENCES

CoN, 2012. *Development Control Plan and Contaminated Land Management Technical Manual.* The City of Newcastle. June 2012.

CSIRO, 2007. *Mobility of Arsenic in Groundwater at Kooragang Island, Newcastle. Stage 1: Adsorption and Desorption Rates.* Commonwealth Scientific and Industrial Research Organisation, 2007.

DEC NSW, 2006. *Contaminated Sites: Guidelines for the NSW Site Auditor Scheme*. Second Edition, Department of Environment NSW, April 2006.

DECCW, 2011a. *“Review of Environmental Factors Template”* Department of Environment, Climate Change and Water (2011/0031)

DECCW, 2011b. *Proponents Guidelines for the Review of Environmental Factors* Department of Environment, Climate Change and Water (2011/0028).

DIPNR, 2004. *Guideline for the Preparation of Environmental Management Plans.* Department of Infrastructure Planning and Natural Resources, 2004.

GHD, 2014. *Orica Kooragang Island Groundwater Remediation Feasibility Assessment, Independent Review of Assessment Process.* GHD Pty Ltd, March 2014.

Golder, 2013. *Orica Kooragang Island, Conceptual Site Model.* Golder Associates Pty Ltd, 29 November 2013.

Golder, 2014. *Orica Kooragang Island. Workplan – Arsenic Management Order*. Golder Associates Pty Ltd, 22 December 2014.

Golder, 2015. *Environment Management Plan – Revision 3*. Golder Associates Pty Ltd. 3 February 2015.

Golder, 2016a. *Reference Specification - Orica Kooragang Island: Arsenic Management Order – Cut-Off Wall* - Golder Associates Pty Ltd (1418917_030_Rev 3)

Golder, 2016b. *Orica Kooragang Island – Arsenic Remediation Project – Capping System Technical Specification* – 1418917-038-S-Rev0 . Golder Associates Pty Ltd. March 2016.

Golder, 2016c. *Preliminary Cut-Off Wall Mix Testing, Greenleaf Road, Kooragang Island, NSW.* Golder Associates Pty Ltd. 26 February 2016.

Golder, 2016d. *Orica Kooragang Island – Arsenic Management Order- Remediation Investigations – 1418917_012-016_R_Rev0* . Golder Associates Pty Ltd, March 2016.

Golder, 2016e. *Technical Memoradum - Geochemical Modeling of Arsenic Attenuation and Release*. Golder Associates Pty Ltd, April 2016.

Golder, 2016f. *Technical Memoradum – Delineation of Arsenic in Near Surface Soils Outside the Cut-off Wall Alignment, Arsenic Remediation, Orica, Kooragang Island*. Golder Associates Pty Ltd. (1418917_054_L_Rev0). 17 June 2016.

Laase, 2016a. *Orica, Koorgang Island. Steady-State Groundwater Flow Model.* A. D. Laase Hydrologic Consulting. Draft 18 January 2016.

Laase, 2016b. *Design Evaluation of a Cap and Cut-Off Wall for Orica Kooragang Island, Former Sludge Disposal Pit.* A. D. Laase Hydrologic Consulting. Draft 26 January 2016.

Landcom, 2004. *Managing Soils and Groundwater. Soils and Construction*. Volume 1, 4th Edition. March, 2004

NEPC, 1999. *National Environment Protection (Assessment of Site Contamination) Measure*. National Environment Protection Council. 2013 Amendment.

NSW EPA, 1995. *Contaminated Sites: Sampling Design Guidelines*. NSW EPA, September 1995

NSW EPA, 1997. *Contaminated Sites: Guidelines for Consultants Reporting on Contaminated Sites.* NSW EPA, September 1997. (Reprinted September 2000. Reissued by NSW Government Office of Environment and Heritage in 2011).

NSW EPA, 2014a. *Waste Classification Guidelines, Part 1: Classifying Waste*. New South Wales Environment Protection Autority. November 2014.

NSW EPA, 2014b. *Resource Recovery Exemption under Part 9, Clauses 91 and 92 of the Protection of the Environment Operations (Waste) Regulation 2014, The Excavated Natural Material Exemption,* NSW EPA

Orica, 2013. *Arsenic Groundwater Remediation – Feasibility Assessment*. Orica Australia Pty Ltd. 30 August 2013.

Orica, 2015. *Orica Kooragang Island EMP Stakeholder Communication Plan – Rev C.* Orica Australia Pty Ltd. February 2015.

Wilkin R.T. 2001. *Iron sulfide-arsenite interactions: adsorption behaviour onto monosulfides and controls on arsenic accumulation in pyrite.* USGS Workshop on Arsenic in the Environment, Denver.

19.0 IMPORTANT INFORMATION ABOUT THIS REPORT

Your attention is drawn to the document titled - “Important Information Relating to this Report”, which is included in **Appendix B** of this report. The statements presented in that document are intended to inform a reader of the report about its proper use. There are important limitations as to who can use the report and how it can be used. It is important that a reader of the report understands and has realistic expectations about those matters. The Important Information document does not alter the obligations Golder Associates has under the contract between it and its client.

Report Signature Page

GOLDER ASSOCIATES PTY LTD

Gavan Butterfield Principal Environmental Scientist	Andrew Holloway Principal Environmental Scientist

GB/AH/gb

A.B.N. 64 006 107 857

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FIGURES

ORICA KOORAGANG ISLAND: ARSENIC MANAGEMENT ORDER – REMEDIATION ACTION PLAN

ORICA KOORAGANG ISLAND

SITE LOCATION

LEGEND

- Orica Kooragang Island Facility
- Incitec Pivot Limited
- Port of Newcastle
- Toll Holdings (Lease)
- Vue Australia

0 50 100 200 300 400 metres

SCALE (at A4) 1:12,500

Coordinate System: GDA 1994 MGA Zone 56

PROJECT:	1418917
DATE:	28/06/2016
DRAWN:	SL
CHECKED:	AH

FIGURE 1

NOTES

Site boundary is approximate.

Golder Associates

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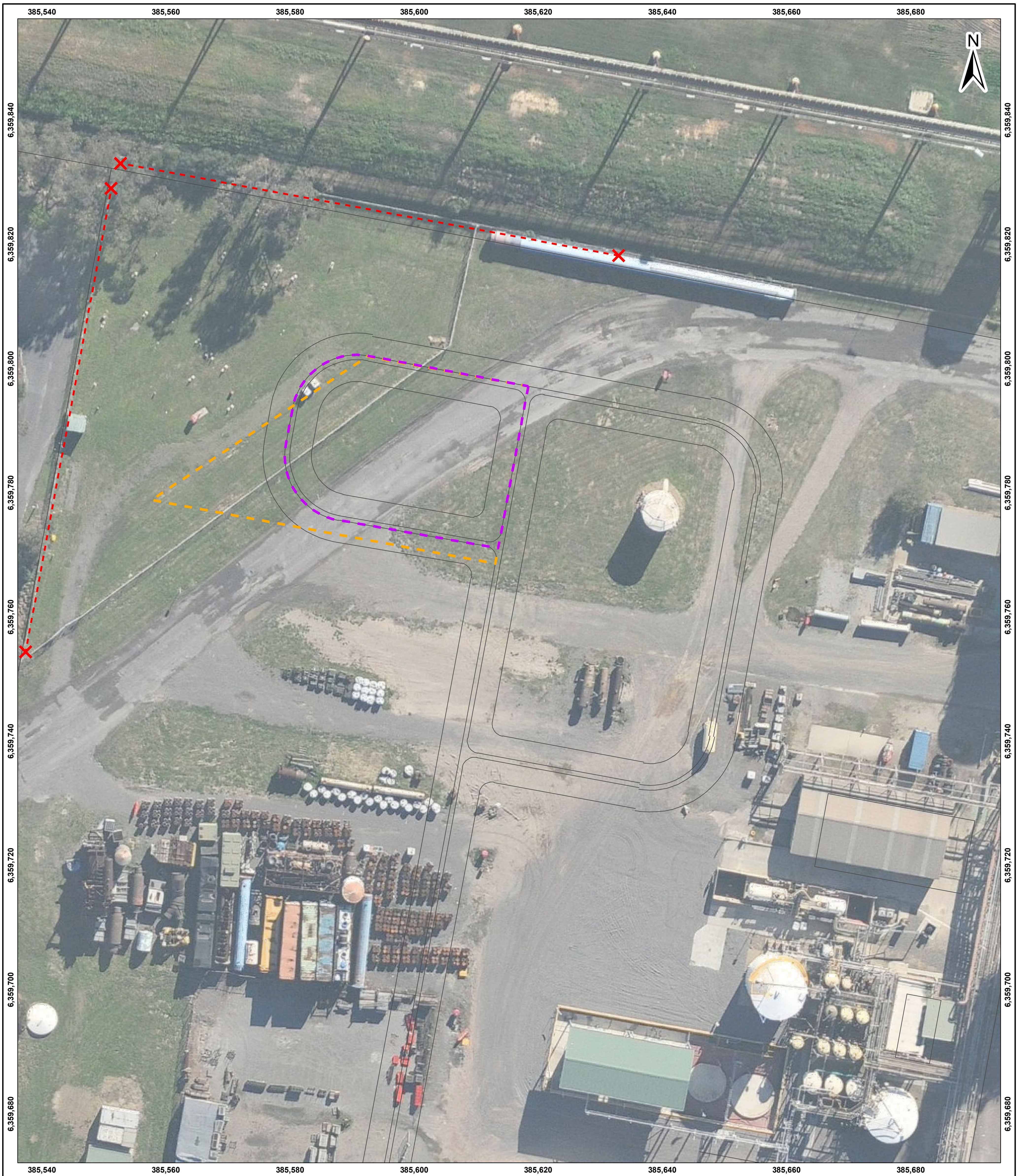
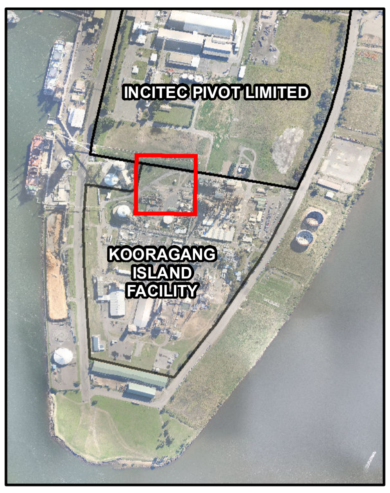


ORICA KOORAGANG ISLAND:
ARSENIC MANAGEMENT ORDER
– REMEDIATION ACTION PLAN

ORICA KOORAGANG ISLAND

FORMER DISPOSAL PIT LOCATION AND PREVIOUS REMEDIATION



LEGEND

- Boundary Survey Point
- Boundary Line

Former Disposal Pit Location

- Maximum known extent of Former Disposal Pit
- Circa 1994 extent of Former Disposal Pit

0 5 10 15 20 25 metres

SCALE (at A3) 1:600

Coordinate System: GDA 1994 MGA Zone 56

PROJECT: 1418917
DATE: 28/06/2016
DRAWN: SL
CHECKED: AH

FIGURE 2

Golder Associates

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APPENDIX A

Wall Alignment and Detail Design for Capping System

ORICA AUSTRALIA
KOORAGANG ISLAND ARSENIC REMEDIATION PROJECT

LOCALITY PLAN
NOT TO SCALE

DRAWING INDEX

DRG. NO.	TITLE
001	LOCALITY PLAN AND DRAWING INDEX
002	EXISTING FEATURES
003	TOP OF FILL PLAN AND SUB-SURFACE DRAINAGE PIPES
004	TOP OF CAP AND STORMWATER DRAINAGE PLAN
005	TYPICAL CROSS SECTIONS
006	TYPICAL SECTIONS AND DETAILS
007	DRAIN AND INFILTRATION PIT DETAILS

NOTES
1. THESE NOTES APPLY TO ALL PROJECT DRAWINGS IN THE SET UNLESS NOTED OTHERWISE AND SHALL BE READ IN CONJUNCTION WITH THE SPECIFICATION.
2. ALL LEVELS ARE IN METRES TO AUSTRALIAN HEIGHT DATUM (AHD).
3. ALL CO-ORDINATES ARE IN METRES TO ORICA SITE CO-ORDINATES.
4. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.
5. DIMENSIONS AND LOCATION OF EXISTING STRUCTURES SHALL BE CONFIRMED ON SITE BY THE CONTRACTOR PRIOR TO COMMENCEMENT OF WORKS.
6. LOCATION AND DEPTH OF ALL SERVICES TO BE VERIFIED BY THE CONTRACTOR PRIOR TO COMMENCEMENT OF WORKS.
7. DIMENSIONS SHALL NOT BE SCALED OFF DRAWINGS.

MATERIALS LIST

- UNIT 1 - REVEGETATION LAYER MATERIAL
- UNIT 2 - FILL MATERIAL
- UNIT 3 - BEARING LAYER MATERIAL
- UNIT 4 - DRAINAGE AGGREGATE
- UNIT 5 - DRAINAGE SAND
- UNIT 6 - ROAD BASE
- UNIT 7 - SEPARATION GEOTEXTILE
- UNIT 8 - GEOSYNTHETIC CLAY LINER
- UNIT 9 - LLDPE GEOMEMBRANE
- UNIT 10 - SUBSURFACE DRAINAGE PIPE (PERFORATED)
- UNIT 10 - SUBSURFACE DRAINAGE PIPE (SOLID WALL)
- UNIT 11 - HDPE PIPE
- UNIT 12 - OVERFLOW PIT
- UNIT 13 - RIP RAP

ISSUED FOR
CONSTRUCTION

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
0	2016-04-11	ISSUED FOR CONSTRUCTION	RH	EJJ	GRS	GRS

CLIENT
ORICA AUSTRALIA PTY LTD.

CONSULTANT
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PROJECT
ORICA KOORAGANG ISLAND ARSENIC REMEDIATION PROJECT

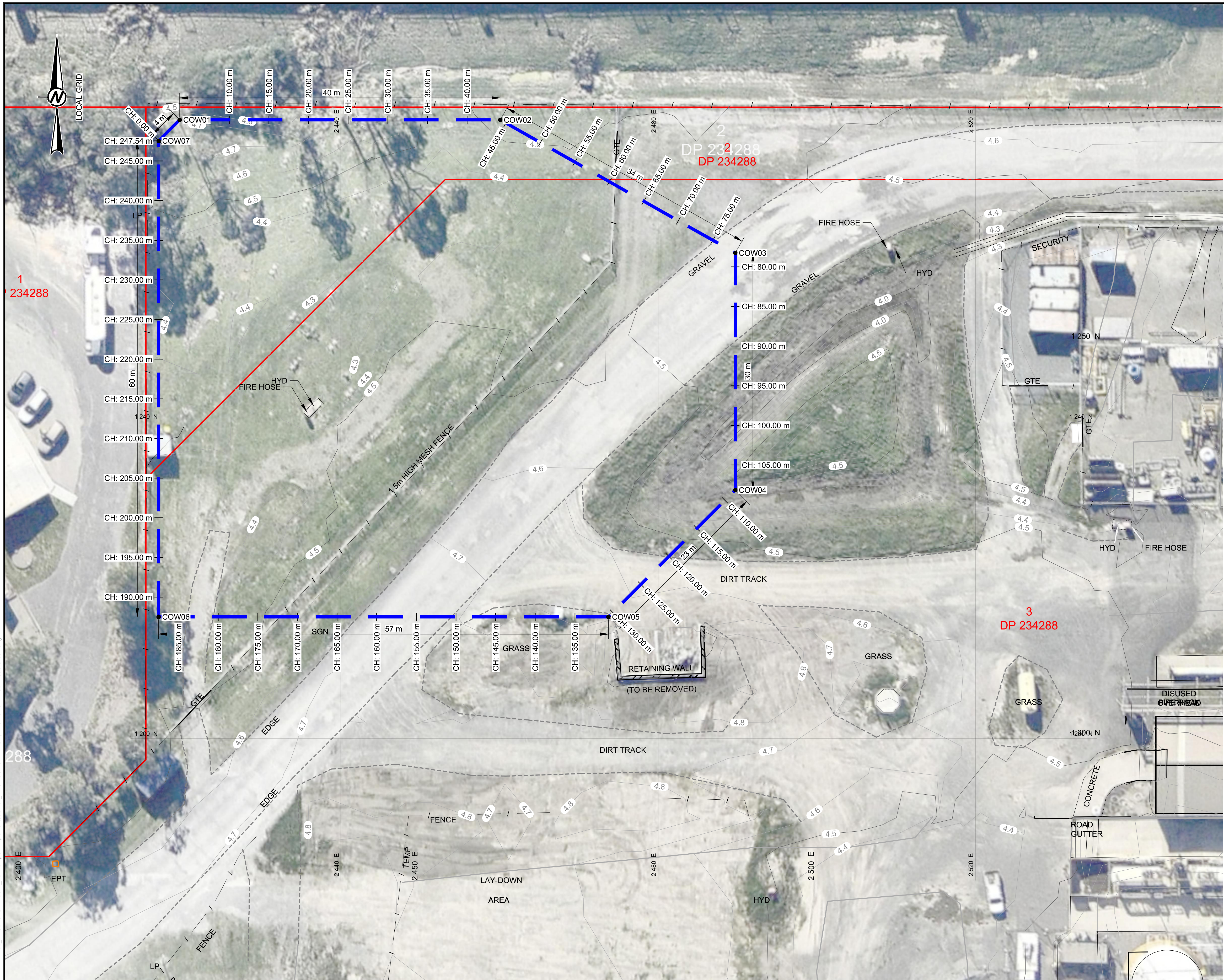
TITLE
COVERSHEET

PROJECT NO.	SPECIFICATION	REV.		DRAWING
1418917	038	0	1 of 7	001

Path: \\golder.gds\gap\Sydney\Geomatics\ORICA_AUSTRALIA\KI99_PROJECTS\1418917_As Workplan Implementation\02_PRODUCTION\DWG\ | File Name: 1418917-038-S-001.dwg

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ISO A3

25 mm



LEGEND

- PROPERTY BOUNDARY
- CUT-OFF WALL
- EXISTING CONTOURS AT 0.1 m INTERVALS

REFERENCE(S)

- BASE MAP SOURCED FROM MONTEATH & POWYS, TITLED "DETAIL SURVEY FOR ARSENIC REMEDIATION PROJECT", DATED 22/07/2015, DRG REF 15-43050, DELIVERED IN .dwg FORMAT
- NEAR MAP IMAGE TRANSFORMED BY GOLDER ASOCIATES PTY LTD

SURVEY INFORMATION

1. THE SURVEY IS ON ORICA SITE CO-ORDINATES. BASED ON SURVEY CONTROL MARK MONUMENT 106 NEAR PRILL TOWER E 2580437.0, N893077.0
2. ORIGIN OF LEVELS MONUMENT 106 NEAR PRILL TOWER RL 3.962 ORICA DATUM
3. CONTOUR INTERVAL IS 100mm.

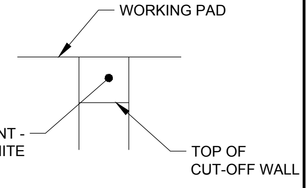
Station	TOP OF RL CUT-OFF WALL (m) (NOTE 1)
0	4.17
5	4.05
10	4.05
15	4.04
20	4.03
25	4.03
30	4.02
35	4.01
40	4.01
45	4.00
50	3.98
55	3.97
60	3.95
65	3.94
70	3.92
75	3.91
80	3.92
85	3.97
90	4.02
95	4.07
100	4.12
105	4.17
110	4.19
110	4.19
115	4.17
120	4.15
125	4.13
130	4.11
135	4.14
140	4.20
145	4.20
150	4.19
155	4.13
160	4.07
165	4.01
170	3.96
175	3.90
180	3.84
185	3.79
190	3.78
195	3.81
200	3.85
205	3.88
210	3.91
215	3.95
220	3.98
225	4.02
230	4.05
235	4.09
240	4.12
245	4.16
247.54	4.17

SETOUT TABLE

POINT No.	EASTING (m)	NORTHING (m)
COW01	2419.66	1277.98
COW02	2460.09	1277.98
COW03	2489.74	1261.19
COW04	2489.74	1231.29
COW05	2473.74	1215.30
COW06	2417.01	1215.30
COW07	2417.01	1275.33

NOTE(S)

1. TOLERANCE FOR TOP OF CUT-OFF WALL = 0 TO -100mm. SOIL-CEMENT BENTONITE ZONE MIN THICKNESS 500mm (REFER KEY SKETCH).



ISSUED FOR

CONSTRUCTION

0 10 20
1:500 METRES

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
0	2016-04-11	ISSUED FOR CONSTRUCTION	RH	EJJ	GRS	GRS

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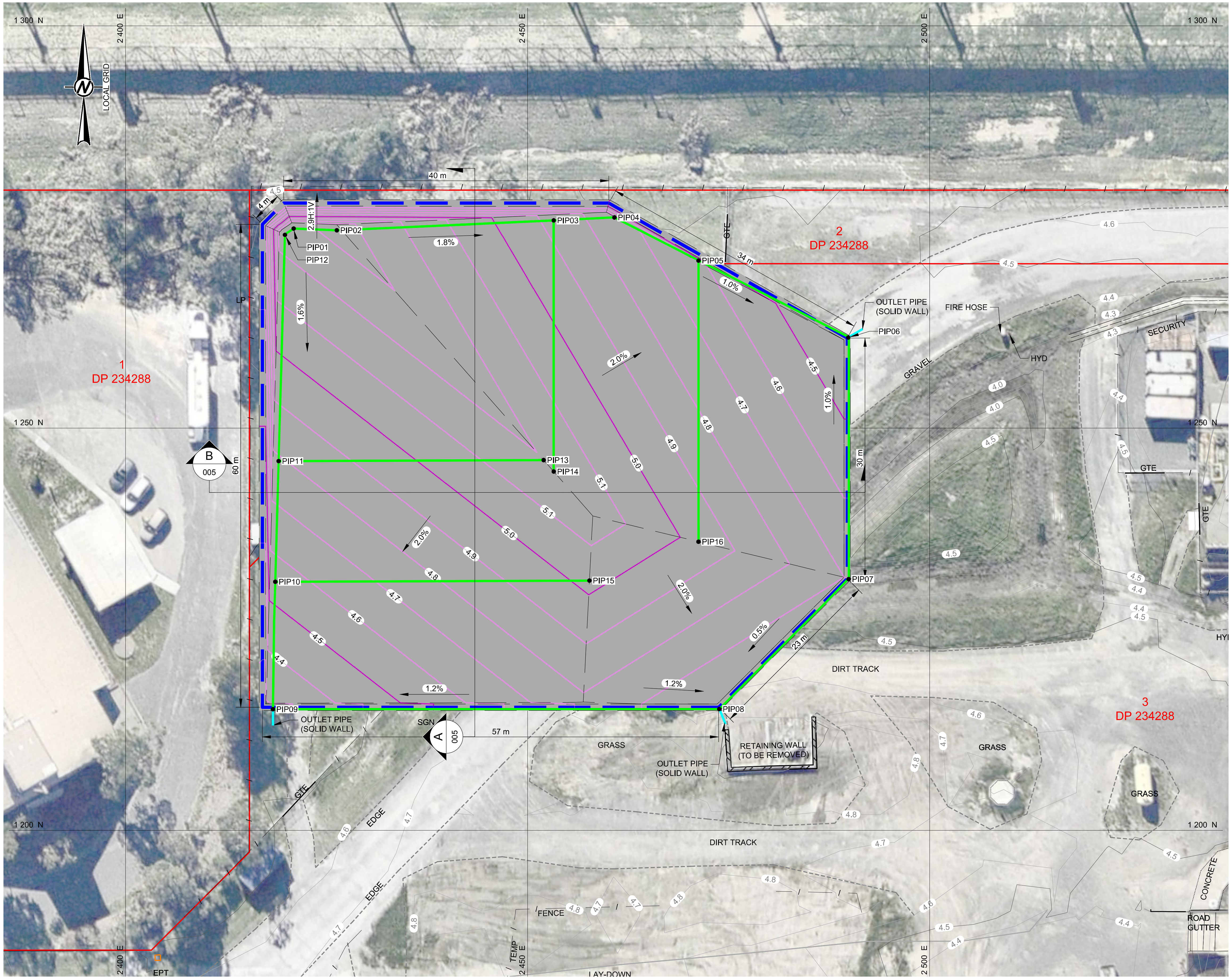
PROJECT
ORICA KOORAGANG ISLAND ARSENIC REMEDIATION PROJECT

TITLE
EXISTING FEATURES

PROJECT NO. 1418917 | SPECIFICATION 038 | REV. 0 | 2 of 7 | DRAWING 002



LEGEND

- PROPERTY BOUNDARY
- CUT OFF WALL ALIGNMENT
- UNIT 10 SUB-SURFACE DRAINAGE PIPE (PERFORATED)
- UNIT 10 SUB-SURFACE DRAINAGE PIPE (SOLID WALL)
- TOP OF FILL CONTOURS AT 0.1 m INTERVALS

REFERENCE(S)

- BASE MAP SOURCED FROM MONTEATH & POWYS, TITLED "DETAIL SURVEY FOR ARSENIC REMEDAITION PROJECT", DATED 22/07/2015, DRG REF 15-43050, DELIVERED IN .dwg FORMAT
- NEAR MAP IMAGE TRANSFORMED BY GOLDER ASSOCIATES PTY LTD

SURVEY INFORMATION

1. THE SURVEY IS ON ORICA SITE CO-ORDINATES. BASED ON SURVEY CONTROL MARK MONUMENT 106 NEAR PRILL TOWER E 2580437.0, N893077.0
2. ORIGIN OF LEVELS MONUMENT 106 NEAR PRILL TOWER RL 3.962 ORICA DATUM
3. CONTOUR INTERVAL IS 100mm.

NOTE(S)

1. OUTLET PIPES OF THE SUB-SURFACE DRAINAGE SYSTEM TO BE DRAINED INTO ADJACENT SURFACE WATER DRAINAGE STRUCTURE.

SETOUT TABLE

POINT No.	EASTING (m)	NORTHING (m)	ELEVATION (RL, m)
PIP01	2420.90	1274.80	5.27
PIP02	2426.26	1274.59	5.33
PIP03	2453.24	1275.82	4.87
PIP04	2460.79	1276.18	4.74
PIP05	2471.24	1270.82	4.61
PIP06	2489.86	1261.26	4.40
PIP07	2489.91	1231.22	4.70
PIP08	2473.83	1215.07	4.60
PIP09	2418.32	1215.05	4.30
PIP10	2418.62	1230.90	4.55
PIP11	2419.03	1245.90	4.79
PIP12	2419.82	1274.02	5.24
PIP13	2451.99	1246.02	5.20
PIP14	2453.24	1244.60	5.19
PIP15	2457.68	1231.04	5.03
PIP16	2471.24	1235.87	4.97

ISSUED FOR

CONSTRUCTION

0 10 20

1:500 METRES

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
0	2016-04-11	ISSUED FOR CONSTRUCTION	RH	EJJ	GRS	GRS

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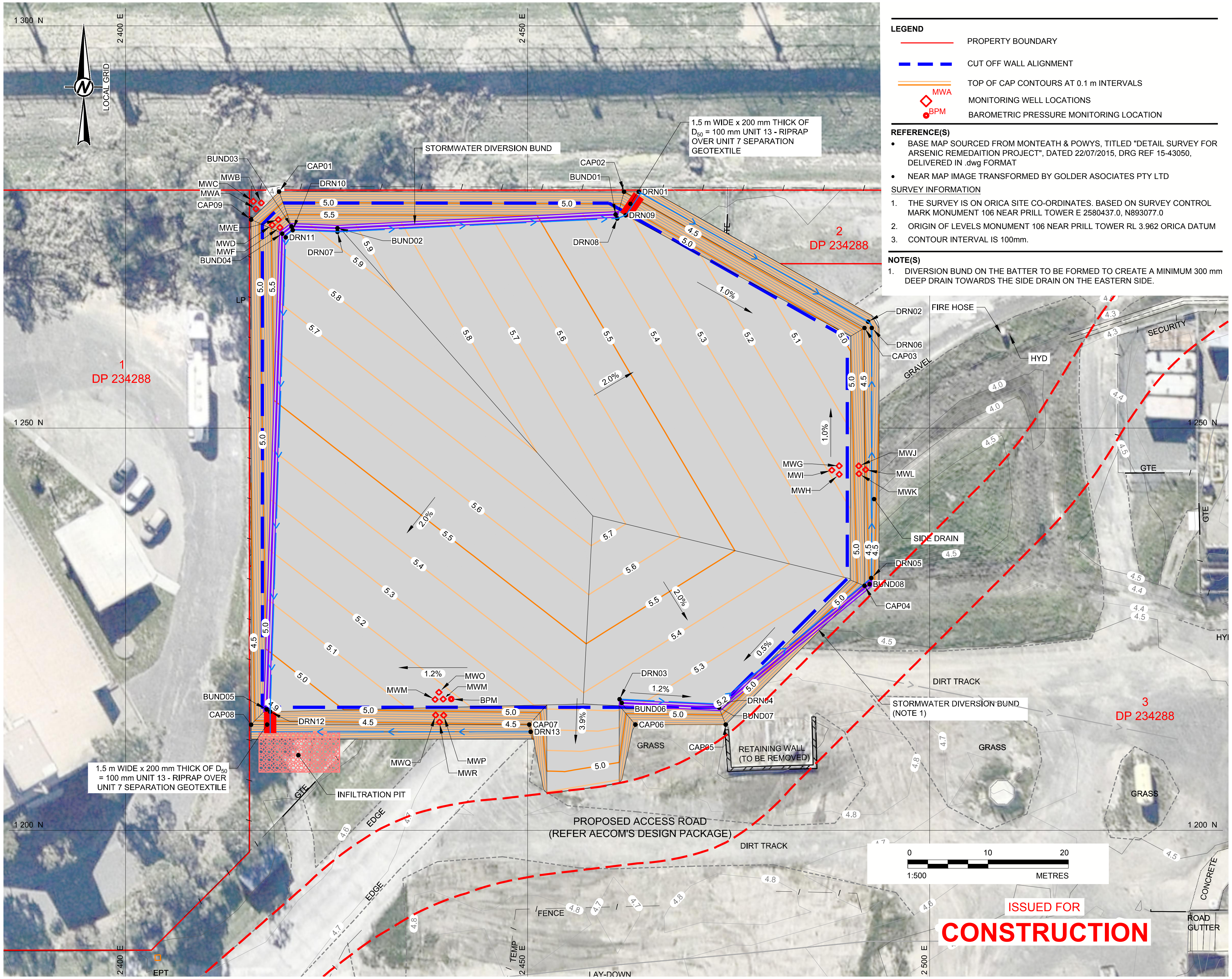
PROJECT
ORICA KOORAGANG ISLAND ARSENIC REMEDIATION PROJECT

TITLE
TOP OF FILL PLAN AND UNIT 10 SUB-SURFACE DRAINAGE PIPES

PROJECT NO.	SPECIFICATION	REV.		DRAWING
1418917	038	0	3 of 7	003



LEGEND

- PROPERTY BOUNDARY
- CUT OFF WALL ALIGNMENT
- TOP OF CAP CONTOURS AT 0.1 m INTERVALS
- MWA — MONITORING WELL LOCATIONS
- BPM — BAROMETRIC PRESSURE MONITORING LOCATION

REFERENCE(S)

- BASE MAP SOURCED FROM MONTEATH & POWYS, TITLED "DETAIL SURVEY FOR ARSENIC REMEDIATION PROJECT", DATED 22/07/2015, DRG REF 15-43050, DELIVERED IN .dwg FORMAT
- NEAR MAP IMAGE TRANSFORMED BY GOLDER ASSOCIATES PTY LTD

SURVEY INFORMATION

1. THE SURVEY IS ON ORICA SITE CO-ORDINATES. BASED ON SURVEY CONTROL MARK MONUMENT 106 NEAR PRILL TOWER E 2580437.0, N893077.0
2. ORIGIN OF LEVELS MONUMENT 106 NEAR PRILL TOWER RL 3.962 ORICA DATUM
3. CONTOUR INTERVAL IS 100mm.

NOTE(S)

1. DIVERSION BUND ON THE BATTER TO BE FORMED TO CREATE A MINIMUM 300 mm DEEP DRAIN TOWARDS THE SIDE DRAIN ON THE EASTERN SIDE.

SETOUT TABLE

POINT No.	EASTING (m)	NORTHING (m)
MWA	2416.22	1277.23
MWB	2416.88	1277.98
MWC	2415.90	1278.18
MWD	2418.24	1275.24
MWE	2418.99	1275.91
MWF	2419.19	1274.92
MWG	2488.74	1245.30
MWH	2488.75	1244.24
MWI	2487.83	1244.76
MWJ	2491.17	1245.29
MWK	2491.20	1244.32
MWL	2492.03	1244.83

SETOUT TABLE

POINT No.	EASTING (m)	NORTHING (m)
MWM	2438.49	1216.26
MWM	2439.50	1216.30
MWO	2438.96	1217.15
MWP	2439.56	1214.30
MWQ	2438.56	1214.32
MWR	2439.03	1213.44

SETOUT TABLE

POINT No.	EASTING (m)	NORTHING (m)
BPM	2440.50	1216.30

SETOUT TABLE

POINT No.	EASTING (m)	NORTHING (m)	ELEVATION (RL)
CAP01	2419.08	1279.38	4.56
CAP02	2461.99	1279.38	4.50
CAP03	2491.89	1262.45	4.40
CAP04	2491.89	1230.40	4.70
CAP05	2474.63	1213.14	4.60
CAP06	2463.39	1213.14	4.55
CAP07	2450.20	1213.14	4.49
CAP08	2415.61	1213.13	4.33
CAP09	2415.61	1275.91	4.67

SETOUT TABLE

POINT No.	EASTING (m)	NORTHING (m)	ELEVATION (RL)
BUND01	2460.93	1276.55	5.63
BUND02	2426.34	1274.85	6.23
BUND03	2420.64	1275.06	6.17
BUND04	2419.48	1274.17	6.14
BUND05	2417.54	1215.03	5.18
BUND06	2461.71	1215.83	5.63
BUND07	2473.81	1215.26	5.49
BUND08	2492.51	1230.60	4.79

SETOUT TABLE

POINT No.	EASTING (m)	NORTHING (m)	ELEVATION (RL)
DRN01	2463.81	1279.38	4.12
DRN02	2492.33	1263.23	4.10
DRN03	2461.43	1216.29	5.34
DRN04	2473.66	1215.71	5.20
DRN05	2492.73	1231.36	4.41
DRN06	2492.79	1262.45	4.10
DRN07	2426.34	1274.40	5.93
DRN08	2461.15	1276.06	5.33
DRN09	2462.18	1276.46	5.31
DRN10	2420.78	1274.61	5.86
DRN11	2419.91	1273.72	5.84
DRN12	2417.98	1214.73	4.88
DRN13	2450.37	1212.24	4.19

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
1	2016-06-28	ISSUED FOR CONSTRUCTION	RH	EJJ	GRS	GRS
0	2016-04-11	ISSUED FOR CONSTRUCTION	RH	EJJ	GRS	GRS

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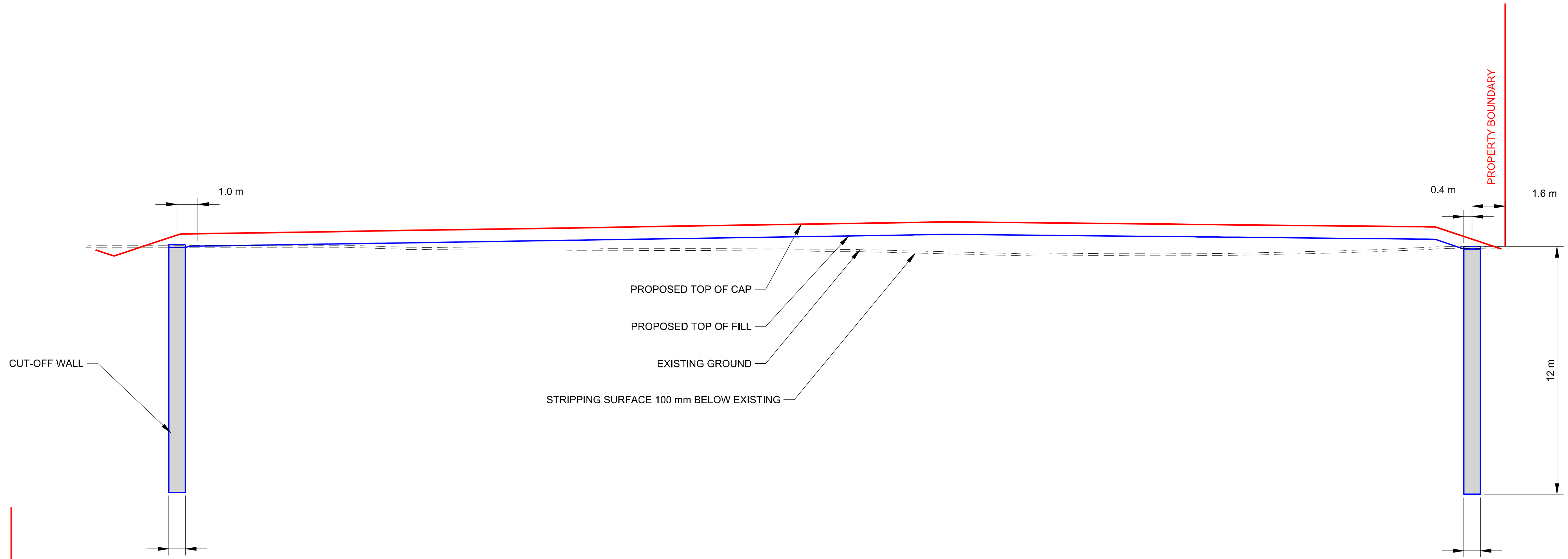
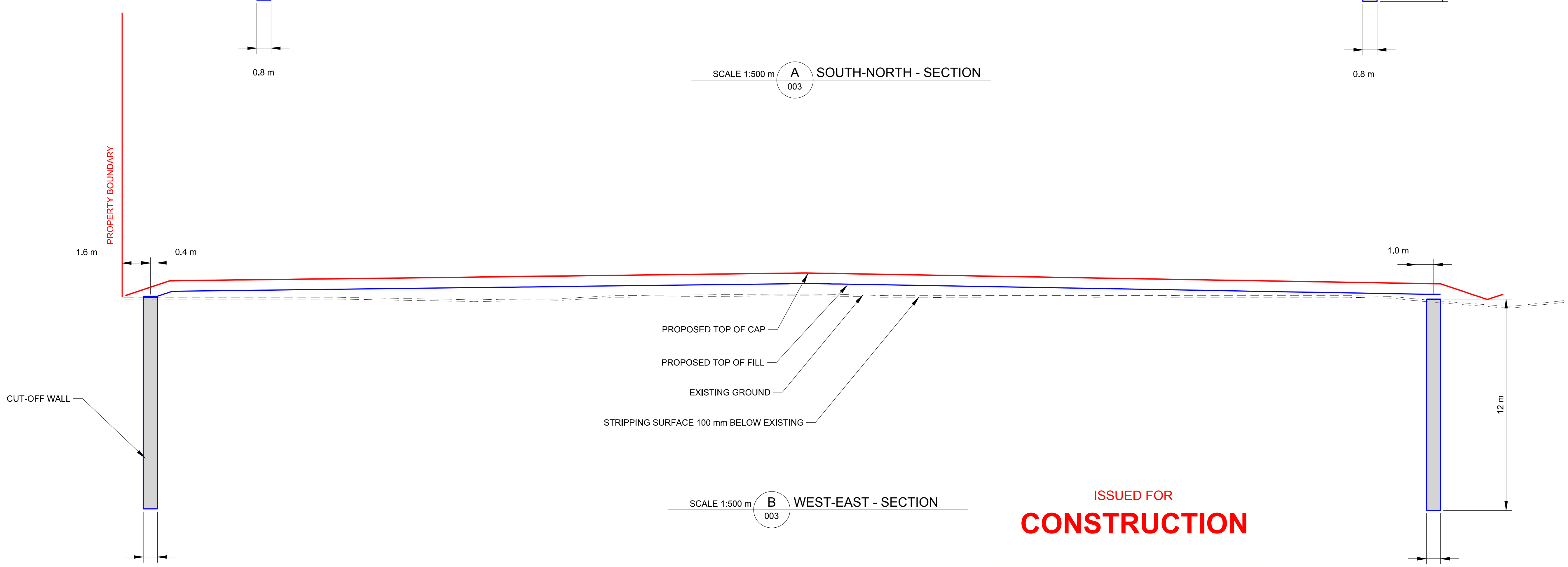
PROJECT
ORICA KOORAGANG ISLAND ARSENIC REMEDIATION PROJECT

TITLE
TOP OF CAP AND STORMWATER DRAINAGE PLAN

PROJECT NO.	SPECIFICATION	REV.		DRAWING
1418917	038	1	4 of 7	004



SCALE 1:500 m A 003 SOUTH-NORTH - SECTION



SCALE 1:500 m B 003 WEST-EAST - SECTION

ISSUED FOR

CONSTRUCTION

0 5 10

1:250 METRES

0	2016-04-11	ISSUED FOR CONSTRUCTION	RH	EJJ	GRS	GRS
REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED

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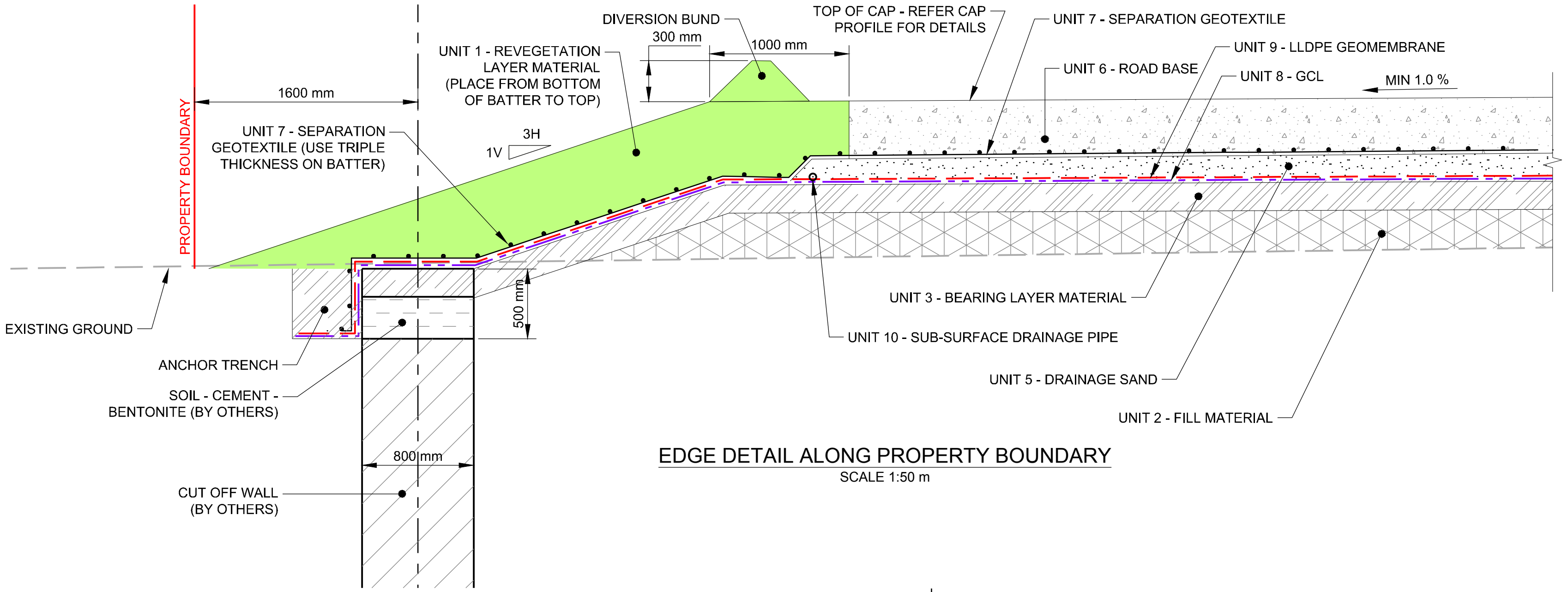
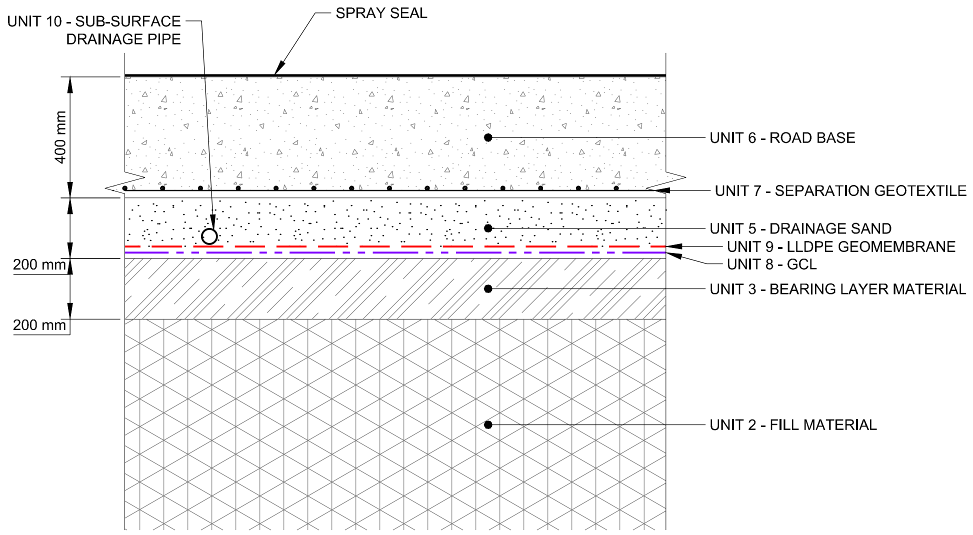
PROJECT
ORICA KOORAGANG ISLAND ARSENIC REMEDIATION PROJECT

TITLE
TYPICAL CROSS SECTIONS

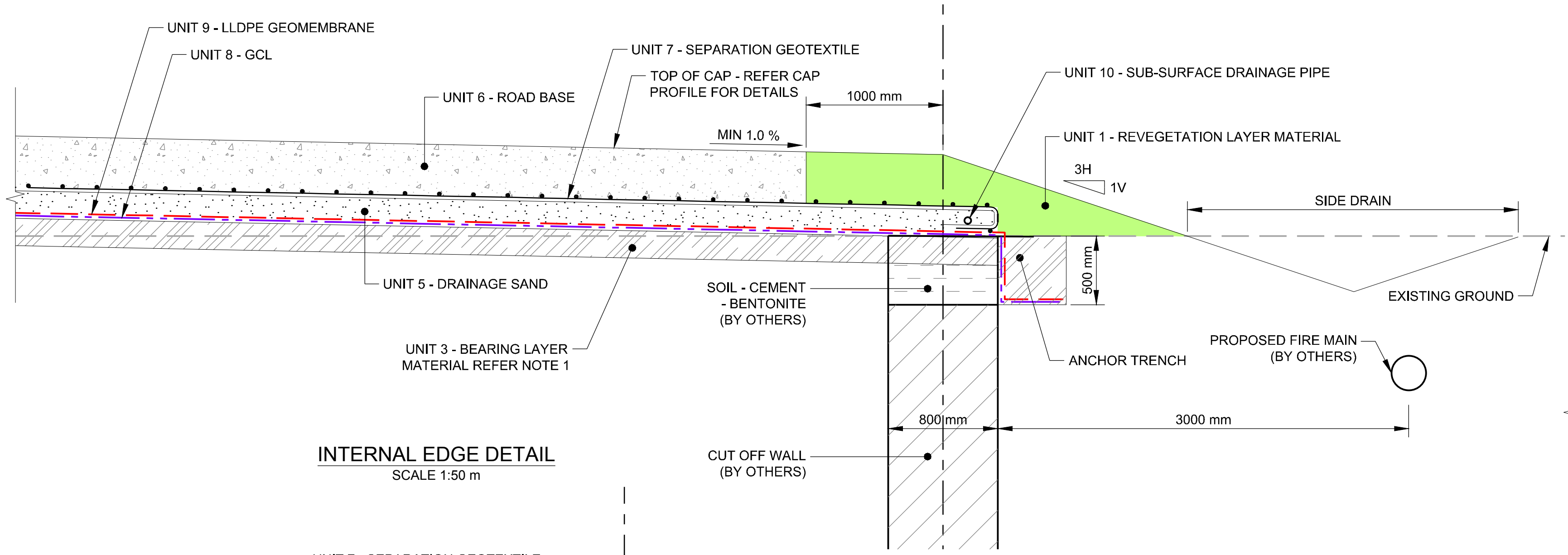
PROJECT NO.	SPECIFICATION	REV.		DRAWING
1418917	038	0	5 of 7	005



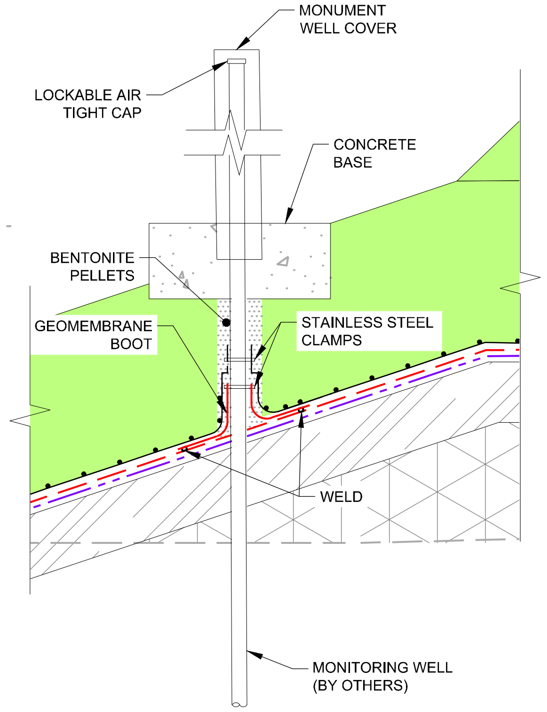
EDGE DETAIL ALONG PROPERTY BOUNDARY
SCALE 1:50 m



CAP PROFILE
SCALE 1:25 m

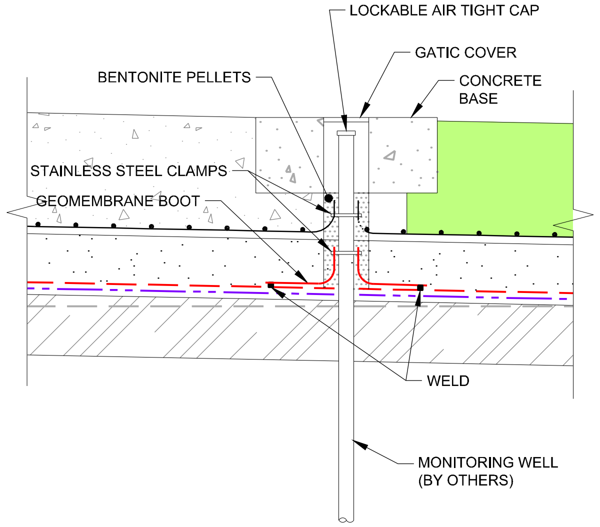


INTERNAL EDGE DETAIL
SCALE 1:50 m



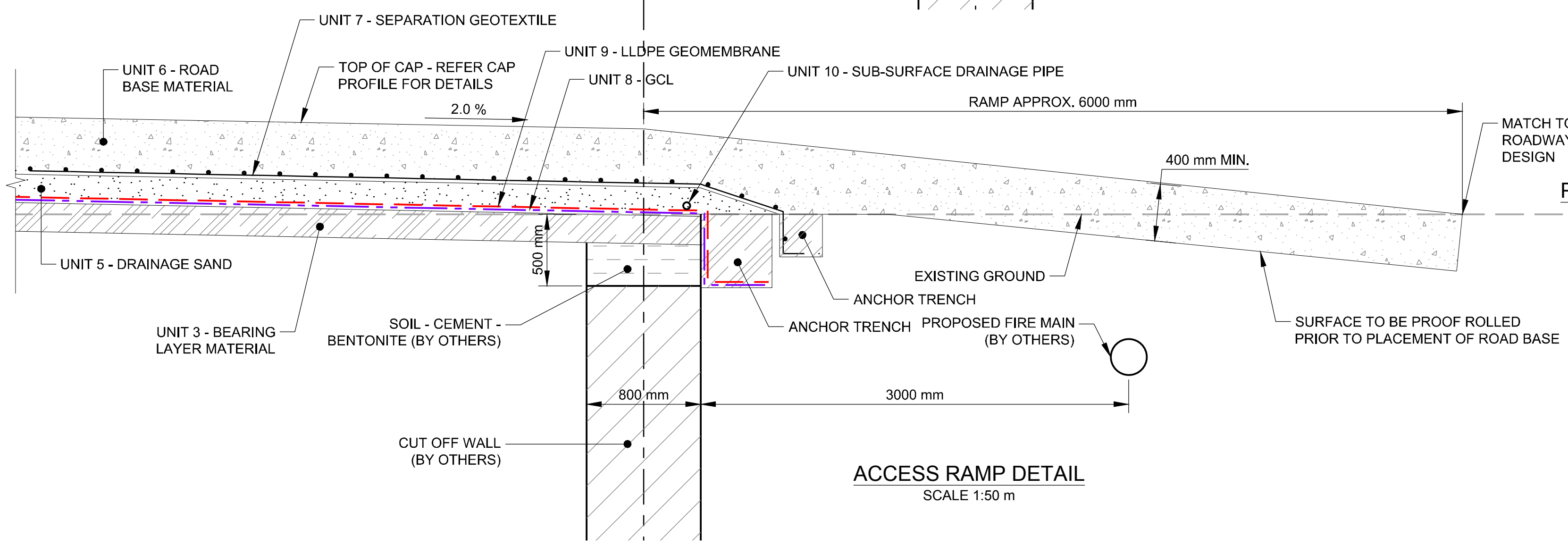
PENETRATION DETAIL OF MONITORING WELL ON BATTER
SCALE 1:25

NOTE: REFER "EDGE DETAIL ALONG PROPERTY BOUNDARY" FOR OTHER DETAILS



PENETRATION DETAIL OF MONITORING WELL ON HARDSTAND
SCALE 1:25

NOTE: REFER "INTERNAL EDGE DETAIL" FOR OTHER DETAILS



ACCESS RAMP DETAIL
SCALE 1:50 m

ISSUED FOR
CONSTRUCTION

NOTE(S)
1. EXISTING MATERIAL SHALL BE REWORKED OR REPLACED BY OTHER SUITABLE ON-SITE MATERIAL TO FORM THE BEARING LAYER.
2. CAP MATERIAL SHALL BE AS FOLLOWS:
   2.1. ON 3:1 BATTERS - REVEGETATION MATERIAL.
   2.2. ON 2% PLATFORM: 200 mm DRAINAGE SAND UNDERLYING 400 mm ROAD BASE MATERIAL.

0 0.5 1
1:25 METRES

0 1 2
1:50 METRES

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
0	2016-04-11	ISSUED FOR CONSTRUCTION	RH	EJJ	GRS	GRS

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PROJECT
ORICA KOORAGANG ISLAND ARSENIC REMEDIATION PROJECT

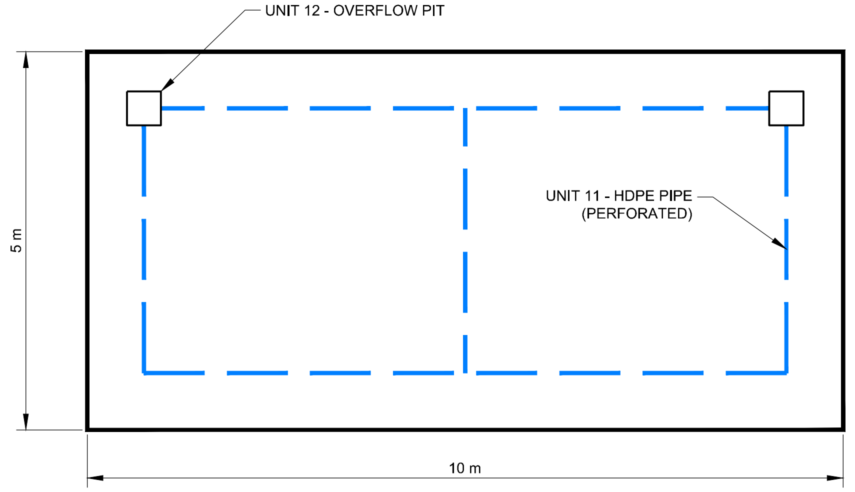
TITLE
TYPICAL SECTIONS AND DETAILS

PROJECT NO.	SPECIFICATION	REV.	6 of 7	DRAWING
1418917	038	0		006

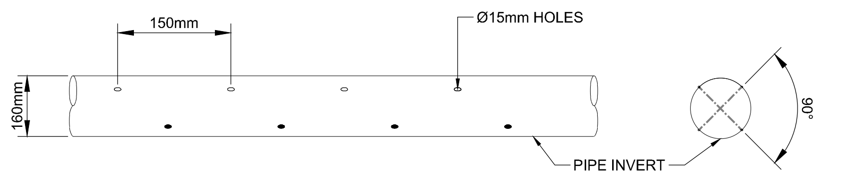
LEGEND

HDPE PIPE Ø160 PERFORATED

OVERFLOW PIT

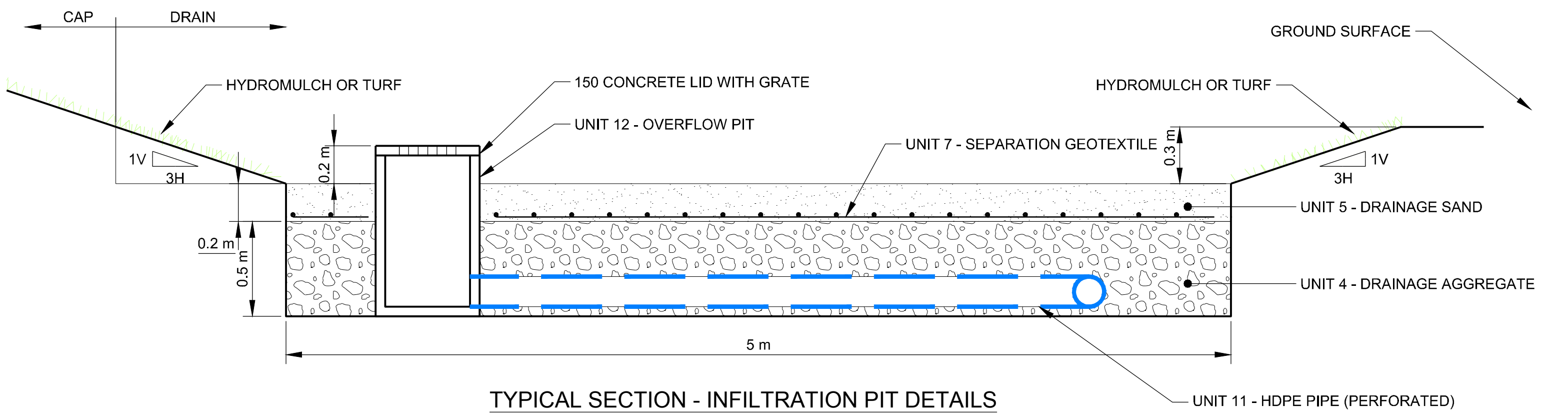


INFILTRATION PIT LAYOUT
SCALE 1:100 m

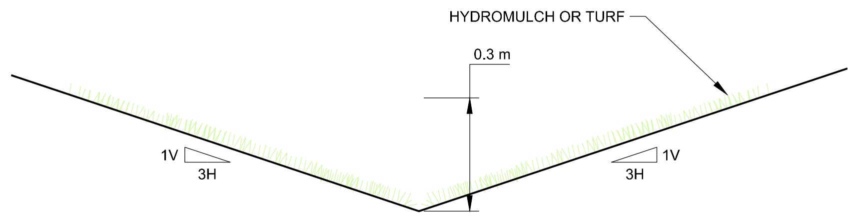


PIPE PERFORATION DETAIL
SCALE 1:20

NOTE: PIPE TO BE INSTALLED WITH HOLES IN ORIENTATION SHOWN



TYPICAL SECTION - INFILTRATION PIT DETAILS
SCALE 1:20 m



TYPICAL SIDE DRAIN
SCALE NTS

ISSUED FOR
CONSTRUCTION

0 0.5 1
1:20 METRES

0 2.5 5
1:100 METRES

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
0	2016-04-11	ISSUED FOR CONSTRUCTION	RH	EJJ	GRS	GRS

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PROJECT
ORICA KOORAGANG ISLAND ARSENIC REMEDIATION PROJECT

TITLE
DRAIN AND INFILTRATION PIT DETAILS

PROJECT NO.	SPECIFICATION	REV.	7 of 7	DRAWING
1418917	038	0		007

Path: \\golder.gds\gap\Sydney\Geomatics\ORICA_AUSTRALIA\K189_PROJECTS\1418917_As Workplan Implementation\02_PRODUCTION\DWG\ | File Name: 1418917-038-S-007.dwg

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ISO A3

25 mm

APPENDIX B

Important Information Relating to this Report

IMPORTANT INFORMATION RELATING TO THIS REPORT

The document ("Report") to which this page is attached and which this page forms a part of, has been issued by Golder Associates Pty Ltd ("Golder") subject to the important limitations and other qualifications set out below.

This Report constitutes or is part of services ("Services") provided by Golder to its client ("Client") under and subject to a contract between Golder and its Client ("Contract"). The contents of this page are not intended to and do not alter Golder's obligations (including any limits on those obligations) to its Client under the Contract.

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This Report has been prepared in the context of the circumstances and purposes referred to in, or derived from, the Contract and Golder accepts no responsibility for use of the Report, in whole or in part, in any other context or circumstance or for any other purpose.

The scope of Golder's Services and the period of time they relate to are determined by the Contract and are subject to restrictions and limitations set out in the Contract. If a service or other work is not expressly referred to in this Report, do not assume that it has been provided or performed. If a matter is not addressed in this Report, do not assume that any determination has been made by Golder in regards to it.

At any location relevant to the Services conditions may exist which were not detected by Golder, in particular due to the specific scope of the investigation Golder has been engaged to undertake. Conditions can only be verified at the exact location of any tests undertaken. Variations in conditions may occur between tested locations and there may be conditions which have not been revealed by the investigation and which have not therefore been taken into account in this Report.

Golder accepts no responsibility for and makes no representation as to the accuracy or completeness of the information provided to it by or on behalf of the Client or sourced from any third party. Golder has assumed that such information is correct unless otherwise stated and no responsibility is accepted by Golder for incomplete or inaccurate data supplied by its Client or any other person for whom Golder is not responsible. Golder has not taken account of matters that may have existed when the Report was prepared but which were only later disclosed to Golder.

Having regard to the matters referred to in the previous paragraphs on this page in particular, carrying out the Services has allowed Golder to form no more than an opinion as to the actual conditions at any relevant location. That opinion is necessarily constrained by the extent of the information collected by Golder or otherwise made available to Golder. Further, the passage of time may affect the accuracy, applicability or usefulness of the opinions, assessments or other information in this Report. This Report is based upon the information and other circumstances that existed and were known to Golder when the Services were performed and this Report was prepared. Golder has not considered the effect of any possible future developments including physical changes to any relevant location or changes to any laws or regulations relevant to such location.

Where permitted by the Contract, Golder may have retained subconsultants affiliated with Golder to provide some or all of the Services. However, it is Golder which remains solely responsible for the Services and there is no legal recourse against any of Golder's affiliated companies or the employees, officers or directors of any of them.

By date, or revision, the Report supersedes any prior report or other document issued by Golder dealing with any matter that is addressed in the Report.

Any uncertainty as to the extent to which this Report can be used or relied upon in any respect should be referred to Golder for clarification.

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For more information, visit golder.com

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