APPENDIX D

Quantity Surveyors Certificate of Cost

Currie & Brown (Australia) Pty Ltd
ACN: 97 128 823 843
Level 9, 8-10 Loftus Street, Sydney,
New South Wales 2000, Australia

Tel: +61 2 8220 0800
Fax: +61 2 9251 5132
www.curriebrown.com

23 January 2017

Orica Mining Services
15 Greenleaf Road,
Kooragang Island NSW 2304

Dear Gary,

ORICA KOORAGANG ISLAND FACILITY – ARSENIC REMEDIATION PROJECT

QUANTITY SURVEYOR'S CERTIFICATE OF COST TO VERIFY THE CAPITAL INVESTMENT VALUE

As requested we have prepared this Quantity Surveyor's Certificate of Cost to verify the Capital Investment Value of the project in accordance with the definition contained in the State Environment Planning Policy (Major Development) 2005.

Under this policy the Capital Investment Value has the same meaning as in the Environmental Planning Assessment Regulation 2000 which was amended on 7 May 2010 to the following;

> *Capital Investment Value of a development or project includes all costs necessary to establish and operate the project, including the design and construction of buildings, structures, associated infrastructure and fixed or mobile plant and equipment, other than the following costs:*
>
> *a) Amounts payable, or the cost of land dedicated or any other benefit provided, under a condition imposed under Division 6 or 6A or Part 4 of the Environmental Planning and Assessment Act or a planning agreement under that division.*
> *b) Costs relating to any part of the development or project that is the subject of a separate development consent or project approval.*
> *c) land costs (including any costs of marketing and selling land)*
> *d) GST (within the meaning of A New Tax System (Goods and Services Tax) Act 1999 of the Commonwealth)*

Based on this definition, we advise that our estimate of Capital Investment Value for this project is $6,500,000 excluding GST.

We refer you to the attached detailed estimated.

We note our estimate excludes allowances for the following items based on advice provided by the NSW Department of Planning and Orica Mining Services;

- Development Application and Construction Certificate Fees
- Authority Fees
- Escalation for potential cost increases beyond January 2017
- Finance costs

We confirm our estimate is based on the following information and documentation provided to us by Orica Mining Services;

- OKI-15033-PM-SCP-002 Rev 1 Project Scope Definition and Brief
- Confirmation on the construction methodology from Orica Mining Services

Should you have any queries or require any further information or comment, please contact the undersigned.

Yours sincerely,

Tim Campbell
Associate Director, NSW

Phone: 0401 030 150
Email: tim.campbell@curriebrown.com

Elemental Summary

Project: Orica Remediation - Kooragang Island	**Details:** CIV Estimate
Building: Orica Remediation - Kooragang Island	

Code	Description	Quantity	Unit	Rate	SubTotal	Factor	Total
	DIRECT COSTS						
	Direct Costs						
	Temporary hard stand around the perimeter				109,120		109,120
	Site facilities				103,300		103,300
	Temporary testing wells				20,000		20,000
	Soil testing and other related testing				30,000		30,000
	Temporary fencing				18,600		18,600
	Realocation of stockpiles				20,000		20,000
	Supply and installation of watertank				20,000		20,000
	Health and safety requirements				282,800		282,800
	Erosion and sediment controls				163,800		163,800
	Management of stormwater				50,000		50,000
	Waste management				99,000		99,000
	Temporary site signage				10,000		10,000
	Bonds and insurances				155,000		155,000
	Permanent Works - Earthworks						
	Cut off wall				1,076,030		1,076,030
	Capping System				880,553		880,553
	Ground water monitoring wells				135,000		135,000
	Signage				30,000		30,000
	Construction supervision cost for all work packages				Incl		Incl
	Permanent Works - Site Works						
	Modification to the existing haulage road				348,000		348,000
	Modification to the existing site underground piping and rerouting firemain				59,000		59,000
	Realocation of the stormwater catchment basin, culvert and drains				50,000		50,000
	Removal of redundant lighting and cabling				10,000		10,000
	Removal of trees				5,000		5,000
	Decommissioning of redundant groundwater wells				15,000		15,000
	Total Direct Costs				**3,690,203**		**3,690,203**
	INDIRECT COSTS						
	Construction supervision and superintendent				297,000		297,000
	Total Indirect Costs				**297,000**		**297,000**

Elemental Summary

Project: Orica Remediation - Kooragang Island **Details:** CIV Estimate
Building: Orica Remediation - Kooragang Island

Code	Description	Quantity	Unit	Rate	SubTotal	Factor	Total
	CONSULTANT AND ORICA DIRECT COSTS						
	Orica and EPCM presentation cost				1,445,000		1,445,000
	EPCM and consultant cost				198,000		198,000
	Orica Implementation cost				264,000		264,000
	Total Consultant and Orica Costs				**1,907,000**		**1,907,000**
	Total Excluding Allowances				**5,894,203**		**5,894,203**
	Contingency (10%)				589,420		589,420
	Total Present Day Costs				**6,483,623**		**6,483,623**
	Escalation				18,000		18,000
	Total Capital Costs				**6,501,623**		**6,501,623**
	Rounding				-1,623		-1,623
	TOTAL PROJECT COST				6,500,000		6,500,000

Trade Detail

Project: Orica Remediation - Kooragang Island **Details:** CIV Estimate
Building: Orica Remediation - Kooragang Island

Code	Description	Quantity	Unit	Rate	Total
	Temporary hard stand around the perimeter				
	Temporary hard stand around the perimeter	248	m	440.00	109,120
	Temporary hard stand around the perimeter				**109,120**
	Site facilities				
	Allowance for site sheds and storage	22	Weeks	1,000.00	22,000
	Allowance for site amenities	22	Weeks	500.00	11,000
	Temporary power to the site, provided with small hired generator	22	Weeks	900.00	19,800
	Temporary water supply to the site	22	Weeks	250.00	5,500
	Site access including roads and entry barriers		Item		25,000
	Traffic control		Item		10,000
	De-mobilization		Item		10,000
	Site facilities				**103,300**
	Temporary testing wells				
	Allowance for temporary testing wells		Item		20,000
	Temporary testing wells				**20,000**
	Soil testing and other related testing				
	Allowance for soil testing		Item		20,000
	Allowance for sundry testing		Item		10,000
	Soil testing and other related testing				**30,000**
	Temporary fencing				
	Temporary fencing	372	m	50.00	18,600
	Temporary fencing				**18,600**
	Realocation of stockpiles				
	Realocation of stockpiles		Item		20,000
	Realocation of stockpiles				**20,000**
	Supply and installation of watertank				
	Supply and installation of watertank, 5000 L		Item		20,000
	Supply and installation of watertank				**20,000**
	Health and safety requirements				
	Site medical practitioner; 1no. (50% project time allocation)	11	Weeks	5,800.00	63,800
	Occupation hygienist; 1no. (50% project time allocation)	11	Weeks	4,500.00	49,500
	Occupational health nurse; 1no. (50% project time allocation)	11	Weeks	4,500.00	49,500
	Safety officer; 1no. (100% project time allocation)	22	Weeks	4,000.00	88,000
	Airborne sampling		Item		5,000

Trade Detail

Project: Orica Remediation - Kooragang Island **Details:** CIV Estimate
Building: Orica Remediation - Kooragang Island

Code	Description	Quantity	Unit	Rate	Total

Health and safety requirements *(Continued)*

	Human biological monitoring		Item		5,000
	Noise management		Item		5,000
	Dust control		Item		5,000
	Managing potential impact from the ammonia plant flare after commissioning in March 2017		Item		10,000
	Safety measures and PPE		Item		2,000

Health and safety requirements **282,800**

Erosion and sediment controls

	Erosion and sediment controls measures		Item		15,000
	Installation of low retaining wall along the boundary	372	m	400.00	148,800

Erosion and sediment controls **163,800**

Management of stormwater

	Management of stormwater		Item		50,000

Management of stormwater **50,000**

Waste management

	Waste management	22	Weeks	4,500.00	99,000

Waste management **99,000**

Temporary site signage

	Temporary site signage		Item		10,000

Temporary site signage **10,000**

Bonds and insurances

	Fees to authorities - council, utility providers etc.		Item		50,000
	Insurances - contracts works, professional indemnity, public liability, workers compensation etc.		Item		105,000

Bonds and insurances **155,000**

Cut off wall

	Excavation	2,381	m3	150.00	357,150
	Earth work support for the excavated trench using bentonite	2,381	m3	60.00	142,860
	Fill material to be a mix of 90% excavated soil and 10% bentonite, including compaction	2,381	m3	220.00	523,820
	Bentonite management		Item		15,000
	Permanent fencing	248	m	150.00	37,200

Cut off wall **1,076,030**

Capping System

	Subgrade preparation	4,419	m2	15.00	66,285
	Fill material	844	m3	200.00	168,800
	Bearing layer material	883	m3	120.00	105,960
	Revegetation layer	1,768	m3	60.00	106,080
	Turfing	4,419	m2	12.00	53,028

Trade Detail

Project: Orica Remediation - Kooragang Island **Details:** CIV Estimate
Building: Orica Remediation - Kooragang Island

Code	Description	Quantity	Unit	Rate	Total
	Capping System				*(Continued)*
	Anchor trench	248	m	60.00	14,880
	Dewatering	6	Weeks	2,000.00	12,000
	GCL layer	4,419	m2	50.00	220,950
	LLDPE Geomembrane	4,419	m2	15.00	66,285
	Separation Geotextile	4,419	m2	15.00	66,285
	Capping System				**880,553**
	Ground water monitoring wells				
	Supply and installation of ground water monitoring wells	18	No	7,500.00	135,000
	Ground water monitoring wells				**135,000**
	Signage				
	Permanent signage		Item		30,000
	Signage				**30,000**
	Modification to the existing haulage road				
	New diverted road sealed with bitumen road	1,400	m2	220.00	308,000
	Connecting to existing road	4	No	10,000.00	40,000
	Modification to the existing haulage road				**348,000**
	Modification to the existing site underground piping and rerouting firemain				
	Diversion of the existing fire water ring main	140	m	350.00	49,000
	Hydrants to be realocated and new valves to be installed	2	No	5,000.00	10,000
	Modification to the existing site underground piping and rerouting firemain				**59,000**
	Realocation of the stormwater catchment basin, culvert and drains				
	Realocation of the stormwater catchment basin, culvert and drains		Item		50,000
	Realocation of the stormwater catchment basin, culvert and drains				**50,000**
	Removal of redundant lighting and cabling				
	Remove redundant lights and cabling		Item		10,000
	Removal of redundant lighting and cabling				**10,000**
	Removal of trees				
	Removal of trees		Item		5,000
	Removal of trees				**5,000**
	Decommissioning of redundant groundwater wells				
	Decommissioning of redundant groundwater wells		Item		15,000
	Decommissioning of redundant groundwater wells				**15,000**
	Construction supervision and superintendent				
	Project Manager; 1no. (70% project time allocation)	16	Weeks	5,500.00	88,000
	Construction Supervisor; 1no (100% project time allocation)	22	Weeks	5,000.00	110,000

Trade Detail

Project: Orica Remediation - Kooragang Island **Details:** CIV Estimate
Building: Orica Remediation - Kooragang Island

Code	Description	Quantity	Unit	Rate	Total
Construction supervision and superintendent					*(Continued)*
	Orica representation; 1no. (80% project time allocation)	18	Weeks	5,500.00	99,000
	Construction supervision and superintendent				**297,000**
Orica and EPCM presentation cost					
	Orica and EPCM presentation cost (as advised by Orica)		Item		1,445,000
	Orica and EPCM presentation cost				**1,445,000**
EPCM and consultant cost					
	Project Management / Engineering / Procurement (assumed 2 resources)	22	Weeks	9,000.00	198,000
	EPCM and consultant cost				**198,000**
Orica Implementation cost					
	Orica project team (assumed approximately 3 resources)	22	Weeks	12,000.00	264,000
	Orica Implementation cost				**264,000**

APPENDIX E

Independent Reviewers Report

Controlled Copy ___

Independent Review

15 Greenleaf Road, Kooragang Island

for Orica IC Assets Pty Ltd

November 2016

J1702.2R-rev0

C. M. Jewell & Associates Pty Ltd

Independent Review – 15 Greenleaf Road, Kooragang Island
November 2016

J1702.2R-rev0

Controlled Copy 1	*Ms Sherree Woodroffe* Orica IC Assets Pty Ltd PO Box 80 MAYFIELD NSW 2304
2	*Mr Steven Tan* NSW Environment Protection Authority Contaminated Sites Unit GPO Box A290 SYDNEY SOUTH NSW 1232
3	CMJA Library

C. M. Jewell & Associates Pty Ltd
ABN: 54 056 283 295
1/13 Kalinda Road, Bullaburra, NSW 2784
PO Box 10, Wentworth Falls, NSW 2782
Phone (02) 4759 3251 Fax (02) 4759 3257
www.cm-jewell.com.au postie@cm-jewell.com.au

CHRIS JEWELL
Principal

TABLE OF CONTENTS

TABLES

FIGURES

List of Abbreviations

Measures

%	per cent
g/d	grams per day
g/L	grams per litre
L/s	litres per second
m	metre
m^3/d	cubic metres per day
m^3/s	cubic metres per second
m/d	metres per day
mg/kg	milligrams per kilogram
mg/L	milligrams per litre
m/m	metres per metre
mm/yr	millimetres per year
mV	millivolts

General

AHD	Australian Height Datum
ANZECC	Australian and New Zealand Environment and Conservation Council
ASC NEPM	*National Environment Protection (Assessment of Site Contamination) Measure* 1999
bgs	below ground surface
CBR	California Bearing Ratio
CEMP	construction environmental management plan
CLM Act	*Contaminated Land Management Act* 1997
CMJA	C. M. Jewell & Associates Pty Ltd
CQA	construction quality assurance
CQC	construction quality control
EPA	NSW Environment Protection Authority
EP&A Act	*Environmental Planning and Assessment Act* 1979
EPI	Environmental Planning Instrument
EPL	Environment Protection Licence
GCL	geocomposite clay liner
Golder	Golder Associates Pty Ltd
HCM	hydrogeological conceptual model
HFB	horizontal flow barrier
Laase	Laase Hydrologic Consulting
LLDPE	linear low density polyethylene
LTEMP	long-term environmental management plan
MHF	major hazard facility
MO	Management Order 20131407
Orica	Orica Australia Pty Ltd
PRB	permeable reactive barrier
PWCS	Port Waratah Coal Services
QA	quality assurance
QC	quality control
RAP	remediation action plan
RPD	relative percentage difference
SEPP	State Environmental Planning Policy
UCL	upper confidence limit

1.0 INTRODUCTION

1.1 Background

Orica Australia Pty Ltd (Orica) operates a site at 15 Greenleaf Road, Kooragang Island in NSW. The site is currently used to manufacture ammonia nitric acid and ammonium nitrate, and has a history of use for chemical manufacturing extending over several decades.

Until the mid-1990s, a solution containing arsenic trioxide and potassium carbonate was used to scrub carbon dioxide from the process gas stream. An unlined sludge pit in the north-western corner of the site was used to store runoff from the ammonia plant and cooling tower backwash water. This liquid contained arsenic at concentrations up to 10 grams per litre (g/L). Seepage from the pit contaminated soil and groundwater; a plume of contaminated groundwater developed between the site and the Hunter River to the north-west.

Partial remediation of the sludge pit, which included removal of most of the highly-contaminated soil and other wastes, was carried out in 2005. However, residual soil contamination with arsenic concentrations up to 1900 milligrams per kilogram (mg/kg) remained on site, and a plume of dissolved arsenic continued to migrate across the site boundary towards the Hunter River. Monitoring has continued since 2005 and has shown decreasing concentrations in this dissolved-phase arsenic plume.

On 28 July 2014, the NSW Environment Protection Authority (EPA) issued Management Order 20131407 (the MO) under s.14 of the *Contaminated Land Management Act* 1997 (CLM Act), requiring Orica to implement works to prevent the further offsite migration of arsenic in groundwater. The MO requires a staged implementation of the works; required action 1(e) specified in the MO is the preparation of a Remediation Action Plan (RAP) (Golder 2016d) and its submission to the EPA for approval. Orica subsequently agreed with the EPA that it would engage a suitable expert to carry out an independent review of the RAP. This report is that review; it has been prepared by Mr Chris Jewell of C. M. Jewell & Associates Pty Ltd (CMJA).

Prior to the issue of the MO, Orica had commenced a program of further site assessment work to inform the selection and design of an appropriate remediation strategy for the arsenic contamination later addressed by the MO. That work was carried out by Golder Associates Pty Ltd (Golder) and continued after the MO was made. Golder ultimately prepared the RAP required by the MO, supported by a set of detailed assessment reports that were presented in modular form.

1.2 Objectives and Scope of Review

This review has been prepared to assist Orica and EPA.

The objectives of this report are to review the RAP (Golder 2016d) and supporting documents prepared by Golder and other consultants, and provide a review document that will assist the EPA in its assessment of the suitability and appropriateness of the RAP to manage the contamination identified in the MO under the specific hydrogeological and geochemical conditions that exist at the site.

In completing this review, I have carried out the following work.

- Meetings with Orica.
- Meetings with Orica’s consultants Golder and Mr Al Laase of A. D. Laase Hydrologic Consulting (Laase).
- Meetings with the EPA.

- A site visit.
- Viewing the core obtained from sonic drilling carried out at the site.
- Review of the reports for each of the assessment modules prepared by Golder, in both draft and final form.
- Review of the groundwater modelling carried out by Laase.
- Review of the final RAP.

The report contains sufficient information about the hydrogeology and geochemistry of the site to enable a reader to understand it without constant cross-referencing, but it is not intended to be a stand-alone report, and must be read in conjunction with the reports that it reviews.

This report does not include a preface executive summary. A detailed summary of all conclusions and recommendations is, however, provided in Section 8, at the end of the report.

1.3 Report Format

Section 2 of this report provides a brief outline of the site setting and history, simply the minimum that is required as an introduction to this review, so that it may be read without needing to cross-reference this basic information, which is provided in more detail in the RAP (Golder 2016d) and its supporting documentation.

Section 3 provides an outline of the remediation proposal, and Section 4 lists the materials that were provided for my review.

Section 5 of this report provides my detailed review of the supporting documentation upon which the RAP relies. This includes the modularised site assessment reports, the groundwater flow modelling report and technical memoranda dealing with geochemistry and migration due to diffusion.

Section 6 provides my review of the remedial design. This includes the design evaluation report prepared by Laase and the RAP prepared by Golder.

Section 7 provides my review of the proposed verification and monitoring program, including construction quality verification and design verification, and also a number of important ancillary issues such as environmental management and work health and safety.

Finally, Section 8 sets out my conclusions.

1.4 Limitations and Intellectual Property Matters

This report has been prepared by C. M. Jewell & Associates Pty Ltd (CMJA) for the use of the client and government agency identified in Section 1.2, for the specific purpose described in that section. The project objectives and scope of work outlined in Section 1.2 were developed for that purpose.

The work has been carried out, and this report prepared, utilising the standards of skill and care normally expected of professional scientists practising in the fields of hydrogeology and contaminated land management in Australia. The level of confidence of the conclusions reached is governed, as in all such work, by the scope of the investigation carried out and by the availability and quality of existing data. Where limitations or uncertainties in conclusions are known, they are identified in this report. However, no liability can be accepted for failure to identify conditions or issues which arise in the future and which could not reasonably have been assessed or predicted using the adopted scope of investigation and the data derived from that investigation.

Data collected by others have been used to support the conclusions of this report, those data have been subjected to reasonable scrutiny but have essentially, and necessarily, been used in good faith. Liability cannot be accepted for errors in data collected by others.

This report, the original data contained in the report, and its findings and conclusions remain the intellectual property of CMJA. A licence to use the report for the specific purpose identified in Section 1.1 is granted to the persons identified in that section on the condition of receipt of full payment for the services involved in the preparation of the report.

This report should not be used by other persons or for other purposes than those identified in Section 1.2, and should not be reproduced except in full and with the permission of CMJA.

2.0 SITE SETTING AND HISTORY

This section provides a very brief summary of the site setting and history, with references to more detailed descriptions in the Golder reports.

2.1 Site Identification and Description

The site with which this review is concerned is located at 15 Greenleaf Road, Kooragang Island NSW and is identified as Lot 3 in DP23428. The site owner as served with the MO is Orica IC Assets Pty Ltd (ACN 010 767 263).

The site is located on the south-eastern peninsula (and at the extreme southern end) of Kooragang Island at the confluence of the North and South Arms of the Hunter River. Kooragang Island was originally a series of smaller islands, which formed part of the Hunter River delta. The southern portion of Kooragang Island was reclaimed 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 as well as other fill materials. The site covers an area of approximately 22 hectares.

The southern portion of Kooragang Island, including the Orica site, is zoned ‘Special Activities’ under the Major Development *State Environmental Planning Policy (Major Projects) Amendment (Three Ports)* 2009.

The primary information source for this section is Section A2.1 of Golder (2016c).

2.2 Site History

Following its reclamation in the 1960s, the site was initially developed by Eastern Nitrogen Limited as a fertiliser plant, opening in 1969. It was acquired by Orica in 2003. It now produces ammonia and nitric acid, and manufactures ammonium nitrate exclusively to service the mining industry.

The Ammonia Plant reforms natural gas to produce hydrogen, which is combined with nitrogen to produce ammonia. Until the mid-1990s the Vetrocoke process was used to remove (scrub) carbon dioxide from the process gas stream prior to the production of ammonia. The Vetrocoke process used a solution containing potassium carbonate and arsenic trioxide to remove the carbon dioxide.

A sludge pit was used for storage of arsenic contaminated runoff from the Ammonia Plant as well as backwash from the cooling tower sand filter. The pit was located in a flat, grassed area west of the Ammonia Plant. The sludge pit covered an area of about 1500 m^2 and was surrounded by a bund wall to about 1.5 m in height. The original pit was unsealed and arsenic-bearing liquid from the Ammonia Plant is likely to have permeated into the underlying soil.

Arsenic concentrations in the concentrated liquid may have been as high as 10 g/L.

The former sludge pit was subsequently modified to minimise infiltration of the arsenic-containing solution into the soil. It is understood that a concrete slab was laid in September 1975 and arsenic bearing materials were encapsulated within multiple layers of concrete. In addition, retaining or bund walls were sealed with compacted road base and a bitumen coating. Towards the end of 1989, the bund was reduced to about half of its original size by moving the western wall eastwards and a geosynthetic (‘Hypalon’) liner was installed. Disposal of arsenic waste materials (primary source) to the then modified pit ceased in 1994.

In addition to sludge from the Ammonia Plant, the pit and surrounding areas may have been used for a variety of activities, including cleaning of equipment, and ad hoc storage of carbon dioxide system saddles and other arsenic bearing materials.

A remediation program was undertaken in 2005 to minimise the potential for further ingress of arsenic contamination into the groundwater from arsenic present within the former pit and/or bound to the underlying soils (secondary sources). The remediation objective of those works was to remove arsenic-contaminated materials (soil and concrete, saddles) including the bunds, to the depth of the water table (1 .3 to 1.8 m) in the vicinity of the former arsenic sludge pit. In addition, surface scrapes (-0.1 m deep) were carried out in two areas to remove surficial arsenic contamination.

The major outcome of the soil remediation program was considered to be the removal of arsenic contaminated materials and soils near the former sludge pit which had been acting as a secondary contaminant source to groundwater.

The primary information source for this section is Section A3.1 of Golder (2016c).

2.3 Current Site Use

The site is currently used for the manufacturing of ammonia and nitric acid as intermediate products in the production of ammonium nitrate for use in the mining industry. 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 primary information source for this section is Section A2.1 of Golder (2016c).

2.4 Surrounding Area

The site is bounded to the east, south and west by the Kooragang Island perimeter road, and then the Hunter River. The south arm of the river is the major navigation channel and it is dredged to a depth of -15 m Australian Height Datum (AHD).

A number of other heavy industrial plants are located to the north and north-west, including Incitec Pivot fertilisers, Cargill Australia (vegetable oils), Boral Concrete and the extensive coal loading facility operated by Port Waratah Coal Services (PWCS).

2.5 Topography and Drainage

In general the site has a low relief, with a ground surface elevation of approximately 3 m AHD and maximum elevation of around 5 m AHD. The land gently slopes from the centre of the site to the east and west towards the North and South Arms of the Hunter River, respectively. A significant portion of the land is unpaved hardstand or grass, which allows significant infiltration of rainfall, which averages approximately 1100 millimetres (mm) per annum for the Newcastle area.

2.6 Geology

The southern portion of Kooragang Island, including the site as well as the Hunter River, is located in a highly modified environment. Kooragang Island was originally a series of smaller islands which formed part of the Hunter River Delta. This environment was likely to have been dynamic and to have comprised mudflats with channels amongst the small islands. The southern portion of Kooragang Island was reclaimed in the 1950s and 1960s using dredged sand from the Hunter River, as well as other fill materials, to obtain the current levels upon which the industrial facilities have been developed.

The original natural highly dynamic estuarine environment followed by the reclamation has resulted in a complex geological and hydrogeological setting.

In simplified terms, the stratigraphy consist of predominantly sandy dredged fill materials extending down to about -0.5 m AHD, then a layer of interbedded clays, silts and sands 2.5 to 5 m thick that are representative of the original mangrove flat and tidal channel system, then predominantly arenaceous Quaternary estuarine and alluvial deposits that generally coarsen with depth, and finally Permian-age bedrock that includes sandstones, claystones and coals, the surface of which is encountered at an elevation of about -37 m AHD.

The primary information source for this section is Section A2.3 of Golder (2016c).

2.7 Hydrogeology

Groundwater under Kooragang Island is inferred to flow radially towards the North and South Arms of the Hunter River, i.e. to the east, south and west of the Kooragang Island peninsula, with a groundwater divide inferred to be located approximately in the centre of the peninsula. In the vicinity of the inferred arsenic source area (the former sludge disposal pit), groundwater flow direction is inferred to be in a west-northwest direction from the former disposal pit to the South Arm of the Hunter River, rather than the direct westerly direction to the river.

It is likely that the flow direction is influenced by the depositional environment including reclamation of the island.

The hydrostratigraphy is comprised of a superficial water table aquifer within the fill sands, underlain by a confining layer composed of estuarine mud and silt, then a leaky / confined aquifer within the underlying sand and gravel estuarine and alluvial deposits.

The water table within the shallow aquifer is mounded, having an elevation of about 3 m AHD in the central-northern part of the site falling to about 1.5 m AHD at the site boundaries, and less than 1 m AHD close to the river, reflecting the radial flow of groundwater described above. The potentiometric surface in the deeper aquifers is tidally influenced and typically about 0.2 to 0.5 m AHD. Data from existing nested groundwater monitoring wells indicates differences in the groundwater potentiometric head in the different hydrostratigraphic layers. The head differences imply that a vertical downwards hydraulic gradient exists between the upper and lower aquifers.

As would be expected in this environment, groundwater beneath the site shows a wide range in salinity, from essentially fresh at some locations in the upper aquifer to salinity close to sea-water concentrations at some locations in the deeper aquifers. The pH shows a range from near-neutral to slightly alkaline (maxima around pH 8.8) and Eh lies in the anaerobic to moderately reducing (manganese and iron reducing, but not sulphate reducing) range.

3.0 OUTLINE OF REMEDIATION PROPOSAL

3.1 Remediation Requirements

The MO requires Orica to 'Implement works that will prevent, to the extent required by Action 1 c [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'.

3.2 Stated Objective

Golder (on behalf of Orica) states the objective of the proposed remediation as:

> 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.

I consider that the remediation objective as stated by Golder is both consistent with the MO and practicable.

3.3 Outline of Remediation

The proposed remediation, as described by Golder in the RAP (Golder 2016d), involves the construction on the site of a containment cell and cap, located as shown on Figure 1.

The cell will have lateral dimensions of approximately 63 metres (m) N-S by 73 m E-W. The walls will be constructed in-situ using a soil-bentonite slurry and will extend to a depth of 12 m. A composite cap will be installed and keyed into the walls.

The walls will extend beyond the maximum vertical extent of contaminated soil (about 8 m). The cell will enclose most of the on-site soil having an arsenic concentration greater than 40 mg/kg. Some shallow soil with concentrations exceeding this value that would not otherwise be within the cell will be excavated and placed within the cell.

Golder states that 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.

A program of verification testing will be completed, and long-term monitoring of groundwater contamination will continue.

3.4 Regulatory Requirements

The site is subject to a Declaration as a Remediation Site (21089, issued 16 November 2005) under s.11 of the CLM Act and a Management Order (20131407, issued 28 July 2014) under s.14 of the CLM Act relating to the arsenic contamination that is the subject of this review. The site is also the subject of another Management Order (20131408, issued 29 April 2014) that relates to nutrient contamination of groundwater, and which is not directly relevant to this review.

The site is subject to a number of State Environmental Planning Policies (SEPP) that are Environmental Planning Instruments (EPI) issued pursuant to s.24(2)(a) of *the Environmental Planning and Assessment Act* 1979 (EP&A Act). These are:

- *SEPP No 55 (Remediation of Land)* (SEPP 55);
- *SEPP (State and Regional Development)* 2011; and
- *SEPP (Three Ports)* 2013.

There is interaction between the requirements of these EPIs with regard to Environmental Protection Works and Remediation works. Golder reviewed this interaction in Section 7 of the RAP (Golder 2016d) and concluded that, in consequence, the proposed remediation work is Category 1 remediation work under Clause 9 of SEPP 55, and that the Consent Authority is the Minister for Planning and Environment.

The site is also subject to the *Newcastle Local Environment Plan* 2012 and to the *Newcastle Development Control Plan* 2012.

The site is subject to an Environment Protection Licence (EPL) (828, issued 14 November 2000). Remediation works will have to comply with the general conditions of the EPL, and the EPA has indicated that the works will also have to be added to the EPL as an ancillary activity.

The provisions of the *Protection of the Environment Operations (Waste) Regulation* 2005 will apply to any materials removed from the site in the course of remediation works.

4.0 MATERIALS PROVIDED FOR REVIEW

4.1 Remediation Investigation

Golder completed and reported on its investigations in a modular format. The five modules were:

- Module A: Project Background Information
- Module B: Environmental Investigation
- Module C: Geotechnical Investigation
- Module D: Hydrogeological Conceptual Model (HCM)
- Module E: Delineation of Arsenic Contamination

This approach enabled the individual components to be managed separately, which was logical as each required different technical skills. Draft module reports were provided for individual review and the finalised set of sub-reports was compiled into Golder's *Remediation Investigations Report* (ref. 1418917-012/016-R-Rev0), dated 29 March 2016 (Golder 2016c).

4.2 Technical Memoranda

In addition to the Remediation Investigations report, Golder provided the reviewer with two technical memoranda dealing with specific issues affecting the remediation design that had emerged during discussions. These were:

- *Geochemical Modelling of Arsenic Attenuation and Release,* dated 4 March 2016 (Golder 2016b); and
- *Assessment of Contaminant Migration due to Diffusion,* dated 29 February 2016 (Golder 2016a).

4.3 Groundwater Modelling

Laase was engaged by Orica to carry out groundwater flow modelling of the site.

The model was a three-dimensional finite difference model built in MODFLOW 2000, and was run as a steady state model only.

The results of the modelling were presented in Laase's final report *Orica, Kooragang Island Steady-State Groundwater Flow Model,* dated July 2016 (Laase 2016a).

4.4 Design Evaluation

Laase was also engaged by Orica to carry out design evaluation of a number of design scenarios for a cut off wall and capping system. That evaluation was provided in *Design Evaluation of a Cap and Cut-Off Wall for Orica Botany Kooragang Island, Former Sludge Disposal Pit,* dated July 2016 (Laase 2016b).

4.5 Remediation Action Plan

The MO deliverable was a Remediation Action Plan (RAP). Utilising the knowledge base provided in Golder (2016c) and Laase (2016a, 2016b), Golder prepared the *Orica Kooragang Island: Arsenic Management Order, Remediation Action Plan* (ref. 1418917_044_R_Rev2), dated 8 July 2016 (Golder 2016d).

4.6 Role of Reviewer

The reviewer held a number of meetings with Orica and its consultants during which the program was explained by Golder and Laase and questions were asked and answered. Some written responses were also provided. Drafts of the reports were provided for review and comments made, and the final versions were then provided.

Meetings

- 7 October 2015 (Golder, Orica and Laase)
- 30 October 2015 (Golder and Orica)
- 11 November 2015 (on site, Orica)
- 17 November 2015 (EPA and Orica)
- 8 April 2016 (Golder)
- 24 May 2016 (Laase)
- 11 August 2016 (Orica and EPA)

Finally, this report was prepared.

5.0 REVIEW OF ASSESSMENT

5.1 Remediation Investigations (Golder 2016c)

5.1.1 Module A: Project Background Information

Module A provides background information concerning site conditions, site history and the surrounding environment, as also summarised in Section 2 of this report. It provides an adequate introduction and the general information required to understand the following modules.

5.1.2 Module B: Environmental Investigation

Scope and Objective

Module B provides the results of what is termed the Remediation Investigations – essentially the investigations carried out to assess the nature and distribution of contaminants in soil and groundwater, and provide the geochemical data necessary to define and model the soil/groundwater system. These investigations followed on from several previous phases of site contamination assessment and characterisation.

The scope included:

- Twenty-one soil assessment bores progressed by sonic drilling.
- Sub-sampling the sonic core for laboratory analysis.
- Laboratory analysis of soil samples for total arsenic, iron, and selectively, sulphate and total organic carbon.
- Seven nested groundwater monitoring wells screened at depths of up to 35 m. Generally the nests consisted of two wells; at one location (BP18) three were installed.
- Well development.
- Groundwater sampling using low-flow techniques.
- Analysis of groundwater samples in the field for pH, redox potential, dissolved oxygen, conductivity and temperature.
- Analysis of groundwater samples in the laboratory for arsenic, iron and manganese, and for sodium, potassium, calcium, magnesium, ammonia, chloride, sulphate, nitrate, and bicarbonate, carbonate and hydroxide alkalinity.

Review

Golder incorporated a quality assurance / quality control (QA / QC) program in the assessment. This is described in Section B4.1. In my opinion, the program as described would be adequate in scope and generally compliant with the recommendations of Appendix C of Schedule B2 of the *National Environment Protection (Assessment of Site Contamination) Measure* 1999 (ASC NEPM).

Field QC sampling and analysis, and interpretation of QC data was restricted primarily to arsenic and to a lesser extent iron. I note that the data validation reports in Appendix 7 address only precision. Accuracy, representativeness, completeness and comparability are not addressed.

Sampling and analytical precision with respect to arsenic was assessed by analysis of duplicate samples. A total of 65 field duplicate samples were obtained for 632 primary samples, an acceptable frequency of just over 10%. Relative percentage differences (RPDs) for 15 of the field duplicate samples (i.e. 20%) were greater than the adopted criterion of 30%.

5.1.3 Module C: Geotechnical Investigation

Scope and Objective

Module C describes and provides the results of the geotechnical testing carried out in conjunction with the collection of geological and hydrogeological data. The purpose of this testing was to provide data to support the design of the proposed containment cell.

The geotechnical testing involved:

- A total of 32 samples obtained from four bores at eight depths for particle size distribution (grading) and Atterberg Limits testing.
- Groundwater samples obtained from seven nested wells and analysed for aggressivity parameter sulphate, chloride and pH.
- Cone Penetrometer Testing to a depth of 15 to 20 m at eight locations around the perimeter of the proposed cell.
- Survey.

Review

In my opinion an appropriate range of geotechnical testing was carried out on an adequate number of samples to inform the preliminary design of a containment cell.

5.1.4 Module D: Hydrogeological Conceptual Model

Objective

The stated purpose of Module D was to present an interpretation of the site hydrostratigraphy and groundwater flow system based on existing and recent hydrogeological data collected during the remediation investigations presented in Module B. The interpretation was intended to inform the development of a numerical groundwater model that would support ongoing design parameters and requirements for a cap and containment remediation approach.

Interpreted Hydrostratigraphy

Golder’s interpretation of the hydrostratigraphy is summarised in Table 1 of Module D (Table 1 below). A more detailed description of each unit is provided in the text of Module D, and a series of detailed sections are provided as figures.

TABLE 1
Summary of Hydrostratigraphy (modified from Golder)

Hydro-stratigraphic Units	Approx. Elevation (m AHD)	Description	Classification	Typical Hydraulic Conductivity*
Unit 1 Fill and reclaimed sand	Top: 3 to 5 Base: -0.5	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	Base: -3 to -5	Fine-grained estuarine sediments predominantly comprised of silts and clays, black in colour. The lower part becomes gradually coarser (i.e. sandier)	Aquitard, porous medium	Upper part: Kh likely 2 orders of magnitude lower than Unit 1**, Kv much lower Lower part: Kh 10^{-5} m/s, Kv significantly lower
Unit 3 Alluvial sand	Base: -12 to -13	Fine to medium-grained alluvial sand, grey in colour, sub-rounded and occasionally interspersed with bands of clay and minor sandy silt	Aquifer, porous medium, confined, anisotropic	Kh 8×10^{-5} m/s to 2×10^{-4} m/s
Unit 4 Coarse fluvial sand	Base: -20 to -25	Dense medium to coarse-grained fluvial sands, with rounded gravels and pebbles, pale brown in colour	Aquifer, porous medium, confined, anisotropic	Kh > 10^{-4} m/s
Unit 5 Deeper Sands and Clays	Base: ~-37	Interbedded strata comprising of: - Upper part: yellow brown uniform fine-grained sand (possibly of terrestrial origin) - Middle part: grey fine to medium-grained sand with rounded coal fragments - Lower part: interspersed black silty clay and sandy clay with minor bands of sand	Succession of thin aquifer zones and aquitards, porous medium, confined, anisotropic	Unknown
Permian Bedrock		Fine to medium grained weathered sandstone, green-blue in colour, dry (predominantly recovered as pulverised material)	Aquifer, fractured rock medium	Unknown, likely to be highly variable

Notes: m/s metres per second
Kh horizontal hydraulic conductivity
Kv vertical hydraulic conductivity
* Data predominantly sourced from slug test interpretation presented in Module B
** Discussed in Section D3.3 of Module D (Interaction between Unit 1 and Unit 3)

Flow Conditions in Individual Units

Flow conditions in each unit are described in the text. The information provided includes groundwater levels, hydraulic gradients, vertical flow direction and estimated lateral flows from each unit to the Hunter River.

Review

The HCM has been checked against the borehole logs and test data and represents a consistent interpretation of those data. In my opinion it provided a sound basis for the numerical model.

5.1.5 Module E: Delineation of Arsenic Contamination

Objective

The stated objective of Module E was to interpret the soil and groundwater quality data collected during the remediation investigations and presented in Module B, to inform the design parameters and requirements for the cap and containment remediation approach.

In effect, this involved delineating the lateral and vertical extent of contamination that should be managed within a containment cell.

Delineation Criteria

My understanding is that Golder set out to delineate arsenic contamination meeting defined concentration criteria that indicated that it would need to be managed within the containment works.

For soil, these were:

- For depths <1 m: 100 mg/kg
- For depths between 1 and 15 m: Individual arsenic concentrations of less than 100 mg/kg and a 95% upper confidence limit (UCL) on the mean of less than 45 mg/kg.

The selection of 100 mg/kg for individual samples and 45 mg/kg for the 95% UCL on the mean was based on previously-completed bench-scale testing.

- Previous leach testing work, including column tests and sequential batch tests (URS 2007, 2009), indicated that desorption from significantly contaminated soils is in the order of 4 to 10% after some 13 to 15 pore volumes.
- Leach assessments 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 milligram per litre (mg/L).

A soil concentration of 45 mg/kg (an order of magnitude less than the concentration used in the contaminated soils leach testing), and subsequently rounded to 40 mg/kg, was adopted as the delineation criterion on the basis that soils that did not exceed that concentration would not act as a significant secondary source of arsenic. This criterion was applied as a UCL on the mean concentration for soil in each bore. In addition to the UCL concentration, no individual sample should have a concentration exceeding 100 mg/kg.

For groundwater, contamination had previously been delineated on the basis of a concentration limit of 1 mg/L. Using this criterion, the lateral footprint of groundwater contamination was consistent with the lateral footprint of the delineated soil contamination. To the south, east and north at 3 m, 6 m and 8 m below ground level the concentrations were in fact generally well below the criterion.

Delineated Extent

The delineated extent of arsenic contamination is shown on Golder's Figure E1.

Review

In my opinion, the approach to delineation adopted by Golder was logical and reasonable, and the delineation criteria were adequately justified. Consequently, I consider that the extent of contamination requiring management as shown on Golder's Figure E1 is a good reflection of the dataset, and formed an appropriate and robust basis for the containment design.

5.2 Technical Memoranda

5.2.1 Geochemical Modelling of Arsenic Attenuation and Release (Golder 2016b)

The work reported in this memorandum was carried out to assess the effect of a change in geochemical conditions within the aquifer system that could occur as a result of construction of the containment cell. Because a necessary consequence of covering and containing the aquifer within the cell is that air will be excluded, then it is likely that conditions will become more reducing, which may affect the solubility of arsenic. The key concern was that under lower Eh (more reducing) conditions, arsenic that is currently adsorbed to the surface of hydrous ferric oxides that coat sand and silt particles in the aquifer matrix could be released or displaced into solution.

Approach

A series of snapshot models was constructed that represents the range of plausible geochemical conditions likely to arise following the installation of the remediation system. The models were built using PHREEQCI Version 3.0. Three models were built to represent the three primary hydrostratigraphic layers underlying the site: Shallow (Layer 1), Intermediate (Layer 2), and Deep (Layer 3). The models were calibrated by creating an iron oxide (Hfo) surface with adsorbed major ions and metals to approximate the surfaces that are currently present in the aquifer. This was achieved by equilibrating the iron oxide surface with a solution that had arsenic concentrations consistent with the original contamination waters (130 mg/L in the case of Layer 1 and 50 mg/L in the case of Layer 2) and taking into account competition with other ions. Once the iron oxide surface had adsorbed-arsenic concentrations that were consistent with those assessed from previous leach test-work, the surface was flushed with a solution consistent with the currently-measured in groundwater chemistry. The intention was to create an initial model representative of current conditions by mimicking the geochemical history since initial contamination occurred. This initial model could then be used as a starting point for forward modelling.

Forward modelling involved two components:

1. Assessing the stability of arsenic in response to a drop in redox (Eh), where the drop in redox potential is a consequence of lower rates of oxygen ingress due to installation of the cap-and-contain system. The models were also used to assess the relative stability of the iron oxide phases present and to identify the formation of other potential arsenic attenuating phases (e.g. sulphides, discrete mineral phases).

2. Assessing the attenuation capacity of Layer 3 based on the presence of iron oxides or sulphides. A worst case scenario was assumed where 9 mg/L arsenic flows into Layer 3 from Layer 2. Note that this scenario assumes that Layer 2 has no attenuation capacity, a very conservative assumption.

Results

The results of the modelling indicated that:

- Goethite is the dominant iron oxide and therefore assumed to be the sorption surface for arsenic.

- As Eh falls:

  - A small amount of the iron oxide dissolves: a maximum of 5% in Layer 1 and 0.1% in Layer 2.

  - Pyrite (FeS_2) precipitates in all three layers and orpiment (As_2S_3) precipitates in Layers 2 and 3.

- The dissolution of iron oxide results in a release of arsenic only once orpiment precipitates. Prior to the formation of orpiment other surface species desorb from the iron oxide surface and arsenic occupies the free sites. Therefore, the mass of arsenic adsorbed onto the iron oxide surface is inversely proportional to the amount of orpiment.
- Aqueous arsenic concentrations decrease. Aqueous arsenic depletion ceases when orpiment precipitates.
- The distribution of species on the iron oxide surface changes as Eh falls. In Layer 1, where arsenic is retained on the iron oxide surface, more phosphate and less carbonate occupies sorption sites at lower Eh. In Layers 2 and 3 where arsenic is released from the iron oxide surface and precipitated as orpiment the proportion of carbonate species on the iron oxide surface increases as Eh is lowered.
- The charge on the surface of goethite changes, though only slightly (less negative in Layers 1 and 3 and more positive in Layer 2).
- pH increases from 7.1 to 8.2.

Review

I consider that Golder used an appropriate modelling approach that, in the circumstances, was more time-efficient than reactive transport modelling and provided an adequate understanding of the geochemical controls on arsenic solubility. The modelling provides the necessary qualitative prediction of the geochemical behaviour of arsenic in the aquifer when the cell is constructed.

Significance

The significant finding of the modelling is that in all three layers, the concentration of dissolved arsenic will not increase as conditions become more reducing and Eh falls. In fact dissolved arsenic concentrations decrease significantly. The reasons for this are quite complex.

Although a slow release of arsenic from surfaces in Layer 1 will continue to occur because those surfaces were in equilibrium with historically-higher dissolved phase concentrations, as Eh falls other ions will be preferentially released from adsorption sites and this will result in the availability of more sites for arsenic adsorption on the surface of soil particles. Thus, in Layer 1 there will be a small increase in adsorbed arsenic concentration as Eh falls. In Layers 2 and 3 there will be a larger increase in adsorbed arsenic concentration until Eh reaches -250 millivolts (mV) but when Eh falls past this point the adsorbed arsenic concentration will decrease significantly. The reason for this is that arsenic will then precipitate as orpiment and possibly pyrite, resulting in a large fall in dissolved phase concentration and consequent release of adsorbed arsenic. The modelled falls in aqueous arsenic concentrations occur in all three layers.

5.2.2 Assessment of Contaminant Migration due to Diffusion (Golder 2016a)

This memorandum considered the vertical diffusion of arsenite (As III) within and from the base of the diffusion cell, and lateral diffusion/advection through the walls of the cell. Vertical diffusion had been raised by the reviewer as an unaddressed potential sensitivity issue.

Approach

Golder assessed the mass flux due to vertical diffusion using Fick’s first law, using literature-derived values for the free solution diffusivity of arsenite and the tortuosity and porosity of the Unit 3 sands. The concentration gradient was estimated conservatively using the upper part of the likely range for contained groundwater (35 to 85 mg/L) and zero for water outside the cell.

Horizontal diffusion was calculated using the method developed by Rowe (1994) for combined diffusion and advection through a clay landfill liner, in that case using a tortuosity factor for clay-bentonite mixtures. In both cases the calculated mass flux was converted to mass transport rates using appropriate cell dimensions.

Results

Golder calculated the mass of arsenic transported from the cell by vertical diffusion as 0.2 to 1.5 grams per day (g/d), and that transported horizontally through the cell walls as negligible to 1.1 g/d.

Review

I consider that Golder used an appropriate methodology and sourced appropriate parameter values from the scientific literature. The results obtained are considered to be sound.

Significance

From my perspective, the significance of these results is that they place an upper limit on the mass of arsenic that may exit the cell through the base and walls that is independent of the groundwater flow velocity past the cell.

5.3 Groundwater Modelling

5.3.1 Approach

Groundwater flow modelling of the southern tip of Kooragang Island was carried out by Al Laase and reported in *Orica, Kooragang Island Steady-State Groundwater Flow Model*, dated July 2016 (Laase 2016a). The model was built in MODFLOW2000 (Harbaugh et al. 2000), the successor to MODFLOW, the widely used and accepted finite-difference code developed by the US Geological Survey (McDonald and Harbaugh 1988). Flow model calibration was conducted using PEST (Doherty 1999) coupled with pilot points (Doherty 2004).

Laase adopted a normal systematic and staged approach to model development, with the following components:

- Data evaluation and analysis
- Development of a conceptual groundwater model
- Configuration of the flow model
- Steady-state calibration of the model
- Evaluation of the model

Data Evaluation and Analysis

The initial evaluation of the available data included an analysis of horizontal groundwater flow directions and gradients.

> Quantitative evaluation of groundwater flow direction and gradient magnitudes in Units 1 through 4 was conducted using the January, May and August 2015 water level data. The analysis employed Visual Three-Point Plus (V3PP), a computer code developed by Oak Ridge National Laboratory (Laase et al. 2001). Triangles are created using wells whose water levels correspond to the triangle vertices. Groundwater flow directions and gradient magnitude are assessed by creating these triangles in the manner described above. Next, groundwater flow direction and gradient for each triangle are calculated using the three vertices water levels as input for three point calculations to determine plane dip direction and magnitude. The results are displayed graphically on a site map as arrows denoting flow direction and are also summarized in tabular form.

The results of this analysis were difficult to interpret due to strong tidal influences.

> Tidal responses in a confined aquifer pose a unique challenge when evaluating groundwater flow directions. For illustration examine the 24-hour hydrograph for BP15_15 (Figure 19). The reported groundwater level for BP15_15 is a function of when the water level was collected. Now consider the

> effect of tidal influences on a single comprehensive groundwater measurement event. It takes all day to collect groundwater level measurement from all the wells on the Kooragang Island Peninsula. Some of the wells will be measured at low elevation and some at high elevation periods. The result is a series of water level measurements that are not representative of instantaneous conditions, which is why the V3PP plots of groundwater flow directions for Units 2 through 4 (Figures 14 through 16) show arrows pointing in seemingly contradictory directions. A consequence of tidal influence on confined aquifers (Units 2 through 5) is that comprehensive water level measurement events, at least in this application, cannot be used as steady-state water level elevation calibration targets for the groundwater flow model. This statement does not apply to Unit 1 groundwater level measurements because Unit 1 is unconfined and in the absence of precipitation, site-wide groundwater levels are not expected to change significantly over the measurement collection period.

Vertical groundwater flow directions and gradients were assessed. The median head difference between Units 1 and 3 is 1.19 m. Unit 2 is typically 2.5 m thick which results in a downward vertical gradient of 0.474 metres per metre (m/m) across Unit 2. This is a relatively steep gradient, indicative of the low vertical hydraulic conductivity of Unit 2.

Laase summarised his assessment of the available horizontal hydraulic conductivity data as follows:

> Horizontal hydraulic conductivity of the Kooragang Island Peninsula sediments was characterized by slug testing selected wells screened primarily in Units 1, 2 and 3. Measured Unit 1 horizontal hydraulic conductivity ranges between 0.6 m/d and 20 m/d with a median value of approximately 4.4 m/d (5×10^{-5} m/s). Unit 2 horizontal hydraulic conductivity ranges from 0.2 m/d to 8 m/d with a typical value of 2 m/d (2.3×10^{-5} m/s). Horizontal hydraulic conductivity is more variable in Unit 3 with measurements ranging from less than 1 m/d to over 100 m/d (1.2×10^{-5} to 1.2×10^{-3} m/s). It should be noted that the higher Unit 3 horizontal hydraulic conductivity measurements were obtained from slug tests conducted in the southern portion of the peninsula. Previous Unit 3 slug tests conducted elsewhere on the Orica site yielded hydraulic conductivity measurements similar to those obtained for Unit 1. Minimal slug test data are available for Units 4 and 5, but based on lithology the horizontal hydraulic conductivity of Unit 4 is expected to be similar to Unit 1. Unit 5, consisting primarily of fine sediments, is expected to have lower hydraulic conductivity than Units 1 through 4.

The dataset was tabulated in this section.

Laase also carried out an analysis of hydraulic conductivity anisotropy. In layered systems, the bulk effective vertical hydraulic conductivity is assessed as the harmonic mean of the individual layer conductivities, weighted by layer thickness, whereas the bulk effective horizontal hydraulic conductivity is assessed as the arithmetic mean of the individual layer conductivities. The effect of this difference is that the vertical conductivity is dominated by the low permeability layers and the horizontal conductivity by the high-conductivity layers. An anisotropy factor of 0.1 (vertical: horizontal) was applied to the aquifer layer. This is a commonly-used default value when the actual anisotropy is unknown. I consider that this is appropriate, but also that it may be an underestimate of the actual anisotropy.

An initial assessment of recharge to the aquifer system was made by considering the water balance: rainfall minus evapotranspiration and runoff.

Based on the annual volumetric rate values presented previously and using the assumption of runoff being 10% of rainfall, typical recharge to groundwater from precipitation from 2005 to 2014 over the area of the model was estimated to be approximately 365 cubic metres per day (m^3/d) (0.004 cubic metres per second – m^3/s).

The potential for local evapotranspiration maxima due to phreatophyte vegetation was considered, and assessed as being insignificant.

The key figures on the discharge side of the water balance are discharge from Unit 1 to the Hunter River and downward flow from Unit 1 across Unit 2 to Unit 3, which is assumed to eventually discharge to the Hunter River.

The groundwater mass balance is summarised in Table 2 below.

TABLE 2
Kooragang Island Groundwater Mass Balance (m^3/d)

Item	In		Out	
	Minimum	Maximum	Minimum	Maximum
Rainfall Recharge	1896	1946		
Evapotranspiration			1338	1338
Unit 1 Discharge to River			107	250
Flow Across Unit 2			50	300
TOTAL	**1896**	**1946**	**1495**	**1888**

Conceptual Groundwater Model

Laase's Conceptual Groundwater Model was a compilation of the data presented in the previous section.

Kooragang Island lithology consists of:

- Five units defined by geology and vertical sequencing:
  - Unit 1 - fill and dredged material (sand)
  - Unit 2 - sandy silt with clay stringers
  - Unit 3 - silty sand
  - Unit 4 - sandy silt
  - Unit 5 - clayey silt

With respect to hydraulic conductivity these apply:

- Unit 1 horizontal hydraulic conductivity ranges between 0.6 and 20 metres per day (m/d).
- Unit 2 horizontal hydraulic conductivity ranges between 0.2 and 8 m/d.
- Unit 3 horizontal hydraulic conductivity ranges between 1 and 100 m/d with the higher values obtained from bores installed in the southern portion of the peninsula. Slug test results for the rest of the peninsula measured horizontal hydraulic conductivity at values similar to those measured for Unit 1.
- Minimal horizontal hydraulic conductivity measurements are available for Units 4 and 5 but based on lithology the horizontal hydraulic conductivity of Unit 4 is expected to be similar to Unit 1. Unit 5, consisting primarily of fine sediments, is expected to have lower hydraulic conductivity than Units 1 through 4.
- Vertical hydraulic conductivity is assumed to be one tenth horizontal hydraulic conductivity.
- Because of the presence of clay stringers the effective vertical hydraulic conductivity of Unit 2 is in the 10^{-4} m/d range.

General groundwater flow is as follows:

- The peninsula is an isolated groundwater flow system.

- Rainfall is the sole source of peninsula groundwater.
- All groundwater discharges to the north and south arms of the Hunter River.

Recharge and Evapotranspiration rates are:

- Median rainfall from 2005 through 2014 is 992 millimetres per year (mm/yr).
- Evapotranspiration is 700 mm/yr.
- Owing to flat terrain and sandy soils surface runoff is minimal and is assumed to be 10% of rainfall (99 mm/yr).
- Net recharge which is rainfall minus evapotranspiration minus surface runoff is 200 mm/yr.
- Volumetrically, net recharge to the groundwater flow system is approximately 365 m^3/d.

Groundwater discharge rates are:

- Unit 1 groundwater discharge to the Hunter River is between 107 and 250 m^3/d.
- Between 100 and 300 m^3/d of groundwater flows downward from Unit 1 across Unit 2 into Unit 3. Ultimately, this groundwater discharges to the Hunter River via Units 3 and 4.
- Groundwater flow volumes decrease with depth; that is groundwater flow volume in Unit 1> Unit 2> Unit 3> Unit 4 >Unit 5.

Finally, with respect to the Kooragang Island peninsula groundwater mass balance:

- Estimated cumulative volumetric groundwater recharge ranges between 1896 and 1946 m^3/d.
- Estimated cumulative volumetric groundwater discharge ranges between 1495 and 1888 m^3/d.
- Based on these recharge and discharge ranges, groundwater mass balance is between 1495 and 1946 m^3/d.

Review Comments

In my opinion, Laase reasonably summarised and interpreted the available data as collated in the Golder reports.

The flow components of the conceptual groundwater model generally reflect the data analysis. However, I disagree with the characterisation of Unit 3 as silty sand. The geological data indicate that this is an alluvial deposit with typically variable lithology, laterally and vertically, and includes fine to medium-grained sands (consistent with the higher end of the hydraulic conductivity range estimated for this unit) and also silty sands and minor sandy silts and clays sands (consistent with the lower end of the hydraulic conductivity range estimated for the unit).

I would have liked to see a statement concerning lateral boundary conditions and the significance of tidal effects included in the conceptual model.

I also disagree that Unit 4 is likely to have a similar hydraulic conductivity to Unit 1, on the basis of similar lithology. The lithological information, as presented by Golder (see Table 1 above) indicates that Unit 4 is likely to have a higher hydraulic conductivity than both Unit 1 and Unit 3. Confirmation of this is available from the high well yields from Unit 4 (in excess of 30 litres per second – L/s) and the large volumes of groundwater that it was necessary to pump from wells screened in Unit 4 in order to dewater Units 1, 2 and 3 during construction of dump stations on the PWCS site to the north.

Calibration

As indicated previously, Laase carried out steady-state calibration of the flow model using PEST coupled with pilot points. PEST has become the standard approach for calibrating complex groundwater models because, as Laase indicates, parameter estimation offers an advantage over trial-and-error model calibration in that the calibrated parameters represent a non-biased answer for the model configuration.

The key model parameters calibrated at steady state are hydraulic conductivity distributions, recharge and evapotranspiration rates. The calibration targets or indicators were groundwater levels and plume flow paths; I note that these are not independent as the plume flow path is controlled by the groundwater level distribution.

The calibrated horizontal hydraulic conductivity fields for model Units 1 and 2 are shown in Figures 36 and 37 of Laase (2016a). Median horizontal hydraulic conductivity for Layer 1 is 6.9 m/d. Laase states that model-predicted Unit 1 horizontal hydraulic conductivity is relatively homogeneous as evidenced by 5-percentile and 95-percentile hydraulic conductivity predictions of 3.6 m/d and 12.2 m/d, respectively, as shown in Table 3 below. Model-predicted horizontal hydraulic conductivity for Unit 2 is also relatively homogeneous with median, 5-percentile and 95-percentile predictions of 1.6 m/d, 1.2 m/d and 2.1 m/d, respectively. Units 3 through 5 had calibrated uniform horizontal hydraulic conductivity values of 1.3 m/d, 1.4 m/d and 0.3 m/d, respectively (i.e. the lateral distribution was not calibrated for these units).

TABLE 3
Calibrated Horizontal and Vertical Hydraulic Conductivity Statistical Distributions

Percentile	Unit 1 Kx (m/d)	Unit 1 Kz (m/d)	Unit 1 Kx/Kz	Unit 2 Kx (m/d)	Unit 2 Kz (m/d)	Unit 2 Kx/Kz
5	3.64E+00	4.29E-01	8.49	1.24E+00	3.36E-04	3689
25	4.68E+00	4.40E-01	10.64	1.42E+00	3.69E-04	3846
50	6.85E+00	4.40E-01	15.56	1.59E+00	3.92E-04	4063
75	8.30E+00	4.52E-01	18.35	1.85E+00	4.48E-04	4138
95	1.22E+01	4.95E-01	24.66	2.11E+00	5.94E-04	3553

The hydraulic conductivity calibration results for Units 1 and 2 are consistent with the described lithology and field data. However, those for Units 3 and 4 are not consistent with the reported lithology and field data. In my opinion they are likely to be underestimates.

The calibrated recharge values for the grass and gravel areas for the January 2015, May 2015 and August 2015 stress periods are shown in Table 4 below. Calibrated grass recharge rates range between 2.3×10^{-3} m/d to 2.5×10^{-3} m/d. Annually these values correspond to recharge rates of 825 mm/yr and 928 mm/yr. Model-predicted recharge to gravel areas is slightly greater relative to the grass areas and ranges between 2.5×10^{-3} m/d (917 mm/yr) to 2.8×10^{-3} m/d (1028 mm/yr). Laase states that the model-predicted values are within the expected recharge range.

TABLE 4
Calibrated Recharge Values

Area/Time	Recharge (mm/d)	Recharge (mm/yr)
Rainfall Recharge - January 2015	2.26	825
Gravel Area Recharge - January 2015	2.51	917
Rainfall Recharge - May 2015	2.54	928
Gravel Area Recharge - May 2015	2.81	1,028
Rainfall Recharge - August 2015	2.41	881
Gravel Area Recharge - August 2015	2.67	975

It is necessary to appreciate that, in the absence of external constraints, model calibration of hydraulic conductivity and recharge is necessarily non-unique, because an equally good fit to groundwater level data can be achieved for other values, provided that recharge and hydraulic conductivity values are adjusted in concert. Of course, rainfall data does provide such a constraint, because rainfall recharge cannot exceed rainfall, or indeed a reasonable proportion of rainfall, since there must necessarily be some evapotranspiration. In some modelling situations the discharge side of the water balance may also be partially constrained, for example by streamflow measurements under baseflow conditions, but that was not the case here, as the actual discharge to the Hunter River from the aquifer system is not measureable.

Model calibration was assessed by comparing model-predicted water levels to measured water levels (the closer the agreement between the two, the better-calibrated the model is assumed to be).

Figure 40 of Laase (2016a) is a plot of Unit 1 target residuals versus target water levels. The majority of the model-predicted water levels are within +/- 0.25 m of the target values; however, some of the model-predicted water levels are over or under predicted by as much as 0.75 m. Comparison of Unit 1 model-predicted and target water levels for the model results in sum of the difference squared of 14.4 m^2 (Figure 40 of Laase 2016a).

Groundwater levels from Units 2 to 5 were not included in the calibration but the measured water levels were compared to model-predicted levels to assess the degree to which the model replicates Units 2 to 5 groundwater flow conditions (Figure 41 of Laase 2016a). In general, most of the model-predicted water levels are within +/- 0.50 m of the target values. Some of the model-predicted water levels are over- or under-predicted by as much as 2 m. As the Units 2 to 5 water levels include tidal fluctuations, it would not be expected that the match between model-predicted and measured water levels would be as good as that obtained for Unit 1.

Comparison of Figures 45 to 47 with Figure 12 of Laase (2016a) indicates that model-predicted and measured Unit 3 potentiometric surfaces are similar. The January 2015, May 2015 and August 2015 model-predicted and observed potentiometric surfaces show a groundwater high located north of the Orica facility. Groundwater flows radially from the high towards the north and south arms of the Hunter River. Similar to the Unit 1 model-predicted water table, groundwater levels rise and fall in response to precipitation. The highest model-predicted Unit 3 water levels are associated with May 2015, a period of significant rainfall. Lower Unit 3 water levels are predicted for January 2015, a period of less rainfall. The model-predicted August 2015 Unit 3 water levels are, as expected, between the January 2015 and May 2015 water levels. While Unit 3 water levels rise and fall in response to rainfall the overall water level pattern remains consistent.

The model-predicted east and west arsenic plume trajectories matched the observed plume trajectories within 3 degrees. Particle traces for particles originating at the source areas follow the plume centrelines (Figure 49 of Laase 2016a). Particles placed within the western arsenic source area and migrated forward with time produce particle traces that mimic the western arsenic plume geometry (Figures 50 and 26 of Laase 2016a).

Calibration Evaluation and Review Comments

Section 7 of Laase (2016a) provides an evaluation of the model.

Laase states:

> For a groundwater flow model to be considered representative, the model needs to reasonably match calibration targets, reproduce the estimated site water balance, mimic observed plume trajectories, and be faithful to the conceptual model. Even if good agreements are achieved, the model still may be lacking in some aspects because all models are an approximation of the real world and require assumptions for construction and simulation and, as such, never will exactly mimic actual conditions. Part of any modelling exercise is to evaluate how the modelling assumptions potentially influence the predictions and attempt to quantify that uncertainty. Finally, the calibrated model needs to be capable of satisfying the modelling objectives, or why develop a model? This section evaluates the model with respect to matching observed conditions, uncertainty and the ability to satisfy the modelling objectives.

I agree completely.

Laase evaluates the model calibration as follows:

> The model reasonably matches target water level elevations and head differences. In addition, based on particle traces, the model reproduces the east and west arsenic plume flow paths. Overall this flow model honours the conceptual model with respect to recharge and discharge rates and volumes and the predicted range of hydraulic conductivities. In summary, the model makes sense when compared to what is known about the Kooragang Island hydrogeology and groundwater flow patterns. Therefore, the calibrated groundwater flow model can be used to simulate Kooragang Island groundwater flow and for remedial design and evaluation.

I also agree with this, *except in respect of the hydraulic conductivity values calibrated for Units 3 and 4.*

In discussing the sensitivity of the model to uncertainty in parameter estimation, Laase indicates:

> Data evaluation demonstrated that because of tidal fluctuations present within Units 2 through 5, water levels measured from these Units could not be used as calibration targets. Lacking head target data, Units 3 through 5 were calibrated as homogeneous properties, that is, a single horizontal hydraulic conductivity value was representative for each of the three units. Unit 2 was calibrated using pilot points because Unit 2 directly underlies Unit 1 and thus Unit 1 head targets are likely influenced by Unit 2 hydraulic conductivity distribution. The lack of head targets in Units 2 through 5 contributes uncertainty to the Unit 2 through 5 calibrated hydraulic conductivity values.
>
> While the calibrated model reasonably reproduces 2005 through 2014 recharge conditions, data evaluation showed that recharge during wet conditions could be as much as 300 mm/year more than current recharge conditions.

And:

> While the results [of a formal model sensitivity evaluation would] provide perspective on which input parameters control the calibration, they [would] provide minimal insight on how parameter uncertainty potentially influences remedial design predictions. With that in mind, sensitivity evaluation was not performed on the calibrated model. Rather sensitivity evaluation should be performed on remedial designs evaluated using this model. As discussed previously, potential uncertain parameters include recharge and Units 2 through 5 hydraulic conductivities.

I agree with these comments, but would add that, to a significant extent, the lower boundary of the calibrated model is the base of Unit 2. I think that the model is likely to be insensitive to the hydraulic conductivity of Units 3 and 4 because these units are part of an extensive water body with very large storage (relative to rainfall recharge within the model domain and downward leakage from the base of Unit 2) and relatively high hydraulic conductivity that is in direct lateral hydraulic continuity with an infinitely large surface water body through the dredged channels in the Hunter River.

Furthermore, I think that the data interpretation and calibration issues caused by tidal fluctuations may be even greater than indicated by Laase. Tidal lag and attenuation of tidal amplitude within the aquifer system depends on aquifer properties, and distance from the river and dredged channels; it will therefore vary in an unpredictable way across the lateral extent of the aquifers. Also, in addition to the diurnal cycle, there are superimposed monthly and semi-annual tidal cycles, which can be confused with recharge responses unless monitoring frequency is high or there are other control data.

Laase did carry out an evaluation of the sensitivity of the remedial design to uncertainty in the hydraulic conductivity of Unit 3, modelling the effect of increasing Unit 3 horizontal and vertical hydraulic conductivity by factors on ten on containment cell performance. This sensitivity modelling indicated that percentage reduction in flow through the arsenic source was insensitive to the hydraulic conductivity of Unit 3, remaining at 96% with the higher modelled hydraulic conductivity.

Therefore, the calibrated groundwater flow model can be used to simulate Kooragang Island groundwater flow and for the purpose of remedial design and evaluation.

6.0 REVIEW OF DESIGN

6.1 Design Evaluation

The report *Design Evaluation of a Cap and Cut-Off Wall for Orica Botany Kooragang Island, Former Sludge Disposal Pit*, dated July 2016 (Laase 2016b) uses the calibrated groundwater flow model to evaluate a number of alternative designs for a containment system for the arsenic contaminated soil and groundwater in terms of their effectiveness in meeting the MO objectives, and also in terms of their sensitivity to uncertainties in the groundwater flow model.

The alternative designs so evaluated are listed in Table 5 below (Table 1 of Laase 2016b).

TABLE 5
Summary of Containment Cell Designs

Design Scenario		Wall and Cap Specification	
Number	**Description**	**Wall Depth (m bgs)**	**Cap Infiltration Rate (mm/yr)**
Design Evaluations			
0	Ambient	NA	NA
1	Cap and Walls	8	10
2A	Cap and Walls	12	10
2B	Cap and Walls	12	0
2C	Cap and Walls	12	41
2D	Cap, Walls and Infiltration Basin	12	10
3	Cap and Walls	16	10
Sensitivity Evaluations			
2E	Cap and Walls – Unit 2 Kx Decreased by a Factor of Ten	12	10
2F	Cap and Walls – Unit 3 Kx and Kz Increased by Factors of Ten	12	10
2G	Cap and Walls – Annual Rainfall is 1300 mm/yr	12	10

Approach

The containment cell evaluations were performed using the steady-state, groundwater flow model representing August 2015 rainfall conditions developed in Laase (2016a). The August 2015 time period was selected because it represents ‘typical’ rainfall conditions rather than dry (January 2015) or wet (May 2015) conditions. Horizontal Flow Barrier (HFB) cells were used to simulate the containment cell cut-off walls. To implement the HFB boundary condition, low-permeability ‘walls’ were assigned to the appropriate vertical faces of the model cells containing the cut-off wall to form a continuous barrier to groundwater flow. For this application, the HFB cells were assigned a hydraulic conductivity of 1.0×10^{-9} m/s and a thickness of 0.8 m. Cut-off wall specifications were not changed during the simulations because construction techniques dictate wall permeability and thickness. To simulate the cap designed to limit rainfall infiltration, a recharge rate representing allowable rainfall infiltration was assigned to the area within the cut-off walls.

The containment cell designs listed in Table 5 have cut-off walls that extend various distances into Unit 3. To facilitate containment cell evaluation, model layer 3 (Unit 3) was subdivided into three layers having bottom elevations corresponding to 8 m, 12 m and 16 m depths below ground surface (bgs). The horizontal and vertical hydraulic conductivity distribution of the three Unit 3 layers was identical to the original layer 3 hydraulic conductivities.

Current groundwater flow rates through the arsenic source material were assessed and used as reference rates for the design effort. Next, design simulations were performed for scenarios listed in Table 5 and the modelled groundwater flow volumes passing through the arsenic source were compared to current flow volumes. Design performance was expressed as the percentage decline in flow volumes through the arsenic source area relative to ambient flow rates. Not every possible combination of cap infiltration and cut-off wall depth was simulated because knowledge gained from the different cap infiltration rate scenarios were found to be applicable to design scenarios employing deeper cut-off wall depths. The same was found to be true of the hydraulic conductivity and recharge sensitivity evaluations.

Results

The results of the design evaluation are summarised in Table 6 below (Table 2 of Laase 2016b).

TABLE 6
Summary and Comparison of Containment Cell Performance

Design Specification		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/yr)	Unit 1	Unit 2	Unit 3	Total	
Design Evaluations								
0	Current	NA	NA	5.12	0.6	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	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
Sensitivity Evaluations								
2E	Cap and Walls – Unit 2 Kx Decreased by a Factor of Ten	12	10	0.16	0.03	0.07	0.26	96
2F	Cap and Walls– Unit 3 Kx and Kz Increased by factors of Ten	12	10	0.16	0.03	0.07	0.26	96
2G	Cap and Walls – Annual Rainfall is 1300 mm/yr	12	10	0.22	0.04	0.06	0.32	95

Laase (2016b) provides a detailed evaluation of each design and sensitivity evaluation that it is unnecessary to repeat here. In fact, to a large extent, Table 6 tells the story itself.

Fundamentally, the key metric, percentage reduction in groundwater flow through arsenic source, is shown to be quite insensitive to variations in containment design. The greatest sensitivity is to an increase in infiltration through the cell cap (2C).

The vital design feature is shown to be full penetration of the cut-off walls through Units 1 and 2, into Unit 3. With this proviso, all groundwater migrating through the discharge cell discharges to Unit 3; the primary discharge conduit is thus changed from Unit 1 to Unit 3.

The parameter sensitivity (i.e. sensitivity to changes in hydrogeological conditions) is also shown to be quite insignificant.

The calibrated Unit 2 median horizontal hydraulic conductivity of 1.6 m/d is much higher than the calibrated Unit 2 median vertical hydraulic conductivity of 3.9×10^{-4} m/d. While the high anisotropy is consistent with the geology, a sensitivity evaluation was appropriate to evaluate how a decrease in Unit 2 bulk hydraulic conductivity (and thus anisotropy) by a factor of ten would influence containment cell performance.

When Unit 2 horizontal hydraulic conductivity is reduced by a factor of ten, the 10 mm/yr cap infiltration rate coupled with 12 m deep cut-off walls results in a groundwater flow rate of 0.26 m^3/d through the arsenic source area, as shown in Table 6. This flow volume represents a 96% decrease in groundwater flow through the arsenic source relative to current conditions, which is the same as that for Design Scenario 2A. This indicates that containment cell performance is not sensitive to uncertainty in Unit 2 bulk horizontal hydraulic conductivity.

As discussed above, Laase considers that there is substantial measured variation in horizontal hydraulic conductivity in Unit 3, and the calibrated values are at the lower end of the measured range. I consider that the horizontal hydraulic conductivity, and thus the anisotropy, of Unit 3 are likely to be considerably higher than the model-calibrated values of 1.3 m/d and 5.9 (h/v) respectively.

Sensitivity evaluation was conducted to determine whether increasing Unit 3 horizontal and vertical hydraulic conductivity by factors of ten (maintaining the anisotropy ratio) would change containment cell performance.

When Unit 3 horizontal and vertical hydraulic conductivities are increased by factors of ten, groundwater flows through the arsenic source area at a rate of 0.26 m^3/d, as shown in Table 6. This flow rate also represents a 96% reduction in flow through the arsenic source area relative to current conditions, the same as Design Scenario 2A, which suggests that containment cell performance is not sensitive to uncertainty in Unit 3 bulk horizontal and vertical hydraulic conductivities.

Laase does not address the effect of a higher horizontal hydraulic conductivity on the behaviour of the existing plume in Unit 1 once the cell is constructed. Regardless of the actual hydraulic conductivity of Unit 3, the modelling shows that the effect of cell installation will be to effectively cut off the source in Unit 1, because groundwater flow through the source is substantially redirected around the source, and any residual flow through the source discharges via Unit 3 instead of Unit 1. Thus, on the basis of normal hydrogeological principle, the existing plume will be cut off from the source and the attenuating residual mass will continue to migrate towards the river, and eventually clear the Unit 1 aquifer. Contaminant mass redirected to Unit 3 will also be advected towards the river, but at a faster rate than in Unit 1 and with less lateral dispersion. If the horizontal hydraulic conductivity in Unit 3 is higher, then this process will occur more quickly, and the narrowing of the plume will be accentuated, but the mass will remain essentially the same as the interlayer flux is controlled by the vertical hydraulic conductivity of Unit 2 and the head difference between Unit 1 and Unit 3.

Laase did consider the effect of tidal fluctuations on groundwater flux out of the containment cell, specifically the questions of whether groundwater flow direction could reverse causing groundwater to flow into the containment cell and whether tidally induced fluctuations could be large enough to dry out portions of the arsenic source area and potentially change reaction chemistry. Laase also used a qualitative analysis of site conditions rather than the model per se.

Observed water levels in a multi-level piezometer (BP15, ports 15 and 4) show 0.79 m tidal fluctuations in Unit 3 and no measurable tidal fluctuation in Unit 1. On the basis of the two order of magnitude difference between Unit 1 specific yield and Unit 3 storativity, Laase indicates that a 0.0079 m (8 mm) fluctuation would be expected in Unit 1, so that wetting and drying of the Unit 1 arsenic source brought about by tidal fluctuations will be minimal.

The Design Scenario 2B simulation, which sets cap infiltration at 0 mm/yr, predicts a Unit 1 cell water table of 0.94 m AHD, essentially the worst case condition. BP15-15, screened in Unit 3 and located in the vicinity of the containment cell, shows minimum and maximum water levels of -0.34 m AHD and 0.45 m AHD for the continuous record. Both of these values are less than the model-predicted 0.94 m AHD Unit 1 water table. Thus, based upon this analysis, groundwater flow from Unit 3 will always be out of the containment cell.

The influence of tidal fluctuations on groundwater flow rates out of the containment cell was also evaluated. The head difference between Unit 1 (0.96 m AHD) and Unit 3 (-0.34 to 0.45 m AHD) ranges between 0.51 and 1.3 m, which causes the vertical hydraulic gradient between the two units to change by a factor of 2.55. In accordance with Darcy's Law (Q = KiA), temporal changes in hydraulic gradient (i) will result in corresponding temporal changes in flow volumes (Q) out of the containment cell. The design rates presented in Laase's report represent long-term average discharge from the containment cell. It is expected that the temporally-varying groundwater flow volumes through the arsenic source will oscillate around the model-predicted rates representative of long-term average conditions.

6.2 Remediation Action Plan

6.2.1 Required Background Information

Golder prepared the *Orica Kooragang Island: Arsenic Management Order Remediation Action Plan* (ref. 1418917_044_R_Rev2), dated 8 July 2016 (Golder 2016d). The RAP provides an introduction to the site, its issues and hydrogeology (as previously discussed in this review) and the MO. It then describes the remediation options review process.

This was a staged process involving:

- Initial screening
- A feasibility assessment of five short listed options
- An external review of the process at that stage
- Two workshops at which all available options were again considered
- Development of a shortlist of four options, being:
    - On-site excavation and off-site disposal ('dig and dump')
    - On-site groundwater extraction with aboveground treatment ('pump and treat')
    - On-site cap and containment ('cap and contain')
    - On-site permeable reactive barrier (PRB)
- Evaluation of the shortlisted options against criteria of
    - Effectiveness

- Implementability
- Operability
- Safety, health, environment and community (SHEC)
- Cost

- Ranking of the shortlisted options
- Selection of a preferred option

The ranking outcome is provided in Table 7, which indicates that on-site cap and containment outranked the options by a considerable margin.

TABLE 7
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
Cost	25	135	97	103
Total	**100**	**664**	**463**	**472**

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 the RAP (Golder 2016d).

Golder defined this option as involving:

> …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.

The RAP summarises the remedial investigations and groundwater modelling carried out, as reviewed in Section 5.2 of this report, and also the regulatory requirements.

Section 1.2 of the RAP (Golder 2016d) incorporates the design evaluation carried out by Laase (2016b) as reviewed in Section 5.5 of this report.

I have reviewed Sections 1 to 7 of the RAP (Golder 2016d) and in my opinion they contain, and adequately present and justify, the information required in summary form in respect of a remedial action plan as indicated in *Guidelines for Consultants Reporting on Contaminated Sites* (EPA 2011).

6.2.2 Cell Design Outline

In Section 8.2 of the RAP, Golder outlines the decision process governing the cell dimensions and wall alignment.

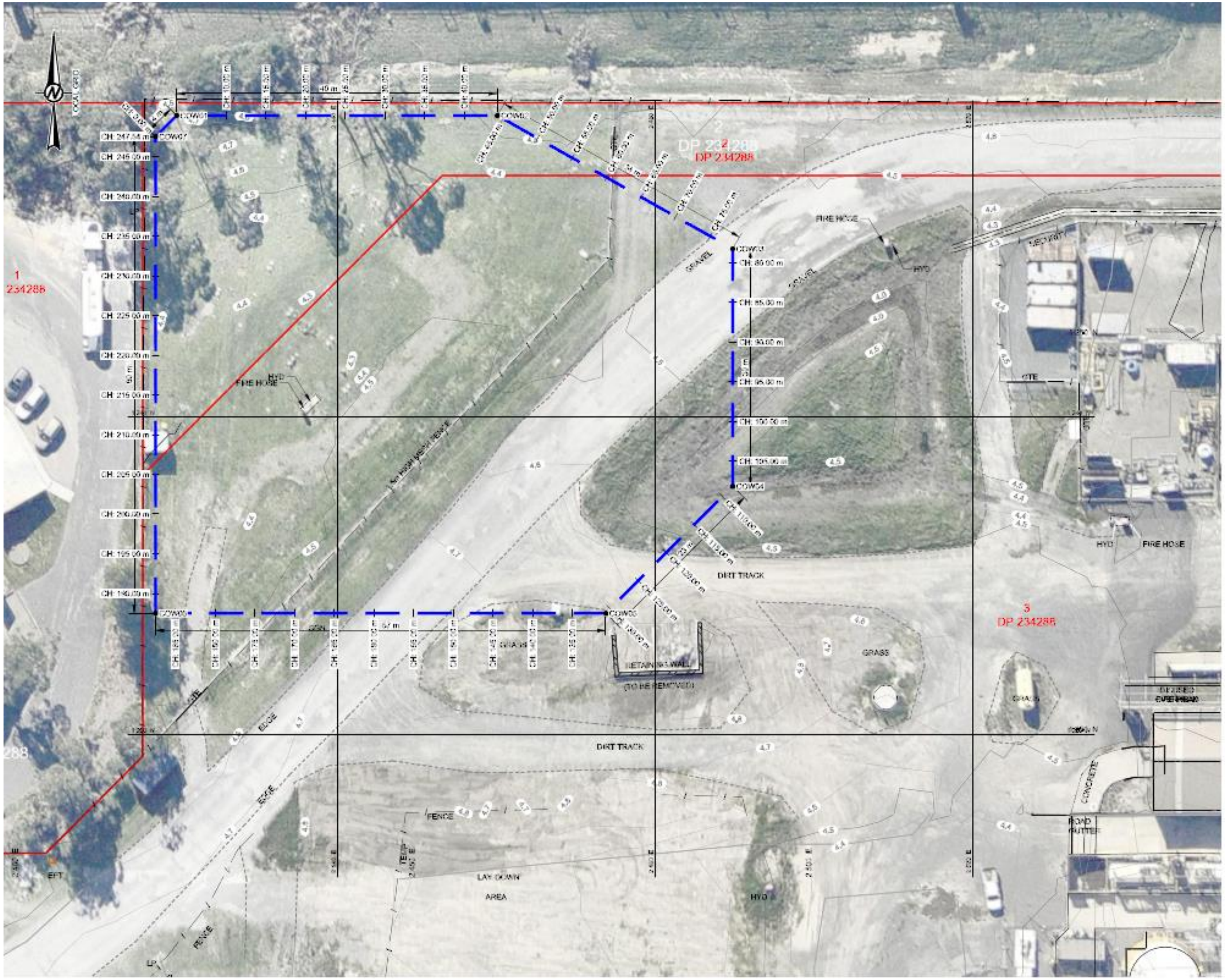
The design intent was to incorporate as much as possible of the defined extent of contaminated soil having a concentration of total arsenic greater than 40 mg/kg within the cell, subject to constraints imposed by the site boundaries, the minimum working area between the cell and the site boundary required by construction practicalities, and site constraints such as drainage and installed services.

Rather than extend the cell to include outlying areas of contaminated soil present only at shallow depths, it was considered more practical to excavate this soil and place it within a more compact cell.

The cell plan resulting from these considerations was a rectangle with chamfered corners and approximate dimensions of 63 m N-S by 73 m E-W as shown below in Figure 1.

On the basis of the results of Laase's (2016b) design evaluation modelling, a wall depth of 12 m was adopted as being appropriately conservative.

In my opinion, the proposed cell design is appropriate for the site conditions and, subject to the excavation and relocation of shallow contaminated soil as proposed in the RAP (Golder 2016d), the design adopted does not compromise performance in any way.



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 REMEDAITION 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, N809077.0
2. ORIGIN OF LEVELS MONUMENT 106 NEAR PRILL TOWER RL 3.982 ORICA DATUM
3. CONTOUR INTERVAL IS 100mm.

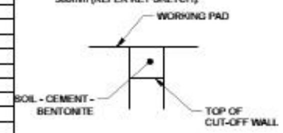
Station	TOP OF RL CUT-OFF WALL (m) (NOTE 1)
0	4.17
5	4.05
10	4.05
15	4.04
20	4.03
25	4.03
30	4.02
35	4.01
40	4.01
45	4.00
50	3.98
55	3.97
60	3.95
65	3.94
70	3.92
75	3.91
80	3.92
85	3.97
90	4.02
95	4.07
100	4.12
105	4.17
110	4.19
110	4.19
115	4.17
120	4.15
125	4.13
130	4.11
135	4.14
140	4.20
145	4.20
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	2419.68	1277.98
COW02	2460.09	1277.98
COW03	2486.74	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

Figure 1: Cell Design Plan

6.2.3 Cell Construction Materials

Three options for construction of the cut-off wall were considered – a soil-bentonite slurry wall, a bentonite-cement slurry wall and a wall constructed using cutter soil mixing technology. Following review of submissions received from specialist contractors, Orica, with input from Golder, decided that soil-bentonite slurry would be the most appropriate construction material.

I have been provided with, and have reviewed, the results of independent mix testing carried out by Golder. This demonstrated that an adequately low hydraulic conductivity (in the range 3.4×10^{-10} to 4.3×10^{-10} m/s for 15% bentonite mixes and 1.6×10^{-10} m/s for a 30% mix) could be obtained with mixes of site soil and bentonite. These values are all lower than the value of 1×10^{-9} m/s used (for 0.8 m thick walls) in the modelling carried out by Laase (2016b). I note that slurried site soil, with no bentonite added, had a hydraulic conductivity of 5×10^{-5} m/s.

Cement-bentonite mixes achieved hydraulic conductivities about an order of magnitude lower than those achieved for soil-bentonite mixes.

Golder made a qualitative evaluation of durability for a soil-bentonite wall based on about 30-years of service-life experience for such walls and the absence of known adverse interactions between site contaminants and bentonite. The proposed use of site soils already equilibrated to site contaminants was noted.

In my opinion the information provided by Golder supports the suitability of a soil-bentonite cut-off wall for the task being considered. I am not aware of any instances of failure of properly-constructed soil-bentonite walls during use in environmental applications, although failures during construction have been reported.

6.2.4 Capping System

The capping system proposed by Golder is a multi-component layered system comprised of:

1. A surface layer comprising a 400 mm thickness of revegetation soil and grass and/or road base with spray seal.
2. A separation geotextile layer to prevent fines entering the sand layer.
3. 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 underlying geomembrane during construction of overlying layers.
4. Linear Low Density Polyethylene (LLDPE) geomembrane: the primary liner layer. With strict Construction Quality Assurance (CQA) processes, the layer would be a reliable barrier minimising water infiltration.
5. Geocomposite Clay Liner (GCL) (typically bentonite sandwiched between two layers of non-woven geotextile): placing the GCL underneath the LLDPE geomembrane will improve performance as it can minimise the leakage through any defects in the geomembrane.
6. Bearing layer: formed by selected on-site materials (California Bearing Ratio (CBR) >8), to provide support for the geosynthetic liner system.

In my opinion, provided that sufficient attention is given to the detailed design and construction of the drainage layer (Layer 3), such a system would be capable of reducing infiltration to <1% of rainfall.

6.2.5 Remediation System Overview

I have reviewed the detailed design information for the capping and the wall alignment specifications contained in Appendix A of the RAP and consider that the system specified is capable of achieving the remediation objectives. I note that the detailed design of the soil-bentonite slurry wall will be the responsibility of the installation contractor.

6.3 Appropriateness of Design

As set out in the preceding subsections, I consider that the design proposed for the remediation system for arsenic contamination in soil and groundwater at the Orica Kooragang Island site is appropriate to meet the objective specified in Action 1 of the MO.

7.0 REVIEW OF PROPOSED VERIFICATION AND MONITORING PROGRAM

Section 9 of the RAP (Golder 2016d) describes a proposed remediation validation approach. This has two components:

1. Verification that the system is constructed in accordance with the design (construction verification).
2. Demonstration that the system is performing in accordance with the design intent (system validation).

7.1 Construction Verification

Golder describes a process of Construction Quality Control (CQC) and CQA for the construction of the cell walls and cap. The information provided in the RAP (Golder 2016d) is a summary of that provided in the reference specification. This review is based on the summary provided in the RAP.

The CQC program to be implemented by the contractor during construction is essentially a list of testing and measurement to be carried out and reported by the contractor. Whilst the testing is appropriate, there is no indication as to the feedback loop and management systems that will be applied to ensure that construction quality is actually controlled, rather than just recorded. An issue that applies to all subsurface construction is that failures to meet materials specifications that are discovered after the event (i.e. when the construction train has moved on), are very difficult to remedy.

As stated by Golder later in the RAP (Section 12.1 under *Contingencies*):

> 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.

I would have expected that the CQC would be risk based – i.e. there would have been a process of identifying and ranking soil-bentonite wall construction hazards with the greatest consequence for the quality of the finished product, then developing a CQC program to minimise the likelihood of such events, as well as promptly identifying and correcting them if they do occur. This should rank both potential failure mechanisms and zones (e.g. low-density sands within Zone 3). I would have expected this risk assessment to be entirely separate from construction risk assessment carried out by the contractor for its own purposes, and I would have expected to see it mentioned in the summary.

Whilst the CQA reporting described appears appropriate, it is described substantially as a post-audit and there is no indication of the feedback and corrective mechanisms that would be employed.

7.2 System Validation

Basis

Laase (2016b) states in Section 6 that:

> After containment cell installation groundwater levels inside and outside the cell can be used to assess whether the cell is performing as expected. Monitoring well pairs should be installed at adjacent locations inside and outside the containment cell in Units 1 through 3. Care should be taken to select well locations so as not to impact future potential uses within the containment cell footprint. If the containment cell is performing as designed, Units 1 and 2 groundwater levels inside the containment cell will be lower relative to those outside the cell. Unit 3 groundwater levels inside and outside the containment cell should be similar. Additionally, Units 1 and 2 groundwater levels measured in monitoring wells located inside the cell should be similar regardless of well location. Lastly, cap performance can be assessed by comparing the increases in Unit 1 water levels inside and outside the containment cell in response to precipitation events. Greater water-level fluctuations should occur in wells located outside the containment cell relative to wells located within the cell.

> It is not recommended that dissolved arsenic concentrations be used for performance monitoring. While changes in groundwater levels are expected to occur relatively instantaneously following containment cell installation, changes in dissolved arsenic concentrations are expected to change much more slowly. In addition, it is impossible to predict how installation of the containment cell will influence short-term arsenic concentrations. It is possible and even likely that arsenic trends following containment cell installation will be confusing. Due to the lower groundwater flow rates through the arsenic source following containment cell installation, it is possible that dissolved arsenic concentrations within the cell may increase due to longer contact times between groundwater and source material. Despite the potential for higher dissolved arsenic concentrations within the containment cell, because of the vastly reduced flow volumes through the source, arsenic loading (groundwater flow volumetric rate × dissolved arsenic concentration) to groundwater will be reduced relative to ambient conditions.

Approach

An approach to hydraulic validation of the system, as suggested by Laase, is set out in Section 9.5 of the RAP (Golder 2016d).

Golder states:

> Hydrostratigraphic conditions in each of Units 1, 2 and 3 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.

This assumption forms the basis of a hydraulic validation approach proposed by Golder.

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 comprises three sets of monitoring wells each consisting of two nests of three wells, one nest inside the wall and one outside, located around the cut-off wall alignment. Golder noted that selection of the proposed locations is somewhat constrained by the site characteristics and design features of the cell, but considered that the wells are best placed to observe the expected effects of design implementation.

At each of the six well nest locations, three separate piezometers will be installed to target Units 1, 2 and 3 individually. This reflects the considerations presented in Laase (2016b) as quoted above.

Identified potential effects indicative of expected system performance included:

- 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.

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.

I note that if the Unit 3 hydraulic conductivity is significantly higher than indicated in Laase's conceptual model, then it is unlikely that there would be measurable differences in water level between the inside and outside of the cell in Unit 3 unless the anisotropy of that unit is also higher. If the anisotropy of Layer 3 is high, then there may be observable difference in the Unit 3 response to tidal fluctuations inside and outside the cell.

Golder also notes 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 containment cell and allow ‘normalisation’ of the internal water level data, if required. An additional monitoring well 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 appropriately designed to prevent air ingress into the space where the logger is located.

The RAP indicates that 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.

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.

Review Comments

I agree that hydraulic monitoring is an appropriate approach to system validation, and I consider that the monitoring network proposed is generally appropriate, although I have recommended some additions.

However, I think it is possible that interpretation of the monitoring data will prove a demanding task. In order to facilitate the task, I recommend that some additional effort is put into collecting as much data as possible at the time of monitoring well installation. This should include, as a minimum:

- Pre-drilling each of the nest sites with a Geoprobe to ensure that the best possible lithological data are obtained.
- Running a hydraulic profiling and electrical conductivity tool at each nest site to profile small-scale hydraulic conductivity variation with depth.
- Installing piezometers at two rather than one depth in Unit 3 (i.e. four piezometers in each nest).
- Carrying out a slug test on each completed piezometer.
- Sampling each piezometer to establish background groundwater chemistry (i.e. a general hydrochemical suite, not contamination monitoring).

The additional Unit 3 piezometer is suggested to allow evaluation of the hydraulic anisotropy in Unit 3 on the basis of response to tidal fluctuations. This may assist in interpretation of the hydraulic monitoring data for validation purposes. It may also be helpful to enlist the aid of the design-evaluation groundwater model in the interpretation of validation data.

7.3 Bulk Materials Validation

I consider that the procedures for validation of bulk materials (both produced and imported) outlined in Section 10 of the RAP (Golder 2016d) are appropriate.

7.4 Validation Reporting

I consider that the general approach to validation reporting outlined in Section 11 of the RAP (Golder 2016d) is appropriate. The scope of the validation assessment (validation assessment inputs) as outlined in Section 11.2 is also generally appropriate. However, I would expect this to specifically include identification of CQC failures or other incidents, and documentation of corrective action taken and subsequent revalidation.

I would expect the remediation validation report to include a detailed technical evaluation of the hydraulic responses.

7.5 Contingencies

Review of construction quality contingencies was incorporated in Section 7.1 above. In my opinion, the contingency measure identified in Section 12.2 of the RAP (Golder 2016d) with regard to hydraulic performance is appropriate, and possibly the only one likely to be available. This contingency measure is stated as:

> 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.

Golder does not explicitly describe the mechanism through which this contingency measure would operate. Although this is fairly obvious, it is worth outlining it for clarity.

Pumping groundwater from Unit 1 inside the cell should lower the hydraulic head in that unit, creating a hydraulic gradient that would ensure an inward flow direction through the cell walls and an upward flow from Unit 3 through Unit 2 to Unit 1. I note that (unless the aquifer is highly anisotropic) pumping sufficient water from Unit 3 to significantly decrease the hydraulic head in that unit is not likely to be possible with small diameter wells, and in any event would not be desirable.

7.6 Environmental Management

I consider that the procedures for construction environmental management, including preparation of a Construction Environmental Management Plan (CEMP), that are outlined in Section 13 of the RAP (Golder 2016d) are adequate and appropriate to achieve compliance with environmental legislation, regulations and policy, State and local. These procedures will, however, need to be reviewed in the light of any specific conditions placed on the EPL in respect of the remediation program.

7.7 Work Health and Safety

The procedures outlined in Section 14 of the RAP (Golder 2016d) including the preparation of a Site Specific Health and Safety Plan (SSHSP) appear generally adequate to ensure compliance with NSW work health and safety regulations, but will need to be reviewed for compliance with any site specific requirements imposed by SafeWork NSW, and Orica company and site-specific requirements.

7.8 Long-Term Environmental Management Plan

The outline for development of a Long-Term Environmental Management Plan (LTEMP) as required by the MO, which is provided in Section 15 of the RAP (Golder 2016d), is considered adequate at this stage of the process. Clearly a more detailed outline will be required once the remediation works are nearing completion, and the LTEMP should be subject to external review.

8.0 SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusions of Review

This review deals with the remedial assessment work carried out by Golder, as reported in 2016, with groundwater modelling carried out by Laase, and with the remediation design and remediation action plan prepared by Golder for Orica.

Golder and Orica identified a remediation objective that is both consistent with the MO and practicable; this provides an appropriate foundation for the remediation design process.

In my opinion the remediation concept, containment and capping within an engineered cell, is appropriate for the contaminant of concern in the conditions of the site. The remediation system design, as outlined in the RAP, is based upon adequate site investigation and groundwater flow modelling that I consider to be robust.

The RAP as a whole contains, and adequately presents and justifies, the information required in respect of a remedial action plan as indicated in *Guidelines for Consultants Reporting on Contaminated Sites* (EPA 2011).

The RAP and supporting documentation reviewed in this report meet the relevant requirement of Action 1 of the MO.

Remedial Investigation

Golder produced a modular assessment report that included modules outlining project background information, and dealing with environmental investigation, geotechnical investigation, a hydrogeological conceptual model and delineation of arsenic contamination.

Golder incorporated a QA / QC program in the environmental investigation that, as described, generally complied with the recommendations of Appendix C of Schedule B2 of the ASC NEPM. However, the data validation reports addressed only sampling and analytical precision for arsenic.

In my opinion, an appropriate range of geotechnical testing was carried out on an adequate number of samples to inform the preliminary design of a containment cell.

I checked the hydrogeological conceptual model against the data available and consider that it represents a consistent interpretation of those data. In my opinion, it provided a sound basis for the numerical model.

The approach to contamination delineation adopted by Golder was logical and reasonable, and the delineation criteria were adequately justified. Consequently, I consider that the extent of contamination requiring management as identified by Golder is a good reflection of the dataset, and formed an appropriate and robust basis for the containment design.

Golder also provided technical memoranda describing geochemical and diffusion modelling for my review. Whilst the results of the work described therein were also incorporated in the final version of the data report, I reviewed the memoranda.

I consider that Golder used an appropriate geochemical modelling approach that, in the circumstances, was more time-efficient than reactive transport modelling and provided an adequate understanding of the geochemical controls on arsenic solubility. The modelling provides the necessary qualitative prediction of the geochemical behaviour of arsenic in the aquifer when the containment cell is constructed. I think that the most significant finding of the geochemical modelling is that in all three layers, the concentration of dissolved arsenic will not increase as conditions become more reducing and Eh falls. In fact dissolved arsenic concentrations decrease significantly. The reasons for this are quite complex.

I consider that Golder also used an appropriate methodology and sourced appropriate parameter values from the scientific literature for diffusion modelling. The results obtained are considered to be sound. I think that the significance of these results is that they place an upper limit on the mass of arsenic that may exit the cell through the base and walls that is independent of the groundwater flow velocity past the cell.

Groundwater Modelling

With respect to the groundwater flow modelling carried out by Laase, I consider that Laase reasonably summarised and interpreted the available hydrogeological data as collated in the Golder reports.

The flow components of the conceptual model generally reflect that data analysis. However, I disagree with the characterisation of Unit 3 as silty sand. The geological data indicate that this is an alluvial deposit with typically variable lithology, laterally and vertically, and includes fine to medium-grained sands (consistent with the higher end of the hydraulic conductivity range estimated for this unit) and also silty sands and minor sandy silts and clays sands (consistent with the lower end of the hydraulic conductivity range estimated for the unit).

I also disagree that Unit 4 is likely to have a similar hydraulic conductivity to Unit 1, on the basis of similar lithology. The lithological information, as presented by Golder indicates that Unit 4 is likely to have a higher hydraulic conductivity than both Unit 1 and Unit 3. Confirmation of this is available from the high well yields from Unit 4 (in excess of 30 L/s) and large volumes of groundwater that is was necessary to pump in order to dewater Units 1, 2 and 3 by pumping from Unit 4 during construction of dump stations on the PWCS site to the north.

I would have liked to see a description of the lateral boundary conditions and the significance of tidal effects included in the conceptual model.

I fully agree with the criteria for model evaluation set out by Laase, and in most respects I agree with his evaluation of the model against those criteria. That evaluation was the model reasonably matches target water level elevations and head differences. In addition, based on particle traces, the model reproduces the east and west arsenic plume flow paths. Overall the flow model honours the conceptual model with respect to recharge and discharge rates and volumes and the predicted range of hydraulic conductivities. In summary, the model makes sense when compared to what is known about the Kooragang Island hydrogeology and groundwater flow patterns. Therefore, the calibrated groundwater flow model can be used to simulate Kooragang Island groundwater flow and for remedial design and evaluation.

I disagree with the hydraulic conductivity values calibrated for Units 3 and 4.

Laase provides a detailed discussion of the sensitivity of the model to uncertainty in parameter estimation. He notes that data evaluation demonstrated that because of tidal fluctuations present within Units 2 through 5, water levels measured from these units could not be used as calibration targets. Lacking head target data, Units 3 to 5 were calibrated as homogeneous properties, that is, a single horizontal hydraulic conductivity value was representative for each of the three units. Unit 2 was calibrated using pilot points because Unit 2 directly underlies Unit 1 and thus Unit 1 head targets are likely influenced by Unit 2 hydraulic conductivity distribution. The lack of head targets in Units 2 through 5 contributes uncertainty to the Unit 2 through 5 calibrated hydraulic conductivity values. While the calibrated model reasonably reproduces 2005 through 2014 recharge conditions, data evaluation showed that recharge during wet conditions could be as much as 300 mm/yr more than current recharge conditions.

Laase also states that while the results [of a formal model sensitivity evaluation would] provide perspective on which input parameters control the calibration, they [would] provide minimal insight on how parameter uncertainty potentially influences remedial design predictions. With that in mind, sensitivity evaluation was not performed on the calibrated model. Rather sensitivity evaluation should be performed on remedial designs evaluated using this model. As discussed previously, potential uncertain parameters include recharge and Units 2 to hydraulic conductivities.

Again, I agree with these comments but add that, to a significant extent, the lower boundary of the calibrated model is the base of Unit 2. I think that the model is likely to be insensitive to the hydraulic conductivity of Units 3 and 4 because these units are part of an extensive water body with very large storage (relative to rainfall recharge within the model domain and downward leakage from the base of Unit 2) that is in lateral direct hydraulic continuity with an infinitely large surface water body through the dredged channels in the Hunter River.

I think that the data interpretation and calibration issues caused by tidal fluctuations may be even greater than indicated by Laase. Tidal lag and attenuation of tidal amplitude within the aquifer system depends on aquifer properties and distance from the river and dredged channels, and will vary in an unpredictable way across the aquifers. Also, in addition to the diurnal cycle, there are superimposed monthly and semi-annual cycles, which can be confused with recharge responses unless monitoring frequency is high or there is other control data.

In summary, I think that the groundwater modelling has been carried out in a very competent and professional manner. Whilst I disagree with the hydraulic conductivity value assigned to Units 3 and 4, neither the model or the remedial design evaluation are sensitive to these values and I do not consider that this difference is significant to the design. However, I think that it may prove to be more significant when the time comes to evaluate hydraulic validation data.

Cell Design

I consider that the design proposed for the remediation system for arsenic contamination in soil and groundwater at the Orica Kooragang Island site is appropriate to meet the objective specified in Action 1 of the MO.

Considering both Laase's design evaluation and the Golder design as presented in the RAP (Golder 2016d), I consider that the proposed cell design is appropriate for the site conditions, and, subject to the excavation and relocation of shallow contaminated soil as proposed in the RAP, the design adopted does not compromise performance in any way. In my opinion, the information provided by Golder supports the suitability of a soil-bentonite cut-off wall for the task being considered. I am not aware of any instances of failure of properly-constructed soil-bentonite walls in environmental applications, although failures during construction have been reported.

In my opinion, provided that sufficient attention is given to the detailed design of the drainage layer (Layer 3) such a system would be capable of reducing infiltration to <1% of rainfall.

I have reviewed the detailed design information for the capping and the wall alignment specifications contained in Appendix A of the RAP and consider that the system specified is capable of achieving the remediation objectives. I note that the detailed design of the soil-bentonite slurry wall will be the responsibility of the installation contractor.

I have identified what I consider to be significant issues regarding the summary of the CQC program provided in the RAP.

I would have expected that the CQC program would be risk based – i.e. there would have been a process of identifying and ranking soil-bentonite wall construction hazards with the greatest consequence for the quality of the finished product, then developing a CQC program to minimise the likelihood of such events, as well as promptly identifying and correcting them if they do occur. This should rank both potential failure mechanisms and zones (e.g. low-density sands within Zone 3). I would have expected this risk assessment to be entirely separate from construction risk assessment carried out by the contractor for its own purposes, and I would have expected to see it mentioned in the summary.

Whilst the CQA reporting described appears appropriate, it is described substantially as a post-audit and there is no indication of the feedback and corrective mechanisms that would be employed.

Validation

I agree that hydraulic monitoring is an appropriate approach to system validation, and I consider that the monitoring network proposed is appropriate.

However, I think it is possible that interpretation of the monitoring data will prove a demanding task. In order to facilitate the task, I recommend that some additional effort is put into collecting as much data as possible at the time of monitoring well installation. This should include, as a minimum:

- Pre-drilling each of the nest sites with a Geoprobe to ensure that the best possible lithological data is obtained;
- Running a hydraulic profiling tool at each nest site to establish small-scale hydraulic conductivity variation with depth;
- Installing piezometers at two rather than one depth in Unit 3;
- Carrying out a slug test on each completed piezometer; and
- Sampling each piezometer to establish background groundwater chemistry (i.e. a general hydrochemical suite, not contamination monitoring).

The additional Unit 3 piezometer is suggested to allow evaluation of the hydraulic anisotropy in Unit 3 on the basis of response to tidal fluctuations. This may assist in interpretation of the hydraulic monitoring data for validation purposes. It may also be helpful to enlist the aid of the design evaluation groundwater model in validation data interpretation.

I consider that the procedures for validation of bulk materials (both produced and imported) outlined in Section 10 of the RAP (Golder 2016d) are appropriate.

I consider that the general approach to validation reporting outlined in Section 11 of the RAP (Golder 2016d) is appropriate. The scope of the validation assessment (validation assessment inputs) as outlined in Section 11.2 of the RAP is also generally appropriate. However, I would expect this to specifically include identification of CQC failures or other incidents, and documentation of corrective action taken and subsequent revalidation.

I would expect the remediation validation report to include a detailed technical evaluation of the hydraulic responses. It may well be necessary to use the numerical model developed by Laase to assist with this process.

In my opinion, the contingency measure identified in Section 12.2 of the RAP with regard to hydraulic performance is appropriate, and possibly the only one likely to be available.

Environmental Management

I consider that the procedures for construction environmental management, including preparation of a CEMP, that are outlined in Section 13 of the RAP (Golder 2016d) are adequate and appropriate to achieve compliance with environmental legislation, regulations and policy, State and local. These procedures will, however, need to be reviewed in the light of any specific conditions placed on the EPL in respect of the remediation program.

The procedures outlined in Section 14 of the RAP including the preparation of a SSHSP appear generally adequate to ensure compliance with NSW work health and safety regulations, but will need to be reviewed for compliance with any site specific requirements imposed by SafeWork NSW, and Orica company and site-specific requirements.

The outline for development of a LTEMP as required by the MO, which is provided in Section 15 of the RAP, is considered adequate at this stage of the process. Clearly a more detailed outline will be required once the remediation works are nearing completion, and the LTEMP should be subject to external review.

REFERENCES

ANZECC 2000, *Australian and New Zealand Guidelines for Fresh and Marine Water Quality,* National Water Quality Management Strategy, Australian and New Zealand Environment and Conservation Council/Agriculture and Resource Management Council of Australia and New Zealand

ASC NEPM, *National Environment Protection (Assessment of Site Contamination) Measure 1999*, as updated May 2013

Doherty, J. 2004, *PEST Model-Independent Parameter Estimation*, Watermark Numerical Computing, 4th Edition

Doherty, J. 1999, *PEST Model-Independent Parameter Estimation*, Watermark Numerical Computing, 1st Edition

EPA 2011, *Guidelines for Consultants Reporting on Contaminated Sites*, NSW Office of Environment and Heritage, Sydney NSW

Golder 2016a, *Orica Kooragang Island – Assessment of Contaminant Migration due to Diffusion*, memorandum prepared by Golder Associates Pty Ltd (ref. 1418917_042_M_Rev1), dated 29 February 2016

Golder 2016b, *Geochemical Modeling of Arsenic Attenuation and Release*, memorandum prepared by Golder Associates Pty Ltd (ref. 1418917-7000), dated 4 March 2016

Golder 2016c, *Orica Kooragang Island: Arsenic Management Order – Remediation Investigations*, prepared by Golder Associates Pty Ltd (ref. 1418917-012/016-R-Rev0), dated 29 March 2016

Golder 2016d, *Orica Kooragang Island: Arsenic Management Order, Remediation Action Plan*, prepared by Golder Associates Pty Ltd (ref. 1418917_044_R_Rev2), dated 8 July 2016

Harbaugh, E., E. Banta, C. Hill and M. McDonald 2000, *MODFLOW-2000, The U. S. Geological Survey Modular Groundwater Model – Users Guide to Modularisation Concepts and Groundwater Flow Process*

Laase 2016a, *Orica, Kooragang Island Steady-State Groundwater Flow Model*, prepared by A. D. Laase Hydrologic Consulting, dated July 2016

Laase 2016b, *Design Evaluation of a Cap and Cut-Off Wall for Orica Botany Kooragang Island, Former Sludge Disposal Pit*, prepared by A. D. Laase Hydrologic Consulting, dated July 2016

Laase, A., J. Wilson and D. Greene 2001, *Evaluation of Natural Flushing Using Three-Point and Partitioning Theory Analysis*, in Proceedings for The Third International Conference on Remediation of Chlorinated and Recalcitrant Compounds, May 2002

McDonald, M. G. and A. W. Harbaugh 1988, *MODFLOW: A modular three-dimensional finite difference ground-water flow model*, U. S. Geological Survey

Rowe, R. K. 1994, *Diffusive Transport of Pollutants through Clay Liners*, in T. H. Christensen, R. Cossu, R. Stegmann (ed.) Landfilling of Waste: Barriers, E. & F. N. Spon, London, pp. 219-245

URS 2009, *Stage 3 Voluntary Remediation Agreement, Treatability Study for In-situ Arsenic Removal from Groundwater, Orica Kooragang Island, NSW*, prepared by URS Australia Pty Ltd

URS 2007, *Stage 2 Voluntary Remediation Agreement, Attenuation of Arsenic in Groundwater, Orica Kooragang Island, NSW,* prepared by URS Australia Pty Ltd

APPENDIX F

Flood Impact Assessment Report

Orica Kooragang Island Remediation Project - Flood Impact Assessment

Reference: L.N20733.002.FIA.docx
Date: November 2016

Orica Kooragang Island Remediation Project - Flood Impact Assessment

Prepared for:	Orica Australia
Prepared by:	BMT WBM Pty Ltd (Member of the BMT group of companies)

Offices

Brisbane
Denver
London
Mackay
Melbourne
Newcastle
Perth
Sydney
Vancouver

Document Control Sheet

BMT WBM Pty Ltd
126 Belford Street
Broadmeadow NSW 2292
Australia
PO Box 266
Broadmeadow NSW 2292

Tel: +61 2 4940 8882
Fax: +61 2 4940 8887

ABN 54 010 830 421

www.bmtwbm.com.au

Document:	L.N20733.002.FIA.docx
Title:	Orica Kooragang Island Remediation Project - Flood Impact Assessment
Project Manager:	Luke Kidd
Author:	Luke Kidd
Client:	Orica Australia
Client Contact:	Sherree Woodroffe
Client Reference:	PO 6201712997

Synopsis: **This report outlines a flood impact assessment in relation to the cap and containment works proposed at the Orica Kooragang Island Remediation site.**

REVISION/CHECKING HISTORY

Revision Number	Date	Checked by		Issued by	
0	7 Nov 2016	L. Kidd	Luke Kidd	L. Kidd	Luke Kidd

DISTRIBUTION

Destination	Revision										
	0	1	2	3	4	5	6	7	8	9	10
Orica Australia	PDF										
BMT WBM File	PDF										
BMT WBM Library											

1 Introduction

1.1 Hunter River Estuary

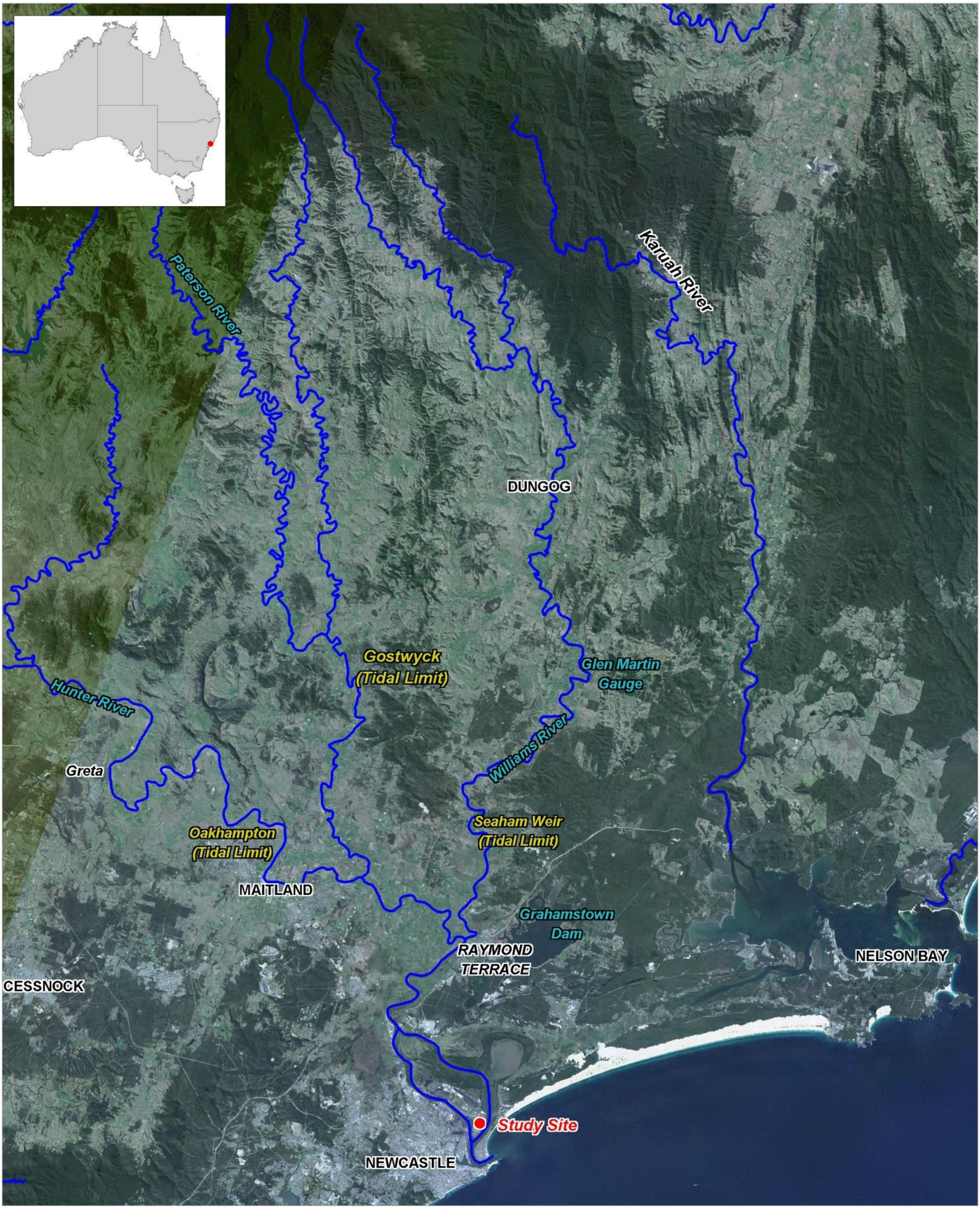
The Hunter estuary is a large riverine estuary system at the downstream end of the extensive Hunter River catchment (size approximately 22,000 km^2). Three major rivers discharge into the estuary, namely the Hunter River, the Paterson River and the Williams River. The confluence of the Williams River and Hunter River is at Raymond Terrace, approximately 30 km upstream of the estuary mouth (i.e. Newcastle Harbour). The Paterson River joins the Hunter River between Morpeth and Hinton some 15 km upstream of Raymond Terrace. The estuary extends a further 20 km along the Hunter River to the tidal limit at Oakhampton, near Maitland.

The study site is located near the confluence of the North Arm and South Arm of the Hunter River near Newcastle Harbour, as shown on Figure 1-1.

1.2 Subject Site and Proposed Development

The location of the subject site in relation to surrounding properties and the Hunter River is shown on Figure 1-2. The proposed development involves the installation of a cap and containment system to enclose arsenic contaminated soil. A plan detailing the alignment and extent of the proposed top of cap is presented on Figure 1-3.

The extent of the proposed works is approximately 75 metres by 50 metres (footprint of about 4000 m^2). The proposed landform of the cap system will include a minimum 2% slope for surface water drainage and a 1-in-3 batter slope around the perimeter of the cap. A 9 metre wide ramp is to be provided for access to the platform area (Orica, 2016). The proposed surface of the platform would range between 5.9 m AHD and 5 m AHD (approximately 1 to 1.5 metres above natural surface).



Title:

Hunter River Estuary Locality Map

Figure: **1-1**

Rev: **A**

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 10 20km

Approx. Scale

BMT WBM

www.bmtwbm.com.au

Filepath : K:\N20733_OricaKooragangIsland_FIA\MI\Workspaces\Figure_1-1_HunterRiverEstuary.WOR

Title:
Site Location

Figure: **1-2**

Rev: **A**

N

0 200 400m

Approx. Scale

BMT WBM
www.bmtwbm.com.au

Filepath : K:\N20733_OricaKooragangIsland_FIA\MI\Workspaces\Figure_1-2_Study_Site_Location.WOR

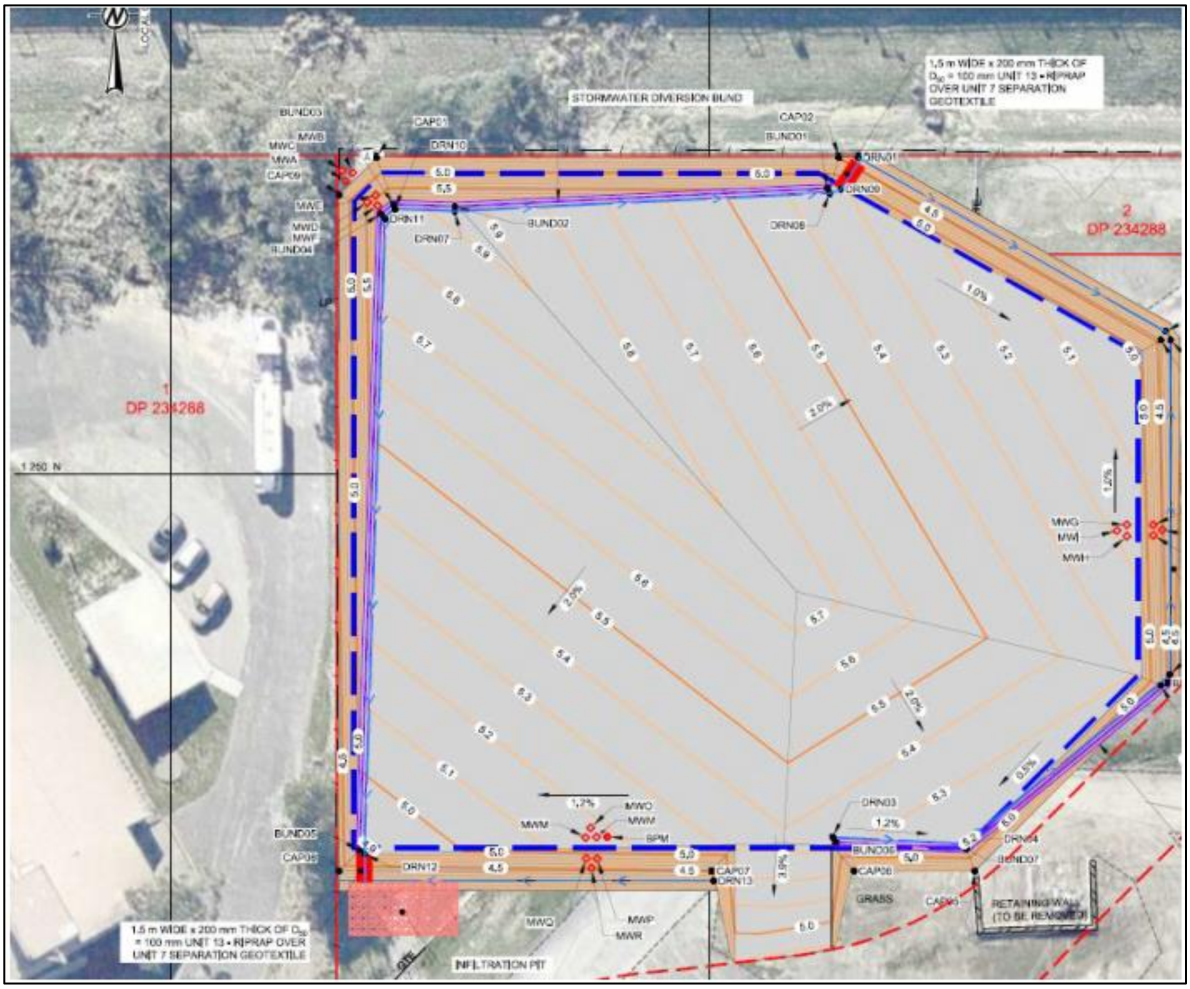


Figure 1-3 Plan Detailing Top of Cap (Orica, 2016)

2 Existing Flooding Behaviour

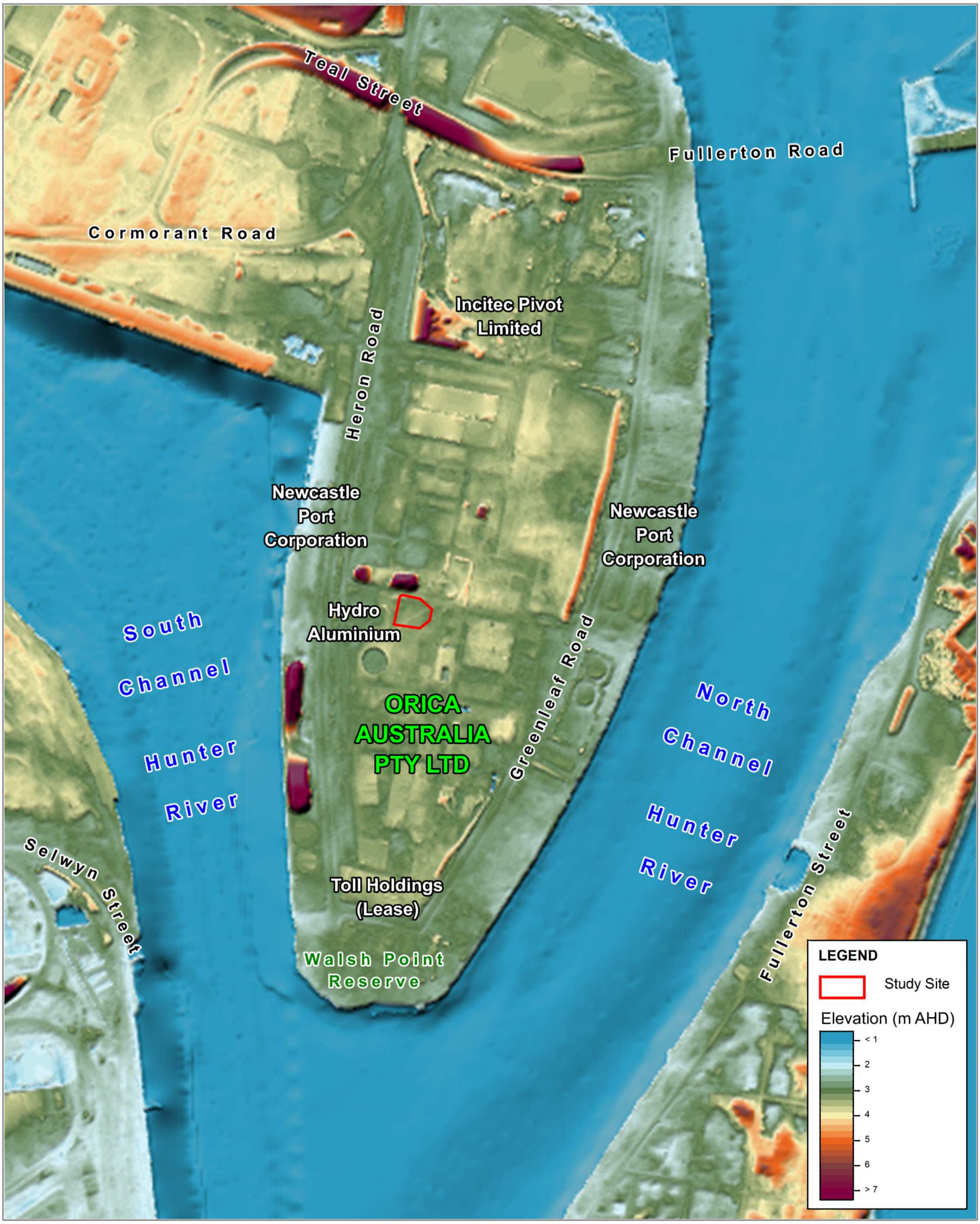
2.1 Flooding Mechanisms

The Hunter River catchment covers an area of the order of 22,000 km^2, which flows into the Tasman Sea through the Port of Newcastle. The lower reaches of the Hunter system are tidal and form the Hunter River estuary. Immediately upstream of Hexham Bridge, the Hunter River changes from a general south-westerly flow direction to a south-easterly flow direction. Downstream of Hexham Bridge the Hunter River main channel splits into two arms, namely the North Arm and the South Arm, separated by Kooragang Island.

The Hunter River has experienced many floods during its recorded history. The largest flood on record was in 1955. After this event, which claimed 14 lives, the Hunter Valley Flood Mitigation Scheme was established, which has subsequently instigated some 160 km of levees, 3.8 km of spillways, 40 km of control banks, 245 floodgates and 120 km of drainage canals. Within the lower estuary, the 1955 flood caused extensive overbank inundation, with flood depths of up to three metres across the Kooragang Island wetlands. This flood has been estimated at approximately a 1-in-100 year event (PWD, 1994).

The proposed development site is located on Kooragang Island downstream of Stockton Bridge (approximately 5 km upstream of the river mouth). The topography of the Hunter River floodplain in the region of the proposed works is shown on Figure 2-1. Major catchment flooding of the Hunter River system is the dominant flooding mechanism for this part of the estuary. Flood levels in the vicinity of the site are controlled by ocean water levels influenced by storm surge and the tide, which have an effect on flood levels within the lower estuary up to Green Rocks (approx. 8 km upstream of the Williams River / Hunter River confluence).

Due to the proximity of the site to the entrance and additional mainstream flood controls and storages upstream of the subject site, this part of Kooragang Island does not receive any significant inundation during major flood events. Further details of design flood conditions and flooding constraints for the site are provided in the following sections.



Title:

Local Floodplain Topography

Figure: **2-1**

Rev: **A**

N

0 200 400m

Approx. Scale

BMT WBM

www.bmtwbm.com.au

Filepath : K:\N20733_OricaKooragangIsland_FIA\MI\Workspaces\Figure_2-1_LocalFloodplainTopography.WOR

2.2 Design Flood Conditions

The existing Hunter River flood mapping adopted by Newcastle City Council (NCC) provides design flood conditions for the proposed development site. Flood mapping is available for a range of design event magnitudes, to establish existing flooding conditions across the site and to provide baseline conditions for assessing the impact of the proposed works on flooding.

Existing flood mapping information indicates that the subject site is located outside of the active floodplain and is flood free for the 1% AEP (100-year ARI) design flood event (see Figure 2-2), which is typically used as the flood planning event for development control. The site is however situated within an area mapped as flood fringe for the Probable Maximum Flood (PMF) event (see Figure 2-3), which is the trigger for this assessment of potential flood impacts associated with the proposed development.

Based on existing Hunter River TUFLOW flood modelling adopted by Port Stephens Council (PSC) (the most up-to-date source of flood mapping for the site), the extent of flooding for the PMF is less than that previously mapped and adopted by NCC. The PMF extents from the modelling adopted by PSC are presented on Figure 2-4. Contrary to the flood modelling adopted by NCC, these PMF extents show the site as being flood free for the PMF event. Parts of the Orica Kooragang Island site would be inundated according to this mapping, however, the footprint of the proposed cap and containment system is situated outside of those inundated extents. Possible reasons for these apparent differences between the two flood mapping data sources include:

- Simplified mapping of flood fringe for all of Kooragang Island adopted by NCC;
- Adoption of different design tailwater water levels between the two flood studies; and
- The 2-D model representation for the PSC study compared to the simplified 1D representation of the DHI model.

To further illustrate the flood immunity of the subject site, Table 2-1 presents simulated peak flood levels for a range of design event magnitudes, including projected sea level rise conditions for 2050 and 2100. There is a general flood water level gradient from along the South Arm and North Arm of the Hunter River, and as such peak water levels are presented for the nearest representative location on the North Arm Channel, which conveys the majority of flood flows around the site.

Table 2-1 Design Flood Levels (m AHD) from the PSC TUFLOW Model near Orica Kooragang Island Remediation Site

Design Flood Magnitude	Hunter River North Arm (approximately 1 km downstream of Stockton Bridge)
10% AEP	1.2
5% AEP	1.2
2% AEP	1.2
1% AEP	1.3
0.5% AEP	1.3
1% AEP 2050	1.7
1% AEP 2100	2.1
PMF	3.3

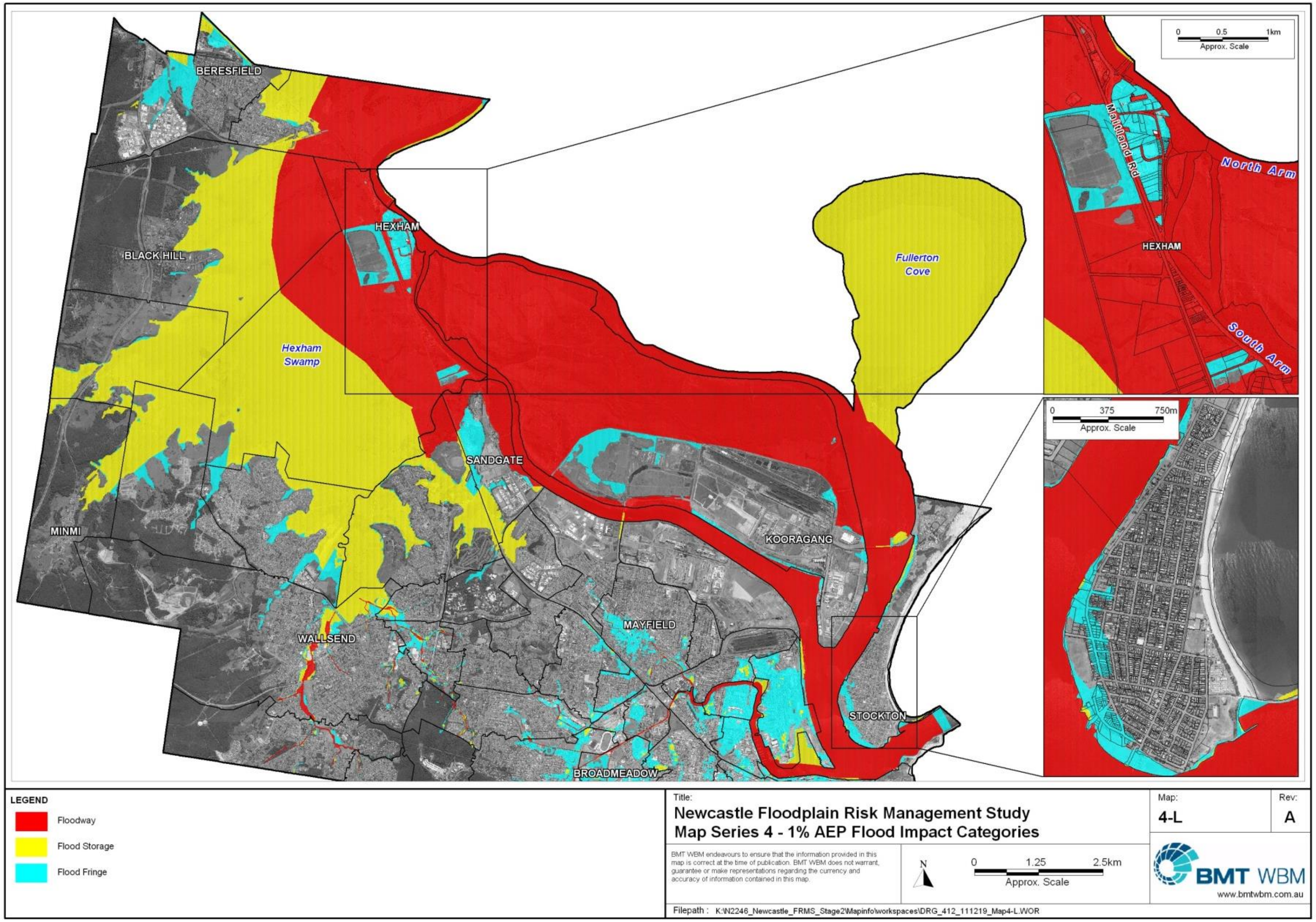


Figure 2-2 1% AEP Flood Impact Categories (NCC, 2012)

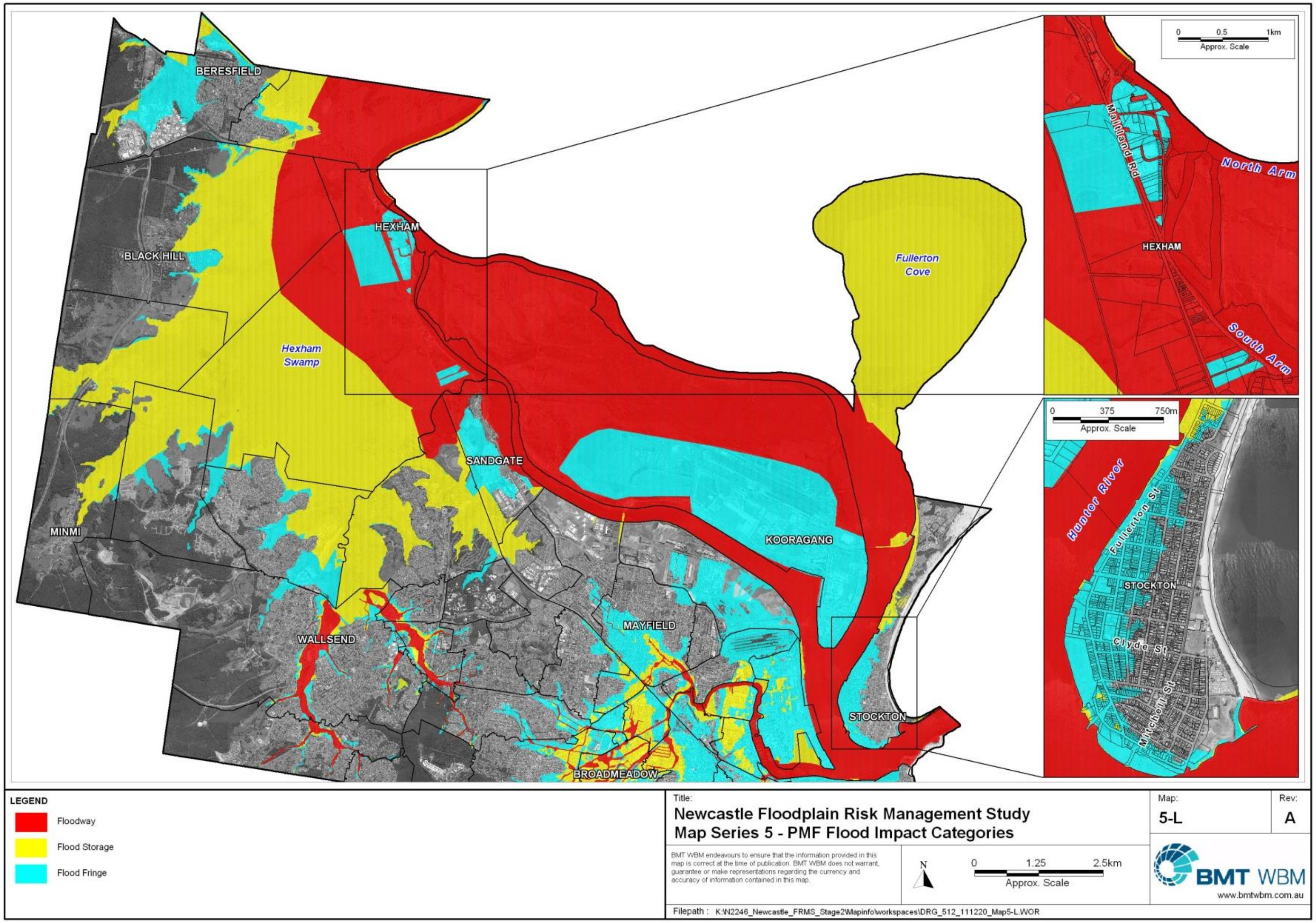
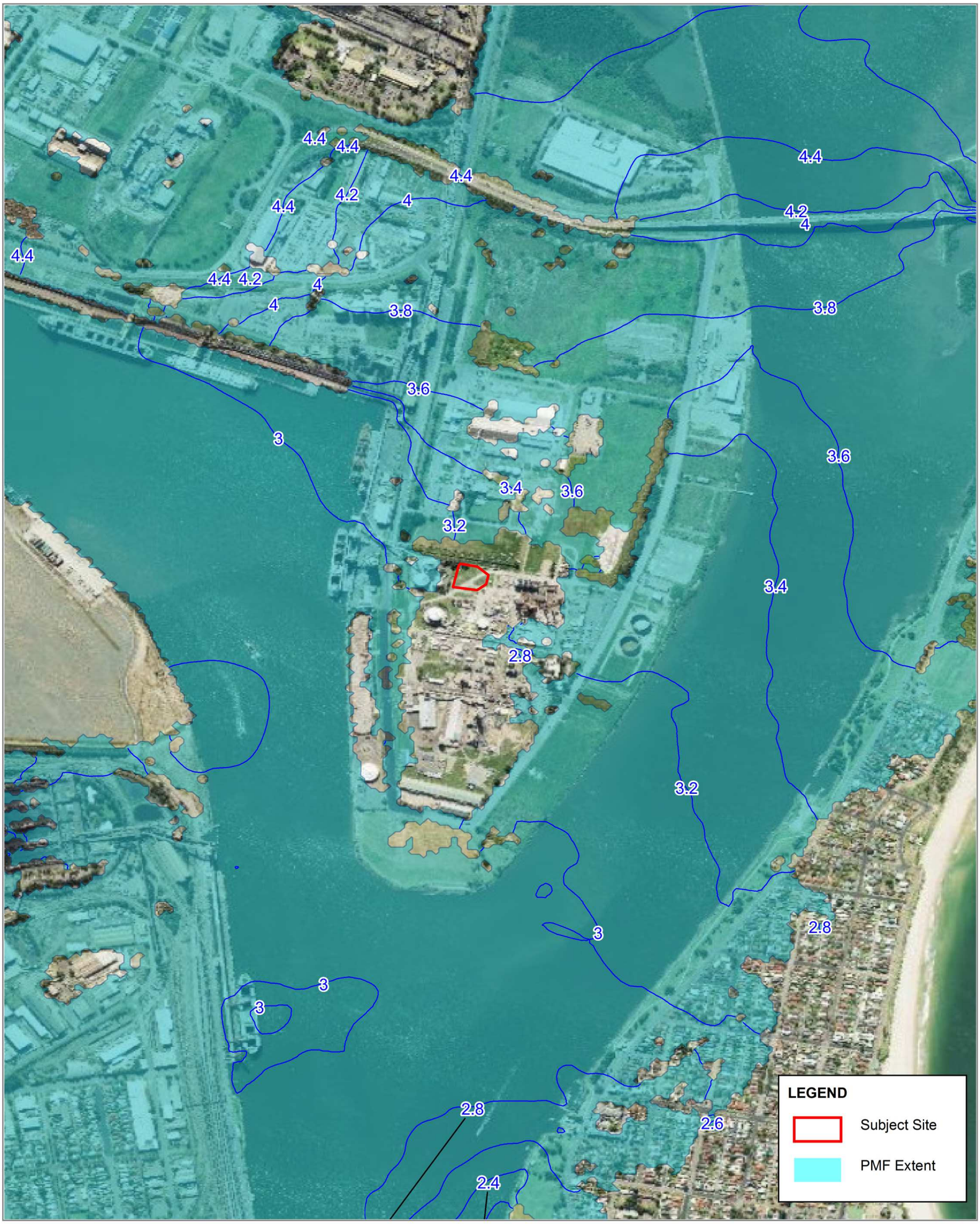


Figure 2-3 PMF Flood Impact Categories (NCC, 2012)



Title:

PMF Flood Extents at the Subject Site (PSC, 2016)

Figure: 2-4

Rev: A

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 250 500m

Approx. Scale

BMT WBM
www.bmtwbm.com.au

Filepath : K:\N20733_OricaKooragangIsland_FIA\MI\Workspaces\Figure_2-4_PMF_FloodExtents.WOR

3 Assessment of Flooding Constraints

Flooding constraints at the subject site would be negligible with respect to risk to property and potential flood impacts, which are typically assessed for major flood event magnitudes such as the 1% AEP (at which the site is flood free). The modelled flood levels provided in Table 2-1 demonstrate that the site remains flood free for all major flood event magnitudes beyond the 1% AEP, including the PMF and under potential future climate change conditions.

Although the PMF extents in Figure 2-4 show the study site as being free from inundation, parts of the broader Kooragang Island are flood affected. The main consideration in relation to flooding with respect to potential development of the site is the management of potential risk to life.

Being a large catchment of some 22,000 km^2, the Hunter River at Newcastle will typically have a significant warning time of any floods that are moving down the catchment. Depending on the specific rainfall distributions in a given event, it is likely that significant flooding near the site will typically not occur until a couple of days after a major rainfall event. Flood warnings issued by the Bureau of Meteorology (BoM) and the State Emergency Service (SES) are given 24 hours in advance for Singleton and Maitland, with several Hunter Valley townships flooded prior to any flooding near the subject site. On this basis, there would be advanced warning of when the flood wave is likely to reach the site.

Given that the proposed development is a non-habitable space over a relatively small footprint at the Orica Kooragang Island Remediation site, it is considered that the proposed development does not constitute any requirement to further manage the risk to life associated with an extreme flood event. The flooding constraints for the proposed development are consistent with the level of current risk posed to the broader Orica Kooragang Island site and is not expected to present any local or regional flood impacts of significance.

In summary, the proposed development would not be affected by flooding for all design flood events up to and including the PMF and as such does not pose any detrimental increase in the potential flood affectation of adjacent properties, assets or infrastructure. The proposed development is compatible with the hydraulic categorisation of the floodplain environment, flood hazard of the land and Councils floodplain risk management plan.

The development does not require any additional emergency management, evacuation and access or contingency measures above that currently required for the broader Orica Kooragang Island site, and would not pose an impact on existing community emergency management arrangements for flooding at other local or regional localities.

The development would not increase erosion or siltation, destruction of riparian vegetation or reduce the stability of river banks or watercourses, and does not pose any impact on social or economic costs to the community as a consequence of flooding.

Overall, it is considered that no adverse flood impacts are likely to occur as a consequence of the proposed development.

4 References

NCC, 2012. Newcastle City-wide Floodplain Risk Management Study and Plan, Draft Report prepared for Newcastle City Council, January 2012.

Orica, 2016. Orica Kooragang Island Remediation Project, July 2016.

PWD, 1994. *Lower Hunter River Flood Study – Green Rocks to Newcastle.*

PSC, 2016, Williamtown Salt Ash Floodplain Risk Management Study and Plan, September 2016

BMT WBM Bangalow	6/20 Byron Street, Bangalow 2479 Tel +61 2 6687 0466 Fax +61 2 66870422 Email bmtwbm@bmtwbm.com.au Web www.bmtwbm.com.au
BMT WBM Brisbane	Level 8, 200 Creek Street, Brisbane 4000 PO Box 203, Spring Hill QLD 4004 Tel +61 7 3831 6744 Fax +61 7 3832 3627 Email bmtwbm@bmtwbm.com.au Web www.bmtwbm.com.au
BMT WBM Denver	8200 S. Akron Street, #B120 Centennial, Denver Colorado 80112 USA Tel +1 303 792 9814 Fax +1 303 792 9742 Email denver@bmtwbm.com Web www.bmtwbm.com
BMT WBM London	International House, 1st Floor St Katharine's Way, London E1W 1AY Email london@bmtwbm.co.uk Web www.bmtwbm.com
BMT WBM Mackay	PO Box 4447, Mackay QLD 4740 Tel +61 7 4953 5144 Fax +61 7 4953 5132 Email mackay@bmtwbm.com.au Web www.bmtwbm.com.au
BMT WBM Melbourne	Level 5, 99 King Street, Melbourne 3000 PO Box 604, Collins Street West VIC 8007 Tel +61 3 8620 6100 Fax +61 3 8620 6105 Email melbourne@bmtwbm.com.au Web www.bmtwbm.com.au
BMT WBM Newcastle	126 Belford Street, Broadmeadow 2292 PO Box 266, Broadmeadow NSW 2292 Tel +61 2 4940 8882 Fax +61 2 4940 8887 Email newcastle@bmtwbm.com.au Web www.bmtwbm.com.au
BMT WBM Perth	Level 3, 20 Parkland Road, Osborne, WA 6017 PO Box 1027, Innaloo WA 6918 Tel +61 8 9328 2029 Fax +61 8 9486 7588 Email perth@bmtwbm.com.au Web www.bmtwbm.com.au
BMT WBM Sydney	Suite G2, 13-15 Smail Street, Ultimo, Sydney 2007 Tel +61 2 8960 7755 Fax +61 2 8960 7745 Email sydney@bmtwbm.com.au Web www.bmtwbm.com.au
BMT WBM Vancouver	Suite 401, 611 Alexander Street Vancouver British Columbia V6A 1E1 Canada Tel +1 604 683 5777 Fax +1 604 608 3232 Email vancouver@bmtwbm.com Web www.bmtwbm.com

APPENDIX G

Human Health Risk Assessment (Construction Phase)

15 February 2017

HUMAN HEALTH RISK ASSESSMENT - CONSTRUCTION PHASE

Orica Kooragang Island Arsenic Remediation Program

Submitted to:
Sherree Woodroffe
Orica Australia Pty Ltd
15 Greenleaf Road
Kooragang Island, NSW 2304

Report Number. 1418917_066_R_Rev0

REPORT

Golder Associates

Table of Contents

1.0 INTRODUCTION

Orica Australia Pty Ltd is preparing an Environmental Impact Statement (EIS) to support a State Significant Development application under Part 4 (Division 4.1) of the *Environmental Planning and Assessment Act 1979.* Division 4.1 of this Act identifies the Minister for Planning as the consent authority for development that is identified as State Significant Development.

The State Significant Development application is seeking to obtain development consent to install a cap and containment remediation system at Orica's Kooragang Island Facility to address on-site arsenic contamination located in a small area in the north-western portion of the Orica Facility (Kooragang Island Remediation Program).

The remediation system is designed to prevent, to the extent practicable, further off-site migration of arsenic and in so doing, address the objective of Management Order 20131407 issued under the *Contaminated Land Management Act 1997*.

To support the EIS and the application, Golder Associates Pty Ltd (Golder) have been contracted to provide a human health risk assessment of the potential risks to humans by on site and off site sources associated with the disturbance of the contaminated material during the construction phase and details of the management measures.

The cap and containment system involves the installation of a low permeability cut-off wall to a depth of approximately 12 metres below ground level and integration of a low permeability capping system.

2.0 BACKGROUND

2.1 Project Description

The Kooragang Island Remediation Program (the Project) is located within an area of approximately 4,200 m^2 (the Site). The Site consists of the identified extent of on-site arsenic contamination (refer to Section 3.3 and the Remediation Action Plan (RAP) in Appendix C), an area that incorporates the remediation works and a temporary amenity area during construction.

The Site is located within a north-western portion of the Orica Kooragang Island facility and is located on a part of Lot 2 and Lot 3 DP 234288. It is currently a vacant area that contains grass and an internal access road.

The Kooragang Island Remediation Program will install a cap and containment remediation system. This will involve the construction of a soil-bentonite cut-off wall (approximately 75 m by 50 m) with a cap constructed to minimise rainfall infiltration and to mitigate the flow through the impacted soil and aquifer material.

The proposed remediation works will be undertaken independently of existing operations with the only interaction consisting of utilising an access road for traffic generated by the Project predominantly during the construction period.

A site layout is provided in Figure 1.1 of the EIS.

The cut-off wall alignment and depth are designed to address the extent of remediation as discussed in Chapter 3 of the EIS. The cut-off wall will be installed to meet the following specifications:

- Nominal depth of 12 m below ground level;
- Nominal thickness of 0.8 m; and
- Permeability of at least (i.e. lower than) 1×10^{-9} m/s.

Due to construction constraints, the cut-off wall will be located approximately 1.6 m from the boundary fence to the west and north of the Site. A hydraulic excavator with a cable-suspended clamshell grab will be used to construct the cut-off wall along the western and northern boundaries. The crane and clam-shell grab enables the cut-off wall to be installed in close proximity to the neighbouring boundary without requiring access to the neighbouring sites. A specialist long-armed excavator will be used to construct the remainder of the cut-off wall.

A graphic demonstrating the cut-off wall construction process is detailed in below (taken from the EIS).

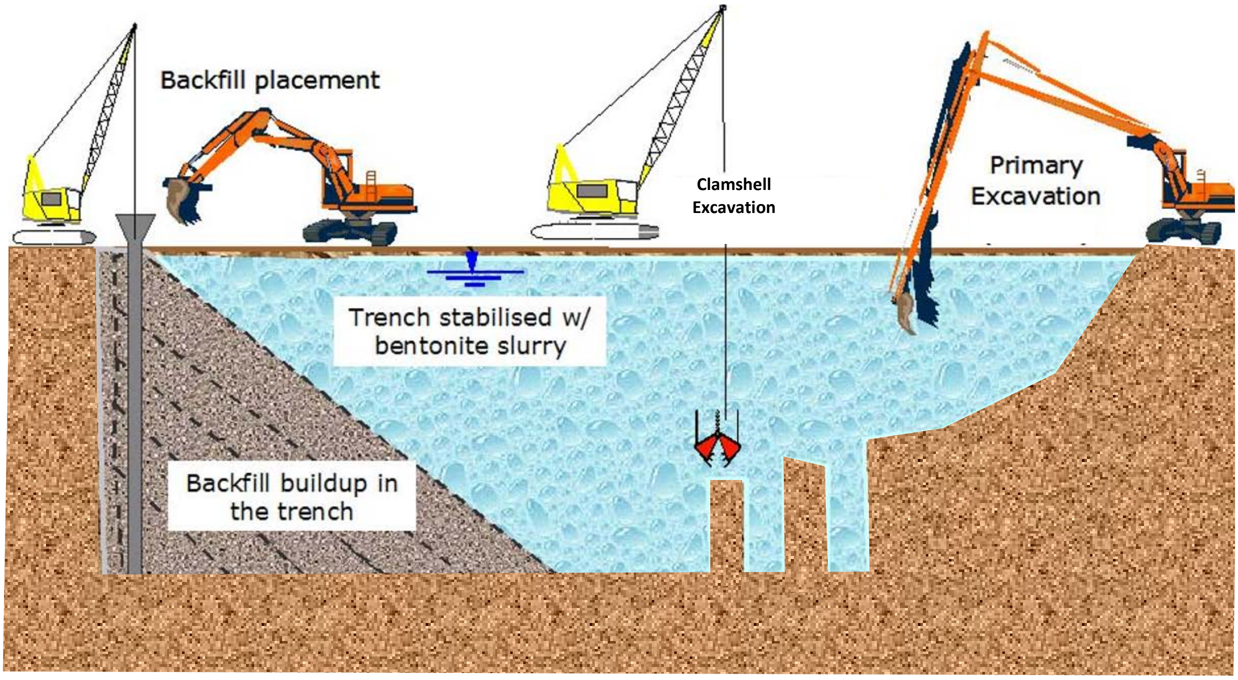


Plate 1: Graphic Illustrating Construction Process

Following construction of the cut-off wall, a capping system will be installed. The primary purpose of the capping system is to limit surface water infiltration within the footprint of the wall alignment. The overall concept involves a layered capping system with a composite liner, comprising a linear low-density polyethylene (LLDPE) geomembrane underlain by a geosynthetic clay liner (GCL) integrated into a landform.

The installation of a cap and containment system will provide isolation of the arsenic (contained in soil and groundwater) located on the Site and prevent, to the extent practicable, the further off-site migration of arsenic in groundwater. The containment system's low permeability subsurface cut-off wall will minimise the flow of groundwater through the impacted soil in the on-site source area and the surface cap will significantly reduce infiltration of rainwater into the containment cell.

3.0 ISSUES IDENTIFICATION

3.1 Contamination

Extensive investigations have been undertaken of the former arsenic sludge disposal pit which have resulted in a detailed understanding of the nature and extent of arsenic in the soil and groundwater in the vicinity of the Site. Groundwater monitoring of arsenic has been routinely undertaken to provide an understanding of temporal and spatial trends in arsenic (dissolved) concentration in groundwater at and down-gradient of the former sludge disposal pit.

Associated with the ongoing management of the residual arsenic contamination an Environmental Management Plan has been in place since 2008.

4.0 ARSENIC CONCENTRATIONS

The arsenic concentrations relevant to the project are summarised from the following documents:

- Golder Associates (2016). Orica Kooragang Island: Arsenic Management Order Remediation Action Plan. Report Number 1418917_044_R_Rev2.
- Pacific Environment (2016). Report: Kooragang Island Remediation Program - Air Quality Assessment Document control number: 21823B, date 10 February 2017.

4.1 Soil

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.

The soil beneath the remediated extent of the former pit has residual arsenic soil concentrations averaging 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.

4.2 Groundwater

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.

The highest dissolved arsenic concentrations occur between 3 and 7 m below ground level (bgl) (nominally Layer 2). At depths greater than 8-9 m bgl, dissolved arsenic concentrations are low (<1 mg/L).

4.3 Ambient Air

Pacific Environment (2016) conducted an assessment of potential arsenic emissions from the proposed Orica Kooragang Island Remediation Program. The assessment conservatively assumed that a stockpile of soil sits at the site boundary, the stockpiled soil has an average arsenic concentration of 200 mg/kg and soil becomes airborne during excavation activities during the construction of the cut-off wall. Using a conservative initial emission rate and site specific meteorological dataset an atmospheric dispersion model approved by NSW EPA was utilised to predict ambient arsenic concentrations (i.e. arsenic concentrations in airborne dust).

The model indicated that 99.9th percentile 1 hour average arsenic concentrations would comply with the Approved Methods impact assessment criterion of 0.09 µg/m^3 in the immediate vicinity, and at all areas downwind of the operation. Peak concentrations within the immediate working area are anticipated to constitute approximately 30% of the arsenic criterion.

Figure 7 of Pacific Environment (2016) (presented below in Plate 2) presents a contour plot of the modelling predictions for the cut-off wall spoil emplacement operation. As evident in the figure (shown below), concentrations are confined to a small area immediately surrounding the operation and are all below the assessment criterion.

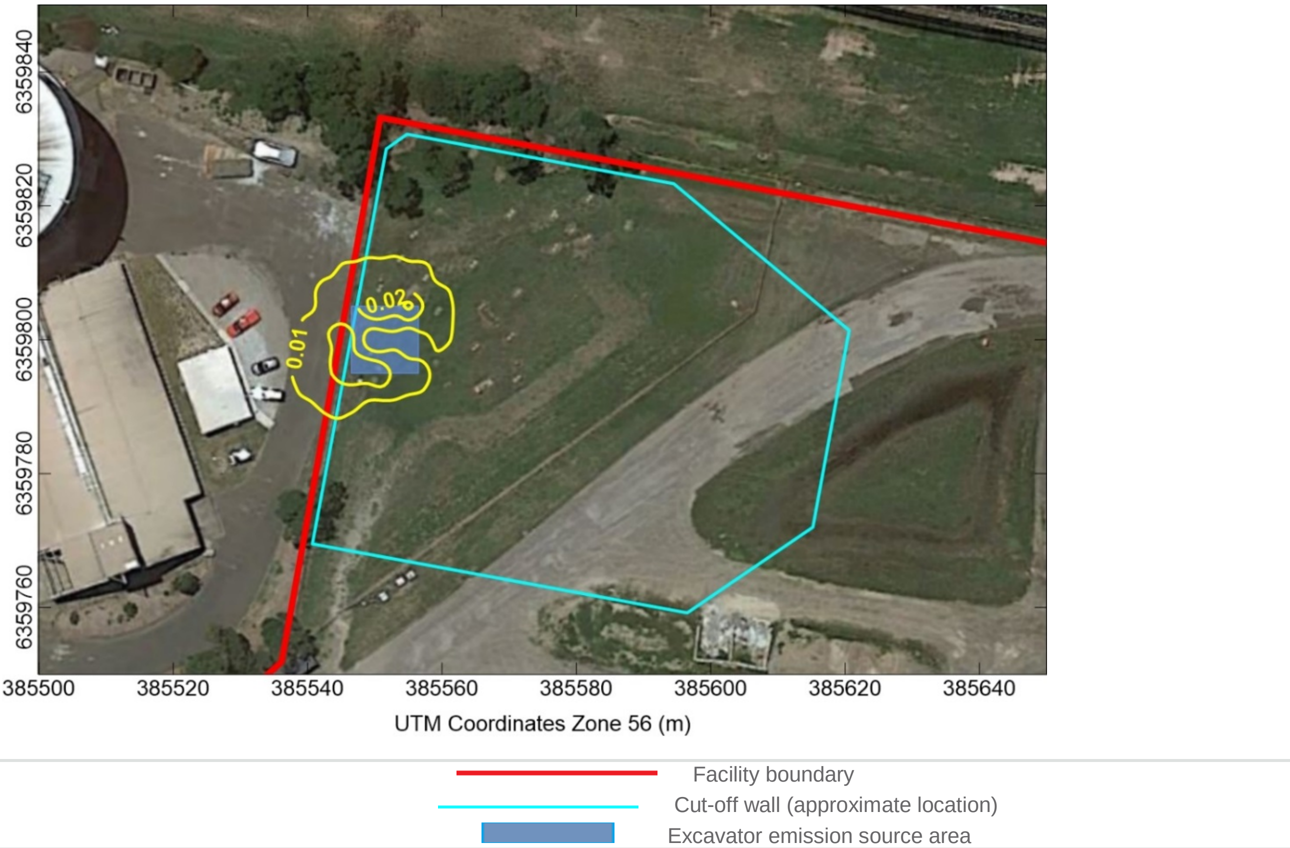


Plate 2: 99.9th percentile 1 hour average arsenic predictions (µg/m3)

Pacific Environment (2016) note that compliance with dust (Total Suspended Particulates and particulate matter less than 10 or 2.5µm) criterion would likely be sufficiently protective in terms of the arsenic criterion.

5.0 HEALTH BASED SCREENING CRITERIA

5.1 Introduction

Health based screening levels are intended as a conservative first stage of an assessment of potential risks to human health from chronic exposure to contaminants. Health based guidelines for soil are referred to in Australia as Health Investigation Levels (HIL). Groundwater screening guidelines are not as readily available for chemical contaminants. Ambient air guideline levels are available for ambient air. In the absence of regulatory health based guidelines screening values can be derived. These screening guidelines are part of an initial process of assessing site contamination and site remediation.

Levels in excess of these screening levels do not imply unacceptability or that a significant health risk is likely to be present. If non-standard circumstances are relevant to a specific site levels below the screening levels do not necessarily imply acceptability or that a health risk is not likely to be present.

For this reason a comparison to health based screening values has been undertaken and additional circumstances considered in Section 6.

5.2 Soil

Appendix A contains all results from arsenic soil sampling at the site. In all 588 samples are reported in Appendix A. Of these 61 samples (i.e. 10% of samples) were reported above the residential arsenic soil level (100 mg/kg arsenic in soil). The arsenic concentrations in soil range between nondetect (<5 mg/kg) and 3,570 mg/kg. Most elevated results occur at a depth of 3 to 5 metres below ground level.

The soil beneath the remediated extent of the former pit has residual arsenic soil concentrations averaging 170, 540 and 130 mg/kg in Layers 1, 2 and 3, respectively. The 95th upper confidence limit (UCL) for all samples is approximately 30 mg/kg. The 95th UCL for each transect of the site assessed range between 5.7 mg/kg (North East corner boundary) and 514.2 mg/kg (western boundary).

The screening level for arsenic in soil is 3,000 mg/kg (derived from the Health Investigation Level (HIL-D) for industrial land within the amended National Environment Protection (Assessment of Site Contamination) Measure (NEPC 2013)). Approximately 90% of the soil samples are less than the HIL for residential sites.

The screening assessment indicates that the stockpiled soil is within the health based screening limits and as such further risk assessment for industrial workers or bystanders (members of the general public that may trespass or accidently be exposed to the stockpiled soil) is not warranted.

5.3 Groundwater

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.

The highest dissolved arsenic concentrations occur between 3 and 7 m below ground level (bgl) (nominally Layer 2). At depths greater than 8-9 m bgl, dissolved arsenic concentrations are low (<1 mg/L).

Golder (2013) derived site-specific target levels (SSTL) for arsenic in groundwater. The SSTLs were intended for commercial workers on- and immediately off-site. It does not include assessment of other potential contaminants in soil or groundwater. This assessment is a review of potential chronic long term effects based on intermittent repeated exposure and as such it does not consider acute health risks to workers.

In particular the SSTLs, were derived based on two identified exposure scenarios:

- A commercial worker using the groundwater, following extraction, for hosing, cleaning and irrigation. Incidental ingestion and dermal contact are the two pathways identified as relevant. Golder is not aware of groundwater currently being extracted for beneficial use.

- A trench worker intersecting the groundwater during occasional trenching activities. Incidental ingestion and dermal contact are the two pathways identified as relevant.

Reasonable maximum exposures have been evaluated and the evaluation of arsenic considered both threshold and non-threshold toxicity with an acceptable target hazard index of 1 for threshold effects and target acceptable cancer risk of 1 x 10^{-5} for non-threshold effects.

The calculated SSTLs are:

- 5 mg/L for a commercial worker, assuming the handling of extracted groundwater for hosing, cleaning or irrigation occurs once a week; and
- 34 mg/L for a trench worker that is exposed to groundwater during excavation for ten days in each year.

Concentrations in groundwater encountered at the site are mostly below these levels. It is important to emphasise that these SSTLs assume direct contact with arsenic as a consequence of use of extracted groundwater. This results in ingestion and dermal exposure during work activities. These work activities are restricted by the requirements of the CEMP. Direct contact with groundwater in a trench is also restricted by the CEMP. Both of these activities are further discussed in Section 6.0 below.

5.4 Ambient Air

Pacific Environment (2016) conducted an assessment of potential arsenic emissions from the proposed Orica Kooragang Island Remediation Program.

The estimated one hour 99th percentile arsenic concentration in ambient air within the site boundary was 0.02 µg/$m^3$and the estimated one hour 99th percentile arsenic concentration in ambient air just beyond the site boundary (adjacent car park to the west of the site boundary) was 0.01 µg/m^3.

The estimated ambient air concentrations are less than arsenic ambient air guidelines intended for the protection of the general population over a short duration of exposure. Two guidelines were used to conduct this comparison:

OEHHA (2016) acute reference exposure level for arsenic of 0.20 µg/m^3 is based on protection of the general public from all adverse health effects. In particular for arsenic the adverse effects on which the guideline was derived included developmental toxicity, cardiovascular and nervous system effects. The estimated boundary concentration is ten times less than the guideline indicating that there is no need for a more detailed risk assessment.

The Texas Centre for Environmental Quality (Texas TCEQ 2012) have also derived a short term guideline for human health protection of the general public. The arsenic guideline is 3 µg/m^3 and is considered by the TCEQ (2012) as protective against all acute duration adverse health effects. The critical effect on which the guideline is based is developmental toxicity. The estimated boundary concentration is 300 hundred times less than the guideline indicating that there is no need for a more detailed risk assessment.

The Australian Site Contamination NEPM (Schedule B7 Appendix A) recommended a chronic inhalation toxicity reference value of 1 µg/m^3 for arsenic. This is based on protection of the general public from all adverse health effects. The critical effect assessed to develop the guideline was lung cancer. The guideline was adopted from the Dutch Institute for Environmental Health (RIVM 2001). The estimated boundary concentration is one hundred times less than the guideline indicating that there is no need for a more detailed risk assessment.

6.0 MANAGEMENT MEASURES

6.1 Groundwater

The exposure to arsenic in soil and groundwater across the Orica KI site is managed through an EMP (URS, 2008). The EMP includes appropriate controls when undertaking intrusive works, such as the use of personal protective equipment when encountering groundwater.

Management controls to minimise direct contact with groundwater during construction phase works are recommended for incorporation into the Construction Environmental Management Plan.

6.2 Ambient Dust / Soil

Pacific Environment (2016) and the Orica CEMP (2016) provide recommended management measures. The relevant table (Table 10) from the Pacific Environment report is reproduced below in Table 1 for completeness.

Table 1 – Summary of recommended air quality management measures

Activity	Management Measure
Administrative	• Project staff to be informed of requirements of the CEMP to minimise air emissions (specifically during handling of arsenic contaminated soils). • Neighbours to be informed of planned works on immediate boundaries and contacts for reporting issues or concerns.
Vehicle operations	• Maintenance and cleaning of internal sealed road surfaces. • Application of vehicle speed limits. • Ensuring that vehicles are: ▪ Restricted to designated vehicle paths with the objective of minimising areas of erodible surface material. ▪ Properly maintained and operating efficiently. ▪ Not left with engines idling for extended periods. • Maintaining visual awareness of vehicle movements with the objective of identifying and addressing the presence of visible dust emissions. • Use of wheel washing for vehicles exiting unsealed areas of the Site (where required). • Inspection and additional cleaning of undercarriage where required. • Ensuring that all trucks transporting soil are covered when exiting the Site. • Ensuring that vehicle tailgates are properly sealed, such that loose material is not deposited onto road surfaces.
Cap excavation	• Installation of plastic sheathing directly adjacent to the excavation face. • Wetting down of soil surfaces prior to commencement of initial excavation. • Use of screening/shade cloth on boundary fences adjacent to the cut-off wall during construction phase. • Operation of excavators in a manner that minimises the potential for slurry splash and mobilisation of spoil material. • Allowing of bucket to drain prior to transfer, as required to manage splash and/or runoff/soiling. • Cessation of activities during high wind~~s~~ gusts. • Minimisation of spoil drop heights. • Application of sprays where required to manage spoil moisture content and / or mixing pond contents. • Maintenance of a clean site including rinsing of soiled surfaces where there may be an opportunity for material to dry and form dust.
Cap Construction	• Wetting down of top soils prior to excavation. • Application of sprays to exposed surface areas where wind erosion is of interest. • Minimisation of drop heights and maintenance of moisture content during emplacement of cut-off wall residual fill material

Unloading to stockpiles (General)	• Maintenance of material moisture content. • Maintenance of material handling equipment to operate in a proper and efficient manner. • Cessation of activities during high winds gusts. • Minimisation of drop heights.
Stockpiling	• Minimisation of stockpile areas. • Covering of stockpiles containing excavated spoil if left overnight or during high winds. • Periodic watering of stockpile areas to promote crusting of stockpile surfaces and ensure moisture content. • Application of sprays to stockpiles where high winds are expected and/or present.
Wind erosion from the general Site	• Washing down • Maintenance of clean road surfaces (where sealed). • Restriction of vehicles to designated vehicle paths.

7.0 HEALTH RISK ASSESSMENT CONCLUSIONS

To support the application, Golder conducted a human health risk assessment of the potential risks to humans by on site and off site activity associated with the disturbance of the contaminated material during the construction of the cap and containment system and details of the management measures.

The cap and containment system involves the installation of a low permeability cut-off wall to a depth of approximately 12 metres below ground level and integration of a low permeability capping system. The site of the remediation works is within the boundaries of the Orica Kooragang Island Facility.

The disturbance of the contaminated material has the potential to result in exposure of workers to arsenic due to contact with contaminated soil, groundwater or arsenic in ambient air.

The arsenic concentrations in soil and groundwater were compared to health based guidelines for the protection of workers. The estimated arsenic concentrations in ambient air were compared to health based guidelines for the protection of the general public given that dust may become airborne beyond the site boundary into an adjacent car park and work area.

Given that the arsenic concentrations in soil, groundwater and ambient air are below relevant health based screening criteria and coupled with the management control measures proposed for the containment of contaminated materials within the site it is concluded that the health risk to workers and the general public is low and acceptable.

8.0 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.

9.0 REFERENCES

Golder Associates (2016). Orica Kooragang Island: Arsenic Management Order Remediation Action Plan. Report Number 1418917_044_R_Rev2.

NEPC (2013). National Environment Protection (Assessment of Site Contamination) Measure as amended. National Environment Protection Council. Adelaide, SA. 2013.

OEHHA (2008). Technical Supporting Document for Noncancer RELs, Appendix D1. Office of Environmental Health Hazard Assessment (OEHHA).

Pacific Environment (2016). Report: Kooragang Island Remediation Program - Air Quality Assessment Document control number: 21823.

RIVM (2001) Baars AJ, Theelen RMC, Janssen PJCM, Hesse JM, van Apeldoorn ME, Meijerink MCM, Verdam L, Zeilmaker MJ. Re-evaluation of human-toxicological maximum permissible risk levels. Report 711701025. National Institute of Public Health and the Environment. Bilthoven, The Netherlands.

URS Australia Pty Ltd (2008). Environmental Management Plan (Revision 1). 20 March 2008

Texas TCEQ (2012). Arsenic and Inorganic Arsenic Compounds. Development Support Document. Texas Commission On Environmental Quality.

Report Signature Page

GOLDER ASSOCIATES PTY LTD

John Frangos
Principal Toxicologist

JF/GB/

A.B.N. 64 006 107 857

\\golder.gds\gap\sydney\jobs\env\2014\1418917_orica_ki_asworkplanimplementation\project doc\ki eis preparation\risk assessment - construction phase\1418917_066_r_rev0.docx

APPENDIX A

Soil Data Spreadsheet

Table: Statistics for Soil Analytical Results for Arsenic
Orica Kooragang Island
1418917

	Southern Boundary								Eastern Boundary			North-eastern Corner Boundary				Northern Boundary			Western Boundary		Former Pit
	Transect			Transect			Transect		Transect			Transect									
Location ID	SB100	SB101	BP15	SB102	SB103	BP16	SB110	SB111	SB104	SB105	BP17	SB106	SB107	SB108	BP18	SB112	SB113	BP20	BP19	BP21	SB109
Depth	Arsenic	Arsenic	Arsenic	Arsenic	Arsenic	Arsenic	Arsenic	Arsenic	Arsenic	Arsenic	Arsenic	Arsenic	Arsenic	Arsenic	Arsenic	Arsenic	Arsenic	Arsenic	Arsenic	Arsenic	Arsenic
(m bgl)	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
0.3-0.5	23	104	17	7	11	51	16	12	23	237	32	18	12	11	23	56	52	9	6	5	21
0.8-1.0	27	77	12	5	19	198	5	7	22	251	59	5	6	5	5	74	70	5	5	20	12
1.3-1.5	86	10	5	21	5	45	5	5	6	52	43	7	5	7	5	28	79	5	12	56	13
1.8-2.0	156	14	5	166	5	5	5	5	13	8	94	5	5	5	5	105	108	5	37	74	110
2.3-2.5	82	5	5	562	5	18	5	5	6	5	16	15	5	6	5	72	53	13	719	49	80
2.8-3.0	17	8	5	427	8	5	27	5	8	8	6	9	5	5	5	143	22	8	321	329	68
3.3-3.5	14	6	5	294	55	5	127	5	10	6	5	29	8	5	5	55	141	36	146	103	121
3.8-4.0	30	6	5	414	8	5	308	6	9	12	6	23	8	6	6	416	381	102	3570	594	225
4.3-4.5	19	7	6	1370	113	5	306	12	16	8	7	12	22	7	5	615	117	30	1660	2280	535
4.8-5.0	250	12	8	372	112	9	27	7	12	8	8	6	10	5	10	25	12	10	572	717	531
5.3-5.5	40	30	5	343	29	5	383	8	8	5	6	5	8	6	7	214	144	19	241	440	273
5.8-6.0	27	8	9	123	102	5	799	8	6	7	9	8	7	5	6	265	405	8	182	530	1780
6.3-6.5	8	8	7	14	17	5	25	9	7	7	7	6	8	5	6	141	21	8	142	28	31
6.8-7.0	8	7	7	10	6	6	33	5	6	5	6	5	5	5	8	10	10	7	65	857	6
7.3-7.5	7	7	13	6	6	7	52	40	5	5	6	6	6	6	6	8	11	11	50	11	7
7.8-8.0	5	7	5	5	6	6	15	5	5	6	6	6	6	5	6	6	7	6	18	72	6
8.3-8.5	5	5	5	6	6	5	5	5	5	5	5	5	5	5	5	16	5	5	8	5	23
8.8-9.0	8	6	5	6	5	5	6	5	5	5	7	5	5	5	6	7	5	6	7	5	8
9.3-9.5	5	5	5	5	5	6	5	8	5	5	9	5	5	5	5	5	5	6	6	6	5
9.8-10.0	5	5	5	5	5	5	5	5	6	5	5	5	5	5	5	5	5	6	5	5	6
10.3-10.5	5	5	6	5	5	5	5	5	5	5	6	6	5	5	5	6	6	5	5	5	6
10.8-11.0	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6	5	5	5	5
11.3-11.55	8	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6	5	5	5	5
11.8-12.0	6	6	5	5	5	5	5	5	5	5	5	5	5	5	6	5	5	5	6	5	5
12.3-12.5	5	5	5	6	5	5	5	5	7	6	6	5	5	7	5	5	7	5	5	5	5
12.8-13.0	5	6	5	5	5	5	5	5	6	6	7	5	6	6	5	7	6	6	6	5	10
13.3-13.5	6	6	6	5	6	5	7	6	5	6	5	7	5	5	5	6	5	6	6	5	8
13.8-14.0	5	5	9	8	6	5	5	5	5	5	5	6	5	6	5	5	5	6	5	5	9
14.3-14.5	5	5	9	5	5	5	5	5	5	6	5	5	5	5	5	5	5	5	5	5	5
14.8-15.0	15	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
15.3-15.5			5																		
18.0-18.2															5						
18.8-19.0			5																5		
19.3-19.5																			5		
22.3-22.5			5																		
35.0-35.2																			5		
Statistics for sample depths between 1 and 15 m bgl.																					
Minimum	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Maximum	250	30	13	1370	113	45	799	40	16	52	94	29	22	7	10	615	405	102	3570	2280	1780
Mean	29.9	7.5	6.1	150.1	19.6	7.2	78.2	7.1	6.8	7.7	10.9	7.7	6.4	5.4	5.6	78.2	56.7	12.3	279.1	221.8	139.0
St Dev	54.7	4.9	1.9	292.0	33.2	7.8	174.8	6.7	2.8	8.8	17.8	5.7	3.3	0.7	1.1	143.7	104.7	19.1	730.5	472.7	352.8
cv/S2	1.8	0.7	0.3	1.9	1.7	1.1	2.2	0.9	0.4	1.1	1.6	0.7	0.5	0.1	0.2	1.8	1.8	1.6	2.6	2.1	2.5
n	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28
n-1	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27
t	1.703	1.703	1.703	1.703	1.703	1.703	1.703	1.703	1.703	1.703	1.703	1.703	1.703	1.703	1.703	1.703	1.703	1.703	1.703	1.703	1.703
95% UCL NSW EPA (Procedure D)	**47.5**	**9.1**	**6.7**	**244.1**	**30.3**	**9.7**	**134.5**	**9.3**	**7.7**	**10.6**	**16.6**	**9.6**	**7.5**	**5.7**	**6.0**	**124.5**	**90.4**	**18.4**	**514.2**	**374.0**	**252.5**
Meets conditions (UCL<45 mg/kg and no sample >100 mg/kg)		Yes	Yes		No	Yes		yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes			Yes			
Soil in top 1 m needs consideration		Yes				yes				Yes											

For detections Less than the practical detection limit (<5 mg/kg), a concentrations of 5 mg/kg was used for statistics calculation

200	Sample exceeds 100 mg/kg
30.3	95 %UCL on the mean concentration is below 45 mg/kg

APPENDIX B

Important Information about 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.

This Report is provided for use solely by Golder's Client and persons acting on the Client's behalf, such as its professional advisers. Golder is responsible only to its Client for this Report. Golder has no responsibility to any other person who relies or makes decisions based upon this Report or who makes any other use of this Report. Golder accepts no responsibility for any loss or damage suffered by any person other than its Client as a result of any reliance upon any part of this Report, decisions made based upon this Report or any other use of it.

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.

As a global, employee-owned organisation with over 50 years of experience, Golder Associates is driven by our purpose to engineer earth's development while preserving earth's integrity. We deliver solutions that help our clients achieve their sustainable development goals by providing a wide range of independent consulting, design and construction services in our specialist areas of earth, environment and energy.

For more information, visit golder.com

Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australasia	+ 61 3 8862 3500
Europe	+ 44 1628 851851
North America	+ 1 800 275 3281
South America	+ 56 2 2616 2000

solutions@golder.com
www.golder.com

Golder Associates Pty Ltd
Building 7, Botanicca Corporate Park
570 – 588 Swan Street
Richmond, Victoria 3121
Australia
T: +61 3 8862 3500

APPENDIX H

Pacific Environment – Air Modelling Report

Report

Kooragang Island Remediation Program - Air Quality Assessment

Document control number: 21823B

Date: 10 February 2016

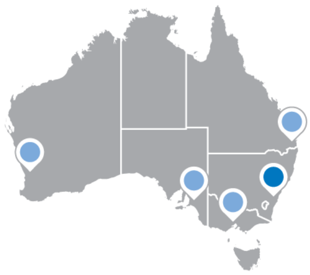
Pacific Environment Limited

Technologies Consulting Monitoring

Project name:	Kooragang Island Remediation Program - Air Quality Assessment
Document control number:	21823B
Prepared for:	Orica Australia Limited
Approved for release by:	Damon Roddis
Disclaimer & copyright:	

Table 1 – Document Control

Version	Date	Comment	Prepared by	Reviewed by
R1	10/02/2017	Final	James Grieve	Damon Roddis



Adelaide

35 Edward Street,
Norwood SA 5067
PO Box 3187, Norwood SA 5067
Ph: +61 8 8332 0960
Fax: +61 7 3844 5858

Brisbane

Level 19, 240 Queen Street
Brisbane Qld 4000
Ph: +61 7 3004 6400
Fax: +61 7 3844 5858

Melbourne

Level 17, 31 Queen Street
Melbourne Vic 3000
Ph: +61 3 9036 2637
Fax: +61 2 9870 0999

Perth

Level 1, Suite 3
34 Queen Street, Perth WA 6000
Ph: +61 8 9481 4961
Fax: +61 2 9870 0999

Sydney Head Office

Suite 1, Level 1, 146 Arthur Street
North Sydney, NSW 2060
Ph: +61 2 9870 0900
Fax: +61 2 9870 0999

Disclaimer

Pacific Environment acts in all professional matters as a faithful advisor to the Client and exercises all reasonable skill and care in the provision of its professional services. Reports are commissioned by and prepared for the exclusive use of the Client. They are subject to and issued in accordance with the agreement between the Client and Pacific Environment. Pacific Environment is not responsible for any liability and accepts no responsibility whatsoever arising from the misapplication or misinterpretation by third parties of the contents of its reports.

Except where expressly stated, Pacific Environment does not attempt to verify the accuracy, validity or comprehensiveness of any information supplied to Pacific Environment for its reports.

Reports cannot be copied or reproduced in whole or part for any purpose without the prior written agreement of Pacific Environment. The validity and comprehensiveness of supplied information has not been independently verified and, for the purposes of this report, it is assumed that the information provided to Pacific Environment is both complete and accurate. It is further assumed that normal activities were being undertaken at the site on the day of the site visit(s), unless explicitly stated otherwise.

Table of contents

List of Figures

List of Tables

Abbreviations

Abbreviation	Definition
BGL	Below Ground Level
DEM	Dust Extinction Moisture
EPA	Environment Protection Authority
G	gram (unit of mass)
m	metre (unit of length)
m^2	square metres (unit of area)
m^3	cubic metre
mg/kg	milligram per kilogram (unit of concentration)
MHM	Material Handling Moisture
PM	Particulate Matter
t	tonne (unit of mass)
µg/m^3	microgram per cubic metre (unit of concentration)
USEPA	United States Environment Protection Agency

1 Introduction

Pacific Environment (PE) has been commissioned by Orica Australia Pty Ltd (Orica) to undertake an Air Quality Assessment for the Orica Kooragang Island Remediation Program (the Project), located at Orica's Kooragang Island ammonium nitrate manufacturing facility (the Facility).

The Project involves the construction of a 'cap and containment' remediation system to enclose arsenic contaminated soil and groundwater within a 4,200 m² area in the north-western corner of the Facility, in an area referred to as 'the Site'.

Figure 1 indicates the location of the Facility and the Site within the Kooragang Island peninsula, whilst **Figure 2** provides detail of the site layout.

Figure 1 – Location of the Facility and Site within the Kooragang Island peninsula

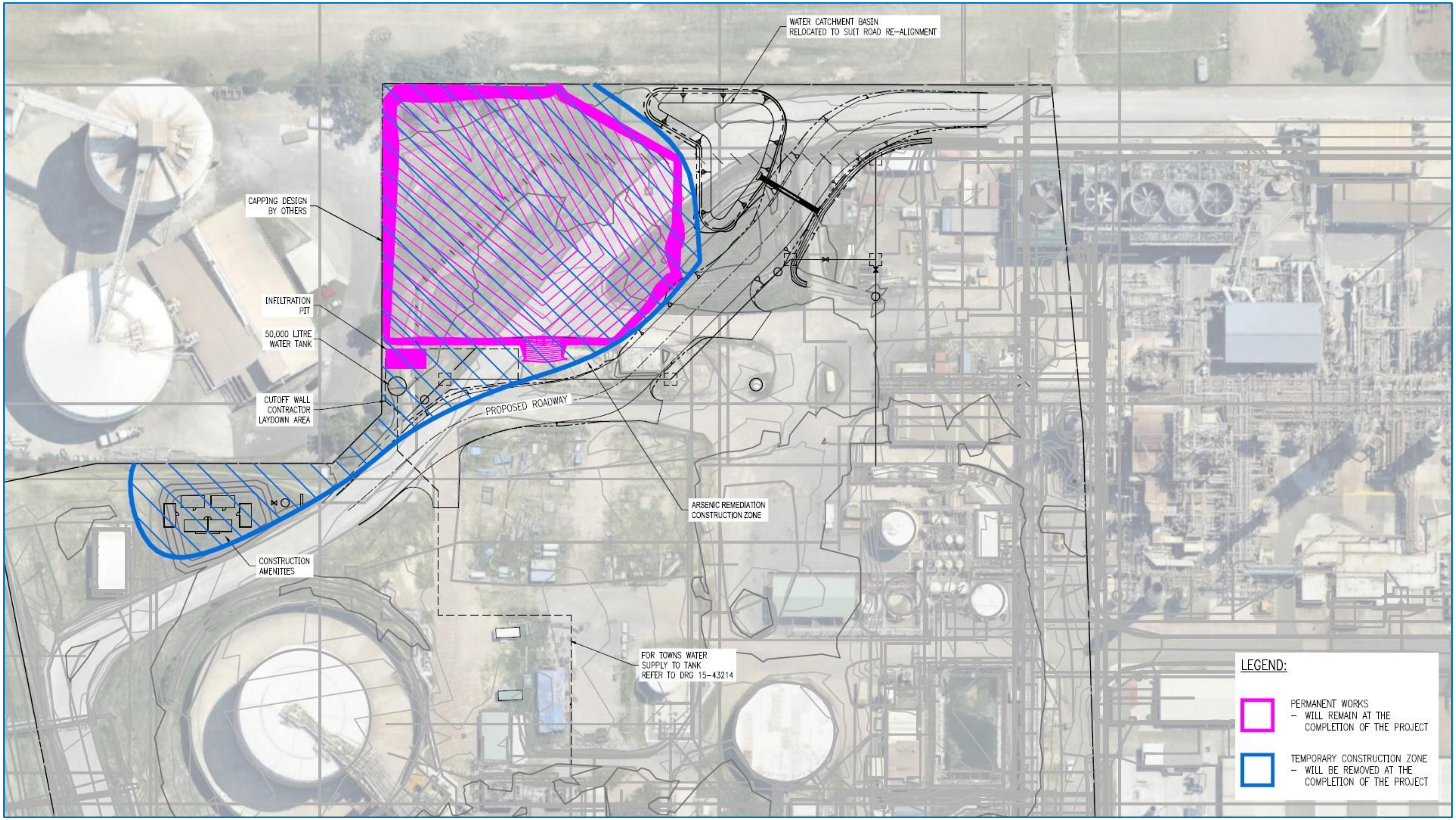


Figure 2 – Site layout

1.1 Assessment Scope

The assessment scope has been designed to provide an understanding of potential air quality risks associated with the handling and storage of arsenic contaminated materials. Noting the small scale and short duration of the Project, it is considered that air quality risks associated with other elements of the Project, such as particulate matter emissions associated with traffic movements to the Facility, are low and capable of being adequately addressed through the implementation of conventional air quality management approaches.

Accordingly, the following scope of works has been undertaken:

- A review of the Project and site conditions with respect to potential air emission sources of arsenic contaminated materials.
- Preparation of a particulate matter emission inventory for key operations that involve arsenic-contaminated material.
- Dispersion modelling of arsenic emissions with comparison against regulatory impact assessment criteria.
- A consideration of the relative importance of arsenic and particulate matter emissions.
- Provision of relevant conclusions and recommended air quality management measures.

2 Project Description

The Project involves the installation of a cap and containment remediation system to enclose Arsenic contaminated soil and prevent offsite migration, to the extent practicable, of arsenic contaminated groundwater in the Site. This involves the construction of a soil-bentonite (clay) cut-off wall around an area of approximately 75 m by 50 m to enclose contamination on-site, with a cap constructed to minimise rainfall infiltration, and mitigate the flow of groundwater through the impacted soil and aquifer material. The Project is proposed to be undertaken independently of the Facility operations.

Cut-off wall construction involves two separate phases that occur sequentially within a total construction period of approximately five months, between the operating hours of 7am – 6 pm (Mon – Fri) and 7 am – 4pm (Sat). These are:

1. Site preparation and installation of the cut-off wall.
2. Cap construction.

Further detail is provided in the following sections.

2.1 Cut-Off Wall Construction

The cut-off wall will be constructed using two excavation techniques, a crane with clam-shell grab bucket along the two boundary fences, and a long-reach excavator that is capable of reaching the base of the proposed 12 m deep trench.

During construction, an initial shallow trench is excavated and filled with bentonite rich slurry. The use of a slurry within the trench allows excavation of soils through the fluid medium, whilst preventing wall collapse as well as ingress of water (or egress of slurry) from the water table.

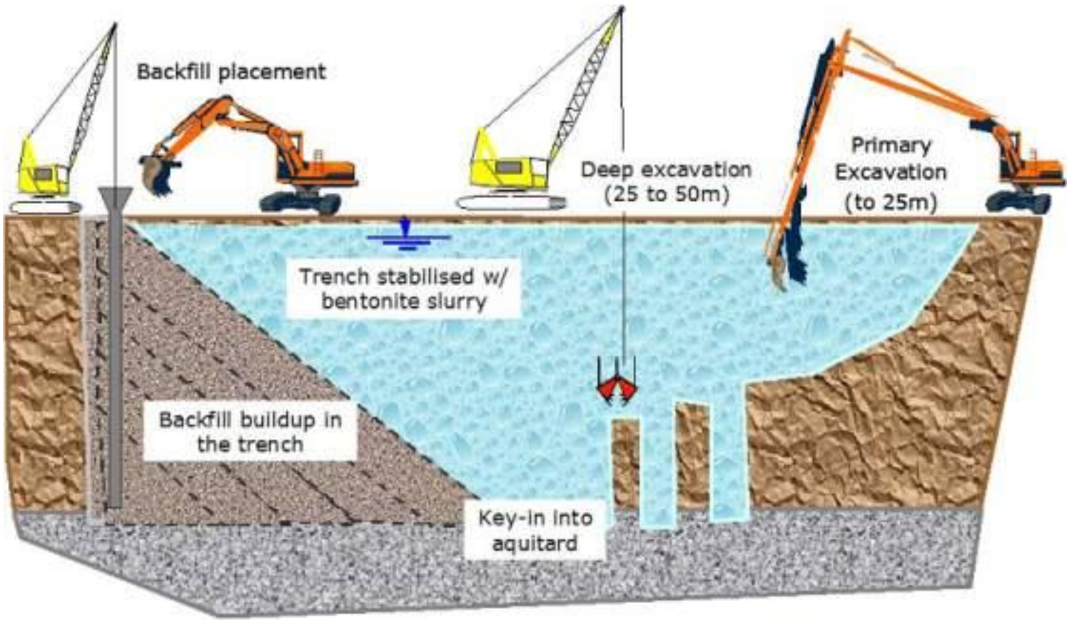


Figure 3 – (Cross-alignment) generic sectional schematic of slurry wall construction techniques

Once excavated, the soil is mixed with bentonite within a bunded mixing area and then back-filled into the trench using a tremie tube. The tremie tube (pictured in the left hand side of **Figure 3**) comprises a funnel into which the soil-bentonite mixture is progressively placed, such that the low permeability material is integrated from the base of the trench in a continuous manner, with material balance being maintained between excavation and backfilling processes. At the completion of the cut-off wall, 10% – 30% of the soil excavated from the trench will remain on the surface within the cut-off wall boundary and will be used as part of the capping layer. It is proposed that this material will be drained and stabilised with a cement additive that will bind contamination, which will restrict the ability of the material to generate particulate matter when stockpiled until it is incorporated into the capping system.

During cut-off wall construction, the level of slurry is maintained at or immediately below the ground surface level. With the exception of raw bentonite clays (i.e. prior to mixing), all working materials are intended to be saturated with moisture. **Table 2** presents a summary of cut-off wall dimensions and volumes.

Table 2 – Summary of cut-off wall dimensions and volumes

Cut-off wall Parameter	Value	Units
Total Length	248	m
Depth	12	m
Width	~1	m
Rate of excavation (peak)	350	m^3/shift
Volume Excavated	2,700	m^3
Bentonite imported	170	m^3
Surplus spoil volume at completion	300 - 1,000	m^3
Total cut-off wall construction duration	~ 8	weeks

The working space for the cut-off wall construction phase comprises the following areas:

- Mixing area: 20 m width on internal cut-off wall alignment.
- Slurry pond: 20 m x 20 m on internal cut-off wall alignment.
- Laydown area: 15 m x 15 m.
- Spoil area: approximately 20 m x 25 m.

2.2 Cap Construction

Upon completion of the cut-off wall construction works, the capping will be installed. The primary purpose of the capping system is to limit surface water infiltration within the footprint of the wall alignment.

The overall concept involves a layered capping system with a composite liner. The capping layer will extend past the cut-off wall, with the geotextile material keyed in around the cut-off wall to assist with the permeability of the design. Spoon drains and diversion bunds will be installed to assist with directing water away from the cut-off wall and into an infiltration pit in the south-west corner and a retention pond in the north east corner.

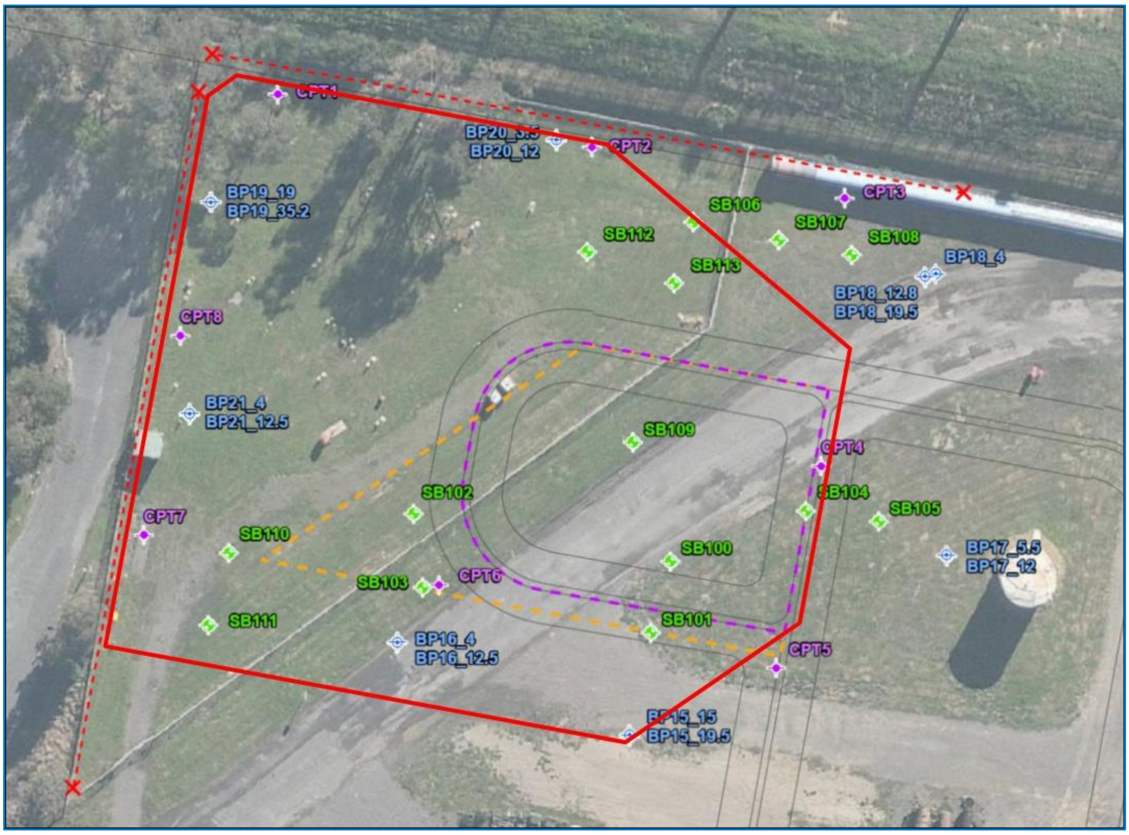
The cap construction is proposed to take place over a total of approximately 8 weeks and will involve the following steps:

- Removal of top soil with an excavator and stockpiling on site.
- Emplacement of cut-off wall residual fill material (~300 – 1000 m^3) and imported bearing layer material (~850 m^3).
- Construction of infiltration pits and side drains.
- Installation of liners and subsurface drainage.
- Emplacement of imported revegetation layer (~2,000 m^3 – with a maximum 200 m^3 stockpiled at once).
- Revegetation.
- Demobilisation.

3 Site Conditions

3.1 Arsenic in Soil

Concentrations of arsenic in soil have been measured during the installation of soil bores and bundled piezometers at the Site. **Figure 5** presents an aerial image showing sampling locations near to the cut-off wall. Data from this sampling has been sourced from Golder (2015).



Cut-off wall (approximate location)

BP: Bundled Piezometer location, CPT: Cone Penetrometer Test location, SB: Soil Bore location

Figure 4 – Soil sample locations near and within the cut-off wall (adapted from Golder [2015])

To provide context on soils that are proposed to be excavated during cut-off wall construction, the Golder (2015) data has been collated to provide a summary of the monitoring points in proximity to each of the cut-off wall boundaries. **Table 3** outlines the sample locations adopted as being representative of conditions at each boundary.

Table 3 – Soil sample locations in proximity to each cut-off wall boundary

Boundary	Sample Locations Included
Northern	BP19, BP20
North-Eastern	SB106, SB107, SB113
Eastern	SB104, SB105
Southern	SB111, BP16, BP15

Western	BP19, BP21, SB110, SB111

Figure 5 presents the average arsenic concentration by depth for each boundary. Also presented is the profile average between 0 m and 12 m below ground level (BGL).

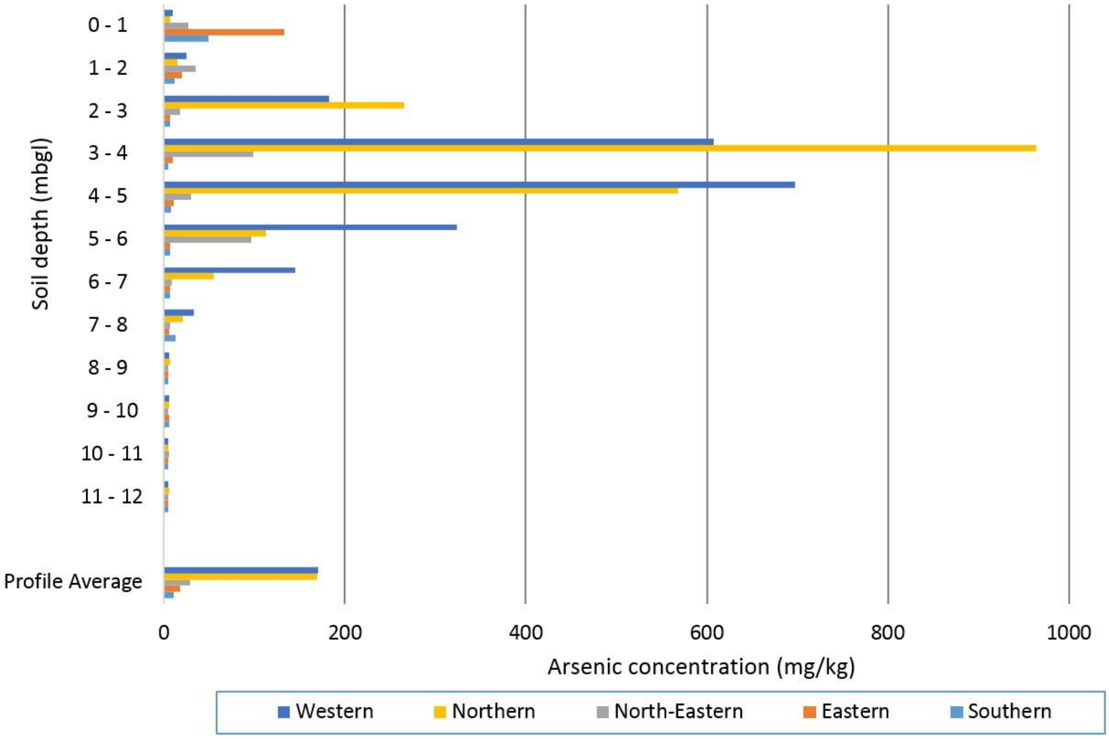


Figure 5 – Variation in soil-bound arsenic by depth and cut-off wall boundary

As shown in **Figure 5**, elevated arsenic concentrations are primarily present between 2 m and 7 m BGL. Also evident is the presence of higher concentrations near to the western and northern cut-off wall boundaries[1], which based on the adopted sample locations, feature average concentrations of up to approximately 200 mg/kg across the 12 m depth profile of the cut-off wall. This concentration is elevated compared with concentrations commonly found in Australian soils, which are typically less than 50 mg/kg with a mean of between 5 – 6 mg/kg, and is similar in scale to those found in areas where the specific lithology of parent rocks contributes to higher background levels in soil (APVMA, 2005).

3.2 Groundwater levels

PE have been provided with on-site well gauging data that was collected by Golder Associates in March 2015. A subset of these data is presented in **Table 4**, showing groundwater levels in shallow wells near to the cut-off wall boundaries.

[1] The application of BP19 data to the northern boundary may represent a conservative estimate.

Table 4 – Summary of groundwater levels on Site (Golder, 2015)

Groundwater Well	Boundary	Water Level (m BGL)
BP16_4.5	Southern	2.08
BP17_5.5	Eastern	2.15
BP18_4.0	North Eastern	1.64
BP20_3.5	Northern	1.80
BP21_4.0	Western	1.54
Average		1.85

Notes - BGL: Below Ground Level. Measurements undertaken by Golder Associates, 2015.

As shown in **Table 4**, groundwater levels near to the boundaries range between approximately 1.5 m to 2 m BGL. It is noted that cut-off wall excavations are proposed to a depth of 12 m BGL.

Accordingly, and highly relevant to the air quality assessment, the majority of excavated material will sourced from below the groundwater table.

Further, it is highlighted that, when considered in conjunction with the soil concentration data (**Figure 5)**, the elevated arsenic concentrations within the cut-off wall excavations will be situated below the water table. It can be assumed therefore that soil containing elevated arsenic concentrations will be saturated with moisture prior to excavation.

4 Assessment Criterion

In New South Wales, *The Approved Methods for Modelling and Assessment of Air Pollutants in New South Wales* (EPA, 2016), provides impact assessment criteria for a range of air quality metrics. Relevant to this assessment, the Approved Methods provide an impact assessment criterion for arsenic, as shown in **Table 5**.

Table 5 – Approved Methods impact assessment criterion for arsenic

Substance	Assessment Criterion	Assessment Statistic
Arsenic (and compounds)	0.09 µg/m^3	99.9th Percentile, 1 hour average.

Note: Criterion applies to the incremental impact of the Project in isolation.

It is also noted that arsenic is classified within the Approved Methods as a principal toxic pollutant, for which emissions must be minimised to the *maximum extent achievable*. In the context of this project, this implies that an appropriate level of particulate matter emission controls are required.

5 Emissions Potential

5.1 Arsenic Emissions

This section provides a qualitative review of the arsenic emission potential associated with the construction phase of the Project, as defined by the following parameters:

- The presence of arsenic contamination in the material being handled.
- The moisture content of the material.

In addition, a quantitative emission estimate is provided for emplacement of arsenic contaminated spoil.

5.1.1 Cut-Off Wall Construction

Table 6 presents a summary of arsenic emission potential associated with the cut-off wall construction works.

Table 6 – Summary of arsenic emission potential: cut-off wall construction

Operation	Arsenic Emission Potential
Preparation of trench aprons	Minor – Slurry materials saturated with moisture.
Bentonite mixing	
Initial excavations	
Spoil / bentonite mixing	
Stockpiling	
Excavation to depth	
Backfilling	

As outlined in **Table 6**, arsenic containing materials handled during the cut-off wall construction phase will be saturated with moisture. During material handling, moisture acts to restrict the ability of solid particles to mobilise into ambient air. With respect to this, *Leading Practice Sustainable Development Program for the Mining Industry – Airborne Contaminants, Noise and Vibration* (DRET, 2009) states:

> *"Moisture is the most significant mitigating agent available for controlling particulate emissions. In general, higher moisture means less dusty conditions...*
>
> *…each raw material has two moisture limits that are critical to understanding the nature and behaviour of the material: the dust extinction moisture (DEM) and the materials handling moisture (MHM). The DEM, which is the lower moisture limit, is the moisture at which the material is no longer dusty.*

It is noted that operating moisture levels for cut-off wall construction would be beyond both the DEM and MHM[2] levels, and would be reflective of saturation levels for soil and bentonite materials. Accordingly, PM emission potential from these sources are considered negligible.

This is with the exception of the potential for mobilisation of slurry droplets during transfer under extremely high wind conditions. Such an emission (of material with relatively large aerodynamic diameter) is easily mitigated with standard air quality management practices including curtailing of operations during high winds, draining of excavator buckets at point of excavation, and minimisation of transfer drop heights.

5.1.2 Cap Construction

Table 7 presents a summary of the anticipated arsenic emission potential associated with the cap construction works.

Table 7 – Summary of arsenic emission potential: Cap construction

Operation	Arsenic Emission Potential
Removal of top soil	Minor – Low concentration of arsenic in surface soils. Application of particulate matter control measures.
Emplacement of cut-off wall spoil material	Moderate – arsenic contaminated materials to be handled via excavator.
Emplacement of bearing layer material	Minor due to use of imported (clean) materials, and encapsulation of cut-off wall spoil at this stage of construction.
Construction of infiltration pits and side drains.	
Installation of liners and subsurface drainage	
Emplacement of imported revegetation layer	

5.2 Odour

Golder (2016) notes that little odour was detected from soils during the installation of groundwater wells on the Site, and that any odours present would be expected to be localised to the area of the stockpiled soil. Groundwater monitoring records indicate the absence of odour from the vast majority of groundwater wells on the Site (Golder, 2015), with slight sulfur odours present in two wells.

Noting the above, it is recommended that the mitigation of potential odour be addressed through the application of standard odour management measures, in the event that odorous material be encountered. Such measures, along with their triggers, should be documented within the relevant Construction Environmental Management Plan for the Project. Accordingly, odour has not been considered further in this assessment.

[2] The MHM is a property relevant to management of a material's potential to adhere to, or clog material handling equipment such as bins, transfer points and conveyors.

6 Quantitative Assessment

6.1 Emission Estimate for Emplacement of spoil

Table 7 identifies the emplacement of surplus cut-off wall spoil as a potential source of airborne arsenic emissions. Site specific particulate matter emissions have been estimated using the moisture and wind speed dependent US EPA AP-42 emission factors for batch loading operations, as shown in **Equation 1**.

$$\text{Emission factor (kg PM / t handled)} = 0.74 \times 0.0016 \times \left(\frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}} \right) \qquad \text{(Equation 1)}$$

Where: $\text{PM} = \text{Particulate Matter}$

$\text{M} = \text{Moisture Content (\%)}$

$\text{U} = \text{Ambient wind speed (m/s)}$

At a moisture content of 10% (as considered representative of saturated material that has been drained and covered) and a wind speed of 3 m/s, this would equate to a particulate matter (PM) emission factor of 0.19 g per tonne of material emplaced.

It is noted that the action of excavating through the profile will inherently result in some mixing of the excavated material. Accordingly, for the consideration of the emission potential associated with the emplacement of surplus spoil, profile average concentrations outlined in **Section 3** are considered likely to be more representative of average concentrations within stockpiled materials. Accordingly, for the purposes of this estimate, an arsenic concentration of 200 mg/kg has been assumed as being representative of the upper range of the estimated profile values.

At a handling rate 50 t/hr, and an emission factor of 0.19 g PM/t, this would equate to a particulate matter emission rate of 9.3 g/hr. At an arsenic concentration of 200 mg/kg, this would equate to arsenic emissions of 1.86 mg/hr (or 0.5 µg/s). **Table 8** provides a summary of this emission estimate.

Table 8 – Estimate of arsenic emissions from emplacement of cut-off wall spoil

Parameter	Value	Units
Moisture content	10	%
Wind speed	3.0	m/s
PM emission factor	0.19	g/t handled
PM emission rate	9.3	g/hr
Arsenic concentration	200	mg/kg
Arsenic emission rate	1.86	mg/hr
	0.5	µg/s

6.2 Dispersion Model Selection

The AERMOD atmospheric dispersion model has been adopted as the most suitable model due to the source types, location of nearest receivers and nature of local topography. AERMOD is the US EPA's recommended steady-state plume dispersion model for regulatory purposes and it is an accepted model of the NSW EPA. AERMOD replaced the Industrial Source Complex (ISC) model for regulatory purposes in the United States in December 2006.

A significant feature of AERMOD is the Pasquill-Gifford stability based dispersion is replaced with a turbulence-based approach that uses the Monin-Obukhov length scale to account for the effects of atmospheric turbulence. The AERMOD system includes AERMET, used for the preparation of meteorological input files and AERMAP, used for the preparation of terrain data.

Terrain data for the wider area was sourced from NASA's Shuttle Radar Topography Mission (SRTM) Data (1 arc second [~30m] resolution). The complete terrain dataset was then processed within AERMAP to create the necessary input files.

Appropriate values for three surface characteristics are required for AERMET as follows:

- Surface roughness, which is the height at which the mean horizontal wind speed approaches zero, based on a logarithmic profile.
- Bowen ratio, which is an indicator of surface moisture.
- Albedo, which is an indicator of reflectivity of the surface.

Values of surface roughness, Bowen ratio and albedo were designated based on a review of aerial photography.

6.3 Climate and Meteorology

Air quality impacts are influenced by meteorological conditions, primarily in the form of wind flow regimes, and by local conditions that are generally driven by topographical features and interactions with coastal influences. Wind speed, wind direction, temperature and relative humidity all affect the potential dispersion and transport of pollutants and are basic input requirements for dispersion modelling.

Table 9 presents the temperature, humidity and rainfall statistics for the Bureau of Meteorology (BoM) Williamtown weather station, which is situated approximately 12 km north-east of the Site. Humidity data consist of monthly averages of 9 am and 3 pm readings. Also presented are monthly averages of maximum and minimum temperatures. Rainfall data consist of mean monthly rainfall and the average number of rain days per month.

The annual average maximum and minimum temperatures recorded at the Williamtown station are 23.1°C and 12.4°C respectively. On average, January is the hottest month, with an average maximum temperature of 28.1°C whilst July is the coldest month, with average minimum temperature of 6.4°C. The annual average relative humidity reading collected at 9 am is 73% and at 3 pm the annual average is 57%. Rainfall data collected at the Williamtown station shows that February through June are the wettest months. The average annual rainfall is 1,127 mm with an average of 138.7 rain days per year.

Table 9 - Summary of Climate Statistics for BoM Williamtown Weather Station (Station: 061078)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
9am Mean Dry-bulb and Wet-bulb Temperatures (ºC) and Relative Humidity (%)													
Dry-bulb	23.0	22.5	21.2	18.2	14.3	11.6	10.5	12.2	15.7	18.8	20.5	22.2	17.6
Humidity	72.0	76.0	77.0	76.0	79.0	80.0	77.0	71.0	66.0	64.0	66.0	68.0	73.0
3pm Mean Dry-bulb and Wet-bulb Temperatures (ºC) and Relative Humidity (%)													
Dry-bulb	26.5	26.1	24.9	22.5	19.3	16.8	16.2	17.6	20.0	21.9	23.8	25.6	21.8
Humidity	59.0	62.0	61.0	59.0	60.0	60.0	55.0	50.0	50.0	54.0	55.0	56.0	57.0
Daily Maximum Temperature (ºC)													
Mean	28.1	27.6	26.3	23.7	20.3	17.7	17.1	18.7	21.4	23.7	25.6	27.3	23.1
Daily Minimum Temperature (º C)													
Mean	18.0	18.1	16.3	13.2	10.1	7.9	6.4	6.9	9.1	11.9	14.4	16.6	12.4
Rainfall (mm)													
Mean	101.1	119.2	118.2	111.8	112.3	121.4	72.5	74.3	60.3	72.7	82.8	79.5	1127.0
Rain days (Number)													
Mean	12.0	11.9	12.8	11.6	12.6	12.6	10.5	10.2	9.8	11.5	11.8	11.4	138.7

Site-specific dispersion meteorology has been prepared for the period March 2014 – February 2015 using wind, temperature and humidity monitoring records from the Orica Stockton Air Quality Monitoring Station (AQMS). These data have been combined with BoM cloud cover records from the BoM Williamtown Airport ceilometer, and processed in the Lakes Environmental AERMET processor to provide surface and profile datasets for use in the AERMOD dispersion model.

Figure 6 provides annual and seasonal wind roses for the Orica Stockton AQMS, as incorporated into the AERMOD meteorological dataset.

Figure 6 – Annual and seasonal wind roses for the Orica Stockton AQMS.

6.4 Emission Source Configuration

Excavator emissions have been incorporated as a ground-based volume source, in accordance with the following:

- Arsenic emission rates based on the estimate documented in Section 5.3, with the exception of wind speed, which has been incorporated as a wind-speed dependent (time-varying) quantity.
- Emission for all days of the modelling dataset, between the hours of 7 am and 6 pm.
- Initial source dimensions of 10 m x 10 m [3] to reflect the working area covered within 1 hour.

6.5 Other Model Settings

Further detail of model configuration has been provided within the AERMOD model list file in **Appendix A**.

6.6 Modelling Results

Figure 7 presents a contour plot of the modelling predictions for the cut-off wall spoil emplacement operation. As evident in the figure, concentrations are confined to a small area immediately surrounding the operation.

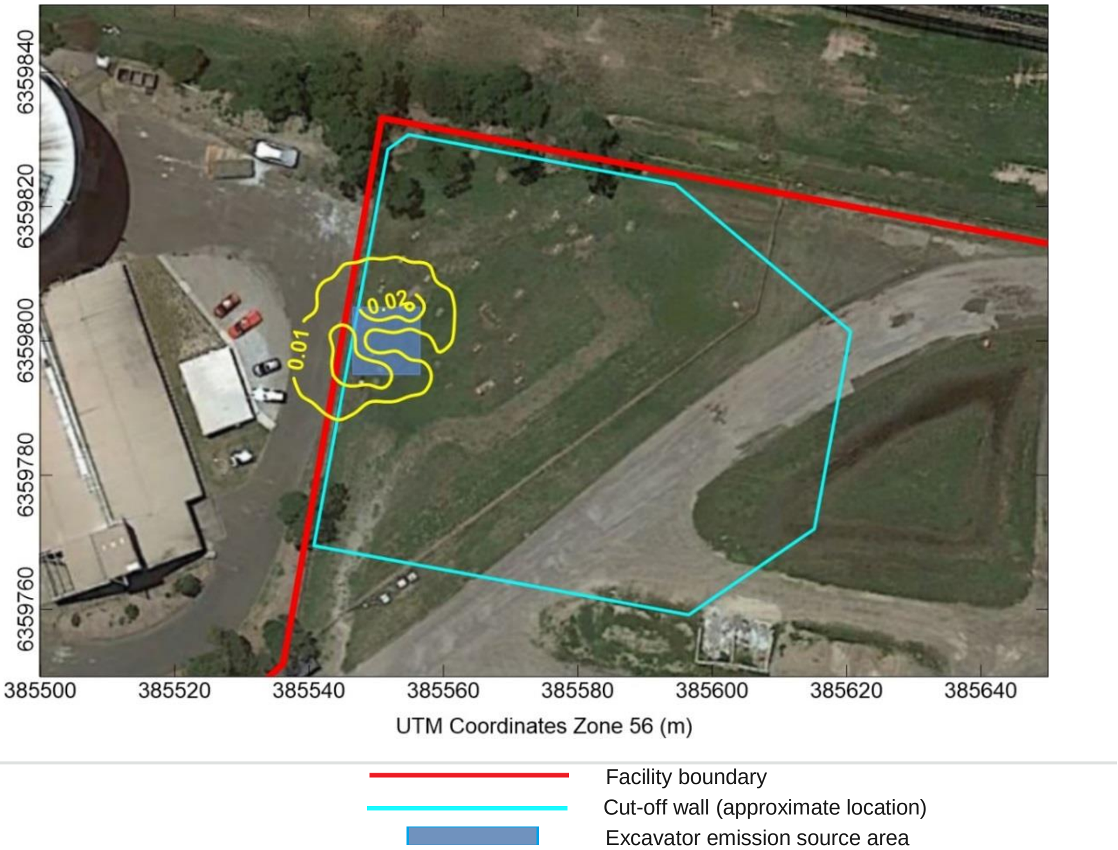


Figure 7 – 99.9th percentile 1 hour average arsenic predictions (µg/m³)

[3] Initial σ_y σ_z values of 1.8 and 1.0 m have been adopted (respectively).

6.7 Discussion

As shown in **Figure 7**, 99.9th percentile 1 hour average arsenic concentrations are predicted to be within the impact assessment criterion of 0.09 µg/m^3. Based on the adopted model scenario of emplacement activities occurring adjacent to the site boundary, 99.9th percentile arsenic concentrations were estimated to comprise 30% of the impact assessment criterion.

To provide some context on the relative importance of arsenic and particulate matter emissions (i.e. to which arsenic is bound) the following discussion is provided:

- At an average arsenic in soil concentration of 200 mg/kg (0.02% by mass), a 99.9th percentile 1 hour average Total Suspended Particulate (TSP) concentration of 450 µg/m^3 would be required to reach an arsenic concentration in air equal to the assessment criterion.
- Within the dispersion modelling, peak 24 hour average concentrations were observed to be approximately 5 times lower than the above 99.9th percentile 1 hour average concentration, implying that a 24 hour average Total Suspended Particulate (TSP) concentration of 90 µg/m^3 (i.e. 1/5th of 450 µg/m^3) would be required to reach an arsenic concentration in air equal to the assessment criterion.
- Assuming that particulate matter less than 10 µm in aerodynamic diameter (PM_{10}) comprises 40% of TSP (SPCC, 1986), it is derived that an incremental 24 hour PM_{10} impact of 36 µg/m^3 (i.e. solely from handling of contaminated soils) would be required to reach an arsenic concentration in air equal to the assessment criterion.

The derived 24 hour PM_{10} concentration of 36 µg/m^3 is above that which is typically achieved using dust management practices. Accordingly it is noted that for a material handling operation on soils with an average arsenic concentration of 200 mg/kg, routine particulate matter management practices are anticipated to be sufficiently protective of the arsenic criterion. Noting this, given that arsenic constitutes a principal toxic contaminant[4], for which emission are to be minimised, particulate matter management practices have been recommended for incorporation within the Construction Environmental Management Plan (CEMP) for the Project. These are outlined **Section 7**.

Lastly, peak predictions for emplacement activities were estimated to be 30% of the arsenic criterion, equating to a peak incremental 24 hour PM_{10} concentration of approximately 11 µg/m^3. Noting that this modelling assumes a static source, and that predictions were significantly lower outside of the immediate working area, actual concentrations are expected to be significantly lower, indicating that with the implementation of dust management practices, ambient particulate matter levels would also be acceptable.

7 Conclusions

An assessment of potential arsenic emissions from the proposed Orica Kooragang Island Remediation Project has been undertaken. This work included a review of conditions on the Site which concluded the following:

[4] i.e. as classified within the Approved Methods.

- Arsenic contamination is varied along the path of the cut-off wall, with elevated arsenic concentrations in excavated cut-off wall soils primarily contained within depths of 2 m to 7 m BGL.
- Groundwater levels are typically between 1.5 – 2.0 m BGL in the vicinity of the cut-off wall.
- Excavated soils with elevated arsenic concentrations are thus anticipated to be saturated with moisture.
- Peak profile average arsenic concentrations are in the vicinity of 200 mg/kg

A subsequent review of the emissions potential of contaminated material handling operations concluded that:

- The risk of airborne arsenic emissions from the handling of saturated materials is minor, and confined to the mobilisation of liquid phase contaminants from material transfer operations during high winds, for which effective, and standard, mitigation measures are available.
- The key potential for the generation of arsenic emissions is associated with the emplacement of partially dried (and stabilised) spoil materials into the containment area.
- Soil blending that will occur during the action of excavation and stockpiling is expected to result in average arsenic concentrations in spoil that are lower than peak concentrations measured in the vicinity of the cut-off wall.

Noting the key emission potential is associated with the emplacement of spoil, an atmospheric dispersion modelling analysis of this activity was undertaken.

This analysis assumed the handling of soils with an average arsenic concentration of 200 mg/kg, via excavator, at a rate of 50 t/hr. Modelling was conducted using an annual site-specific meteorological dataset, with operations assumed to occur continuously between the hours of 7 am and 6 pm on all days of the dataset. In contrast, it is noted that at the modelled handling rate, the emplacement of surplus spoil would be complete within a period of between 6 and 20 operating hours[5], implying that the representation of these emissions within the model is highly conservative.

Predictions for this modelling indicated that 99.9th percentile 1 hour average arsenic concentrations would comply with the Approved Methods impact assessment criterion of 0.09 µg/m^3 in the immediate vicinity, and at all areas downwind of the operation.

Peak concentrations within the immediate working area are anticipated to constitute approximately 30% of the arsenic criterion. For the modelled case, this addressed the emplacement of material adjacent to the site boundary.

With regard to potential for odour emissions, the assessment provided within Golder (2016) noted that little odour was detected from soils during the installation of groundwater wells on the Site. Noting this, it is recommended that the Construction Environmental Management Plan (CEMP) should include control measures to be implemented in the event the odorous material is encountered.

[5] As based on the range of surplus spoil estimates (10% and 30%).

Based on the analysis undertaken, it is considered that the potential for the Project to result in adverse air quality impacts is considered to be low. Noting this, it is recommended that construction air quality management be addressed via the preparation of a project-specific CEMP. Suggestions for appropriate air quality management requirements are outlined in **Table** 10.

Table 10 – Summary of recommended air quality management measures

Activity	Management Measure
Administrative	• Project staff to be informed of requirements of the CEMP to minimise air emissions (specifically during handling of arsenic contaminated soils). • Neighbours to be informed of planned works on immediate boundaries and contacts for reporting issues or concerns.

Vehicle operations	• Maintenance and cleaning of internal sealed road surfaces.
	• Application of vehicle speed limits.
	• Ensuring that vehicles are:
	  ▪ restricted to designated vehicle paths with the objective of minimising areas of erodible surface material.
	  ▪ properly maintained and operating efficiently.
	  ▪ not left with engines idling for extended periods.
	• Maintaining visual awareness of vehicle movements with the objective of identifying and addressing the presence of visible dust emissions.
	• Use of wheel washing for vehicles exiting unsealed areas of the Site (where required).
	• Inspection and additional cleaning of undercarriage where required.
	• Ensuring that all trucks transporting soil are covered when exiting the Site.
	• Ensuring that vehicle tailgates are properly sealed, such that loose material is not deposited onto road surfaces.

Cap excavation	• Installation of plastic sheathing directly adjacent to the excavation face. • Wetting down of soil surfaces prior to commencement of initial excavation. • Use of screening/shade cloth on boundary fences adjacent to the cut-off wall during construction phase. • Operation of excavators in a manner that minimises the potential for slurry splash and mobilisation of spoil material. • Allowing of bucket to drain prior to transfer, as required to manage splash and/or runoff/soiling. • Cessation of activities during high wind gusts. • Minimisation of spoil drop heights. • Application of sprays where required to manage spoil moisture content and / or mixing pond contents. • Maintenance of a clean site including rinsing of soiled surfaces where there may be an opportunity for material to dry and form dust.
Cap Construction	• Wetting down of top soils prior to excavation. • Application of sprays to exposed surface areas where wind erosion is of interest. • Minimisation of drop heights and maintenance of moisture content during emplacement of cut-off wall residual fill material
Unloading to stockpiles (General)	• Maintenance of material moisture content. • Maintenance of material handling equipment to operate in a proper and efficient manner. • Cessation of activities during high winds gusts. • Minimisation of drop heights.
Stockpiling	• Minimisation of stockpile areas. • Covering of stockpiles containing excavated spoil if left overnight or during high winds. • Periodic watering of stockpile areas to promote crusting of stockpile surfaces and ensure moisture content. • Application of sprays to stockpiles where high winds are expected and/or present.
Wind erosion from the general Site	• Washing down • Maintenance of clean road surfaces (where sealed). • Restriction of vehicles to designated vehicle paths.

8 References

APVMA 2005 *Arsenic Timber Treatments Final Report: Environmental Assessment*, Australian Pesticides and Veterinary Medicines Association, Published 1 March 2005 http://apvma.gov.au/node/12366 (accessed 0102/2016).

DRET 2009 *Leading Practice Sustainable Development Program for the Mining Industry – Airborne Contaminants, Noise and Vibration*, Australian Government, Department of Resources, Energy and Tourism, October 2009.

EPA 2017 *The Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*, New South Wales Environment Protection Authority, January 2017.

Golder 2015 *Orica Kooragang Island: Arsenic Management Order – Remediation Investigations,* Groundwater and Soil Monitoring Data – Various Tables and Figures, Golder Associates, 2015.

Golder 2016 *Environmental Impact Statement – Orica Kooragang Island Remediation Program,* Golder Associates, 15 December 2016.

SPCC 1986 *Particle Size Distributions in Dust from Open Cut Coal Mines in the Hunter Valley*, NSW State Pollution Control Commission, August 1986

USEPA (2006) *AP-42 Compilation of Pollutant Emission Factors*, United States Environmental Protection Agency, 2006.

Appendix A

Sample Aermod List File

```
** Lakes Environmental AERMOD MPI
**
****************************************
**
** AERMOD Input Produced by:
** AERMOD View Ver. 9.2.0
** Lakes Environmental Software Inc.
** Date: 2/2/2017
** File: C:\Users\OKI000\OKI000.ADI
**
****************************************
**
**
****************************************
** AERMOD Control Pathway
****************************************
**
**
CO STARTING
   TITLEONE C:\Users\OKI000\OKI000.isc
   MODELOPT DFAULT CONC
   AVERTIME 1 24 PERIOD
   POLLUTID TSP
   RUNORNOT RUN
   ERRORFIL OKI000.err
CO FINISHED
**
****************************************
** AERMOD Source Pathway
****************************************
**
**
SO STARTING
** Source Location **
** Source ID - Type - X Coord. - Y Coord. **
   LOCATION EXC       VOLUME     385551.500  6359800.000       8.150
** DESCRSRC Excavator Loading @ 50 t/hr
** Source Parameters **
   SRCPARAM EXC             1.0     0.000     1.802     1.000
   HOUREMIS OKI000.EMI EXC
   SRCGROUP ALL
SO FINISHED
**
****************************************
** AERMOD Receptor Pathway
****************************************
**
**
RE STARTING
   INCLUDED OKI000.rou
RE FINISHED
**
****************************************
** AERMOD Meteorology Pathway
****************************************
**
**
ME STARTING
   SURFFILE "02 MET\OKI001.SFC"
   PROFFILE "02 MET\OKI001.PFL"
   SURFDATA 12345 2014
   UAIRDATA 12345 2014
   PROFBASE 8.0 METERS
ME FINISHED
**
****************************************
** AERMOD Output Pathway
```



```
****************************************
**
**
OU STARTING
   RECTABLE ALLAVE 1ST 9TH
   RECTABLE 1 1ST 9TH
   RECTABLE 24 1ST 9TH
** Auto-Generated Plotfiles
   PLOTFILE 1 ALL 1ST OKI000.AD\01H1GALL.PLT 31
   PLOTFILE 24 ALL 1ST OKI000.AD\24H1GALL.PLT 32
   PLOTFILE 1 ALL 9TH OKI000.AD\01H9GALL.PLT 33
   PLOTFILE 24 ALL 9TH OKI000.AD\24H9GALL.PLT 34
   PLOTFILE PERIOD ALL OKI000.AD\PE00GALL.PLT 35
   SUMMFILE OKI000.sum
OU FINISHED

 ***********************************
 *** SETUP Finishes Successfully ***
 ***********************************
```

```
 *** AERMOD - VERSION  15181 ***   *** C:\Users\OKI000\OKI000.isc
 ***        02/02/17
 *** AERMET - VERSION  15181 ***   ***
 ***        13:04:26

PAGE   1
 **MODELOPTs:   RegDFAULT CONC      ELEV      RURAL

                                           ***     MODEL SETUP OPTIONS
                                           SUMMARY       ***
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
 - - - - - - - - - - - - - - - - - - - - - - - - - -

 **Model Is Setup For Calculation of Average CONCentration Values.

   --  DEPOSITION LOGIC  --
 **NO GAS DEPOSITION Data Provided.
 **NO PARTICLE DEPOSITION Data Provided.
 **Model Uses NO DRY DEPLETION.  DRYDPLT  =  F
 **Model Uses NO WET DEPLETION.  WETDPLT  =  F

 **Model Uses RURAL Dispersion Only.

 **Model Uses Regulatory DEFAULT Options:
         1. Stack-tip Downwash.
         2. Model Accounts for ELEVated Terrain Effects.
         3. Use Calms Processing Routine.
         4. Use Missing Data Processing Routine.
         5. No Exponential Decay.

 **Model Assumes No FLAGPOLE Receptor Heights.

 **The User Specified a Pollutant Type of:  TSP

 **Model Calculates  2 Short Term Average(s) of:   1-HR  24-HR
     and Calculates PERIOD Averages

 **This Run Includes:      1 Source(s);       1 Source Group(s); and
 441 Receptor(s)

                with:      0 POINT(s), including
                           0 POINTCAP(s) and      0 POINTHOR(s)
                 and:      1 VOLUME source(s)
                 and:      0 AREA type source(s)
                 and:      0 LINE source(s)
                 and:      0 OPENPIT source(s)


 **Model Set To Continue RUNning After the Setup Testing.

 **The AERMET Input Meteorological Data Version Date:  15181

 **Output Options Selected:
          Model Outputs Tables of PERIOD Averages by Receptor
          Model Outputs Tables of Highest Short Term Values by Receptor
          (RECTABLE Keyword)
          Model Outputs External File(s) of High Values for Plotting
          (PLOTFILE Keyword)
          Model Outputs Separate Summary File of High Ranked Values
          (SUMMFILE Keyword)

 **NOTE:  The Following Flags May Appear Following CONC Values:  c for Calm
 Hours
                                                                 m for
                                                                 Missing
                                                                 Hours
                                                                 b for Both
```



```
                                                                 Calm and
                                                                 Missing
                                                                 Hours

 **Misc. Inputs:  Base Elev. for Pot. Temp. Profile (m MSL) =     8.00 ;
 Decay Coef. =    0.000     ;  Rot. Angle =     0.0
                  Emission Units = GRAMS/SEC
                  ;  Emission Rate Unit Factor =   0.10000E+07
                  Output Units   = MICROGRAMS/M**3

 **Approximate Storage Requirements of Model =      3.7 MB of RAM.

 **Detailed Error/Message File:   OKI000.err
 **File for Summary of Results:   OKI000.sum
```

```
 *** AERMOD - VERSION  15181 ***   *** C:\Users\OKI000\OKI000.isc
 ***        02/02/17
 *** AERMET - VERSION  15181 ***   ***
 ***        13:04:26

PAGE   2
 **MODELOPTs:   RegDFAULT CONC      ELEV      RURAL


                                                  *** VOLUME SOURCE DATA
                                                  ***

              NUMBER EMISSION RATE                  BASE    RELEASE
              INIT.    INIT.   URBAN  EMISSION RATE
   SOURCE      PART.  (GRAMS/SEC)     X        Y      ELEV.   HEIGHT
   SY      SZ     SOURCE  SCALAR VARY
     ID        CATS.               (METERS) (METERS) (METERS) (METERS)
     (METERS) (METERS)             BY
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
 - - - - - - - - - - - - - - - - - - - - - - - -

 EXC            0   0.10000E+01  385551.5 6359800.0     8.2     0.00
 1.80     1.00     NO    HOURLY
```



```
 *** AERMOD - VERSION  15181 ***   *** C:\Users\OKI000\OKI000.isc
 ***        02/02/17
 *** AERMET - VERSION  15181 ***   ***
 ***        13:04:26

PAGE   3
 **MODELOPTs:   RegDFAULT CONC      ELEV      RURAL


                                           *** SOURCE IDs DEFINING SOURCE
                                           GROUPS ***

 SRCGROUP ID                                              SOURCE IDs
 -----------                                              ----------


  ALL        EXC         ,
```

```
 *** AERMOD - VERSION  15181 ***   *** C:\Users\OKI000\OKI000.isc
 ***        02/02/17
 *** AERMET - VERSION  15181 ***   ***
 ***        13:04:26

PAGE   4
 **MODELOPTs:   RegDFAULT CONC      ELEV      RURAL
```

*** GRIDDED RECEPTOR NETWORK SUMMARY ***

*** NETWORK ID: UCART1 ; NETWORK TYPE: GRIDCART ***

*** X-COORDINATES OF GRID ***
(METERS)

```
385500.0,  385505.0,  385510.0,  385515.0,  385520.0,  385525.0,
385530.0,  385535.0,  385540.0,  385545.0,
385550.0,  385555.0,  385560.0,  385565.0,  385570.0,  385575.0,
385580.0,  385585.0,  385590.0,  385595.0,
385600.0,
```

*** Y-COORDINATES OF GRID ***
(METERS)

```
6359750.0, 6359755.0, 6359760.0, 6359765.0, 6359770.0, 6359775.0,
6359780.0, 6359785.0, 6359790.0, 6359795.0,
6359800.0, 6359805.0, 6359810.0, 6359815.0, 6359820.0, 6359825.0,
6359830.0, 6359835.0, 6359840.0, 6359845.0,
6359850.0,
```



```
 *** AERMOD - VERSION  15181 ***   *** C:\Users\OKI000\OKI000.isc
 ***        02/02/17
 *** AERMET - VERSION  15181 ***   ***
 ***        13:04:26

PAGE   5
 **MODELOPTs:   RegDFAULT CONC      ELEV      RURAL
```

*** NETWORK ID: UCART1 ; NETWORK TYPE: GRIDCART ***

* ELEVATION HEIGHTS IN METERS *

Y-COORD (METERS) | X-COORD (METERS) |	385500.00	385505.00	385510.00	385515.00	385520.00	385525.00	385530.00	385535.00	385540.00
6359850.00 |	9.70	9.40	9.10	8.90	8.60	8.40	8.10	7.90	7.60
6359845.00 |	9.80	9.50	9.30	9.00	8.70	8.50	8.20	8.00	7.70
6359840.00 |	9.90	9.60	9.40	9.10	8.90	8.60	8.30	8.10	7.80
6359835.00 |	10.00	9.70	9.50	9.20	9.00	8.70	8.50	8.20	8.00
6359830.00 |	10.10	9.80	9.60	9.30	9.10	8.80	8.60	8.30	8.10
6359825.00 |	10.20	10.00	9.70	9.40	9.20	8.90	8.70	8.40	8.20
6359820.00 |	10.30	10.10	9.80	9.60	9.30	9.00	8.80	8.50	8.30
6359815.00 |	10.40	10.20	9.90	9.70	9.40	9.20	8.90	8.70	8.40
6359810.00 |	10.50	10.30	10.00	9.80	9.50	9.30	9.00	8.80	8.50
6359805.00 |	10.60	10.40	10.10	9.90	9.60	9.40	9.10	8.90	8.60
6359800.00 |	10.70	10.50	10.30	10.00	9.70	9.50	9.20	9.00	8.70
6359795.00 |	10.80	10.60	10.40	10.10	9.90	9.60	9.30	9.10	8.80
6359790.00 |	10.90	10.70	10.50	10.20	10.00	9.70	9.50	9.20	9.00
6359785.00 |	11.00	10.80	10.60	10.30	10.10	9.80	9.60	9.30	9.10
6359780.00 |	11.10	10.90	10.60	10.40	10.10	9.90	9.60	9.40	9.10
6359775.00 |	10.90	10.80	10.50	10.30	10.00	9.80	9.50	9.30	9.00
6359770.00 |	10.80	10.70	10.40	10.20	9.90	9.70	9.40	9.20	9.00
6359765.00 |	10.70	10.60	10.30	10.10	9.90	9.60	9.40	9.10	8.90
6359760.00 |	10.60	10.50	10.20	10.00	9.80	9.50	9.30	9.00	8.80
6359755.00 |	10.50	10.40	10.10	9.90	9.70	9.40	9.20	8.90	8.70
6359750.00 |	10.40	10.30	10.00	9.80	9.60	9.30	9.10	8.90	8.60

*** AERMOD - VERSION 15181 *** *** C:\Users\OKI000\OKI000.isc
*** 02/02/17
*** AERMET - VERSION 15181 *** ***
*** 13:04:26

PAGE 6
**MODELOPTs: RegDFAULT CONC ELEV RURAL

*** NETWORK ID: UCART1 ; NETWORK TYPE: GRIDCART ***

* ELEVATION HEIGHTS IN METERS *

Y-COORD (METERS) | X-COORD (METERS)	385545.00	385550.00	385555.00	385560.00	385565.00	385570.00	385575.00	385580.00	385585.00
6359850.00	7.40	7.10	6.90	6.60	6.40	6.10	5.80	5.60	5.60
6359845.00	7.50	7.20	7.00	6.70	6.50	6.20	6.00	5.70	5.70
6359840.00	7.60	7.30	7.10	6.80	6.60	6.30	6.10	5.80	5.80
6359835.00	7.70	7.40	7.20	6.90	6.70	6.40	6.20	5.90	5.90
6359830.00	7.80	7.60	7.30	7.10	6.80	6.50	6.30	6.00	6.00
6359825.00	7.90	7.70	7.40	7.20	6.90	6.70	6.40	6.10	6.10
6359820.00	8.00	7.80	7.50	7.30	7.00	6.80	6.50	6.30	6.20
6359815.00	8.10	7.90	7.60	7.40	7.10	6.90	6.60	6.40	6.30
6359810.00	8.30	8.00	7.70	7.50	7.20	7.00	6.70	6.50	6.40
6359805.00	8.40	8.10	7.90	7.60	7.40	7.10	6.80	6.60	6.50
6359800.00	8.50	8.20	8.00	7.70	7.50	7.20	7.00	6.70	6.60
6359795.00	8.60	8.30	8.10	7.80	7.60	7.30	7.10	6.80	6.70
6359790.00	8.70	8.40	8.20	7.90	7.70	7.40	7.20	6.90	6.80
6359785.00	8.80	8.60	8.30	8.10	7.80	7.50	7.30	7.00	6.90
6359780.00	8.90	8.60	8.40	8.10	7.80	7.60	7.30	7.10	6.90
6359775.00	8.80	8.50	8.30	8.00	7.80	7.50	7.30	7.00	6.90
6359770.00	8.70	8.50	8.20	8.00	7.70	7.50	7.20	7.00	6.80
6359765.00	8.60	8.40	8.10	7.90	7.70	7.40	7.20	6.90	6.80
6359760.00	8.60	8.30	8.10	7.80	7.60	7.30	7.10	6.90	6.80
6359755.00	8.50	8.20	8.00	7.80	7.50	7.30	7.10	6.80	6.70
6359750.00	8.40	8.20	7.90	7.70	7.50	7.20	7.00	6.80	6.70

*** AERMOD - VERSION 15181 *** *** C:\Users\OKI000\OKI000.isc
*** 02/02/17
*** AERMET - VERSION 15181 *** ***
*** 13:04:26

PAGE 7
**MODELOPTs: RegDFAULT CONC ELEV RURAL

*** NETWORK ID: UCART1 ; NETWORK TYPE: GRIDCART ***

* ELEVATION HEIGHTS IN METERS *

Y-COORD (METERS) | X-COORD (METERS)	385590.00	385595.00	385600.00
6359850.00	5.60	5.60	5.60
6359845.00	5.70	5.70	5.70
6359840.00	5.80	5.80	5.80
6359835.00	5.90	5.90	5.90
6359830.00	6.00	6.00	6.00
6359825.00	6.10	6.10	6.10
6359820.00	6.20	6.20	6.10
6359815.00	6.30	6.20	6.20
6359810.00	6.40	6.30	6.30
6359805.00	6.50	6.40	6.40
6359800.00	6.50	6.50	6.50
6359795.00	6.60	6.60	6.60
6359790.00	6.70	6.70	6.60
6359785.00	6.80	6.80	6.70
6359780.00	6.90	6.80	6.80
6359775.00	6.80	6.80	6.70
6359770.00	6.80	6.80	6.70
6359765.00	6.80	6.70	6.70
6359760.00	6.70	6.70	6.70
6359755.00	6.70	6.70	6.70
6359750.00	6.70	6.70	6.70

*** AERMOD - VERSION 15181 *** *** C:\Users\OKI000\OKI000.isc
*** 02/02/17
*** AERMET - VERSION 15181 *** ***
*** 13:04:26

PAGE 8
**MODELOPTs: RegDFAULT CONC ELEV RURAL

*** NETWORK ID: UCART1 ; NETWORK TYPE: GRIDCART ***

* HILL HEIGHT SCALES IN METERS *

Y-COORD (METERS) | X-COORD (METERS)	385500.00	385505.00	385510.00	385515.00	385520.00	385525.00	385530.00	385535.00	385540.00
6359850.00	9.70	9.40	9.10	8.90	8.60	8.40	8.10	7.90	7.60
6359845.00	9.80	9.50	9.30	9.00	8.70	8.50	8.20	8.00	7.70
6359840.00	9.90	9.60	9.40	9.10	8.90	8.60	8.30	8.10	7.80
6359835.00	10.00	9.70	9.50	9.20	9.00	8.70	8.50	8.20	8.00
6359830.00	10.10	9.80	9.60	9.30	9.10	8.80	8.60	8.30	8.10
6359825.00	10.20	10.00	9.70	9.40	9.20	8.90	8.70	8.40	8.20
6359820.00	10.30	10.10	9.80	9.60	9.30	9.00	8.80	8.50	8.30
6359815.00	10.40	10.20	9.90	9.70	9.40	9.20	8.90	8.70	8.40
6359810.00	10.50	10.30	10.00	9.80	9.50	9.30	9.00	8.80	8.50
6359805.00	10.60	10.40	10.10	9.90	9.60	9.40	9.10	8.90	8.60
6359800.00	10.70	10.50	10.30	10.00	9.70	9.50	9.20	9.00	8.70
6359795.00	10.80	10.60	10.40	10.10	9.90	9.60	9.30	9.10	8.80
6359790.00	10.90	10.70	10.50	10.20	10.00	9.70	9.50	9.20	9.00
6359785.00	11.00	10.80	10.60	10.30	10.10	9.80	9.60	9.30	9.10
6359780.00	11.10	10.90	10.60	10.40	10.10	9.90	9.60	9.40	9.10
6359775.00	10.90	10.80	10.50	10.30	10.00	9.80	9.50	9.30	9.00
6359770.00	10.80	10.70	10.40	10.20	9.90	9.70	9.40	9.20	9.00
6359765.00	10.70	10.60	10.30	10.10	9.90	9.60	9.40	9.10	8.90
6359760.00	10.60	10.50	10.20	10.00	9.80	9.50	9.30	9.00	8.80
6359755.00	10.50	10.40	10.10	9.90	9.70	9.40	9.20	8.90	8.70
6359750.00	10.40	10.30	10.00	9.80	9.60	9.30	9.10	8.90	8.60

*** AERMOD - VERSION 15181 *** *** C:\Users\OKI000\OKI000.isc
*** 02/02/17
*** AERMET - VERSION 15181 *** ***
*** 13:04:26

PAGE 9
**MODELOPTs: RegDFAULT CONC ELEV RURAL

*** NETWORK ID: UCART1 ; NETWORK TYPE: GRIDCART ***

* HILL HEIGHT SCALES IN METERS *

Y-COORD (METERS) | X-COORD (METERS)	385545.00	385550.00	385555.00	385560.00	385565.00	385570.00	385575.00	385580.00	385585.00
6359850.00	7.40	7.10	6.90	6.60	6.40	6.10	5.80	5.60	5.60
6359845.00	7.50	7.20	7.00	6.70	6.50	6.20	6.00	5.70	5.70
6359840.00	7.60	7.30	7.10	6.80	6.60	6.30	6.10	5.80	5.80
6359835.00	7.70	7.40	7.20	6.90	6.70	6.40	6.20	5.90	5.90
6359830.00	7.80	7.60	7.30	7.10	6.80	6.50	6.30	6.00	6.00
6359825.00	7.90	7.70	7.40	7.20	6.90	6.70	6.40	6.10	6.10
6359820.00	8.00	7.80	7.50	7.30	7.00	6.80	6.50	6.30	6.20
6359815.00	8.10	7.90	7.60	7.40	7.10	6.90	6.60	6.40	6.30
6359810.00	8.30	8.00	7.70	7.50	7.20	7.00	6.70	6.50	6.40
6359805.00	8.40	8.10	7.90	7.60	7.40	7.10	6.80	6.60	6.50
6359800.00	8.50	8.20	8.00	7.70	7.50	7.20	7.00	6.70	6.60
6359795.00	8.60	8.30	8.10	7.80	7.60	7.30	7.10	6.80	6.70
6359790.00	8.70	8.40	8.20	7.90	7.70	7.40	7.20	6.90	6.80
6359785.00	8.80	8.60	8.30	8.10	7.80	7.50	7.30	7.00	6.90
6359780.00	8.90	8.60	8.40	8.10	7.80	7.60	7.30	7.10	6.90
6359775.00	8.80	8.50	8.30	8.00	7.80	7.50	7.30	7.00	6.90
6359770.00	8.70	8.50	8.20	8.00	7.70	7.50	7.20	7.00	6.80
6359765.00	8.60	8.40	8.10	7.90	7.70	7.40	7.20	6.90	6.80
6359760.00	8.60	8.30	8.10	7.80	7.60	7.30	7.10	6.90	6.80
6359755.00	8.50	8.20	8.00	7.80	7.50	7.30	7.10	6.80	6.70
6359750.00	8.40	8.20	7.90	7.70	7.50	7.20	7.00	6.80	6.70

```
 *** AERMOD - VERSION  15181 ***   *** C:\Users\OKI000\OKI000.isc
 ***        02/02/17
 *** AERMET - VERSION  15181 ***   ***
 ***        13:04:26

PAGE  10
 **MODELOPTs:   RegDFAULT CONC      ELEV      RURAL

                                  *** NETWORK ID: UCART1   ;  NETWORK TYPE:
                                  GRIDCART ***

                                                * HILL HEIGHT SCALES IN
                                                METERS *

    Y-COORD  |                                               X-COORD
    (METERS)
    (METERS) |     385590.00    385595.00    385600.00
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

  6359850.00 |          5.60         5.60         5.60
  6359845.00 |          5.70         5.70         5.70
  6359840.00 |          5.80         5.80         5.80
  6359835.00 |          5.90         5.90         5.90
  6359830.00 |          6.00         6.00         6.00
  6359825.00 |          6.10         6.10         6.10
  6359820.00 |          6.20         6.20         6.10
  6359815.00 |          6.30         6.20         6.20
  6359810.00 |          6.40         6.30         6.30
  6359805.00 |          6.50         6.40         6.40
  6359800.00 |          6.50         6.50         6.50
  6359795.00 |          6.60         6.60         6.60
  6359790.00 |          6.70         6.70         6.60
  6359785.00 |          6.80         6.80         6.70
  6359780.00 |          6.90         6.80         6.80
  6359775.00 |          6.80         6.80         6.70
  6359770.00 |          6.80         6.80         6.70
  6359765.00 |          6.80         6.70         6.70
  6359760.00 |          6.70         6.70         6.70
  6359755.00 |          6.70         6.70         6.70
  6359750.00 |          6.70         6.70         6.70
```



```
 *** AERMOD - VERSION  15181 ***   *** C:\Users\OKI000\OKI000.isc
 ***        02/02/17
 *** AERMET - VERSION  15181 ***   ***
 ***        13:04:26

PAGE  11
 **MODELOPTs:   RegDFAULT CONC      ELEV      RURAL

                      * SOURCE-RECEPTOR COMBINATIONS FOR WHICH CALCULATIONS
                      MAY NOT BE PERFORMED *
                        LESS THAN 1.0 METER; WITHIN OPENPIT; OR BEYOND 80KM
                        FOR FASTAREA/FASTALL

                              SOURCE          - - RECEPTOR LOCATION - -
                              DISTANCE
                                ID            XR (METERS)   YR (METERS)
                                (METERS)
                            - - - - - - - - - - - - - - - - - - - - - - - -
                            - - - - - - -

                             EXC                 385550.0    6359800.0
                             -2.37
                             EXC                 385555.0    6359800.0
                             -0.37
```

```
 *** AERMOD - VERSION  15181 ***   *** C:\Users\OKI000\OKI000.isc
 ***        02/02/17
 *** AERMET - VERSION  15181 ***   ***
 ***        13:04:26

PAGE  12
 **MODELOPTs:   RegDFAULT CONC      ELEV      RURAL

                                        *** METEOROLOGICAL DAYS
                                        SELECTED FOR PROCESSING ***
                                                          (1=YES;
                                                          0=NO)

            1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1
            1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1
            1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1
            1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1
            1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1
            1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1
            1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1
            1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1
            1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1
            1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1
            1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1
            1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1
            1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1
            1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1
            1 1 1 1 1 1 1 1 1 1  1 1 1 1 1

                NOTE:  METEOROLOGICAL DATA ACTUALLY PROCESSED WILL ALSO
                DEPEND ON WHAT IS INCLUDED IN THE DATA FILE.


                              *** UPPER BOUND OF FIRST THROUGH FIFTH
                              WIND SPEED CATEGORIES ***
                                                       (METERS/SEC)

                                             1.54,   3.09,   5.14,
                                             8.23,  10.80,
```



```
 *** AERMOD - VERSION  15181 ***   *** C:\Users\OKI000\OKI000.isc
 ***        02/02/17
 *** AERMET - VERSION  15181 ***   ***
 ***        13:04:26

PAGE  13
 **MODELOPTs:   RegDFAULT CONC      ELEV      RURAL

                                    *** UP TO THE FIRST 24 HOURS OF
                                    METEOROLOGICAL DATA ***

   Surface file:   02 MET\OKI001.SFC
   Met Version:  15181
   Profile file:   02 MET\OKI001.PFL
   Surface format: FREE
   Profile format: FREE
   Surface station no.:    12345                  Upper air station no.:
   12345
                  Name: UNKNOWN                                     Name:
                  UNKNOWN
                  Year:   2014                                      Year:
                  2014

 First 24 hours of scalar data
 YR MO DY JDY HR     H0     U*     W*  DT/DZ ZICNV ZIMCH  M-O LEN    Z0
 BOWEN ALBEDO  REF WS   WD     HT  REF TA     HT
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
- - - - - - - - - - - - - - - - - - - - - - - - -
 14 03 01  60 01 -999.0 -9.000 -9.000 -9.000 -999. -999. -99999.0  0.70
 1.50   1.00  999.00  999.   -9.0  999.0   -9.0
 14 03 01  60 02  -34.8  0.321 -9.000 -9.000 -999.  436.     85.8  0.70
 1.50   1.00    2.60  200.   10.0  292.9    2.0
 14 03 01  60 03  -34.8  0.321 -9.000 -9.000 -999.  436.     85.8  0.70
 1.50   1.00    2.60  210.   10.0  292.9    2.0
 14 03 01  60 04  -34.8  0.321 -9.000 -9.000 -999.  436.     85.8  0.70
 1.50   1.00    2.60  210.   10.0  292.9    2.0
 14 03 01  60 05  -34.8  0.321 -9.000 -9.000 -999.  436.     85.7  0.70
 1.50   1.00    2.60  200.   10.0  292.8    2.0
 14 03 01  60 06  -31.6  0.331 -9.000 -9.000 -999.  457.    103.9  0.70
 1.50   1.00    2.60  200.   10.0  292.8    2.0
 14 03 01  60 07    8.1  0.242  0.224  0.005   50.  290.   -158.1  0.70
 1.50   0.41    1.50  210.   10.0  292.8    2.0
 14 03 01  60 08   89.6  0.292  0.946  0.005  341.  379.    -25.1  0.70
 1.50   0.25    1.50   40.   10.0  293.1    2.0
 14 03 01  60 09  169.7  0.394  1.397  0.005  582.  593.    -32.5  0.70
 1.50   0.20    2.10   40.   10.0  293.2    2.0
 14 03 01  60 10  231.6  0.324  1.697  0.005  763.  445.    -13.2  0.70
 1.50   0.19    1.50   70.   10.0  293.9    2.0
 14 03 01  60 11  187.5  0.531  1.765  0.005 1062.  928.    -72.1  0.70
 1.50   0.18    3.10   90.   10.0  294.6    2.0
 14 03 01  60 12  300.8  0.551  2.207  0.005 1295.  981.    -50.3  0.70
 1.50   0.18    3.10   90.   10.0  295.4    2.0
 14 03 01  60 13  290.6  0.482  2.291  0.005 1499.  809.    -34.9  0.70
 1.50   0.18    2.60   90.   10.0  295.4    2.0
 14 03 01  60 14  256.1  0.477  2.293  0.005 1705.  790.    -38.2  0.70
 1.50   0.18    2.60   80.   10.0  295.4    2.0
 14 03 01  60 15  234.9  0.473  2.313  0.005 1908.  781.    -40.7  0.70
 1.50   0.18    2.60  100.   10.0  295.5    2.0
 14 03 01  60 16  183.5  0.464  2.203  0.005 2110.  758.    -49.1  0.70
 1.50   0.20    2.60  100.   10.0  294.9    2.0
 14 03 01  60 17  106.4  0.444  1.897  0.005 2322.  711.    -74.3  0.70
 1.50   0.23    2.60  110.   10.0  293.9    2.0
 14 03 01  60 18   23.8  0.259  1.181  0.005 2501.  345.    -66.0  0.70
 1.50   0.36    1.50  140.   10.0  293.6    2.0
 14 03 01  60 19  -18.9  0.256 -9.000 -9.000 -999.  311.     80.1  0.70
 1.50   1.00    2.10  130.   10.0  293.8    2.0
 14 03 01  60 20  -62.3  0.578 -9.000 -9.000 -999. 1054.    279.9  0.70
```

```
 1.50   1.00    4.10  110.   10.0  294.4    2.0
 14 03 01  60 21  -43.8  0.413 -9.000 -9.000 -999.  661.    145.1  0.70
 1.50   1.00    3.10  120.   10.0  294.6    2.0
 14 03 01  60 22  -44.4  0.412 -9.000 -9.000 -999.  635.    142.2  0.70
 1.50   1.00    3.10  120.   10.0  294.4    2.0
 14 03 01  60 23  -39.8  0.419 -9.000 -9.000 -999.  651.    167.1  0.70
 1.50   1.00    3.10   90.   10.0  293.9    2.0
 14 03 01  60 24   -7.6  0.113 -9.000 -9.000 -999.  252.     17.1  0.70
 1.50   1.00    1.50   80.   10.0  293.4    2.0


 First hour of profile data
 YR MO DY HR HEIGHT F  WDIR    WSPD AMB_TMP sigmaA  sigmaW  sigmaV
 14 03 01 01   10.0 1 -999.  -99.00  -999.0   99.0  -99.00  -99.00

 F indicates top of profile (=1) or below (=0)
```



```
 *** AERMOD - VERSION  15181 ***   *** C:\Users\OKI000\OKI000.isc
 ***        02/02/17
 *** AERMET - VERSION  15181 ***   ***
 ***        13:04:26

PAGE  14
 **MODELOPTs:   RegDFAULT CONC      ELEV      RURAL

                              *** THE PERIOD (  8784 HRS) AVERAGE
                              CONCENTRATION   VALUES FOR SOURCE GROUP: ALL
                              ***
                                  INCLUDING SOURCE(S):     EXC        ,

                                   *** NETWORK ID: UCART1   ;  NETWORK
                                   TYPE: GRIDCART ***

                                        ** CONC OF TSP      IN MICROGRAMS/
                                        M**3                          **

    Y-COORD  |                                               X-COORD
    (METERS)
    (METERS) |     385500.00    385505.00    385510.00    385515.00
    385520.00    385525.00    385530.00    385535.00    385540.00
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

  6359850.00 |       0.00002      0.00002      0.00002      0.00002
  0.00002      0.00003      0.00003      0.00003      0.00003
  6359845.00 |       0.00002      0.00002      0.00002      0.00002
  0.00003      0.00003      0.00003      0.00004      0.00004
  6359840.00 |       0.00002      0.00002      0.00002      0.00003
  0.00003      0.00004      0.00004      0.00004      0.00005
  6359835.00 |       0.00002      0.00002      0.00003      0.00003
  0.00004      0.00004      0.00005      0.00005      0.00006
  6359830.00 |       0.00002      0.00003      0.00003      0.00004
  0.00004      0.00005      0.00006      0.00007      0.00008
  6359825.00 |       0.00003      0.00003      0.00003      0.00004
  0.00005      0.00006      0.00007      0.00009      0.00011
  6359820.00 |       0.00003      0.00003      0.00004      0.00005
  0.00006      0.00007      0.00009      0.00012      0.00015
  6359815.00 |       0.00003      0.00003      0.00004      0.00005
  0.00007      0.00009      0.00012      0.00016      0.00022
  6359810.00 |       0.00003      0.00004      0.00005      0.00006
  0.00008      0.00010      0.00014      0.00021      0.00034
  6359805.00 |       0.00003      0.00004      0.00005      0.00006
  0.00008      0.00011      0.00017      0.00027      0.00050
  6359800.00 |       0.00003      0.00004      0.00005      0.00006
  0.00009      0.00012      0.00018      0.00030      0.00061
  6359795.00 |       0.00003      0.00004      0.00005      0.00006
  0.00008      0.00012      0.00018      0.00029      0.00053
  6359790.00 |       0.00003      0.00004      0.00005      0.00006
  0.00008      0.00011      0.00016      0.00023      0.00036
  6359785.00 |       0.00003      0.00004      0.00005      0.00006
  0.00007      0.00010      0.00013      0.00017      0.00023
  6359780.00 |       0.00003      0.00004      0.00004      0.00005
  0.00006      0.00008      0.00010      0.00012      0.00015
  6359775.00 |       0.00003      0.00003      0.00004      0.00005
  0.00006      0.00007      0.00008      0.00009      0.00010
  6359770.00 |       0.00003      0.00003      0.00003      0.00004
  0.00005      0.00005      0.00006      0.00007      0.00008
  6359765.00 |       0.00002      0.00003      0.00003      0.00003
  0.00004      0.00004      0.00005      0.00005      0.00006
  6359760.00 |       0.00002      0.00002      0.00003      0.00003
  0.00003      0.00004      0.00004      0.00004      0.00004
  6359755.00 |       0.00002      0.00002      0.00002      0.00003
  0.00003      0.00003      0.00003      0.00003      0.00004
  6359750.00 |       0.00002      0.00002      0.00002      0.00002
```

```
  0.00002      0.00003      0.00003      0.00003      0.00003
```



```
 *** AERMOD - VERSION  15181 ***   *** C:\Users\OKI000\OKI000.isc
 ***         02/02/17
 *** AERMET - VERSION  15181 ***   ***
 ***         13:04:26

PAGE  15
 **MODELOPTs:   RegDFAULT CONC      ELEV      RURAL

                              *** THE PERIOD (  8784 HRS) AVERAGE
                              CONCENTRATION   VALUES FOR SOURCE GROUP: ALL
                              ***
                                  INCLUDING SOURCE(S):     EXC        ,

                                   *** NETWORK ID: UCART1   ;  NETWORK
                                   TYPE: GRIDCART ***

                                        ** CONC OF TSP      IN MICROGRAMS/
                                        M**3                             **

    Y-COORD  |                                                X-COORD
    (METERS)
    (METERS) |     385545.00    385550.00    385555.00    385560.00
    385565.00    385570.00    385575.00    385580.00    385585.00
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

  6359850.00 |       0.00003      0.00003      0.00003      0.00003
  0.00003      0.00003      0.00003      0.00002      0.00002
  6359845.00 |       0.00004      0.00004      0.00004      0.00004
  0.00004      0.00003      0.00003      0.00003      0.00003
  6359840.00 |       0.00005      0.00005      0.00005      0.00005
  0.00005      0.00004      0.00004      0.00003      0.00003
  6359835.00 |       0.00007      0.00007      0.00007      0.00006
  0.00006      0.00005      0.00005      0.00004      0.00003
  6359830.00 |       0.00009      0.00009      0.00009      0.00008
  0.00008      0.00007      0.00006      0.00005      0.00004
  6359825.00 |       0.00012      0.00013      0.00013      0.00012
  0.00010      0.00008      0.00007      0.00005      0.00005
  6359820.00 |       0.00018      0.00020      0.00020      0.00017
  0.00014      0.00011      0.00008      0.00006      0.00005
  6359815.00 |       0.00030      0.00035      0.00033      0.00027
  0.00019      0.00014      0.00010      0.00008      0.00006
  6359810.00 |       0.00055      0.00076      0.00069      0.00045
  0.00027      0.00017      0.00012      0.00009      0.00006
  6359805.00 |       0.00113      0.00260      0.00193      0.00077
  0.00037      0.00021      0.00013      0.00009      0.00007
  6359800.00 |       0.00180      0.00000      0.00000      0.00101
  0.00041      0.00022      0.00014      0.00010      0.00007
  6359795.00 |       0.00118      0.00257      0.00189      0.00076
  0.00037      0.00021      0.00013      0.00009      0.00007
  6359790.00 |       0.00055      0.00073      0.00066      0.00044
  0.00027      0.00017      0.00012      0.00008      0.00006
  6359785.00 |       0.00029      0.00033      0.00032      0.00026
  0.00019      0.00014      0.00010      0.00007      0.00006
  6359780.00 |       0.00017      0.00019      0.00019      0.00016
  0.00013      0.00011      0.00008      0.00006      0.00005
  6359775.00 |       0.00012      0.00012      0.00012      0.00011
  0.00010      0.00008      0.00007      0.00005      0.00004
  6359770.00 |       0.00008      0.00009      0.00008      0.00008
  0.00007      0.00006      0.00005      0.00005      0.00004
  6359765.00 |       0.00006      0.00006      0.00006      0.00006
  0.00006      0.00005      0.00004      0.00004      0.00003
  6359760.00 |       0.00005      0.00005      0.00005      0.00005
  0.00004      0.00004      0.00004      0.00003      0.00003
  6359755.00 |       0.00004      0.00004      0.00004      0.00004
  0.00004      0.00003      0.00003      0.00003      0.00003
  6359750.00 |       0.00003      0.00003      0.00003      0.00003
```

0.00003 0.00003 0.00003 0.00002 0.00002

*** AERMOD - VERSION 15181 *** *** C:\Users\OKI000\OKI000.isc
*** 02/02/17
*** AERMET - VERSION 15181 *** ***
*** 13:04:26

PAGE 16
**MODELOPTs: RegDFAULT CONC ELEV RURAL

*** THE PERIOD (8784 HRS) AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): EXC ,

*** NETWORK ID: UCART1 ; NETWORK TYPE: GRIDCART ***

** CONC OF TSP IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS)		
	385590.00	385595.00	385600.00
6359850.00	0.00002	0.00002	0.00002
6359845.00	0.00002	0.00002	0.00002
6359840.00	0.00003	0.00002	0.00002
6359835.00	0.00003	0.00003	0.00002
6359830.00	0.00003	0.00003	0.00002
6359825.00	0.00004	0.00003	0.00003
6359820.00	0.00004	0.00003	0.00003
6359815.00	0.00005	0.00004	0.00003
6359810.00	0.00005	0.00004	0.00003
6359805.00	0.00005	0.00004	0.00003
6359800.00	0.00005	0.00004	0.00003
6359795.00	0.00005	0.00004	0.00003
6359790.00	0.00005	0.00004	0.00003
6359785.00	0.00005	0.00004	0.00003
6359780.00	0.00004	0.00003	0.00003
6359775.00	0.00004	0.00003	0.00003
6359770.00	0.00003	0.00003	0.00002
6359765.00	0.00003	0.00003	0.00002
6359760.00	0.00003	0.00002	0.00002
6359755.00	0.00002	0.00002	0.00002
6359750.00	0.00002	0.00002	0.00002

*** AERMOD - VERSION 15181 *** *** C:\Users\OKI000\OKI000.isc
*** 02/02/17
*** AERMET - VERSION 15181 *** ***
*** 13:04:26

PAGE 17
**MODELOPTs: RegDFAULT CONC ELEV RURAL

*** THE 1ST HIGHEST 1-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): EXC ,

*** NETWORK ID: UCART1 ; NETWORK TYPE: GRIDCART ***

** CONC OF TSP IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS) 385500.00	385505.00	385510.00	385515.00	385520.00
6359850.0	0.00115 (14120519)	0.00098 (14120519)	0.00106 (14041819)	0.00116 (14041819)	0.00126 (14041819)
6359845.0	0.00160 (14120519)	0.00143 (14120519)	0.00122 (14120519)	0.00128 (14041819)	0.00141 (14041819)
6359840.0	0.00218 (14120519)	0.00204 (14120519)	0.00182 (14120519)	0.00154 (14120519)	0.00159 (14041819)
6359835.0	0.00286 (14120519)	0.00281 (14120519)	0.00266 (14120519)	0.00239 (14120519)	0.00199 (14120519)
6359830.0	0.00358 (14120519)	0.00370 (14120519)	0.00371 (14120519)	0.00358 (14120519)	0.00324 (14120519)
6359825.0	0.00423 (14120519)	0.00458 (14120519)	0.00489 (14120519)	0.00508 (14120519)	0.00503 (14120519)
6359820.0	0.00468 (14120519)	0.00529 (14120519)	0.00597 (14120519)	0.00664 (14120519)	0.00723 (14120519)
6359815.0	0.00479 (14120519)	0.00561 (14120519)	0.00664 (14120519)	0.00786 (14120519)	0.00931 (14120519)
6359810.0	0.00448 (14120519)	0.00538 (14120519)	0.00659 (14120519)	0.00818 (14120519)	0.01037 (14120519)
6359805.0	0.00408 (14091419)	0.00486 (14091419)	0.00588 (14091419)	0.00728 (14120519)	0.00959 (14120519)
6359800.0	0.00291 (14091419)	0.00348 (14091419)	0.00423 (14120519)	0.00537 (14120519)	0.00704 (14120519)
6359795.0	0.00191 (14120519)	0.00224 (14120519)	0.00269 (14052218)	0.00330 (14052218)	0.00411 (14052218)
6359790.0	0.00197 (14052218)	0.00225 (14052218)	0.00257 (14052218)	0.00296 (14052218)	0.00432 (14120419)
6359785.0	0.00167 (14052218)	0.00222 (14120419)	0.00301 (14060119)	0.00416 (14060119)	0.00561 (14060119)
6359780.0	0.00225 (14060119)	0.00291 (14060119)	0.00371 (14060119)	0.00455 (14060119)	0.00531 (14060119)
6359775.0	0.00270 (14060119)	0.00319 (14060119)	0.00366 (14060119)	0.00396 (14060119)	0.00394 (14060119)
6359770.0	0.00272 (14060119)	0.00294 (14060119)	0.00302 (14060119)	0.00286 (14060119)	0.00278 (14061917)
6359765.0	0.00239 (14060119)	0.00235 (14060119)	0.00217 (14120419)	0.00221 (14061917)	0.00262 (14070319)
6359760.0	0.00187 (14060119)	0.00177 (14061917)	0.00182 (14061917)	0.00212 (14070319)	0.00235 (14070319)
6359755.0	0.00151 (14061917)	0.00152 (14061917)	0.00177 (14070319)	0.00198 (14070319)	0.00192 (14070319)
6359750.0	0.00130 (14061917)	0.00149 (14070319)	0.00168		

(14070319) 0.00168 (14070319) 0.00145 (14070319)

```
*** AERMOD - VERSION  15181 ***   *** C:\Users\OKI000\OKI000.isc
***        02/02/17
*** AERMET - VERSION  15181 ***   ***
***        13:04:26

PAGE  18
 **MODELOPTs:   RegDFAULT CONC      ELEV      RURAL

                              *** THE   1ST HIGHEST  1-HR AVERAGE
                              CONCENTRATION   VALUES FOR SOURCE GROUP:  ALL
                              ***
                                  INCLUDING SOURCE(S):     EXC         ,

                                   *** NETWORK ID: UCART1   ;  NETWORK
                                   TYPE: GRIDCART ***

                                        ** CONC OF TSP      IN MICROGRAMS/
                                        M**3                          **

  Y-COORD  |                                                 X-COORD
  (METERS)
  (METERS) |       385525.00               385530.00
  385535.00              385540.00              385545.00
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

 6359850.0 |      0.00136 (14041819)      0.00145 (14041819)      0.00167
 (14112319)      0.00244 (14091018)      0.00321 (14091018)
 6359845.0 |      0.00154 (14041819)      0.00167 (14041819)      0.00187
 (14112319)      0.00267 (14091018)      0.00368 (14091018)
 6359840.0 |      0.00176 (14041819)      0.00194 (14041819)      0.00210
 (14112319)      0.00293 (14091018)      0.00427 (14091018)
 6359835.0 |      0.00203 (14041819)      0.00227 (14041819)      0.00251
 (14041819)      0.00321 (14112319)      0.00503 (14091018)
 6359830.0 |      0.00268 (14120519)      0.00269 (14041819)      0.00305
 (14041819)      0.00383 (14112319)      0.00601 (14091018)
 6359825.0 |      0.00464 (14120519)      0.00377 (14120519)      0.00377
 (14041819)      0.00460 (14112319)      0.00729 (14091018)
 6359820.0 |      0.00751 (14120519)      0.00711 (14120519)      0.00567
 (14120519)      0.00566 (14041819)      0.00892 (14091018)
 6359815.0 |      0.01084 (14120519)      0.01213 (14120519)      0.01216
 (14120519)      0.00938 (14120519)      0.01226 (14112319)
 6359810.0 |      0.01331 (14120519)      0.01732 (14120519)      0.02204
 (14120519)      0.02509 (14120519)      0.01802 (14120519)
 6359805.0 |      0.01309 (14120519)      0.01887 (14120519)      0.02883
 (14120519)      0.04718 (14120519)      0.07337 (14120519)
 6359800.0 |      0.00960 (14120519)      0.01398 (14120519)      0.02215
 (14120519)      0.04082 (14120519)      0.09530 (14120519)
 6359795.0 |      0.00529 (14052218)      0.00699 (14052218)      0.01266
 (14060119)      0.02501 (14060119)      0.04297 (14060119)
 6359790.0 |      0.00661 (14060119)      0.00999 (14060119)      0.01428
 (14060119)      0.01673 (14060119)      0.01707 (14070319)
 6359785.0 |      0.00729 (14060119)      0.00862 (14060119)      0.00859
 (14060119)      0.00964 (14070319)      0.00905 (14041819)
 6359780.0 |      0.00564 (14060119)      0.00519 (14120419)      0.00623
 (14070319)      0.00577 (14070319)      0.00621 (14041819)
 6359775.0 |      0.00363 (14061917)      0.00444 (14070319)      0.00450
 (14070319)      0.00411 (14041819)      0.00462 (14041819)
 6359770.0 |      0.00333 (14070319)      0.00356 (14070319)      0.00288
 (14041819)      0.00325 (14041819)      0.00357 (14041819)
 6359765.0 |      0.00286 (14070319)      0.00250 (14070319)      0.00241
 (14041819)      0.00265 (14041819)      0.00285 (14041819)
 6359760.0 |      0.00219 (14070319)      0.00185 (14041819)      0.00204
 (14041819)      0.00220 (14041819)      0.00232 (14041819)
 6359755.0 |      0.00156 (14070319)      0.00161 (14041819)      0.00175
 (14041819)      0.00185 (14041819)      0.00193 (14041819)
 6359750.0 |      0.00131 (14041819)      0.00141 (14041819)      0.00150
```



```
 (14041819)      0.00158 (14041819)      0.00164 (14041819)
```

*** AERMOD - VERSION 15181 *** *** C:\Users\OKI000\OKI000.isc
*** 02/02/17
*** AERMET - VERSION 15181 *** ***
*** 13:04:26

PAGE 19
**MODELOPTs: RegDFAULT CONC ELEV RURAL

*** THE 1ST HIGHEST 1-HR AVERAGE
CONCENTRATION VALUES FOR SOURCE GROUP: ALL
***
INCLUDING SOURCE(S): EXC ,

*** NETWORK ID: UCART1 ; NETWORK
TYPE: GRIDCART ***

** CONC OF TSP IN MICROGRAMS/
M**3 **

Y-COORD | X-COORD
(METERS)
(METERS) | 385550.00 385555.00
385560.00 385565.00 385570.00
- -
- -

6359850.0 | 0.00361 (14091018) 0.00348 (14091018) 0.00384
(14032819) 0.00402 (14032819) 0.00390 (14032819)
6359845.0 | 0.00422 (14091018) 0.00413 (14032819) 0.00461
(14032819) 0.00473 (14032819) 0.00445 (14032819)
6359840.0 | 0.00503 (14091018) 0.00510 (14032819) 0.00561
(14032819) 0.00560 (14032819) 0.00507 (14032819)
6359835.0 | 0.00615 (14091018) 0.00645 (14032819) 0.00697
(14032819) 0.00670 (14032819) 0.00577 (14032819)
6359830.0 | 0.00777 (14091018) 0.00844 (14032819) 0.00890
(14032819) 0.00806 (14032819) 0.00650 (14032819)
6359825.0 | 0.01020 (14091018) 0.01150 (14032819) 0.01159
(14032819) 0.00972 (14032819) 0.00746 (14060418)
6359820.0 | 0.01418 (14091018) 0.01661 (14032819) 0.01552
(14032819) 0.01160 (14032819) 0.00915 (14060418)
6359815.0 | 0.02144 (14091018) 0.02603 (14032819) 0.02120
(14032819) 0.01423 (14060418) 0.00832 (14060418)
6359810.0 | 0.03931 (14032819) 0.04584 (14032819) 0.02838
(14032819) 0.01575 (14062018) 0.01619 (14062018)
6359805.0 | 0.09529 (14032819) 0.09283 (14032819) 0.04676
(14062018) 0.03235 (14062018) 0.02054 (14062018)
6359800.0 | 0.00000 (00000000) 0.00000 (00000000) 0.04331
(14062018) 0.01943 (14062018) 0.01037 (14062018)
6359795.0 | 0.06370 (14112419) 0.07174 (14112419) 0.03027
(14112419) 0.01441 (14043019) 0.01033 (14043019)
6359790.0 | 0.02529 (14112419) 0.03256 (14112419) 0.02331
(14112419) 0.01376 (14112419) 0.00790 (14112419)
6359785.0 | 0.01334 (14112419) 0.01738 (14112419) 0.01570
(14112419) 0.01162 (14112419) 0.00789 (14112419)
6359780.0 | 0.00828 (14112419) 0.01064 (14112419) 0.01071
(14112419) 0.00911 (14112419) 0.00706 (14112419)
6359775.0 | 0.00566 (14112419) 0.00716 (14112419) 0.00761
(14112419) 0.00707 (14112419) 0.00598 (14112419)
6359770.0 | 0.00411 (14112419) 0.00513 (14112419) 0.00563
(14112419) 0.00552 (14112419) 0.00500 (14112419)
6359765.0 | 0.00313 (14112419) 0.00385 (14112419) 0.00430
(14112419) 0.00439 (14112419) 0.00415 (14112419)
6359760.0 | 0.00246 (14112419) 0.00300 (14112419) 0.00338
(14112419) 0.00354 (14112419) 0.00346 (14112419)
6359755.0 | 0.00199 (14112419) 0.00240 (14112419) 0.00272
(14112419) 0.00289 (14112419) 0.00291 (14112419)
6359750.0 | 0.00166 (14041819) 0.00196 (14112419) 0.00223

(14112419) 0.00241 (14112419) 0.00247 (14112419)

```
 *** AERMOD - VERSION  15181 ***   *** C:\Users\OKI000\OKI000.isc
 ***        02/02/17
 *** AERMET - VERSION  15181 ***   ***
 ***        13:04:26

PAGE  20
 **MODELOPTs:   RegDFAULT CONC      ELEV      RURAL

                              *** THE   1ST HIGHEST  1-HR AVERAGE
                              CONCENTRATION   VALUES FOR SOURCE GROUP:  ALL
                              ***
                                  INCLUDING SOURCE(S):     EXC         ,

                                   *** NETWORK ID: UCART1   ;  NETWORK
                                   TYPE: GRIDCART ***

                                        ** CONC OF TSP      IN MICROGRAMS/
                                        M**3                          **

  Y-COORD  |                                                 X-COORD
  (METERS)
  (METERS) |       385575.00               385580.00
  385585.00               385590.00               385595.00
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

 6359850.0 |      0.00354 (14032819)      0.00307 (14032819)      0.00257
 (14032819)      0.00270 (14060418)      0.00258 (14060418)
 6359845.0 |      0.00392 (14032819)      0.00325 (14032819)      0.00311
 (14060418)      0.00304 (14060418)      0.00260 (14060418)
 6359840.0 |      0.00428 (14032819)      0.00361 (14060418)      0.00363
 (14060418)      0.00311 (14060418)      0.00236 (14060418)
 6359835.0 |      0.00462 (14032819)      0.00443 (14060418)      0.00381
 (14060418)      0.00282 (14060418)      0.00198 (14071419)
 6359830.0 |      0.00565 (14060418)      0.00480 (14060418)      0.00344
 (14060418)      0.00236 (14071419)      0.00208 (14062018)
 6359825.0 |      0.00642 (14060418)      0.00434 (14060418)      0.00287
 (14071419)      0.00323 (14062018)      0.00366 (14062018)
 6359820.0 |      0.00581 (14060418)      0.00444 (14062018)      0.00516
 (14062018)      0.00543 (14062018)      0.00533 (14062018)
 6359815.0 |      0.00817 (14062018)      0.00845 (14062018)      0.00795
 (14062018)      0.00710 (14062018)      0.00611 (14062018)
 6359810.0 |      0.01382 (14062018)      0.01109 (14062018)      0.00872
 (14062018)      0.00684 (14062018)      0.00534 (14062018)
 6359805.0 |      0.01329 (14062018)      0.00898 (14062018)      0.00632
 (14062018)      0.00461 (14062018)      0.00343 (14062018)
 6359800.0 |      0.00659 (14043019)      0.00478 (14043019)      0.00370
 (14043019)      0.00295 (14043019)      0.00243 (14043019)
 6359795.0 |      0.00763 (14043019)      0.00577 (14043019)      0.00456
 (14043019)      0.00369 (14043019)      0.00306 (14043019)
 6359790.0 |      0.00514 (14043019)      0.00455 (14043019)      0.00398
 (14043019)      0.00346 (14043019)      0.00301 (14043019)
 6359785.0 |      0.00527 (14112419)      0.00354 (14112419)      0.00256
 (14043019)      0.00249 (14043019)      0.00237 (14043019)
 6359780.0 |      0.00519 (14112419)      0.00376 (14112419)      0.00273
 (14112419)      0.00203 (14112419)      0.00162 (14041819)
 6359775.0 |      0.00478 (14112419)      0.00369 (14112419)      0.00283
 (14112419)      0.00216 (14112419)      0.00167 (14112419)
 6359770.0 |      0.00425 (14112419)      0.00348 (14112419)      0.00279
 (14112419)      0.00223 (14112419)      0.00177 (14112419)
 6359765.0 |      0.00372 (14112419)      0.00319 (14112419)      0.00268
 (14112419)      0.00222 (14112419)      0.00181 (14112419)
 6359760.0 |      0.00323 (14112419)      0.00289 (14112419)      0.00251
 (14112419)      0.00214 (14112419)      0.00180 (14112419)
 6359755.0 |      0.00280 (14112419)      0.00258 (14112419)      0.00232
 (14112419)      0.00204 (14112419)      0.00176 (14112419)
 6359750.0 |      0.00242 (14112419)      0.00230 (14112419)      0.00212
```



```
 (14112419)      0.00192 (14112419)      0.00170 (14112419)
```

*** AERMOD - VERSION 15181 *** *** C:\Users\OKI000\OKI000.isc
*** 02/02/17
*** AERMET - VERSION 15181 *** ***
*** 13:04:26

PAGE 21
**MODELOPTs: RegDFAULT CONC ELEV RURAL

*** THE 1ST HIGHEST 1-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): EXC ,

*** NETWORK ID: UCART1 ; NETWORK TYPE: GRIDCART ***

** CONC OF TSP IN MICROGRAMS/M**3 **

Y-COORD (METERS) | X-COORD (METERS)	385600.00
6359850.0	0.00222 (14060418)
6359845.0	0.00201 (14060418)
6359840.0	0.00168 (14071419)
6359835.0	0.00167 (14071419)
6359830.0	0.00248 (14062018)
6359825.0	0.00386 (14062018)
6359820.0	0.00497 (14062018)
6359815.0	0.00518 (14062018)
6359810.0	0.00422 (14062018)
6359805.0	0.00262 (14062018)
6359800.0	0.00204 (14043019)
6359795.0	0.00258 (14043019)
6359790.0	0.00263 (14043019)
6359785.0	0.00220 (14043019)
6359780.0	0.00154 (14043019)
6359775.0	0.00131 (14041819)
6359770.0	0.00140 (14112419)
6359765.0	0.00147 (14112419)
6359760.0	0.00150 (14112419)
6359755.0	0.00151 (14112419)
6359750.0	0.00148 (14112419)

*** AERMOD - VERSION 15181 *** *** C:\Users\OKI000\OKI000.isc
*** 02/02/17
*** AERMET - VERSION 15181 *** ***
*** 13:04:26

PAGE 22
**MODELOPTs: RegDFAULT CONC ELEV RURAL

*** THE 9TH HIGHEST 1-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): EXC ,

*** NETWORK ID: UCART1 ; NETWORK TYPE: GRIDCART ***

** CONC OF TSP IN MICROGRAMS/M**3 **

Y-COORD (METERS) | X-COORD (METERS)	385500.00	385505.00	385510.00	385515.00	385520.00
6359850.0	0.00052 (14052517)	0.00053 (14052517)	0.00061 (15013019)	0.00063 (14120519)	0.00067 (14112419)
6359845.0	0.00058 (14052517)	0.00061 (14052517)	0.00064 (14112319)	0.00074 (14112319)	0.00076 (14112419)
6359840.0	0.00055 (14112319)	0.00069 (14052517)	0.00073 (14052517)	0.00080 (14112319)	0.00095 (14112319)
6359835.0	0.00060 (14112319)	0.00067 (14112319)	0.00087 (14080818)	0.00090 (14052517)	0.00103 (14112319)
6359830.0	0.00064 (14112319)	0.00072 (14052517)	0.00084 (14112319)	0.00105 (14080818)	0.00114 (14112319)
6359825.0	0.00069 (14112419)	0.00078 (15013019)	0.00089 (14072318)	0.00106 (14052517)	0.00131 (14080818)
6359820.0	0.00073 (14112419)	0.00085 (14112419)	0.00100 (14083119)	0.00119 (14112319)	0.00137 (14091419)
6359815.0	0.00076 (14112319)	0.00089 (14112319)	0.00108 (14112419)	0.00130 (14090718)	0.00162 (14112319)
6359810.0	0.00085 (14053019)	0.00093 (14033119)	0.00110 (14083119)	0.00136 (14083119)	0.00174 (14051319)
6359805.0	0.00114 (14032819)	0.00131 (14033119)	0.00152 (14033119)	0.00179 (14033119)	0.00216 (14033119)
6359800.0	0.00114 (14032819)	0.00136 (14032819)	0.00166 (14032819)	0.00208 (14032819)	0.00263 (14033119)
6359795.0	0.00114 (14033119)	0.00134 (14032819)	0.00163 (14032819)	0.00194 (14053019)	0.00240 (14120419)
6359790.0	0.00108 (14040119)	0.00129 (14060119)	0.00154 (14100518)	0.00181 (14052617)	0.00257 (14051717)
6359785.0	0.00102 (14052617)	0.00131 (14051717)	0.00158 (14041819)	0.00190 (14090919)	0.00231 (14061217)
6359780.0	0.00105 (14090919)	0.00121 (14080419)	0.00150 (14041819)	0.00189 (14061917)	0.00225 (14090919)
6359775.0	0.00106 (14041819)	0.00124 (14032219)	0.00156 (14080419)	0.00168 (14090919)	0.00208 (14031519)
6359770.0	0.00109 (14052717)	0.00125 (14080419)	0.00137 (14031519)	0.00166 (14031519)	0.00185 (14051519)
6359765.0	0.00101 (14080419)	0.00118 (14031519)	0.00135 (14042018)	0.00143 (14041819)	0.00146 (14120419)
6359760.0	0.00102 (14031519)	0.00107 (14090119)	0.00117 (14031519)	0.00114 (14120419)	0.00121 (14052718)
6359755.0	0.00092 (14090119)	0.00098 (14031519)	0.00092 (14120419)	0.00097 (14032819)	0.00080 (14042818)
6359750.0	0.00084 (14031519)	0.00077 (14031519)	0.00080		

(14032819) 0.00073 (14042818) 0.00066 (14112319)

*** AERMOD - VERSION 15181 *** *** C:\Users\OKI000\OKI000.isc
*** 02/02/17
*** AERMET - VERSION 15181 *** ***
*** 13:04:26

PAGE 23
**MODELOPTs: RegDFAULT CONC ELEV RURAL

*** THE 9TH HIGHEST 1-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): EXC ,

*** NETWORK ID: UCART1 ; NETWORK TYPE: GRIDCART ***

** CONC OF TSP IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS) 385525.00	385530.00	385535.00	385540.00	385545.00
6359850.0	0.00072 (14112419)	0.00087 (14051218)	0.00087 (14072219)	0.00085 (14112419)	0.00077 (14082419)
6359845.0	0.00092 (14082418)	0.00090 (14112419)	0.00102 (14032319)	0.00101 (14112419)	0.00102 (14082419)
6359840.0	0.00096 (14112419)	0.00107 (14050118)	0.00126 (14051218)	0.00122 (14112419)	0.00122 (14053018)
6359835.0	0.00126 (14032319)	0.00129 (14082418)	0.00146 (14051218)	0.00154 (14032319)	0.00154 (14051218)
6359830.0	0.00140 (14112319)	0.00171 (14032319)	0.00179 (14050118)	0.00204 (14051218)	0.00204 (14051218)
6359825.0	0.00156 (14112319)	0.00192 (15013019)	0.00248 (14032319)	0.00255 (14051218)	0.00280 (14112419)
6359820.0	0.00170 (14052517)	0.00229 (14112319)	0.00296 (14032319)	0.00356 (14072218)	0.00402 (14051218)
6359815.0	0.00207 (15013019)	0.00243 (14091419)	0.00374 (14112319)	0.00521 (14032319)	0.00617 (14112419)
6359810.0	0.00232 (14112319)	0.00313 (14090718)	0.00453 (15013019)	0.00693 (14060517)	0.01047 (14050118)
6359805.0	0.00264 (14033119)	0.00338 (14080819)	0.00514 (14051319)	0.00871 (14090718)	0.01761 (14032319)
6359800.0	0.00339 (14033119)	0.00463 (14033119)	0.00678 (14033119)	0.01122 (14033119)	0.02701 (14112419)
6359795.0	0.00324 (14052617)	0.00462 (14061217)	0.00760 (14032819)	0.01265 (14052218)	0.02512 (14052717)
6359790.0	0.00331 (14061217)	0.00429 (14112119)	0.00664 (14041819)	0.00983 (14051717)	0.01213 (14061917)
6359785.0	0.00314 (14090919)	0.00397 (14041819)	0.00532 (14042018)	0.00634 (14120419)	0.00470 (14102819)
6359780.0	0.00269 (14041819)	0.00339 (14041819)	0.00379 (14032819)	0.00332 (14112319)	0.00247 (14070318)
6359775.0	0.00241 (14041819)	0.00253 (14102819)	0.00229 (14042818)	0.00202 (14102819)	0.00184 (14062119)
6359770.0	0.00189 (14102819)	0.00188 (14042818)	0.00168 (14112319)	0.00130 (14070318)	0.00138 (14101319)
6359765.0	0.00155 (14032819)	0.00123 (14112319)	0.00113 (14102819)	0.00106 (14062119)	0.00109 (14101319)
6359760.0	0.00094 (14112419)	0.00104 (14112319)	0.00082 (14070318)	0.00085 (14101319)	0.00089 (14101319)
6359755.0	0.00081 (14112319)	0.00072 (14102819)	0.00070 (14062119)	0.00071 (14101319)	0.00074 (14101319)
6359750.0	0.00071 (14102819)	0.00057 (14070318)	0.00059		

(14090119) 0.00061 (14101319) 0.00063 (14043018)

*** AERMOD - VERSION 15181 ***   *** C:\Users\OKI000\OKI000.isc
***   02/02/17
*** AERMET - VERSION 15181 ***   ***
***   13:04:26

PAGE 24
**MODELOPTs: RegDFAULT CONC ELEV RURAL

*** THE 9TH HIGHEST 1-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): EXC ,

*** NETWORK ID: UCART1 ; NETWORK TYPE: GRIDCART ***

** CONC OF TSP IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS) 385550.00	385555.00	385560.00	385565.00	385570.00
6359850.0	0.00079 (14070217)	0.00082 (14052118)	0.00079 (14060417)	0.00080 (14040518)	0.00076 (14053017)
6359845.0	0.00092 (14070217)	0.00094 (14052118)	0.00093 (14060417)	0.00092 (14040518)	0.00099 (14060118)
6359840.0	0.00109 (14070217)	0.00111 (14060417)	0.00121 (14040518)	0.00111 (14060118)	0.00117 (14072119)
6359835.0	0.00133 (14032919)	0.00138 (14060417)	0.00147 (14040518)	0.00145 (14060118)	0.00126 (14072119)
6359830.0	0.00167 (14070217)	0.00175 (14060417)	0.00184 (14040518)	0.00186 (14072119)	0.00146 (14032519)
6359825.0	0.00228 (14051218)	0.00235 (14060518)	0.00261 (14112419)	0.00226 (14112419)	0.00197 (14032519)
6359820.0	0.00348 (14082418)	0.00354 (14053018)	0.00360 (14060118)	0.00300 (14112419)	0.00213 (14060118)
6359815.0	0.00597 (14072218)	0.00599 (14060418)	0.00539 (14060118)	0.00378 (14032519)	0.00268 (14052319)
6359810.0	0.01187 (14051218)	0.01074 (14040518)	0.00836 (14061118)	0.00492 (14052319)	0.00349 (14052319)
6359805.0	0.02894 (14082419)	0.03313 (14061118)	0.01124 (14092919)	0.00534 (14060418)	0.00317 (14092518)
6359800.0	0.00000 (00000000)	0.00000 (00000000)	0.01148 (14092919)	0.00547 (14092919)	0.00313 (14092919)
6359795.0	0.03086 (14051519)	0.01573 (14043019)	0.00753 (14051918)	0.00423 (14072419)	0.00268 (14070318)
6359790.0	0.00730 (14070418)	0.00707 (14052219)	0.00505 (14062119)	0.00348 (14062119)	0.00240 (14070318)
6359785.0	0.00412 (14062119)	0.00409 (14062119)	0.00348 (14062119)	0.00271 (14072419)	0.00204 (14072419)
6359780.0	0.00274 (14062119)	0.00273 (14062119)	0.00247 (14070318)	0.00208 (14062119)	0.00169 (14062119)
6359775.0	0.00198 (14062119)	0.00197 (14072419)	0.00183 (14070318)	0.00162 (14062119)	0.00137 (14062119)
6359770.0	0.00144 (14101319)	0.00149 (14072419)	0.00142 (14062119)	0.00128 (14070318)	0.00113 (14062119)
6359765.0	0.00113 (14101319)	0.00113 (14043018)	0.00113 (14070318)	0.00104 (14070318)	0.00093 (14070318)
6359760.0	0.00091 (14043018)	0.00091 (14101319)	0.00092 (14070318)	0.00086 (14070318)	0.00078 (14070318)
6359755.0	0.00076 (14043018)	0.00075 (14043018)	0.00077 (14072419)	0.00072 (14062119)	0.00067 (14070318)
6359750.0	0.00064 (14043018)	0.00063 (14043018)	0.00065		

(14062119) 0.00062 (14062119) 0.00058 (14070318)


```
*** AERMOD - VERSION  15181 ***   *** C:\Users\OKI000\OKI000.isc
***         02/02/17
*** AERMET - VERSION  15181 ***   ***
***         13:04:26

PAGE  25
**MODELOPTs:   RegDFAULT CONC      ELEV      RURAL

                    *** THE   9TH HIGHEST  1-HR AVERAGE
                    CONCENTRATION   VALUES FOR SOURCE GROUP:  ALL
                    ***
                       INCLUDING SOURCE(S):     EXC        ,

                        *** NETWORK ID: UCART1   ;  NETWORK
                        TYPE: GRIDCART ***

                            ** CONC OF TSP      IN MICROGRAMS/
                            M**3                           **

 Y-COORD  |                                                 X-COORD
 (METERS)
 (METERS) |       385575.00            385580.00
 385585.00            385590.00            385595.00
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
- - - - - - - - - - - - - - - - - - - - - - - - - - - - -

6359850.0 |      0.00071 (14112419)     0.00062 (14072119)      0.00061
(14112419)     0.00056 (14112419)     0.00052 (14112419)
6359845.0 |      0.00082 (14112419)     0.00075 (14112419)      0.00068
(14112419)     0.00063 (14112419)     0.00050 (14060118)
6359840.0 |      0.00089 (14032519)     0.00089 (14061118)      0.00077
(14112419)     0.00061 (14060118)     0.00053 (14052319)
6359835.0 |      0.00113 (14071419)     0.00099 (14112419)      0.00077
(14060118)     0.00073 (14060518)     0.00061 (14032519)
6359830.0 |      0.00134 (14112419)     0.00101 (14060118)      0.00095
(14060518)     0.00072 (14032519)     0.00065 (14092919)
6359825.0 |      0.00141 (14060118)     0.00125 (14032519)      0.00087
(14032519)     0.00089 (14092919)     0.00072 (14060418)
6359820.0 |      0.00170 (14032519)     0.00128 (14092919)      0.00127
(14092919)     0.00071 (14060418)     0.00063 (14061317)
6359815.0 |      0.00206 (14092919)     0.00155 (14060418)      0.00093
(14061317)     0.00082 (14061317)     0.00070 (14061318)
6359810.0 |      0.00173 (14092518)     0.00136 (14071419)      0.00105
(14070119)     0.00089 (14070119)     0.00073 (14043019)
6359805.0 |      0.00216 (14052319)     0.00151 (14070119)      0.00118
(14070119)     0.00095 (14070119)     0.00079 (14042419)
6359800.0 |      0.00203 (14092919)     0.00142 (14050619)      0.00110
(14050619)     0.00088 (14050619)     0.00073 (14050619)
6359795.0 |      0.00187 (14072419)     0.00136 (14070318)      0.00107
(14070318)     0.00086 (14072419)     0.00072 (14070318)
6359790.0 |      0.00175 (14072419)     0.00130 (14070318)      0.00104
(14072419)     0.00085 (14072419)     0.00071 (14072419)
6359785.0 |      0.00156 (14062119)     0.00121 (14070318)      0.00098
(14070318)     0.00081 (14070318)     0.00069 (14070318)
6359780.0 |      0.00135 (14072419)     0.00107 (14070418)      0.00089
(14072419)     0.00076 (14070318)     0.00065 (14070318)
6359775.0 |      0.00115 (14062119)     0.00095 (14072419)      0.00081
(14072419)     0.00069 (14072419)     0.00060 (14072419)
6359770.0 |      0.00097 (14062119)     0.00083 (14062119)      0.00071
(14072419)     0.00063 (14072419)     0.00054 (14043018)
6359765.0 |      0.00083 (14062119)     0.00072 (14062119)      0.00064
(14072419)     0.00057 (14072419)     0.00051 (14070318)
6359760.0 |      0.00071 (14070318)     0.00063 (14062119)      0.00057
(14070318)     0.00051 (14062119)     0.00047 (14072419)
6359755.0 |      0.00061 (14062119)     0.00055 (14062119)      0.00050
(14072419)     0.00046 (14062119)     0.00043 (14070318)
6359750.0 |      0.00053 (14072419)     0.00049 (14070318)      0.00045
```

(14062119) 0.00042 (14062119) 0.00039 (14072419)

*** AERMOD - VERSION 15181 *** *** C:\Users\OKI000\OKI000.isc
*** 02/02/17
*** AERMET - VERSION 15181 *** ***
*** 13:04:26

PAGE 26
**MODELOPTs: RegDFAULT CONC ELEV RURAL

*** THE 9TH HIGHEST 1-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): EXC ,

*** NETWORK ID: UCART1 ; NETWORK TYPE: GRIDCART ***

** CONC OF TSP IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS) 385600.00
6359850.0	0.00041 (14060118)
6359845.0	0.00043 (14052319)
6359840.0	0.00052 (14032519)
6359835.0	0.00048 (14092919)
6359830.0	0.00067 (14092919)
6359825.0	0.00049 (14070318)
6359820.0	0.00057 (14061317)
6359815.0	0.00060 (14061317)
6359810.0	0.00065 (14070119)
6359805.0	0.00068 (14042419)
6359800.0	0.00062 (14050619)
6359795.0	0.00062 (14072419)
6359790.0	0.00060 (14070318)
6359785.0	0.00059 (14072419)
6359780.0	0.00057 (14062119)
6359775.0	0.00053 (14070318)
6359770.0	0.00049 (14062119)
6359765.0	0.00044 (14051019)
6359760.0	0.00042 (14070318)
6359755.0	0.00039 (14072419)
6359750.0	0.00036 (14070318)

```
 *** AERMOD - VERSION  15181 ***   *** C:\Users\OKI000\OKI000.isc
 ***        02/02/17
 *** AERMET - VERSION  15181 ***   ***
 ***        13:04:26

PAGE  27
 **MODELOPTs:   RegDFAULT CONC      ELEV      RURAL

                              *** THE   1ST HIGHEST 24-HR AVERAGE
                              CONCENTRATION   VALUES FOR SOURCE GROUP:  ALL
                              ***
                                  INCLUDING SOURCE(S):     EXC         ,

                                   *** NETWORK ID: UCART1   ;  NETWORK
                                   TYPE: GRIDCART ***

                                        ** CONC OF TSP      IN MICROGRAMS/
                                        M**3                          **

  Y-COORD  |                                                 X-COORD
  (METERS)
  (METERS) |       385500.00              385505.00
  385510.00              385515.00              385520.00
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

 6359850.0 |      0.00006b(14120524)      0.00006 (14051324)      0.00006
 (14051324)      0.00006 (14041824)      0.00007 (14041824)
 6359845.0 |      0.00009b(14120524)      0.00008b(14120524)      0.00007
 (14051324)      0.00007 (14051324)      0.00007 (14041824)
 6359840.0 |      0.00012b(14120524)      0.00011b(14120524)
 0.00010b(14120524)      0.00009 (14051324)      0.00009 (14051324)
 6359835.0 |      0.00016b(14120524)      0.00016b(14120524)
 0.00015b(14120524)      0.00013b(14120524)      0.00011b(14120524)
 6359830.0 |      0.00020b(14120524)      0.00021b(14120524)
 0.00021b(14120524)      0.00020b(14120524)      0.00018b(14120524)
 6359825.0 |      0.00024b(14120524)      0.00025b(14120524)
 0.00027b(14120524)      0.00028b(14120524)      0.00028b(14120524)
 6359820.0 |      0.00026b(14120524)      0.00029b(14120524)
 0.00033b(14120524)      0.00037b(14120524)      0.00040b(14120524)
 6359815.0 |      0.00027b(14120524)      0.00031b(14120524)
 0.00037b(14120524)      0.00044b(14120524)      0.00052b(14120524)
 6359810.0 |      0.00025b(14120524)      0.00030b(14120524)
 0.00037b(14120524)      0.00045b(14120524)      0.00058b(14120524)
 6359805.0 |      0.00021b(14120524)      0.00026b(14120524)
 0.00032b(14120524)      0.00040b(14120524)      0.00053b(14120524)
 6359800.0 |      0.00016b(14120524)      0.00019b(14120524)
 0.00024b(14120524)      0.00030b(14120524)      0.00039b(14120524)
 6359795.0 |      0.00011b(14120524)      0.00012b(14120524)      0.00015
 (14052224)      0.00019 (14052224)      0.00024 (14052224)
 6359790.0 |      0.00011 (14052224)      0.00012 (14052224)      0.00016
 (14052624)      0.00021 (14052624)      0.00029 (14052624)
 6359785.0 |      0.00012 (14052624)      0.00015 (14052624)      0.00019
 (14052624)      0.00024 (14052624)      0.00032b(14120424)
 6359780.0 |      0.00013 (14052624)      0.00017b(14120424)
 0.00021b(14120424)      0.00025b(14120424)      0.00030b(14120424)
 6359775.0 |      0.00015b(14120424)      0.00018b(14120424)
 0.00020b(14120424)      0.00022b(14120424)      0.00023b(14120424)
 6359770.0 |      0.00015b(14120424)      0.00016b(14120424)
 0.00017b(14120424)      0.00018 (14061924)      0.00020 (14061924)
 6359765.0 |      0.00013b(14120424)      0.00013b(14120424)      0.00014
 (14061924)      0.00016 (14061924)      0.00016 (14061924)
 6359760.0 |      0.00011b(14120424)      0.00012 (14061924)      0.00013
 (14061924)      0.00013 (14061924)      0.00014 (14070324)
 6359755.0 |      0.00010 (14061924)      0.00011 (14061924)      0.00010
 (14061924)      0.00012 (14070324)      0.00012 (14070324)
 6359750.0 |      0.00009 (14061924)      0.00009 (14061924)      0.00010
```



```
 (14070324)      0.00010 (14070324)      0.00009 (14070324)
```

```
 *** AERMOD - VERSION  15181 ***   *** C:\Users\OKI000\OKI000.isc
 ***        02/02/17
 *** AERMET - VERSION  15181 ***   ***
 ***        13:04:26

PAGE  28
 **MODELOPTs:   RegDFAULT CONC      ELEV      RURAL

                              *** THE   1ST HIGHEST 24-HR AVERAGE
                              CONCENTRATION   VALUES FOR SOURCE GROUP:  ALL
                              ***
                                  INCLUDING SOURCE(S):     EXC        ,

                                   *** NETWORK ID: UCART1   ;  NETWORK
                                   TYPE: GRIDCART ***

                                        ** CONC OF TSP      IN MICROGRAMS/
                                        M**3                          **

  Y-COORD  |                                                  X-COORD
  (METERS)
  (METERS) |       385525.00              385530.00
  385535.00              385540.00              385545.00
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

 6359850.0 |      0.00009 (14082424)      0.00012 (14082424)      0.00013
 (14082424)      0.00013 (14091024)      0.00016 (14091024)
 6359845.0 |      0.00009 (14082424)      0.00013 (14082424)      0.00015
 (14082424)      0.00014 (14082424)      0.00019 (14091024)
 6359840.0 |      0.00009 (14041824)      0.00014 (14082424)      0.00018
 (14082424)      0.00018 (14082424)      0.00022 (14091024)
 6359835.0 |      0.00011 (14041824)      0.00013 (14082424)      0.00020
 (14082424)      0.00023 (14082424)      0.00027 (14091024)
 6359830.0 |      0.00015b(14120524)      0.00015 (14041824)      0.00021
 (14082424)      0.00028 (14082424)      0.00033 (14091024)
 6359825.0 |      0.00026b(14120524)      0.00021b(14120524)      0.00021
 (14082424)      0.00034 (14082424)      0.00041 (14091024)
 6359820.0 |      0.00042b(14120524)      0.00040b(14120524)
 0.00032b(14120524)      0.00040 (14082424)      0.00054 (14082424)
 6359815.0 |      0.00060b(14120524)      0.00067b(14120524)
 0.00068b(14120524)      0.00052b(14120524)      0.00079 (14082424)
 6359810.0 |      0.00074b(14120524)      0.00096b(14120524)
 0.00122b(14120524)      0.00139b(14120524)      0.00110 (14082424)
 6359805.0 |      0.00073b(14120524)      0.00105b(14120524)
 0.00160b(14120524)      0.00262b(14120524)      0.00408b(14120524)
 6359800.0 |      0.00053b(14120524)      0.00078b(14120524)
 0.00123b(14120524)      0.00227b(14120524)      0.00529b(14120524)
 6359795.0 |      0.00033 (14052624)      0.00052 (14052624)      0.00089
 (14052624)      0.00161 (14052624)      0.00278 (14052624)
 6359790.0 |      0.00041 (14052624)      0.00058 (14052624)
 0.00081b(14120424)      0.00105 (14061924)      0.00144 (14052724)
 6359785.0 |      0.00041b(14120424)      0.00049b(14120424)      0.00058
 (14061924)      0.00068 (14052724)      0.00072 (14052724)
 6359780.0 |      0.00032b(14120424)      0.00037 (14061924)      0.00040
 (14052724)      0.00044 (14052724)      0.00039 (14052724)
 6359775.0 |      0.00026 (14061924)      0.00027 (14070324)      0.00029
 (14070324)      0.00028 (14052724)      0.00026 (14041824)
 6359770.0 |      0.00020 (14070324)      0.00022 (14070324)      0.00021
 (14052724)      0.00019 (14052724)      0.00020 (14041824)
 6359765.0 |      0.00017 (14070324)      0.00017 (14070324)      0.00015
 (14052724)      0.00015 (14041824)      0.00016 (14041824)
 6359760.0 |      0.00014 (14070324)      0.00013 (14052724)      0.00012
 (14052724)      0.00012 (14041824)      0.00013 (14041824)
 6359755.0 |      0.00011 (14070324)      0.00010 (14052724)      0.00009
 (14041824)      0.00010 (14041824)      0.00010 (14041824)
 6359750.0 |      0.00008 (14052724)      0.00008 (14052724)      0.00008
```



```
 (14041824)      0.00008 (14041824)      0.00009 (14041824)
```

```
*** AERMOD - VERSION  15181 ***   *** C:\Users\OKI000\OKI000.isc
***        02/02/17
*** AERMET - VERSION  15181 ***   ***
***        13:04:26

PAGE  29
**MODELOPTs:   RegDFAULT CONC      ELEV      RURAL

                              *** THE   1ST HIGHEST 24-HR AVERAGE
                              CONCENTRATION   VALUES FOR SOURCE GROUP:  ALL
                              ***
                                  INCLUDING SOURCE(S):     EXC         ,

                                   *** NETWORK ID: UCART1   ;  NETWORK
                                   TYPE: GRIDCART ***

                                        ** CONC OF TSP      IN MICROGRAMS/
                                        M**3                            **

 Y-COORD  |                                                  X-COORD
 (METERS)
 (METERS) |       385550.00              385555.00
 385560.00              385565.00              385570.00
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
- - - - - - - - - - - - - - - - - - - - - - - - - - - - -

6359850.0 |      0.00018 (14091024)      0.00017 (14091024)      0.00018
(14032824)      0.00018 (14032824)      0.00018 (14032824)
6359845.0 |      0.00021 (14091024)      0.00020 (14091024)      0.00021
(14032824)      0.00022 (14032824)      0.00020 (14032824)
6359840.0 |      0.00025 (14091024)      0.00024 (14091024)      0.00026
(14032824)      0.00026 (14032824)      0.00023 (14032824)
6359835.0 |      0.00031 (14091024)      0.00030 (14032824)      0.00032
(14032824)      0.00031 (14032824)      0.00027 (14032824)
6359830.0 |      0.00040 (14091024)      0.00040 (14032824)      0.00042
(14032824)      0.00038 (14032824)      0.00031 (14032824)
6359825.0 |      0.00054 (14091024)      0.00055 (14032824)      0.00055
(14032824)      0.00046 (14032824)      0.00040 (14060424)
6359820.0 |      0.00077 (14091024)      0.00080 (14032824)      0.00074
(14032824)      0.00058 (14060424)      0.00049 (14060424)
6359815.0 |      0.00121 (14091024)      0.00127 (14032824)      0.00103
(14032824)      0.00080 (14060424)      0.00048 (14060424)
6359810.0 |      0.00223 (14091024)      0.00231 (14032824)      0.00157
(14060424)      0.00099b(14062024)      0.00094b(14062024)
6359805.0 |      0.00557 (14032824)      0.00504 (14032824)
0.00288b(14062024)      0.00189b(14062024)      0.00118b(14062024)
6359800.0 |      0.00000 (00000000)      0.00000 (00000000)
0.00288b(14062024)      0.00128b(14062024)      0.00069 (14043024)
6359795.0 |      0.00464 (14052724)      0.00437 (14112424)      0.00180
(14112424)      0.00107 (14043024)      0.00071 (14043024)
6359790.0 |      0.00157 (14112424)      0.00183 (14112424)      0.00128
(14112424)      0.00076 (14112424)      0.00046 (14043024)
6359785.0 |      0.00079 (14112424)      0.00095 (14112424)      0.00083
(14112424)      0.00062 (14112424)      0.00043 (14051024)
6359780.0 |      0.00048 (14112424)      0.00057 (14112424)      0.00056
(14112424)      0.00047 (14112424)      0.00037 (14112424)
6359775.0 |      0.00032 (14112424)      0.00038 (14112424)      0.00039
(14112424)      0.00036 (14112424)      0.00030 (14112424)
6359770.0 |      0.00023 (14112424)      0.00027 (14112424)      0.00029
(14112424)      0.00028 (14112424)      0.00025 (14112424)
6359765.0 |      0.00017 (14112424)      0.00020 (14112424)      0.00022
(14112424)      0.00022 (14112424)      0.00021 (14112424)
6359760.0 |      0.00014 (14112424)      0.00016 (14112424)      0.00017
(14112424)      0.00018 (14112424)      0.00017 (14112424)
6359755.0 |      0.00011 (14112424)      0.00013 (14112424)      0.00014
(14112424)      0.00014 (14112424)      0.00014 (14112424)
6359750.0 |      0.00009 (14112424)      0.00010 (14112424)      0.00011
```



```
(14112424)      0.00012 (14112424)      0.00012 (14112424)
```

```
 *** AERMOD - VERSION  15181 ***   *** C:\Users\OKI000\OKI000.isc
 ***        02/02/17
 *** AERMET - VERSION  15181 ***   ***
 ***        13:04:26

PAGE  30
 **MODELOPTs:   RegDFAULT CONC      ELEV      RURAL

                              *** THE   1ST HIGHEST 24-HR AVERAGE
                              CONCENTRATION   VALUES FOR SOURCE GROUP:  ALL
                              ***
                                  INCLUDING SOURCE(S):     EXC         ,

                                   *** NETWORK ID: UCART1   ;  NETWORK
                                   TYPE: GRIDCART ***

                                        ** CONC OF TSP      IN MICROGRAMS/
                                        M**3                          **

  Y-COORD  |                                                X-COORD
  (METERS)
  (METERS) |       385575.00               385580.00
  385585.00               385590.00               385595.00
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

 6359850.0 |      0.00016 (14032824)      0.00014 (14032824)      0.00013
 (14060424)      0.00013 (14060424)      0.00013 (14060424)
 6359845.0 |      0.00018 (14032824)      0.00015 (14032824)      0.00016
 (14060424)      0.00015 (14060424)      0.00013 (14060424)
 6359840.0 |      0.00020 (14032824)      0.00019 (14060424)      0.00018
 (14060424)      0.00016 (14060424)      0.00012 (14060424)
 6359835.0 |      0.00023 (14060424)      0.00023 (14060424)      0.00019
 (14060424)      0.00015 (14060424)      0.00010 (14060424)
 6359830.0 |      0.00030 (14060424)      0.00025 (14060424)      0.00018
 (14060424)      0.00012 (14071424)      0.00013b(14062024)
 6359825.0 |      0.00034 (14060424)      0.00023 (14060424)
 0.00017b(14062024)      0.00019b(14062024)      0.00021b(14062024)
 6359820.0 |      0.00032 (14060424)      0.00027b(14062024)
 0.00030b(14062024)      0.00031b(14062024)      0.00029b(14062024)
 6359815.0 |      0.00049b(14062024)      0.00048b(14062024)
 0.00044b(14062024)      0.00039b(14062024)      0.00034b(14062024)
 6359810.0 |      0.00078b(14062024)      0.00062b(14062024)
 0.00049b(14062024)      0.00038b(14062024)      0.00030b(14062024)
 6359805.0 |      0.00077b(14062024)      0.00052b(14062024)
 0.00037b(14062024)      0.00027b(14062024)      0.00020b(14062024)
 6359800.0 |      0.00046 (14043024)      0.00033 (14043024)      0.00025
 (14043024)      0.00020 (14043024)      0.00016 (14043024)
 6359795.0 |      0.00050 (14043024)      0.00037 (14043024)      0.00029
 (14043024)      0.00023 (14043024)      0.00019 (14043024)
 6359790.0 |      0.00038 (14043024)      0.00031 (14043024)      0.00026
 (14043024)      0.00022 (14043024)      0.00018 (14043024)
 6359785.0 |      0.00031 (14051024)      0.00021 (14051024)      0.00019
 (14043024)      0.00017 (14043024)      0.00016 (14043024)
 6359780.0 |      0.00028 (14051024)      0.00023 (14051024)      0.00017
 (14051024)      0.00012 (14051024)      0.00012 (14043024)
 6359775.0 |      0.00024 (14112424)      0.00020 (14051024)      0.00017
 (14051024)      0.00014 (14051024)      0.00011 (14051024)
 6359770.0 |      0.00021 (14112424)      0.00018 (14112424)      0.00015
 (14051024)      0.00014 (14051024)      0.00011 (14051024)
 6359765.0 |      0.00018 (14112424)      0.00016 (14112424)      0.00013
 (14112424)      0.00012 (14051024)      0.00011 (14051024)
 6359760.0 |      0.00016 (14112424)      0.00014 (14112424)      0.00012
 (14112424)      0.00011 (14112424)      0.00010 (14051024)
 6359755.0 |      0.00014 (14112424)      0.00013 (14112424)      0.00011
 (14112424)      0.00010 (14112424)      0.00009 (14112424)
 6359750.0 |      0.00012 (14112424)      0.00011 (14112424)      0.00010
```



```
 (14112424)      0.00009 (14112424)      0.00008 (14112424)
```

*** AERMOD - VERSION 15181 *** *** C:\Users\OKI000\OKI000.isc
*** 02/02/17
*** AERMET - VERSION 15181 *** ***
*** 13:04:26

PAGE 31
**MODELOPTs: RegDFAULT CONC ELEV RURAL

*** THE 1ST HIGHEST 24-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): EXC ,

*** NETWORK ID: UCART1 ; NETWORK TYPE: GRIDCART ***

** CONC OF TSP IN MICROGRAMS/M**3 **

Y-COORD (METERS) | X-COORD (METERS) |	385600.00
6359850.0	0.00011 (14060424)
6359845.0	0.00010 (14060424)
6359840.0	0.00009 (14060424)
6359835.0	0.00009b(14062024)
6359830.0	0.00014b(14062024)
6359825.0	0.00021b(14062024)
6359820.0	0.00027b(14062024)
6359815.0	0.00028b(14062024)
6359810.0	0.00024b(14062024)
6359805.0	0.00016b(14062024)
6359800.0	0.00014 (14043024)
6359795.0	0.00016 (14043024)
6359790.0	0.00016 (14043024)
6359785.0	0.00014 (14043024)
6359780.0	0.00011 (14043024)
6359775.0	0.00008 (14051024)
6359770.0	0.00009 (14051024)
6359765.0	0.00010 (14051024)
6359760.0	0.00009 (14051024)
6359755.0	0.00008 (14051024)
6359750.0	0.00007 (14112424)

*** AERMOD - VERSION 15181 *** *** C:\Users\OKI000\OKI000.isc
*** 02/02/17
*** AERMET - VERSION 15181 *** ***
*** 13:04:26

PAGE 32
**MODELOPTs: RegDFAULT CONC ELEV RURAL

*** THE 9TH HIGHEST 24-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): EXC ,

*** NETWORK ID: UCART1 ; NETWORK TYPE: GRIDCART ***

** CONC OF TSP IN MICROGRAMS/M**3 **

Y-COORD (METERS) | X-COORD (METERS) |	385500.00	385505.00	385510.00	385515.00	385520.00
6359850.0	0.00003 (14052524)	0.00003 (14112324)	0.00004 (14032324)	0.00004 (14082424)	0.00005 (14112324)
6359845.0	0.00004 (14090724)	0.00004 (14052524)	0.00004 (14112324)	0.00005 (14112324)	0.00005 (14032324)
6359840.0	0.00004 (14060524)	0.00004 (14090724)	0.00005 (14090724)	0.00005 (14112324)	0.00006 (14032324)
6359835.0	0.00004 (14112424)	0.00004 (14060524)	0.00005 (14050124)	0.00006 (14090724)	0.00007 (14112324)
6359830.0	0.00004c(14112124)	0.00005 (14112424)	0.00006c(14080824)	0.00007 (14072324)	0.00008 (14090724)
6359825.0	0.00005 (14083124)	0.00006 (14092724)	0.00006 (14092724)	0.00007 (14112324)	0.00009 (14072324)
6359820.0	0.00005 (14083124)	0.00006 (14083124)	0.00007 (14083124)	0.00008 (14092724)	0.00010 (14091424)
6359815.0	0.00005 (14072324)	0.00006 (14072324)	0.00008 (14083124)	0.00010 (14083124)	0.00012 (14083124)
6359810.0	0.00006 (14033124)	0.00007 (14050224)	0.00008 (14083124)	0.00010 (14050224)	0.00013 (14083124)
6359805.0	0.00006 (14032824)	0.00008 (14032824)	0.00009 (14032824)	0.00012 (14033124)	0.00015 (14033124)
6359800.0	0.00007 (14071524)	0.00008 (14071524)	0.00010 (14071524)	0.00013 (14052624)	0.00017 (14052624)
6359795.0	0.00007 (14041824)	0.00008 (14041824)	0.00010 (14041824)	0.00013 (14041824)	0.00016 (14060124)
6359790.0	0.00007 (14060124)	0.00008 (14100524)	0.00009 (14071524)	0.00012 (14050224)	0.00015c(14062724)
6359785.0	0.00006 (14050224)	0.00008 (14041824)	0.00009c(14062724)	0.00012c(14062724)	0.00015 (14052724)
6359780.0	0.00006c(14062724)	0.00007c(14112124)	0.00009 (14090924)	0.00012c(14062724)	0.00016 (14042824)
6359775.0	0.00007 (14090924)	0.00008 (14052724)	0.00010c(14062724)	0.00012 (14061224)	0.00014 (14070324)
6359770.0	0.00007c(14062724)	0.00008 (14061224)	0.00009 (14061224)	0.00011 (14070324)	0.00012 (14052624)
6359765.0	0.00007 (14061224)	0.00007 (14061224)	0.00009 (14042024)	0.00009 (14090124)	0.00009 (14060124)
6359760.0	0.00006 (14070324)	0.00007 (14042024)	0.00008 (14090124)	0.00007 (14041824)	0.00008 (14041824)
6359755.0	0.00006 (14051524)	0.00006 (14090124)	0.00006 (14041824)	0.00006 (14041824)	0.00006 (14032824)
6359750.0	0.00005 (14060124)	0.00005 (14041824)	0.00005		

(14041824) 0.00005 (14042824) 0.00004 (14051724)


```
 *** AERMOD - VERSION  15181 ***   *** C:\Users\OKI000\OKI000.isc
 ***         02/02/17
 *** AERMET - VERSION  15181 ***   ***
 ***         13:04:26

PAGE  33
 **MODELOPTs:   RegDFAULT CONC      ELEV      RURAL

                              *** THE   9TH HIGHEST 24-HR AVERAGE
                              CONCENTRATION   VALUES FOR SOURCE GROUP:  ALL
                              ***
                                  INCLUDING SOURCE(S):     EXC        ,

                                   *** NETWORK ID: UCART1   ;  NETWORK
                                   TYPE: GRIDCART ***

                                        ** CONC OF TSP      IN MICROGRAMS/
                                        M**3                          **

  Y-COORD  |                                               X-COORD
  (METERS)
  (METERS) |      385525.00              385530.00
  385535.00              385540.00              385545.00
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

 6359850.0 |      0.00005c(14080824)     0.00005 (14042124)     0.00006
 (14062224)     0.00006b(14062024)     0.00006b(14053024)
 6359845.0 |      0.00006 (14032324)     0.00006 (14032324)     0.00007
 (14042124)     0.00007b(14062024)     0.00007 (14080724)
 6359840.0 |      0.00007 (14112324)     0.00008 (14060524)     0.00008
 (14032324)     0.00009 (14062224)     0.00009 (14080724)
 6359835.0 |      0.00008 (14082424)     0.00009 (14050124)
 0.00010b(14062024)     0.00010 (14062224)     0.00011b(14062024)
 6359830.0 |      0.00009 (14112324)     0.00011 (14072224)     0.00013
 (14032324)     0.00014 (14032324)     0.00015b(14062024)
 6359825.0 |      0.00011 (14090724)     0.00013 (15013024)     0.00017
 (14050124)     0.00018b(14062024)     0.00020b(14062024)
 6359820.0 |      0.00013 (14060524)     0.00017 (14090724)     0.00020
 (14032324)     0.00027 (14060524)     0.00029 (14112424)
 6359815.0 |      0.00015 (14092724)     0.00020 (14091424)     0.00028
 (15013024)     0.00038 (14050124)     0.00047 (14062424)
 6359810.0 |      0.00018 (14072324)     0.00024 (14050124)     0.00034
 (14050124)     0.00055 (14050124)     0.00088 (14051224)
 6359805.0 |      0.00019 (14050224)     0.00027 (14050224)     0.00042
 (14062424)     0.00078 (14062424)     0.00170 (14041824)
 6359800.0 |      0.00022 (14033124)     0.00032 (14032824)     0.00051
 (14032824)     0.00096 (14050224)     0.00262c(14080124)
 6359795.0 |      0.00023 (14041824)     0.00035b(14120524)
 0.00052c(14062724)     0.00102 (14052724)     0.00207 (14061224)
 6359790.0 |      0.00022c(14062724)     0.00032c(14112124)
 0.00048c(14062724)     0.00076 (14042824)     0.00093 (14041824)
 6359785.0 |      0.00021c(14062724)     0.00029 (14061224)     0.00040
 (14051524)     0.00043c(14062724)     0.00046 (14062424)
 6359780.0 |      0.00019 (14061224)     0.00025 (14051524)     0.00025
 (14102824)     0.00027 (14051724)     0.00028 (14062424)
 6359775.0 |      0.00017 (14052624)     0.00017 (14102824)     0.00017
 (14032824)     0.00017 (14112324)     0.00018 (14090124)
 6359770.0 |      0.00012 (14102824)     0.00012 (14042824)     0.00012
 (14112424)     0.00012 (14043024)     0.00013c(14080124)
 6359765.0 |      0.00010 (14042824)     0.00009 (14051724)     0.00009
 (14102824)     0.00010 (14043024)     0.00010c(14080124)
 6359760.0 |      0.00007 (14051724)     0.00007 (14112424)     0.00007
 (14043024)     0.00007 (14090124)     0.00007c(14080124)
 6359755.0 |      0.00005 (14112424)     0.00006 (14102824)     0.00006
 (14043024)     0.00006 (14101324)     0.00006 (14051924)
 6359750.0 |      0.00005 (14112424)     0.00005 (14043024)     0.00005
```

```
 (14051524)      0.00005 (14101324)      0.00005 (14051924)
```



```
 *** AERMOD - VERSION  15181 ***   *** C:\Users\OKI000\OKI000.isc
 ***         02/02/17
 *** AERMET - VERSION  15181 ***   ***
 ***         13:04:26

PAGE  34
 **MODELOPTs:   RegDFAULT CONC      ELEV      RURAL

                              *** THE   9TH HIGHEST 24-HR AVERAGE
                              CONCENTRATION   VALUES FOR SOURCE GROUP:  ALL
                              ***
                                  INCLUDING SOURCE(S):     EXC        ,

                                   *** NETWORK ID: UCART1   ;  NETWORK
                                   TYPE: GRIDCART ***

                                        ** CONC OF TSP      IN MICROGRAMS/
                                        M**3                          **

  Y-COORD  |                                               X-COORD
  (METERS)
  (METERS) |       385550.00            385555.00
  385560.00            385565.00            385570.00
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

 6359850.0 |      0.00006 (14080724)      0.00006 (14040524)      0.00006
 (14040524)      0.00007 (14062124)      0.00007 (14072124)
 6359845.0 |      0.00008 (14080724)      0.00007 (14040524)      0.00007
 (14040524)      0.00008 (14060424)      0.00007b(14053024)
 6359840.0 |      0.00009 (14080724)      0.00009 (14070224)      0.00009
 (14060424)      0.00010 (14072124)      0.00008 (14072124)
 6359835.0 |      0.00012 (14070224)      0.00012 (14040524)      0.00013
 (14062124)      0.00012b(14053024)      0.00009 (14072124)
 6359830.0 |      0.00016 (14070224)      0.00016 (14040524)      0.00018
 (14060424)      0.00014 (14072124)      0.00011 (14071424)
 6359825.0 |      0.00022 (14072224)      0.00022 (14040524)      0.00023
 (14072124)      0.00017 (14072124)      0.00014 (14032524)
 6359820.0 |      0.00033b(14053024)      0.00034 (14060524)      0.00030
 (14072124)      0.00022 (14032524)      0.00018 (14052324)
 6359815.0 |      0.00055 (14062424)      0.00060b(14053024)      0.00044
 (14071424)      0.00031 (14052324)      0.00022 (14112424)
 6359810.0 |      0.00114c(14080124)      0.00107 (14072124)      0.00074
 (14060124)      0.00044 (14062424)      0.00028 (14061324)
 6359805.0 |      0.00383 (14050324)      0.00306 (14061124)
 0.00119c(14080124)      0.00058 (14071424)      0.00034 (14062424)
 6359800.0 |      0.00000 (00000000)      0.00000 (00000000)      0.00157
 (14112424)      0.00065c(14062824)      0.00036c(14062824)
 6359795.0 |      0.00371 (14090124)      0.00290 (14050324)      0.00121
 (14071024)      0.00058c(14080124)      0.00033 (14112324)
 6359790.0 |      0.00112c(14070424)      0.00102 (14050324)      0.00070
 (14071024)      0.00043 (14112324)      0.00028 (14062424)
 6359785.0 |      0.00053c(14080124)      0.00050 (14071024)      0.00042
 (14112324)      0.00031 (14043024)      0.00022 (14062424)
 6359780.0 |      0.00030 (14052724)      0.00029 (14071024)
 0.00026c(14080124)      0.00022 (14062424)      0.00017 (14062424)
 6359775.0 |      0.00019c(14080124)      0.00019c(14080124)      0.00018
 (14043024)      0.00016 (14062424)      0.00013 (14043024)
 6359770.0 |      0.00013c(14080124)      0.00013c(14080124)      0.00013
 (14061324)      0.00012 (14062424)      0.00010 (14043024)
 6359765.0 |      0.00010c(14080124)      0.00010c(14080124)      0.00010
 (14052224)      0.00009 (14052224)      0.00008 (14043024)
 6359760.0 |      0.00008c(14080124)      0.00008c(14072424)
 0.00007c(14072424)      0.00007 (14052224)      0.00007 (14052224)
 6359755.0 |      0.00006c(14072424)      0.00006c(14072424)      0.00006
 (14062424)      0.00006 (14052224)      0.00006 (14052224)
 6359750.0 |      0.00005 (14070324)      0.00005 (14062424)      0.00005
```

(14062424) 0.00005c(14072424) 0.00005 (14052224)


```
 *** AERMOD - VERSION  15181 ***   *** C:\Users\OKI000\OKI000.isc
 ***        02/02/17
 *** AERMET - VERSION  15181 ***   ***
 ***        13:04:26

PAGE  35
 **MODELOPTs:   RegDFAULT CONC      ELEV      RURAL

                              *** THE   9TH HIGHEST 24-HR AVERAGE
                              CONCENTRATION   VALUES FOR SOURCE GROUP:  ALL
                              ***
                                  INCLUDING SOURCE(S):     EXC        ,

                                   *** NETWORK ID: UCART1   ;  NETWORK
                                   TYPE: GRIDCART ***

                                        ** CONC OF TSP      IN MICROGRAMS/
                                        M**3                          **

  Y-COORD  |                                             X-COORD
  (METERS)
  (METERS) |      385575.00             385580.00
  385585.00             385590.00             385595.00
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

 6359850.0 |     0.00005b(14053024)     0.00004 (14072124)     0.00004
 (14071424)     0.00004 (14112424)     0.00003 (14112424)
 6359845.0 |     0.00006b(14053024)     0.00005 (14112424)     0.00005
 (14061124)     0.00004 (14112424)     0.00004 (14112424)
 6359840.0 |     0.00006 (14112424)     0.00006 (14032524)     0.00005
 (14112424)     0.00005 (14112424)     0.00004 (14052324)
 6359835.0 |     0.00008 (14032524)     0.00007 (14112424)     0.00006
 (14052324)     0.00006 (14060124)     0.00004 (14060124)
 6359830.0 |     0.00010 (14061124)     0.00008 (14052324)     0.00007
 (14060124)     0.00006 (14060124)     0.00005 (14112424)
 6359825.0 |     0.00011 (14052324)     0.00010 (14060124)     0.00007
 (14092924)     0.00007 (14112424)     0.00006 (14112324)
 6359820.0 |     0.00014 (14060124)     0.00011 (14112424)     0.00009
 (14061324)     0.00007 (14112424)     0.00006 (14112424)
 6359815.0 |     0.00016 (14112424)     0.00013 (14112324)     0.00010
 (14112424)     0.00008 (14112424)     0.00007 (14112324)
 6359810.0 |     0.00020 (14043024)     0.00014 (14112324)     0.00011
 (14112324)     0.00009 (14112324)     0.00007 (14112424)
 6359805.0 |     0.00022 (14112324)     0.00015 (14112424)     0.00012
 (14112424)     0.00009 (14061324)     0.00007 (14042424)
 6359800.0 |     0.00023 (14062424)     0.00015c(14062824)
 0.00011c(14062824)     0.00009c(14062824)     0.00007c(14062824)
 6359795.0 |     0.00021c(14062824)     0.00015c(14062824)     0.00011
 (14062424)     0.00008 (14062424)     0.00007 (14062424)
 6359790.0 |     0.00019 (14070124)     0.00014 (14062424)     0.00010
 (14062424)     0.00008c(14062824)     0.00006 (14062424)
 6359785.0 |     0.00016c(14080124)     0.00012c(14070424)     0.00009
 (14070124)     0.00007 (14062424)     0.00006 (14062424)
 6359780.0 |     0.00013 (14062424)     0.00010c(14080124)
 0.00008c(14080124)     0.00007c(14080124)     0.00005 (14070124)
 6359775.0 |     0.00011 (14061324)     0.00009 (14062424)
 0.00007c(14080124)     0.00006c(14080124)     0.00005 (14042424)
 6359770.0 |     0.00009 (14043024)     0.00008 (14061324)     0.00006
 (14062424)     0.00005c(14080124)     0.00004c(14080124)
 6359765.0 |     0.00007 (14043024)     0.00007 (14043024)     0.00006
 (14061324)     0.00005 (14062424)     0.00004c(14072424)
 6359760.0 |     0.00006 (14043024)     0.00006 (14043024)     0.00005
 (14043024)     0.00004 (14061324)     0.00004c(14072424)
 6359755.0 |     0.00005 (14051024)     0.00005 (14043024)     0.00004
 (14043024)     0.00004 (14043024)     0.00003 (14061324)
 6359750.0 |     0.00004 (14052224)     0.00004 (14043024)     0.00004
```

(14043024) 0.00004 (14043024) 0.00003 (14043024)


```
*** AERMOD - VERSION  15181 ***   *** C:\Users\OKI000\OKI000.isc
***         02/02/17
*** AERMET - VERSION  15181 ***   ***
***         13:04:26

PAGE  36
**MODELOPTs:   RegDFAULT CONC      ELEV      RURAL

                              *** THE   9TH HIGHEST 24-HR AVERAGE
                              CONCENTRATION   VALUES FOR SOURCE GROUP:  ALL
                              ***
                                  INCLUDING SOURCE(S):     EXC        ,

                                   *** NETWORK ID: UCART1   ;  NETWORK
                                   TYPE: GRIDCART ***

                                        ** CONC OF TSP      IN MICROGRAMS/
                                        M**3                          **

 Y-COORD  |                                              X-COORD
 (METERS)
 (METERS) |       385600.00
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
- - - - - - - - - - - - - - - - - - - - - - - - - - - - -

6359850.0 |      0.00003 (14112424)
6359845.0 |      0.00003 (14032524)
6359840.0 |      0.00004 (14060124)
6359835.0 |      0.00004 (14092924)
6359830.0 |      0.00005 (14061324)
6359825.0 |      0.00005 (14112424)
6359820.0 |      0.00005 (14043024)
6359815.0 |      0.00006 (14112324)
6359810.0 |      0.00006 (14112424)
6359805.0 |      0.00006 (14112424)
6359800.0 |      0.00006c(14062824)
6359795.0 |      0.00005b(14062024)
6359790.0 |      0.00005 (14062424)
6359785.0 |      0.00005 (14062424)
6359780.0 |      0.00005 (14062424)
6359775.0 |      0.00004c(14080124)
6359770.0 |      0.00004c(14080124)
6359765.0 |      0.00004c(14072424)
6359760.0 |      0.00003 (14051924)
6359755.0 |      0.00003c(14072424)
6359750.0 |      0.00003c(14072424)
```

```
 *** AERMOD - VERSION  15181 ***   *** C:\Users\OKI000\OKI000.isc
 ***        02/02/17
 *** AERMET - VERSION  15181 ***   ***
 ***        13:04:26

PAGE  37
 **MODELOPTs:   RegDFAULT CONC      ELEV      RURAL

                                        *** THE SUMMARY OF MAXIMUM PERIOD (
                                        8784 HRS) RESULTS ***

                                    ** CONC OF TSP      IN MICROGRAMS/M**3
                                    **

NETWORK
GROUP ID                       AVERAGE CONC                RECEPTOR  (XR,
YR, ZELEV, ZHILL, ZFLAG)  OF TYPE  GRID-ID
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
- - - - - - - - - - - - - - - - - - - - - -

ALL       1ST HIGHEST VALUE IS       0.00260 AT (  385550.00,  6359805.00,
8.10,     8.10,    0.00)  GC  UCART1
          2ND HIGHEST VALUE IS       0.00257 AT (  385550.00,  6359795.00,
          8.30,     8.30,    0.00)  GC  UCART1
          3RD HIGHEST VALUE IS       0.00193 AT (  385555.00,  6359805.00,
          7.90,     7.90,    0.00)  GC  UCART1
          4TH HIGHEST VALUE IS       0.00189 AT (  385555.00,  6359795.00,
          8.10,     8.10,    0.00)  GC  UCART1
          5TH HIGHEST VALUE IS       0.00180 AT (  385545.00,  6359800.00,
          8.50,     8.50,    0.00)  GC  UCART1
          6TH HIGHEST VALUE IS       0.00118 AT (  385545.00,  6359795.00,
          8.60,     8.60,    0.00)  GC  UCART1
          7TH HIGHEST VALUE IS       0.00113 AT (  385545.00,  6359805.00,
          8.40,     8.40,    0.00)  GC  UCART1
          8TH HIGHEST VALUE IS       0.00101 AT (  385560.00,  6359800.00,
          7.70,     7.70,    0.00)  GC  UCART1
          9TH HIGHEST VALUE IS       0.00077 AT (  385560.00,  6359805.00,
          7.60,     7.60,    0.00)  GC  UCART1
         10TH HIGHEST VALUE IS       0.00076 AT (  385560.00,  6359795.00,
         7.80,     7.80,    0.00)  GC  UCART1

 *** RECEPTOR TYPES:  GC = GRIDCART
                      GP = GRIDPOLR
                      DC = DISCCART
                      DP = DISCPOLR
```



```
 *** AERMOD - VERSION  15181 ***   *** C:\Users\OKI000\OKI000.isc
 ***        02/02/17
 *** AERMET - VERSION  15181 ***   ***
 ***        13:04:26

PAGE  38
 **MODELOPTs:   RegDFAULT CONC      ELEV      RURAL

                                                *** THE SUMMARY OF HIGHEST
                                                1-HR RESULTS ***

                                    ** CONC OF TSP      IN MICROGRAMS/M**3
                                    **

                                                        DATE
                                                        NETWORK
GROUP ID                          AVERAGE CONC     (YYMMDDHH)
RECEPTOR  (XR, YR, ZELEV, ZHILL, ZFLAG)    OF TYPE  GRID-ID
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
- - - - - - - - - - - - - - - - - - - - - - - - - - - -

ALL      HIGH   1ST HIGH VALUE IS       0.09530  ON 14120519: AT (
385545.00,  6359800.00,     8.50,     8.50,    0.00)  GC  UCART1
         HIGH   9TH HIGH VALUE IS       0.03313  ON 14061118: AT (
         385555.00,  6359805.00,     7.90,     7.90,    0.00)  GC  UCART1

 *** RECEPTOR TYPES:  GC = GRIDCART
                      GP = GRIDPOLR
                      DC = DISCCART
                      DP = DISCPOLR
```

```
 *** AERMOD - VERSION  15181 ***   *** C:\Users\OKI000\OKI000.isc
 ***        02/02/17
 *** AERMET - VERSION  15181 ***   ***
 ***        13:04:26

PAGE  39
 **MODELOPTs:   RegDFAULT CONC      ELEV      RURAL

                                                *** THE SUMMARY OF HIGHEST
                                                24-HR RESULTS ***


                                    ** CONC OF TSP      IN MICROGRAMS/M**3
                                    **

                                                      DATE
                                                      NETWORK
GROUP ID                          AVERAGE CONC     (YYMMDDHH)
RECEPTOR  (XR, YR, ZELEV, ZHILL, ZFLAG)    OF TYPE  GRID-ID
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
- - - - - - - - - - - - - - - - - - - - - - - - - - - - -

ALL      HIGH   1ST HIGH VALUE IS       0.00557  ON 14032824: AT (
385550.00,  6359805.00,     8.10,     8.10,    0.00)  GC  UCART1
         HIGH   9TH HIGH VALUE IS       0.00383  ON 14050324: AT (
         385550.00,  6359805.00,     8.10,     8.10,    0.00)  GC  UCART1


 *** RECEPTOR TYPES:  GC = GRIDCART
                      GP = GRIDPOLR
                      DC = DISCCART
                      DP = DISCPOLR
```


OKI000 - CUT DOWN.ADO 2/2/2017

```
 *** AERMOD - VERSION  15181 ***   *** C:\Users\OKI000\OKI000.isc
 ***        02/02/17
 *** AERMET - VERSION  15181 ***   ***
 ***        13:04:26

PAGE  40
 **MODELOPTs:   RegDFAULT CONC      ELEV      RURAL

 *** Message Summary : AERMOD Model Execution ***

  --------- Summary of Total Messages --------

 A Total of            0 Fatal Error Message(s)
 A Total of            0 Warning Message(s)
 A Total of          234 Informational Message(s)

 A Total of         8784 Hours Were Processed

 A Total of           72 Calm Hours Identified

 A Total of          162 Missing Hours Identified (  1.84 Percent)


    ******** FATAL ERROR MESSAGES ********
               ***  NONE  ***


    ********   WARNING MESSAGES   ********
               ***  NONE  ***


    ************************************
    *** AERMOD Finishes Successfully ***
    ************************************
```

APPENDIX I

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.

This Report is provided for use solely by Golder's Client and persons acting on the Client's behalf, such as its professional advisers. Golder is responsible only to its Client for this Report. Golder has no responsibility to any other person who relies or makes decisions based upon this Report or who makes any other use of this Report. Golder accepts no responsibility for any loss or damage suffered by any person other than its Client as a result of any reliance upon any part of this Report, decisions made based upon this Report or any other use of it.

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.