Our Ref: UID-56400

Your Ref:

Dr Tom Hatton
Chair
Environmental Protection Authority
The Atrium
168 St Georges Terrace
PERTH WA 6000

Fortescue
The New Force in Iron Ore

11 February 2016

Dear Dr Hatton

REFERRAL OF A PROPOSAL TO THE ENVIRONMENTAL PROTECTION AUTHORITY UNDER SECTION 38(1) OF THE ENVIRONMENTAL PROTECTION ACT 1986 – THE PILBARA MARINE TUG HAVEN FACILITY

Pilbara Marine, a 100% owned subsidiary of Fortescue Metals Group Pty Ltd (Fortescue) wishes to formally refer the Pilbara Marine Tug Haven Facility (the Tug Haven Facility) to the Environmental Protection Authority for assessment under Section 38 of the *Environmental Protection Act 1986*. Please find enclosed a completed referral form for consideration, with accompanying supporting documentation and shapefiles on CD.

The Tug Haven Facility consists of new infrastructure to be constructed within the Herb Elliott Port Precinct at the Port Hedland Inner Harbour in the Pilbara region of Western Australia. The Tug Haven Facility will provide towage services to all Port Hedland Port users. Pilbara Marine is committed to working collaboratively with the Pilbara Port Authority to identify efficient practices to improve towage in Port Hedland.

Should you have any further queries please contact Andrew Winzer on 6218 8914 or at awinzer@fmgl.com.au.

Yours sincerely
FORTESCUE METALS GROUP

BRETT MCGUIRE
Group Manager, Environment

Enc.

Attachment 1	EPA referral form
Attachment 2	Supporting Documentation, Appendices and Shapefiles (CD)

Fortescue Metals Group Limited ABN 57 002 594 872 ACN 002 594 872
ADDRESS Level 2, 87 Adelaide Terrace, East Perth, Western Australia 6004
POSTAL ADDRESS PO Box 6915, East Perth, Western Australia 6892
TEL +61 8 6218 8888 **FAX** +61 8 6218 8880 **EMAIL** fmgl@fmgl.com.au

This page has been left blank intentionally

Attachment 1:

This page has been left blank intentionally

Environmental Protection Authority

GOVERNMENT OF WESTERN AUSTRALIA

EPA REFERRAL FORM

Referral of a Proposal to the Environmental Protection Authority under Section 38 of the *Environmental Protection Act 1986*.

PURPOSE OF THIS FORM

Section 38 of the *Environmental Protection Act 1986* (EP Act) makes provision for the referral to the Environmental Protection Authority (EPA) of a proposal (significant proposals, strategic proposals and proposals under an assessed scheme) by a proponent, a decision making authority (DMA), or any other person.

The purpose of this form is to ensure that EPA has sufficient information about a proposal to make a decision about the nature of the proposal and whether or not the proposal should be assessed under Part IV of the EP Act. Information provided in the referral form must be brief (no more than 30 pages), sharp and succinct to achieve the purposes of this form.

This form does not prevent the referrer from providing a supplementary referral report. Should a referrer choose to submit a supplementary referral report please ensure the following.

i. Information is short, sharp and succinct.
ii. Attachments are below eight megabytes (8 MB) as they will be published on the EPA's website (exemptions apply) for public comment. To minimise file size, "flatten" maps and optimise pdf files.
iii. Cross-references are provided in the referral form to the appropriate section/s in the supplementary referral report.

This form is to be used for all proposals[1] which can be referred to the EPA under section 38 of the EP Act; i.e. referrals from: **proponents** of proposals (significant proposals, strategic proposals, derived proposals, proposals under an assessed scheme); **DMAs** (significant proposals); and **third parties** (significant proposals).

This form is divided into several sections, including; Referral requirements and Declaration; Part A - Information of the proposal and proponent; and Part B Environmental Factors. Guidance on successfully completing this form is provided throughout the form and is also available in the EPA's *Environmental Assessment Guideline for Referral of a Proposal under s38 of the EP Act (EAG 16)*.

Send completed forms to

Office of the Environmental Protection Authority

Locked Bag 10, East Perth WA 6892 or

Email: Registrar@epa.wa.gov.au

Enquiries: Office of the Environmental Protection Authority

Locked Bag 10, East Perth WA 6892

Telephone: 6145 0800

Fax: 6145 0895

Email: info@epa.wa.gov.au

Website: www.epa.wa.gov.au

[1] Please note that this form consolidates and replaces the following forms: *Referral of a Proposal by the Proponent to the EPA under section 38(1) of the EP Act*; *Referral of a Proposal by a third party to the EPA under section 38(1) of the EP Act*; and *Referral of a development proposal to the EPA by the decision making authority*.

Referral requirements and Declaration

The following section outlines the referral information required from a proponent, decision making authority and third party.

(a) Proponents

Proponents are expected to complete all sections of the form and provide GIS spatial data to enable the EPA to consider the referral. Spatial GIS data is necessary to inform the EPA's decision.

The EPA expects that a proponent will address Part B of the form as thoroughly as possible to demonstrate whether or not the EPA's objectives for environmental factors can be met.

If insufficient information is provided the EPA will request more information and processing of the referral will commence once the information is provided or the EPA decides to make a precautionary determination on the available information.

Proponent to complete before submitting form	
Completed all the questions in Part A (essential)	☒ Yes ☐ No
Completed all the questions in Part B	☒ Yes ☐ No
Completed all other applicable questions	☒ Yes ☐ No
Included Attachment 1 – any additional document(s) the proponent wishes to provide	☒ Yes ☐ No
Included Attachment 2 – confidential information (if applicable)	☐ Yes ☒ No
Enclosed an electronic copy of all referral information, including spatial data and contextual mapping but clearly separating any confidential information	☒ Yes ☐ No
Completed the Declaration	☒ Yes ☐ No
What is the type of proposal being referred? ** a referred proposal seeking to be declared a derived proposal*	☒ significant ☐ strategic ☐ derived* ☐ under an assessed scheme
Do you consider the proposal requires formal environmental impact assessment?	☐ Yes ☒ No
If yes, what level of assessment? *API = Assessment of Proponent Information* *PER = Public Environmental Review*	☐ API Category A ☐ API Category B ☐ PER

NB: The EPA may apply an Assessment on Proponent Information (API) level of assessment when the proponent has provided sufficient information about:

- the proposal;
- the proposed environmental impacts;
- the proposed management of the environmental impacts; and
- when the proposal is consistent with API criteria outlined in the *Environmental Impact Assessment (Part IV Division 1 and 2) Administrative Procedures 2012*.

If an API A formal level of assessment is considered appropriate, please refer to Environmental Assessment Guideline No. 14 *Preparation for an Assessment on Proponent Information (Category A) Environmental Review Document EAG 14* (EAG14).

Declaration

I, Brett Peter McGuire, *(full name)* declare that I am authorised on behalf of Fortescue Metals Group (being the person responsible for the proposal) to submit this form and further declare that the information contained in this form is true and not misleading.

Signature	(signed)	Name (print)	Brett McGuire	
Position	Group Manager Environment	Organisation	Fortescue Metals Group Ltd	
Email	bmcguire@fmgl.com.au			
Address	87	Adelaide Tce		
	East Perth		WA	6004
Date	11/02/2016.			

(b) Decision-making authority

The EPA expects decision-making authorities to complete applicable sections of Part A of the form and provide the proponent an opportunity to provide additional information in Part B of the form where appropriate.

Wherever possible the DMA should obtain relevant spatial information from the proponent and provide this to the EPA with the referral.

DMA to complete before submitting form	
Completed all the questions in Part A (essential)	☐ Yes ☐ No
Provided Part B to the proponent for completion	☐ Yes ☐ No
Completed all other applicable questions	☐ Yes ☐ No
Included Attachment 1 – any supporting information	☐ Yes ☐ No
Enclosed an electronic copy of all referral information including spatial data and contextual mapping	☐ Yes ☐ No
Completed the below Declaration	☐ Yes ☐ No
Do you consider the proposal requires formal environmental impact assessment?	☐ Yes ☐ No
What is the type of proposal being referred?	☐ significant proposal ☐ significant proposal under an assessed scheme

Declaration

I, ... *(full name)* submit this referral to the EPA for consideration of the environmental significance of its impacts.

Signature		Name (print)	
Position		Organisation	
Email			
Address	Street No	Street Name	
	Suburb	State	Postcode
Date			

(c) Third Party

Third parties are asked to have consideration for the Significance Test outlined in Part A Section 1.5 of this form before referring a significant proposal to the EPA. The EPA will only consider proposals that are likely, if implemented, to have a significant effect on the environment.

Third parties are to provide sufficient information to clearly identify the significant proposal, the proponent, and their reasons for referring the proposal. This can be done by completing as much of Part A of the form as possible, taking into consideration the information available. Third parties may wish to fill in Part B of the form to advance their own views of the significance of the environmental impacts and the need for EPA assessment.

In most cases the EPA will seek additional information from the proponent. This will be to confirm or amend the identity of the proponent, the proposal, and to allow the proponent opportunity to provide its views on the significance of the environmental impacts and the need for EPA assessment.

Third Party to complete before submitting form	
Complete all applicable questions in Part A and B	☐ Yes ☐ No
Completed the Declaration	☐ Yes ☐ No
Do you consider the proposal requires formal environmental impact assessment?	☐ Yes ☐ No

Declaration

I, ... *(full name)* submit this referral to the EPA for consideration of the environmental significance of its impacts.

Signature		Name (print)		
Email				
Position		Organisation		
Address	Street No	Street Name		
	Suburb		State	Postcode
Date				

PART A: Information on the proposal and the proponent

All fields of Part A must be completed by the proponent and/or decision-making authority for this document to be processed as a referral. Third party referrers are only expected to fill in the fields they have information for.

1 PROPONENT AND PROPOSAL DESCRIPTION

1.1 The proponent of the proposal

Proponent and/or DMA to complete	
Name of the proponent	Pilbara Marine Pty Ltd
Joint Venture parties (if applicable)	N/A
Australian Company Number(s)	160 019 205
Postal Address *(Where the proponent is a corporation or an association of persons, whether incorporated or not, the postal address is that of the principal place of business or of the principal office in the State)*	PO Box 6915 East Perth, WA, 6915
Key proponent contact for the proposal *Please include: name; physical address; phone; and email.*	Sean McGunnigle Manager, Environmental Approvals Fortescue Metals Group PO Box 6915 East Perth, WA, 6915 (08) 6218 8415 smcgunnigle@fmgl.com.au
Consultant for the proposal (if applicable) *Please include: name; physical address; phone; and email.*	N/A

1.2 Proposal

Proposal is defined under the EP Act to mean a "project, plan, programme policy, operation, undertaking or development or change of land use, or amendment of any of the foregoing, but does not include scheme". Before completing this section please refer to *Environmental Protection Bulletin 17 – Strategic and derived proposals (EPB 17)* *and* *Environmental Assessment Guideline for Defining the Key Characteristics of a proposal (EAG 1).*

Proponent and/or DMA to complete	
Title of the proposal	Anderson Point Tug Haven
What project phase is the proposal at?	☐ Scoping ☒ Feasibility ☐ Detailed design ☐ Other ________
Proposal type *More than one proposal type can be identified, however for filtering purposes it is recommended that only the primary proposal type is identified.*	☐ **Power/Energy Generation** ☐ Hydrocarbon Based – coal ☐ Hydrocarbon Based – gas ☐ Waste to energy ☐ Renewable – wind

Proponent and/or DMA to complete	
	☐ Renewable – wave ☐ Renewable – solar ☐ Renewable – geothermal ☐ **Mineral / Resource Extraction** ☐ Exploration – seismic ☐ Exploration – geotechnical ☐ Development ☐ **Oil and Gas Development** ☐ Exploration ☐ Onshore – seismic ☐ Onshore – geotechnical ☐ Onshore – development ☐ Offshore – seismic ☐ Offshore – geotechnical ☐ Offshore – development ☐ **Industrial Development** ☐ Processing ☐ Manufacturing ☐ Beneficiation ☐ **Land Use and Development** ☐ Residential – subdivision ☐ Residential – development ☐ Commercial – subdivision ☐ Commercial – development ☐ Industrial – subdivision ☐ Industrial – development ☐ Agricultural – subdivision ☐ Agricultural – development ☐ Tourism ☐ **Linear Infrastructure** ☐ Rail ☐ Road ☐ Power Transmission ☐ Water Distribution ☐ Gas Distribution ☐ Pipelines ☐ **Water Resource Development** ☐ Desalination ☐ Surface or Groundwater ☐ Drainage ☐ Pipelines ☐ Managed Aquifer Recharge ☒ **Marine Developments** ☐ Port ☒ Jetties ☐ Marina

Proponent and/or DMA to complete	
	☐ Canal ☐ Aquaculture ☒ Dredging *If other, please state below:* ☐ **Other** ________________

Proponent and/or DMA to complete	
Description of the proposal – describe the key characteristics of the proposal in accordance with EAG 1.	Pilbara Marine proposed to develop the Anderson Point Tug Haven Facility (the Facility) at Port Hedland in the Pilbara Region of Western Australia (Figure 1). The tugs at the Facility will be used to support shipping being undertaken for all Port users in the Port Hedland Harbour. The Facility comprises the following physical characteristics: • abutment • dredged approach channel and berth pockets • dredge spoil pipelines • use of existing, approved dredged material management areas (DMMAs) • access walkway • service berth • pontoons and pens for nine tugs (expandable to 13) • cyclone moorings (including stand-alone piles) • navigation leads • fuel facility and fuel service system • administration buildings • sewage facilities • workshop and warehouse • hydrocarbons storage area • associated access roads and vehicle parking areas. Significant construction activities include: • land based earthworks and general construction • dredging of 0.8 Mm^3 for the berth pocket area and access channel • transport of dredged material by pipeline and disposal in existing, approved DMMAs

Proponent and/or DMA to complete	
	• construction of marine structures including piling. The Facility is described in more detail within Section 2 of the Supporting Document for this Referral, including a Key Characteristics Table presented in Section 2.2.1.
Timeframe in which the proposal is to occur (including start and finish dates where applicable).	Subject to the receipt of all approvals, construction is anticipated to commence in July 2016 and be complete by January 2017
Details of any staging of the proposal.	There is no staging of the Proposal
What is the current land use on the property, and the extent (area in hectares) of the property?	The Proposed Tug Haven is located within Fortescue Metals Group Ltd's Anderson Point Port Precinct.
Have pre-referral discussions taken place with the OEPA? If yes, please provide the case number. If a case number was not provided, please state the date of the meeting and names of attendees.	Pre-referral meeting was held with OEPA on 18 December 2015 and a site visit incorporating tour of the Proposed Tug Haven areas was undertaken on 13 January 2016.
DMA (Responsible Authority) to complete	
For a proposal under an assessed scheme (as defined in section 3 of the EP Act, applicable only to the proponent and DMA) provide details (in an attachment) as to whether: • *The environmental issues raised by the proposal were assessed in any assessment of the assessed scheme.* • *The proposal complies with the assessed scheme and any environmental conditions in the assessed scheme*	N/A

1.3 Strategic / derived proposals

Complete this section if the proposal being referred is a strategic proposal or you are seeking the proposal to be declared a derived proposal. Note: Only a proponent may refer a strategic proposal and seek a proposal to be declared a derived proposal.

Proponent to complete	
Is this referred proposal a strategic proposal?	☐ Yes ☒ No
Are you seeking that this proposal be declared a derived proposal?	☐ Yes ☒ No
If you are seeking that this proposal be declared a derived proposal, what is the Ministerial Statement number (MS #) of the associated strategic proposal?	MS # ____________ N/A

1.4 Location

Proponents and DMAs must provide spatial data. Please refer to EAG 1 for more detail.

Proponent, DMA and Third Party to complete	
Name of the Local Government Authority in which the proposal is located.	Town of Port Hedland
Location: a) street address; lot number; suburb; and nearest road intersection; or b) if remote the nearest town; and distance and direction from that town to the proposal site.	Port Hedland Port Precinct – Anderson Point
Have maps and figures been included with the referral (consistent with EAG 1 where appropriate)? *The types of maps and figures which need to be provided (depending on the nature of the proposal) include:* • *maps showing the regional location and context of the proposal; and* • *figures illustrating the proposal elements.*	☒ Yes ☐ No
Proponent and DMA to complete	
Have electronic copies of spatial data been included with the referral? ***NB:*** *Electronic spatial (GIS or CAD) data, geo-referenced and conforming to the following parameters:* • *GIS: polygons representing all activities and named;* • *CAD: simple closed polygons representing all activities and named;* • *datum: GDA94;* • *projection: Geographic (latitude/longitude) or Map Grid of Australia (MGA);* • *format: ESRI geodatabase or shapefile, MapInfo Interchange Format, Microstation or AutoCAD..*	☒ Yes ☐ No

1.5 Significance test and environmental factors

Proponent, DMA and Third Party to complete	
What are the likely significant environmental factors for this proposal?	☒ Benthic Communities and Habitat ☒ Coastal Processes ☒ Marine Environmental Quality ☐ Marine Fauna ☐ Flora and Vegetation ☐ Landforms ☐ Subterranean Fauna ☐ Terrestrial Environmental Quality ☐ Terrestrial Fauna ☐ Hydrological Processes ☐ Inland Waters Environmental Quality

Proponent, DMA and Third Party to complete	
	☐ Air Quality & Atmospheric Gases ☐ Amenity ☐ Heritage ☐ Human Health ☐ Offsets ☐ Rehabilitation and Decommissioning
Having regard to the Significance Test (refer to Section 7 of the *EIA Administrative Procedures 2012*) in what ways do you consider the proposal may have a significant effect on the environment and warrant referral to the EPA?	Pilbara Marine considers that the Proposal is not significant enough to warrant formal assessment.

1.6 Confidential information

All information will be made publically available unless authorised for exemption under the EP Act or subject to the Freedom of Information Act 1992.

Proponent to complete	
Does the proponent request that the EPA treat any part of the referral information as confidential? *Ensure all confidential information is provided in a separate attachment in hard copy.*	☐ Yes ☒ No

2 REGULATORY CONSIDERATIONS

This section applies to the Local, State and Commonwealth regulatory considerations for the referred proposal.

2.1 Government approvals

2.1.1 State or Local Government approvals

DMA to complete	
What approval(s) is (are) required from you as a decision-making authority?	N/A
Is rezoning of any land required before the proposal can be implemented? If yes, please provide details.	☐ Yes ☐ No N/A

2.1.2 Regulation of aspects of the proposal

Complete the following to the extent possible.

Proponent to complete	
Do you have legal access required for the implementation of all aspects of the proposal? *If yes, provide details of legal access authorisations / agreements / tenure.* *If no, what authorisations / agreements / tenure is required and from whom?*	☒ Yes ☐ No An agreement has been reached between Pilbara Marine and The Pilbara Infrastructure (a subsidiary of Fortescue Metals Group Ltd), the leaseholder and owner of the existing infrastructure at Anderson Point.

Outline both the existing approvals and approvals that will be / are being sought as a part of this proposal.

Proponent to complete			
Aspects* of the proposal	**Type of approval**	**Legislation regulating this activity**	**Which State agency /entity regulate this activity?**
Existing Part IV for Construction and Operation of Anderson Point Port (Construction, Processing)	Ministerial Statement 690	EP Act 1986 – Part IV	EPA
Existing Part IV for Construction of Third Berth (Construction)	Ministerial Statement 771	EP Act 1986 – Part IV	EPA
Existing Part IV for South West Creek Dredging (Dredging)	Ministerial Statement 859	EP Act 1986 – Part IV	EPA
Existing Operating Licence for the Operation of Anderson Point Port (Discharge and Processing)	L8194/2007/3	EP Act 1986 – Part V	DER
Existing 5C Licence for the Anderson Point Port (Groundwater Use)	GWL163999	RIWI Act 1914	DoW

**e.g. mining, processing, dredging*

2.1.3 Commonwealth Government *Environment Protection and Biodiversity Conservation Act 1999* approvals

Refer to the assessment bilateral agreement between the Commonwealth of Australia and the State of Western Australia for assistance on this section.

Proponent to complete	
1. Does the proposal involve an action that may be or is a controlled action under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)?	☐ Yes ☒ No *If no continue to Part A section 2.1.4.*

Proponent to complete	
	action
3. If the action has been referred, when was it referred and what is the reference number (Ref #)?	Date: ________ Ref #: ________
4. If the action has been assessed, provide the decision in an attachment. Has an attachment been provided?	☐ Yes ☐ No
5. Do you request this proposal to be assessed under the bilateral agreement?	☐ Yes ☐ No

Complete the following to the extent possible for the Public Comment of EPBC Act referral documentation.

Proponent to complete	
6. Have you invited the public to comment on your referral documentation?	☐ Yes ☐ No
7. How was the invitation published?	☐ newspaper ☐ website
8. Did the invitation include all of the following?	
(a) brief description of the action	☐ Yes ☐ No
(b) the name of the action	☐ Yes ☐ No
(c) the name of the proponent	☐ Yes ☐ No
(d) the location of the action	☐ Yes ☐ No
(e) the matters of national environmental significance that will be or are likely to be significantly impacted	☐ Yes ☐ No
(f) how the relevant documents may be obtained	☐ Yes ☐ No
(g) the deadline for public comments	☐ Yes ☐ No
(h) available for public comment for 14 calendar days	☐ Yes ☐ No
(i) the likely impacts on matters of national environmental significance	☐ Yes ☐ No
(j) any feasible alternatives to the proposed action	☐ Yes ☐ No
(k) possible mitigation measures	☐ Yes ☐ No
9. Were any submissions received during the public comment period?	☐ Yes ☐ No
10. Have public submissions been addressed? If yes provide attachment	☐ Yes ☐ No

2.1.4 Other Commonwealth Government Approvals

Proponent, DMA and Third Party to complete			
Is approval required from other Commonwealth Government/s for any part of the proposal?		☐ Yes ☒ No *If yes, please complete the table below.*	
Agency / Authority	Approval required	Application lodged?	Agency / Local Authority contact(s) for proposal
		☐ Yes ☐ No	
		☐ Yes ☐ No	

3. SUPPORTING INFORMATION

Please attach copies of any relevant information on the proposal, supporting evidence and / or existing environmental surveys, studies or monitoring information undertaken and list the documents below.

Proponent, DMA and Third Party to complete			
(1)	Anderson Point Tug Haven Facility – Referral Supporting Document	Andrew Winzer	Additional information regarding the Proposal and its impact to the environment. Also includes all appendices and figures.

PART B: ENVIRONMENTAL FACTORS

The purpose of Part B is to assist the EPA to determine the significance of the likely environmental impacts of the proposal in accordance with the EPA's *Environmental Assessment Guideline for Environmental factors and objectives* (EAG 8) and *Environmental Assessment Guideline for Application of a significant framework in the EIA process* (EAG 9). Referrers completing Part B should refer closely to EAG 8 and EAG 9.

The EPA has prepared *Referral of a Proposal under s38 of the EP Act EAG No.16 - Appendix A* (Appendix A) to assist in identifying factors and completing the below table. Further guidance can be found in the guidance and policy documents cited in Appendix A under each factor.

How to complete Part B

For each environmental factor, that is likely to be significantly impacted by the implementation of the proposal, make a copy of the table below and insert a summary of the relevant information relating to the proposal. The table can be broken down into more than one table per factor, if the need arises. For example the hydrological processes factor can be presented in two separate tables, one for surface water and one for groundwater, or similarly one for construction and one for operations.

For complex proposals a supplementary referral report can be provided in addition to the referral form. If this option is chosen the table must still be completed (summaries are acceptable) to assist the Office of the EPA with statistical reporting and filtering proposals for processing.

Proponents expecting an API level of assessment must provide information in accordance with the EPA's *Environmental Assessment Guideline for Preparation of an API-A environmental review document* (EAG 14).

For each of the significant environmental factors, complete the following table (Questions 1 – 10).

Proponent to complete. DMA and Third Party to complete to the best of their knowledge.		
1	Factor, *as defined in EAG 8*	Coastal Processes
2	EPA Objective, *as defined in EAG 8*	To maintain the morphology of the subtidal, intertidal and supratidal zones and the local geophysical processes that shape them.
3	Guidance - what established policies, guidelines, and standards apply to this factor in relation to the proposal?	• EAG7: Environmental Assessment Guideline for Marine Dredging Proposals • Australian and New Zealand guidelines for fresh and marine water quality • Pilbara coastal water quality consultation outcomes: environmental values and environmental quality objectives • National assessment guidelines for dredging (NAGD)

Proponent to complete. DMA and Third Party to complete to the best of their knowledge.		
4	Consultation - outline the need for consultation and the outcomes of any consultation in relation to the potential environmental impacts, including: • *anticipated level of public interest in the impact;* • *consultation with regulatory agencies; and* • *consultation with community.*	See Section 3 of Supporting Documentation
5	Baseline information - describe the relevant characteristics of the receiving environment. *This may include: regional context; known environmental values, current quality, sensitivity to impact, and current level of cumulative impacts.*	See Section 5.2.1 (**Existing Environment)** of Supporting Documentation
6	Impact assessment - describe the potential impact/s that may occur to the environmental factor as a result of implementing the proposal.	See Section 5.2.1 (**Potential Impact)** of Supporting Documentation
7	Mitigation measures - what measures are proposed to mitigate the potential environmental impacts? The following should be addressed: • *Avoidance - avoiding the adverse environmental impact altogether;* • *Minimisation - limiting the degree or magnitude of the adverse impact;* • *Rehabilitate – restoring the maximum environmental value that is reasonably practicable; and* • *Offsets – actions that provide environmental benefits to counterbalance significant residual environmental impacts or risks of a project or activity.*	See Section 5.2.1 (**Proposed Mitigation and Monitoring)** of Supporting Documentation

Proponent to complete. DMA and Third Party to complete to the best of their knowledge.		
8	Residual impacts – review the residual impacts against the EPA objectives. *It is understood that the extent of any significant residual impacts may be hard to quantify at the referral stage. Referrers are asked to provide, as far as practicable, a discussion on the likely residual impacts and form a conclusion on whether the EPA's objective for this factor would be met if residual impacts remain. This will require:* • *quantifying the predicted impacts (extent, duration, etc.) acknowledging any uncertainty in predictions;* • *putting the impacts into a regional or local context, incorporating knowable cumulative impacts; and* • *comparison against any established environmental policies, guidelines, and standards.*	See Section 5.2.1 (**Outcome)** of Supporting Documentation
9	EPA's Objective – from your perspective and based on your review, which option applies to the proposal in relation to this factor? *Refer to EAG 9*	☒ *meets the EPA's objective* ☐ *may meet the EPA's objective* ☐ *is unlikely to meet the EPA's objective*
10	Describe any assumptions critical to your conclusion (in Question 9). *e.g. particular mitigation measures or regulatory conditions.*	See Section 5.2.1 of Supporting Documentation

Proponent to complete. DMA and Third Party to complete to the best of their knowledge.		
1	Factor, *as defined in* *EAG 8*	Marine Environmental Quality
2	EPA Objective, *as defined in* *EAG 8*	To maintain the quality of water, sediment and biota so that the environmental values, both ecological and social, are protected.
3	Guidance - what established policies, guidelines, and standards apply to this factor in relation to the proposal?	• EAG7: Environmental Assessment Guideline for Marine Dredging Proposals • EAG15: Environmental Assessment Guideline for Protecting the Quality of Western Australia's Marine Environment • Australian and New Zealand guidelines for fresh and marine water quality • Pilbara coastal water quality consultation outcomes: environmental values and environmental quality objectives • National assessment guidelines for dredging (NAGD) • Assessment and management of contaminated sites: Contaminated sites guidelines. Department of Environment Regulation. December 2014 • Identification and Investigation of Acid Sulfate Soils and Acidic Landscapes. Department of Environment Regulation. June 2015 • National Environment Protection (Assessment of Site Contamination) Measure. National Environment Protection Council
4	Consultation - outline the need for consultation and the outcomes of any consultation in relation to the potential environmental impacts, including: • *anticipated level of public interest in the impact;* • *consultation with regulatory agencies; and* • *consultation with community.*	See Section 3 of Supporting Documentation

<table>
<tr><th colspan="3">Proponent to complete. DMA and Third Party to complete to the best of their knowledge.</th></tr>
<tr><td>5</td><td>Baseline information - describe the relevant characteristics of the receiving environment.

This may include: regional context; known environmental values, current quality, sensitivity to impact, and current level of cumulative impacts.</td><td>See Section 5.2.2 (Existing Environment) of Supporting Documentation</td></tr>
<tr><td>6</td><td>Impact assessment - describe the potential impact/s that may occur to the environmental factor as a result of implementing the proposal.</td><td>See Section 5.2.2 (Potential Impact) of Supporting Documentation</td></tr>
<tr><td>7</td><td>Mitigation measures - what measures are proposed to mitigate the potential environmental impacts? The following should be addressed:

• Avoidance - avoiding the adverse environmental impact altogether;
• Minimisation - limiting the degree or magnitude of the adverse impact;
• Rehabilitate – restoring the maximum environmental value that is reasonably practicable; and
• Offsets – actions that provide environmental benefits to counterbalance significant residual environmental impacts or risks of a project or activity.</td><td>See Section 5.2.2 (Proposed Mitigation and Monitoring) of Supporting Documentation</td></tr>
<tr><td>8</td><td>Residual impacts – review the residual impacts against the EPA objectives.

It is understood that the extent of any significant residual impacts may be hard to quantify at the referral stage. Referrers are asked to provide, as far as practicable, a discussion on the likely residual impacts and form a conclusion on whether the EPA's objective for this factor would be met if residual impacts remain. This will require:
• quantifying the predicted impacts (extent, duration, etc.) acknowledging any uncertainty in predictions;
• putting the impacts into a regional or local context, incorporating knowable cumulative impacts; and
• comparison against any established environmental policies, guidelines, and standards.</td><td>See Section 5.2.2 (Outcome) of Supporting Documentation</td></tr>
<tr><td>9</td><td>EPA's Objective – from your perspective and based on your review, which option applies to the proposal in relation to this factor? Refer to EAG 9</td><td>☒ meets the EPA's objective
☐ may meet the EPA's objective
☐ is unlikely to meet the EPA's objective</td></tr>
<tr><td>10</td><td>Describe any assumptions critical to your conclusion (in Question 9). e.g. particular mitigation measures or regulatory conditions.</td><td>See Section 5.2.2 of Supporting Documentation</td></tr>
</table>

Proponent to complete. DMA and Third Party to complete to the best of their knowledge.		
1	Factor, *as defined in* *EAG 8*	Benthic Communities and Habitat
2	EPA Objective, *as defined in* *EAG 8*	To maintain the structure, function, diversity, distribution and viability of benthic communities and habitats at local and regional scales.
3	Guidance - what established policies, guidelines, and standards apply to this factor in relation to the proposal?	• EAG3: Protection of Benthic Primary Producer Habitats in Western Australia's Marine Environment • EAG7: Environmental Assessment Guideline for Marine Dredging Proposals • Guidance for the Assessment of Environmental Factors No. 1: Guidance statement for the Protection of Tropical Arid Zone Mangroves along the Pilbara Coastline • Environmental Protection Bulletin No. 14: Guidance for the assessment of benthic primary producer habitat loss in and around Port Hedland.
4	Consultation - outline the need for consultation and the outcomes of any consultation in relation to the potential environmental impacts, including: • *anticipated level of public interest in the impact;* • *consultation with regulatory agencies; and* • *consultation with community.*	See Section 3 of Supporting Documentation
5	Baseline information - describe the relevant characteristics of the receiving environment. *This may include: regional context; known environmental values, current quality, sensitivity to impact, and current level of cumulative impacts.*	See Section 5.2.3 (**Existing Environment)** of Supporting Documentation
6	Impact assessment - describe the potential impact/s that may occur to the environmental factor as a result of implementing the proposal.	See Section 5.2.3 (**Potential Impact)** of Supporting Documentation

Proponent to complete. DMA and Third Party to complete to the best of their knowledge.		
7	Mitigation measures - what measures are proposed to mitigate the potential environmental impacts? The following should be addressed: • *Avoidance - avoiding the adverse environmental impact altogether;* • *Minimisation - limiting the degree or magnitude of the adverse impact;* • *Rehabilitate – restoring the maximum environmental value that is reasonably practicable; and* • *Offsets – actions that provide environmental benefits to counterbalance significant residual environmental impacts or risks of a project or activity.*	See Section 5.2.3 (**Proposed Mitigation and Monitoring)** of Supporting Documentation
8	Residual impacts – review the residual impacts against the EPA objectives. *It is understood that the extent of any significant residual impacts may be hard to quantify at the referral stage. Referrers are asked to provide, as far as practicable, a discussion on the likely residual impacts and form a conclusion on whether the EPA's objective for this factor would be met if residual impacts remain. This will require:* • *quantifying the predicted impacts (extent, duration, etc.) acknowledging any uncertainty in predictions;* • *putting the impacts into a regional or local context, incorporating knowable cumulative impacts; and* • *comparison against any established environmental policies, guidelines, and standards.*	See Section 5.2.3 (**Outcome)** of Supporting Documentation
9	EPA's Objective – from your perspective and based on your review, which option applies to the proposal in relation to this factor? *Refer to EAG 9*	☒ *meets the EPA's objective* ☐ *may meet the EPA's objective* ☐ *is unlikely to meet the EPA's objective*
10	Describe any assumptions critical to your conclusion (in Question 9). *e.g. particular mitigation measures or regulatory conditions.*	See Section 5.2.3 (**Outcome)** of Supporting Documentation

In circumstances where there was some uncertainty on the level of significance of a particular factor it is recommended that a brief summary (no longer than 1 - 2 paragraphs) is provided on the steps taken to determine why a factor was not considered to be significant.

Attachment: 2

This page has been left blank intentionally

Report

Referral Supporting Document

Anderson Point Tug Haven

13 January 2016
560PO-4347-AP-EN-0001

Fortescue
The New Force in Iron Ore

	Referral Supporting Document: Anderson Point Tug Haven		**560PO-4347-AP-EN-0001**
Revision Number	**DRAFT A**		**4/02/2016**
Status	**IFR - ISSUED FOR REVIEW**		
Author	R. Sharp	Signature	13/01/2016
Checked	A. Winzer	Signature	13/01/2016
Approved	David Aston	Signature	9/02/2016
Confidentiality	**PUBLIC USE (ACCESS TO ALL)**	**Publish on Extranet**	☐ Yes ☒ No
Review Date	N/A		

EXECUTIVE SUMMARY

Pilbara Marine Pty Ltd (Pilbara Marine) propose to develop the Anderson Point Tug Haven Facility (the Facility) at Port Hedland in the Pilbara Region of Western Australia (Figure 1). Pilbara Marine is 100% owned subsidiary of Fortescue Metals Group (Fortescue). The tugs at the Facility will be used to support shipping being undertaken for all Port users in the Port Hedland Harbour.

The Proposal consists of construction and operation of a Tug Haven adjacent to the existing Herb Elliott Port Facility Third Berth (AP3). Dredging of 0.8 Mm^3 will be required for an approach channel and tug pen area. The marine infrastructure footprint covers 9.02 ha within the Herb Elliott Port Facility, of which 6.83 ha has been previously approved under other projects which are yet to be constructed. The remaining 2.19 ha of proposed disturbance occurs outside previously approved areas.

This Referral Supporting Document contains and Environmental Impact Assessment of the Facility in accordance with the Environmental Protection Authority (EPA) *Assessment Guideline Number 8: Environmental Assessment Guideline for Environmental Factors and Objectives (EAG 8)*. The key environmental factors which form part of the environmental impact assessment for the Pilbara Marine proposal are Coastal Processes, Marine Environmental Quality and Benthic Primary Producer Habitat. A summary of the findings of these studies is provided below.

Coastal Processes

Impacts on tidal hydrodynamics, including current velocity and water-level conditions, are expected to be minimal and limited to the immediate Proposal area. Key findings include:

- Current directions are relatively unchanged
- Differences in inundation patterns are negligible
- Current velocities are slightly more (approximately 7%) energetic during the Winter tidal cycle
- On average, there is a 1% difference in the maximum current for all locations apart from location 7 (directly adjacent to the Lumsden Point development, with impacts assumed to be attributable to the Lumsden Point development).

Sediment deposition resulting from the Proposal is expected to be minimal, with no areas outside the dredge footprint and existing berth pockets expected to experience sedimentation of more than 50 mm.

Marine Environmental Quality

Sediment quality in the Proposal area is consistent with previous studies in Port Hedland and the sediment from the dredge area is considered to be suitable for onshore disposal. No significant impacts associated with release of metals or acidification are anticipated to occur.

Dredging activities are expected to result in temporary increases to suspended sediment concentrations (SSC) and total sedimentation due to deposition of the resultant dredge plume. Sediment plume modelling was undertaken to determine the extent of these increases which are predicted to be within natural background levels:

- SSC is expected to be less than 50 mg/L around the proposal area for 80% of the time.
- SSC is expected to be less than 10 mg/L near the harbour entrance for at least 80% of the time.
- Sedimentation due to deposition of the dredge plume of up to 200mm is expected at localised areas within mooring basins AP2 (second berth) and AP3 (third berth).

Benthic Primary Producer Habitat

Impacts to Benthic Primary producer habitat (BPPH) have been limited through the design of the marine infrastructure and resultant dredge volume. The proposal will result in the direct loss of 2.19 ha of sandy habitat due to dredging. Indirect impacts include temporary, non-lethal impacts to 3.9 ha of sandy habitat as a result of elevated suspended sediment in the Zone of Moderate Impact (see Section 5.2.3).

The permanent loss of 2.19 ha of sandy habitat will lead to a cumulative loss of 263.53 ha within the Port Hedland Local Assessment Unit (LAU) (11.24%). The overall percentage cumulative loss of sandy habitat within the LAU directly attributable to the proposal is 0.11%. This represents a very small proportion of the total BPPH found in Port Hedland and will have a negligible impact on the ecological integrity of the broader Port Hedland LAU.

Through implementation of the existing Fortescue environmental management framework, it is very likely that the EPA’s objectives for the protection of environmental factors will be met for this Proposal.

TABLE OF CONTENTS

List of Tables

List of Plates

List of Figures

List of Appendices

1. INTRODUCTION

Pilbara Marine Pty Ltd (Pilbara Marine) proposes to develop the Anderson Point Tug Haven Facility (the Facility) at Port Hedland in the Pilbara Region of Western Australia (Figure 1). The tugs at the Facility will be used to support shipping being undertaken for all Port users in the Port Hedland Harbour.

1.1 Purpose of this Document

This document presents supporting information to accompany the referral of the Proposal to the Environmental Protection Authority (EPA) under Section 38 of the *Environmental Protection Act 1986* (the EP Act). This document presents a description of the key components of the Proposal and an assessment of the environmental impacts of the proposal in accordance with Environmental Assessment Guideline 14, published by the EPA (2015a).

1.2 Proponent

The Proponent for the Facility is Pilbara Marine, a wholly-owned subsidiary of Fortescue Metals Group Ltd (Fortescue).

Pilbara Marine Pty Ltd
Level 2, 87 Adelaide Terrace
EAST PERTH WA 6004

PO Box 6915
EAST PERTH WA 6892

ACN: 160 019 205
ABN: 80 160 019 205

All correspondence should be addressed to the key contact person for this application:

Sean McGunnigle
Manager, Environmental Approvals
Ph: 6218 8415
Email: smcgunnigle@fmgl.com.au

1.3 Proposal Location

The Tug Haven Facility (the Facility) is located within Fortescue's Herb Elliott Port Precinct at Anderson Point, within the Town of Port Hedland in the Pilbara Region of Western Australia. Anderson Point is approximately 1.7 km south of the western end of Port Hedland. The location of the Herb Elliott Port and the Facility is depicted in Figure 1.

1.4 Assessment Approach

The preliminary key environmental factors associated with this proposal are summarised in Section 5.1. These preliminary key environmental factors were identified through understanding of the existing environment, the potential impacts posed by the Proposal, *Environmental Assessment Guideline for Environmental Principles, Factors and Objectives* (EAG 8) and discussions with the Office of the Environmental Protection Authority (OEPA).

A suite of environmental studies have been undertaken in order to fully understand the receiving environment and the potential impacts associated with the Proposal. These studies include:

- Sediment Analysis Plan Implementation
- Hydrodynamic and Sediment Plume Modelling
- Benthic Primary Producer Habitat Survey and Impact Assessment
- Surface Water Impact Assessment.

The Port Hedland Harbour has been extensively studied as a result of the numerous developments that have been formally assessed by the EPA in recent years. The environmental data available from these and other projects which were not formally assessed e.g. Stingray Creek Cyclone Mooring Facility allows for a detailed understanding of the environmental impacts associated with developments in the Port precinct. Furthermore, the management and mitigation measures implemented for these projects and their effectiveness at reducing environmental impacts are well documented.

This document outlines these factors, discusses the potential impacts, assesses the impact to the environment as a result of the proposal and outlines management measures to be adopted to reduce the level of these impacts such that the Proposal will meet the EPA’s objectives.

1.5 Alternative Options Considered

A number of locations were considered for the Facility. The site was selected based on the following criteria:

- dredge volume
- proximity to existing dredge spoil disposal areas
- ocean conditions, including wave and swell protection
- proximity to services
- proximity to Fortescue’s Herb Elliott Port Facility.
- project schedule

2. PROJECT DESCRIPTION

2.1 Project Location and Existing Land Use

Pilbara Marine proposes to construct the Facility at Anderson Point, adjacent to Fortescue's Herb Elliot Port Facility. The Facility is accessed from Utah Road, through Fortescue's Port offices and infrastructure. The Facility is located immediately south of Fortescue's AP1 to AP3 berths at the north-east corner of Australia Island. The proposed general arrangement is shown in Figure 2.

2.2 Project Overview

The Facility is currently designed to accommodate 9 tugs, however it is readily expandable in the future to allow both service and cyclone moorings for up to 13 tugs with no further dredging required (Figure 3). The scope of this Proposal covers the expanded option, servicing up to 13 tugs.

The Facility comprises the following physical characteristics:

- Picnic Point Abutment to Anderson Point
- dredged approach channel and berth pocket
- dredge spoil pipelines
- use of existing, approved Pilbara Port Authority dredged material management areas (DMMAs)
- access walkway
- service berth
- pontoons and pens for nine tugs (expandable to 13)
- cyclone moorings (including stand-alone piles)
- navigation leads
- fuel facility and fuel service system
- administration buildings
- sewage facilities
- workshop and warehouse
- hydrocarbons storage area
- associated access roads and vehicle parking areas.

Significant construction activities include:

- land based earthworks and general construction
- dredging of the berth pocket area and access channel
- transport of dredged material by pipeline and disposal in existing, approved Dredge Material Management Areas (DMMAs)
- construction of marine structures including piling.

2.2.1 Key Characteristics

The Key Characteristics of the Proposal are defined in Table 1, in accordance with the requirements of the EPA's EAG1.

Table 1: Anderson Point Tug Haven Key Characteristics

Summary of the Proposal		
Proposal Title	Anderson Point Tug Haven	
Proponent Name	Pilbara Marine Pty Ltd	
Short Description	Construction of a Tug Haven Facility at Anderson Point, including the following infrastructure: • Picnic Point Abutment to Anderson Point • dredged approach channel and berth pockets • dredge spoil pipelines • use of existing, approved dredged material management areas (DMMAs) • access walkway • service berth • pontoons and pens for nine tugs (expandable to 13) • cyclone moorings (including stand-alone piles) • navigation leads • fuel facility and fuel service system • administration buildings • sewage facilities • workshop and warehouse • hydrocarbons storage area • associated access roads and vehicle parking areas.	
Physical Elements		
Element	**Location**	**Proposed Extent**
Onshore Infrastructure	Figure 2	Onshore extent of 3 ha within the Port Facility. All infrastructure will be located within previously disturbed areas. No additional disturbance is required.
Marine Infrastructure	Figure 3	Marine Infrastructure footprint of 9.02 ha within the Port Facility, of which 6.83 ha has been previously approved in other projects. 2.19 ha of proposed disturbance outside approved areas.
Dredging	Figure 3	0.8 Mm^3

BPPH within proposed disturbance footprint areas		
Element	**Location**	**Proposed Disturbance**
Area of direct impact to mangroves	Figure 5	0 ha
Area of direct impact to Sandy Habitat	Figure 5	2.19 ha
Area of direct impact to other BPPH (Coral, Macroalgae, Saltmarsh, cyanobacterial Mats)	Figure 5	0 ha

2.2.2 Relationship to Other Projects

Fortescue constructed the Anderson Point Port Facility under Ministerial Statement 690 and Ministerial Statement 771. Dredging in South West Creek was undertaken under Ministerial Statement 859. Fortescue currently operates five berths at the Anderson Point Port Facility. The Proposal is located adjacent to berth AP3 (Figure 2).

A portion of the dredge area overlaps with the dredge footprints of approved projects in Port Hedland; the Stingray Creek Cyclone Mooring Facility (not assessed at State level) and the Lumsden Point General Cargo Facility (Ministerial Statement 967).

2.3 Project Infrastructure

Sections 2.3.1 to 2.3.8 below provide detailed information on each aspect of project design.

2.3.1 Onshore Infrastructure

All onshore infrastructure will be constructed in areas of previous disturbance, including the abutment, fuel facilities, administration facilities and dredged material transport pipelines. No additional onshore land clearing is required for this Proposal.

2.3.2 Dredging

Dredging of the approach channel and Tug Haven is required as part of the construction of the Facility. The approach channel and Tug Haven areas will be dredged to -8.0 m chart datum (CD) (Figure 3). Approximately 0.8 Mm^3 of material will be removed using a cutter suction dredge. This area is relatively shallow (to -6 m CD) and is sheltered behind the existing Anderson Point wharf and berth areas.

Dredging activities will be undertaken in accordance with the Dredging and Spoil Disposal Management Plan (DSDMP) (Fortescue 2016).

2.3.3 Disposal of Dredged Material

Dredged material will be piped to existing, established Dredged Material Management Areas (DMMAs). Pipes will be a combination of floating pipeline, submerged pipeline and conventional above-ground pipeline (Figure 2).

The dredged material will be pumped to Fortescue's DMMA A, located to the west of the Fortescue stockyards. Within DMMA A, grits will settle in the Northern Sediment Area (NSA) and fines will move to the Southern Sediment Area (SSA). Fines and water from the SSA will be pumped to DMMA B, located to the east of the Fortescue stockyards. Fines will settle in the Eastern Settlement Area (ESA) and tailwater will flow on to the South Eastern Settlement Area (SESA) before being released into South Creek. The DMMAs and settlement areas are shown on Figure 2.

Dredged material will be transported in floating pipelines from the dredge location. To avoid impacts to fringing mangroves, the material will then be pumped via a submerged line, before coming above-ground at the boundary of the existing cleared area at Australia Island. The above-ground pipeline will be routed along the existing causeway and around the existing DMMAs.

Disposal of dredged material will be undertaken in accordance with the DSDMP (Fortescue 2016).

2.3.4 Picnic Point Abutment to Anderson Point

The existing substructure (abutment) on the end of Anderson Point, referred to as Picnic Point will be used to service the proposed Tug Haven (see Figure 2). No additional works are required as part of this Proposal.

2.3.5 Access Walkway

The access walkway will be approximately 150 m in length and 1.8 m wide, running from the abutment to the berthing area. It will be constructed using piles and will not form a barrier to water or sediment movement.

2.3.6 Service Berth

A double service berth for two individual tugs will be constructed as part of the tug berth arrangement (Figure 3).

2.3.7 Maintenance Berth

A maintenance berth for a single tug will be constructed on the south-eastern side of the existing Fortescue Wharf (opposite berth AP3) (Figure 3).

2.4 Tenure

TPI hold a lease over the Herb Elliott Port from the Pilbara Port Authority. TPI and Pilbara Marine have an agreement for access to TPI's lease area and existing port facilities.

2.5 Approval Timeframes

It is anticipated that primary environmental approval will be in place for the Tug Haven Facility by mid-2016, based on submission of this referral in February 2016. Commissioning of the facility will commence by early 2017.

3. STAKEHOLDER CONSULTATION

Consultation with key stakeholders and the community is an important element of the environmental impact assessment process. Pilbara Marine considers that consultation with the community, key stakeholders and decision-making authorities is vitally important to ensure all parties have the opportunity to make informed comment about the proposal.

3.1 Stakeholder Identification and Engagement

A Communications Strategy has been developed to recognise key stakeholders and plan for their engagement with the proposal at the earliest opportunity in a format applicable to their level of interest and involvement. Key stakeholders identified for the Tug Haven Facility are:

Government (State and Commonwealth)

- Environmental Protection Authority (EPA)
- Department of the Environment (Cwlth)
- Department of State Development
- Department of Environment Regulation
- Pilbara Port Authority
- Department of Mines and Petroleum
- Department of Parks and Wildlife

Local Government

- Town of Port Hedland

Indigenous Groups

- Native Title Claimants – Kariyarra
- Aboriginal Corporations – Yamitji Marlpa Aboriginal Corporation

Community Interest Groups

- Care for Hedland.

3.2 Stakeholder Comments and Outcomes

A summary of stakeholder consultation for the proposal to date and where specific comments, if any, are addressed in the document is shown in Table 2.

Table 2: Summary of Consultation Undertaken to Date

Stakeholder	Format	Comments Noted	Where Addressed
Kariyarra Native Title Group 15 July 2015	Written notification of intention to submit s18 Notice, for the right to use Land potentially containing Aboriginal Sites for the purpose of "the construction, operation & maintenance of a tug haven & associated infrastructure",	N/A	N/A
Marapikkurinya and Kariyarra Native Title Groups July – August 2015	Consultation with Marapikkurinya Kariyarra, via legal representative, regarding proposed s18 Notice and Tug Haven project	N/A	N/A
Kariyarra Native Title Group 5 August 2015 11 August 2015	Draft s18 Notice distributed to Kariyarra legal representatives and claim anthropologist. Follow up meeting.	Negotiations regarding content of s18	N/A
Kariyarra Native Title Group 20 August 2015	Final version of s18 Notice distributed to Kariyarra legal representatives and claim anthropologist (in conjunction with submission to Department of Aboriginal Affairs)	N/A	N/A
Department of State Development 27 August 2015	– Tug tender bid raised at regular meeting to ensure that DSD are aware of Fortescue's continued interest in tendering for 2nd Tug License	No issues raised	N/A
Department of State Development 29 October 2015	Brief DSD on relevant operational aspects of tender.	No adverse comments received. Queries raised about the extent of the dredging to be undertaken.	Section 2, Figure 3
Department of State Development 25 November 2015	Detailed discussion with DSD around ownership of tenure, area of dredging, dredge spoil disposition.	No concerns raised.	Section 2, Figures 2 and 3
Pilbara Ports Authority 8 December 2015	Presentation to PPA outlining key characteristics of Proposal and overview of environmental impact assessment.	**How will DMMA A contamination and potential listing of DMMA A by the DER contaminated lands branch be avoided** – The Sediment Analysis Plan (SAP) Implementation	Majority of comments were addressed in the meeting

Stakeholder	Format	Comments Noted	Where Addressed
		Report confirmed Nickel and Chromium concentrations were below ANZECC (2000) and NEPM HILS which are the relevant State criteria to determine suitability of dredge spoil for onshore disposal. This combined with the dredge spoil bulking factor will also dilute potential contaminants concentrations to below NAGD screening levels. Furthermore, monitoring in the DMMA A will also occur throughout the dredging program to ensure DMMA A remains contaminant free. **Please confirm the scale on the Hydrodynamic Model output slides** –A decrease in current velocity of up to 0.2m/sec is predicted within the project footprint, no change in mean flow velocity is predicted outside the project footprint (a legend has been added to this slide in the attached version) **Please confirm what the pink boundary represents** - The pink boundary denotes the Project study area which encompasses AP1-3 in order to quantify changes in sedimentation as a result of the Tug haven facility dredge plan. **Construction Environmental Noise Management Plan** – has been updated to include tug haven proposal incorporating piling one Sunday each fortnight in consultation with the PPA **Dredge Spoil Disposal Management Plan** – to be based on a revision to the DSMP submitted with the Tug Haven PPA Development Application. The revised DSDMP will then be submitted with the EPA referral in early February 2016.	(as noted). Additional detail can be found in Section 5.2
Office of the EPA 18 December 2015	Presentation to the EPA outlining the Proposal, key characteristics and preferred approvals approach.	**What is the need for the Proposal given there is already a tug operator in Port Hedland-** this facility would be available to all Port users. The PPA believes two tug operators are required to optimise shipping movements. **Please ensure alternate options are discussed in the referral –** See Section 2.3 of the Benthic Primary Producer Impact Assessment Report. **Please confirm DSD and PPA support has been received for the proposal.**	Section 2.3 of the Benthic Primary Producer Impact Assessment Report.

Stakeholder	Format	Comments Noted	Where Addressed
		Ensure results of elutriation tests are reported – The Sediment Analysis Plan is based on onshore spoil disposal and meets Contaminated site guidelines (DER 2014) and NEPM (2013) requirements. Elutriation testing was not conducted however testing of SEM (Simultaneously Extracted Metals) and AVS (Acid Volatile Sulphur) was conducted to estimate bioavailability of metals (including Ni) in the sediment. In the absence of any elutriate data, the AVS data does provide additional confidence to quantify the likelihood of release of metals in the sediment.	Section 4.3.5 of Sediment Analysis Plan Implementation Report
Office of the EPA 13 January 2016	Site visit incorporating tour of proposed landside and marine construction areas for the Tug Haven.	**Landside footprint recognised as pre-disturbed.**	
Town of Port Hedland 1 February 2016	Presentation to CEO and Executive	**Does the Pilbara Marine Tug Haven Options Analysis consider the 100 pen Pilbara Marina Waterfront Development. The current construction timeline is Q1 2019 –** This location was considered in the early stages of the tug haven facility development. The Q1 2019 Pilbara Marina Development schedule is in excess of 15 months later than the Pilbara Marine requirement. **How will the tugs be serviced. Would a dry dock facility at the Pilbara Marina Waterfront Development be of interest to tug haven proposal –** The options being considered for dry docking are Dampier and Singapore. This is only required every 5 years. It is intended our strategy relating to this will be further developed over the execution phase of the project. If there was a dry dock facility at Port Hedland, this would come under consideration as an option (subject to the typical commercial and technical evaluation of options). **What is the estimated cost of the Tug Haven Facility –** The Tug Haven is still under evaluation and it's too early to provide guidance on this matter.	Section 2.3 of the Benthic Primary Producer Impact Assessment Report. Section 1.5 and 2.5 (Project Schedule).
Care for Hedland	Presentation to Committee members and Chair	**Request that dredging schedule consider turtle nesting and hatchling season –** the dredging	Appendix 6

Stakeholder	Format	Comments Noted	Where Addressed
1 February 2016		schedule is yet to be confirmed. Onshore disposal of dredge spoil effectively minimises interaction with marine fauna such as turtle hatchlings. **Request the referral supporting document outline water quality and sediment management –** the DSDMP contains a tiered management framework for water quality and sediment which will be implemented as per previous dredging campaigns e.g. AP4, AP5. **Commended the marine layout overlapping with other approved proposals which effectively minimises dredge volumes** **Herb Elliott Port site tour requested –** The Care for Hedland Group would be most welcome on site. Timeframe for site tour to be confirmed.	

3.3 Ongoing Consultation

Pilbara Marine will continue to consult with key stakeholders during the construction and operations phases. In addition, Fortescue maintains a community office in South Hedland where stakeholders can access information on all of Fortescue's developments.

4. ENVIRONMENTAL STUDIES

The key environmental factors for this proposal have been considered and a range of environmental studies to support the assessment of the environmental impacts associated with this proposal have been undertaken. All studies have undertaken in accordance with guidance statements with reference to regulatory thresholds and targets.

All studies are detailed in Table 3.

Table 3: Summary of Environmental Studies Undertaken to Date

Environmental Study	Consultant	Summary Description	Study Area	Reference
Sediment Analysis Plan (SAP) Implementation Report	Advisian Pty Ltd	The SAP Implementation report describes the sampling and analysis procedures used to determine sediment quality for a range of physical and chemical properties. Sampling conducted in accordance with the Contaminated Sites Guidelines (DER 2014) and NEPM (NEPC 1999) requirements. Results compared with the following criteria to determine suitability for onshore disposal: • ANZECC/ARMCANZ (2000) ISQG assessment levels • NEPM assessment levels (NEPC 1999).	Sampling was undertaken in the proposed dredging area. Data recovered from previous sediment investigations in the immediate area were also used.	Report 560PO-4347-RP-EN-0002 Advisian (2015a) Appendix 1
Hydrodynamic Impact Assessment	Worley Parsons	Investigation to identify and quantify any potential change in current and water level conditions as a result of the Proposal.	Model domain incorporates an extent 60 km offshore from Port Hedland, between Depuch Island and Larrey Point. Impact assessment is concentrated around the dredging area and immediate surrounds within the inner harbour.	Report 560PO-4347-RP-EN-0004 Worley Parsons (2015a) Appendix 2
Sediment Plume Dispersion Modelling	Worley Parsons	Investigation into the fate of sediment plumes generated by dredging activities associated with the Proposal.	Model domain incorporates an extent 60 km offshore from Port Hedland, between Depuch Island and Larrey Point. Impact assessment is concentrated around the dredging area and immediate surrounds within the inner harbour.	Report 560PO-4347-RP-EN-0003 Worley Parsons (2015b) Appendix 3

Environmental Study	Consultant	Summary Description	Study Area	Reference
Benthic Primary Producer Habitat Survey and Impact Assessment	Advisian Pty Ltd	Describes the benthic communities and habitats within the Proposal area and defines direct and indirect impacts to these habitat areas as a result of the Proposal.	Port Hedland Local Assessment Unit (LAU)	Report 560PO-4347-RP-EN-0005 Advisian (2015b) Appendix 4
Surface Water Impact Assessment	Advisian Pty Ltd	Estimation of run-off peaks, hydrographs and flow volumes and comparison with current conditions. Impact assessment and presentation of management measures.	Catchment boundary as shown within the report (forms part of Australia Island).	Report 560PO-4347-RP-EN-0001 Advisian (2015c) Appendix 5

5. ASSESSMENT OF PRELIMINARY ENVIRONMENTAL FACTORS

The purpose of this section is to summarise key considerations in the environmental assessment of the proposal and show how the proposal can be managed to meet the EPA's objectives for each preliminary key environmental factor.

5.1 List of Preliminary Environmental Factors

The preliminary key environmental factors identified through understanding of the existing environment, the potential impacts posed by the Proposal and discussions with the OEPA, are listed in Table 4.

Table 4: Preliminary Key Environmental Factors

Factor	Envelope	Environmental Aspect	Impact
Coastal Processes	Port Facility	Tug Haven infrastructure located within supratidal and intertidal zones Dredging and Spoil Disposal	Changes to hydrodynamics Deposition of sediment
Marine Environmental Quality	Port Facility	Tug Haven infrastructure located within supratidal and intertidal zones. Marine dredging and spoil disposal. Concrete piling in intertidal zone exposing Potential Acid Sulphate Soils (PASS) Chemical and Hydrocarbon Spill potentially caused by fuel facilities	Sediment plume (altered water quality) resulting from dredging and disposal activities Change to marine water quality due to discharge/runoff of surface water, exposure of PASS or hydrocarbon spills.
Benthic Primary Producer Habitat	Port Facility	Direct disturbance (clearing) of BPPH Chemical and Hydrocarbon Spill potentially caused by fuel facilities Concrete piling in intertidal zone exposing Potential Acid Sulphate Soils (PASS)	Loss of BPPH Degradation of BPPH

A number of other environmental factors (not considered to be key environmental factors) have been identified in relation to this Proposal:

- amenity (noise)
- air quality and atmospheric gases (dust)
- terrestrial fauna
- marine fauna (including introduced marine species).

5.2 Impact Assessment for Preliminary Key Environmental Factors

An assessment of the impact of the proposal on the preliminary key environmental factors is presented in Sections 5.2.1 to 5.2.3.

5.2.1 Coastal Processes

Objective

To maintain the morphology of the subtidal, intertidal and supratidal zones and the local geophysical processes that shape them.

Guidance

Relevant policies and guidelines include:

- EAG7: *Environmental Assessment Guideline for Marine Dredging Proposals* (EPA 2011a)
- *Australian and New Zealand guidelines for fresh and marine water quality* (ANZECC/ARMCANZ 2000)
- *Pilbara coastal water quality consultation outcomes: environmental values and environmental quality objectives* (DOE 2006)
- *National assessment guidelines for dredging (NAGD)* (CoA 2009).

Existing Environment

The Port Hedland oceanographic environment is dominated by a large tidal range which drives flood and ebb tidal currents. Tidal current velocities are in the order of 1 m/s in nearshore and tidal creek areas. The existing environment is described in detail in Appendix 3 with reference to oceanography, tidal levels and winds.

Potential Impact

Potential impacts to coastal processes resulting from implementation of the Proposal include:

- Change in current velocities
- Change in current direction
- Change to areas of inundation/submergence
- Deposition of sediments as a result of dredge plumes.

Hydrodynamic Impacts

An assessment of hydrodynamic and sediment plume dispersion impact due to the proposed dredging works was undertaken as part of the proposal. The hydrodynamic impact assessment (Worley Parsons 2015a, Appendix 3) was carried out using Worley Parsons' 3D numerical hydrodynamic model of the Port Hedland region. The impact of dredging on hydrodynamic conditions was assessed by applying the model to simulate conditions for both pre- and post-development. For modelling purposes, the pre-development (base) case was defined by the port layout and bathymetry as of May 2014, updated to include dredging approved by the EPA to January 2015. The post-development (test) case incorporates the effects of two subsequently approved developments (Stingray Creek Small Vessel Cyclone Mooring Protection Facility and Lumsden Point General Cargo Facility), along with the Tug Haven Proposal (Plate 1). This approach was selected based on consultation with the OEPA.

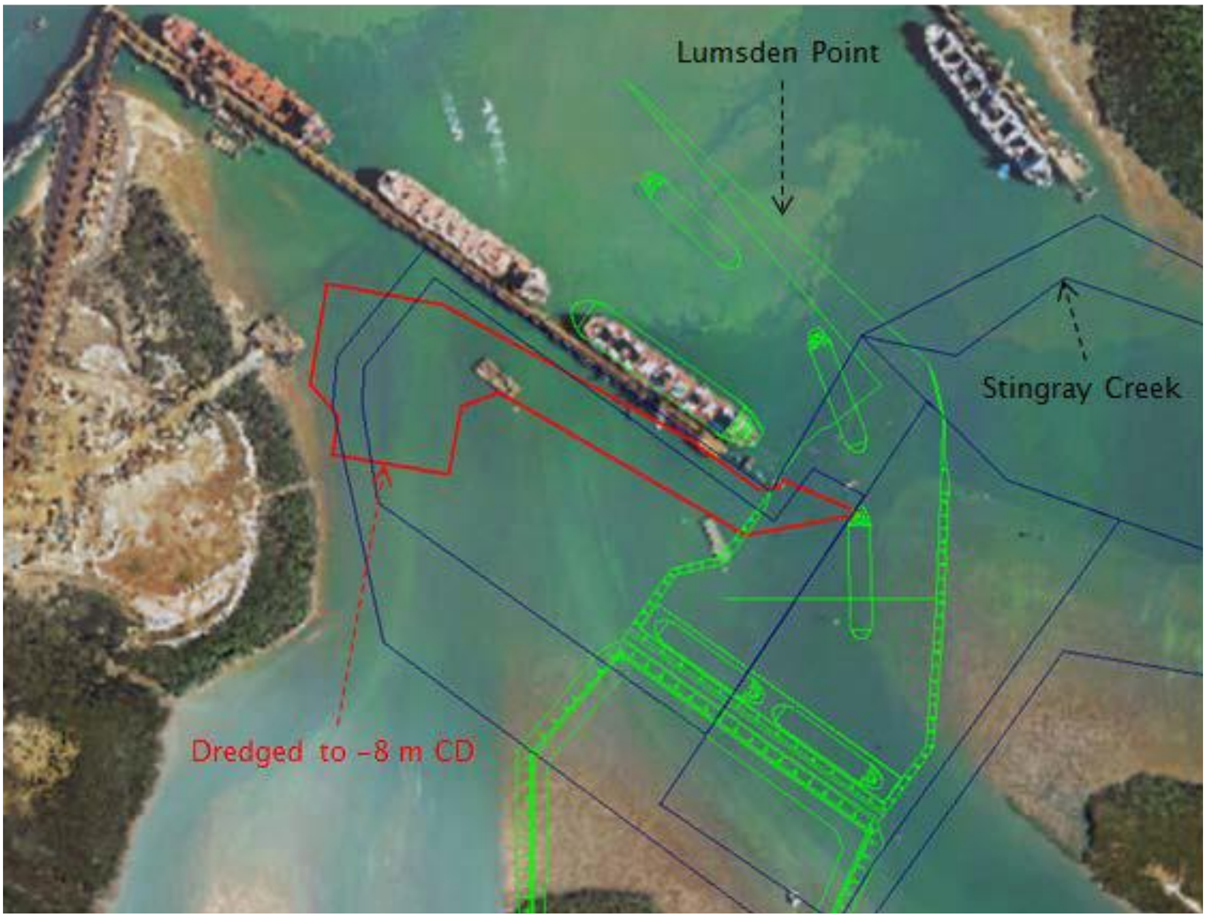


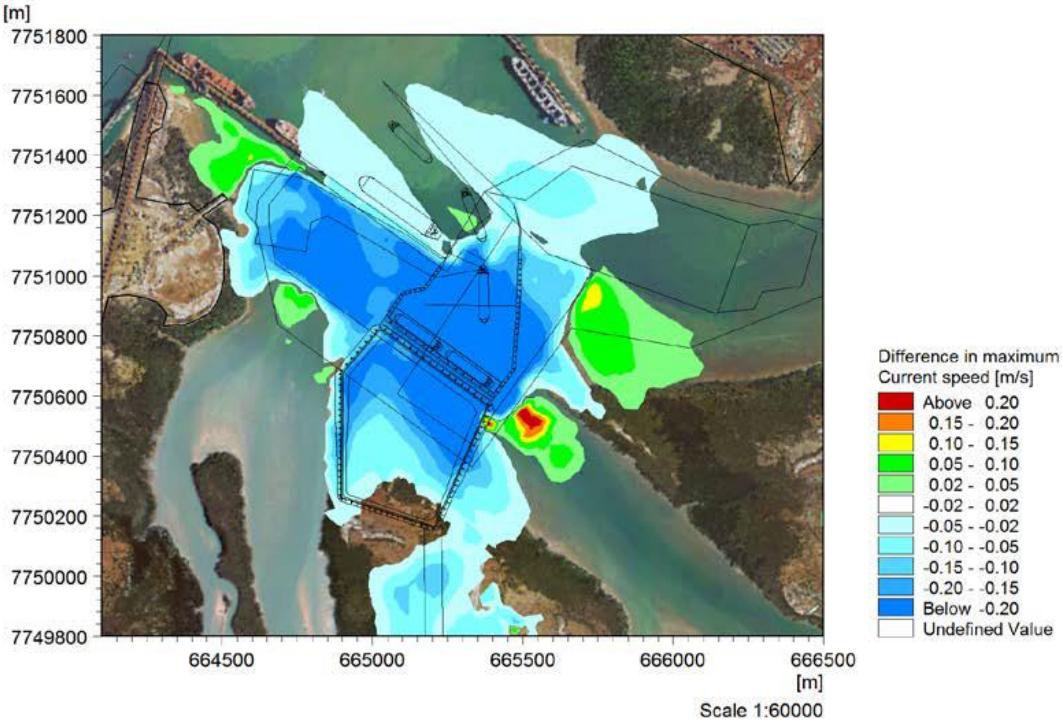
Plate 1: Approved Dredging Proposals

The numerical modelling simulations have been analysed to determine the extent of changes to the seasonal (summer and winter) flood and ebb tidal currents and water levels near the development area. Further information on the model setup, inputs and validation are included in Appendix 3.

Results of the assessment predict that impacts on tidal hydrodynamics i.e. inundation patterns, including current velocity and water-level conditions, are expected to be minimal and limited to the immediate Proposal area (Plates 2 and 3). Key findings are:

- Current directions are relatively unchanged between the Base Case and Test Case
- Differences in inundation patterns between the Base Case and Test Case are negligible

- On average, there is a 1% difference in the maximum current velocity between the Base Case and Test Case for all locations apart from location 7 (directly adjacent to the Lumsden Point development)
- For location 7, the Test Case clearly demonstrates an average reduction of 27% in the maximum current velocity; largely due to the inclusion of Lumsden Point and Stingray Creek developments.



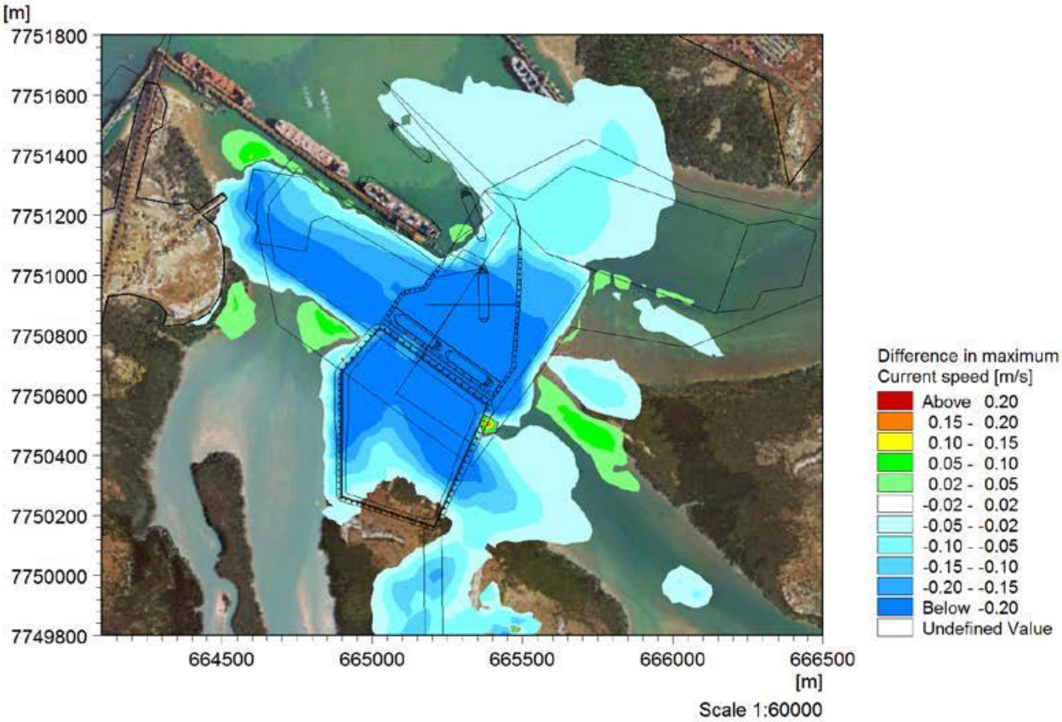
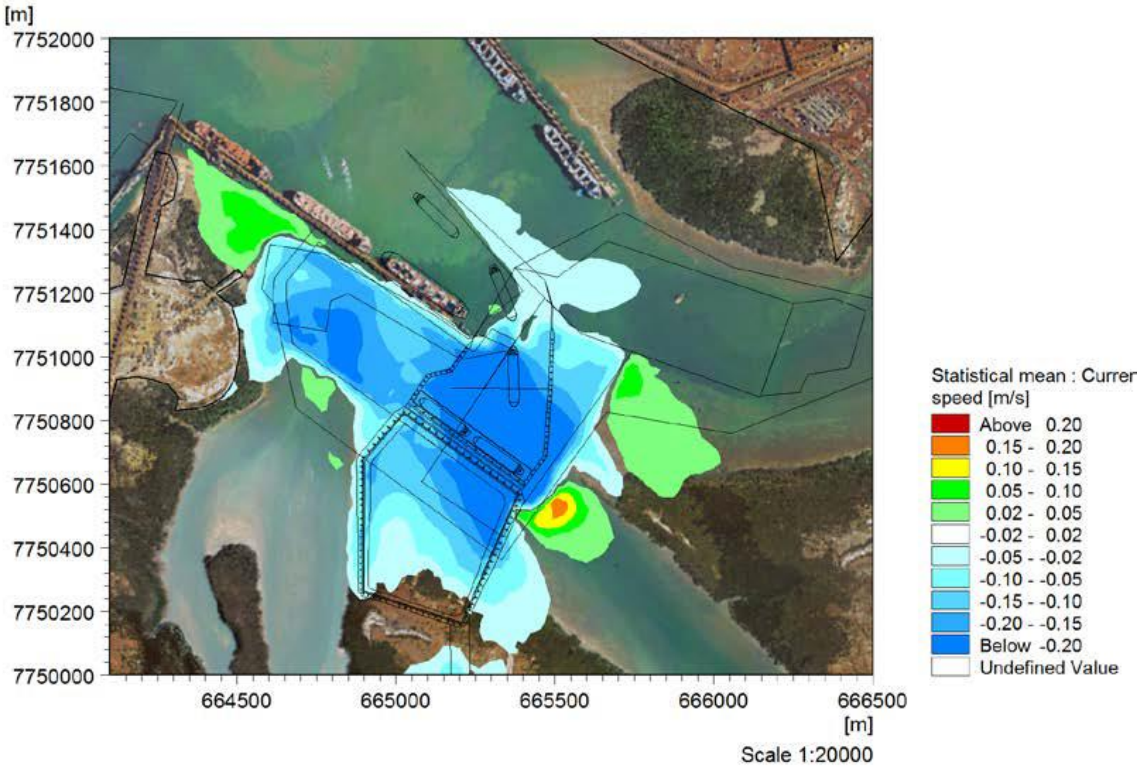


Plate 2: Difference in maximum current speed over Ebb (top) and Flood (bottom) tidal cycles



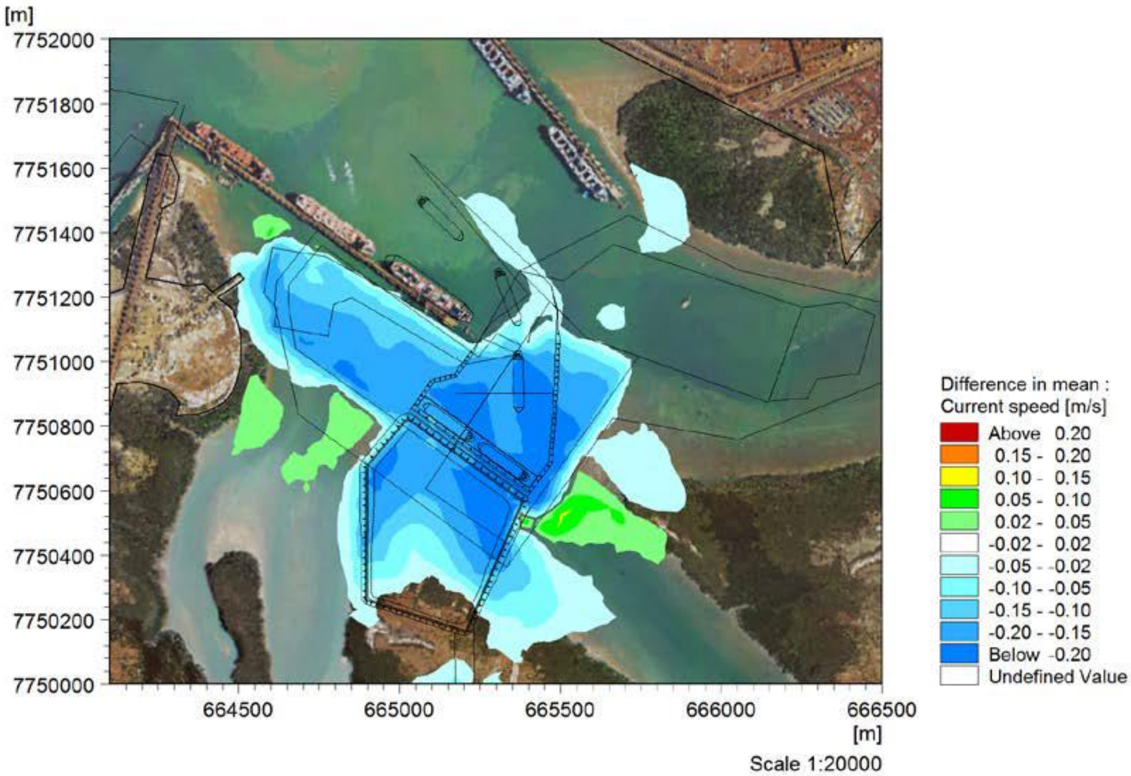


Plate 3: Difference in mean current speed over Ebb (top) and Flood (bottom) tidal cycles

Based upon the modelling and analysis presented in Appendix 3, the Proposal will have negligible impact on flow velocities and inundation patterns outside the immediate vicinity of the Proposal Area. Although there are subtle differences between flood and ebb tides, the effect is consistent across both mean and maximum flow velocities.

Sediment Deposition Impacts

The Sediment Dispersion Modelling was carried out using Worley Parsons Port Hedland Sediment Dispersion model, which consists of hydrodynamic module, mud transport module and spectral wave module. The impact of dredging on sediment plume dispersion was assessed by applying the model to the dredging program in a summer and a winter scenario.

The Base Case Bathymetry (Pre-development) represents the existing condition and includes the existing bathymetry updated with future stages of approved developments and bathymetric surveys, including:

- Channel and harbour maintenance dredging
- BHP Hunt Point CLOF (survey JDN, 2012)
- Utah Point dredging and development
- Fortescue Anderson Point dredging and development (AP1, AP2, AP3)
- BHP Billiton Harriet Point dredging and development
- BHP Billiton Nelson Point dredging and development
- South West Creek dredging and development: AP4, AP5 (Fortescue), and SP1, SP2 (Roy Hill)
- Stingray Creek dredging (Eastern part of the Stingray creek dredged for BHP tugboats cyclone mooring)
- Near shore – Offshore outer harbour survey
- Outer Harbour Bathymetric LIDAR survey.

Future approved developments, have been added onto the existing bathymetry in their full extent of approval as described below:

- BHP Billiton, Hunt Point Marine Precinct (Tug Harbour)
- PHPA, South West Creek Dredging and Reclamation.

The Test Case Bathymetry (Post-development) includes the proposed tug haven. It should be noted that not all future approved developments included in the hydrodynamic impact assessment's test case (Worley Parsons 2015a) are included in the sediment plume dispersion model because both studies aim to provide a conservative assessment of the both dredge plume and the cumulative hydrodynamic impact.

Modelling determined that the base case bathymetry was the most conservative in terms of impacts associated with sediment deposition. As such, the base case bathymetry has been used for impact assessment purposes.

Sediment dispersion model results were analysed to predict:

- suspended sediment concentration (SSC); and
- total sedimentation due to deposition of the dredge plume at completion of the dredging program.

Additional information regarding model setup and detailed results is available in Appendix 4. Findings related to suspended sediment are presented in Section 5.2.2 (Marine Environmental Quality).

Model results for sediment deposition are provided in Plates 4 and 5 overleaf. These plates allow comparison between the expected sedimentation range due to dredging for the Summer and Winter cases.

Key findings related to sediment deposition, outside the dredge footprint are summarised below:

- Sedimentation due to deposition of the dredge plume of up to 200 mm is expected at localised areas within the existing AP2 and AP3 mooring basins.
- Sedimentation due to deposition of the dredge plume in South Creek is expected to be generally less than 10 mm with sedimentation up to 50 mm in localised areas within the mangroves.
- Outside the areas discussed above, sedimentation due to the dredge plume is expected to be less than 5 mm.

Sediment deposition resulting from the Proposal is expected to be minimal, with no areas outside the dredge footprint and existing berth pockets expected to experience sedimentation of more than 50 mm.

Impacts to BPPH as a result of sediment deposition are assessed in Section 5.2.3.

Proposed Mitigation and Monitoring

Modelling has demonstrated that there will be negligible impacts to current direction, current velocity, areas of inundation or sediment deposition resulting from the Proposal. Therefore, no specific mitigation actions are required to manage residual impacts to coastal processes.

Proposed Regulatory Mechanisms

Not required

Outcome

The Proposal has been designed to limit the disturbance to coastal processes to as low as reasonably practicable. No significant impacts are expected to occur as a result of the implementation of the Proposal. As such, the EPA’s objective for coastal processes can be met.

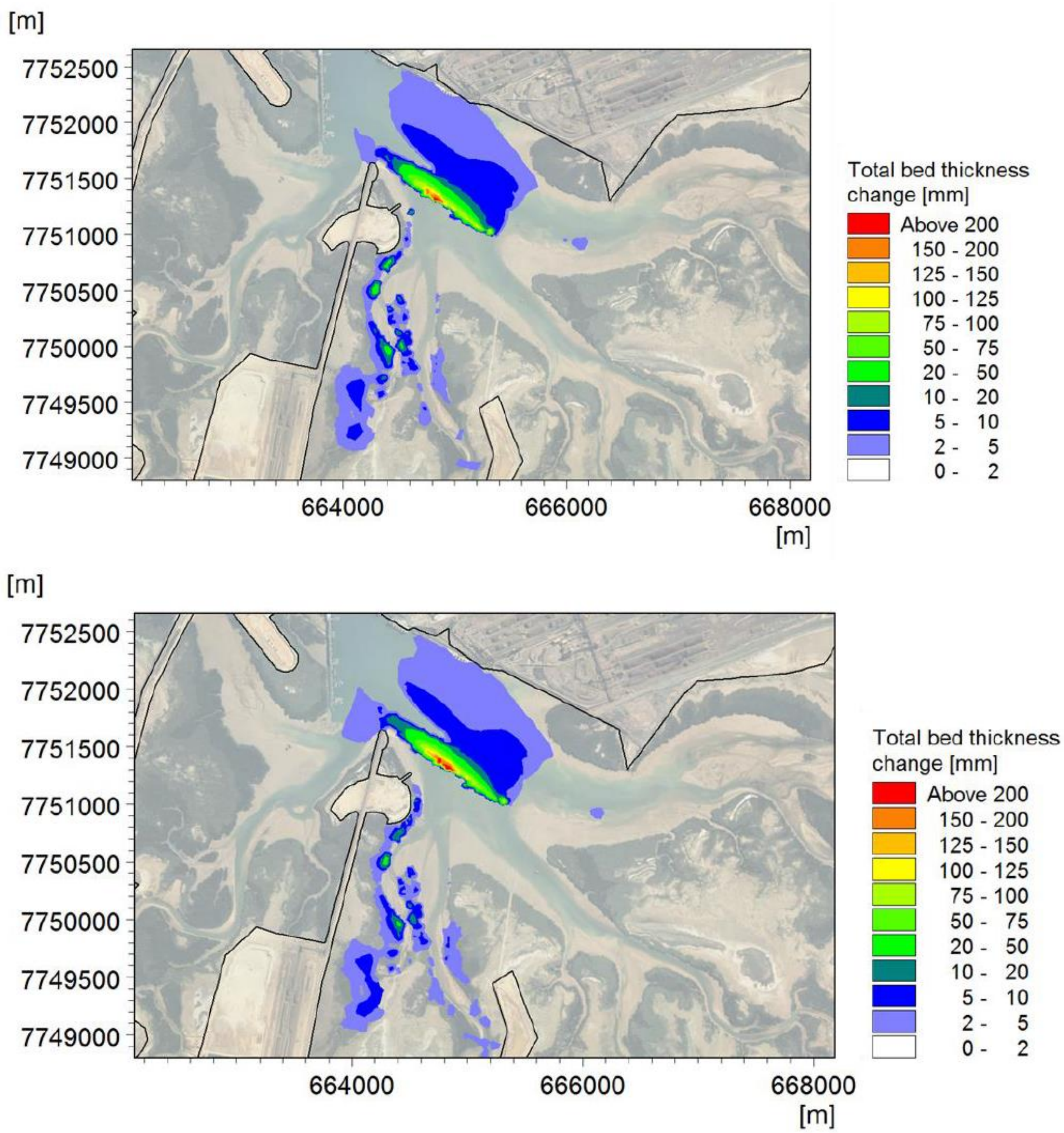


Plate 4: Seabed thickness change after completion of dredging in summer (above) and winter (below)

5.2.2 Marine Environmental Quality

Objective

To maintain the quality of water, sediment and biota so that the environmental values, both ecological and social, are protected.

Guidance

Relevant policies and guidelines include:

- EAG7: *Environmental Assessment Guideline for Marine Dredging Proposals* (EPA 2011a)
- EAG15: *Environmental Assessment Guideline for Protecting the Quality of Western Australia's Marine Environment* (EPA 2015b)
- *Australian and New Zealand guidelines for fresh and marine water quality* (ANZECC/ARMCANZ 2000)
- *Pilbara coastal water quality consultation outcomes: environmental values and environmental quality objectives* (DoE 2006)
- *National assessment guidelines for dredging (NAGD)* (CoA 2009)
- *Assessment and management of contaminated sites: Contaminated sites guidelines*. Department of Environment Regulation. December 2014 (DER 2014)
- *Identification and Investigation of Acid Sulfate Soils and Acidic Landscapes*. Department of Environment Regulation. June 2015 (DER 2015)
- *National Environment Protection (Assessment of Site Contamination) Measure*. National Environment Protection Council (NEPC 1999).

In accordance with EAG15 (EPA 2015b), Levels of Ecological Protection (LEP) the Proposal area and associated thresholds for marine and sediment quality have been adopted based on the *Pilbara coastal water quality consultation outcomes: environmental values and environmental quality objectives (DoE 2006).* Table 5 details the LEPs described by DoE (2006).

Table 5: Pilbara Coastal Waters LEPs

LEP	Environmental Quality Condition (Limit of acceptable change)	
	Contaminant Concentration Indicators	Biological Indicators
Maximum	No contaminants – pristine	No detectable change from natural variation
High	Very low levels of contaminants	No detectable change from natural variation
Moderate	Elevated levels of contaminants	Moderate changes from natural variation
Low	High levels of contaminants	Large changes from natural variation

The industrialised portions of the inner Harbour of Port Hedland were classified as a Moderate LEP in 2006 (DoE 2006), based on proximity of 250 m from existing, new or approved infrastructure. The Proposal areas is within 250 m of the existing AP1-AP3 berths, and Australia Island. As such, a Moderate LEP is considered to be applicable to this area. The Moderate LEP corresponds with an ANZECC threshold of 90% level of ecological protection for water quality.

In regards to sediment quality, the NAGD screening level (equivalent to the ANZECC/ARMCANZ ISGQ Low level for most analytes) acts as a trigger level warranting further investigation. Biological effects would rarely occur at or below these concentrations (DEC 2010) The ANZECC/ARMCANZ ISGQ High level reflects a concentration where biological effects may occur at or over these concentrations (ANZECC/ARMCANZ 2000). The HIL Commercial/Industrial levels reflect concentrations which may be harmful to human health (NEPC 1999).

Existing Environment

Water Quality

Water quality in the Port Hedland Inner Harbour has been the subject of numerous monitoring campaigns to support the various developments in the area. The most recent compilation of monitoring data was undertaken as part of the Anderson Point fifth berth dredging campaign (Worley Parsons 2014). A brief summary of this water quality data is provided below (Table 6). Note the two reference sites are Salmon and Oyster Creeks.

Table 6: Port Hedland Water Quality

Site	Mean Turbidity (NTU)	Mean pH	Mean Temperature (deg C)	Mean Dissolved Oxygen (%)	Mean Salinity
Stingray Creek (SRC)	8.4	-	-	-	-
South East Creek (SEC)	9.5	8.18	27.42	76.3	36.5
South West Creek (SWC)	19.8	7.67	31.71	74.0	37.5
South Creek Discharge (SCD)	13.4	8.0	31.2	76.7	-
Salmon Creek (SOL)	10.4	7.6	31.5	77.7	
Oyster Creek (OSC)	8.1	8.1	31.3	75.9	

Source: Worley Parsons 2014

Sediment Quality

A summary of sediment characteristics in the Port Hedland harbour is provided in Advisian (2015b), Appendix 4. A brief summary of general sediment characteristics and upper geology is provided below (based on Advisian 2015b):

- Marine sediments are generally fine to medium grained, sub-angular to sub-rounded quartz grains, with flakey and platey shell fragments.
- Surficial deposits are typically underlain by coastal limestone (ranging from 1 to 3 m), generally comprised of siliceous calcarenite.
- Coastal limestone outcrops form a prominent feature of variable thickness along the coastline adjacent to Port Hedland.
- A relatively thick succession of alluvial sand, clay, gravel and silt (Upper and Lower Red Beds) comprises the bulk of the geological profile within the harbour area.
- The Upper and Lower Red Beds are generally differentiated based on strength and cementation, and have a maximum thickness of about 15 m.
- Underlying the Lower Red Beds is a 4 to 5 m thick layer of breccia, as well as silcrete, ferruginous cements and authigenic clays.
- Beneath the breccia is a thick succession of interbedded alluvial deposits, predominantly comprising sandstone and conglomerates which are generally less than 20 m thick.
- The thick alluvial profile unconformably overlies bedrock which is likely to comprise granite or metasediments.

The Port Hedland Harbour has been the subject of numerous sediment sampling campaigns to support dredging and development projects. Recent studies in vicinity of the Proposal include:

- *Nearshore Environmental Sampling for Lumsden Point General Cargo Facility* (Worley Parsons 2013a)
- *Small Vessel Cyclone Mooring Facility: SAP Implementation Report* (GHD 2011)
- *RGP6 Definition Phase - Inner Harbour Geotechnical Investigation*. Factual Report (Worley Parsons 2010).

In all studies, concentrations of analytes tested (including metals and nutrients) were below the Department of Environment Regulation (DER) Ecological Investigation Levels (EIL) (DEC 2003). Results from the most recent study (Worley Parsons 2013) show:

- Of the 20 primary samples analysed for inorganics and assessed against the NAGD/ISQG levels and EILs, marginal exceedences of ISQG Low levels were reported for chromium and nickel. There were no exceedences of DEC EILs.
- Six near surface sediment samples were analysed for TPH; PAHs; OC and OP pesticides; and PCBs at ultra-low levels of detection. No results were reported above the corresponding laboratory PQLs.
- Laboratory performed ASS 'field' tests were performed on 20 primary samples with no significant indication of the presence of AASS or PASS reported.

- Results for analysis of nine samples for the SPOCAS and CRS methods of ASS assessment indicated that acid generation was possible at some locations; however due to increased neutralising capacity from the calcareous materials, no samples exceeded the DEC (2013) Action Criteria for net acidity.

The outcomes of previous sampling indicates a low risk of sediment contamination for the Proposal.

In order to assess local sediment quality for a range of physical and chemical properties, a Sampling and Analysis Plan (SAP) was developed for the Proposal (Advisian 2015a). Results from the implementation of this SAP are provided in Appendix 2 and summarised below:

- There were no exceedences of DER EILs (DER 2015).
- Most metals were recorded in concentrations below the NAGD and ANZECC/ARMCANZ ISGQ Low trigger levels. Only chromium and nickel were above the trigger level in a few of the samples, however they were below the ANZECC/ARMCANZ ISGQ High assessment levels and well below the NEPM HIL in all samples.
- The actual acidity in the sedimentary layer was above the action criteria but the net acidity which takes into account the Acid Neutralising Capacity (ANC) stored within the dredge material will neutralise any acidity generated.
- The dredge material is suitable for onshore disposal in accordance with the DER (2015) guidelines.

The results presented in the SAP Implementation confirm that there is no significant contamination of sediments in the Proposal area.

Potential Impact

Potential impacts of the Proposal related to water and sediment quality include:

- Suspended sediment
- Contamination of water
- Contamination of onshore areas

Suspended Sediment

To determine areas of indirect impact, sediment plume dispersion modelling was undertaken by Worley Parsons (2015b, Appendix 4). The dispersion and deposition of sediment from the proposed dredging activities was simulated with Worley Parsons' existing sediment plume dispersion model, coupled with Worley Parsons' validated hydrodynamic model for Port Hedland and the local wave model.

Outcomes of the sediment plume dispersion modelling are detailed in Appendix 4. The predicted Suspended Sediment Concentration (SSC) from the proposed dredging activities is expected to be lower in summer than winter. The 50th-percentile and 80th-percentile SSC under the winter scenario is shown in Plate 5.

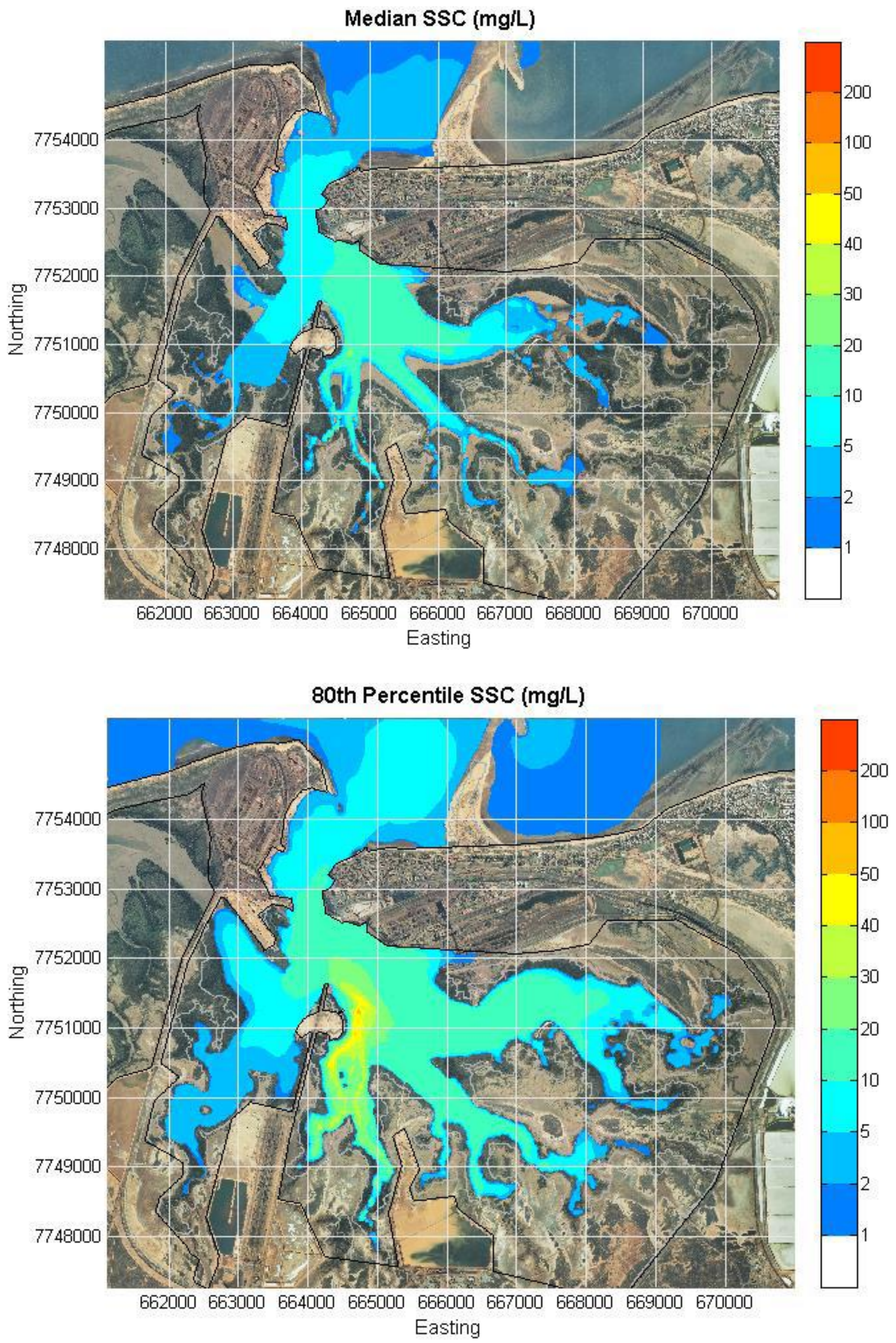


Plate 5: Predicted 50th percentile (above) and 80th percentile (below) depth-averaged SSC in the Inner Harbour: winter scenario

Key outcomes from SSC modelling of the proposed dredging campaign are provided below:

- SSC is expected to be less than 20 mg/L around the Proposal area for 50% of the time.
- SSC is expected to be less than 50 mg/L around the Proposal area for 80% of the time.
- SSC is expected to be less than 10 mg/L near the harbour entrance for at least 80% of the time.
- SSC throughout the harbour is expected to be lower in summer than in winter.

Potential impacts to BPPH as a result of suspended sediment are assessed in Section 5.2.3.

Contamination of Water

Aside from increased suspended sediment resulting from dredging activities (addressed above), contamination of water could potentially occur as a result of sedimentation through the settling of the dredge plume (addressed in Section 5.2.3).

Contamination of water could potentially occur as a result of hydrocarbon spills during construction and operation of the Hug Haven or surface water runoff from onshore infrastructure areas.

A Surface Water Impact Assessment was undertaken in order to identify surface water risks and management measures and complete an impact assessment with the proposed management measures in place (Advisian 2015c). This assessment is provided as Appendix 6. Potential impacts to water quality related to surface water include:

- Increased sediment loads from run-off
- Hydrocarbon discharge
- Increased turbidity.

Contamination of Onshore Areas

Contamination of onshore sediments could potentially occur as a result of deposition of dredged material into the existing DMMAs.

The SAP Implementation report (Advisian 2015a) confirms that sediment quality in the Proposal area is consistent with previous studies in Port Hedland and that sediment from the proposed dredge area is considered to be suitable for onshore disposal. No significant impacts associated with release of metals or acidification are anticipated to occur.

Proposed Mitigation and Monitoring

A summary of dredge spoil discharge monitoring commitments is provided in Section 9.1 of the Dredge Spoil Disposal Management Plan (Fortescue 2016).

Standard control measures associated with hydrocarbon storage and handling, surface water and stormwater management will be implemented as per the existing management of the Port Facility.

In addition, the following surface water management measures will be implemented:

- Runoff during construction will be managed to trap sediments prior to any discharge to tidal creeks
- Run-off during operations will be captured in the existing surface drainage network at Anderson Point to remove suspended sediment prior to discharge to tidal creeks.

Proposed Regulatory Mechanisms

Existing management plans associated required as part of the Anderson Point Port Facility, Third Berth and South West Creek Dredging Project will continue to be implemented, as required under their relevant Ministerial Statements:

- Fortescue's *Environmental Policy* (100-PO-EN-0001);
- *Mangrove Protection Management Plan* (P-PL-EN-0012)
- *Dredge Spoil Disposal Management Plan* (560PO-C0001-4320-PL-MA-0001)
- *Self-Verification of High Risk Environmental Legal Obligations Guideline* (100-GU-EN-0030);
- *Port Facility – Acid Sulphate Soils Management Plan* (P-PL-EN-0014);
- *Port Facility – Dust Environmental Management Plan* (P-PL-EN -0010);
- *Dust Response Procedure* (P-PR-EN-0007);
- *Dust Management Procedure* (200CO-00000-PR-SA-00006_Rev0);
- *Port Facility – Construction Environmental Noise Management Plan* (P-PL-EN-0016);
- *Noise Management Procedure* (45-PR-SA-0029);
- *Waste Management Plan* (45-PL-EN-0014);
- *Construction Environmental Noise Management Plan* (P-PL-EN-0016);
- *Chemical and Hydrocarbon Management Plan* (45-PL-EN-0011);
- *Chemical and Hydrocarbon Spills Procedure* (45-PR-EN-0014);

- *Chemical and Hydrocarbon Storage Procedure* (45-PR-EN-0015);
- *Hazardous Materials Management Procedure* (45-PR-SA-0051);
- *Introduced Marine Pests Management Plan* (P-PL-EN-0017);

Ongoing implementation of these plans, in conjunction with implementation of the Tug Haven DSDMP (ref) provides the regulatory mechanism for protection of marine environmental quality which may be impacted through the implementation of the Proposal.

In addition, hydrocarbons and surface water quality are also regulated through the existing Part V licence at the Port (L8194/2007/3).

Outcome

Water and sediment quality in Port Hedland is well understood and has been the subject of numerous monitoring campaigns. No unusual or unexpected contaminants were identified as part of the SAP implementation, and sediments are considered to be suitable for onshore disposal.

Impacts to water quality (suspended sediment) resulting from dredging activities are expected to be limited, localised and short term. Established surface water management methods will ensure that the water quality of tidal creeks is protected.

As such, the EPA's objective for marine environmental quality can be met.

5.2.3 Benthic Primary Producer Habitat

Objective

To maintain the structure, function, diversity, distribution and viability of benthic communities and habitats at local and regional scales.

Guidance

Relevant policies and guidelines include:

- EAG3: *Protection of Benthic Primary Producer Habitats in Western Australia's Marine Environment* (EPA 2009).

  EAG3 specifically addresses protection of BPPHs in Western Australia's marine environment. The EAG defines BPPH as seabed communities within which algae (e.g. macroalgae, turf and benthic microalgae), seagrass, mangroves, corals or mixtures of these groups are prominent components.

- EAG7: *Environmental Assessment Guideline for Marine Dredging Proposals* (EPA 2011a).

EAG7 provides specific guidance on the layout and presentation of predicted impacts associated with dredging activities on benthic communities and habitats. EAG7 also describes a spatially-based zonation scheme to describe the predicted extent, severity and duration of the impacts associated with dredging. The three zones of impact are:

- Zone of High Impact (ZoHI): the area where impacts on benthic organisms are predicted to be irreversible. These areas would include the zones within and directly adjacent to the proposed dredge area.

  In the ZoHI, it is predicted that a 100% loss of the benthic communities due to the dredging activities will occur, either from the habitat being removed and disposed of, or due to chronic stress from turbidity or sedimentation.

- Zone of Moderate Impact (ZoMI): the area within which the predicted impact on benthic organisms are sub-lethal, and/or the impact are recoverable. This zone would be located immediately outside of the ZoHI.

  In the ZoMI it is predicted that sub-lethal impact to benthic communities will occur, such as reduced photosynthetic activity or increased mucous production (in corals).

- Zone of Influence (ZoI): the area within which changes in environmental quality associated with dredge plumes are predicted and anticipated during the project, but where these changes would not results in a detectable impact on benthic biota.

  In the ZoI the dredging activities may have some influence, however the impacts would not be sub-lethal and no detectable loss or impact would be present.

- Guidance for the Assessment of Environmental Factors No. 1: *Guidance statement for the Protection of Tropical Arid Zone Mangroves along the Pilbara Coastline* (EPA 2001).

  This Guidance Statement specifically addresses the protection of tropical arid zone mangroves, habitats and dependent habitats along the Pilbara coastline. The Proposal is situated within the Guideline 4 area: Other mangrove areas inside dedicated industrial areas and associated port areas.

- Environmental Protection Bulletin No. 14: *Guidance for the assessment of benthic primary producer habitat loss in and around Port Hedland*. (EPA 2011b).

  The guidance for assessing BPPH in and around Port Hedland provides a set LAU boundary to aid proponents to comply with EAG3 for proposals in Port Hedland.

Existing Environment

EAG3 defines BPPH as seabed communities within which algae, seagrass, mangroves, corals or mixtures of these groups are prominent components, including areas of seabed which can support these communities (EPA 2009). These communities support complex marine ecosystems and aid in the maintenance of biodiversity by provision of habitat, refugia and food supply.

BPPH Mapping

Benthic habitat in Port Hedland has been extensively studied to support numerous developments in the area over the past five years. BPPH mapping presented in this document is based on a compilations of the following:

- Cumulative loss assessments for South West Creek dredging project (Worley Parsons 2012)
- EPA Report and Recommendations for the Port Hedland Outer Harbour Development (EPA 2012)
- Lumsden Point General Cargo Facility (Worley Parsons 2013b).

The extent of BPPH within the Port Hedland LAU as of December 2015 is shown in Figure 4. The historical extent and cumulative losses as a result of developments in the Port Hedland area is presented in Table 7.

Table 7: BPPH Extent within the Port Hedland LAU, December 2015

BPPH Type	Historical area (ha)	Estimated Cumulative Loss[1] (ha)	Resultant extent of habitat (ha)	Percentage impact (%)
Mangroves	2,676	389.98	2,286.02	14.57
Coral (soft and hard)	19	0.1	19	0.7
Macroalgae	73	49	23	68
Sandy Habitat (potential MPB)	2,349	261.34	2,087.66	11.13
Saltmarsh (potential)	3,394	1,623	1,771	48
Saltmarsh (actual)	628	327	301	52
Cyanobacterial mats (potential)	4,274	1,849	2,425	43
Cyanobacterial mats (actual)	299	129	170	43

Source: Advisian 2015b

[1] Includes both projects which have been completed and projects which have been approved but not completed.

Potential Impact

Direct Loss

The Proposal will not result in any direct loss of mangrove vegetation as part of onshore or marine works. Disturbance to mangroves has been deliberately avoided throughout the design phase of the Proposal.

Dredging and construction of marine infrastructure will result in direct disturbance of 9.02 ha of marine subtidal seabed. Of this area, 6.83 ha has been previously approved as part of other project assessments (Stingray Creek Cyclone Mooring Facility and Lumsden Point General Cargo Facility) (Plate 1). These two approved projects are yet to commence construction. The remaining 2.19 ha is classified as Sandy Habitat which has the potential to contain or support microphytobenthos or benthic microalgae. Photographs taken at low tide show that this area is devoid of seagrass, corals and macroalgae (Plate 6, Plate 7).

Plate 6: Tug Haven Site from Abutment, Australia Island

Plate 7: Tug Haven Site from AP3 Berth

With reference to Table 7, the proposed direct loss 2.19 ha of Sandy Habitat will lead to a cumulative loss of 263.53 ha within the LAU (11.24%). The overall percentage cumulative loss of sandy habitat within the LAU directly attributable to the proposal is 0.11%.

Indirect Loss

Potential indirect impacts to BPPH as a result of dredging or marine construction activities include:

- smothering of intertidal and subtidal BPPH outside the dredge footprint as a result of sediment deposition
- temporary or permanent loss of subtidal BPPH outside the dredge footprint as a result of elevated suspended sediment concentrations blocking sunlight required for photosynthesis.

Sediment Deposition

The accepted mortality threshold for Port Hedland mangrove species is sedimentation of 100 mm (Worley Parsons 2010). Model results do not predict sedimentation outside the dredge footprint in excess of 50 mm. As such, no indirect impacts to mangroves are expected to occur.

Sediment deposition is expected to occur as a result of dredging activities as described in Section 5.2.1, resulting in deposition of up to 50mm in localised areas. Considering BPPH communities in the Port Hedland harbour have survived turbidity and sedimentation effects from previous, larger and longer duration dredging projects, it can be reasonably predicted that the Proposal will not result in significant impacts to BPPH through sediment deposition.

Suspended Sediment

Suspended sediment concentrations of up to 50 mg/l can be considered a temporary, non-lethal impact to subtidal BPPH. Sediment plume modelling (as described in Section 5.2.1) has been used to predict the area where concentrations between 20 mg/l and 50 mg/l will occur 20% of the time (80^{th} percentile) within the immediate project footprint largely due to episodic resuspension caused by spring tides and energetic wave conditions in shallow water. Concentrations below 5 mg/l do not result in a discernible impact to BPPH.

Temporary, non-lethal impacts to BPPH resulting from elevated suspended sediment concentrations (to 100 mg/L) do not represent a permanent reduction in BPPH extent within the Port Hedland LAU.

A recent study investigated the predicted changes between baseline and post construction surface irradiance levels for numerous Port Hedland inner harbour dredging campaigns (Worley Parsons 2010). No significant difference in light levels between baseline and post construction was reported which resulted in no indirect BPPH loss. It can be reasonably assumed all BPPH communities will not be impacted from the disturbance associated with the current project, of which the construction timeframe is considerably shorter in duration.

Zones of Impact and Influence

The spatial extent of the ZoHI, ZoMI and ZoI have been mapped in accordance with EAG7 to integrate the predicted extent, severity and duration of impacts associated with the proposed dredging (Plate 8).

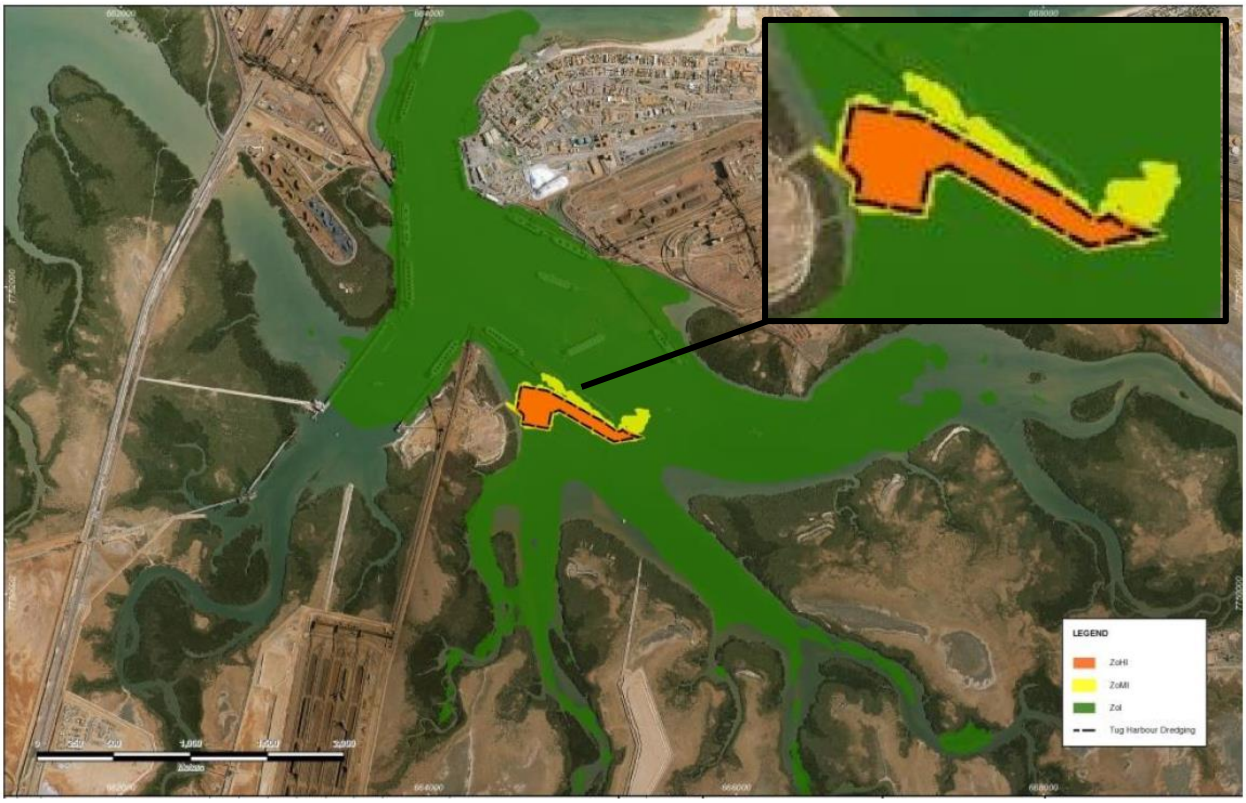


Plate 8: Zones of Influence and Impact

The ZoHI (irreversible impact) is confined to the area of dredging where direct removal of sediment and BPPH will occur (9.02 ha). The BPPH impacts in this area are assessed under the Direct Loss section above.

The ZoMI (sub-lethal impact) is defined as the area where SSC is between 5 mg/l and 50 mg/l for 50% of the time (3.9 ha). The BPPH occurring within the ZOMI is classified as Sandy Habitat. Indirect, temporary impacts to this area may occur as a result of suspended sediment from the proposed dredging campaign. As the impacts are non-lethal and temporary, they do not reflect a reduction in extent of BPPH in the Port Hedland LAU that would be attributable to the Proposal.

The ZoI (discernible change to water quality not resulting in impact) has been defined as the area where a SSC threshold of 5 mg/l is exceeded for more than 50% of the time (552 ha). Water quality data from a range of sites within the harbour confirm that TSS (and turbidity) is naturally high and that 5 mg/l is a realistic concentration in trying to discern a visible plume.

Proposed Mitigation and Monitoring

Direct disturbance to BPPH has been deliberately avoided in the design of the Proposal and through options analysis phases. The dredge footprint has been designed to utilise areas already approved for dredging under other Projects where possible.

Standard control measures associated with hydrocarbon storage and handling, surface water and stormwater management will be implemented as per the existing management of the Port Facility.

The Tiered Management Framework to mitigate potential impacts of the proposal on BPPH and water quality are summarised in Section 10 of the DSDMP (Fortescue 2016).

Proposed Regulatory Mechanisms

Existing management plans associated required as part of the Anderson Point Port Facility, Third Berth and South West Creek Dredging Project will continue to be implemented, as required under their relevant Ministerial Statements:

- Fortescue's *Environmental Policy* (100-PO-EN-0001);
- *Mangrove Protection Management Plan* (P-PL-EN-0012)
- *Dredge Spoil Disposal Management Plan* (560PO-C0001-4320-PL-MA-0001)
- *Self-Verification of High Risk Environmental Legal Obligations Guideline* (100-GU-EN-0030);
- *Port Facility – Acid Sulphate Soils Management Plan* (P-PL-EN-0014);
- *Port Facility – Dust Environmental Management Plan* (P-PL-EN -0010);
- *Dust Response Procedure* (P-PR-EN-0007);
- *Dust Management Procedure* (200CO-00000-PR-SA-00006_Rev0);
- *Port Facility – Construction Environmental Noise Management Plan* (P-PL-EN-0016);
- *Noise Management Procedure* (45-PR-SA-0029);
- *Waste Management Plan* (45-PL-EN-0014);
- *Construction Environmental Noise Management Plan* (P-PL-EN-0016);
- *Chemical and Hydrocarbon Management Plan* (45-PL-EN-0011);
- *Chemical and Hydrocarbon Spills Procedure* (45-PR-EN-0014);
- *Chemical and Hydrocarbon Storage Procedure* (45-PR-EN-0015);
- *Hazardous Materials Management Procedure* (45-PR-SA-0051);
- *Introduced Marine Pests Management Plan* (P-PL-EN-0017);

Ongoing implementation of these plans, in conjunction with implementation of the Tug Haven DSDMP (ref) provides the regulatory mechanism for protection of BPPH which may be impacted through the implementation of the Proposal.

In addition, hydrocarbons and surface water quality are also regulated through the existing Part V licence at the Port (L8194/2007/3).

Outcome

No unusual, unique or highly significant habitat complexes were identified in the disturbance footprint. The direct loss of subtidal BPPH due to the dredging and construction activities associated with this proposal also represent a very small proportion of the total BPPH found in Port Hedland and will have a negligible impact on the ecological integrity of the broader Port Hedland LAU. The ecological significance of estimated benthic community losses are also minimal as over 75% of the total proposed construction footprint is already within an approved area of cumulative loss.

A maximum of 2.19 ha of bare substrate will be removed within the construction and dredging footprint, representing only 0.11% cumulative loss within the Port Hedland LAU, which would increase the total cumulative loss of this habitat type from 11.13% to 11.24%.

Temporary, non-lethal impacts to 3.9 ha of BPPH within the ZOMI may also occur as a result of elevated suspended sediment concentrations associated with dredging.

The ecological significance of the impacts to BPPH arising from the Proposal is considered minimal as the direct losses of intertidal habitat associated with the proposal are negligible and unlikely to affect the ecological integrity of the broader Port Hedland LAU. As such, the EPA's objective for BPPH can be met.

5.3 Impact Assessment for Other Environmental Factors

A brief assessment of the impact of the proposal on other environmental factors is presented in Table 8.

Table 8: Assessment Table – Other Environmental Factors

Factor/ Existing Environment	Potential Impacts	Proposed Management Controls and Regulatory Mechanisms	Predicted Outcome
Amenity (Noise)			
Port Hedland is a relatively noisy environment, with significant noise sources in operational port and industrial facilities, and ongoing marine and onshore construction projects. Sensitive receptors for noise are located in Port Hedland town (established monitoring locations at the Esplanade Hotel, McKay St and Crowe St),	During construction, significant noise sources include earthworks and pile driving. It is proposed to undertake pile driving within the following times: • 7 am to 7 pm, Monday to Saturday • 7 am to 7 pm, two Sundays per month plus public holidays (dates of non-piling Sundays to be agreed with Port	The construction work and dredging activity will be carried out in accordance with the Environmental Protection (Noise) Regulations 1997 and the control of noise practices set out in Section 6 of Australian Standard 2436-1981 Guide to noise control on construction, maintenance and demolition sites. Amendment of the existing Fortescue *Port Facility Construction*	Piling associated with the proposal is expected to be short term. Noise impacts associated with the Proposal will be managed through implementation of existing control mechanisms, ensuring that the EPA's objectives for amenity can be met.

Factor/ Existing Environment	Potential Impacts	Proposed Management Controls and Regulatory Mechanisms	Predicted Outcome
Wedgefield and South Hedland (Parker Street).	Hedland Port Authority to correspond with other proponents in the Port Hedland area) • 7 pm to 9 pm on piling days, when required, in order to safely finish driving of piles. No new piles will be commenced after 7 pm. Earthworks will be undertaken on a 24-hour, 7 days/week basis. During operations, no significant noise sources are anticipated, which could be differentiated from ordinary Port operations.	*Environmental Noise Management Plan* (Appendix 8) is required to incorporate construction activities associated with the Proposal. Standard noise management controls will be in place, including: • Consideration of noise during equipment selection • Shrouding of impact hammers during piling • Broadband reversing beepers to be used where occupational health and safety requirements can be met.	
Air Quality and Atmospheric Gases (Dust)			
Port Hedland is recognised as a relatively dusty environment due to the existing bulk material handling facilities operating around the harbour.	Construction earthworks and onshore disposal of dredged materials have the potential to generate dust.	Existing DMMAs will be operated in accordance with their relevant Ministerial Statements, which include provisions for dust management. Onshore infrastructure will be subject to regulation under Part V of the *Environmental Protection Act* (1986). Standard dust management controls will be in place for earthworks for onshore infrastructure, including: • Use of water carts for unsealed roads, exposed surfaces and active construction areas • Restriction of vehicle movements and speeds.	Onshore construction activities will be short term and localised. Ongoing operation of DMMAs is regulated through existing Part IV approvals. Dust impacts associated with the Proposal will be managed through implementation of existing Fortescue control mechanisms, ensuring that the EPA's objectives for air quality and atmospheric gases can be met.
Terrestrial Fauna			
Terrestrial fauna of the Port area was extensively surveyed and assessed as part of the original Stage A approval process (Ministerial Statement 690).	The onshore infrastructure will be situated in existing cleared areas, thereby avoiding significant impacts to terrestrial fauna and associated habitat. Limited impacts to terrestrial fauna may occur as some fauna	No clearing of vegetation will be undertaken as part of the Proposal. Impacts to cleared but undeveloped land will be minimised, with the onshore infrastructure footprint at Australia Island being limited to 3 ha.	Impacts to fauna and fauna habitat are not considered to be significant. The EPA's objective for terrestrial fauna can be met.

Factor/ Existing Environment	Potential Impacts	Proposed Management Controls and Regulatory Mechanisms	Predicted Outcome
	utilise the existing cleared but undeveloped areas on Australia Island as opportunistic habitat.	Standard disturbance and fauna management measures will be in place for all onshore activities.	
Marine Fauna			
Marine turtles and (more rarely) dolphins and dugongs are known to occur within the Port Hedland harbour.	Dredging equipment and support vessels may strike marine fauna (boat strike) Noise impacts associated with piling and dredging.	Standard management measures relating to marine fauna will be implemented, including: • Speed limits to be enforced for all vessels operating within the harbour • Prior to the commencement of dredging or pile driving activities, a 300 m exclusion zone will be inspected for the presence of significant marine fauna (turtles, whales, dolphins and dugongs). • If any significant marine fauna are sighted in the exclusion zone, dredging or pile driving activities will not commence until 15 minutes after the last marine mammal/turtle is observed to leave the exclusion zone or the dredge is to move to another area of the dredge site to maintain a minimum distance of 300 m between the vessel and any significant marine fauna identified during observations.	Implementation of the management measures will ensure that the potential for boat strike is minimised.

6. PRINCIPLES OF THE EP ACT

The EP Act sets out five principles by which protection of the environment is to be achieved in Western Australia. Consideration has been given to these five principles and the manner in which they have been applied is outlined in Table 9.

Table 9: Principles of Environmental Protection

Principle	Consideration Given by the Project
1. Precautionary Principle Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In the application of the precautionary principle, decisions should be guided by: • Careful evaluation to avoid, where practicable, serious or irreversible damage to the environment • An assessment of the risk-weighted consequences of various options.	The Proponent recognises the importance of minimising environmental impacts as it is vital in ensuring the longevity, success, growth and positioning of the Proponent and Fortescue in domestic and global markets. This will be achieved by successful management of potential risks to the environment. The Proponent operates under Fortescue's existing environmental management system (EMS) that addresses all of its activities with potential to affect the environment. The key elements of the EMS include assessing environmental risk arising from environmental aspects with the intention of identifying issues early in the process to enable planning for avoidance and/or mitigation. Part of this process includes undertaking detailed site investigations of the biological and physical environs. Where these investigations identify significance conservation issues, management measures are incorporated into project design to avoid, where practicable, or minimise any potential impacts. As a result this project has been designed to minimise potential impacts to key environmental values of the local environment.
2. Intergenerational Equity The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.	The Proponent's decision-making processes incorporate sustainability principles and the implementation of new and better technologies where feasible. The Proponent aims to inspire an ethic and attitude that strives for continuous improvement and ongoing learning. Employees are encouraged to engage in positive attitudes and behaviour concerning respect for the environment. We recognise sustainability cannot be achieved without the contribution and action of the entire team.
3. Conservation of Biological Diversity and Ecological Integrity Conservation of biological diversity and ecological integrity should be a fundamental consideration.	Conservation of biological diversity and ecological integrity is fundamental to the Proponent's approach to environmental management and is a major environmental consideration for the Project. Biological investigations have been undertaken by the Proponent early in the project planning process to identify values of environmental conservation significance required to be protected from disturbance. This Project has been designed to minimise potential impacts to the key environmental values associated with the marine and terrestrial environment.

Principle	Consideration Given by the Project
4. Improved valuation, pricing and incentives mechanisms Environmental factors should be included in the valuation of assets and services. The polluter pays principle – those who generate pollution and waste should bear the cost of containment, avoidance or abatement. The users of goods and services should pay prices based on the full life cycle costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any wastes. Environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentives structures, including market mechanisms, which enable those best placed to maximise benefits and/or minimise costs to develop their own solutions and responses to environmental problems.	The Proponent acknowledges the need for improved valuation, pricing and incentive mechanisms and endeavours to pursue these principles when and wherever possible. For example: • Environmental factors have heavily influenced project design • The Proponent has put in place procedures that will ensure that pollution-type impacts are minimised as far as practicable.
5. Waste Minimisation All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge into the environment.	The Proponent's approach to waste management is, in order of priority: • Avoid and reduce at source • Reuse and recycle • Treat and/or dispose. Dust and Noise emissions have been reduced to lowest reasonably practicable through Project design.

7. CONCLUSION

Development and operation of the Pilbara Marine Tug Haven has the potential to result in impacts to Coastal Processes, Marine Environmental Quality and Benthic Primary Producer Habitat i.e. sandy habiat. At demonstrated in Section 5, impacts which cannot be avoided through project design can be effectively managed using a combination of existing, established environmental management framework and the implementation of the DSDMP (Fortescue 2016). Pilbara Marine considers that the Proposal can be implemented in accordance with the EPAs guidance and the EPA's objectives for the protection of key environmental factors can be met. As a result, it is anticipated that the Proposal will not require assessment under the EP Act.

REFERENCES

Advisian (2015a). *Tug Haven Anderson Point: Sampling and Analysis Implementation Report*, 560PO-4347-RP-EN-0002.

Advisian (2015b). *Tug Haven Marine Studies: Benthic Primary Producer Habitat Survey and Impact Assessment*. 560PO-4347-RP-EN-0005.

Advisian (2015c). *Fortescue Towing Services: Tug Haven Marine Studies Surface Water Impact Assessment*. 560PO-4347-RP-EN-0001.

ANZECC/ARMCANZ (2000). *Water Quality and Monitoring Guidelines in National Water Quality Management Strategy*. Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resources Management Council of Australia and New Zealand (ARMCANZ).

CoA (2009) *National Assessment Guidelines for Dredging* (NAGD). Commonwealth of Australia.

DOE (2006) *MR1 Pilbara Coastal Water Quality Consultation Outcomes: Environmental Values and Environmental Quality Objectives*. Report from the Department of Environment to the Environmental Protection Authority and the Rangelands NRM Coordinating Group.

DER (2014)*. Assessment and management of contaminated sites*: Contaminated sites guidelines. Department of Environment Regulation.

DER (2015) *Identification and Investigation of Acid Sulfate Soils and Acidic Landscapes*. Department of Environment Regulation. June 2015.

EPA. 2001. *Guidance for the Assessment of Environmental Factors No 1: Guidance Statement for the Protection of Tropical Arid Zone Mangroves along the Pilbara Coastline*. Perth, Western Australia: Environmental Protection Authority.

EPA (2009). *EAG3: Environmental Assessment Guidelines for Protection of Benthic Primary Producer Habitats in Western Australia*. Perth, Western Australia: Environmental Protection Authority.

EPA (2011a). *EAG7: Environmental Assessment Guideline for Marine Dredging Proposals*. Perth, Western Australia: Environmental Protection Authority.

EPA. (2011b). *Environmental Protection Bulletin No. 14 - Guidance for the assessment of benthic primary producer habitat loss in and around Port Hedland*. Perth, Western Australia: Environmental Protection Authority.

EPA. (2012). *Report and Recommendations for the Port Hedland Outer Harbour Development*. Perth, Western Australia: Environmental Protection Authority. Report 1427, January 2012.

EPA (2015a) EAG14: *Environmental Assessment Guideline for Preparation of an API – Category A Environmental Review Document*, January 2015, Environmental Protection Authority, Western Australia.

EPA (2015b). *EAG15: Environmental Assessment Guideline for Protecting the Quality of Western Australia's Marine Environment*. Perth, Western Australia: Environmental Protection Authority.

Fortescue (2016). *Dredging and Spoil Disposal Management Plan: Anderson Point Towage Infrastructure and Services*. 560PO-C0001-4320-PL-MA-0001. Fortescue Metals Group Ltd.

GHD (2011). *Report for Small Vessel Cyclone Mooring Facility: SAP Implementation Report*. Prepared for Port Hedland Port Authority.

NEPC (1999) *National Environment Protection (Assessment of Site Contamination) Measure*. National Environment Protection Council. As amended May 2013.

WorleyParsons (2010). *RGP6 Definition Phase - Inner Harbour Geotechnical Investigation. Factual Report - Implementation of the Environmental Sampling Programme* -Lumsden Point Tug Harbour.

WorleyParsons (2012) *South West Creek Dredging and Reclamation Project. Benthic Primary Producer Habitat Survey and Cumulative Loss Assessment: Port Hedland Local Assessment Unit*. Prepared for Port Hedland Port Authority.

WorleyParsons (2013a) *Nearshore Environmental Sampling for Lumsden Point General Cargo Facility*.

WorleyParsons (2013b) *Lumsden Point General Cargo Facility: Ecosystem and Cumulative Impact Assessment*. Prepared for Port Hedland Port Authority.

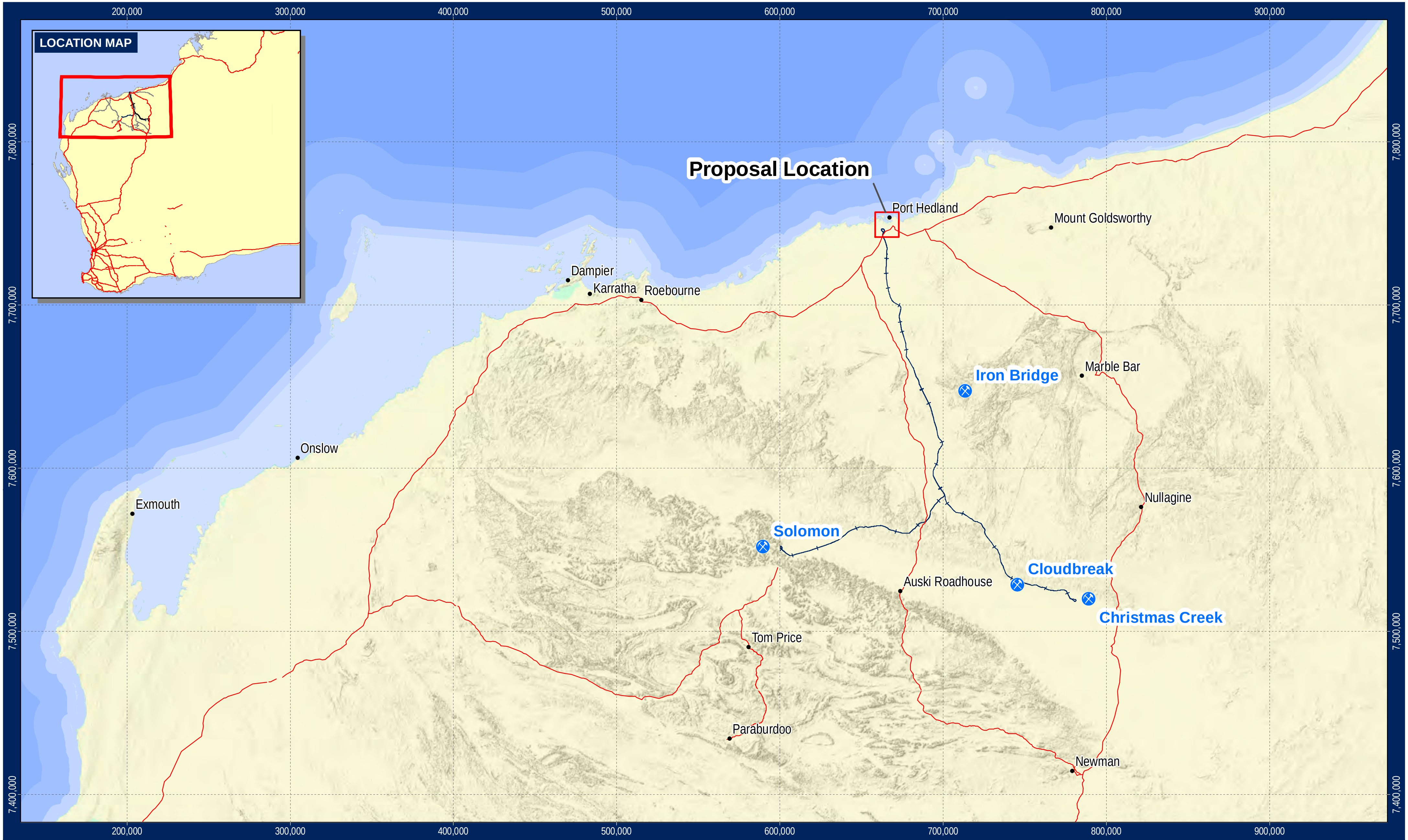
WorleyParsons (2015a). *FMG Tug Haven Marine Studies: Hydrodynamic Impact Assessment*. 201320-08579 – CS-REP-0002. FMG Document 560PO-4347-RP-EN-0004.

WorleyParsons (2015b). *FMG Tug Haven Marine Studies: Sediment Plume Dispersion Modelling*. 201320-08579 – CS-REP-0001. FMG Document 560PO-4347-RP-EN-003

This page has been left blank intentionally

Figure 1: Anderson Point Tug Haven Location

This page has been left blank intentionally



LEGEND

- • Towns
- FMG Mines
- Major Roads
- FMG Rail

Data Sources:
Towns,Roads, Aus Coast, Landgate.
DEM, Geoscience Aus.
Rail, FMG, 2015.

N

0 20 40 60 80 100
Kilometres

Requested By: R. Sharp
Drawn By: S. Costello
Revised By: scostello
Approved By: P. Mastalir
Scale: 1:3,000,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: P_MP_EN_0137.001_r0

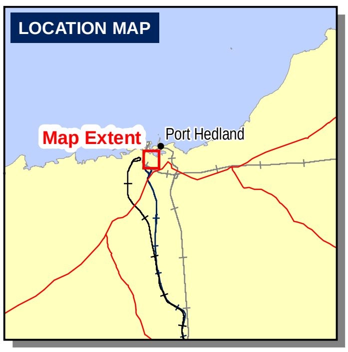
Date: 15/12/2015
Size: A4L
Revision: 0
Confidentiality: 0

Proposal Location

Fortescue Metals Group Ltd
The New Force in Iron Ore

Figure 2: Anderson Point Tug Haven Proposal Layout

This page has been left blank intentionally



LEGEND

- Infrastructure Outline
- Proposed Floating Line
- Proposed Shore Line
- Proposed Submerged Line
- DMMA A
- DMMA B

Data Sources:
Data, FMG, 2015.

N

0 200 400 600 800 1,000
Meters

Proposal Layout
Anderson Point

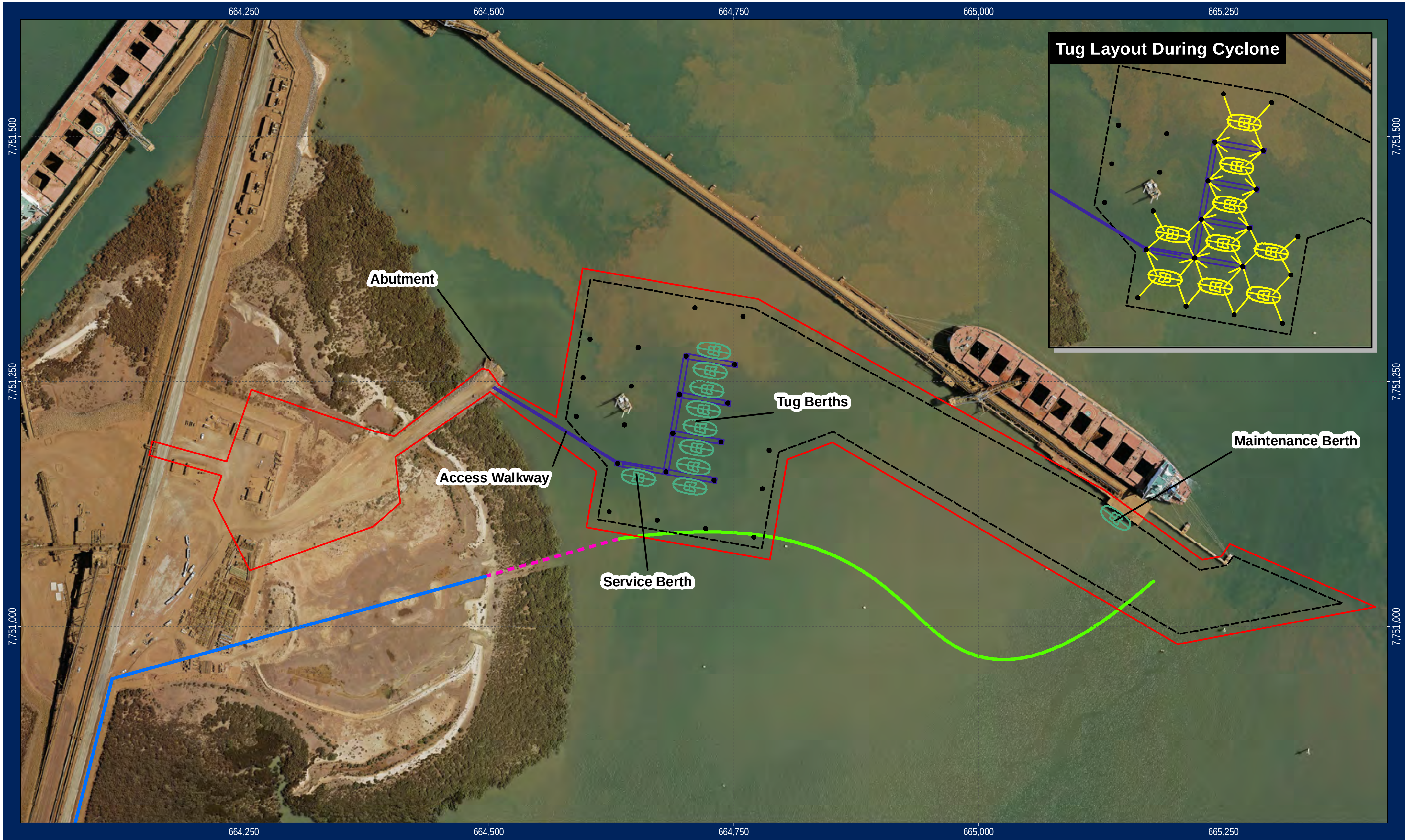
Requested By: R. Sharp
Drawn By: S. Costello
Revised By: scostello
Approved By: P. Mastalir
Scale: 1:25,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: P_MP_EN_0137.002_r0

Date: 15/12/2015
Size: A4P
Revision: 0
Confidentiality: 0

Fortescue Metals Group Ltd
The New Force in Iron Ore

Figure 3: Tug Haven Marine Layout

This page has been left blank intentionally



LEGEND

- Tug Boats (Operational Layout)
- Tug Boats (Cyclone Layout)
- Walkways
- Pilons
- Dredge Footprint
- Infrastructure Outline
- Proposed Floating Line
- Proposed Shore Line
- Proposed Submerged Line

Data Sources:
All data, FMG, 2015.

N

0 50 100 150 200 250
Meters

Requested By: R. Sharp
Drawn By: S. Costello
Revised By: scostello
Approved By: P. Mastalir
Scale: 1:5,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: P_MP_EN_0137.003_r0

Date: 15/12/2015
Size: A4L
Revision: 0
Confidentiality: 0

Tug Haven Layout
Anderson Point

Fortescue Metals Group Ltd
The New Force in Iron Ore

Figure 4: Port Hedland Benthic Primary Producer Habitats

This page has been left blank intentionally

Advisian
WorleyParsons Group

OneWay
EcoNomics

LEGEND

- Clearance Areas
- A. marina (closed canopy, seaward edge)
- A. marina (closed canopy, landward edge)
- A. marina (open canopy)
- R. stylosa / A. marina (closed canopy)
- R. stylosa (closed canopy)

Offshore Data

- reef habitat
- sandy (benthic microalgal) habitat
- Saltflats

Datum : GDA94
Map Grid of Australia
Zone 50

BENTHIC PRIMARY PRODUCER HABITAT
OF THE PORT HEDLAND LAU

DATE : 09 Dec 2015
SCALE : 1:40,000
CUSTOMER :
AUTHOR : PIR
MAP : 201320-08579-GIS-SKT-004.mxd
REV : A

Produced By: PIR - Geomatics W.A.

Location: I:\Projects\201320-08579 FMG Tug Haven Marine Studies\5_Engineering\GM-Geomatics\03Project\Workspace_SKT\201320-08579-GIS-SKT-004.mxd

Figure 5: Tug Haven Benthic Primary Producer Habitats

This page has been left blank intentionally

LEGEND

- - - Tug Harbour Dredge Footprint

BPPH Within Tug Haven Footprint

Data Sources:
All data: FMG, 2016

N

0 100 200 300 400
Meters

Requested By: A. Winzer
Drawn By: S. Costello
Revised By: scostello
Approved By:
Scale: 1:5,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: P_MP_EN_0139_r0

Date: 15/01/2016
Size: A3L
Revision: 0
Confidentiality: 0

Tug Haven
Benthic Primary Producer Habitat

Fortescue Metals Group Ltd
The New Force in Iron Ore

Appendix 1: Sampling and Analysis Implementation Report

This page has been left blank intentionally

Advisian
WorleyParsons Group

Fortescue Metals Group

Tug Haven Anderson Point

Sampling and Analysis Implementation Report

17 December 2015

Client Reference: 560PO-4347-RP-EN-0002

Advisian is a global advisory firm that provides project and business solutions to clients who develop, operate and maintain physical assets in the infrastructure and resources sectors.

Advisian Pty Ltd
Level 2
235 Georges Terrace
Perth WA 6000
Australia

P +61 8 9278 8111
F +61 8 9278 8110
Advisian trading as WorleyParsons Services Pty Ltd
ABN: 61 001 279 812

Advisian
WorleyParsons Group

Disclaimer

PROJECT NO201320-08242– TUG HAVEN ANDERSON POINT: SAMPLING AND ANALYSIS IMPLEMENTATION REPORT

Rev	Description	Author	Review	Advisian Approval	Date
0	Issued for Use	N Claydon N Claydon	H Houridis H Houridis	P Shipley P Shipley	17/12/15

Advisian
WorleyParsons Group

Table of Contents

Advisian
WorleyParsons Group

List of Appendices

List of Figures

List of Tables

1 Introduction

Port Hedland is located approximately 1650 km north of Perth within the Pilbara region of Western Australia. The Port of Port Hedland (the Port) is defined as "water within a radius of 10 nautical miles off Hunt Point Beacon (Beacon 47)" (PHPA 2001) and is managed by the Pilbara Ports Authority (PPA) under the Port Authorities Act 1999 (WA). The Port consists of a 20 nautical mile dredged channel leading to a dredged basin between Nelson Point and Finucane Island, where several intertidal creeks converge. The Port has been highly modified by dredging activities, and development and operation of port related industry.

1.1 Background

Herb Elliott Port Facility is the location of the existing berths for the Fortescue Metals Groups Pilbara Iron Ore operation. Pilbara Marine Pty Ltd (Pilbara Marine) is seeking the second licence for tug operation to support the iron ore operation. This requires the supply and construction of infrastructure.

The Tug Infrastructure will support the safe mooring of tugs with safe access and the provision of service facilities. To provide access to the facility, Pilbara Marine is proposing to undertake capital dredging over an area of 90,830 m^2 to a maximum depth of -8.0m Chart Datum (CD) within the vicinity of Anderson Point (Figure 1-1). It is also proposed that dredge material will be disposed into an existing onshore containment area.

To assess the sediment quality of the dredge material and its suitability for disposal onshore, a Sampling and Analysis Plan (SAP) was developed and implemented. This document reports the findings of the SAP implementation program which was commissioned in September, 2015.

1.2 Objectives

The aim of this SAP implementation report is to:

- Describe the sampling and analysis procedures that were undertaken consistent with the SAP methodology
- Present the results of the sediment quality assessment for a range of physical and chemical properties
- Provide comparison of chemical concentrations against the ANZECC/ARMCANZ (2000) ISQG assessment levels, and the NEPM (1999) assessment levels to assess the suitability of material for onshore disposal.

NOTES:

1. ALL DIMENSIONS IN MILLIMETRES (mm)
2. ALL LEVELS IN METRES (m)

LEGEND:

- - - — - - - — BATTERY LIMIT
- - - - - - - - DREDGE FOOTPRINT

DREDGE FOOTPRINT SETOUT POINTS

PT No.	EASTING	NORTHING
01	665260.10	7751071.56
02	665253.51	7751062.29
03	665226.06	7751057.11
04	665123.17	7751130.27
05	666771.09	7751324.36
06	664603.67	7751353.88
07	664578.53	7751211.20
08	664620.82	7751163.20
09	664611.24	7751108.85
10	664778.65	7751079.33
11	664796.07	7751177.81
12	664851.56	7751198.56
13	665204.99	7750992.08
14	665371.08	7751023.41

INDICATIVE BOREHOLE SETOUT POINTS

PT No.	EASTING	NORTHING
A	664704.91	7751292.66
B	664637.69	7751226.62
C	664679.10	7751139.73
D	664752.57	7751205.78

Figure 1-1: Proposed Dredge Footprint

2 Existing conditions

2.1 Background

Port Hedland harbour has been an operating port since the late 1800s, when a jetty was created to service the pastoral industry of the eastern Pilbara region. In 1965, with the development of the iron ore industry in the region, dredging activities altered the natural bathymetry of the harbour. Dredge material from these previous campaigns has been disposed of at existing offshore spoil grounds located east of the shipping channel, and into land-based dredge material management areas (DMMAs).

Water circulation and currents in the Port Hedland region are determined by a combination of large scale ocean circulation, tides, local winds (including tropical cyclones) and non-tidal long period waves (continental shelf waves and meteorological effects) (Asia Pacific Applied Science Associates 2009). The large semi-diurnal tidal regime dominates the coastal oceanographic system in the region. Regional currents are also affected by wind to a lesser extent. Extreme waves, wind and swell occur during intense storms and cyclones that usually occur between December and May (wet season). Port Hedland receives 3 to 4 cyclones a year on average, which can expand nearshore sediment dispersion and deposition patterns by significantly altering the tidal-driven circulation and producing large influxes of freshwater run-off and sediment load into the coastal marine environment (WorleyParsons 2011a).

The granular component of marine sediments is mostly fine to medium grained, sub-angular to sub-rounded quartz grains, with flakey and platey shell fragments. Lithic fragments are present in trace quantities in some locations. Where present, gravel-size particles include platey shells up to 80 mm or more wide, as well as angular to subangular quartz, lithics and calcarenite fragments (WorleyParsons 2012).

Surficial deposits are typically underlain by coastal limestone (ranging from 1 to 3 m), which may consist of several carbonate material types but are most likely to comprise siliceous calcarenite. Coastal limestone outcrops can be seen at Hunt Point and near the public jetty during low tide, and form a prominent feature of variable thickness along the coastline adjacent to Port Hedland. A relatively thick succession of alluvial sand, clay, gravel and silt (Upper and Lower Red Beds) is likely to comprise the bulk of the geological profile at the Project site. The Upper and Lower Red Beds are generally differentiated based on strength and cementation, and have a maximum thickness of about 15 m (WorleyParsons 2011b).

Underlying the Lower Red Beds is a 4 to 5 m thick layer of breccia formed by post-depositional leaching and precipitation of carbonate (including calcrete), as well as silcrete, ferruginous cements and authigenic clays. Beneath the breccia is a thick succession of interbedded alluvial deposits, predominantly comprising sandstone and conglomerates which are generally less than 20 m thick. The thick alluvial profile unconformably overlies bedrock which is likely to comprise granite or metasediments (WorleyParsons 2011b).

2.2 Previous sediment quality investigations

Sediment investigations have been undertaken on numerous occasions since 1990 to identify potential contamination risks associated with dredging within the Port. To assess the sediment quality within the proposed dredge footprint and its suitability for onshore disposal, a review of all (recent) relevant studies was undertaken. Relevant studies that included collection of samples within the proposed dredge footprint were the:

- RGP6 Definition Phase - Inner Harbour Geotechnical Investigation. Factual Report (WorleyParsons 2010)
- Small Vessel Cyclone Mooring Facility: SAP Implementation Report (GHD 2011)
- Nearshore Environmental Sampling for Lumsden Point General Cargo Facility (WorleyParsons 2013)

These studies confirmed that all concentrations of analytes tested were below the Department of Environment Regulation (DER) Ecological Investigation Levels (EIL). Analytes tested included metals (As, Cr, Cu, Pb, Mn, Ni, Zn, Hg, Ba) nutrients which were below the DER EILs (DEC 2003).

The most recent study which also involved sampling immediately adjacent to the proposed dredge footprint was the nearshore environmental sampling that was done for the Lumsden Point General Cargo Facility (WorleyParsons 2013).

A combined geotechnical and (opportunistic) environmental program was undertaken between 10 February and 9 March 2013 and included drilling and sampling in the areas of the proposed Lumsden Point jetty alignment and proposed dredged berthing area as part of the Lumsden Point general cargo facility environmental assessment (WorleyParsons 2013). A total of seven boreholes were drilled of which five were selected for environmental sampling. Key findings from the investigation were as follows:

- Of the 20 primary samples analysed for inorganics and assessed against the NAGD (2009) ISQG levels and EILs, marginal exceedences were reported for chromium (one ISQG exceedences) and nickel (seven ISQG exceedences). There were no exceedences of DEC EILs.
- Six near surface sediment samples were analysed for TPH; PAHs; OC and OP pesticides; and PCBs at ultra-low levels of detection. No results were reported above the corresponding laboratory PQLs.
- No EIL assessment criteria were exceeded during the investigation.
- Laboratory performed ASS ‘field’ tests were performed on 20 primary samples with no significant indication of the presence of AASS or PASS reported. The presence of shells and/or calcareous materials was frequently reported in the geological profile which may provide an indication of the ability of the sequence to buffer acidity and resist the lowering of pH in these locations (not including >1mm shells).
- Results for analysis of nine samples for the SPOCAS and CRS methods of ASS assessment indicated that acid generation was possible in Horizon 1 at three locations; LSD#2-H1, LSD#6-H1 and LSD#7-H1, however due to increased neutralising capacity from the calcareous materials, no samples exceeded the DEC (2013) Action Criteria for net acidity requiring no active ASS management measures to be implemented.

In reviewing all these previous studies, it is evident that previous sediment sampling does not show any high contamination and minimal ASS potential which would indicate any unsuitability for onshore disposal.

A summary of all sampling locations from each of the relevant studies discussed has been included in Figure 2-1.

Figure 2-1: Sediment sampling locations from previous relevant studies

3 Methods

The sampling and analysis was undertaken in accordance with the sediment SAP which was prepared by Advisian on behalf of Fortescue (Appendix A).

3.1 Sampling procedures

3.1.1 Sample collection

The samples were collected during the geotechnical investigation that was undertaken within the proposed dredging area between the 15th and 27th of September 2015. The cores were drilled using a jack-up barge drill rig, which collected a sediment core to a depth of approximately -30 m CD. Environment samples were taken from the surface and from each distinct geological horizon. Surficial samples were collected using a Van Veen grab sampler as the geotechnical cores had a low ability of retaining the top sediments.

The sampling was undertaken by suitably qualified environmental professional with knowledge of the *Contaminated Sites Guidelines* (DER 2014) and NEPM (2013) requirements.

The barge was used as the platform for the sampling and was operated by licenced personnel. The cores were drilled at the set coordinates given in the SAP (WorleyParsons 2015). All working areas of the barge were thoroughly checked, cleaned and prepared for sediment sampling activities prior to material extraction at each site location. An on-board deck hose was available for washing down and cleaning the surfaces prior to sampling.

Data sheets were completed in the field for each core, and details of the sediment was taken. Photographs were taken of the cores and the sample s. these photographs are presented in Appendix B. At each core, details of the horizons were recorded, and a sample from each horizon was taken. The horizons sampled are presented in Table 3-1.

Table 3-1: Horizons within the geotechnical boreholes

Borehole	Location Coordinates		Horizon	
	Easting	Northing	Description	Depth Range
BH-T1	664678.48	7751141.86	Sediment	0 – 1.7m
			Upper Red Beds	1.7 – 9.2m
			Lower Red Beds	9.2 – 13.45m
			Conglomerate / Older Alluvium	>13.45m
BH-T2	664751.68	7751204.77	Sediment	0 – 0.9m
			Upper Red Beds	0.9 – 7.05m
			Lower Red Beds	7.05 – 13.7m
			Conglomerate / Older Alluvium	>13.7m
BH-T3	664705.44	7751293.21	Marine Sediment	0 – 0.4m
			Upper Red Beds	0.4 – 10.15m
			Lower Red Beds	10.15 – 13.35m
			Conglomerate / Older Alluvium	>13.35m
BH-T4	664639.54	7751226.53	Marine Sediment	0 – 0.75m
			Upper Red Beds	0.75 – 11.1m

Borehole	Location Coordinates		Horizon	
	Easting	Northing	Description	Depth Range
			Lower Red Beds	11.1 – 14.1m
			Conglomerate	14.1 – 17.5m
			Older Alluvium	>17.5m

3.2 Laboratory analysis

3.2.1 Metals

The assessment levels used are shown in Table 3-2. The sediment guidelines were used as conservative trigger levels, and the Health Investigation Levels (HILs) were used if the sediment levels were exceeded.

Table 3-2: Assessment levels for sediment and soil for the contaminants.

Contaminant	Assessment levels for sediment – ISQG-Low (Trigger value)	Assessment levels for sediment – ISQG-High	Health-based Investigation Levels (NEPM 1999) for soil Residential A	Health-based Investigation Levels (NEPM 1999) for soil Commercial/Industrial
Arsenic	20	70	100	3 000
Cadmium	1.5	10	20	900
Chromium	80	370	100	3 600
Copper	65	270	6 000	240 000
Lead	50	220	3 00	1 500
Mercury	0.15	1	40	730
Nickel	21	52	400	6 000
Silver	1.0	3.7	-	-
Zinc	200	410	7 400	400 000

3.2.2 Acid sulfate soils

Due to the short laboratory analysis holding time for ASS samples (24 hours), samples were collected in laboratory-supplied sampling bags with as much air removed from the bags as possible and then frozen for handling and transport. Freezing samples without air effectively suspends or significantly slows the oxidation (and resulting acidification) reaction the samples undergo when exposed to oxygen. All ASS samples were subjected to the Chromium Reducible Sulfur (CRS) acid-base accounting analytical suite and part of the SPOCAS suite. The CRS suite analyses for the following:

- Actual Acidity: pH_{KCl}, Titratable Actual Acidity (TAA) and Sulfidic – TAA
- Potential Acidity: Chromium Reducible Sulfur (CRS) and Acidity – CRS
- Acid Neutralising Capacity: Acid Neutralising Capacity (ANC), Acidity – ANC and Sulfidic – ANC
- Acid Base Accounting: ANC Fineness Factor, Net Acidity (sulfur and acidity units), Liming Rate, Net Acidity excluding ANC (sulfur and acidity units) and Liming Rate excluding ANC.

The analytes commonly part of the SPOCAS suite analysed included:

- pHox
- Titratable Peroxide Activity (TPA)
- Acid Neutralising Capacity (ANC), Acidity – ANC and Sulfidic – ANC

Additional laboratory analyses included:

- Avid Volatile Sulfur (AVS)
- Simultaneously Extracted Metals (SEM).

3.3 Quality control – Field sampling

Quality Control during sampling was ensured by:

- Using suitably qualified environmental staff experienced in sediment sampling, field supervision and sediment logging
- Logs were completed for each sample collected including time, location, initials of sampler, duplicate type, chemical analyses to be performed and site observations
- Chain-of-Custody (CoC) forms identifying (for each sample) the sampler, nature of the sample, collection date and time, analyses to be performed, sample preservation method and departure time from the site
- Using a surveyed vessel which is thoroughly inspected and washed down
- Samples contained in appropriately cleaned, pre-treated and labelled sample containers
- Samples kept cool (4 °C) or frozen after sampling and during transport, stored in eskies with pre-frozen ice bricks
- Transportation of samples under CoC documentation
- All field QC duplicate/triplicate samples were 'blind' labelled in the field with QC field numbers which do not relate to sampling location names
- All sampling equipment, including mixing bowls etc. was decontaminated between sampling locations via a decontamination procedure involving a wash with ambient seawater and Decon 90, (laboratory grade detergent), and successive rinsing with seawater
- Collection of a field replicate (2 separate samples taken at the same location) at 10% of sites, to determine the variability of the sediment physical and chemical characteristics
- Collection of secondary replicate (1 sample split into 2 containers) at 5% of sites, known as the split replicate, to assess variation in results between laboratory analysis method and process and variation between laboratories associated with sub-sample handling.

A summary of QA samples and site location each QA sample was collected from are shown in Table 3-3.

Table 3-3: Summary of field and split replicate samples collected during sampling program

Site	Horizon Depth (m)	Field Replicate	Split Replicate
BH-T3	0	X	
BH-T4	3.7-3.9	X	X

3.4 Quality control – Laboratory

The primary laboratory was MPL, and the secondary laboratory was ALS. The secondary laboratory was used for the split replicate samples, taken for the quality check of the primary laboratory.

4 Results

4.1 Particle size distribution

The particle size distribution was assessed as part of the geotechnical studies, and a summary is presented in Figure 4-1. In some samples, the clay and silt fractions were combined as the PSD curve ended at 0.075mm. The detailed results are presented in Appendix C.

The results were varied throughout the sites and the depths, however the sand fraction was dominant in all samples. Sand ranged between 49% and 87%, while the gravel fraction was generally lower than the silt and clay fractions. Gravel was highest in borehole 4, with 33% at 3.2-3.5m depth.

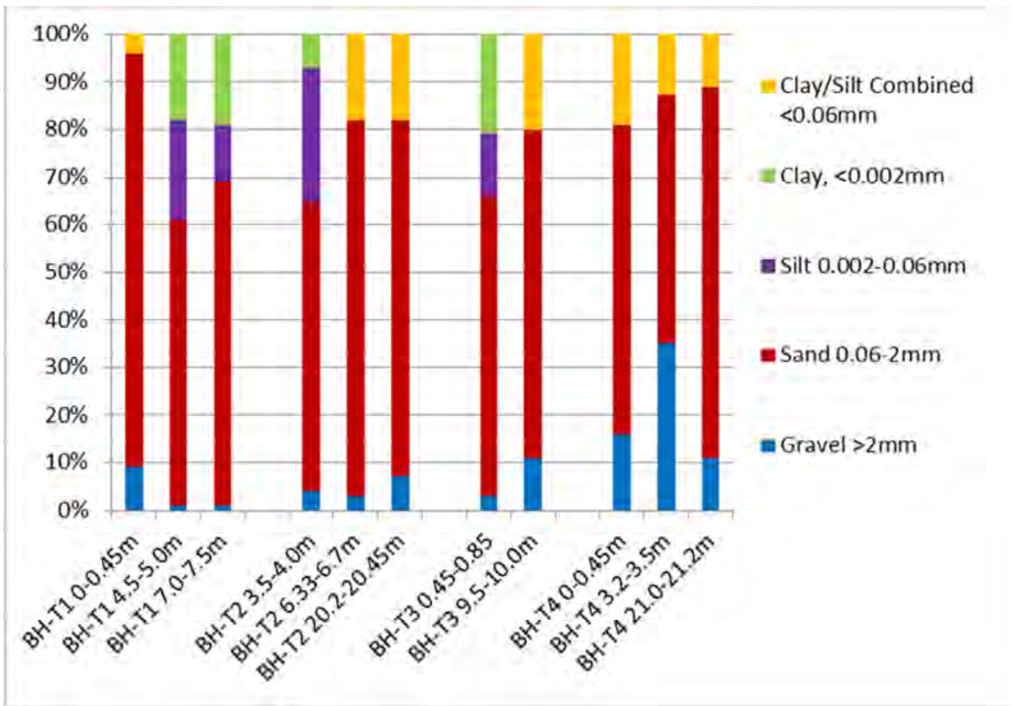


Figure 4-1: Particle size distribution within the geotechnical layers of the boreholes.

4.2 Metals

Metals analysed were compared with the NAGD screening levels, the ANZECC (2000) assessment levels and the NEPM HIL (Table 4-1). All results for arsenic, cadmium, copper, lead, silver, zinc and mercury were below all assessment levels and screening levels. Chromium exceeded the NAGD screening level at one site, BH-T1 4.0-4.1m, but did not exceed the high levels or the HILs. Nickel exceeded the NAGD screening level of 21 mg/kg in seven of the 20 samples. None of these samples were above the ISQG-high or the HIL. All the higher concentrations were also recorded in the sub-surface layers of sediment.

Table 4-1: Metal concentrations in the sediments analysed

Sample	Date Sampled	Arsenic	Cadmium	Chromium	Copper	Lead	Nickel	Silver	Zinc	Mercury
Units		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
PQL		0.5	0.1	0.5	0.5	0.5	0.5	0.1	0.5	0.01
NAGD Screening Level		20	1.5	80	65	50	21	1.0	200	0.15
ANZECC (2000) ISGQ - High		70	10	370	270	220	52	3.7	410	1
HIL (NEPM 1999) Commercial/ Industrial		3000	900	3600	240000	1500	6000	-	40000	730
BH-T1 0m	17/09/2015	6.3	<0.1	17	1.1	1	1.9	<0.1	6.3	<0.01
BH-T1 4.0-4.1m	17/09/2015	5.8	<0.1	93	12	9.9	48	<0.1	17	<0.01
BH-T1 10.10-10.25m	17/09/2015	2.8	<0.1	45	7.4	5.7	23	<0.1	7.1	<0.01
BH-T1 14.60-14.75m	18/09/2015	3.1	<0.1	41	5.5	3	15	0.1	4.5	<0.01
BH-T1 22.85-23.0m	18/09/2015	2.3	<0.1	44	11	7.7	22	0.1	18	<0.01
BH-T2 0m	19/08/2015	12	<0.1	37	12	4	13	<0.1	25	0.02
BH-T2 3.5-3.6m	20/09/2015	2.9	<0.1	67	8.6	5.6	33	<0.1	14	<0.01
BH-T2 7.85-8.0m	20/09/2015	3.4	<0.1	42	11	11	24	<0.1	9.1	<0.01
BH-T2 12.10-15.25m	21/09/2015	4.8	<0.1	50	4.8	1.8	12	<0.1	6.9	<0.01
BH-T2 21.0-21.15m	21/09/2015	2.5	<0.1	32	7.7	2.6	13	<0.1	15	<0.01
BH-T3 0m	22/09/2015	6.7	<0.1	22	4.2	2.2	6	<0.1	11	<0.01
BH-T3 1.50-1.65m	23/09/2015	4.4	<0.1	55	7.7	5.7	28	<0.1	11	<0.01
BH-T3 11.35-11.50m	23/09/2015	6	<0.1	30	7.5	7	14	0.1	4.4	<0.01
BH-T3 17.3-17.4m	23/09/2015	5.1	<0.1	46	9	5.1	20	0.1	19	<0.01
BH-T3 26.85-27.0m	24/09/2015	4	<0.1	37	6.5	2.4	10	<0.1	17	<0.01
BH-T4 0m	25/09/2015	15	<0.1	47	20	6.5	20	<0.1	40	0.02
BH-T4 3.7-3.9m	25/09/2015	4.7	<0.1	64	14	8.4	30	<0.1	13	<0.01
BH-T4 13.8-14.8m	26/09/2015	5.9	<0.1	42	9.4	15	14	0.1	4.7	<0.01
BH-T4 16.5-16.7m	26/09/2015	3.4	<0.1	37	5.6	5.9	13	<0.1	8.3	<0.01
BH-T4 20.8-21.0m	26/09/2015	2.5	<0.1	41	10	2.6	15	0.4	15	<0.01

4.3 Acid sulfate soils

This suite of analyses defines the factors used to determine the Net Acidity to compare against the DER Action Criterion of 0.03%w/w S. Net Acidity is determined by the following equation:

$$Net\ Acidity = Actual\ Acidity + Potential\ Acidity - Acid\ Neutralising\ Capacity$$

This equation assumes that the acid neutralising capacity is chemically available. However, to calculate the Action Criteria in accordance with Section 6.1 of DER (2015)(as developed by QASSIT and outlined in the *Guidelines for Sampling and Analysis of lowland Acid Sulfate Soils in Queensland* 1998), the following equation is to be used:

$$Net\ Acidity = Actual\ Acidity + Potential\ Acidity$$

4.3.1 Actual acidity

Actual acidity is assessed by the measurement of Titratable Actual Acidity (TAA). The determination of pH potassium chloride (pH_{KCl}) is a means of estimating the actual soil acidity which is used to calculate TAA.

TAA at all locations and across each horizon was less than the laboratory detection level of 5 mole H^+/t (0.01%w/w S). This indicates all samples collected have very little or no actual acidity. Furthermore, as no samples returned pH_{KCl} values less than 4.5, they were not tested for retained acidity.

4.3.2 Potential acidity

Potential acidity is assessed through the measurement of S_{CR}. Three of the twenty samples analysed for S_{CR} returned values greater than laboratory Limit of Reporting (LoR) of 0.005%S. All three of these samples were within the surface sedimentary horizon.

4.3.3 Acid neutralising capacity

Acid Neutralising Capacity (ANC) is a soil's natural ability to buffer acidity either through the dissolution of calcium and/or magnesium carbonates (i.e. shells), cation exchange reactions, reaction of organic and clay fractions or other soil minerals. The effectiveness of neutralisation can be hindered somewhat depending on the available forms of acid buffering. For example, where carbonates are stored in coarse shells, acid buffering may not be readily available due to the armouring effect of the shell's coating. In the laboratory, through the sample preparation process, carbonates (such as shell fragments) in the collected samples are physically reduced to finer particles by crushing/grinding, increasing the reactive surface area to volume ratio of the neutralising materials causing the acid neutralization capacity to increase. This can result in overestimation of the ANC of the sample. This is however accounted for by a correction factor of 1.5 - 2 incorporated into liming rates reported with the final acid base accounting. To account for this, larger shell fragments are typically removed from samples following acquisition or during the sample preparation stage prior to grinding.

The ANC between samples ranged from 0.5 to 54 %$CaCO_3$. These values significantly outweigh the existing acidity and the acid generating capacity of the samples. Therefore, although the net acidity (as calculated for the comparison to the action criteria) in the sedimentary layer may be above the action criteria, it is considered likely that the stored neutralising capacity within the dredge material will neutralise any acidity generated.

This approach to the assessment of ANC has also been confirmed through discussions with the Principal Hydrogeologist at Department of Environment and Conservation (Steven Appleyard, pers.comm).

4.3.4 Net acidity and liming rate

The Net Acidity (without ANC) indicates that three (3) samples, all from the surface sediment horizon exceed the DER action criterion of 0.03%w/w S. The calculated liming rate for these samples range between 2.3 and 4.7 kg $CaCO_3$/tonne, utilising a fineness factor of 2. However, as stated in Section 4.3.3, it is considered likely that the ANC will result in neutralisation of any acidity generated by the sedimentary layer. Hence, no liming would be required.

4.3.5 Acid volatile sulfides and simultaneously extracted metals

The ratio of Acid Volatile Sulfides (AVS) to Simultaneously Extracted Metals (SEM) is used as an indicator of the bioavailability of metals in sediments. If AVS is greater than SEM (SEM:AVS ratio less than 1), this indicates that metals are bound to sulfide complexes and are unlikely to be bioavailable. In addition to this ratio, Simpson *et al* (2005) recommends using a differential approach with a recommended screening level of 5mmol/kg dry weight. This is the difference of AVS and total SEM. This method is considered to give a better representation of results at low AVS concentrations.

Results of AVS/SEM are shown in Table 4-2. For samples in most locations and horizons AVS was below the LOR of 0. 5 % dry weight except for BH-T2 0m and BH-T4 0m. Cadmium, mercury and silver SEM concentrations were below their respective LORs for all samples. Chromium was the only metal that detected concentrations above the LOR for all samples, while copper, lead, manganese and zinc were above the LOR in the majority of samples. Total SEM, for the purposes of comparison with AVS, is calculated as the sum of the concentrations of Cd, Cu, Ni, Pb and Zn. Based on this, SEM results ranged between <0.13 and 1 µmole/g dry weight, and most SEM/AVS ratios could not be calculated (as results were less than the LOR). At BH-T2 0m and BH-T4 0m ratios were 0.56 and 0.77 respectively. Therefore, as the ratio is less than 1, metals are unlikely to be bioavailable.

As AVS results below LOR limit the ability to accurately determine a ratio, the differential method (SEM-AVS) has been used to give an assessment of the bioavailability of metals within the sediments below the LOR limit. Using a conservative AVS value of 0.5 µmole/g dry weight, all samples are below the recommended 5 mmol/kg dry weight indicating that metals are likely to be bound to sulfide complexes and are not readily bioavailable.

Table 4-2: SEM and AVS results in sediments

Sample	Date Sampled	Moisture	Acid Volatile Sulphide	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc	Total SEM	Silver*
	Units	%	µmole/g dry weight	µmole/g dry weight	µmole/g dry weight	µmole/g dry weight	µmole/g dry weight	µmole/g dry weight	µmole/g dry weight	µmole/g dry weight	µmole/g dry weight	µmole/g dry weight	µmole/g dry weight
	PQL	0.1	0.5	0.05	0.01	0.01	0.02	0.005	0.0005	0.02	0.02	0.13	0.05
Guideline												5 000	
BH-T1 0m	17/09/2015	15	<0.5	<0.05	<0.01	0.03	<0.02	<0.005		<0.02	0.06	<0.13	<0.05
BH-T1 4.0-4.1m	17/09/2015	16	<0.5	<0.05	<0.01	0.02	0.03	0.01		0.02	<0.02	<0.13	<0.05
BH-T1 10.10-10.25m	17/09/2015	14	<0.5	<0.05	<0.01	0.03	0.02	0.02		0.03	<0.02	<0.13	<0.05
BH-T1 14.60-14.75m	18/09/2015	27	<0.5	<0.05	<0.01	0.1	0.03	0.01		0.05	<0.02	0.18	<0.05
BH-T1 22.85-23.0m	18/09/2015	18	<0.5	<0.05	<0.01	0.01	0.03	0.02		0.09	<0.02	0.15	<0.05
BH-T2 0m	19/08/2015	24	0.84	<0.05	<0.01	0.07	0.11	0.01		0.02	0.26	0.47	<0.05
BH-T2 3.5-3.6m	20/09/2015	16	<0.5	<0.05	<0.01	0.02	<0.02	0.01		<0.02	<0.02	<0.13	<0.05
BH-T2 7.85-8.0m	20/09/2015	19	<0.5	<0.05	<0.01	0.01	0.02	0.02		0.03	<0.02	<0.13	<0.05
BH-T2 12.10-15.25m	21/09/2015	28	<0.5	<0.05	<0.01	0.07	0.03	0.01	<0.0005	0.03	0.02	0.15	<0.05
BH-T2 21.0-21.15m	21/09/2015	16	<0.5	<0.05	<0.01	0.02	0.03	0.03	<0.0005	0.04	<0.02	0.13	<0.05
BH-T3 0m	22/09/2015	17	<0.5	<0.05	<0.01	0.08	0.04	0.01	<0.0005	0.03	0.11	0.28	<0.05
BH-T3 1.50-1.65m	23/09/2015	12	<0.5	<0.05	<0.01	0.01	0.02	0.01	<0.0005	0.04	<0.02	<0.13	<0.05
BH-T3 11.35-11.50m	23/09/2015	14	<0.5	<0.05	<0.01	0.01	0.02	0.01	<0.0005	<0.02	<0.02	<0.13	<0.05
BH-T3 17.3-17.4m	23/09/2015	23	<0.5	<0.05	<0.01	0.07	0.03	0.01	<0.0005	0.04	<0.02	0.15	<0.05
BH-T3 26.85-27.0m	24/09/2015	17	<0.5	<0.05	<0.01	0.03	<0.02	<0.005	<0.0005	0.02	<0.02	<0.13	<0.05
BH-T4 0m	25/09/2015	36	1.3	0.05	<0.01	0.12	0.24	0.03	<0.0005	0.04	0.54	1	<0.05
BH-T4 3.7-3.9m	25/09/2015	11	<0.5	<0.05	<0.01	0.03	0.06	0.02	<0.0005	0.02	<0.02	<0.13	<0.05
BH-T4 13.8-14.8m	26/09/2015	10	<0.5	<0.05	<0.01	0.04	<0.02	0.02	<0.0005	0.02	<0.02	<0.13	<0.05
BH-T4 16.5-16.7m	26/09/2015	26	<0.5	<0.05	<0.01	0.1	0.02	0.01	<0.0005	0.03	0.02	0.18	<0.05
BH-T4 20.8-21.0m	26/09/2015	16	<0.5	<0.05	<0.01	0.03	0.04	0.02	<0.0005	0.03	<0.02	<0.13	<0.05

5 Chemical data validation

This section examines the validity of the analytical data obtained in the study and justifies confidence in the actual results presented.

5.1 Field analytical quality control

The veracity of field based QA/QC procedures was assessed by collecting field and inter-laboratory replicate samples. The primary method to assess the consistency of the analytical results for the replicate samples is to calculate the Relative Percentage Difference (RPD) between the primary and replicate analyses results. The RPD is calculated via the following equation:

$$RPD(\%) = \left|\frac{A - B}{(A + B)/2}\right| \times 100$$

Where:

A = Analysis result for primary sample; and

B = Analysis result for replicate sample.

Acceptance criteria for the RPD are based on the magnitude of the values relative to the LoR:

- 80% for values 1 – 10 times the LoR;
- 50% for values 10 – 30 times the LoR; or
- 30% for values > 30 times the LoR.

5.1.1 Field replicates

Several RPD values were identified to exceed the acceptance criteria between the primary and field replicate samples. Concentrations of chromium and copper in BH-T4 0m showed the greatest variation. In addition, values for excess ANC also showed elevated RPD values. Both analyses are highly dependent on sample homogeneity and it is possible that the samples were inadequately homogenised prior to replicate sub-sampling. It is important to note however that the analytical results are of a similar order and that variations in the values do not affect the conclusions drawn from the results.

5.1.2 Split replicates

No split replicate samples resulted in RPDs outside the acceptance criteria.

5.2 Laboratory QA/QC

Several laboratory QA/QC analyses showed values outside the acceptance criteria. The following list summarises these values:

- Two intra-laboratory replicate sample analyses showed RPD values outside the acceptance criteria:
  - BH-T1 10.1-10.25m: Lead (35%) and Silver (67%).
- One Laboratory Control Sample (LCS) showed a recovery rate of 130% for Zinc, outside the acceptance criteria.
- There was less than the expected number of Matrix Spike (MS) samples for the total sampling program.

It is important to note however, that none of the laboratory QA/QC analyses result in a material change to the reported data; hence, the conclusions drawn based on the laboratory data remain valid.

Both RPD exceedences for the intra-laboratory replicate samples are for low-level metals concentrations. These concentrations are of a similar order and are far below their respective assessment criteria; hence, the results of the analysis are unaffected.

The high recovery rate for zinc in the LCS does not affect the results of the analysis.

The number of MS samples resulted from the primary samples being sent to the laboratory in multiple batches. The total number of samples was 22, with the frequency requirement as 1-in-20, this resulted in two MS samples being required but only one was analysed and reported. Notably, the results of the MS analysis are within the acceptance criteria.

5.3 Summary

Table 5-1 summarises the performance against the DQOs for the assessment.

Table 5-1: QA/QC Results Summary

Data Quality Objective	Parameter	Objective Achieved (Y/N)
Precision	Intra-laboratory field replicate samples (Duplicates)	See Below
	Inter-laboratory field replicate samples (Triplicates)	Yes
	Laboratory replicate samples	See Below
	Laboratory method blank samples	Yes
Accuracy	Laboratory matrix spike samples	Yes
	Laboratory control samples	See Below
Representativeness	Sampling, handling, storage and transport appropriate for sample data	Yes
	Trip (travel) blank samples	N/A
	Samples extracted and analysed within holding times	Yes
Comparability	Standard operating procedures used for sample collection, handling and decontamination	Yes
	Standard analytical methods used for all analyses	Yes
	Consistent field conditions, field staff and laboratory analyses	Yes
	Appropriate and consistent LoRs	Yes
Completeness	Field Description and CoCs appropriately completed	Yes
	Appropriate documentation for analysis	Yes

Two field replicate (duplicate) samples calculated RPD values greater than the targeted:

- 80% for values 1 – 10 times the LoR;
- 50% for values 10 – 30 times the LoR; or
- 30% for values > 30 times the LoR.

In this case, these values relate to variation in the reported ANC, which is by nature highly dependent on sample homogeneity. It is probable that the collected replicate samples did not contain similar levels of ANC; hence the variation in analysed values. It is important to note however, that the values remain large compared to the acid generating capacities of the samples; hence the conclusions drawn from the analysis remain valid.

Two laboratory replicate samples show minor RPD exceedences for lead and silver concentrations. The concentrations however are of a similar order and far below their respective assessment criteria; hence, the results of the analysis are unaffected.

One Laboratory Control Sample showed a high recovery percentage for zinc analysis. The control sample exceedance does not affect the interpretation of the analytical results.

Therefore, the results are considered appropriate for the investigation and suitable for interpretation.

6 Conclusions and recommendations

The dredge material is suitable for disposal within a DMMA, with most metals being below the NAGD screening level and soil guidelines. Only chromium and nickel were above the NAGD screening level in a few of the samples, however they were below the ANZECC (2000) assessment levels and the NEPM HIL, and therefore suitable for onshore disposal.

Although the net acidity (as calculated for the comparison to the action criteria) in the sedimentary layer was above the action criteria, it is considered likely that the stored neutralising capacity within the dredge material will neutralise any acidity generated. It is recommended that monitoring is undertaken of the discharge point of the DMMA for pH, dissolved oxygen, and salinity to monitor the potential discharge of acid impacted water.

7 References

DER (2015) Identification and investigation of acid sulfate soils and acidic landscapes.

GHD (2011) Report for Small Vessel Cyclone Mooring Facility. SAP Implementation Report. Report prepared for the Port Hedland Port Authority. November 2011.

PHPA (2013) Lumsden Point General Cargo Facility Benthic Habitat Survey. Report Prepared by WorleyParsons.

SKM (2009) RGP6 Port Facilities Definition Phase Study. Benthic Primary Producer Assessment: Intertidal. Report prepared by Sinclair Knight Merz for BHP Billiton Iron Ore.

WorleyParsons (2009) The Heng Shan Project. Anderson Point Berth 3 (AP3) Geotechnical Investigation – Interpretive Report. Report prepared by WorleyParsons for Fortescue Metals Group.

WorleyParsons (2011a) Hunt Point Marine Precinct: Review of Revised Dredging Configuration and Its Impact on Hydrodynamic and Sediment Plume Dispersion Modelling Results

WorleyParsons (2011b) Inner Harbour Geotechnical Investigation Quantum Load Out Facility – Geotechnical Interpretive Report, prepared by WorleyParsons for the FAST JV.

WorleyParsons (2011c). Benthic Habitat Survey: Junction of Stingray and South East Creeks, Report to PHPA by WorleyParsons: 23 pp.

WorleyParsons (2012) North Star Magnetite Project Feasibility Study: Port:Geotechnical Desk Study Report.

WorleyParsons (2013) Nearshore Environmental Sampling for Lumsden Point General Cargo Facility. Report prepared by WorleyParsons for Port Hedland Port Authority.

Appendix A

Anderson Point Tug Haven Onshore Disposal Sampling and Analysis Plan

Advisian
WorleyParsons Group

Anderson Point Tug Haven

Onshore Disposal Sampling and Analysis Plan

July 2015

Advisian is a global advisory firm that provides project and business solutions to clients who develop, operate and maintain physical assets in the infrastructure and resources sectors.

Confidentiality

This document has been prepared for the sole purpose of documenting our tender for consultancy services associated with the Anderson Point Tug Haven and Onshore Disposal Sampling and Analysis Plan.

It is expected that this document and its contents, including work scope, methodology and commercial terms will be treated in strict confidence by Fortescue Metals Group and that the contents will be used by Fortescue Metals Group only for the purpose of selecting a consultant for the project.

ANDERSON POINT TUG HAVEN: ONSHORE DISPOSAL SAMPLING AND ANALYSIS PLAN

Rev	Description	Author	Review	Advisian Approval	Date
A	For Internal Review	N Claydon N Claydon	H Houridis H Houridis	NA	7-Jul-15
B	For Client Review	N Claydon N Claydon	H Houridis H Houridis	P Shipley P Shipley	9-Jul-15
C	For Client Review	N Claydon N Claydon	H Houridis H Houridis	P Shipley P Shipley	10-Jul-15
D	For Client Review	N Claydon	H Houridis	P Shipley	16-Jul-15

Table of Contents

List of Appendices

List of Figures

List of Tables

Acronyms

Acronym	Definition
ANZECC/ ARMCANZ	Australian and New Zealand Guidelines for Fresh and Marine Water Quality
ASRIS	Australian Soil Resource Information System
BHPBIO	BHP Billiton Iron Ore
CD	Chart Datum
DER	Department of Environmental Regulation
EIL	Ecological Investigation Levels
Fortescue	Fortescue Metals Group
GPS	Geographic Positioning System
LOR	Limit of Reporting
m CD	Metres Chart Datum
NAGD	National Assessment Guidelines for Dredging
NATA	National Association of Testing Authorities
NEPM	National Environment Protection (Assessment of Site Contamination) Measure
PHPA	Port Hedland Port Authority (now PPA)
PPA	Pilbara Ports Authority (formerly PHPA)
PSI	Preliminary Site Investigation
PQL	Practical Quantitation Limit
QA/QC	Quality Assurance / Quality Control
SAP	Sampling and Analysis Plan
The Port	The Port of Port Hedland
WA	Western Australia

1 Introduction

Port Hedland is located approximately 1650 km north of Perth within the Pilbara region of Western Australia. The Port of Port Hedland (the Port) is defined as “water within a radius of 10 nautical miles off Hunt Point Beacon (Beacon 47)” (PHPA 2001) and is managed by the Pilbara Ports Authority (PPA) under the Port Authorities Act 1999 (WA). The Port consists of a 20 nautical mile dredged channel leading to a dredged basin between Nelson Point and Finucane Island, where several intertidal creeks converge. The Port has been highly modified by dredging activities, and development and operation of port related industry.

Fortescue Metals Group (Fortescue) is proposing to undertake dredging within the proposed tug haven infrastructure footprint at Port Hedland Port, Anderson Point.

This document provides the proposed plan for the sampling and analysis of sediments that would be dredged during the capital dredging campaign and placed onshore. This sampling and analysis plan (SAP) is designed to comply with the sampling and analysis requirements of the *Contaminated Lands Act 2003*.

1.1 Objectives

The aim of this SAP is to outline a set of procedures that when implemented, will provide a valid representation of the physicochemical properties of sediments to be dredged and an assessment of the likely impacts of onshore disposal of the dredged sediment. The specific objectives of this SAP are to:

- Provide a brief summary of the dredging operations relevant to the SAP
- Provide a summary of the catchment and land-use activities with the potential to impact upon the quality of dredged material
- Collate a contaminants list for testing of sediments, based on potential contaminant sources and results of prior testing
- Identify the number of samples required to provide an adequate representation of the sediments being dredged
- Develop protocols for the collection and handling of sediment samples
- Identify the types of analyses to be performed on sediment samples
- Outline quality assurance and quality control (QA/QC) procedures for the collection, handling and laboratory analysis of samples
- Describe statistical techniques to determine the status of potential contaminants within dredged material
- Prescribe a reporting framework for all data, results and conclusions which will address the requirements of the Determining Authority.

1.2 Description of the proposed dredging and disposal

Fortescue is proposing to dredge in the vicinity of Anderson Point in order to develop infrastructure for a tug haven (Figure 1-1). Capital dredging over an area of 90,830 m^2 to a maximum depth of -8.0m CD will be required from within the defined area and then placed into a containment area onshore.

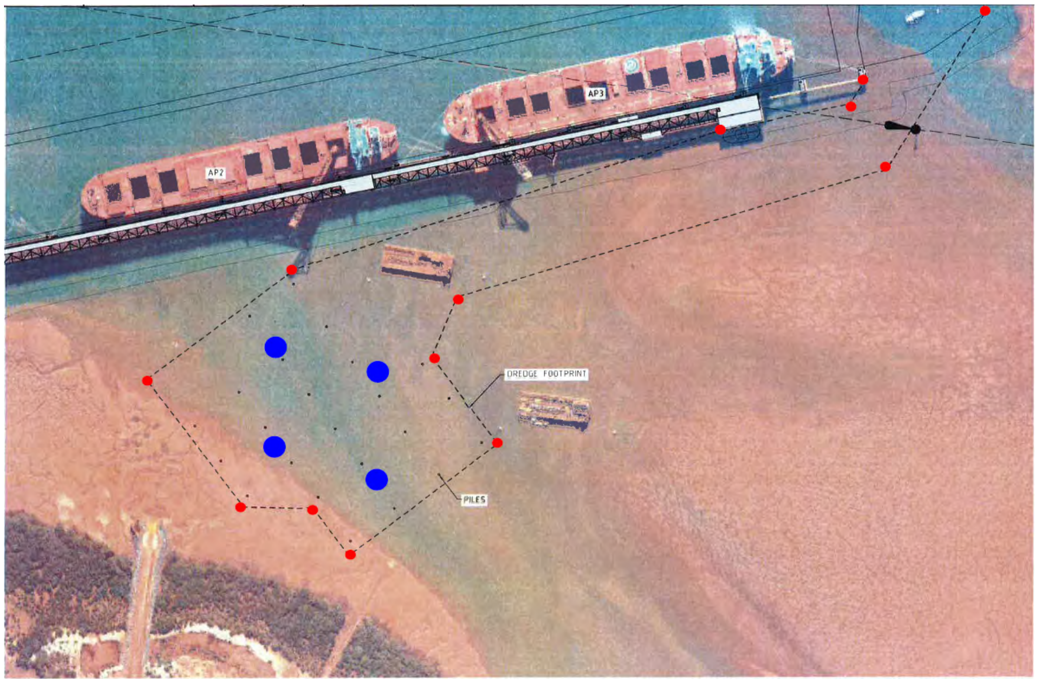


Figure 1-1: Proposed Dredge Footprint

2 Review of existing information

2.1 Overview

Major redevelopment of Port Hedland Harbour began in the 1960s which coincided with the development of the iron ore industry in the region. Since that time, modifications have included extensive dredging and reclamation activities, construction of new wharves and berths. Further, the continual deposition of sediment in the harbour channel requires maintenance dredging to be conducted every 3-4 years by PPA.

There has been considerable testing of sediments in the Port in the past to support a number of maintenance and capital dredging projects. As such, the sediment quality of the location is well understood.

Capital and maintenance dredging conducted within the Port include (based on information from SKM 2008 and GHD 2011):

- 1977 – Maintenance dredging for PHPA (150,000 m^3)
- 1981 –Maintenance dredging for PHPA (268,000 m^3)
- 1985 – Capital and maintenance dredging for PHPA (7,000,000 m^3)
- 1986 – Capital dredging for PHPA (13,600,000 m^3)
- 1990 - Maintenance dredging for PHPA (350,000 m^3)
- 1993 – Maintenance dredging for PHPA (200,000 m^3)
- 1994 - Maintenance dredging for PHPA (114,000 m^3)
- 1997 - Maintenance dredging for PHPA (330,000 m^3)
- 2001 - Maintenance dredging for PHPA (580,000 m^3)
- 2002 - Capital dredging for BHP Billiton Iron Ore (BHPBIO) (460,000 m^3)
- 2004 - Maintenance dredging for PHPA (550,000 m^3)
- 2006-07 - Capital dredging for Fortescue Metals Group Ltd (Fortescue) (5,000,000 m^3)
- 2007 - Maintenance dredging for PHPA (825,000 m^3)
- 2008 – Capital dredging for Fortescue (3,400,000 m^3)
- 2009 – Capital dredging for BHPBIO (3,900,000 m^3)
- 2010 – Capital dredging for BHPBIO (approx. 6,000,000 m^3)
- 2010 – Maintenance dredging for PHPA (500,000 m^3)
- 2011 - 2012– Capital dredging for BHPBIO (approx. 7,400,000 m^3)
- 2012 – Capital dredging for PHPA (1,600,000 m^3)
- 2014 – Capital dredging for PHPA (approx. 900,000 m^3)
- 2015 – Capital dredging for BHPBIO (173,000 m^3)

2.2 Site condition

The Port is located on the confluence of five shallow ephemeral creek systems that provide occasional freshwater inflows into the port area following rainfall events. During these periods it is likely that the water quality within port limits would experience substantial physical and chemical variation due to impacts from catchment run off, particularly from contaminants that enter the catchment from urbanised areas located to the southeast of the port.

Other anthropogenic (specifically port-related) sources likely to contribute to water quality include:

- Deposition of iron ore dust from ship loading activities
- Leaching of antifouling contaminants from ship hulls through mechanical abrasion against seabed and wharf infrastructure
- Mobilisation of sediment from propeller wash, dredging and dewatering activities
- Run off from port infrastructure.

2.3 Seabed geology

Overlying surface sediments within Port Hedland are relatively homogenous across the entire area. Surface sediments are generally unconsolidated fine material classed as clayey silts and silty fine sands which extend to depths of approximately 2.5 m below the surface. Beneath these sediments are layers of consolidated material that consist of sand/clay and gravel sediments to a depth of 8-10 m below the surface.

Cores collected in Port Hedland harbour since 1964 demonstrate that beneath a shallow layer of soft, depositional material that is approximately 2 m deep, the geology is comprised of stable materials with a low potential for holding contaminants (i.e. sands, quartz and cemented materials). The surficial sediment layer is created and replenished by tidal flushing and terrestrial inputs, although it should be noted that due to the low amounts of rainfall in the region, terrestrial inputs and associated organic content are limited and sporadic (SKM 2008).

Geotechnical assessment within the proposed dredging area will be undertaken concurrently in order to understand the geology within the specified area.

2.4 Previous relevant sediment investigations

Sediment investigations have been undertaken on numerous occasions since 1990 to identify potential contamination risks associated with dredging within the Port. To assess the sediment quality within the proposed dredge footprint and its suitability for onshore disposal, a review of all (recent) relevant studies was undertaken. Two previous studies were found to include samples within the proposed dredge footprint and reviewed as part of this assessment:

- RGP6 Definition Phase - Inner Harbour Geotechnical Investigation. Factual Report (WorleyParsons 2010); and
- Small Vessel Cyclone Mooring Facility: SAP Implementation Report (GHD 2011).

These studies indicate that six samples were taken from within the proposed dredging area (Figure 2-1). Within the four surface (0-0.5 m) samples (GHD 2011) all concentrations of analytes were below the Department of Environment Regulation (DER)(DEC 2003) Ecological Investigation Levels (EIL). Analytes included metals (As, Cr, Cu, Pb, Mn, Ni, Zn, Hg, Ba) and Total Organic Carbon (TOC). The two geotechnical sample locations were CMBH01 (up to 16.5 m depth), and THBH01 (7.5 m depth) (WorleyParsons 2010). Metals (Ag, As, Ba, Cd, Co, Cr, Cu, Hg, Mo, Mn, Ni, Pb, Sb, Se, Sn, Zn), nitrogen, nitrates and nitrites and phosphorus were sampled and all analytes were below the DER EILs (DEC 2003).

Figure 2-1: Locations of previous samples within the proposed dredge footprint

A third recent study also involved sampling immediately adjacent to the proposed dredge footprint. A combined geotechnical and (opportunistic) environmental program was undertaken between 10 February and 9 March 2013 (WorleyParsons 2013) and included drilling and sampling in the areas of the proposed Lumsden Point jetty alignment and proposed dredged berthing area as part of the Lumsden Point general cargo facility environmental assessment. A total of seven boreholes were drilled of which five were selected for environmental sampling. Key findings from the investigation were as follows:

- Of the 20 primary samples analysed for inorganics and assessed against the NAGD (2009) ISQG levels and EILs, marginal exceedences were reported for chromium (one ISQG exceedences) and nickel (seven ISQG exceedences). There were no exceedences of DEC EILs.
- Six near surface sediment samples were analysed for TPH; PAHs; OC and OP pesticides; and PCBs at ultra-low levels of detection. No results were reported above the corresponding laboratory PQLs.
- No EIL assessment criteria were exceeded during the investigation.
- Laboratory performed ASS ‘field’ tests were performed on 20 primary samples with no significant indication of the presence of AASS or PASS reported. The presence of shells and/or calcareous materials was frequently reported in the geological profile which may provide an indication of the ability of the sequence to buffer acidity and resist the lowering of pH in these locations (not including >1mm shells).
- Results for analysis of nine samples for the SPOCAS and CRS methods of ASS assessment indicated that acid generation was possible in Horizon 1 at three locations; LSD#2-H1, LSD#6-H1 and LSD#7-H1, however due to increased neutralising capacity from the calcareous materials, no samples exceeded the DEC (2013) Action Criteria for net acidity requiring no active ASS management measures to be implemented.

In reviewing all these previous studies, it is evident that previous sediment sampling does not show any high contamination and minimal ASS potential which would indicate any unsuitability for onshore disposal.

3 Sample and Analysis

3.1 Sediment Assessment Criteria Framework

The objectives of the environmental component of the Anderson Point Tug Haven study is to assess the suitability of the dredge material for disturbance and disposal at an onshore location by comparison of the analytical results against assessment criteria. On this basis, sediment quality will be assessed and compared against the following guidelines:

- National Assessment Guidelines for Dredging 2009 (CoA, 2009);
- Guidance document for Identification and Investigation of Acid Sulfate Soils and Acidic Landscapes, (DER 2015)
- National Environment Protection (Assessment of Site Contamination) Measure (NEPM)(NEPC 1999)
- Assessment and management of contaminated sites guidelines, (DER 2014)

3.2 Sampling Rationale

In accordance with DER (2015), the number of sampling locations based on the anticipated area of the dredge footprint is approximately 18. In comparison, the number of sampling locations based on the anticipated area of the dredge footprint using the NAGD (2009) is 17 but would be reduced to 9 based on the availability of current data.

Taking into consideration the existing knowledge of the geological profile in the vicinity of Anderson Point and the wealth of available data, opportunistic sampling for acid sulfate soils (and contaminants of potential concern) is proposed at four locations down to dredging depth as part of the broader geotechnical scope.

Although the DER (2015) also recommends sampling at regular 0.25m depth intervals, it is also proposed that sampling be undertaken within each of the distinct geological profiles encountered while drilling. With the existing knowledge regarding the geological profile, it is anticipated that the following geological horizons will be encountered (Table 3-1). Previous studies have found that PASS is most likely to be present in the Marine Sediments layer (WorleyParsons 2013), and less so in the deeper layers. It is proposed therefore, that one composite sample be collected from each of the deeper horizons, and two from the Marine Sediment horizon per location.

Table 3-1: Generalised Subsurface Profile within Port Hedland Inner Harbour

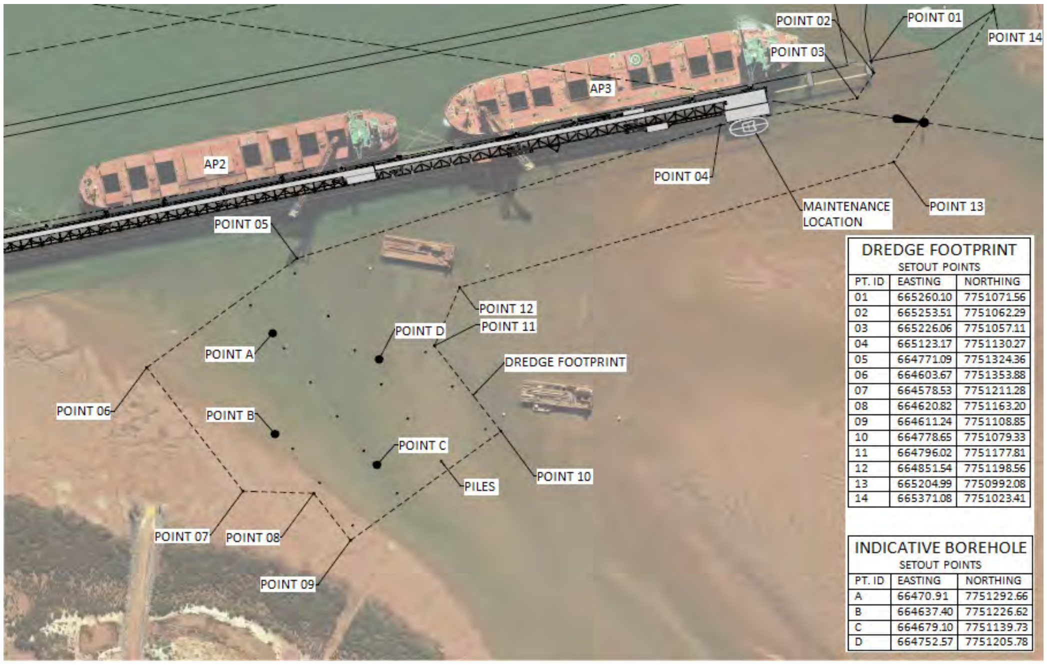
Horizon	Elevation of Layer (m CD)*	Average Layer Thickness (m)	Description / Remarks
1	+4.09 to -3.55	1.4	MARINE SEDIMENTS: Calcareous Silica SAND, Calcareous Gravelly Silica SAND, Calcareous Silty Silica SAND

Horizon	Elevation of Layer (m CD)*	Average Layer Thickness (m)	Description / Remarks
2	+2.99 to -7.90	5.1	UPPER RED BEDS: Sandy CLAY, Clayey SAND, Silty SAND, CLAY
3	-1.24 to -12.95	6.8	LOWER RED BEDS: Clayey SANDSTONE, Silty SANDSTONE
4	-10.20 to -17.35	4.0	CONGLOMERATE: Calcareous Conglomeratic SANDSTONE, (Calcareous) Clayey CONGLOMERATE, Sandy CONGLOMERATE, Calcreted / Silcreted BRECCIA

3.3 Sampling Locations (and Horizons)

Four sampling locations are proposed based on the mobilisation of the drill rig. Six sampling locations have previously been sampled within the dredging footprint, as discussed in Section 2.4, and this data will be incorporated into the subsequent implementation report. Proposed sampling locations and coordinates have been provided in Figure 3-1.

The geotechnical bore holes will be drilled from a jack-up barge (with support vessels) to a depth of approximately -30m CD. As dredging is only required to -8.0m, environmental samples will be sub-sampled from the top 1m and from each geological horizon encountered between the surface and -8.0m CD.



DREDGE FOOTPRINT SETOUT POINTS		
PT. ID	EASTING	NORTHING
01	665260.10	7751071.56
02	665253.51	7751062.29
03	665226.06	7751057.11
04	665123.17	7751130.27
05	664771.09	7751324.36
06	664603.67	7751353.88
07	664578.53	7751211.28
08	664620.82	7751163.20
09	664611.24	7751108.85
10	664778.65	7751079.33
11	664796.02	7751177.81
12	664851.54	7751198.56
13	665204.99	7750992.08
14	665371.08	7751023.41

INDICATIVE BOREHOLE SETOUT POINTS		
PT. ID	EASTING	NORTHING
A	66470.91	7751292.66
B	664637.40	7751226.62
C	664679.10	7751139.73
D	664752.57	7751205.78

Figure 3-1: Proposed sampling locations within dredge footprint

3.4 Contaminant Analysis

A review of previous sediment investigations has identified low levels of organics and occasional elevations of individual metal species in subsurface sediment located between 4 and 25 m CD.

Advisian propose to undertake analysis for the following parameters:

- Moisture content
- 9 Trace Metals (includes digestion) (As, Cd, Cr, Cu, Pb, Hg, Ni, Ag, Zn)
- Chromium Reducible Sulfur suite (CRS)
- Acid Volatile Sulfides (AVS) Simultaneously Extracted Metals (SEM)
- Excess Acid Neutralising Capacity (ANC) and pHox

It is assumed that particle size distribution will be taken during the geotechnical studies, and this information will also be available for the SAP implementation report. If this is not the case, then particle size distribution will also be required.

All parameters will be assessed using NATA accredited methods and will be reported to Assessment Levels for Soil, Sediment and Water practical quantification limits (DER 2014).

Acid sulfate soils will be analysed using the chromium suite analysis, Acid Volatile Sulfide analysis (AVS), pHox, Acid Neutralizing Capacity (ANC) and Simultaneous Extraction of Metals (SEM).

3.5 Sample collection and processing

3.5.1 Sample collection

Samples will be collected using a jack-up barge drill rig that will collect a disturbed sediment core to a depth of approximately -30 m CD. Environment samples will only be required to be collected from the surface to -8.0m CD.

The sampling will be led by a suitably qualified environmental professional with experience in the application of the DER's *Contaminated Sites Guidelines* (2014) and sediment quality assessment.

The barge will be used as the platform for the sampling and will be operated by licensed personnel and will include:

- On board GPS (accurate to at least ± 10 m); and
- An ability to maintain clean surfaces e.g. an on-board deck-hose for wash down (seawater to be drawn from below the surface).

All working areas of the barge will be thoroughly checked, cleaned and prepared for sediment sampling activities prior to material extraction at each site location

Data sheets will be completed in the field (for each sampling location) to document collection details and sediment descriptions for later compilation onto a standardised core description log. Photographs will be taken of samples obtained at each sampling location. Examples of data sheets are presented in Appendix A.

3.5.2 Sample processing

Samples will be collected from each sediment horizon at all sampling locations. Samples will be inspected for integrity to ensure that samples collected are representative of the sediment sampled. Sample handling on board the vessel will include sediment description logging, sample homogenisation, and containment for dispatch to analytical laboratories under chain of custody documentation. Samples will be homogenised in large stainless steel mixing bowls using gloved hands (powderless latex gloves). Samples will be stored in Teflon-lined, acid-rinsed containers.

A table of containers to be used for samples is provided in Table 3-2. Sample containers will be labelled using indelible ink to record the sample location number and date on both the label and lid of the container, and will be stored either in refrigerators or in 'eskies' with ice packs, and will remain refrigerated until dispatched to the analytical testing laboratory where they will be maintained at 4°C.

Table 3-2: Sample Containers

Analyte	Containers per Sample
Chemical Suite	2 x 500 ml solvent washed, glass jar with a Teflon lined lid
Particle Size	1 x plastic bag to hold a minimum of 500 g sample
Acid Sulfate Soils	2 x plastic bag to hold a minimum of 200 g sample
Elutriate water (sea water)	3 x 1.5L seawater in clean polythene container

3.5.3 Hold Samples

A 500 ml hold sample (i.e. a small duplicate split taken from the homogenised sample material for each horizon at each location) will be submitted to the analytical laboratory, to be stored under appropriate conditions, in order to remain viable for additional analysis. This includes any elutriate or bioavailability analyses.

3.6 Contingency Plan

Sampling is proposed to be undertaken in early August 2015. Weather forecasts will be reviewed prior to mobilisation and, if the pending weather is deemed unsatisfactory, fieldwork will be rescheduled. If significant/unsafe weather conditions arise during sample collection, sampling will be suspended while further weather data can be assessed. If works cannot recommence safely, sampling will be either temporarily suspended on site, or the team will be demobilised and return to complete the task at the earliest opportunity. The risk of weather conditions hampering the proposed operation are unlikely given the sheltered conditions generally experienced within the inner port area and the currently proposed timeline being outside of the regular cyclone season.

The potential for contingency due to gear failure will be minimised through properly maintained equipment and redundancy of critical gear as required. If an equipment failure occurs, some parts may be repaired with spare parts taken to site or repaired locally at Port Hedland. If serious equipment failure occurs, then demobilisation and rescheduling following equipment repair would be required. The currently proposed timeline assumes no delays due to weather or significant gear failure.

3.7 Laboratory Analysis

Table 3-3 provides summary details regarding the laboratory method information for the suite of total concentrations tests to be undertaken on sediment samples.

Table 3-3: Method Summary for Sediments

Activity / Test	Method Reference	Method Summary	PQL
Moisture content	Gravimetric	Oven-dry overnight, measure weight before and after drying	0.1%
Particle size distribution (if required)	Sieve and hydrometer	Sieve and hydrometer	To 2 m
Trace Metals and Total P	USEPA 3050/200.7 ICP/AES	Nitric/hydrochloric acid digestion, ICP/AES	0.1 mg/kg
Mercury	USEPA 3050/7471A CVAAS	Nitric/hydrochloric acid digestion, CV/AAS	0.01 mg/kg
ASS (SPOCAS)	Ahern 2004	Extraction with 1M KCL, oxidation of the soil with hydrogen peroxide, digested solution is analysed by ICP – AES and then titration with 0.05 M NaOH.	0.02% S 2mol H+/t
Chromium Reducible Sulfur suite (CRS)	Ahern 2004/ASSMAC	Distillation followed by titration	0.01%
Acid Volatile Sulfides (AVS) Simultaneously Extracted Metals (SEM)	Laboratory Specific Method	Distillation followed by titration and ICP-OES and cold vapour AAS.	0.1%
pHf & pHfox	Ahern 2004/ASSMAC	pH measured using pH probe before and after oxidation with peroxide	0.1 unit
Excess Acid Neutralising Capacity (ANC) & pHox	Ahern 2004/ASSMAC	Part of SPOCAS	0.1%

4 Sampling and Analysis Quality Control

4.1 Quality Control – Field Sampling

Quality control during sampling will be ensured by:

- Using suitably qualified environmental staff experienced in sediment sampling, field supervision and sediment logging
- Maintaining logs for each sample collected including time, location, initials of sampler, duplicate type, chemical analyses to be performed and site observations
- Utilising chain of custody forms identifying (for each sample) the sampler, nature of the sample, collection date and time, analyses to be performed, sample preservation method and departure time from the site
- Using a surveyed jack up barge which is thoroughly inspected and washed down
- Containing samples in appropriately cleaned, pre-treated and labelled sample containers
- Chilling samples (4°C) after sampling and during transport, stored in 'eskies' with pre-frozen ice bricks
- Transporting samples under chain of custody documentation
- Generating additional QC samples in accordance with the contaminated land management series (refer to Section 4.2)
- Ensuring all field QC duplicate/triplicate samples are 'blind' labelled in the field with QC field numbers which do not relate to sampling location names
- Ensuring all sampling equipment, including mixing bowls etc. is decontaminated between sampling locations via a decontamination procedure involving a wash with ambient sea water and a laboratory grade detergent, and successive rinsing with deionised water; or by a similarly acceptable method.

4.2 Quality Control – Analysis

All laboratories used for analyses will be NATA accredited for the methods used and will be experienced in the analysis of marine sediments.

The following quality control measures will be implemented:

- Triplicates from 5% of samples collected will be split and transferred to a separate laboratory to assess in field variability and laboratory performance
- Field rinsate blanks – collected from sample handling tools or drill core liners to assess the potential of cross-contamination in the field
- Field blanks delivered to laboratory to assess the integrity and quality of deionised water used to perform the rinsate blank.

The laboratory quality assurance program should include the following quality control samples to be analysed in each batch (10-20 samples). This is, in addition to the laboratory's own internal procedures, to ensure analytical procedures are conducted properly and produce reliable results:

- One laboratory blank sample
- One sample spiked with the parameters being determined (or a surrogate spike for certain organics) at a concentration within the range of the method being employed – this will

determine whether the recovery rate of the analytical method is adequate or not (that is, that all the chemicals present in the sample are actually being found in the analysis)

- One replicate sample to determine the precision of the analysis; the standard deviation and coefficient of variation to be documented.

A validation of the analytical data obtained will be undertaken and will include a consideration of results for blanks, standards and spikes, replicate samples and duplicate samples. Relative percent differences and relative standard deviations between quality control duplicate and triplicate samples will be compared against relevant criteria.

In accordance with the requirements of NEPM (NEPC 1999), signed chain-of-custody forms will record the receipt date, receipt time and identity of samples in each shipment.

5 Analysis of Results

5.1 Assessment Framework

The suitability of the material for use in land based reclamation will be assessed by comparing concentrations of contaminants with the EILs and health investigation levels prescribed in the NEPM (NEPC 1999) Sediment quality screening levels from ANZECC/ARMCANZ guidelines will also be adopted to identify potential toxic impacts from onshore discharges to the marine environment.

The hierarchy of assessment will be as follows:

- Acid sulfate soils will be assessed using the chromium reducible sulfur suite, acid volatile sulfates and simultaneous extraction of metals.
- Where all sediment contaminants are below the EIL Screening Levels, no further testing will be required.
- Where sediment contaminants are above the adopted EIL Screening Level, the following will be carried out:
  - Leachate testing will be undertaken and compared against relevant ANZECC/ARMCANZ (2000) guideline values;
  - If water quality guidelines are exceeded then a toxicity assessment will be undertaken on the leachate samples to determine whether the return water is likely to be toxic; and
  - If return water is likely to be toxic, modelling to determine the area of plume dispersion
- Where sediment contaminants are above the HILs, further sediment sampling will be undertaken to delineate “hot spot” areas.

5.2 Leachate Analyses

Liberation of potential contaminants into the water during dredging may be altered by a variety of chemical changes. Under certain circumstances, oxygen deprivation may cause some waste materials to liquefy into an acidic water solution (“leachate”). Such an acidic solution may have good solvent properties and liberate toxic components within the soils. Should sampled sediments exceed EIL Screening Levels, leachate testing will be undertaken using the Australian Standard Leaching Procedure.

5.3 Acid Sulfate Soils Analyses

Chromium reducible sulfur suite analysis will used to provide an estimate of the soil’s sulfide content. This will be undertaken in combination with identifying ANC, pHox, AVS and SEM.

pHox provides an indication of the potential acid sulfate soil (PASS) or stored acidity within the profile. When the pHox is less than 3, PASS is assumed likely while AVS has been shown to be a major factor controlling the bioavailability and toxicity of many common trace metals, such as Cd, Cu, Ni, Pb, and Zn (Burton *et. al*. 2007).

ANC is a measure of a soil's ability to buffer acidity and resist the lowering of pH. ANC may be provided by dissolution of calcium and or magnesium carbonates (shell or limestone), cation exchange reactions and by reaction with the organic and clay fractions (DER 2014).

The results for levels of oxidisable sulfur will be assessed using the action criteria in *Identification and Investigation of Acid Sulfate Soils and acidic landscapes (*DER 2015).

6 Reporting

A PSI report containing the following information will be prepared at the conclusion of sampling and analysis for submission to the DER:

- Introduction and description of the study area;
- Details of the sampling methodology including any deviations from the approved SAP;
- Demonstration of sampling locations;
- Descriptions of the core samples, based upon the photographs and core logs;
- Descriptions of any observations or anomalies during sampling and/or analysis;
- Table of laboratories used and the analytical methods employed;
- Quality Assurance procedures and results;
- Summary table of results for each parameter analysed;
- Comparison and interpretation of the results as indicated above;
- Conclusions;
- Recommendations; and
- Appendices containing all laboratory reports and QA / QC analyses.

7 References

ANZECC/ARMCANZ 2000. Water Quality and Monitoring Guidelines in National Water Quality Management Strategy.

Burton GA, Green A, et al. 2007. "Characterizing sediment acid volatile sulfide concentrations in European streams." Environmental Toxicology and Chemistry 26(1): 1-12.

Commonwealth of Australia (2009) National Assessment Guidelines for Dredging (NAGD)

DER 2014. Assessment and management of contaminated sites: Contaminated sites guidelines. Department of Environment Regulation.

DER 2015. Identification and Investigation of Acid Sulfate Soils and Acidic Landscapes. Department of Environment and Conservation.

DER 2014. Assessment and management of contaminated sites. *Contaminated sites guidelines*.

GHD 2011. Report for Small Vessel Cyclone Mooring Facility: SAP Implementation Report. Prepared for Port Hedland Port Authority.

Koskela Group 2007. Port of Port Hedland Maintenance Dredging Campaign 2007: Sediment and Sampling Analysis Report. Prepared for Port Hedland Port Authority.

NEPC (1999) National Environment Protection (Assessment of Site Contamination) Measure. National Environment Protection Council.

SKM 2008. RGP5 Port Facilities Definition Phase Study Harriet Point Sampling and Analysis Plan Results Report for Land Disposal. Report prepared by SKM for BHP Billiton

URS 2009. Sediment Quality of proposed fourth and fifth berths. Report prepared by URS for Fortescue Metals Group (FMG)

WorleyParsons 2010. RGP6 Definition Phase - Inner Harbour Geotechnical Investigation. Factual Report - Implementation of the Environmental Sampling Programme -Lumsden Point Tug Harbour.

Appendix A

Field Sampling Sheets

Tug Haven
SAP Survey

CLIENT: Fortescue Metals Group

DATE OF CORING: ________________

TIME OF CORING: ________________

COLLECTION DETAILS	
General location of core or sampling location	
Site/location number	
Sample Id's assigned	
Easting/Longitude of core location (from onboard GPS)	
Northing/Latitude of core location (from onboard GPS)	
Water depth at core location	
Sample collector	
Type of core sampler	
Sea state at time of coring	
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	
General comments	

Advisian
WorleyParsons Group

Tug Haven SAP Survey

CLIENT: Fortescue Metals Group

SEDIMENT DESCRIPTION	
Sample Location	
Date / Sample Time	
Depth Retained	

Strata Change (m)	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% Stones	Shell/grit and/or biota	Odour

*Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay*.

**Field Texture: clay, silt, sand, gravel, etc

Appendix B
Sampling Core Photographs

BH-T1 0-4.0m

BH-T1 4.0-8.0m

BH-T1 8.0-12.0m

BH-T1 12.0-15.80m

BH-T1 15.80 -19.45m	BH-T1 19.45-23.30
	
BH-T1 23.30-26.95m	BH-T1 26.95-30.0m
	

BH-T2 0-4.0m

BH-T2 4.0-8.0m

BH-T3 8.0-12.0m

BH-T2 12.0-15.85m

BH-T2 15.85-19.50m 	BH-T2 19.50-23.30m 
BH-T2 23.30-27.0m 	BH-T2 27.0-30.0m 

BH-T3 0-4.0m	BH-T3 4.0-8.0m
	
BH-T3 8.0-12.0m	BH-T3 12.0-15.50m
	

BH-T3 15.50-19.15m

BH-T3 19.15-23.30m

BH-T3 23.30-26.70m

BH-T3 26.70-30.0m

BH-T4 0-4.0m	BH-T4 4.0-8.0m
	
BH-T4 8.0-12.0m	BH-T4 12.0-16.0m
	

BH-T4 16.0-20.0 m

BH-T4 20.0-24.0m

BH-T4 24.0-28.0m

Appendix C

Laboratory Analysis Results

CHAIN OF CUSTODY - Client

ENVIROLAB GROUP - National phone number 1300 42 43 44

Sydney Lab - Envirolab Services
12 Ashley St, Chatswood, NSW 2067
Ph 02 9910 6200 / sydney@envirolab.com.au

Perth Lab - MPL Laboratories
16-18 Hayden Crt Myaree, WA 6154
Ph 08 9317 2505 / lab@mpl.com.au

Melbourne Lab - Envirolab Services
1A Dalmore Drive Scoresby VIC 3179
Ph 03 9763 2500 / melbourne@envirolab.com.au

Brisbane Office - Envirolab Services
20a, 10-20 Depot St, Banyo, QLD 4014
Ph 07 3266 9532 / brisbane@envirolab.com.au

Adelaide Office - Envirolab Services
7a The Parade, Norwood, SA 5067
Ph 0406 350 706 / adelaide@envirolab.com.au

Client: Advisian
Contact Person: Nadene Claydon, RYAN COLCOTT
Project Mgr: Peter Shipley
Sampler: Andrew Larsen
Address: Level 2, Bishop See, 235 St Georges Tce, Perth 6000
Phone: 9278 8361 **Mob:**
Email: RYAN.COLCOTT@ADVISIAN.COM
nadene.claydon@advisian.com

Client Project Name / Number / Site etc (ie report title): 201320-08242 Tug Haven
PO No.:
Envirolab Quote No. : 15P519v1
Date results required: Standard
Or choose: standard / same day / 1 day / 2 day / 3 day
Note: Inform lab in advance if urgent turnaround is required - surcharges apply
Report format: esdat / equis /
Lab Comments:

Envirolab Sample ID	Client Sample ID or information	Depth	Date sampled	Type of sample	Moisture	SCR Suite Complete	pHox - TPA, ANDCe	Metals	Mercury	AVS	SEM	~~[illegible]~~	~~[illegible]~~	pH, chloride, sulfate, EC					Comments: Provide as much information about the sample as you can
1	Trip 1	2x bags + Jars			X	X	X	X	X	X	X								
2	BH-T2	15.10-15.25m	21/9	1xJar-soil										X					
3	BH-T3	26.85-27.0m	24/9	1xJar-soil										X					
4	BH-T4	13.80-14.0m	26/9	1xJar-soil										X					
5	BH-T4	16.50-16.70m	26/9	1xJar-soil										X					

Environmental Division
Perth
Work Order Reference
EP1514383

Telephone : + 61-8-9209 7655

Relinquished by (Company): ~~RYAN~~ ADVISIAN
Print Name: RYAN COLCOTT
Date & Time: 0830 01/10/15
Signature: Ryan Colcott

Received by (Company): ~~[illegible]~~ ALS
Print Name: M Westwell
Date & Time: 1/10/15 1000
Signature: [signature]

Lab use only:
Samples Received: (Cool) or Ambient (circle one)
Temperature Received at: 13.8 (if applicable)
Transported by: (Hand delivered) / courier

CHAIN OF CUSTODY - Client

ROLAB

ENVIROLAB GROUP - National phone number 1300 42 43 44

Sydney Lab - Envirolab Services
12 Ashley St, Chatswood, NSW 2067
Ph 02 9910 6200 / sydney@envirolab.com.au

Perth Lab - MPL Laboratories
16-18 Hayden Crt Myaree, WA 6154
Ph 08 9317 2505 / lab@mpl.com.au

Melbourne Lab - Envirolab Services
1A Dalmore Drive Scoresby VIC 3179
Ph 03 9763 2500 / melbourne@envirolab.com

Brisbane Office - Envirolab Services
20a, 10-20 Depot St, Banyo, QLD 4014
Ph 07 3266 9532 / brisbane@envirolab.com.au

Adelaide Office - Envirolab Services
7a The Parade, Norwood, SA 5067
Ph 0406 350 706 / adelaide@envirolab.com.au

...dene Claydon	Client Project Name / Number / Site etc (ie report title): 201320-08242 Tug Haven
...eter Shipley	PO No.:
...drew Larsen	Envirolab Quote No. : 15P519v1
Level 2, Bishop See, 235 St Georges Tce, Perth 6000	Date results required: Standard Or choose: standard / same day / 1 day / 2 day / 3 day *Note: Inform lab in advance if urgent turnaround is required - surcharges apply*
...e: 9278 8361 Mob:	Report format: esdat / equis /
Email: nadene.claydon@advisian.com	Lab Comments:

Envirolab Sample ID	Client Sample ID or information	Depth	Date sampled	Type of sample	Moisture	SCR Suite Complete	pHox - TPA, ANDCe	Metals	Mercury	AVS	SEM	CEC	TOC							Comments: Provide as much information about the sample as you can
1	BH-T2	15.10-15.25	21/9/15	Soil	X	X	X	X	X	X	X									
2	BH-T2	21.0-21.5	21/9	Soil	X	X	X	X	X	X	X									
3	BH-T3	0	22/9	Soil	X	X	X	X	X	X	X									
4	BH-T3	1.50-1.65	23/9	Soil	X	X	X	X	X	X	X									
5	BH-T3	11.35-11.50	23/9	Soil	X	X	X	X	X	X	X									
6	BH-T3	17.3-17.4	23/9	Soil	X	X	X	X	X	X	X									
7	BH-T3	26.85-27.0	24/9	Soil	X	X	X	X	X	X	X									
8	DUP 1			Soil	X	X	X	X	X	X	X									

mpl Laboratories / ENVIROLAB GROUP
Job No.- 171513
Date Rec - 29/9
Time Rec - 1030
Rec By - meg
TAT Req - SAME 1 / 2 / 3 / STD
Temp - cool / ambient
Cooling - Ice / Ice pack / None
Security Seal - Yes / No

Relinquished by (Company):	Received by (Company): MPL	*Lab use only:*
Print Name:	Print Name: Megan Connor	Samples Received: Cool or Ambient (circle one)
Date & Time:	Date & Time: 29/9 1030	Temperature Received at: 20 (if applicable)
Signature:	Signature: [signature]	Transported by: Hand delivered / courier

White - Lab copy / Blue - Client copy / Pink - Retain in Book Page No:

CHAIN OF CUSTODY - Client

ENVIROLAB GROUP - National phone number 1300 42 43 44

Sydney Lab - Envirolab Services
12 Ashley St, Chatswood, NSW 2067
Ph 02 9910 6200 / sydney@envirolab.com.au

Perth Lab - MPL Laboratories
16-18 Hayden Crt Myaree, WA 6154
Ph 08 9317 2505 / lab@mpl.com.au

Melbourne Lab - Envirolab Services
1A Dalmore Drive Scoresby VIC 3179
Ph 03 9763 2500 / melbourne@envirolab.com.au

Brisbane Office - Envirolab Services
20a, 10-20 Depot St, Banyo, QLD 4014
Ph 07 3266 9532 / brisbane@envirolab.com.au

Adelaide Office - Envirolab Services
7a The Parade, Norwood, SA 5067
Ph 0406 350 706 / adelaide@envirolab.com.au

Client: Advisian
Contact Person: Nadene Claydon
Project Mgr: Peter Shipley
Sampler: Andrew Larsen
Address: Level 2, Bishop See, 235 St Georges Tce, Perth 6000
Phone: 9278 8361 **Mob:**
Email: nadene.claydon@advisian.com

Client Project Name / Number / Site etc (ie report title): 201320-08242 Tug Haven
PO No.:
Envirolab Quote No. : 15P519v1
Date results required: Standard
Or choose: standard / same day / 1 day / 2 day / 3 day
Note: Inform lab in advance if urgent turnaround is required - surcharges apply
Report format: esdat / equis /
Lab Comments: #6 - Bag not received. @29-9 to be sent 30-9.

Sample information					Tests Required									Comments
Envirolab Sample ID	Client Sample ID or information	Depth (m)	Date sampled	Type of sample	Moisture	SCR Suite Complete	pHox - TPA, ANDCe	Metals	Mercury	AVS	SEM	CEC	TOC	Provide as much information about the sample as you can
1	BH-T4 0m	0	25/9/15	Jar + Bag	X	X	X	X	X	X	X			
2	BH-T4 3.7-3.9m	3.7-3.9	25/9/15	Jar + Bag	X	X	X	X	X	X	X			
3	BH-T4 13.8-14.8m	13.8-14.8	26/9/15	Jar + Bag	X	X	X	X	X	X	X			
4	BH-T4 16.5-16.7m	16.5-16.7	26/9/15	Jar + Bag	X	X	X	X	X	X	X			
5	BH-T4 20.8-21.0m	20.8-21.0	26/9/15	Jar + Bag	X	X	X	X	X	X	X			
6	BH-T4 Dup 2	-	-	Jar + Bag	X	X	X	X	X	X	X			

mpl Laboratories / Envirolab Group
Job No.- 171496
Date Rec - 29/9
Time Rec - 8:05
Rec By - meg
TAT Req - SAME 1 / 2 / 3 / STD
Temp - Cool / ambient
Cooling - Ice / Ice pack / None
Security Seal - Yes / No

Relinquished by (Company): Advisian
Print Name: RYAN COLCOTT
Date & Time: 08 29/9/15
Signature: Ryan Colcott

Received by (Company): MPL
Print Name: Megan Connop
Date & Time: 29/9 8:05
Signature: [signature]

Lab use only:
Samples Received: Cool or Ambient (circle one)
Temperature Received at: 3 **(if applicable)**
Transported by: Hand delivered / courier

White - Lab copy / Blue - Client copy / Pink - Retain in Book

Page No:

CHAIN OF COSTODY - Client

ENVIROLAB GROUP

ENVIROLAB GROUP - National phone number 1300 42 43 44

Sydney Lab - Envirolab Services
12 Ashley St, Chatswood, NSW 2067
Ph 02 9910 6200 / sydney@envirolab.com.au

Perth Lab - MPL Laboratories
16-18 Hayden Crt Myaree, WA 6154
Ph 08 9317 2505 / lab@mpl.com.au

Melbourne Lab - Envirolab Services
1A Dalmore Drive Scoresby VIC 3179
Ph 03 9763 2500 / melbourne@envirolab.com.au

Brisbane Office - Envirolab Services
20a, 10-20 Depot St, Banyo, QLD 4014
Ph 07 3266 9532 / brisbane@envirolab.com.au

Adelaide Office - Envirolab Services
7a The Parade, Norwood, SA 5067
Ph 0406 350 706 / adelaide@envirolab.com.au

Client: Advisian	**Client Project Name / Number / Site etc (ie report title):** 201320-08242 Tug Haven
Contact Person: Nadene Claydon	
Project Mgr: Peter Shipley	**PO No.:**
Sampler: Andrew Larsen	**Envirolab Quote No. :** 15P519v1
Address: Level 2, Bishop See, 235 St Georges Tce, Perth 6000	**Date results required:** Standard **Or choose: standard / same day / 1 day / 2 day / 3 day** *Note: Inform lab in advance if urgent turnaround is required - surcharges apply*
Phone: 9278 8361 **Mob:**	**Report format: esdat / equis /**
Email: nadene.claydon@advisian.com	**Lab Comments:**

Sample information					Tests Required															Comments
Envirolab Sample ID	Client Sample ID or information	Depth	Date sampled	Type of sample	Moisture	SCR Suite Complete	pHox - TPA, ANDCe	Metals	Mercury	AVS	SEM	CEC	TOC							Provide as much information about the sample as you can
1	BH-T1	0	17/9/15	Soil	X	X	X	X	X	X	X									
2	BH-T1	4.0-4.1m	17/9/15	↓	X	X	X	X	X	X	X									
3	BH-T1	10.10-10.25	17/9/15	↓	X	X	X	X	X	X	X									
4	BH-T1	14.60-14.75	18/9/15	↓	X	X	X	X	X	X	X									
5	BH-T1	22.85-23.0	18/9/15	↓	X	X	X	X	X	X	X									
6	BH-T2	0	19/9/15	↓	X	X	X	X	X	X	X									
7	BH-T2	3.5-3.65	20/9/15	↓	X	X	X	X	X	X	X									
8	BH-T2	7.85-8.0	20/9/15	↓	X	X	X	X	X	X	X									

mpl Laboratories ENVIROLAB
Job No.- 171259
Date Rec- 23-9
Time Rec- 940
Rec By- MC
TAT Req- SAME 1 / 2 / 3 / STD
Temp - cool / ambient
Cooling - Ice / Ice pack / None
Security Seal - Yes / No

Relinquished by (Company): Worley Parsons	**Received by (Company):** Port Hedland Air Freight	***Lab use only:***
Print Name: Gavin Fisher	**Print Name:** Lacey Fielding	**Samples Received: Cool or Ambient (circle one)**
Date & Time: 21/09/15 08h55	**Date & Time:** 21/9/15 8:55am	**Temperature Received at: (if applicable)**
Signature:	**Signature:**	**Transported by: Hand delivered / courier**

White - Lab copy / Blue - Client copy / Pink - Retain in Book Page No:

mpl Laboratories

Part of the Envirolab Group ENVIROLAB GROUP

16 - 18 Hayden Court, Myaree, Western Australia 6154
PO Box 4023 Myaree BC, Western Australia 6960
Tel: +61 8 9317 2505 / Fax: +61 8 9317 4163
email: laboratory@mpl.com.au
www.envirolabservices.com.au
Envirolab Services (WA) Pty Ltd ABN 53 140 099 207

CERTIFICATE OF ANALYSIS 171513

Client:

Advisian - WorleyParsons Group
Level 7, QV1 Building
250 St Georges Tce
Perth
WA 6000

Attention: Nadene Claydon

Sample log in details:

Your Reference:	**201320-08242 Tug Haven**
No. of samples:	8 Soil
Date samples received:	29/09/2015
Date completed instructions received:	29/09/2015
Location:	

Analysis Details:

Please refer to the following pages for results, methodology summary and quality control data.
Samples were analysed as received from the client. Results relate specifically to the samples as received.
Results are reported on a dry weight basis for solids and on an as received basis for other matrices.
Please refer to the last pages of this report for any comments relating to the results.

Report Details:

Date results requested by:	7/10/15
Date of Preliminary Report:	06/10/2015
Issue Date:	7/10/15

NATA accreditation number 2901. This document shall not be reproduced except in full.
Accredited for compliance with ISO/IEC 17025.
Tests not covered by NATA are denoted with *.

Results Approved By:

Stacey Hawkins
Acid Soils/Acid Mine Drainage Supervisor

Joshua Lim
Operations Manager

MPL Reference: 171513
Revision No: R 01

NATA ACCREDITED FOR TECHNICAL COMPETENCE

Chromium Suite						
Our Reference:	UNITS	171513-1	171513-2	171513-3	171513-4	171513-5
Your Reference	-------------	BH-T2	BH-T2	BH-T3	BH-T3	BH-T3
Depth	------------	12.10-15.25	21.0-21.15	0	1.50-1.65	11.35-11.50
Date Sampled		21/09/2015	21/09/2015	22/09/2015	23/09/2015	23/09/2015
Type of sample		Soil	Soil	Soil	Soil	Soil
Date analysed	-	02/10/2015	02/10/2015	02/10/2015	02/10/2015	02/10/2015
pH_{kcl}	pH units	8.8	6.7	9.3	7.0	9.2
TAA	moles H^+/t	<5	<5	<5	<5	<5
S_{KCl}	%w/w S	NT	NT	NT	NT	NT
Chromium Reducible Sulfur	% w / w	<0.005	<0.005	0.079	<0.005	<0.005
ANC_{BT}	% $CaCO_3$	12	0.96	7.2	0.71	34
S_{HCl}	%w/w S	NT	NT	NT	NT	NT
s-TAA	%w/w S	<0.01	<0.01	<0.01	<0.01	<0.01
a-Chromium Reducible Sulfur	moles H^+/t	<5.0	<5.0	50	<5.0	<5.0
a-ANC_{BT}	moles H^+/t	2,458	193	1,439	142	6,761
s-ANC_{BT}	%w/w S	3.9	0.31	2.3	0.23	11
Fineness Factor		2	2	2	2	2
S_{NAS}	%w/w S	NT	NT	NT	NT	NT
a-S_{NAS}	moles H^+/t	NT	NT	NT	NT	NT
s-S_{NAS}	%w/w S	NT	NT	NT	NT	NT
s-Net Acidity	%w/w S	<0.005	<0.005	<0.005	<0.005	<0.005
a-Net Acidity	moles H^+/t	-1,639	-128	-910	-94	-4,506
Liming rate	kg $CaCO_3$/t	<0.75	<0.75	<0.75	<0.75	<0.75
s-Net Acidity without ANCE	% w/w S	<0.005	<0.005	0.079	<0.005	<0.005
a-Net Acidity without ANCE	moles H^+/t	<10	<10	50	<10	<10
Liming rate without ANCE	kg $CaCO_3$/t	<0.75	<0.75	3.7	<0.75	<0.75

Chromium Suite Our Reference: Your Reference Depth Date Sampled Type of sample	UNITS ------------- ------------	171513-6 BH-T3 17.3-17.4 23/09/2015 Soil	171513-7 BH-T3 26.85-27.0 24/09/2015 Soil	171513-8 DUP1 - Soil
Date analysed	-	02/10/2015	02/10/2015	02/10/2015
pH_{kcl}	pH units	8.7	7.4	9.3
TAA	moles H^+/t	<5	<5	<5
S_{KCl}	%w/w S	NT	NT	NT
Chromium Reducible Sulfur	%w/w	<0.005	<0.005	0.086
ANC_{BT}	% $CaCO_3$	13	0.81	16
S_{HCl}	%w/w S	NT	NT	NT
s-TAA	%w/w S	<0.01	<0.01	<0.01
a-Chromium Reducible Sulfur	moles H^+/t	<5.0	<5.0	54
a-ANC_{BT}	moles H^+/t	2,509	162	3,229
s-ANC_{BT}	%w/w S	4.0	0.26	5.2
Fineness Factor		2	2	2
S_{NAS}	%w/w S	NT	NT	NT
a-S_{NAS}	moles H^+/t	NT	NT	NT
s-S_{NAS}	%w/w S	NT	NT	NT
s-Net Acidity	%w/w S	<0.005	<0.005	<0.005
a-Net Acidity	moles H^+/t	-1,673	-108	-2,099
Liming rate	kg $CaCO_3$/t	<0.75	<0.75	<0.75
s-Net Acidity without ANCE	% w/w S	<0.005	<0.005	0.086
a-Net Acidity without ANCE	moles H^+/t	<10	<10	54
Liming rate without ANCE	kg $CaCO_3$/t	<0.75	<0.75	4.0

sPOCAS Our Reference: Your Reference Depth Date Sampled Type of sample	UNITS ------------- ------------	171513-1 BH-T2 12.10-15.25 21/09/2015 Soil	171513-2 BH-T2 21.0-21.15 21/09/2015 Soil	171513-3 BH-T3 0 22/09/2015 Soil	171513-4 BH-T3 1.50-1.65 23/09/2015 Soil	171513-5 BH-T3 11.35-11.50 23/09/2015 Soil
Date prepared	-	29/09/2015	29/09/2015	29/09/2015	29/09/2015	29/09/2015
Date analysed	-	02/10/2015	02/10/2015	02/10/2015	02/10/2015	02/10/2015
pH_{Ox}	pH units	8.1	7.6	8.4	7.6	8.5
TPA	moles H^+/t	<5.0	<5.0	<5.0	<5.0	<5.0
a-ANC_E	moles H^+/t	2,200	120	1,400	72	2,300
ANC_E	% $CaCO_3$	11	0.59	7.0	0.4	12
s-ANC_E	%w/w S	3.6	0.19	2.2	0.11	3.7

sPOCAS Our Reference: Your Reference Depth Date Sampled Type of sample	UNITS ------------- ------------	171513-6 BH-T3 17.3-17.4 23/09/2015 Soil	171513-7 BH-T3 26.85-27.0 24/09/2015 Soil	171513-8 DUP1 - Soil
Date prepared	-	29/09/2015	29/09/2015	29/09/2015
Date analysed	-	02/10/2015	02/10/2015	02/10/2015
pH_{Ox}	pH units	8.4	7.3	8.1
TPA	moles H^+/t	<5.0	<5.0	<5.0
a-ANC_E	moles H^+/t	2,400	82	3,100
ANC_E	% $CaCO_3$	12	0.4	16
s-ANC_E	%w/w S	3.8	0.13	5.0

Metals - soil						
Our Reference:	UNITS	171513-1	171513-2	171513-3	171513-4	171513-5
Your Reference	-------------	BH-T2	BH-T2	BH-T3	BH-T3	BH-T3
Depth	------------	12.10-15.25	21.0-21.15	0	1.50-1.65	11.35-11.50
Date Sampled		21/09/2015	21/09/2015	22/09/2015	23/09/2015	23/09/2015
Type of sample		Soil	Soil	Soil	Soil	Soil
Date digested	-	05/10/2015	05/10/2015	05/10/2015	05/10/2015	05/10/2015
Date analysed	-	06/10/2015	06/10/2015	06/10/2015	06/10/2015	06/10/2015
Arsenic	mg/kg	4.8	2.5	6.7	4.4	6.0
Cadmium	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	mg/kg	50	32	22	55	30
Copper	mg/kg	4.8	7.7	4.2	7.7	7.5
Lead	mg/kg	1.8	2.6	2.2	5.7	7.0
Nickel	mg/kg	12	13	6.0	28	14
Silver	mg/kg	<0.1	<0.1	<0.1	<0.1	0.1
Zinc	mg/kg	6.9	15	11	11	4.4
Mercury	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01

Metals - soil				
Our Reference:	UNITS	171513-6	171513-7	171513-8
Your Reference	-------------	BH-T3	BH-T3	DUP1
Depth	------------	17.3-17.4	26.85-27.0	-
Date Sampled		23/09/2015	24/09/2015	
Type of sample		Soil	Soil	Soil
Date digested	-	05/10/2015	05/10/2015	05/10/2015
Date analysed	-	06/10/2015	06/10/2015	06/10/2015
Arsenic	mg/kg	5.1	4.0	9.7
Cadmium	mg/kg	<0.1	<0.1	<0.1
Chromium	mg/kg	46	37	30
Copper	mg/kg	9.0	6.5	5.3
Lead	mg/kg	5.1	2.4	3.0
Nickel	mg/kg	20	10	8.5
Silver	mg/kg	0.1	<0.1	<0.1
Zinc	mg/kg	19	17	13
Mercury	mg/kg	<0.01	<0.01	<0.01

Moisture Our Reference: Your Reference Depth Date Sampled Type of sample	UNITS ------------- ------------	171513-1 BH-T2 12.10-15.25 21/09/2015 Soil	171513-2 BH-T2 21.0-21.15 21/09/2015 Soil	171513-3 BH-T3 0 22/09/2015 Soil	171513-4 BH-T3 1.50-1.65 23/09/2015 Soil	171513-5 BH-T3 11.35-11.50 23/09/2015 Soil
Date prepared	-	05/10/2015	05/10/2015	05/10/2015	05/10/2015	05/10/2015
Date analysed	-	06/10/2015	06/10/2015	06/10/2015	06/10/2015	06/10/2015
Moisture	%	28	16	17	12	14

Moisture Our Reference: Your Reference Depth Date Sampled Type of sample	UNITS ------------- ------------	171513-6 BH-T3 17.3-17.4 23/09/2015 Soil	171513-7 BH-T3 26.85-27.0 24/09/2015 Soil	171513-8 DUP1 - Soil
Date prepared	-	05/10/2015	05/10/2015	05/10/2015
Date analysed	-	06/10/2015	06/10/2015	06/10/2015
Moisture	%	23	17	32

AVS/SEM						
Our Reference:	UNITS	171513-1	171513-2	171513-3	171513-4	171513-5
Your Reference	-------------	BH-T2	BH-T2	BH-T3	BH-T3	BH-T3
Depth	------------	12.10-15.25	21.0-21.15	0	1.50-1.65	11.35-11.50
Date Sampled		21/09/2015	21/09/2015	22/09/2015	23/09/2015	23/09/2015
Type of sample		Soil	Soil	Soil	Soil	Soil
Acid Volatile Sulphide	µmole/g dry weight	<0.50	<0.50	<0.50	<0.50	<0.50
Arsenic	µmole/g dry weight	<0.05	<0.05	<0.05	<0.05	<0.05
Cadmium	µmole/g dry weight	<0.01	<0.01	<0.01	<0.01	<0.01
Chromium	µmole/g dry weight	0.07	0.02	0.08	0.01	0.01
Copper	µmole/g dry weight	0.03	0.03	0.04	0.02	0.02
Lead	µmole/g dry weight	0.010	0.030	0.010	0.010	0.010
Mercury	µmole/g dry weight	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Nickel	µmole/g dry weight	0.03	0.04	0.03	0.04	<0.02
Zinc	µmole/g dry weight	0.02	<0.02	0.11	<0.02	<0.02
Total SEM	µmole/g dry weight	0.15	0.13	0.28	<0.13	<0.13
SEM/AVS ratio	-	[NT]	[NT]	[NT]	[NT]	[NT]
Silver*	µmole/g dry weight	<0.05	<0.05	<0.05	<0.05	<0.05

AVS/SEM Our Reference: Your Reference Depth Date Sampled Type of sample	UNITS ------------- ------------	171513-6 BH-T3 17.3-17.4 23/09/2015 Soil	171513-7 BH-T3 26.85-27.0 24/09/2015 Soil	171513-8 DUP1 - Soil
Acid Volatile Sulphide	µmole/g dry weight	<0.50	<0.50	<0.50
Arsenic	µmole/g dry weight	<0.05	<0.05	<0.05
Cadmium	µmole/g dry weight	<0.01	<0.01	<0.01
Chromium	µmole/g dry weight	0.07	0.03	0.07
Copper	µmole/g dry weight	0.03	<0.02	0.05
Lead	µmole/g dry weight	0.010	<0.005	0.010
Mercury	µmole/g dry weight	<0.0005	<0.0005	<0.0005
Nickel	µmole/g dry weight	0.04	0.02	0.02
Zinc	µmole/g dry weight	<0.02	<0.02	0.11
Total SEM	µmole/g dry weight	0.15	<0.13	0.26
SEM/AVS ratio	-	[NT]	[NT]	[NT]
Silver*	µmole/g dry weight	<0.05	<0.05	<0.05

Method ID	Methodology Summary
INORG-064	Suspension Peroxide Oxidation Combined Acidity and Sulphate (SPOCAS) using ASSMAC guidelines.
INORG-068	Chromium Reducible Sulfur - Hydrogen Sulfide is quantified by iodometric titration after distillation to determine potential acidity. Based on Acid Sulfate Soils Laboratory Methods Guidelines, Version 2.1 - June 2004.
Metals-022	Determination of various metals by ICP-MS.
Metals-021	Determination of Mercury by Cold Vapour AAS.
INORG-008	Moisture content determined by heating at 105 deg C for a minimum of 12 hours.
AVS-SEM	Determination of Acid Volatile Sulfide (AVS) and Simultaneously Extractable Metals (SEM) in sediment - determined colurimetrically and ICP-OES and cold vapour-AAS.

QUALITY CONTROL Chromium Suite	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date analysed	-			[NT]	171513-1	02/10/2015 || 02/10/2015	[NR]	[NR]
pH kcl	pH units		INORG-064	[NT]	171513-1	8.8 || 8.8 || RPD: 0	LCS-1	100%
TAA	moles H^+/t	5	INORG-064	[NT]	171513-1	<5 || <5	LCS-1	103%
S_{KCl}	%w/w S	0.005	INORG-064	[NT]	171513-1	NT || NT	[NR]	[NR]
Chromium Reducible Sulfur	%w/w	0.005	INORG-068	[NT]	171513-1	<0.005 || <0.005	LCS-1	98%
ANC_{BT}	% $CaCO_3$	0.05	INORG-068	[NT]	171513-1	12 || 12 || RPD: 0	LCS-1	100%
S_{HCl}	%w/w S	0.005	INORG-068	[NT]	171513-1	NT || NT	[NR]	[NR]
s-TAA	%w/w S	0.01	INORG-068	[NT]	171513-1	<0.01 || <0.01	[NR]	[NR]
a-Chromium Reducible Sulfur	moles H^+/t	5	INORG-068	[NT]	171513-1	<5.0 || <5.0	[NR]	[NR]
a-ANC_{BT}	moles H^+/t	0.05	INORG-068	[NT]	171513-1	2458 || 2468 || RPD: 0	LCS-1	100%
s-ANC_{BT}	%w/w S	0.05	INORG-068	[NT]	171513-1	3.9 || 4.0 || RPD: 3	LCS-1	100%
Fineness Factor			INORG-064	[NT]	171513-1	2 || 2 || RPD: 0	[NR]	[NR]
S_{NAS}	%w/w S	0.005	INORG-068	[NT]	171513-1	NT || NT	[NR]	[NR]
a-S_{NAS}	moles H^+/t	5	INORG-064	[NT]	171513-1	NT || NT	[NR]	[NR]
s-S_{NAS}	%w/w S	0.01	INORG-064	[NT]	171513-1	NT || NT	[NR]	[NR]
s-Net Acidity	%w/w S	0.005	INORG-064	[NT]	171513-1	<0.005 || <0.005	[NR]	[NR]
a-Net Acidity	moles H^+/t		INORG-064	[NT]	171513-1	-1639 || -1645 || RPD: 0	[NR]	[NR]
Liming rate	kg $CaCO_3$/t	0.75	INORG-068	[NT]	171513-1	<0.75 || <0.75	[NR]	[NR]
s-Net Acidity without ANCE	% w/w S	0.005	INORG-064	[NT]	171513-1	<0.005 || <0.005	[NR]	[NR]
a-Net Acidity without ANCE	moles H^+/t	10	INORG-064	[NT]	171513-1	<10 || <10	[NR]	[NR]
Liming rate without ANCE	kg $CaCO_3$/t	0.75	INORG-064	[NT]	171513-1	<0.75 || <0.75	[NR]	[NR]

QUALITY CONTROL sPOCAS	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			[NT]	171513-1	29/09/2015 || 29/09/2015	[NR]	[NR]
Date analysed	-			[NT]	171513-1	02/10/2015 || 02/10/2015	[NR]	[NR]
pH $_{Ox}$	pH units		INORG-064	[NT]	171513-1	8.1 || 8.3 || RPD: 2	LCS-1	105%
TPA	moles H^+/t	5	INORG-064	[NT]	171513-1	<5.0 || <5.0	LCS-1	93%
a-ANC$_E$	moles H^+/t	5	INORG-064	[NT]	171513-1	2200 || 2200 || RPD: 0	[NR]	[NR]
ANC$_E$	% $CaCO_3$	0.05	INORG-064	[NT]	171513-1	11 || 11 || RPD: 0	[NR]	[NR]
s-ANC$_E$	%w/w S	0.005	INORG-064	[NT]	171513-1	3.6 || 3.6 || RPD: 0	[NR]	[NR]

QUALITY CONTROL Metals - soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date digested	-			05/10/2015	171513-1	05/10/2015 || 05/10/2015	LCS-1	05/10/2015
Date analysed	-			06/10/2015	171513-1	06/10/2015 || 06/10/2015	LCS-1	06/10/2015
Arsenic	mg/kg	0.5	Metals-022	<0.5	171513-1	4.8 || 6.3 || RPD: 27	LCS-1	105%
Cadmium	mg/kg	0.1	Metals-022	<0.1	171513-1	<0.1 || <0.1	LCS-1	114%
Chromium	mg/kg	0.5	Metals-022	<0.5	171513-1	50 || 49 || RPD: 2	LCS-1	103%
Copper	mg/kg	0.5	Metals-022	<0.5	171513-1	4.8 || 5.2 || RPD: 8	LCS-1	105%
Lead	mg/kg	0.5	Metals-022	<0.5	171513-1	1.8 || 2.3 || RPD: 24	LCS-1	109%
Nickel	mg/kg	0.5	Metals-022	<0.5	171513-1	12 || 13 || RPD: 8	LCS-1	104%
Silver	mg/kg	0.1	Metals-022	<0.1	171513-1	<0.1 || <0.1	LCS-1	99%
Zinc	mg/kg	0.5	Metals-022	<0.5	171513-1	6.9 || 6.2 || RPD: 11	LCS-1	118%
Mercury	mg/kg	0.01	Metals-021	<0.01	171513-1	<0.01 || <0.01	LCS-1	120%

QUALITY CONTROL Moisture	UNITS	PQL	METHOD	Blank
Date prepared	-			05/10/2015
Date analysed	-			06/10/2015
Moisture	%	0.1	INORG-008	<0.10

QUALITY CONTROL AVS/SEM	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Acid Volatile Sulphide	µmole/g dry weight	0.5	AVS-SEM	<0.50	171513-6	<0.50 || <0.50	LCS-1	103%
Arsenic	µmole/g dry weight	0.05	AVS-SEM	<0.05	171513-6	<0.05 || <0.05	LCS-1	101%
Cadmium	µmole/g dry weight	0.01	AVS-SEM	<0.01	171513-6	<0.01 || <0.01	LCS-1	113%
Chromium	µmole/g dry weight	0.01	AVS-SEM	<0.01	171513-6	0.07 || 0.07 || RPD: 0	LCS-1	106%

QUALITY CONTROL AVS/SEM	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Copper	µmole/g dry weight	0.02	AVS-SEM	<0.02	171513-6	0.03 || 0.02 || RPD: 40	LCS-1	106%
Lead	µmole/g dry weight	0.005	AVS-SEM	<0.005	171513-6	0.010 || 0.010 || RPD: 0	LCS-1	107%
Mercury	µmole/g dry weight	0.0005	AVS-SEM	<0.0005	171513-6	<0.0005 || <0.0005	LCS-1	104%
Nickel	µmole/g dry weight	0.02	AVS-SEM	<0.02	171513-6	0.04 || 0.03 || RPD: 29	LCS-1	107%
Zinc	µmole/g dry weight	0.02	AVS-SEM	<0.02	171513-6	<0.02 || <0.02	LCS-1	109%
Total SEM	µmole/g dry weight	0.13	AVS-SEM	<0.13	171513-6	0.15 || <0.13	[NR]	[NR]
SEM/AVS ratio	-	0	AVS-SEM	[NT]	[NT]	[NT]	[NR]	[NR]
Silver*	µmole/g dry weight	0.05	AVS-SEM	<0.05	171513-6	<0.05 || <0.05	LCS-1	101%

QUALITY CONTROL Metals - soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date digested	-	[NT]	[NT]	171513-2	05/10/2015
Date analysed	-	[NT]	[NT]	171513-2	06/10/2015
Arsenic	mg/kg	[NT]	[NT]	[NR]	[NR]
Cadmium	mg/kg	[NT]	[NT]	[NR]	[NR]
Chromium	mg/kg	[NT]	[NT]	[NR]	[NR]
Copper	mg/kg	[NT]	[NT]	[NR]	[NR]
Lead	mg/kg	[NT]	[NT]	[NR]	[NR]
Nickel	mg/kg	[NT]	[NT]	[NR]	[NR]
Silver	mg/kg	[NT]	[NT]	[NR]	[NR]
Zinc	mg/kg	[NT]	[NT]	[NR]	[NR]
Mercury	mg/kg	[NT]	[NT]	171513-2	82%

Report Comments:

AVS/SEM analysed by Envirolab Sydney report 135164

Asbestos Signatories:

Asbestos was analysed by Approved Identifier: Not applicable for this job

Airborne fibres were analysed by Approved Counter: Not applicable for this job

Definitions:

NT: Not tested NA: Test not required INS: Insufficient sample for this test PQL: Practical Quantitation Limit
<: Less than >: Greater than RPD: Relative Percent Difference LCS: Laboratory Control Sample
NS: Not Specified NEPM: National Environmental Protection Measure NR: Not Reported

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011

Quality Control Definitions

Blank: This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate: This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike : A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample) : This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike: Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.
Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.
Spikes for Physical and Aggregate Tests are not applicable.
For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.
Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Part of the Envirolab Group

16 - 18 Hayden Court, Myaree, Western Australia 6154
PO Box 4023 Myaree BC, Western Australia 6960
Tel: +61 8 9317 2505 / Fax: +61 8 9317 4163
email: laboratory@mpl.com.au
www.envirolabservices.com.au
Envirolab Services (WA) Pty Ltd ABN 53 140 099 207

CERTIFICATE OF ANALYSIS 171496

Client:
Advisian - WorleyParsons Group
Level 7, QV1 Building
250 St Georges Tce
Perth
WA 6000

Attention: Nadene Claydon

Sample log in details:

Your Reference:	**201320-08242 Tug Haven**
No. of samples:	6 Soil
Date samples received:	29/09/2015
Date completed instructions received:	29/09/2015
Location:	

Analysis Details:
Please refer to the following pages for results, methodology summary and quality control data.
Samples were analysed as received from the client. Results relate specifically to the samples as received.
Results are reported on a dry weight basis for solids and on an as received basis for other matrices.
Please refer to the last pages of this report for any comments relating to the results.

Report Details:

Date results requested by:	7/10/15
Date of Preliminary Report:	06/10/2015
Issue Date:	7/10/15

NATA accreditation number 2901. This document shall not be reproduced except in full.
Accredited for compliance with ISO/IEC 17025.
Tests not covered by NATA are denoted with *.

Results Approved By:

Stacey Hawkins
Acid Soils/Acid Mine Drainage Supervisor

Joshua Lim
Operations Manager

MPL Reference: 171496
Revision No: R 01

ACCREDITED FOR TECHNICAL COMPETENCE

Chromium Suite						
Our Reference:	UNITS	171496-1	171496-2	171496-3	171496-4	171496-5
Your Reference	-------------	BH-T4	BH-T4	BH-T4	BH-T4	BH-T4
Depth	------------	0	3.7-3.9	13.8-14.8	16.5-16.7	20.8-21.0
Date Sampled		25/09/2015	25/09/2015	26/09/2015	26/09/2015	26/09/2015
Type of sample		Soil	Soil	Soil	Soil	Soil
Date analysed	-	01/10/2015	01/10/2015	01/10/2015	01/10/2015	01/10/2015
pH_{kcl}	pH units	9.1	8.3	7.3	8.1	7.3
TAA	moles H^+/t	<5	<5	<5	<5	<5
S_{KCl}	%w/w S	NT	NT	NT	NT	NT
Chromium Reducible Sulfur	% w/w	0.10	<0.005	<0.005	<0.005	<0.005
ANC_{BT}	% $CaCO_3$	11	1.3	0.86	1.4	1.0
S_{HCl}	%w/w S	NT	NT	NT	NT	NT
s-TAA	%w/w S	<0.01	<0.01	<0.01	<0.01	<0.01
a-Chromium Reducible Sulfur	moles H^+/t	62	<5.0	<5.0	<5.0	<5.0
a-ANC_{BT}	moles H^+/t	2,271	264	172	279	203
s-ANC_{BT}	%w/w S	3.6	0.42	0.28	0.45	0.32
Fineness Factor		2	2	2	2	2
S_{NAS}	%w/w S	NT	NT	NT	NT	NT
a-S_{NAS}	moles H^+/t	NT	NT	NT	NT	NT
s-S_{NAS}	%w/w S	NT	NT	NT	NT	NT
s-Net Acidity	%w/w S	<0.005	<0.005	<0.005	<0.005	<0.005
a-Net Acidity	moles H^+/t	-1,452	-176	-113	-185	-135
Liming rate	kg $CaCO_3$/t	<0.75	<0.75	<0.75	<0.75	<0.75
s-Net Acidity without ANCE	% w/w S	0.10	<0.005	<0.005	<0.005	<0.005
a-Net Acidity without ANCE	moles H^+/t	62	<10	<10	<10	<10
Liming rate without ANCE	kg $CaCO_3$/t	4.7	<0.75	<0.75	<0.75	<0.75

Chromium Suite		
Our Reference:	UNITS	171496-6
Your Reference	-------------	BH-T4
Depth	------------	-
Date Sampled		
Type of sample		Soil
Date analysed	-	01/10/2015
pH_{kcl}	pH units	7.9
TAA	moles H^+/t	<5
S_{KCl}	%w/w S	NT
Chromium Reducible Sulfur	%w/w	<0.005
ANC_{BT}	% $CaCO_3$	0.96
S_{HCl}	%w/w S	NT
s-TAA	%w/w S	<0.01
a-Chromium Reducible Sulfur	moles H^+/t	<5.0
a-ANC_{BT}	moles H^+/t	193
s-ANC_{BT}	%w/w S	0.31
Fineness Factor		2
S_{NAS}	%w/w S	NT
a-S_{NAS}	moles H^+/t	NT
s-S_{NAS}	%w/w S	NT
s-Net Acidity	%w/w S	<0.005
a-Net Acidity	moles H^+/t	-128
Liming rate	kg $CaCO_3$/t	<0.75
s-Net Acidity without ANCE	% w/w S	<0.005
a-Net Acidity without ANCE	moles H^+/t	<10
Liming rate without ANCE	kg $CaCO_3$/t	<0.75

sPOCAS Our Reference: Your Reference Depth Date Sampled Type of sample	UNITS ------------- ------------	171496-1 BH-T4 0 25/09/2015 Soil	171496-2 BH-T4 3.7-3.9 25/09/2015 Soil	171496-3 BH-T4 13.8-14.8 26/09/2015 Soil	171496-4 BH-T4 16.5-16.7 26/09/2015 Soil	171496-5 BH-T4 20.8-21.0 26/09/2015 Soil
Date prepared	-	29/09/2015	29/09/2015	29/09/2015	29/09/2015	29/09/2015
Date analysed	-	02/10/2015	02/10/2015	02/10/2015	02/10/2015	02/10/2015
pH_{Ox}	pH units	8.4	8.0	7.7	7.6	7.3
TPA	moles H^+/t	<5.0	<5.0	<5.0	<5.0	<5.0
$a\text{-}ANC_E$	moles H^+/t	2,000	200	880	180	100
ANC_E	% $CaCO_3$	10	1.0	4.4	0.89	0.52
$s\text{-}ANC_E$	%w/w S	3.3	0.32	1.4	0.29	0.17

sPOCAS Our Reference: Your Reference Depth Date Sampled Type of sample	UNITS ------------- ------------	171496-6 BH-T4 - Soil
Date prepared	-	29/09/2015
Date analysed	-	02/10/2015
pH_{Ox}	pH units	7.6
TPA	moles H^+/t	<5.0
$a\text{-}ANC_E$	moles H^+/t	140
ANC_E	% $CaCO_3$	0.72
$s\text{-}ANC_E$	%w/w S	0.23

Metals - soil						
Our Reference:	UNITS	171496-1	171496-2	171496-3	171496-4	171496-5
Your Reference	-------------	BH-T4	BH-T4	BH-T4	BH-T4	BH-T4
Depth	------------	0	3.7-3.9	13.8-14.8	16.5-16.7	20.8-21.0
Date Sampled		25/09/2015	25/09/2015	26/09/2015	26/09/2015	26/09/2015
Type of sample		Soil	Soil	Soil	Soil	Soil
Date digested	-	05/10/2015	05/10/2015	05/10/2015	05/10/2015	05/10/2015
Date analysed	-	06/10/2015	06/10/2015	06/10/2015	06/10/2015	06/10/2015
Arsenic	mg/kg	15	4.7	5.9	3.4	2.5
Cadmium	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	mg/kg	47	64	42	37	41
Copper	mg/kg	20	14	9.4	5.6	10
Lead	mg/kg	6.5	8.4	15	5.9	2.6
Nickel	mg/kg	20	30	14	13	15
Silver	mg/kg	<0.1	<0.1	0.1	<0.1	0.4
Zinc	mg/kg	40	13	4.7	8.3	15
Mercury	mg/kg	0.02	<0.01	<0.01	<0.01	<0.01

Metals - soil		
Our Reference:	UNITS	171496-6
Your Reference	-------------	BH-T4
Depth	------------	-
Date Sampled		
Type of sample		Soil
Date digested	-	05/10/2015
Date analysed	-	06/10/2015
Arsenic	mg/kg	5.4
Cadmium	mg/kg	<0.1
Chromium	mg/kg	67
Copper	mg/kg	12
Lead	mg/kg	7.8
Nickel	mg/kg	30
Silver	mg/kg	0.3
Zinc	mg/kg	13
Mercury	mg/kg	<0.01

Moisture Our Reference: Your Reference Depth Date Sampled Type of sample	UNITS ------------- ------------	171496-1 BH-T4 0 25/09/2015 Soil	171496-2 BH-T4 3.7-3.9 25/09/2015 Soil	171496-3 BH-T4 13.8-14.8 26/09/2015 Soil	171496-4 BH-T4 16.5-16.7 26/09/2015 Soil	171496-5 BH-T4 20.8-21.0 26/09/2015 Soil
Date prepared	-	05/10/2015	05/10/2015	05/10/2015	05/10/2015	05/10/2015
Date analysed	-	06/10/2015	06/10/2015	06/10/2015	06/10/2015	06/10/2015
Moisture	%	36	11	10	26	16

Moisture Our Reference: Your Reference Depth Date Sampled Type of sample	UNITS ------------- ------------	171496-6 BH-T4 - Soil
Date prepared	-	05/10/2015
Date analysed	-	06/10/2015
Moisture	%	10

AVS/SEM Our Reference: Your Reference Depth Date Sampled Type of sample	UNITS ------------- ------------	171496-1 BH-T4 0 25/09/2015 Soil	171496-2 BH-T4 3.7-3.9 25/09/2015 Soil	171496-3 BH-T4 13.8-14.8 26/09/2015 Soil	171496-4 BH-T4 16.5-16.7 26/09/2015 Soil	171496-5 BH-T4 20.8-21.0 26/09/2015 Soil
Acid Volatile Sulphide	µmole/g dry weight	1.3	<0.50	<0.50	<0.50	<0.50
Arsenic	µmole/g dry weight	0.05	<0.05	<0.05	<0.05	<0.05
Cadmium	µmole/g dry weight	<0.01	<0.01	<0.01	<0.01	<0.01
Chromium	µmole/g dry weight	0.12	0.03	0.04	0.10	0.03
Copper	µmole/g dry weight	0.24	0.06	<0.02	0.02	0.04
Lead	µmole/g dry weight	0.030	0.020	0.020	0.010	0.020
Mercury	µmole/g dry weight	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Nickel	µmole/g dry weight	0.04	0.02	0.02	0.03	0.03
Zinc	µmole/g dry weight	0.54	<0.02	<0.02	0.02	<0.02
Total SEM	µmole/g dry weight	1.0	<0.13	<0.13	0.18	<0.13
SEM/AVS ratio	-	[NT]	[NT]	[NT]	[NT]	[NT]
Silver*	µmole/g dry weight	<0.05	<0.05	<0.05	<0.05	<0.05

AVS/SEM		
Our Reference:	UNITS	171496-6
Your Reference	-------------	BH-T4
Depth	------------	-
Date Sampled		
Type of sample		Soil
Acid Volatile Sulphide	µmole/g dry weight	<0.50
Arsenic	µmole/g dry weight	<0.05
Cadmium	µmole/g dry weight	<0.01
Chromium	µmole/g dry weight	0.02
Copper	µmole/g dry weight	0.05
Lead	µmole/g dry weight	0.010
Mercury	µmole/g dry weight	<0.0005
Nickel	µmole/g dry weight	0.02
Zinc	µmole/g dry weight	<0.02
Total SEM	µmole/g dry weight	<0.13
SEM/AVS ratio	-	[NT]
Silver*	µmole/g dry weight	<0.05

Method ID	Methodology Summary
INORG-064	Suspension Peroxide Oxidation Combined Acidity and Sulphate (SPOCAS) using ASSMAC guidelines.
INORG-068	Chromium Reducible Sulfur - Hydrogen Sulfide is quantified by iodometric titration after distillation to determine potential acidity. Based on Acid Sulfate Soils Laboratory Methods Guidelines, Version 2.1 - June 2004.
Metals-022	Determination of various metals by ICP-MS.
Metals-021	Determination of Mercury by Cold Vapour AAS.
INORG-008	Moisture content determined by heating at 105 deg C for a minimum of 12 hours.
AVS-SEM	Determination of Acid Volatile Sulfide (AVS) and Simultaneously Extractable Metals (SEM) in sediment - determined colurimetrically and ICP-OES and cold vapour-AAS.

QUALITY CONTROL Chromium Suite	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date analysed	-			[NT]	171496-1	01/10/2015 || 01/10/2015	[NR]	[NR]
pH $_{kcl}$	pH units		INORG-064	[NT]	171496-1	9.1 || 9.1 || RPD: 0	[NR]	[NR]
TAA	moles H^+/t	5	INORG-064	[NT]	171496-1	<5 || <5	LCS-1	100%
S_{KCl}	%w/w S	0.005	INORG-064	[NT]	171496-1	NT || NT	LCS-1	98%
Chromium Reducible Sulfur	%w/w	0.005	INORG-068	[NT]	171496-1	0.10 || 0.10 || RPD: 0	LCS-1	98%
ANC_{BT}	% $CaCO_3$	0.05	INORG-068	[NT]	171496-1	11 || 11 || RPD: 0	LCS-1	100%
S_{HCl}	%w/w S	0.005	INORG-068	[NT]	171496-1	NT || NT	[NR]	[NR]
s-TAA	%w/w S	0.01	INORG-068	[NT]	171496-1	<0.01 || <0.01	[NR]	[NR]
a-Chromium Reducible Sulfur	moles H^+/t	5	INORG-068	[NT]	171496-1	62 || 63 || RPD: 2	[NR]	[NR]
a-ANC_{BT}	moles H^+/t	0.05	INORG-068	[NT]	171496-1	2271 || 2261 || RPD: 0	LCS-1	100%
s-ANC_{BT}	%w/w S	0.05	INORG-068	[NT]	171496-1	3.6 || 3.6 || RPD: 0	LCS-1	100%
Fineness Factor			INORG-064	[NT]	171496-1	2 || 2 || RPD: 0	[NR]	[NR]
S_{NAS}	%w/w S	0.005	INORG-068	[NT]	171496-1	NT || NT	[NR]	[NR]
a-S_{NAS}	moles H^+/t	5	INORG-064	[NT]	171496-1	NT || NT	[NR]	[NR]
s-S_{NAS}	%w/w S	0.01	INORG-064	[NT]	171496-1	NT || NT	[NR]	[NR]
s-Net Acidity	%w/w S	0.005	INORG-064	[NT]	171496-1	<0.005 || <0.005	[NR]	[NR]
a-Net Acidity	moles H^+/t		INORG-064	[NT]	171496-1	-1452 || -1444 || RPD: -1	[NR]	[NR]
Liming rate	kg $CaCO_3$ /t	0.75	INORG-068	[NT]	171496-1	<0.75 || <0.75	[NR]	[NR]
s-Net Acidity without ANCE	% w/w S	0.005	INORG-064	[NT]	171496-1	0.10 || 0.10 || RPD: 0	[NR]	[NR]
a-Net Acidity without ANCE	moles H^+/t	10	INORG-064	[NT]	171496-1	62 || 63 || RPD: 2	[NR]	[NR]
Liming rate without ANCE	kg $CaCO_3$ /t	0.75	INORG-064	[NT]	171496-1	4.7 || 4.7 || RPD: 0	[NR]	[NR]

QUALITY CONTROL sPOCAS	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			[NT]	171496-1	29/09/2015 || 29/09/2015	[NR]	[NR]
Date analysed	-			[NT]	171496-1	02/10/2015 || 02/10/2015	[NR]	[NR]
pH $_{Ox}$	pH units		INORG-064	[NT]	171496-1	8.4 || 8.4 || RPD: 0	LCS-1	105%
TPA	moles H^+/t	5	INORG-064	[NT]	171496-1	<5.0 || <5.0	LCS-1	93%
a-ANC$_E$	moles H^+/t	5	INORG-064	[NT]	171496-1	2000 || 2000 || RPD: 0	[NR]	[NR]
ANC$_E$	% $CaCO_3$	0.05	INORG-064	[NT]	171496-1	10 || 10 || RPD: 0	[NR]	[NR]
s-ANC$_E$	%w/w S	0.005	INORG-064	[NT]	171496-1	3.3 || 3.3 || RPD: 0	[NR]	[NR]

QUALITY CONTROL Metals - soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date digested	-			05/10/2015	[NT]	[NT]	LCS-1	05/10/2015
Date analysed	-			06/10/2015	[NT]	[NT]	LCS-1	06/10/2015
Arsenic	mg/kg	0.5	Metals-022	<0.5	[NT]	[NT]	LCS-1	105%
Cadmium	mg/kg	0.1	Metals-022	<0.1	[NT]	[NT]	LCS-1	114%
Chromium	mg/kg	0.5	Metals-022	<0.5	[NT]	[NT]	LCS-1	103%
Copper	mg/kg	0.5	Metals-022	<0.5	[NT]	[NT]	LCS-1	105%
Lead	mg/kg	0.5	Metals-022	<0.5	[NT]	[NT]	LCS-1	109%
Nickel	mg/kg	0.5	Metals-022	<0.5	[NT]	[NT]	LCS-1	104%
Silver	mg/kg	0.1	Metals-022	<0.1	[NT]	[NT]	LCS-1	99%
Zinc	mg/kg	0.5	Metals-022	<0.5	[NT]	[NT]	LCS-1	118%
Mercury	mg/kg	0.01	Metals-021	<0.01	[NT]	[NT]	LCS-1	120%

QUALITY CONTROL Moisture	UNITS	PQL	METHOD	Blank
Date prepared	-			05/10/2015
Date analysed	-			06/10/2015
Moisture	%	0.1	INORG-008	<0.10

QUALITY CONTROL AVS/SEM	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Acid Volatile Sulphide	µmole/g dry weight	0.5	AVS-SEM	<0.50	171496-1	1.3 || 1.6 || RPD: 21	LCS-1	103%
Arsenic	µmole/g dry weight	0.05	AVS-SEM	<0.05	171496-1	0.05 || 0.05 || RPD: 0	LCS-1	101%
Cadmium	µmole/g dry weight	0.01	AVS-SEM	<0.01	171496-1	<0.01 || <0.01	LCS-1	113%
Chromium	µmole/g dry weight	0.01	AVS-SEM	<0.01	171496-1	0.12 || 0.11 || RPD: 9	LCS-1	106%

QUALITY CONTROL AVS/SEM	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Copper	µmole/g dry weight	0.02	AVS-SEM	<0.02	171496-1	0.24 || 0.23 || RPD: 4	LCS-1	106%
Lead	µmole/g dry weight	0.005	AVS-SEM	<0.005	171496-1	0.030 || 0.030 || RPD: 0	LCS-1	107%
Mercury	µmole/g dry weight	0.0005	AVS-SEM	<0.0005	171496-1	<0.0005 || <0.0005	LCS-1	104%
Nickel	µmole/g dry weight	0.02	AVS-SEM	<0.02	171496-1	0.04 || 0.04 || RPD: 0	LCS-1	107%
Zinc	µmole/g dry weight	0.02	AVS-SEM	<0.02	171496-1	0.54 || 0.53 || RPD: 2	LCS-1	109%
Total SEM	µmole/g dry weight	0.13	AVS-SEM	<0.13	171496-1	1.0 || 0.99 || RPD: 1	[NR]	[NR]
SEM/AVS ratio	-	0	AVS-SEM	[NT]	[NT]	[NT]	[NR]	[NR]
Silver*	µmole/g dry weight	0.05	AVS-SEM	<0.05	171496-1	<0.05 || <0.05	LCS-1	101%

Report Comments:

AVS/SEM analysed by Envirolab Sydney report 135164 & 135329

Asbestos Signatories:

Asbestos was analysed by Approved Identifier: Not applicable for this job

Airborne fibres were analysed by Approved Counter: Not applicable for this job

Definitions:

NT: Not tested NA: Test not required INS: Insufficient sample for this test PQL: Practical Quantitation Limit
<: Less than >: Greater than RPD: Relative Percent Difference LCS: Laboratory Control Sample
NS: Not Specified NEPM: National Environmental Protection Measure NR: Not Reported

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011

Quality Control Definitions

Blank: This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate: This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike : A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample) : This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike: Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.
Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.
Spikes for Physical and Aggregate Tests are not applicable.
For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.
Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
enquiries@envirolabservices.com.au
www.envirolabservices.com.au

CERTIFICATE OF ANALYSIS **134824**

Client:
MPL Laboratories
Envirolab Services (WA) Pty Ltd
16-18 Hayden Court
Myaree
WA 6154

Attention: Joshua Lim

Sample log in details:

Your Reference:	**171259**	
No. of samples:	8 Soils	
Date samples received / completed instructions received	23/09/15	/ 23/09/15

Analysis Details:
Please refer to the following pages for results, methodology summary and quality control data.
Samples were analysed as received from the client. Results relate specifically to the samples as received.
Results are reported on a dry weight basis for solids and on an as received basis for other matrices.
Please refer to the last page of this report for any comments relating to the results.

Report Details:

Date results requested by: / Issue Date:	29/09/15	/ 29/09/15
Date of Preliminary Report:	Not Issued	

NATA accreditation number 2901. This document shall not be reproduced except in full.
Accredited for compliance with ISO/IEC 17025. **Tests not covered by NATA are denoted with *.**

Results Approved By:

Jacinta Hurst
Laboratory Manager

AVS/SEM Our Reference: Your Reference Type of sample	UNITS ------------ ------------	134824-1 171259-1 Soil	134824-2 171259-2 Soil	134824-3 171259-3 Soil	134824-4 171259-4 Soil	134824-5 171259-5 Soil
Date prepared	-	29/09/2015	29/09/2015	29/09/2015	29/09/2015	29/09/2015
Date analysed	-	29/09/2015	29/09/2015	29/09/2015	29/09/2015	29/09/2015
Acid Volatile Sulphide	µmole/g dry weight	<0.50	<0.50	<0.50	<0.50	<0.50
Arsenic	µmole/g dry weight	<0.05	<0.05	<0.05	<0.05	<0.05
Cadmium	µmole/g dry weight	<0.01	<0.01	<0.01	<0.01	<0.01
Chromium	µmole/g dry weight	0.03	0.02	0.03	0.10	0.01
Copper	µmole/g dry weight	<0.02	0.03	0.02	0.03	0.03
Lead	µmole/g dry weight	<0.005	0.010	0.020	0.010	0.020
Nickel	µmole/g dry weight	<0.02	0.02	0.03	0.05	0.09
Zinc	µmole/g dry weight	0.06	<0.02	<0.02	<0.02	<0.02
Total SEM	µmole/g dry weight	<0.13	<0.13	<0.13	0.18	0.15
SEM/AVS ratio	-	[NT]	[NT]	[NT]	[NT]	[NT]
Silver*	µmole/g dry weight	<0.05	<0.05	<0.05	<0.05	<0.05

AVS/SEM Our Reference: Your Reference Type of sample	UNITS ------------- ------------	134824-6 171259-6 Soil	134824-7 171259-7 Soil	134824-8 171259-8 Soil
Date prepared	-	29/09/2015	29/09/2015	29/09/2015
Date analysed	-	29/09/2015	29/09/2015	29/09/2015
Acid Volatile Sulphide	µmole/g dry weight	0.84	<0.50	<0.50
Arsenic	µmole/g dry weight	<0.05	<0.05	<0.05
Cadmium	µmole/g dry weight	<0.01	<0.01	<0.01
Chromium	µmole/g dry weight	0.07	0.02	0.01
Copper	µmole/g dry weight	0.11	<0.02	0.02
Lead	µmole/g dry weight	0.010	0.010	0.020
Nickel	µmole/g dry weight	0.02	<0.02	0.03
Zinc	µmole/g dry weight	0.26	<0.02	<0.02
Total SEM	µmole/g dry weight	0.47	<0.13	<0.13
SEM/AVS ratio	-	0.56	[NT]	[NT]
Silver*	µmole/g dry weight	<0.05	<0.05	<0.05

Moisture Our Reference: Your Reference Type of sample	UNITS ------------- ------------	134824-1 171259-1 Soil	134824-2 171259-2 Soil	134824-3 171259-3 Soil	134824-4 171259-4 Soil	134824-5 171259-5 Soil
Date prepared	-	28/09/2015	28/09/2015	28/09/2015	28/09/2015	28/09/2015
Date analysed	-	29/09/2015	29/09/2015	29/09/2015	29/09/2015	29/09/2015
Moisture	%	1.2	1.1	1.1	1.2	1.1

Moisture Our Reference: Your Reference Type of sample	UNITS ------------- ------------	134824-6 171259-6 Soil	134824-7 171259-7 Soil	134824-8 171259-8 Soil
Date prepared	-	28/09/2015	28/09/2015	28/09/2015
Date analysed	-	29/09/2015	29/09/2015	29/09/2015
Moisture	%	1.3	1.1	1.1

Method ID	Methodology Summary
AVS-SEM	Determination of Acid Volatile Sulfide (AVS) and Simultaneously Extractable Metals (SEM)/Bioavailable Metals in sediment - determined colourimetrically and using ICP-OES and cold vapour-AAS.
Inorg-008	Moisture content determined by heating at 105+/-5 deg C for a minimum of 12 hours.

QUALITY CONTROL AVS/SEM	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			29/09/2015	134824-1	29/09/2015 || 29/09/2015	LCS-1	29/09/2015
Date analysed	-			29/09/2015	134824-1	29/09/2015 || 29/09/2015	LCS-1	29/09/2015
Acid Volatile Sulphide	µmole/g dry weight	0.5	AVS-SEM	<0.50	134824-1	<0.50 || <0.50	LCS-1	81%
Arsenic	µmole/g dry weight	0.05	AVS-SEM	<0.05	134824-1	<0.05 || <0.05	LCS-1	100%
Cadmium	µmole/g dry weight	0.01	AVS-SEM	<0.01	134824-1	<0.01 || <0.01	LCS-1	110%
Chromium	µmole/g dry weight	0.01	AVS-SEM	<0.01	134824-1	0.03 || 0.02 || RPD: 40	LCS-1	100%
Copper	µmole/g dry weight	0.02	AVS-SEM	<0.02	134824-1	<0.02 || <0.02	LCS-1	100%
Lead	µmole/g dry weight	0.005	AVS-SEM	<0.005	134824-1	<0.005 || <0.005	LCS-1	100%
Nickel	µmole/g dry weight	0.02	AVS-SEM	<0.02	134824-1	<0.02 || <0.02	LCS-1	100%
Zinc	µmole/g dry weight	0.02	AVS-SEM	<0.02	134824-1	0.06 || 0.05 || RPD: 18	LCS-1	100%
Total SEM	µmole/g dry weight	0.13	AVS-SEM	<0.13	134824-1	<0.13 || <0.13	[NR]	[NR]
SEM/AVS ratio	-	0	AVS-SEM	[NT]	134824-1	[NT] || [N/T]	[NR]	[NR]
Silver*	µmole/g dry weight	0.05	AVS-SEM	<0.05	134824-1	<0.05 || <0.05	LCS-1	94%

QUALITY CONTROL AVS/SEM	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date prepared	-	[NT]	[NT]	134824-2	29/09/2015
Date analysed	-	[NT]	[NT]	134824-2	29/09/2015
Acid Volatile Sulphide	µmole/g dry weight	[NT]	[NT]	[NR]	[NR]
Arsenic	µmole/g dry weight	[NT]	[NT]	134824-2	#
Cadmium	µmole/g dry weight	[NT]	[NT]	134824-2	110%
Chromium	µmole/g dry weight	[NT]	[NT]	134824-2	99%
Copper	µmole/g dry weight	[NT]	[NT]	134824-2	110%

QUALITY CONTROL AVS/SEM	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Lead	µmole/g dry weight	[NT]	[NT]	134824-2	100%
Nickel	µmole/g dry weight	[NT]	[NT]	134824-2	100%
Zinc	µmole/g dry weight	[NT]	[NT]	134824-2	100%
Total SEM	µmole/g dry weight	[NT]	[NT]	[NR]	[NR]
SEM/AVS ratio	-	[NT]	[NT]	[NR]	[NR]
Silver*	µmole/g dry weight	[NT]	[NT]	134824-2	74%

Report Comments:

Low spike recovery was obtained for this sample. This maybe due to matrix interferences. However, an acceptable recovery was obtained for the LCS.

Asbestos ID was analysed by Approved Identifier:	Not applicable for this job
Asbestos ID was authorised by Approved Signatory:	Not applicable for this job

INS: Insufficient sample for this test	PQL: Practical Quantitation Limit	NT: Not tested
NA: Test not required	RPD: Relative Percent Difference	NA: Test not required
<: Less than	>: Greater than	LCS: Laboratory Control Sample

Quality Control Definitions

Blank: This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.

Duplicate: This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.

Matrix Spike : A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.

LCS (Laboratory Control Sample) : This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.

Surrogate Spike: Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

16 - 18 Hayden Court, Myaree, Western Australia 6154
PO Box 4023 Myaree BC, Western Australia 6960
Tel: +61 8 9317 2505 / Fax: +61 8 9317 4163
email: laboratory@mpl.com.au
www.envirolabservices.com.au
Envirolab Services (WA) Pty Ltd ABN 53 140 099 207

Part of the Envirolab Group

CERTIFICATE OF ANALYSIS 171259

Client:
Advisian - WorleyParsons Group
Level 7, QV1 Building
250 St Georges Tce
Perth
WA 6000

Attention: Nadene Claydon

Sample log in details:

Your Reference:	**201320-08242 Tug Haven**
No. of samples:	8 Soil
Date samples received:	22/09/2015
Date completed instructions received:	22/09/2015
Location:	

Analysis Details:
Please refer to the following pages for results, methodology summary and quality control data.
Samples were analysed as received from the client. Results relate specifically to the samples as received.
Results are reported on a dry weight basis for solids and on an as received basis for other matrices.
Please refer to the last pages of this report for any comments relating to the results.

Report Details:

Date results requested by:	29/09/15
Date of Preliminary Report:	Not Issued
Issue Date:	29/09/15

NATA accreditation number 2901. This document shall not be reproduced except in full.
Accredited for compliance with ISO/IEC 17025.
Tests not covered by NATA are denoted with *.

Results Approved By:

Stacey Hawkins
Acid Soils/Acid Mine Drainage Supervisor

Pamela Adams
Assistant Operations Manager

ACCREDITED FOR TECHNICAL COMPETENCE

Metals - soil						
Our Reference:	UNITS	171259-1	171259-2	171259-3	171259-4	171259-5
Your Reference	-------------	BH-T1	BH-T1	BH-T1	BH-T1	BH-T1
Depth	------------	0	4.0-4.1m	10.10-10.25m	14.60-14.75m	22.85-23.0m
Date Sampled		17/09/2015	17/09/2015	17/09/2015	18/09/2015	18/09/2015
Type of sample		Soil	Soil	Soil	Soil	Soil
Date digested	-	25/09/2015	25/09/2015	25/09/2015	25/09/2015	25/09/2015
Date analysed	-	29/09/2015	29/09/2015	29/09/2015	29/09/2015	29/09/2015
Arsenic	mg/kg	6.3	5.8	2.8	3.1	2.3
Cadmium	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	mg/kg	17	93	45	41	44
Copper	mg/kg	1.1	12	7.4	5.5	11
Mercury	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01
Lead	mg/kg	1	9.9	5.7	3.0	7.7
Nickel	mg/kg	1.9	48	23	15	22
Silver	mg/kg	<0.1	<0.1	<0.1	0.1	0.1
Zinc	mg/kg	6.3	17	7.1	4.5	18

Metals - soil				
Our Reference:	UNITS	171259-6	171259-7	171259-8
Your Reference	-------------	BH-T2	BH-T2	BH-T2
Depth	------------	0	3.5-3.6m	7.85-8.0m
Date Sampled		19/08/2015	20/09/2015	20/09/2015
Type of sample		Soil	Soil	Soil
Date digested	-	25/09/2015	25/09/2015	25/09/2015
Date analysed	-	29/09/2015	29/09/2015	29/09/2015
Arsenic	mg/kg	12	2.9	3.4
Cadmium	mg/kg	<0.1	<0.1	<0.1
Chromium	mg/kg	37	67	42
Copper	mg/kg	12	8.6	11
Mercury	mg/kg	0.02	<0.01	<0.01
Lead	mg/kg	4.0	5.6	11
Nickel	mg/kg	13	33	24
Silver	mg/kg	<0.1	<0.1	<0.1
Zinc	mg/kg	25	14	9.1

Moisture						
Our Reference:	UNITS	171259-1	171259-2	171259-3	171259-4	171259-5
Your Reference	-------------	BH-T1	BH-T1	BH-T1	BH-T1	BH-T1
Depth	------------	0	4.0-4.1m	10.10-10.25m	14.60-14.75m	22.85-23.0m
Date Sampled		17/09/2015	17/09/2015	17/09/2015	18/09/2015	18/09/2015
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	25/09/2015	25/09/2015	25/09/2015	25/09/2015	25/09/2015
Date analysed	-	29/09/2015	29/09/2015	29/09/2015	29/09/2015	29/09/2015
Moisture	%	15	16	14	27	18

Moisture				
Our Reference:	UNITS	171259-6	171259-7	171259-8
Your Reference	-------------	BH-T2	BH-T2	BH-T2
Depth	------------	0	3.5-3.6m	7.85-8.0m
Date Sampled		19/08/2015	20/09/2015	20/09/2015
Type of sample		Soil	Soil	Soil
Date prepared	-	25/09/2015	25/09/2015	25/09/2015
Date analysed	-	29/09/2015	29/09/2015	29/09/2015
Moisture	%	24	16	19

External Testing						
Our Reference:	UNITS	171259-1	171259-2	171259-3	171259-4	171259-5
Your Reference	-------------	BH-T1	BH-T1	BH-T1	BH-T1	BH-T1
Depth	------------	0	4.0-4.1m	10.10-10.25m	14.60-14.75m	22.85-23.0m
Date Sampled		17/09/2015	17/09/2015	17/09/2015	18/09/2015	18/09/2015
Type of sample		Soil	Soil	Soil	Soil	Soil
Envirolab ID		see attached	see attached	see attached	see attached	see attached

External Testing				
Our Reference:	UNITS	171259-6	171259-7	171259-8
Your Reference	-------------	BH-T2	BH-T2	BH-T2
Depth	------------	0	3.5-3.6m	7.85-8.0m
Date Sampled		19/08/2015	20/09/2015	20/09/2015
Type of sample		Soil	Soil	Soil
Envirolab ID		see attached	see attached	see attached

Chromium Suite Our Reference: Your Reference Depth Date Sampled Type of sample	UNITS ------------- ------------	171259-1 BH-T1 0 17/09/2015 Soil	171259-2 BH-T1 4.0-4.1m 17/09/2015 Soil	171259-3 BH-T1 10.10-10.25m 17/09/2015 Soil	171259-4 BH-T1 14.60-14.75m 18/09/2015 Soil	171259-5 BH-T1 22.85-23.0m 18/09/2015 Soil
Date analysed	-	25/09/2015	25/09/2015	25/09/2015	25/09/2015	25/09/2015
pH_{kcl}	pH units	9.8	8.7	7.0	9.2	7.4
TAA	moles H^+/t	<5	<5	<5	<5	<5
S_{KCl}	%w/w S	<0.005	<0.005	<0.005	<0.005	<0.005
Chromium Reducible Sulfur	%w/w	<0.005	<0.005	<0.005	<0.005	<0.005
ANC_{BT}	% $CaCO_3$	4.2	2.8	0.50	54	0.65
S_{HCl}	%w/w S	NT	NT	NT	NT	NT
s-TAA	%w/w S	<0.01	<0.01	<0.01	<0.01	<0.01
a-Chromium Reducible Sulfur	moles H^+/t	<5.0	<5.0	<5.0	<5.0	<5.0
a-ANC_{BT}	moles H^+/t	840	554	101	10,864	130
s-ANC_{BT}	%w/w S	1.3	0.89	0.16	17	0.21
Fineness Factor		2	2	2	2	2
S_{NAS}	%w/w S	NT	NT	NT	NT	NT
a-S_{NAS}	moles H^+/t	NT	NT	NT	NT	NT
s-S_{NAS}	%w/w S	NT	NT	NT	NT	NT
s-Net Acidity	%w/w S	<0.005	<0.005	<0.005	<0.005	<0.005
a-Net Acidity	moles H^+/t	-558	-369	-67	-7,243	-86
Liming rate	kg $CaCO_3$/t	<0.75	<0.75	<0.75	<0.75	<0.75
s-Net Acidity without ANCE	% w/w S	<0.005	<0.005	<0.005	<0.005	<0.005
a-Net Acidity without ANCE	moles H^+/t	<10	<10	<10	<10	<10
Liming rate without ANCE	kg $CaCO_3$/t	<0.75	<0.75	<0.75	<0.75	<0.75

Chromium Suite				
Our Reference:	UNITS	171259-6	171259-7	171259-8
Your Reference	-------------	BH-T2	BH-T2	BH-T2
Depth	------------	0	3.5-3.6m	7.85-8.0m
Date Sampled		19/08/2015	20/09/2015	20/09/2015
Type of sample		Soil	Soil	Soil
Date analysed	-	25/09/2015	25/09/2015	25/09/2015
pH_{kcl}	pH units	9.2	9.0	8.7
TAA	moles H^+/t	<5	<5	<5
S_{KCl}	%w/w S	<0.005	<0.005	<0.005
Chromium Reducible Sulfur	%w/w	0.050	<0.005	<0.005
ANC_{BT}	% $CaCO_3$	11	1.7	6.8
S_{HCl}	%w/w S	NT	NT	NT
s-TAA	%w/w S	<0.01	<0.01	<0.01
a-Chromium Reducible Sulfur	moles H^+/t	31	<5.0	<5.0
a-ANC_{BT}	moles H^+/t	2,102	347	1,367
s-ANC_{BT}	%w/w S	3.4	0.56	2.2
Fineness Factor		2	2	2
S_{NAS}	%w/w S	NT	NT	NT
a-S_{NAS}	moles H^+/t	NT	NT	NT
s-S_{NAS}	%w/w S	NT	NT	NT
s-Net Acidity	%w/w S	<0.005	<0.005	<0.005
a-Net Acidity	moles H^+/t	-1,370	-231	-910
Liming rate	kg $CaCO_3$/t	<0.75	<0.75	<0.75
s-Net Acidity without ANCE	% w/w S	0.050	<0.005	<0.005
a-Net Acidity without ANCE	moles H^+/t	31	<10	<10
Liming rate without ANCE	kg $CaCO_3$/t	2.3	<0.75	<0.75

sPOCAS						
Our Reference:	UNITS	171259-1	171259-2	171259-3	171259-4	171259-5
Your Reference	-------------	BH-T1	BH-T1	BH-T1	BH-T1	BH-T1
Depth	------------	0	4.0-4.1m	10.10-10.25m	14.60-14.75m	22.85-23.0m
Date Sampled		17/09/2015	17/09/2015	17/09/2015	18/09/2015	18/09/2015
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	22/09/2015	22/09/2015	22/09/2015	22/09/2015	22/09/2015
Date analysed	-	25/09/2015	25/09/2015	25/09/2015	25/09/2015	25/09/2015
pH_{Ox}	pH units	8.4	8.0	7.3	8.3	7.4
TPA	moles H^+/t	<5.0	<5.0	<5.0	<5.0	<5.0
$a\text{-}ANC_E$	moles H^+/t	780	350	57	11,000	100
ANC_E	% $CaCO_3$	3.9	1.8	0.3	55	0.52
$s\text{-}ANC_E$	%w/w S	1.3	0.57	0.092	18	0.17

sPOCAS				
Our Reference:	UNITS	171259-6	171259-7	171259-8
Your Reference	-------------	BH-T2	BH-T2	BH-T2
Depth	------------	0	3.5-3.6m	7.85-8.0m
Date Sampled		19/08/2015	20/09/2015	20/09/2015
Type of sample		Soil	Soil	Soil
Date prepared	-	22/09/2015	22/09/2015	22/09/2015
Date analysed	-	25/09/2015	25/09/2015	25/09/2015
pH_{Ox}	pH units	8.3	8.0	8.2
TPA	moles H^+/t	<5.0	<5.0	<5.0
$a\text{-}ANC_E$	moles H^+/t	2,100	300	1,300
ANC_E	% $CaCO_3$	10	1.5	6.4
$s\text{-}ANC_E$	%w/w S	3.3	0.48	2.1

Method ID	Methodology Summary
Metals-022	Determination of various metals by ICP-MS.
Metals-021	Determination of Mercury by Cold Vapour AAS.
INORG-008	Moisture content determined by heating at 105 deg C for a minimum of 12 hours.
Ext-054	Analysed by Envirolab Services Sydney, accreditation number 2901
INORG-064	Suspension Peroxide Oxidation Combined Acidity and Sulphate (SPOCAS) using ASSMAC guidelines.
INORG-068	Chromium Reducible Sulfur - Hydrogen Sulfide is quantified by iodometric titration after distillation to determine potential acidity. Based on Acid Sulfate Soils Laboratory Methods Guidelines, Version 2.1 - June 2004.

QUALITY CONTROL Metals - soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date digested	-			25/09/2015	171259-3	25/09/2015 || 25/09/2015	LCS-1	25/09/2015
Date analysed	-			29/09/2015	171259-3	29/09/2015 || 29/09/2015	LCS-1	29/09/2015
Arsenic	mg/kg	0.5	Metals-022	<0.5	171259-3	2.8 || 4.3 || RPD: 42	LCS-1	115%
Cadmium	mg/kg	0.1	Metals-022	<0.1	171259-3	<0.1 || <0.1	LCS-1	107%
Chromium	mg/kg	0.5	Metals-022	<0.5	171259-3	45 || 55 || RPD: 20	LCS-1	117%
Copper	mg/kg	0.5	Metals-022	<0.5	171259-3	7.4 || 9.3 || RPD: 23	LCS-1	117%
Mercury	mg/kg	0.01	Metals-021	<0.01	171259-3	<0.01 || <0.01	LCS-1	103%
Lead	mg/kg	0.5	Metals-022	<0.5	171259-3	5.7 || 4.0 || RPD: 35	LCS-1	113%
Nickel	mg/kg	0.5	Metals-022	<0.5	171259-3	23 || 26 || RPD: 12	LCS-1	115%
Silver	mg/kg	0.1	Metals-022	<0.1	171259-3	<0.1 || 0.2	LCS-1	107%
Zinc	mg/kg	0.5	Metals-022	<0.5	171259-3	7.1 || 7.5 || RPD: 5	LCS-1	128%

QUALITY CONTROL Moisture	UNITS	PQL	METHOD	Blank
Date prepared	-			25/09/2015
Date analysed	-			29/09/2015
Moisture	%	0.1	INORG-008	<0.10

QUALITY CONTROL External Testing	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD
Envirolab ID			Ext-054	[NT]	171259-1	see attached || see attached

QUALITY CONTROL Chromium Suite	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date analysed	-			25/09/2015	171259-1	25/09/2015 || 25/09/2015	LCS	25/09/2015
pH_{kcl}	pH units		INORG-064	[NT]	171259-1	9.8 || 9.8 || RPD: 0	LCS	103%
TAA	moles H^+/t	5	INORG-064	<5	171259-1	<5 || <5	LCS	101%
S_{KCl}	%w/w S	0.005	INORG-064	<0.005	171259-1	<0.005 || <0.005	[NR]	[NR]
Chromium Reducible Sulfur	%w/w	0.005	INORG-068	<0.005	171259-1	<0.005 || <0.005	LCS	96%
ANC_{BT}	% $CaCO_3$	0.05	INORG-068	<0.05	171259-1	4.2 || 4.3 || RPD: 2	LCS	99%
S_{HCl}	%w/w S	0.005	INORG-068	<0.005	171259-1	NT || NT	[NR]	[NR]
s-TAA	%w/w S	0.01	INORG-068	<0.01	171259-1	<0.01 || <0.01	[NR]	[NR]
a-Chromium Reducible Sulfur	moles H^+/t	5	INORG-068	<5.0	171259-1	<5.0 || <5.0	[NR]	[NR]
a-ANC_{BT}	moles H^+/t	0.05	INORG-068	<0.05	171259-1	840 || 855 || RPD: 2	LCS	99%

QUALITY CONTROL Chromium Suite	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
s-ANC_{BT}	%w/w S	0.05	INORG-068	<0.05	171259-1	1.3 || 1.4 || RPD: 7	LCS	99%
Fineness Factor			INORG-064	[NT]	171259-1	2 || 2 || RPD: 0	[NR]	[NR]
S_{NAS}	%w/w S	0.005	INORG-068	<0.005	171259-1	NT || NT	[NR]	[NR]
a-S_{NAS}	moles H^+/t	5	INORG-064	<5	171259-1	NT || NT	[NR]	[NR]
s-S_{NAS}	%w/w S	0.01	INORG-064	<0.01	171259-1	NT || NT	[NR]	[NR]
s-Net Acidity	%w/w S	0.005	INORG-064	<0.005	171259-1	<0.005 || <0.005	[NR]	[NR]
a-Net Acidity	moles H^+/t		INORG-064	[NT]	171259-1	-558 || -568 || RPD: -2	[NR]	[NR]
Liming rate	kg $CaCO_3$/t	0.75	INORG-068	<0.75	171259-1	<0.75 || <0.75	[NR]	[NR]
s-Net Acidity without ANCE	% w/w S	0.005	INORG-064	<0.005	171259-1	<0.005 || <0.005	[NR]	[NR]
a-Net Acidity without ANCE	moles H^+/t	10	INORG-064	<10	171259-1	<10 || <10	[NR]	[NR]
Liming rate without ANCE	kg $CaCO_3$/t	0.75	INORG-064	<0.75	171259-1	<0.75 || <0.75	[NR]	[NR]

QUALITY CONTROL sPOCAS	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			22/09/2015	171259-1	22/09/2015 || 22/09/2015	LCS	22/09/2015
Date analysed	-			25/09/2015	171259-1	25/09/2015 || 25/09/2015	LCS	25/09/2015
pH_{Ox}	pH units		INORG-064	[NT]	171259-1	8.4 || 8.4 || RPD: 0	LCS	101%
TPA	moles H^+/t	5	INORG-064	<5.0	171259-1	<5.0 || <5.0	LCS	95%
a-ANC_E	moles H^+/t	5	INORG-064	<5	171259-1	780 || 800 || RPD: 3	[NR]	[NR]
ANC_E	% $CaCO_3$	0.05	INORG-064	<0.05	171259-1	3.9 || 4.0 || RPD: 3	[NR]	[NR]
s-ANC_E	%w/w S	0.005	INORG-064	<0.005	171259-1	1.3 || 1.3 || RPD: 0	[NR]	[NR]

Report Comments:

Percent recovery not available due to the analyte signal being much greater than the spike amount. An acceptable recovery was achieved for the LCS.

AVS and SEM ICPMS metals analysed by Envirolab Sydney report 134824. See attached report for results.

Asbestos Signatories:

Asbestos was analysed by Approved Identifier: Not applicable for this job
Airborne fibres were analysed by Approved Counter: Not applicable for this job

Definitions:

NT: Not tested NA: Test not required INS: Insufficient sample for this test PQL: Practical Quantitation Limit
<: Less than >: Greater than RPD: Relative Percent Difference LCS: Laboratory Control Sample
NS: Not Specified NEPM: National Environmental Protection Measure

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011

Quality Control Definitions

Blank: This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate: This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike : A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample) : This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike: Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.
Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.
Spikes for Physical and Aggregate Tests are not applicable.
For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.
Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EP1514383**	Page	: 1 of 4
Client	: **WORLEY PARSONS - INFRASTRUCTURE MWE**	Laboratory	: Environmental Division Perth
Contact	: PETER SHIPLEY	Contact	: Customer Services EP
Address	: QV1 Building Lvl 7 250 St Georges Tce PERTH WA, AUSTRALIA 6000	Address	: 10 Hod Way Malaga WA Australia 6090
E-mail	: peter.shipley@worleyparsons.com	E-mail	: ALSEnviro.Perth@alsglobal.com
Telephone	: 08 9278 8111	Telephone	: +61-8-9209 7655
Facsimile	: ----	Facsimile	: +61-8-9209 7600
Project	: 201320-08242 Tug Haven	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Order number	: 201320-08242-G0004	Date Samples Received	: 01-Oct-2015 10:00
C-O-C number	: ----	Date Analysis Commenced	: 01-Oct-2015
Sampler	: ANDREW LARSEN	Issue Date	: 13-Oct-2015 14:30
Site	: ----		
		No. of samples received	: 5
Quote number	: ----	No. of samples analysed	: 5

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA WORLD RECOGNISED ACCREDITATION

NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Canhuang Ke	Metals Instrument Chemist	Perth Inorganics
Daniel Fisher	Inorganics Analyst	Perth ASS
Daniel Fisher	Inorganics Analyst	Perth Inorganics
Jeremy Truong	Laboratory Supervisor	Perth Inorganics
Satishkumar Trivedi	Acid Sulfate Soils Supervisor	Brisbane Acid Sulphate Soils

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.

- ASS: EA033 (CRS Suite):Retained Acidity not required because pH KCl greater than or equal to 4.5
- ASS: EA033 (CRS Suite): Liming rate is calculated and reported on a dry weight basis assuming use of fine agricultural lime (CaCO3) and using a safety factor of 1.5 to allow for non-homogeneous mixing and poor reactivity of lime. For conversion of Liming Rate from 'kg/t dry weight' to 'kg/m3 in-situ soil', multiply 'reported results' x 'wet bulk density of soil in t/m3'.
- ASS: EA029 (SPOCAS): Liming rate is calculated and reported on a dry weight basis assuming use of fine agricultural lime (CaCO3) and using a safety factor of 1.5 to allow for non-homogeneous mixing and poor reactivity of lime. For conversion of Liming Rate from kg/t dry weight to kg/m3 in-situ soil, multiply reported results x wet bulk density of soil in t/m3.

Work Order : EP1514383
Client : WORLEY PARSONS - INFRASTRUCTURE MWE
Project : 201320-08242 Tug Haven

Analytical Results

Sub-Matrix: SOIL
(Matrix: SOIL)

Client sample ID				Trip 1	BH-T2 15.10-15.25m	BH-T3 26.85-27.0m	BH-T4 13.8-14.0m	BH-T4 16.50-16.70m
Client sampling date / time				[01-Oct-2015]	[29-Sep-2015]	[24-Sep-2015]	[26-Sep-2015]	[29-Sep-2015]
Compound	CAS Number	LOR	Unit	EP1514383-001	EP1514383-002	EP1514383-003	EP1514383-004	EP1514383-005
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	----	8.1	7.2	7.3	7.7
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	----	5770	3940	2310	4540
EA029-A: pH Measurements								
pH OX (23B)	----	0.1	pH Unit	7.7	----	----	----	----
EA029-B: Acidity Trail								
Titratable Peroxide Acidity (23G)	----	2	mole H+ / t	<2	----	----	----	----
EA029-F: Excess Acid Neutralising Capacity								
Excess Acid Neutralising Capacity (23Q)	----	0.02	% CaCO3	0.675	----	----	----	----
acidity - Excess Acid Neutralising Capacity (a-23Q)	----	10	mole H+ / t	135	----	----	----	----
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	8.2	----	----	----	----
Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	----	----	----	----
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	----	----	----	----
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)	----	0.005	% S	<0.005	----	----	----	----
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	----	----	----	----
EA033-C: Acid Neutralising Capacity								
Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	0.64	----	----	----	----
acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	129	----	----	----	----
sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	0.21	----	----	----	----
EA033-E: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	1.5	----	----	----	----
Net Acidity (sulfur units)	----	0.02	% S	<0.02	----	----	----	----
Net Acidity (acidity units)	----	10	mole H+ / t	<10	----	----	----	----
Liming Rate	----	1	kg CaCO3/t	<1	----	----	----	----
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	<0.02	----	----	----	----
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	<10	----	----	----	----
Liming Rate excluding ANC	----	1	kg CaCO3/t	<1	----	----	----	----
EA038: Acid Volatlile Sulfur								

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Trip 1	BH-T2 15.10-15.25m	BH-T3 26.85-27.0m	BH-T4 13.8-14.0m	BH-T4 16.50-16.70m
			Client sampling date / time	[01-Oct-2015]	[29-Sep-2015]	[24-Sep-2015]	[26-Sep-2015]	[29-Sep-2015]
Compound	CAS Number	LOR	Unit	EP1514383-001	EP1514383-002	EP1514383-003	EP1514383-004	EP1514383-005
				Result	Result	Result	Result	Result
EA038: Acid Volatlile Sulfur - Continued								
Acid Volatile Sulfur	----	0.001	%	<0.001	----	----	----	----
EA055: Moisture Content								
^ Moisture Content (dried @ 103°C)	----	1	%	**10.1**	**28.8**	**13.5**	**12.0**	**22.3**
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	----	**1890**	**970**	**590**	**1480**
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	----	**11400**	**6400**	**3720**	**8040**
EG005T: Total Metals by ICP-AES								
Arsenic	7440-38-2	5	mg/kg	<5	----	----	----	----
Cadmium	7440-43-9	1	mg/kg	<1	----	----	----	----
Chromium	7440-47-3	2	mg/kg	**61**	----	----	----	----
Copper	7440-50-8	5	mg/kg	**17**	----	----	----	----
Lead	7439-92-1	5	mg/kg	**8**	----	----	----	----
Nickel	7440-02-0	2	mg/kg	**33**	----	----	----	----
Zinc	7440-66-6	5	mg/kg	**11**	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	----	----	----	----

Environmental

QUALITY CONTROL REPORT

Work Order	: **EP1514383**	Page	: 1 of 6
Client	: **WORLEY PARSONS - INFRASTRUCTURE MWE**	Laboratory	: Environmental Division Perth
Contact	: PETER SHIPLEY	Contact	: Customer Services EP
Address	: QV1 Building Lvl 7 250 St Georges Tce PERTH WA, AUSTRALIA 6000	Address	: 10 Hod Way Malaga WA Australia 6090
E-mail	: peter.shipley@worleyparsons.com	E-mail	: ALSEnviro.Perth@alsglobal.com
Telephone	: 08 9278 8111	Telephone	: +61-8-9209 7655
Facsimile	: ----	Facsimile	: +61-8-9209 7600
Project	: 201320-08242 Tug Haven	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Order number	: 201320-08242-G0004	Date Samples Received	: 01-Oct-2015
C-O-C number	: ----	Date Analysis Commenced	: 01-Oct-2015
Sampler	: ANDREW LARSEN	Issue Date	: 13-Oct-2015
Site	: ----	No. of samples received	: 5
Quote number	: ----	No. of samples analysed	: 5

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

NATA

WORLD RECOGNISED ACCREDITATION

NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Canhuang Ke	Metals Instrument Chemist	Perth Inorganics
Daniel Fisher	Inorganics Analyst	Perth ASS
Daniel Fisher	Inorganics Analyst	Perth Inorganics
Jeremy Truong	Laboratory Supervisor	Perth Inorganics
Satishkumar Trivedi	Acid Sulfate Soils Supervisor	Brisbane Acid Sulphate Soils

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to high

Key :
- Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
- CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
- LOR = Limit of reporting
- RPD = Relative Percentage Difference
- # = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR:- 0% - 50%; Result > 20 times LOR:0% - 20%.

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EA002 : pH (Soils) (QC Lot: 232090)									
EP1514383-002	BH-T2 15.10-15.25m	EA002: pH Value	----	0.1	pH Unit	8.1	8.1	0.00	0% - 20%
EA010: Conductivity (QC Lot: 232092)									
EP1514383-002	BH-T2 15.10-15.25m	EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	5770	5680	1.52	0% - 20%
EA029-A: pH Measurements (QC Lot: 233107)									
EP1514383-001	Trip 1	EA029-TPA: pH OX (23B)	----	0.1	pH Unit	7.7	7.8	0.00	0% - 20%
EA029-B: Acidity Trail (QC Lot: 233107)									
EP1514383-001	Trip 1	EA029-TPA: Titratable Peroxide Acidity (23G)	----	2	mole H+ / t	<2	<2	0.00	No Limit
EA029-F: Excess Acid Neutralising Capacity (QC Lot: 233108)									
EP1514383-001	Trip 1	EA029: Excess Acid Neutralising Capacity (23Q)	----	0.02	% CaCO3	0.675	0.678	0.448	0% - 20%
		EA029: acidity - Excess Acid Neutralising Capacity (a-23Q)	----	10	mole H+ / t	135	135	0.00	0% - 50%
EA033-A: Actual Acidity (QC Lot: 233106)									
EP1514383-001	Trip 1	EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	0.00	No Limit
		EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	0.00	No Limit
		EA033: pH KCl (23A)	----	0.1	pH Unit	8.2	8.2	0.00	0% - 20%
EA033-B: Potential Acidity (QC Lot: 233106)									
EP1514383-001	Trip 1	EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	<0.005	<0.005	0.00	No Limit
		EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	<10	0.00	No Limit
EA033-C: Acid Neutralising Capacity (QC Lot: 233106)									
EP1514383-001	Trip 1	EA033: Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	0.64	0.67	4.58	0% - 20%
		EA033: sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	0.21	0.21	0.00	0% - 20%
		EA033: acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	129	134	3.57	0% - 50%
EA033-E: Acid Base Accounting (QC Lot: 233106)									
EP1514383-001	Trip 1	EA033: Net Acidity (sulfur units)	----	0.02	% S	<0.02	<0.02	0.00	No Limit
		EA033: Net Acidity excluding ANC (sulfur units)	----	0.02	% S	<0.02	<0.02	0.00	No Limit
		EA033: Liming Rate	----	1	kg CaCO3/t	<1	<1	0.00	No Limit
		EA033: Liming Rate excluding ANC	----	1	kg CaCO3/t	<1	<1	0.00	No Limit
		EA033: Net Acidity (acidity units)	----	10	mole H+ / t	<10	<10	0.00	No Limit
		EA033: Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	<10	<10	0.00	No Limit
EA038: Acid Volatlile Sulfur (QC Lot: 239919)									
EP1514383-001	Trip 1	EA038: Acid Volatile Sulfur	----	0.001	%	<0.001	<0.001	0.00	No Limit

Sub-Matrix: **SOIL**

Laboratory Duplicate (DUP) Report

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EA055: Moisture Content (QC Lot: 232893)									
EP1514383-001	Trip 1	EA055-103: Moisture Content (dried @ 103°C)	----	1	%	10.1	10.4	2.99	0% - 50%
ED040S: Soluble Major Anions (QC Lot: 232091)									
EP1514383-002	BH-T2 15.10-15.25m	ED040S: Sulfate as SO4 2-	14808-79-8	10	mg/kg	1890	1860	1.60	0% - 20%
ED045G: Chloride by Discrete Analyser (QC Lot: 232093)									
EP1514383-002	BH-T2 15.10-15.25m	ED045G: Chloride	16887-00-6	10	mg/kg	11400	11400	0.942	0% - 20%
EG005T: Total Metals by ICP-AES (QC Lot: 233791)									
EP1514379-013	Anonymous	EG005T: Cadmium	7440-43-9	1	mg/kg	<1	<1	0.00	No Limit
		EG005T: Chromium	7440-47-3	2	mg/kg	9	9	0.00	No Limit
		EG005T: Nickel	7440-02-0	2	mg/kg	<2	<2	0.00	No Limit
		EG005T: Arsenic	7440-38-2	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Copper	7440-50-8	5	mg/kg	11	14	25.3	No Limit
		EG005T: Lead	7439-92-1	5	mg/kg	100	94	5.56	0% - 50%
		EG005T: Zinc	7440-66-6	5	mg/kg	99	91	8.13	0% - 50%
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 233789)									
EP1514354-001	Anonymous	EG035T: Mercury	7439-97-6	0.1	mg/kg	0.2	0.2	0.00	No Limit
EP1514354-055	Anonymous	EG035T: Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	0.00	No Limit

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **SOIL**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EA002 : pH (Soils) (QCLot: 232090)								
EA002: pH Value	----	----	pH Unit	----	4 pH Unit	99.8	70	130
				----	7 pH Unit	100	70	130
EA010: Conductivity (QCLot: 232092)								
EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	<1	4000 µS/cm	98.9	94	106
EA029-B: Acidity Trail (QCLot: 233107)								
EA029-TPA: Titratable Peroxide Acidity (23G)	----	2	mole H+ / t	<2	----	----	----	----
EA033-A: Actual Acidity (QCLot: 233106)								
EA033: pH KCl (23A)	----	0.1	pH Unit	<0.1	----	----	----	----
EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	----	----	----	----
EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	73.0756 mole H+ / t	93.9	79	103
EA033-B: Potential Acidity (QCLot: 233106)								
EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	----	----	----	----
EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	<0.005	0.1798 % S	83.4	77	117
EA033-C: Acid Neutralising Capacity (QCLot: 233106)								
EA033: Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	<0.01	4.9 % CaCO3	103	95	109
EA033: acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	<10	----	----	----	----
EA033: sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	<0.01	----	----	----	----
EA033-E: Acid Base Accounting (QCLot: 233106)								
EA033: Liming Rate	----	1	kg CaCO3/t	<1	----	----	----	----
EA033: Net Acidity (acidity units)	----	10	mole H+ / t	<10	----	----	----	----
EA033: Net Acidity (sulfur units)	----	0.02	% S	<0.02	----	----	----	----
EA038: Acid Volatlile Sulfur (QCLot: 239919)								
EA038: Acid Volatile Sulfur	----	0.001	%	<0.001	0.17 %	95.8	87	97
ED040S: Soluble Major Anions (QCLot: 232091)								
ED040S: Sulfate as SO4 2-	14808-79-8	10	mg/kg	<10	250 mg/kg	97.4	86	116
ED045G: Chloride by Discrete Analyser (QCLot: 232093)								
ED045G: Chloride	16887-00-6	10	mg/kg	<10	50 mg/kg	102	82	126
				<10	5000 mg/kg	96.2	82	126
EG005T: Total Metals by ICP-AES (QCLot: 233791)								
EG005T: Arsenic	7440-38-2	5	mg/kg	<5	22 mg/kg	108	86	116
EG005T: Cadmium	7440-43-9	1	mg/kg	<1	5 mg/kg	105	82	112
EG005T: Chromium	7440-47-3	2	mg/kg	<2	34 mg/kg	110	90	112
EG005T: Copper	7440-50-8	5	mg/kg	<5	34 mg/kg	95.3	93	115

Sub-Matrix: **SOIL**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report Result	Laboratory Control Spike (LCS) Report Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High
EG005T: Total Metals by ICP-AES (QCLot: 233791) - continued								
EG005T: Lead	7439-92-1	5	mg/kg	<5	40 mg/kg	105	89	111
EG005T: Nickel	7440-02-0	2	mg/kg	<2	51 mg/kg	114	91	115
EG005T: Zinc	7440-66-6	5	mg/kg	<5	62 mg/kg	112	87	113
EG035T: Total Recoverable Mercury by FIMS (QCLot: 233789)								
EG035T: Mercury	7439-97-6	0.1	mg/kg	<0.1	2.154 mg/kg	101	81	115

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **SOIL**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report Spike Concentration	SpikeRecovery(%) MS	Recovery Limits (%) Low	Recovery Limits (%) High
ED045G: Chloride by Discrete Analyser (QCLot: 232093)							
EP1514383-003	BH-T3 26.85-27.0m	ED045G: Chloride	16887-00-6	1250 mg/kg	89.6	70	130
EG005T: Total Metals by ICP-AES (QCLot: 233791)							
EP1514379-013	Anonymous	EG005T: Arsenic	7440-38-2	50 mg/kg	102	70	130
		EG005T: Cadmium	7440-43-9	50 mg/kg	111	70	130
		EG005T: Chromium	7440-47-3	50 mg/kg	103	70	130
		EG005T: Copper	7440-50-8	50 mg/kg	111	70	130
		EG005T: Lead	7439-92-1	50 mg/kg	115	70	130
		EG005T: Nickel	7440-02-0	50 mg/kg	110	70	130
		EG005T: Zinc	7440-66-6	50 mg/kg	106	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 233789)							
EP1514354-001	Anonymous	EG035T: Mercury	7439-97-6	10 mg/kg	100	70	130

ALS Environmental

QA/QC Compliance Assessment for DQO Reporting

Work Order	: **EP1514383**	Page	: 1 of 8
Client	: **WORLEY PARSONS - INFRASTRUCTURE MWE**	Laboratory	: Environmental Division Perth
Contact	: PETER SHIPLEY	Telephone	: +61-8-9209 7655
Project	: 201320-08242 Tug Haven	Date Samples Received	: 01-Oct-2015
Site	: ----	Issue Date	: 13-Oct-2015
Sampler	: ANDREW LARSEN	No. of samples received	: 5
Order number	: 201320-08242-G0004	No. of samples analysed	: 5

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO Method Blank value outliers occur.**
- **NO Duplicate outliers occur.**
- **NO Laboratory Control outliers occur.**
- **NO Matrix Spike outliers occur.**
- **For all regular sample matrices, NO surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

- **Analysis Holding Time Outliers exist - please see following pages for full details.**

Outliers : Frequency of Quality Control Samples

- **Quality Control Sample Frequency Outliers exist - please see following pages for full details.**

Outliers : Analysis Holding Time Compliance

Matrix: **SOIL**

Method	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)	Date extracted	Due for extraction	Days overdue	Date analysed	Due for analysis	Days overdue
EA002 : pH (Soils)						
Soil Glass Jar - Unpreserved						
BH-T3 - 26.85-27.0m	02-Oct-2015	01-Oct-2015	**1**	----	----	----
EA010: Conductivity						
Soil Glass Jar - Unpreserved						
BH-T3 - 26.85-27.0m	02-Oct-2015	01-Oct-2015	**1**	----	----	----
EA038: Acid Volatlile Sulfur						
Snap Lock Bag						
Trip 1	----	----	----	12-Oct-2015	02-Oct-2015	**10**

Outliers : Frequency of Quality Control Samples

Matrix: **SOIL**

Quality Control Sample Type	Count		Rate (%)		Quality Control Specification
Method	QC	Regular	Actual	Expected	
Laboratory Control Samples (LCS)					
Suspension Peroxide Oxidation-Combined Acidity and Sulphate	0	1	0.00	5.00	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Method Blanks (MB)					
Suspension Peroxide Oxidation-Combined Acidity and Sulphate	0	1	0.00	5.00	NEPM 2013 Schedule B(3) and ALS QCS3 requirement

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for ***VOC in soils*** vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **SOIL**

Evaluation: ✘ = Holding time breach ; ✓ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA002 : pH (Soils)							
Soil Glass Jar - Unpreserved (EA002)							
BH-T3 - 26.85-27.0m	**24-Sep-2015**	**02-Oct-2015**	01-Oct-2015	✘	**02-Oct-2015**	02-Oct-2015	✓
Soil Glass Jar - Unpreserved (EA002)							
BH-T4 - 13.8-14.0m	**26-Sep-2015**	**02-Oct-2015**	03-Oct-2015	✓	**02-Oct-2015**	02-Oct-2015	✓
Soil Glass Jar - Unpreserved (EA002)							
BH-T2 - 15.10-15.25m, BH-T4 - 16.50-16.70m	**29-Sep-2015**	**02-Oct-2015**	06-Oct-2015	✓	**02-Oct-2015**	02-Oct-2015	✓

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / *Container / Client Sample ID(s)*	*Sample Date*	*Extraction / Preparation*			*Analysis*		
		Date extracted	*Due for extraction*	*Evaluation*	*Date analysed*	*Due for analysis*	*Evaluation*
EA010: Conductivity							
Soil Glass Jar - Unpreserved (EA010) BH-T3 - 26.85-27.0m	**24-Sep-2015**	**02-Oct-2015**	01-Oct-2015	×	**02-Oct-2015**	30-Oct-2015	✓
Soil Glass Jar - Unpreserved (EA010) BH-T4 - 13.8-14.0m	**26-Sep-2015**	**02-Oct-2015**	03-Oct-2015	✓	**02-Oct-2015**	30-Oct-2015	✓
Soil Glass Jar - Unpreserved (EA010) BH-T2 - 15.10-15.25m, BH-T4 - 16.50-16.70m	**29-Sep-2015**	**02-Oct-2015**	06-Oct-2015	✓	**02-Oct-2015**	30-Oct-2015	✓
EA029-F: Excess Acid Neutralising Capacity							
Snap Lock Bag (EA029) Trip 1	**01-Oct-2015**	**01-Oct-2015**	02-Oct-2015	✓	**08-Oct-2015**	30-Dec-2015	✓
EA029-A: pH Measurements							
Snap Lock Bag (EA029-TPA) Trip 1	**01-Oct-2015**	**01-Oct-2015**	02-Oct-2015	✓	**08-Oct-2015**	30-Dec-2015	✓
EA033-A: Actual Acidity							
Snap Lock Bag (EA033) Trip 1	**01-Oct-2015**	**01-Oct-2015**	02-Oct-2015	✓	**08-Oct-2015**	30-Dec-2015	✓
EA038: Acid Volatlile Sulfur							
Snap Lock Bag (EA038) Trip 1	**01-Oct-2015**	**----**	----	----	**12-Oct-2015**	02-Oct-2015	×
EA055: Moisture Content							
Soil Glass Jar - Unpreserved (EA055-103) Trip 1	**01-Oct-2015**	**----**	----	----	**05-Oct-2015**	15-Oct-2015	✓
Soil Glass Jar - Unpreserved (EA055-103) BH-T3 - 26.85-27.0m	**24-Sep-2015**	**----**	----	----	**05-Oct-2015**	08-Oct-2015	✓
Soil Glass Jar - Unpreserved (EA055-103) BH-T4 - 13.8-14.0m	**26-Sep-2015**	**----**	----	----	**05-Oct-2015**	10-Oct-2015	✓
Soil Glass Jar - Unpreserved (EA055-103) BH-T2 - 15.10-15.25m, BH-T4 - 16.50-16.70m	**29-Sep-2015**	**----**	----	----	**05-Oct-2015**	13-Oct-2015	✓
ED040S : Soluble Sulfate by ICPAES							
Soil Glass Jar - Unpreserved (ED040S) BH-T3 - 26.85-27.0m	**24-Sep-2015**	**02-Oct-2015**	22-Oct-2015	✓	**02-Oct-2015**	30-Oct-2015	✓
Soil Glass Jar - Unpreserved (ED040S) BH-T4 - 13.8-14.0m	**26-Sep-2015**	**02-Oct-2015**	24-Oct-2015	✓	**02-Oct-2015**	30-Oct-2015	✓
Soil Glass Jar - Unpreserved (ED040S) BH-T2 - 15.10-15.25m, BH-T4 - 16.50-16.70m	**29-Sep-2015**	**02-Oct-2015**	27-Oct-2015	✓	**02-Oct-2015**	30-Oct-2015	✓
ED045G: Chloride by Discrete Analyser							
Soil Glass Jar - Unpreserved (ED045G) BH-T3 - 26.85-27.0m	**24-Sep-2015**	**02-Oct-2015**	22-Oct-2015	✓	**02-Oct-2015**	30-Oct-2015	✓
Soil Glass Jar - Unpreserved (ED045G) BH-T4 - 13.8-14.0m	**26-Sep-2015**	**02-Oct-2015**	24-Oct-2015	✓	**02-Oct-2015**	30-Oct-2015	✓
Soil Glass Jar - Unpreserved (ED045G) BH-T2 - 15.10-15.25m, BH-T4 - 16.50-16.70m	**29-Sep-2015**	**02-Oct-2015**	27-Oct-2015	✓	**02-Oct-2015**	30-Oct-2015	✓

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EG005T: Total Metals by ICP-AES							
Soil Glass Jar - Unpreserved (EG005T)							
Trip 1	**01-Oct-2015**	**06-Oct-2015**	29-Mar-2016	✓	**07-Oct-2015**	29-Mar-2016	✓
EG035T: Total Recoverable Mercury by FIMS							
Soil Glass Jar - Unpreserved (EG035T)							
Trip 1	**01-Oct-2015**	**06-Oct-2015**	29-Oct-2015	✓	**09-Oct-2015**	29-Oct-2015	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **SOIL**

Evaluation: ✗ = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Acid Volatile Sulfur	EA038	1	1	**100.00**	**10.00**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Chloride Soluble By Discrete Analyser	ED045G	1	4	**25.00**	**10.00**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Chromium Suite for Acid Sulphate Soils	EA033	1	1	**100.00**	**10.00**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Electrical Conductivity (1:5)	EA010	1	4	**25.00**	**10.00**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Major Anions - Soluble	ED040S	1	4	**25.00**	**10.00**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Moisture Content	EA055-103	1	6	**16.67**	**10.00**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
pH (1:5)	EA002	1	4	**25.00**	**10.00**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Suspension Peroxide Oxidation-Combined Acidity and Sulphate	EA029	1	1	**100.00**	**10.00**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Suspension Peroxide Oxidation-Combined Acidity and Sulphate	EA029-TPA	1	1	**100.00**	**10.00**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Total Mercury by FIMS	EG035T	2	14	**14.29**	**10.00**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-AES	EG005T	1	10	**10.00**	**10.00**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Laboratory Control Samples (LCS)							
Acid Volatile Sulfur	EA038	1	1	**100.00**	**5.00**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Chloride Soluble By Discrete Analyser	ED045G	2	4	**50.00**	**10.00**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Chromium Suite for Acid Sulphate Soils	EA033	1	1	**100.00**	**5.00**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Electrical Conductivity (1:5)	EA010	1	4	**25.00**	**5.00**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Major Anions - Soluble	ED040S	1	4	**25.00**	**5.00**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
pH (1:5)	EA002	2	4	**50.00**	**10.00**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Suspension Peroxide Oxidation-Combined Acidity and Sulphate	EA029	0	1	**0.00**	**5.00**	✗	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Total Mercury by FIMS	EG035T	1	14	**7.14**	**5.00**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-AES	EG005T	1	10	**10.00**	**5.00**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Method Blanks (MB)							
Acid Volatile Sulfur	EA038	1	1	**100.00**	**5.00**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Chloride Soluble By Discrete Analyser	ED045G	1	4	**25.00**	**5.00**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Chromium Suite for Acid Sulphate Soils	EA033	1	1	**100.00**	**5.00**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Electrical Conductivity (1:5)	EA010	1	4	**25.00**	**5.00**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Major Anions - Soluble	ED040S	1	4	**25.00**	**5.00**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Suspension Peroxide Oxidation-Combined Acidity and Sulphate	EA029	0	1	**0.00**	**5.00**	✗	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Suspension Peroxide Oxidation-Combined Acidity and Sulphate	EA029-TPA	1	1	**100.00**	**5.00**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Total Mercury by FIMS	EG035T	1	14	**7.14**	**5.00**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-AES	EG005T	1	10	**10.00**	**5.00**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement

Matrix: **SOIL**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Matrix Spikes (MS)							
Chloride Soluble By Discrete Analyser	ED045G	1	4	**25.00**	**5.00**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Total Mercury by FIMS	EG035T	1	14	**7.14**	**5.00**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-AES	EG005T	1	10	**10.00**	**5.00**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
pH (1:5)	EA002	SOIL	In house: Referenced to APHA 4500H+. pH is determined on soil samples after a 1:5 soil/water leach. This method is compliant with NEPM (2013) Schedule B(3) (Method 103)
Electrical Conductivity (1:5)	EA010	SOIL	In house: Referenced to APHA 2510. Conductivity is determined on soil samples using a 1:5 soil/water leach. This method is compliant with NEPM (2013) Schedule B(3) (Method 104)
Suspension Peroxide Oxidation-Combined Acidity and Sulphate	EA029	SOIL	In house: Referenced to Ahern et al 2004 - a suspension peroxide oxidation method following the 'sulfur trail' by determining the level of 1M KCL extractable sulfur and the sulfur level after oxidation of soil sulphides. The 'acidity trail' is followed by measurement of TAA, TPA and TSA. Liming Rate is based on results for samples as submitted and incorporates a minimum safety factor of 1.5.
Suspension Peroxide Oxidation-Combined Acidity and Sulphate	EA029-TPA	SOIL	In house: Referenced to Ahern et al 2004 - a suspension peroxide oxidation method following the 'sulfur trail' by determining the level of 1M KCL extractable sulfur and the sulfur level after oxidation of soil sulphides. The 'acidity trail' is followed by measurement of TAA, TPA and TSA. Liming Rate is based on results for samples as submitted and incorporates a minimum safety factor of 1.5.
Chromium Suite for Acid Sulphate Soils	EA033	SOIL	In house: Referenced to Ahern et al 2004. This method covers the determination of Chromium Reducible Sulfur (SCR); pHKCl; titratable actual acidity (TAA); acid neutralising capacity by back titration (ANC); and net acid soluble sulfur (SNAS) which incorporates peroxide sulfur. It applies to soils and sediments (including sands) derived from coastal regions. Liming Rate is based on results for samples as submitted and incorporates a minimum safety factor of 1.5.
Acid Volatile Sulfur	EA038	SOIL	In house: Referenced to Sullivan et al (1998). The AVS method converts reduced inorganic Sulfur to H2S by way of a cold 12MHCl acid digest; the evolved H2S is trapped in a Zinc Acetate solution as ZnS which is quantified by iodometric titration.
Moisture Content	EA055-103	SOIL	In-house. A gravimetric procedure based on weight loss over a 12 hour drying period at 103-105 degrees C. This method is compliant with NEPM (2013) Schedule B(3) Section 7.1 and Table 1 (14 day holding time).
Major Anions - Soluble	ED040S	SOIL	In-house. Soluble Anions are determined off a 1:5 soil / water extract by ICPAES.
Chloride Soluble By Discrete Analyser	ED045G	SOIL	In house: Referenced to APHA 21st edition 4500-Cl- E. The thiocyanate ion is liberated from mercuric thiocyanate through sequestration of mercury by the chloride ion to form non-ionised mercuric chloride.in the presence of ferric ions the librated thiocynate forms highly-coloured ferric thiocynate which is measured at 480 nm. Analysis is performed on a 1:5 soil / water leachate.
Total Metals by ICP-AES	EG005T	SOIL	In house: Referenced to APHA 3120; USEPA SW 846 - 6010. Metals are determined following an appropriate acid digestion of the soil. The ICPAES technique ionises samples in a plasma, emitting a characteristic spectrum based on metals present. Intensities at selected wavelengths are compared against those of matrix matched standards. This method is compliant with NEPM (2013) Schedule B(3)
Total Mercury by FIMS	EG035T	SOIL	In house: Referenced to AS 3550, APHA 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) FIM-AAS is an automated flameless atomic absorption technique. Mercury in solids are determined following an appropriate acid digestion. Ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (2013) Schedule B(3)

Preparation Methods	*Method*	*Matrix*	*Method Descriptions*
Drying at 85 degrees, bagging and labelling (ASS)	EN020PR	SOIL	In house

Particle Size Distribution & Plasticity Index tests

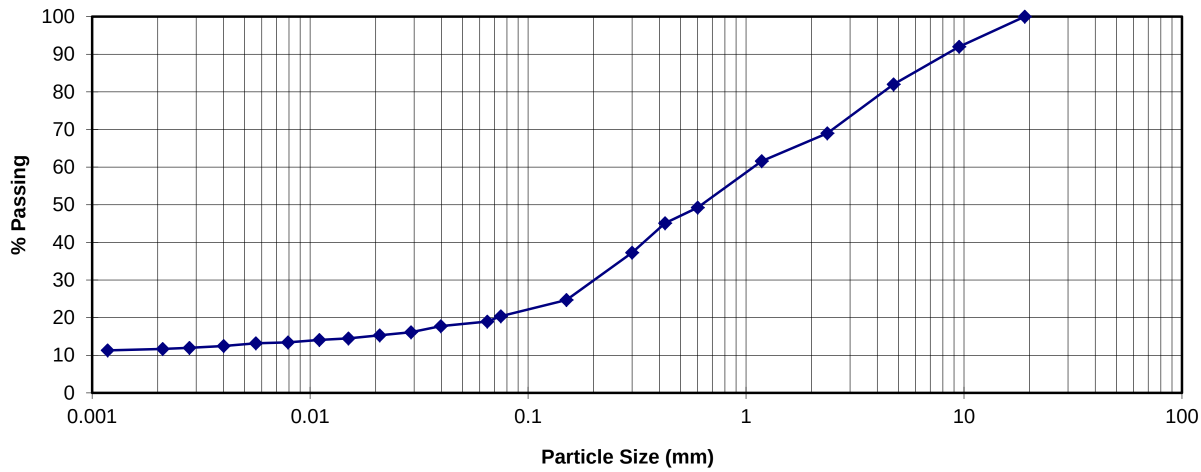
Mining & Civil Geotest Pty Ltd
unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022 Fax (08) 9414 8011
Email: kevin@mcgeotest.com.au

Job No: 60001
Report No: 60001-P15/7138
Sample No: P15/7138
Issue Date: 17 October 2015

Client: **WorleyParsons (201012-00457)**
Sample Location: **BH - T4**
Project: **FMG, Port Towage Services - Tug Infrastructure**
Sample Depth (m): **3.2 - 3.5**
Location: **Port Hedland**

Sieve Analysis	**AS 1289.3.6.1**	**Hydrometer**	**AS1289.3.6.3**
Sieve Size (mm)	% Passing	Diameter (mm)	% Passing
75.0		0.065	19
37.5		0.040	18
19.0	100	0.029	16
9.5	92	0.021	15
4.75	82	0.015	14
2.36	69	0.011	14
1.18	62	0.008	13
0.600	49	0.006	13
0.425	45	0.004	12
0.300	37	0.003	12
0.150	25	0.002	12
0.075	20	0.001	11

Plasticity index tests		
AS 1289		
Liquid limit 3.1.1	35	%
Plastic limit 3.2.1	15	%
Plasticity index 3.3.1	20	%
Linear shrinkage 3.4.1	7.0	%
Soil Particle Density		
AS 1289.3.5.1	2.66	g/cm^3
WA 915.1		
Calcium Carbonate Content	na	%



Sampling Procedure: Tested as received

Authorised signature

Kevin M Jones

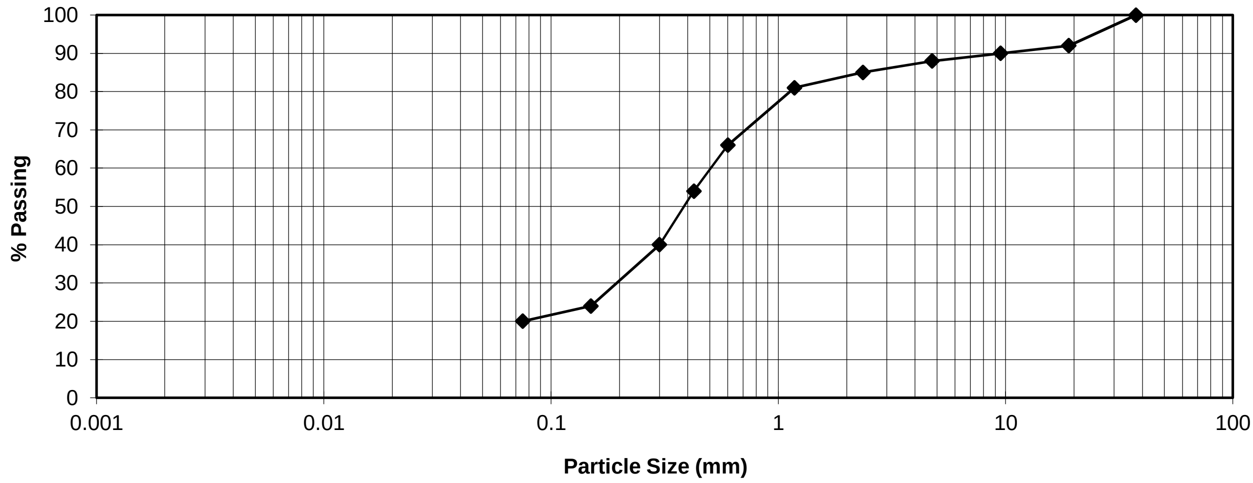
Particle Size Distribution & Plasticity Index tests

Mining & Civil Geotest Pty Ltd
unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022
Email: kevin@mcgeotest.com.au

Job No: 60001
Report No: 60001-P15/7137
Sample No: P15/7137
Issue Date: 17 October 2015

Client: WorleyParsons (201012-00457)
Project: FMG Port Towage Services - Tug Infrastructure
Location: Port Hedland

Sample location: BH - T4
Sample Depth (m): 0.0 - 0.45



SIEVE ANALYSIS AS 1289.3.6.1

Sieve Size (mm)	% Passing
75.0	
37.5	100
19.0	92
9.5	90
4.75	88
2.36	85
1.18	81
0.600	66
0.425	54
0.300	40
0.150	24
0.075	20

Plasticity index tests
AS 1289

Liquid limit 3.1.1	28	%
Plastic limit 3.2.1	14	%
Plasticity index 3.3.1	14	%
Linear shrinkage 3.4.1	6.5	%

Cracked ☐

Curled ☐

WA 915.1
Calcium Carbonate Content na %

Sampling Procedure: Tested as received

NATA WORLD RECOGNISED ACCREDITATION

Accreditation for compliance with ISO/IEC 17025.
This document may not be reproduced except in full.
Accreditation No 15545.

Approved signature

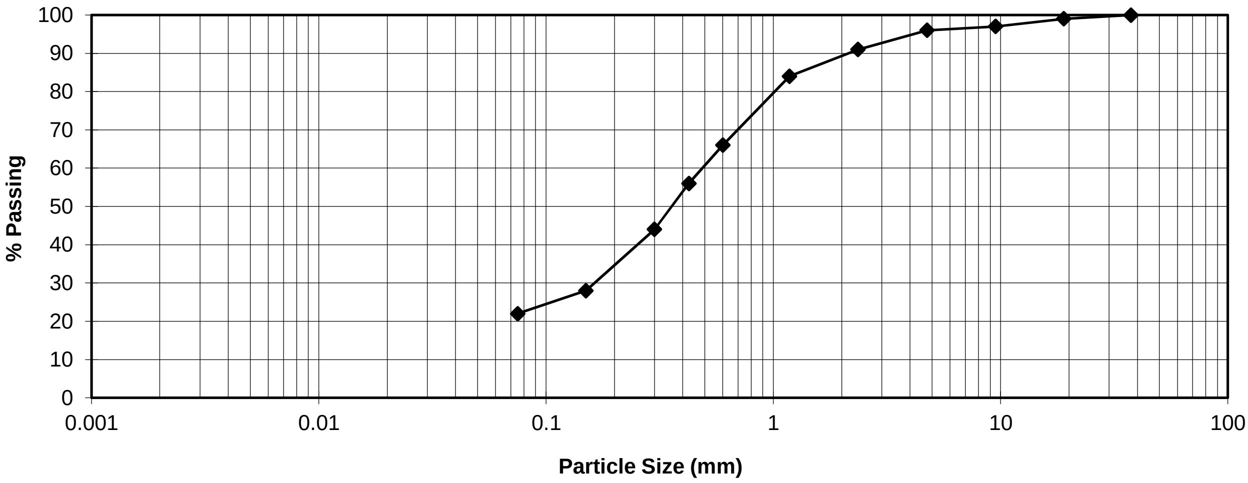
Kevin M Jones

Particle Size Distribution & Plasticity Index tests

Mining & Civil Geotest Pty Ltd
unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022
Email: kevin@mcgeotest.com.au

Job No:	60001
Report No:	60001-P15/7125
Sample No:	P15/7125
Issue Date:	17 October 2015

Client:	WorleyParsons (201012-00457)	Sample location:	BH - T3
Project:	FMG Port Towage Services - Tug Infrastructure	Sample Depth (m):	9.5 - 10.0
Location:	Port Hedland		



SIEVE ANALYSIS AS 1289.3.6.1

Sieve Size (mm)	% Passing
75.0	
37.5	100
19.0	99
9.5	97
4.75	96
2.36	91
1.18	84
0.600	66
0.425	56
0.300	44
0.150	28
0.075	22

Plasticity index tests
AS 1289

Liquid limit 3.1.1	31	%
Plastic limit 3.2.1	14	%
Plasticity index 3.3.1	17	%
Linear shrinkage 3.4.1	7.0	%
Cracked	☑	
Curled	☐	

WA 915.1

Calcium Carbonate Content	na	%

Sampling Procedure: Tested as received

Accreditation for compliance with ISO/IEC 17025.
This document may not be reproduced except in full.
Accreditation No 15545.

Approved signature

Kevin M Jones

Particle Size Distribution & Plasticity Index tests

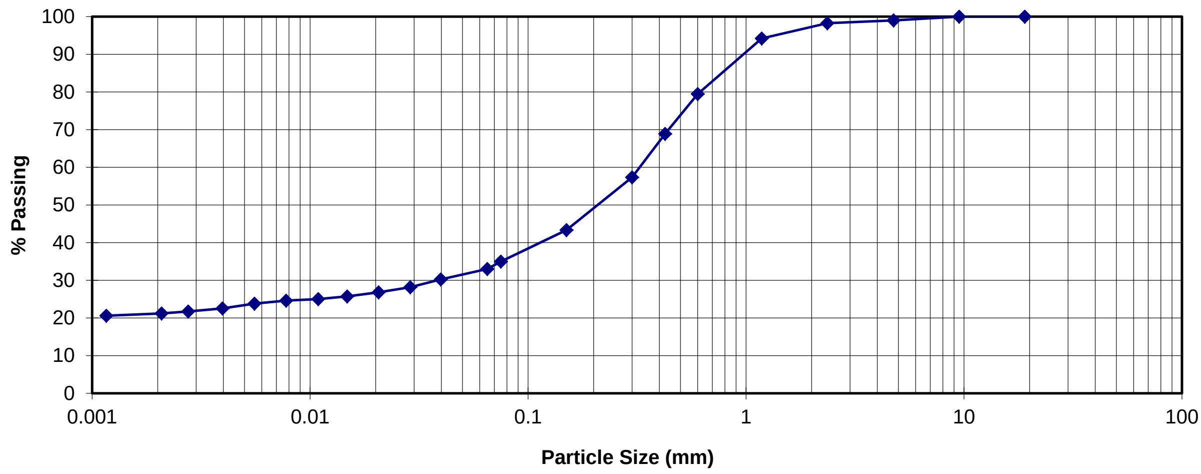
Mining & Civil Geotest Pty Ltd
unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022   Fax (08) 9414 8011
Email: kevin@mcgeotest.com.au

Job No:	**60001**
Report No:	**60001-P15/7123**
Sample No:	**P15/7123**
Issue Date:	**17 October 2015**

Client:	**WorleyParsons (201012-00457)**	Sample Location:	**BH - T3**
Project:	**FMG, Port Towage Services - Tug Infrastructure**	Sample Depth (m):	**0.45 - 0.85**
Location:	**Port Hedland**		

Sieve Analysis	**AS 1289.3.6.1**	**Hydrometer**	**AS1289.3.6.3**
Sieve Size (mm)	% Passing	Diameter (mm)	% Passing
75.0		0.065	33
37.5		0.040	30
19.0	100	0.029	28
9.5	100	0.021	27
4.75	99	0.015	26
2.36	98	0.011	25
1.18	94	0.008	25
0.600	79	0.006	24
0.425	69	0.004	23
0.300	57	0.003	22
0.150	43	0.002	21
0.075	35	0.001	21

Plasticity index tests		
AS 1289		
Liquid limit 3.1.1	38	%
Plastic limit 3.2.1	15	%
Plasticity index 3.3.1	23	%
Linear shrinkage 3.4.1	9.5	%
Soil Particle Density		
AS 1289.3.5.1	2.66	g/cm^3
WA 915.1		
Calcium Carbonate Content	na	%



Sampling Procedure: Tested as received

Authorised signature

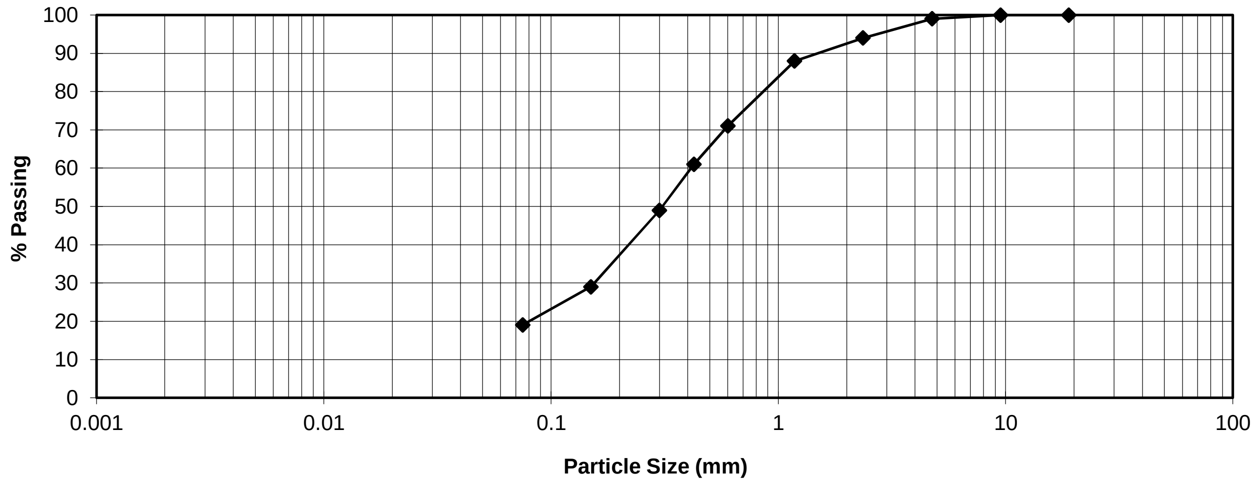
Kevin M Jones

Particle Size Distribution & Plasticity Index tests

Mining & Civil Geotest Pty Ltd
unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022
Email: kevin@mcgeotest.com.au

Job No:	60001
Report No:	60001-P15/7121
Sample No:	P15/7121
Issue Date:	17 October 2015

Client:	WorleyParsons (201012-00457)	Sample location:	BH - T2
Project:	FMG Port Towage Services - Tug Infrastructure	Sample Depth (m):	20.2 - 20.45
Location:	Port Hedland		



SIEVE ANALYSIS AS 1289.3.6.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	100
9.5	100
4.75	99
2.36	94
1.18	88
0.600	71
0.425	61
0.300	49
0.150	29
0.075	19

Plasticity index tests
AS 1289

Liquid limit 3.1.1	na	%
Plastic limit 3.2.1		%
Plasticity index 3.3.1		%
Linear shrinkage 3.4.1		%

Cracked ☐

Curled ☐

WA 915.1

Calcium Carbonate Content	na	%

Sampling Procedure: Tested as received

NATA
WORLD RECOGNISED ACCREDITATION

Accreditation for compliance with ISO/IEC 17025.
This document may not be reproduced except in full.
Accreditation No 15545.

Approved signature

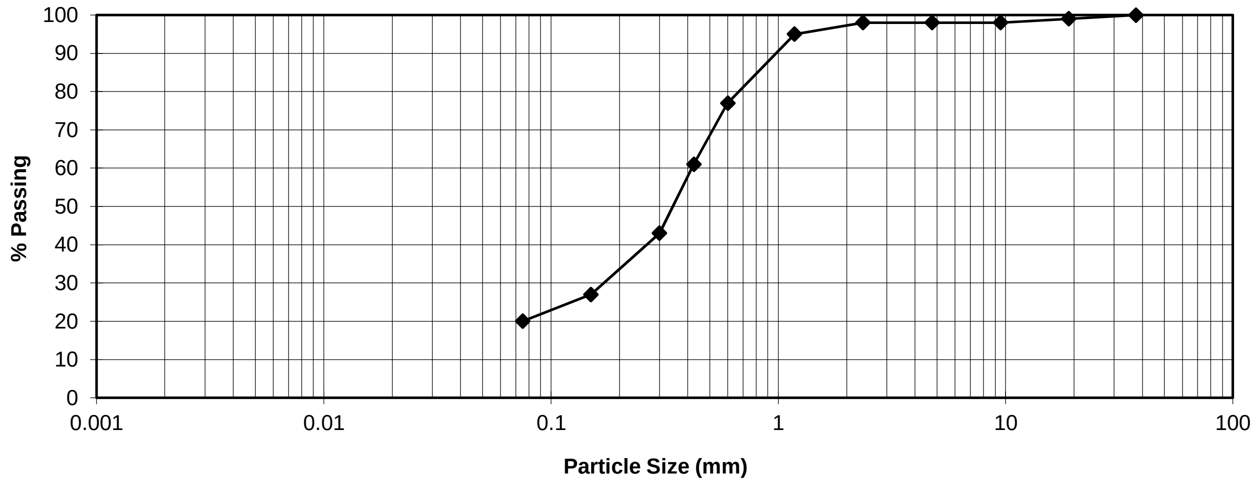
Kevin M Jones

Particle Size Distribution & Plasticity Index tests

Mining & Civil Geotest Pty Ltd
unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022
Email: kevin@mcgeotest.com.au

Job No:	60001
Report No:	60001-P15/7113
Sample No:	P15/7113
Issue Date:	17 October 2015

Client:	WorleyParsons (201012-00457)	Sample location:	BH - T2
Project:	FMG Port Towage Services - Tug Infrastructure	Sample Depth (m):	6.33 - 6.7
Location:	Port Hedland		



SIEVE ANALYSIS AS 1289.3.6.1

Sieve Size (mm)	% Passing
75.0	
37.5	100
19.0	99
9.5	98
4.75	98
2.36	98
1.18	95
0.600	77
0.425	61
0.300	43
0.150	27
0.075	20

Plasticity index tests
AS 1289

Liquid limit 3.1.1	32	%
Plastic limit 3.2.1	13	%
Plasticity index 3.3.1	19	%
Linear shrinkage 3.4.1	7.0	%

Cracked ☑

Curled ☐

WA 915.1

Calcium Carbonate Content	na	%

Sampling Procedure: Tested as received

Accreditation for compliance with ISO/IEC 17025.
This document may not be reproduced except in full.
Accreditation No 15545.

Approved signature

Kevin M Jones

Particle Size Distribution & Plasticity Index tests

Mining & Civil Geotest Pty Ltd

unit1/1 Pusey Road, Jandakot, WA 6164

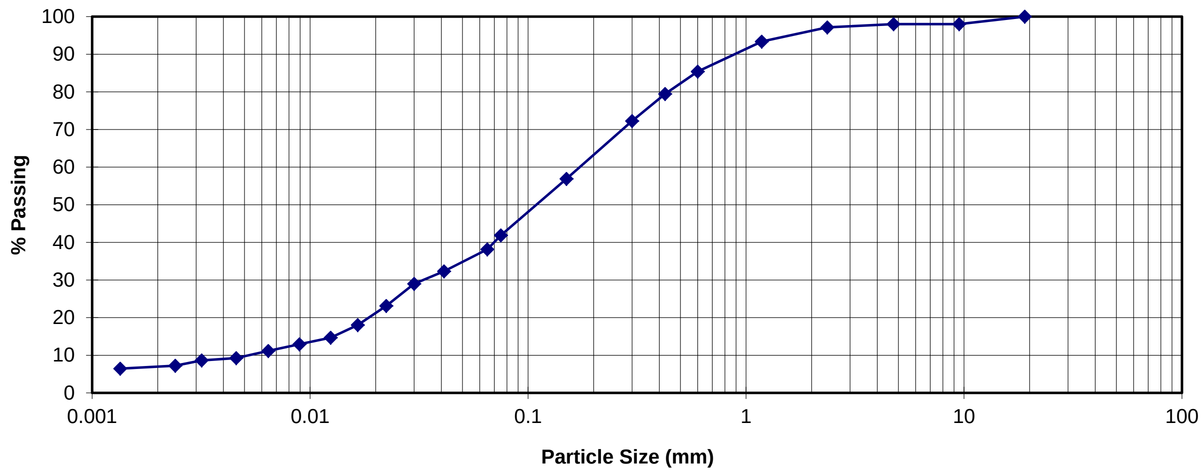
Ph (08) 9414 8022 Fax (08) 9414 8011

Email: kevin@mcgeotest.com.au

Job No:	**60001**
Report No:	**60001-P15/7112**
Sample No:	**P15/7112**
Issue Date:	**17 October 2015**

Client:	**WorleyParsons (201012-00457)**	Sample Location:	**BH - T2**
Project:	**FMG, Port Towage Services - Tug Infrastructure**	Sample Depth (m):	**3.5 - 4.0**
Location:	**Port Hedland**		

Sieve Analysis	**AS 1289.3.6.1**	**Hydrometer**	**AS1289.3.6.3**			
Sieve Size (mm)	% Passing	Diameter (mm)	% Passing			
75.0		0.065	38			
37.5		0.041	32			
19.0	100	0.030	29	**Plasticity index tests**		
9.5	98	0.022	23	**AS 1289**		
4.75	98	0.017	18	**Liquid limit 3.1.1**	40	%
2.36	97	0.012	15	**Plastic limit 3.2.1**	19	%
1.18	93	0.009	13	**Plasticity index 3.3.1**	21	%
0.600	85	0.006	11	**Linear shrinkage 3.4.1**	9.0	%
0.425	79	0.005	9			
0.300	72	0.003	9	**Soil Particle Density**		
0.150	57	0.002	7	**AS 1289.3.5.1**	2.66	g/cm^3
0.075	42	0.001	6	**WA 915.1**		
				Calcium Carbonate Content	4.8	%



Sampling Procedure: Tested as received

Authorised signature

Kevin M Jones

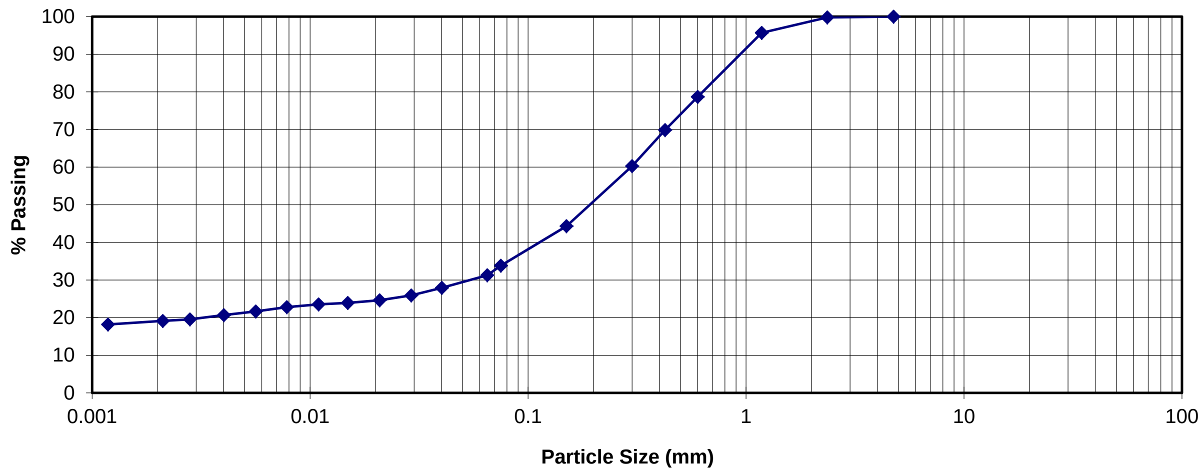
Particle Size Distribution & Plasticity Index tests

Mining & Civil Geotest Pty Ltd
unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022 Fax (08) 9414 8011
Email: kevin@mcgeotest.com.au

Job No:	60001
Report No:	60001-P15/7101
Sample No:	P15/7101
Issue Date:	17 October 2015

Client:	**WorleyParsons (201012-00457)**	Sample Location:	**BH - T1**
Project:	**FMG, Port Towage Services - Tug Infrastructure**	Sample Depth (m):	**7.0 - 7.5**
Location:	**Port Hedland**		

Sieve Analysis	**AS 1289.3.6.1**	**Hydrometer**	**AS1289.3.6.3**			
Sieve Size (mm)	% Passing	Diameter (mm)	% Passing			
75.0		0.065	31			
37.5		0.040	28			
19.0		0.029	26	**Plasticity index tests**		
9.5		0.021	25	**AS 1289**		
4.75	100	0.015	24	**Liquid limit 3.1.1**	33	%
2.36	100	0.011	24	**Plastic limit 3.2.1**	13	%
1.18	96	0.008	23	**Plasticity index 3.3.1**	20	%
0.600	79	0.006	22	**Linear shrinkage 3.4.1**	9.0	%
0.425	70	0.004	21			
0.300	60	0.003	20	**Soil Particle Density**		
0.150	44	0.002	19	**AS 1289.3.5.1**	2.66	g/cm^3
0.075	34	0.001	18			



Sampling Procedure: Tested as received

Authorised signature

Kevin M Jones

Particle Size Distribution & Plasticity Index tests

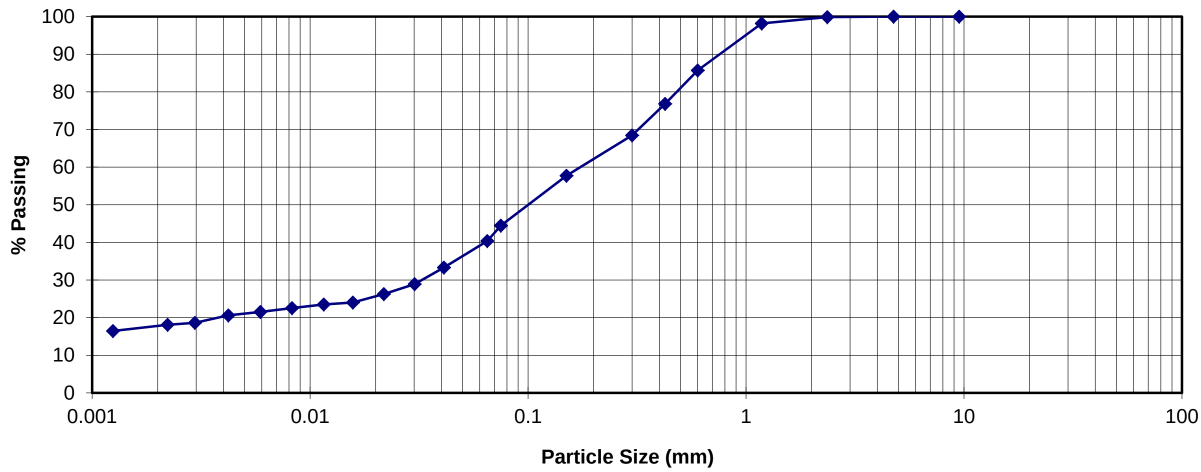
Mining & Civil Geotest Pty Ltd
unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022 Fax (08) 9414 8011
Email: kevin@mcgeotest.com.au

Job No: 60001
Report No: 60001-P15/7100
Sample No: P15/7100
Issue Date: 17 October 2015

Client: **WorleyParsons (201012-00457)**
Sample Location: **BH - T1**
Project: **FMG, Port Towage Services - Tug Infrastructure**
Sample Depth (m): **4.5 - 5.0**
Location: **Port Hedland**

Sieve Analysis	**AS 1289.3.6.1**	**Hydrometer**	**AS1289.3.6.3**
Sieve Size (mm)	% Passing	Diameter (mm)	% Passing
75.0		0.065	40
37.5		0.041	33
19.0		0.030	29
9.5	100	0.022	26
4.75	100	0.016	24
2.36	100	0.012	24
1.18	98	0.008	23
0.600	86	0.006	22
0.425	77	0.004	21
0.300	68	0.003	19
0.150	58	0.002	18
0.075	44	0.001	16

Plasticity index tests		
AS 1289		
Liquid limit 3.1.1	31	%
Plastic limit 3.2.1	14	%
Plasticity index 3.3.1	17	%
Linear shrinkage 3.4.1	8.0	%
Soil Particle Density		
AS 1289.3.5.1	2.68	g/cm^3



Sampling Procedure: Tested as received

Authorised signature

Kevin M Jones

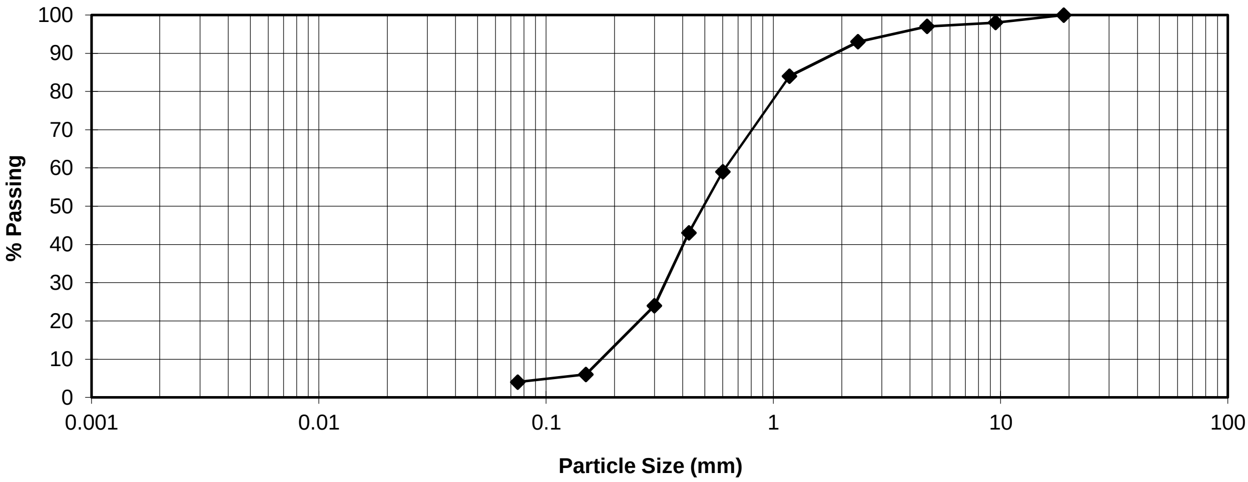
Particle Size Distribution & Plasticity Index tests

Mining & Civil Geotest Pty Ltd
unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022
Email: kevin@mcgeotest.com.au

Job No:	60001
Report No:	60001-P15/7099
Sample No:	P15/7099
Issue Date:	17 October 2015

Client: WorleyParsons (201012-00457)
Project: FMG Port Towage Services - Tug Infrastructure
Location: Port Hedland

Sample location: BH - T1
Sample Depth (m): 0.0 - 0.45



SIEVE ANALYSIS AS 1289.3.6.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	100
9.5	98
4.75	97
2.36	93
1.18	84
0.600	59
0.425	43
0.300	24
0.150	6
0.075	4

Plasticity index tests
AS 1289

Liquid limit 3.1.1	na	%
Plastic limit 3.2.1		%
Plasticity index 3.3.1		%
Linear shrinkage 3.4.1		%

Cracked ☐

Curled ☐

WA 915.1
Calcium Carbonate Content 10.5 %

Sampling Procedure: Tested as received

Accreditation for compliance with ISO/IEC 17025.
This document may not be reproduced except in full.
Accreditation No 15545.

Approved signature

Kevin M Jones

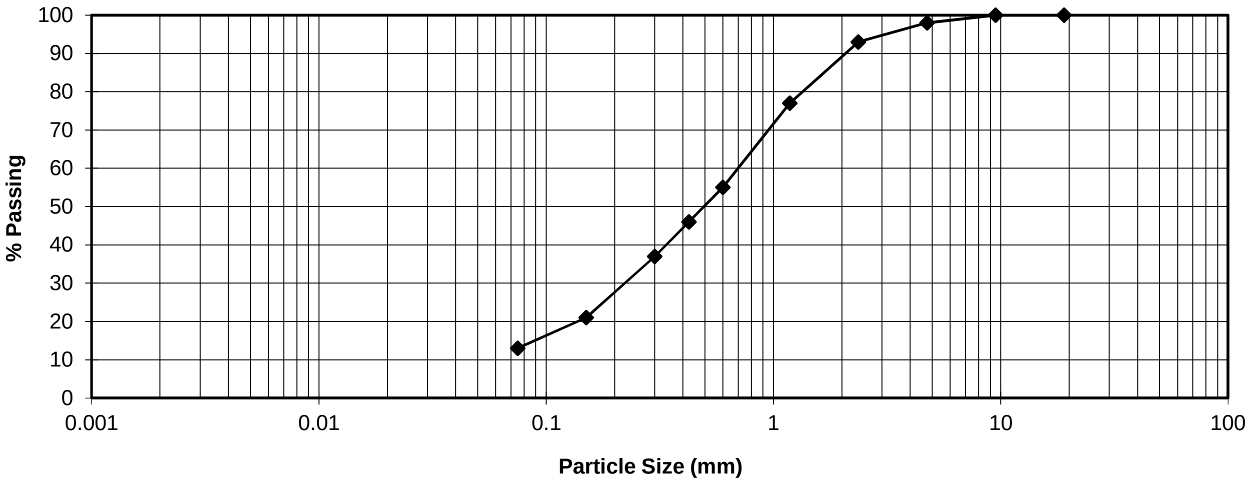
Particle Size Distribution & Plasticity Index tests

Mining & Civil Geotest Pty Ltd
unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022
Email: kevin@mcgeotest.com.au

Job No:	60001
Report No:	60001-P15/7146
Sample No:	P15/7146
Issue Date:	17 October 2015

Client: WorleyParsons (201012-00457)
Project: FMG Port Towage Services - Tug Infrastructure
Location: Port Hedland

Sample location: BH - T4
Sample Depth (m): 21.0 - 21.2



SIEVE ANALYSIS AS 1289.3.6.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	100
9.5	100
4.75	98
2.36	93
1.18	77
0.600	55
0.425	46
0.300	37
0.150	21
0.075	13

Plasticity index tests
AS 1289

Liquid limit 3.1.1	na	%
Plastic limit 3.2.1		%
Plasticity index 3.3.1		%
Linear shrinkage 3.4.1		%

Cracked ☐

Curled ☐

WA 915.1

Calcium Carbonate Content	na	%

Sampling Procedure: Tested as received

NATA WORLD RECOGNISED ACCREDITATION

Accreditation for compliance with ISO/IEC 17025.
This document may not be reproduced except in full.
Accreditation No 15545.

Approved signature

Kevin M Jones

AS PSDPI May 2009

Appendix 2: Hydrodynamic Impact Assessment

This page has been left blank intentionally

WorleyParsons
Consulting

Fortescue
The New Force in Iron Ore

FMG

FMG Tug Haven Marine Studies

Hydrodynamic Impact Assessment

201320-08579 – CS-REP-0002

FMG Document 560PO-4347-RP-EN-0004

9 Dec 2015

Level 7, QV1 Building,
250 St. Georges Terrace
Perth WA 6000
Australia
Telephone: +61 8 9278 8111
Facsimile: +61 8 9278 8110
www.worleyparsons.com
ABN 61 001 279 812

Disclaimer

This report has been prepared on behalf of and for the exclusive use of FMG, and is subject to and issued in accordance with the agreement between FMG and WorleyParsons. WorleyParsons accepts no liability or responsibility whatsoever for it in respect of any use of or reliance upon this report by any third party.

Copying this report without the permission of FMG or WorleyParsons is not permitted.

PROJECT 201320- 08579 - FMG TUG HAVEN MARINE STUDIES

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CUSTOMER APPROVAL	DATE
A	Issued for Internal Review	M Morris-Thomas	D Hansen		30 Oct		
B	Issued for Client Review	M Morris-Thomas	D Hansen	H Houridis	5 Nov		
0	Issued for Use	M Morris-Thomas	D Hansen	H Houridis	9 Dec		

CONTENTS

EXECUTIVE SUMMARY

Fortescue Metals Group (FMG) requires capital dredging to be conducted for the proposed port towage services tug infrastructure facility at Anderson Point in Port Hedland. WorleyParsons has been commissioned by FMG to assess hydrodynamic and sediment plume dispersion impact due to the proposed dredging works.

This report describes the Hydrodynamic Impact Assessment that was performed to identify and quantify any potential change in current and water-level conditions as a result of the dredging works.

The Hydrodynamic Impact Assessment was carried out using WorleyParsons' three-dimensional (3D) numerical hydrodynamic model of the Port Hedland region. The impact of dredging on hydrodynamic conditions was assessed by applying the model to simulate conditions for both pre- and post-development. For modelling purposes, the pre-development case (Base Case) was defined by the port layout and bathymetry as of May 2014, updated with projects approved by the Environmental Protection Authority (EPA) up to and including January 2015. The post-development case (Test Case) was based on the proposed dredging layout and two future approved developments ie., Pilbara Ports Authority (PPA) Stingray Creek Small Vessel Cyclone Mooring Protection Facility and PPA Lumsden Point General Cargo Facility (MS 967). The model simulations incorporated all changes in bathymetry related to the proposed dredging footprint.

The numerical modelling simulations have been analysed to determine the extent of changes to the seasonal (summer and winter) flood and ebb tidal currents and water levels near the development area. A multi-faceted approach was applied to identify and quantify any modifications to the existing dynamics comprising:

- Spatial maximum and mean flow velocity analysis;
- A point location analysis for flow velocity and direction (seven locations); and
- An inundation/submergence analysis at key locations.

Results of the assessment predict that impacts on tidal hydrodynamics, including current velocity and water-level conditions, are expected to be minimal and limited to the immediate areas near the proposed developments. Key findings are:

- A negligible difference in maximum and mean current velocity outside of the project area;
- Over the project footprint, the maximum and mean flow velocities are similar for both flood and ebb tides with some very localised subtle differences;

- A reduction in flow velocity in the immediate vicinity of the proposed development (up to 0.2 m/s). It is believed this is caused by the inclusion of both Stingray Creek and the Lumsden Point developments in the post-development (Test Case) modelling scenario;
- A spatial difference in current velocity of approximately 0.4 m/s over the south east boundary of the Stingray Creek development;
- Apart from location 7 (Upstream of South West Creek), negligible differences in peak flow velocity are expected at all key output locations; and
- A negligible difference in inundation patterns is expected between pre-development and post-development at the five key output locations.

ACRONYMS

3D	Three Dimensional
AHS	Australian Hydrographic Service
BC	Base Case
BoM	Bureau of Meteorology
CD	Chart Datum
EIA	Environmental Impact Assessment
DHI	Danish Hydraulic Institute
EPA	Environmental Protection Authority
FMG	Fortescue Metals Group
GDA	Geocentric Datum of Australia
Hs	significant wave height
HAT	Highest Astronomical Tide
LAT	Lowest Astronomical Tide
MGA	Map Grid of Australia
MHWS	Mean High Water Spring Tide
MHWN	Mean High Water Neap Tide
MLWN	Mean Low Water Neap Tide
MLWS	Mean Low Water Spring Tide
MS 967	WA Ministerial Statement covering Lumsden Point
MSL	Mean Sea Level
PPA	Pilbara Ports Authority
SI	International System of Units
TC	Test Case
Tp	peak wave period
TPXO	TOPEX/Poseidon Global Tidal model
TSS	Total Suspended Sediment

1. INTRODUCTION

Fortescue Metals Group (FMG) requires dredging work to be conducted for the proposed port towage services tug infrastructure facility at Anderson Point in Port Hedland. The dredging area is located to the north of South Creek and the proposed dredging works consist of:

- dredging of approach channel to -8.0 mCD and dredging of tug pens to -8.0 mCD (approximate total volume 800,655m^3);
- onshore dredge spoil disposal to existing Dredged Material Management Areas (DMMA).

The proposed dredging layout and the corresponding set out points are presented in Figure 1-1 and Table 1-1, respectively.

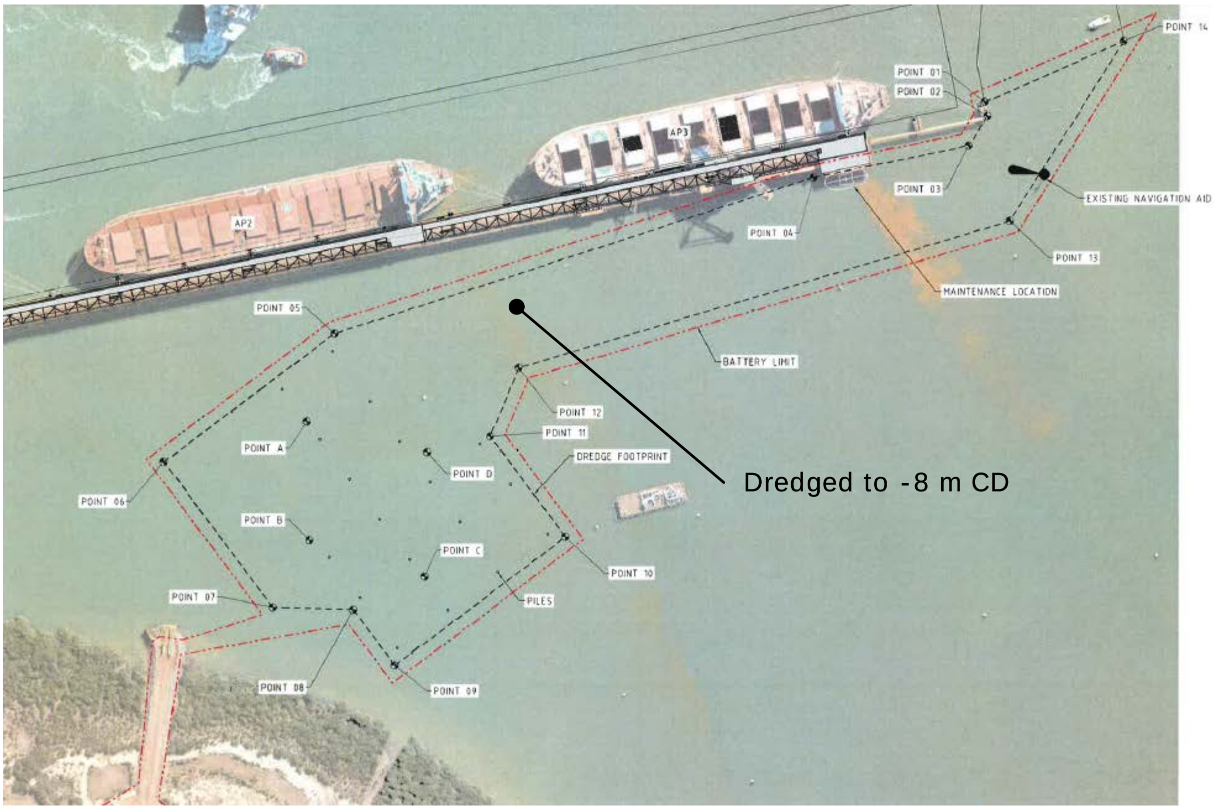


Figure 1- 1: Proposed dredging layout

Table 1- 1: Proposed dredging set out points

Point Number	Easting [m]	Northing [m]
01	665260.10	7751071.56
02	665253.51	7751062.29
03	665226.06	7751057.11
04	665123.17	7751130.27
05	664771.09	7751324.36
06	664603.67	7751353.88
07	664578.53	7751211.28
08	664620.82	7751163.20
09	664611.24	7751108.85
10	664778.65	7751079.33
11	664796.02	7751177.81
12	664851.54	7751198.56
13	665204.99	7750992.08
14	665371.08	7751023.41

1.1 Project background

WorleyParsons has been commissioned by FMG to conduct hydrodynamic and sediment plume dispersion impact assessment for a proposed dredging works at Anderson Point in Port Hedland.

The proposed dredging location is shown in Figure 1-2.

Figure 1- 2: Proposed dredging location

In order to support the required Marine Studies; two numerical modelling studies are required to identify potential environmental effects resulting from the proposed dredging work. These studies include:

- a Hydrodynamic Modelling and Impact Assessment to quantify any potential change in current conditions and water levels as a result of the proposed project; and
- a Sediment Plume Dispersion Modelling (WorleyParsons, 2015) to investigate the transport and fate of the sediment plume generated by dredging.

This report presents the Project's Hydrodynamic Impact Assessment.

1.2 Scope of work

The Hydrodynamic Impact Assessment was undertaken to identify and quantify any potential changes in current conditions and water levels as a result of the proposed Project. The assessment was based on numerical model predictions, applying the WorleyParsons 3D hydrodynamic model of the Port Hedland region.

The scope of work comprised application of the hydrodynamic model to provide water level and current conditions for both the pre- and post-development cases, highlighting any differences between the two. The model outputs were then used to identify the environmental impacts associated with observed changes in the region's hydrodynamics. The following tasks were undertaken:

- applying the WorleyParsons 3D Port Hedland hydrodynamic model using the MIKE3 FM-HD software module, including representation of both the pre- and post-development bathymetries;
- running two 14-day (one full length spring-neap tidal cycle) simulations to represent the seasonal variation (summer-winter) in wind and tidal condition for the pre- and post-development scenarios; and
- post processing of the model outcomes, including generation of spatial plots of peak and mean flow velocity across the Inner Harbour, as well as time-series of flow velocity and directions at key output locations.

The model application is described in Section 3. The Hydrodynamic Impact Assessment results, comparing model simulations for the pre- and post-development cases, are provided in Section 4.

1.3 Study datum

Water depths and levels presented in this report are referenced to Port Hedland Chart Datum (CD), unless otherwise stated, and are in units of metres.

Geographical positions are provided in the Map Grid of Australia (MGA 94) coordinate system, which employs the Geocentric Datum of Australia (GDA 94) Geodetic Datum, unless stated otherwise.

All units are in standard International System of Units (SI) unless otherwise stated, with all bearings and directions provided in degrees relative to True North.

2. CLIMATE DESCRIPTION

2.1 General Oceanography

The coastal regions of the North West Shelf near Port Hedland experience a tropical arid climate, with a quasi-monsoonal seasonal shift in wind direction and rainfall patterns.

The hydrodynamics of the coastal waters near this site, and within the Port Hedland estuary, are dominated by a large tidal range that drives strong flood and ebb tidal currents. These currents are of scales of about 1 m/s in the near shore region, and more than 1 m/s in the estuary entrances and deeper channels in the tidal creeks during peak ebb and flood tides. The tidal currents are typically aligned along local bathymetric contours. Substantial areas of drying mudflats occur along the coastline and within the Port Hedland estuary. The bathymetry is flat and shallow, typical of intertidal flats in the region.

In this region wind forcing is secondary to tidal forcing for local currents, although wind forcing drives residual flows along the coastline, which is an important transport mechanism for suspended sediments. The winds in summer are quite persistent from the west/north-west and typically result in a long-term drift towards the north and east, following the coastline. Weaker and less persistent current reversals occur during times of northerly and easterly winds during autumn and winter.

2.2 Tidal levels

Tides at Port Hedland are semi-diurnal and macro-tidal with a mean spring tidal range of 5.5 m (AHS 2012). Standard tidal levels are given in Table 2-1.

Table 2- 1: Port Hedland tidal planes (AHS 2012)

Tidal plane	Elevation above CD [m]
HAT (highest astronomical tide)	7.5
MHWS (mean high water springs)	6.7
MHWN (mean high water neaps)	4.6
MSL (mean sea level)	4.0
MLWN (mean low water neaps)	3.3
MLWS (mean low water springs)	1.2
LAT (lowest astronomical tide)	0.0

A typical spring-neap cycle is shown in Figure 2-1 (first two weeks in April 2004), determined from harmonic analysis using the published constituents for Port Hedland (AHS 2012).

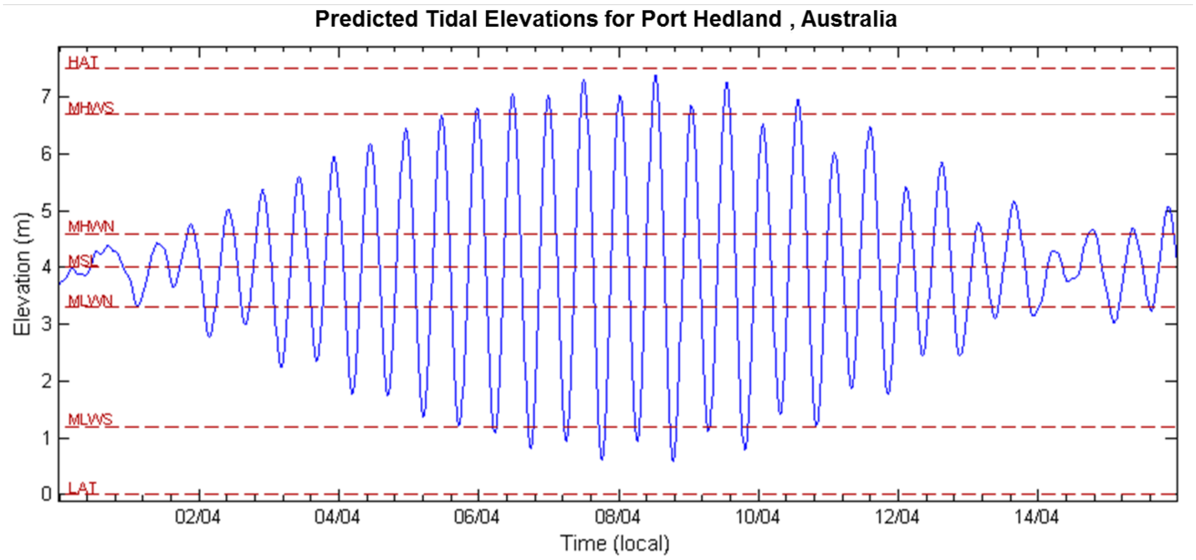


Figure 2- 1: Typical spring- neap tidal cycle at Port Hedland

2.3 Winds

Wind roses presenting the seasonal variation in wind conditions at the onshore Bureau of Meteorology (BoM) weather station at Port Hedland Airport and the offshore PPA buoy at Beacon 15 are given in Figure 2-2. The roses show the wind speed and proportion of time that winds occur from each direction sector during each season. A comprehensive long-term series of data is available at each site, with the roses based on an 18-year record (1993–2011) at Port Hedland Airport, and a 10-year record (2000–2009) at Beacon 15.

The wind roses for Port Hedland Airport show the onshore wind climate is dominated by north-westerly onshore winds and south-easterly offshore winds. Offshore at Beacon 15 (approximately 20 km north-west of the Project site), the north-westerly onshore winds and south-easterly offshore winds are also evident, with a moderately higher occurrence of westerly winds and more consistent directionality to these dominant wind directions than that at Port Hedland Airport. Recorded wind speeds at Beacon 15 are also approximately 10 to 15% higher than those measured at the airport station in most cases.

The highest winds at Port Hedland are associated with the passage of a tropical cyclone, which affect the region from November to April. High wind gusts may also be associated with thunderstorms and squalls. These can occur with limited warning but are short-lived localised events, generally lasting less than an hour.

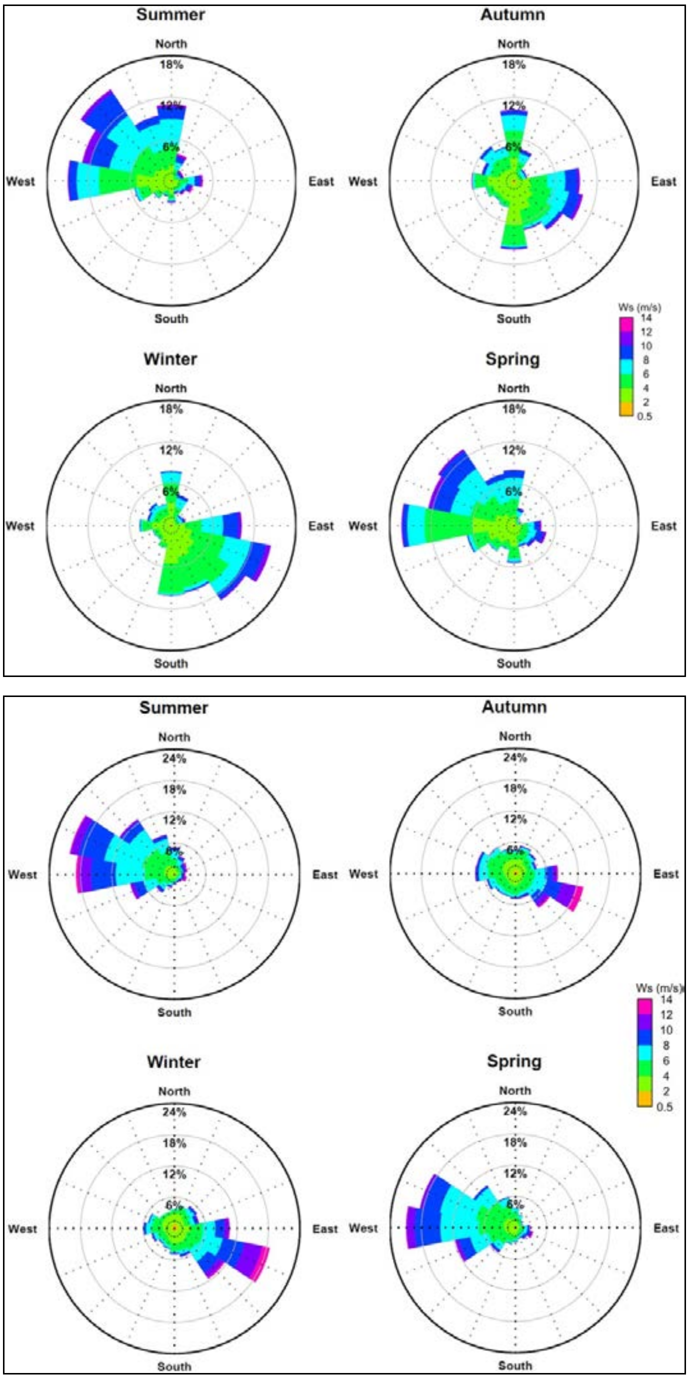


Figure 2- 2: Seasonal wind roses at Port Hedland Airport (top) and Beacon 15 (bottom)

3. HYDRODYNAMIC MODEL

3.1 Introduction

WorleyParsons' existing calibrated and validated 3D hydrodynamic model of the Port Hedland region was applied as the basis of modelling for the Hydrodynamic Impact Assessment. The model domain spans approximately 170 km from Depuch Island in the west to Larrey Point in the east, and extends from 40 to 60 km offshore. The large size of the domain allows an accurate representation of the tides offshore from Port Hedland within the model, which is integral to ensuring that tidal hydrodynamics within the Inner Harbour are correctly characterised.

3.2 Model description

MIKE 3 HD numerically solves the 3D incompressible Reynolds averaged Navier-Stokes equations subject to the assumptions of Boussinesq and of hydrostatic pressure. Thus the model consists of continuity, momentum, temperature, salinity and density equations and it is closed by a turbulent closure scheme. The free surface is taken into account using a sigma-coordinate transformation. Wetting and drying effects in intertidal areas are also accounted for in the model, which is particularly important to this study given the large tidal range at Port Hedland.

The equations are solved using an unstructured mesh applying a cell-centred finite volume method. A total of five different turbulent closures can be employed: constant eddy viscosity, Smagorinsky subgrid scale model, k model, k-e model, or a mixed Smagorinsky/k-e model. The equations allow wave radiation stress input to address surf area current due to wave breaking.

3.3 WorleyParsons existing models

WorleyParsons has undertaken numerous hydrodynamic, sediment transport and plume dispersion modelling projects in Port Hedland in the past. As part of these previous modelling studies, model calibration and validation exercises have been undertaken to improve the accuracy of the model. The data sets used for calibration and validation of the previous modelling studies included:

- physical sediment characterisation data including more than 100 particle-size distribution samples, collected from approximately 40 geochemical cores;
- Acoustic Doppler Current Profiler (ADCP) transects (Figure 3-1);
- 20 years of met ocean data (current, wind and wave);

- 24 months of physico-chemical water quality data collected from more than 20 monitoring sites ;
- collection of total suspended soils (TSS) and turbidity samples to determine the relationship between TSS and turbidity within the inner port area;
- accurate determination of the extent and magnitude of actual plume dispersion using a mobile ADCP, in conjunction with a turbidity profiler during backacter and cutter suction dredging activities;
- daily *in situ* sediment deposition data collected at 11 inner port monitoring sites for approximately 18 months.

Following completion of these validation studies, WorleyParsons has a high level of confidence in the model accuracy.

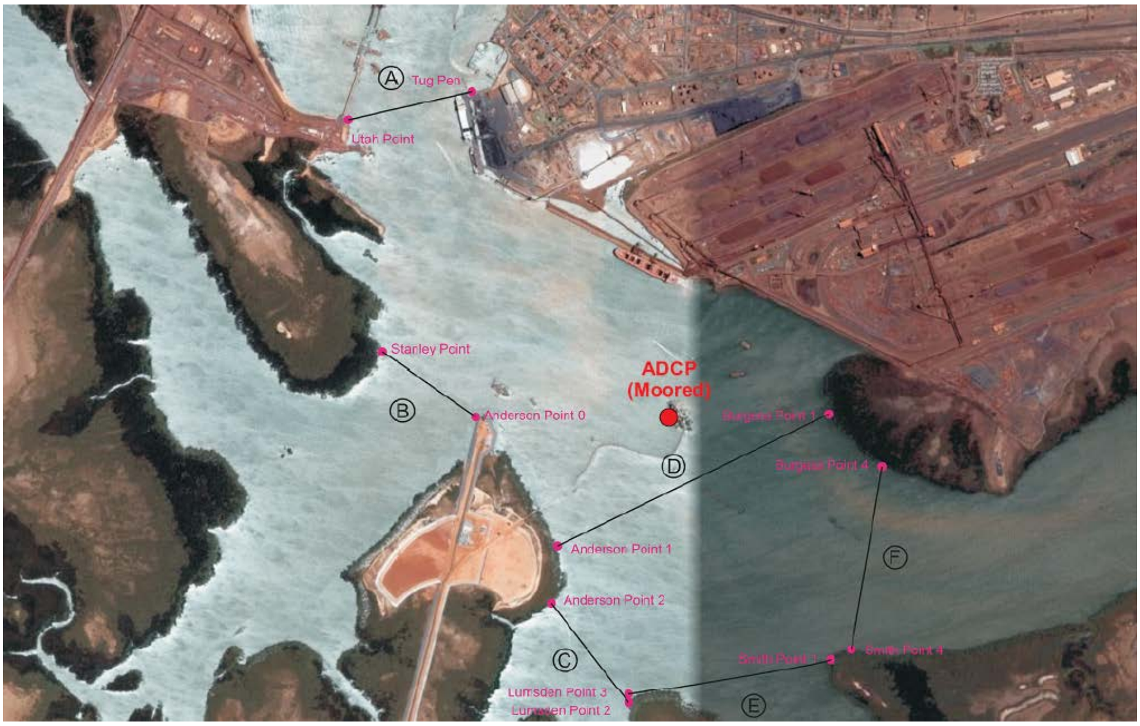


Figure 3- 1: Locations of measurement data (ADCP transects and moored ADCP) for validation

3.4 Data sources

The existing WorleyParsons Port Hedland hydrodynamic model employed for this study was developed through a comprehensive investigation of data sources available within Port Hedland's Inner Harbour and offshore. The data sources used are summarised in Table 3-1.

Table 3- 1: Key data sources used in the hydrodynamic model development

Data Type	Description	Year
Bathymetry	Various inshore and offshore bathymetric surveys provided by PHPA	1999–2013
Winds	Port Hedland Airport, BoM (118.6317°E, -20.3725S°).	1993–2011
	Beacon 15 (118.5167°E; -20.11667°S).	2001–2011
Water levels	Topex Poseidon Global Tide model (TPXO7.0)	
	Bedout Islet tide station (AHS 2012)	
	Depuch Island tide station (AHS 2012)	
	Offshore tide gauge (118.4667°E; -20.0167°S) – Halpern Glick Maunsell.	March to May 1998*
Currents	Offshore current meter (118.4667°E, -20.1531°S) – Halpern Glick Maunsell.	March to May 1998*
	Inner Harbour moored ADCP (118.582°E, -20.325°S) – Cardno Lawson Treloar	October and November 2007*
	Beacon 15 (118.5167°E, -20.11667°S).	2001–2011
	Beacon 16 (118.51012°E, -20.17222°S)	March 2010 – October 2012

*Previous validation with this data provided by PHPA.

3.5 Model domain and bathymetry

The large domain extent of the existing WorleyParsons Port Hedland hydrodynamic model captures the full effects of wind and tidal-induced forcing on the circulation within the coastal region near and within Port Hedland estuary. The offshore extent covers an area 60 km offshore from Port Hedland, to a water depth of approximately 30 m, and between Depuch Island in the west and Larrey Point in the east. The model domain's extent is presented graphically in Figure 3-2.

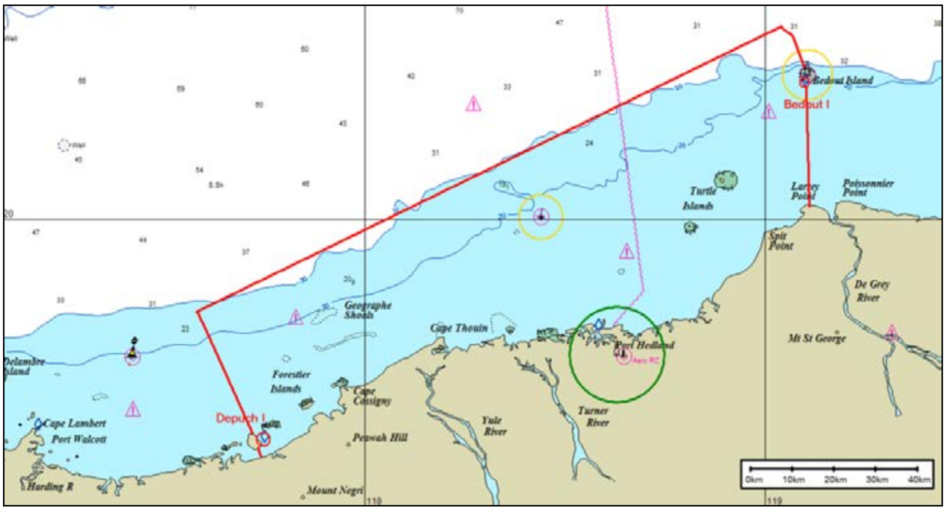


Figure 3- 2: Mike 3 HD model domain (inside red boundary)

The model's "Pre-development" (Base Case) local bathymetry is based on a series of hydrographic and LIDAR surveys, with dredging and developments included between 2000 and May 2014 including but not limited to:

1. Channel and harbour maintenance dredging
2. BHP Hunt Point CLOF (survey JDN, 2012)
3. Utah Point dredging and development
4. Anderson Point dredging and development (AP1, AP2, AP3)
5. Harriet Point dredging and development
6. Nelson Point dredging and development
7. South West Creek dredging and development: AP4, AP5 (FMG), and SP1, SP2 (Roy Hill)
8. Stingray Creek dredging (Eastern part of the Stingray creek dredged for BHP tugboats cyclone mooring)
9. Near shore – Offshore outer harbour survey
10. Outer Harbour Bathymetric LIDAR survey

Future approved developments, have been added onto the existing bathymetry in their full extent of approval in order to be in line with the guidelines in EPA (2009) on a cumulative impact assessment. These are:

11. BHPBilliton, Hunt Point Marine Precinct (Tug Harbour)
12. PPA, South West Creek Dredging and Reclamation

Outside this area bathymetry data is extracted from the C-MAP digital chart database (DHI 2011). This bathymetry data was applied to represent the pre-development case in the model. For the post-development case the model bathymetry was adjusted to reflect proposed dredging scenarios as described in Section 3.8.1.

The hydrodynamic model uses an unstructured computational mesh which allows for higher resolution around areas of specific interest or that have complex bathymetries or morphologies. Computational length scales of the triangles range from 2000 m at the coarsest scale down to 10 m at the finest scale, to minimise run time while still giving a suitable level of accuracy in results for the assessment. To maintain computational accuracy, it is ensured that the mesh traversed this length scale range by no more than a factor of two across the entire computational domain (i.e. smaller cells are no smaller than 50% of the larger adjacent cell).

A mesh showing the model bathymetry is shown in Figure 3-3. The mesh shows the current bathymetry, updated with the future stages of the approved developments.

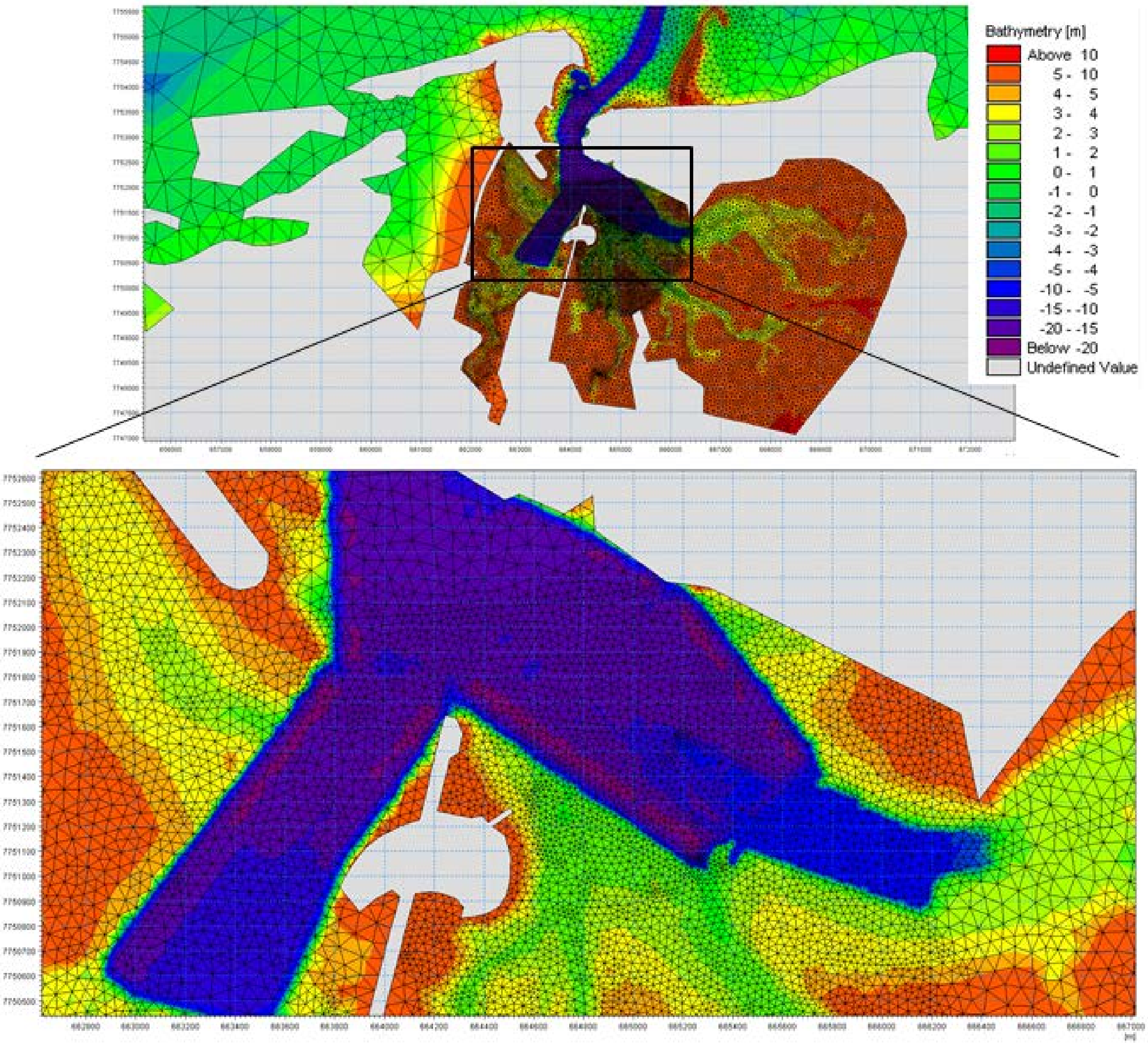


Figure 3-3: Model mesh showing pre-development model bathymetry, i.e. existing bathymetry updated with future stages of approved developments.

In the vertical domain of the model, a sigma layer system was adopted, whereby the same number of vertical layers is present at each point of the computational domain irrespective of water depth. The sigma layers were set as equal across the model domain, with each layer spanning 20% of the local water depth. Five layers were considered appropriate to resolve the 3D hydrodynamics both offshore and near the project site, with these layers spread evenly across the vertical space.

3.6 Marine forcing functions

The main hydrodynamic driving forces at the sites can be divided into tidal and non-tidal processes. Compared with the tidal and wind forcing, the hydrology of the adjacent watershed (e.g. river discharge) plays a minor role in ambient currents. The local meteorological conditions (e.g. wind) are expected to contribute to surface currents, with these effects having more influence during slack and neap tide periods. Although waves are expected to influence the re-suspension of sediments, and are thus included in the Sediment Plume Dispersion Modelling (WorleyParsons, 2015) their influence on the current regime is relatively insignificant compared with the dominant role that tides play on the Port Hedland region's hydrodynamics. As such, waves are not considered to be a significant forcing mechanism in the hydrodynamic model and are thus omitted. Also not included are ocean currents, which are unlikely to affect the hydrodynamic process within the Inner Harbour.

3.6.1 Tides

Tidal data at the hydrodynamic model's ocean boundaries are taken from the TPXO7.0 dataset. This is a global database of harmonic tidal constituents published by the US National Climatic Data Center derived from the 10-year TOPEX/Poseidon satellite mission. The astronomical tides are included on all the open boundaries by spatial interpolation of the tidal constituent data (amplitude and phase) provided by the TOPEX/Poseidon global tidal altimetry data (TPXO7.0). The eight dominant semi-diurnal and diurnal tidal constituents are used in the simulations, in addition to the yearly constituents (Sa and Ssa), given they account for most of the tidal amplitude.

At the model coastal boundaries, the TOPEX tidal data is supplemented with predictions at local tide stations, available in the Australian tide tables (AHS 2012). Constituents derived from the Depuch Island tidal station, located on the western boundary, are included in conjunction with the TPXO7.0 model data to generate an interpolated tide forcing along the western boundary. Tidal forcing on the eastern boundary will be generated by interpolation of the Bedout Islet tidal constituents and the TPXO7.0 data.

On all the open boundaries, the predicted water levels are site specific and vary in local time and along the boundary line. At the points along the boundary where water is flowing into the model domain, the flow is forced perpendicular to the boundary orientation, while at points where the water is flowing out of the model domain, the flow direction is extrapolated from the nearest points inside the model domain.

The model boundaries and location of the Bedout Islet and Depuch Island tidal stations are shown in Figure 3-2.

3.6.2 Ambient winds

Ambient wind conditions are analysed using offshore wind measurements at the Beacon 15 buoy, as well as land-based measurements from the Port Hedland Airport BoM station, 6 km inland of the Project site. All datasets have been interrogated and it appears that the consistent measurements at Beacon 15 during the selected simulation period are the most appropriate for hydrodynamic model forcing because they better represent local wind conditions over water.

3.7 Model set-up parameters

Key model parameters and formulations are summarised in Table 3-2.

Table 3-2: Key hydrodynamic model parameters and formulations

Parameter	Description	Value
Timestep	Maximum computational timestep	600 seconds
	Minimum computational timestep	0.01 seconds
Eddy viscosity	Smagorinsky formulation, constant	0.4 m^2/s
Bed resistance	Roughness height	Mangrove area: 0.3 m Remainder area: 0.065 m
Approximate spatial resolution	Open boundaries	2000 m
	Offshore and coastline >10 km from project site	500–2000 m
	Shoal areas and offshore <10 km from site	100–600 m
	Development site, navigation channel and Inner Harbour	10–120 m

3.8 Simulation scenarios

3.8.1 Project Layout

For the hydrodynamic impact assessment, two cases were set up, pre-development and post development conditions:

- **Base Case (Pre-development)** – As a baseline case to represent the existing condition in order to evaluate and quantify potential impacts. This case includes the existing bathymetry updated with future stages of approved developments as discussed in Section 3.5;

- **Test Case (Post- development)** – The pre-development condition with the following additions: The proposed tug haven dredging as shown in Figure 3-4, as well as the two future approved developments in the immediate project vicinity, in their full extent of approval:
    1. PPA, Stingray Creek Small Vessel Cyclone Mooring Protection Facility ;
    2. PPA, Lumsden Point.

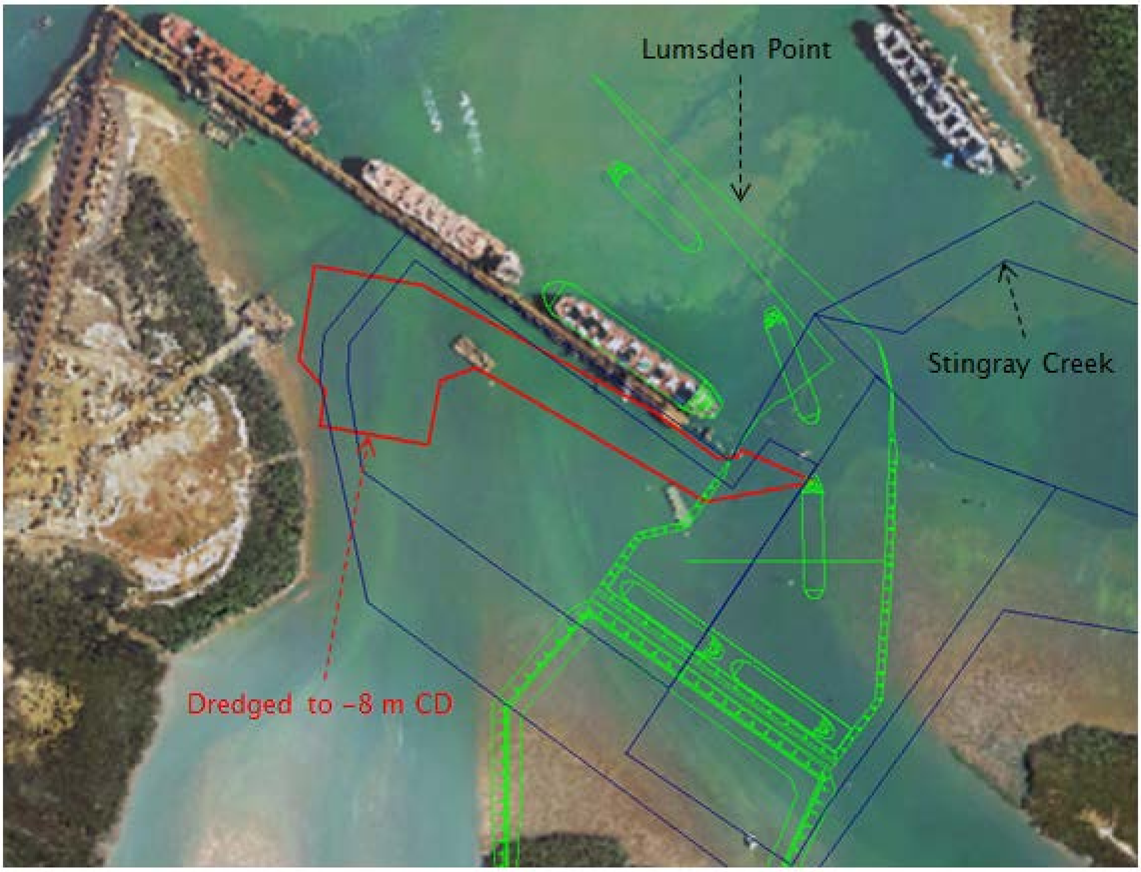


Figure 3- 4: Test Case – post- development situation.

3.8.2 Periods of Simulation

The WorleyParsons Port Hedland hydrodynamic model was applied to simulate current velocities and water levels across the region for two seasonal scenarios. The seasonal scenarios represent typical summer and winter seasonal variation in wind and tidal components. The greatest hydrodynamic impacts expected during the seasonal scenarios have been ascertained from the output.

Scenarios are listed in Table 3-3. Winter and summer scenarios were run for both the pre-development case and post-development cases. Each scenario was run for a 14-day period to represent a complete tidal cycle.

Table 3- 3: Hydrodynamic model simulation scenarios

Run	Seasonal Scenario	Period of simulation (excluding warm- up period)	Bathymetry
0-S	Summer	12:00 AM 02/01/2004 to 12:00 AM 16/01/2004	Base Case
0-W	Winter	12:00 AM 01/07/2004 to 12:00 AM 15/07/2004	Base Case
1-S	Summer	12:00 AM 02/01/2004 to 12:00 AM 16/01/2004	Test Case for Hydrodynamic Impact Assessment
1-W	Winter	12:00 AM 01/07/2004 to 12:00 AM 15/07/2004	Test Case for Hydrodynamic Impact Assessment

3.8.3 Validation

To assess the convergence of the numerical model, a comparison was made with measured tidal data at the location 664000E 7753000N (GDA94 MGA50) situated in the Port Hedland entrance channel. This was performed for the Base Case bathymetry during both summer and winter modelling scenarios.

The results of this comparison are provided in Figure 3-5. The agreement between present numerical results and measurements is favorable.

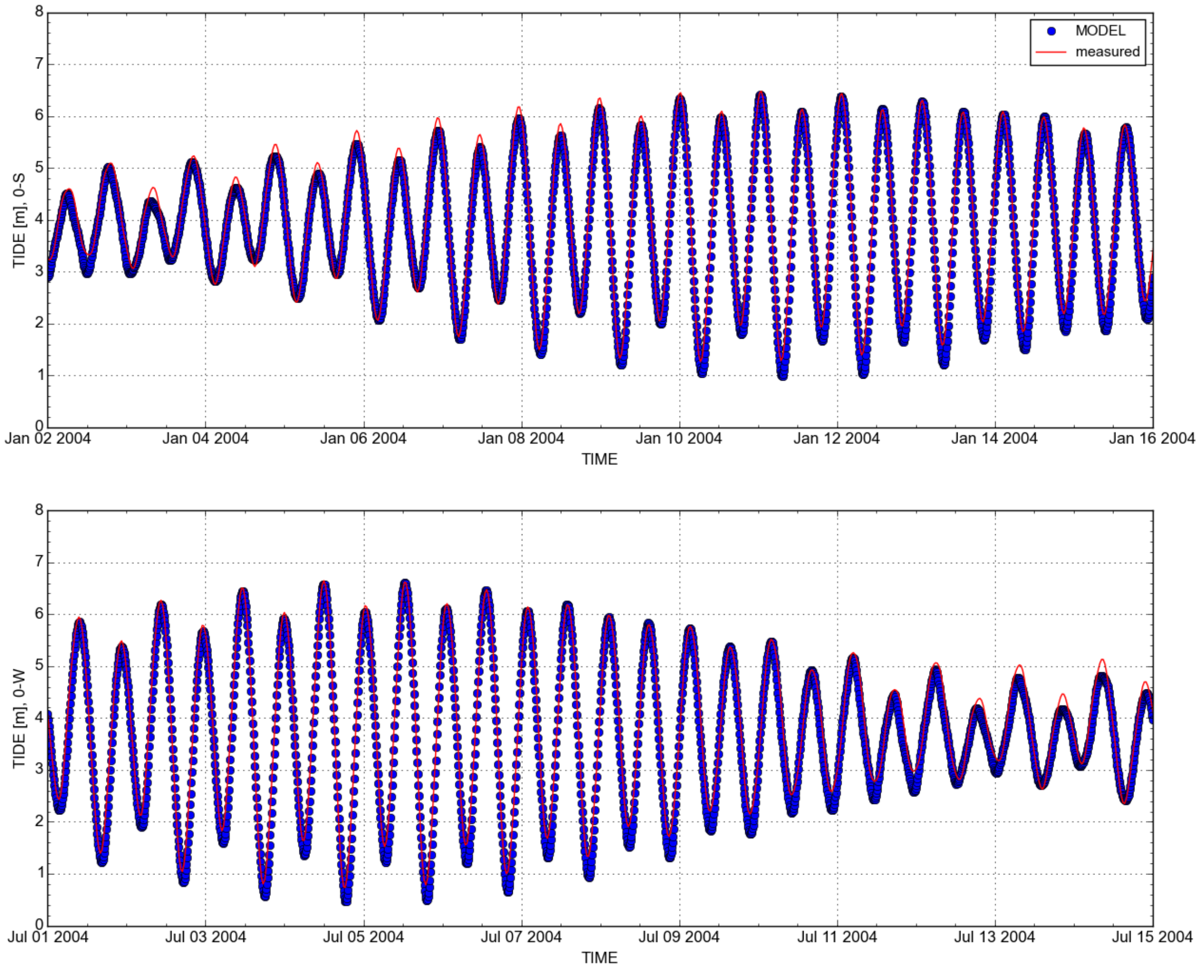


Figure 3- 5: Comparison of tide levels for the Base Case bathymetry during summer and winter modelling scenarios – present numerical results versus measurements at the location 664000E 7753000N (GDA94 MGA50).

4. HYDRODYNAMIC IMPACT ASSESSMENT

This section describes the comparative assessment of predicted changes in current and water-level conditions pre- and post-development:

- 'Base Case' – pre-development;
- 'Test Case' – post development.

A detailed cross comparison was performed between the pre- and post-development cases for each of the modelled scenarios, along with a quantitative analysis to determine the magnitude of the expected hydrodynamic changes on locations immediately adjacent to the Project site. It was considered appropriate to adopt a multi-faceted approach to comprehensively quantify the impact of the development, with the separate components of this analysis comprising:

- Spatial maximum and mean flow velocity analysis;
- A point location analysis for flow velocity and direction; and
- An inundation/submergence analysis at key locations.

The results from each of these separate analyses are presented in Sections 4.1 to 4.2.

4.1 Flow velocity analysis

4.1.1 Approach

A spatial analysis of the representative current field, maximum and mean flood and ebb flow velocities were undertaken to analyse typical flow patterns within the adjacent waters to the proposed development, and to quantitatively assess its impact on the pre-development flow regime.

Representative current fields are presented as spatial flow velocity plots showing a snapshot of the flow at the time of peak current at the Project site for both flood and ebb tidal current.

The maximum flow velocity is calculated as the spatial maximum current speed (i.e. maximum current observed at each grid cell) during the peak flood and ebb tides of the simulation period.

Mean flow velocity is similarly calculated as the spatial mean current speed (i.e. mean current observed at each grid cell throughout the entire water column) during the peak flood and ebb tides through the simulation period.

4.1.2 Seasonal variation in current conditions

To assess the seasonal variation in the current conditions from the model results, depth averaged current speeds were extracted from the model results at one location (GDA94 MGA50, 664000E 7753000N) in the Port Hedland entrance channel. Figure 4-1 presents the predicted current conditions for each season for the Base Case.

For comparative purposes, the results are plotted across an identical timeframe (a 12-hour tidal cycle) for the highest spring tide observed to occur in each of the two seasons. The cycle begins with a Flood tide and ends with an Ebb tide.

The plot shows a consistent variation in current speed through the tidal cycle in each season, with the highest speeds predicted to occur during winter. In terms of hydrodynamic impact, modelling results concentrate on the winter scenario, which represents the higher peak currents and greater potential hydrodynamic impact than the summer scenario.

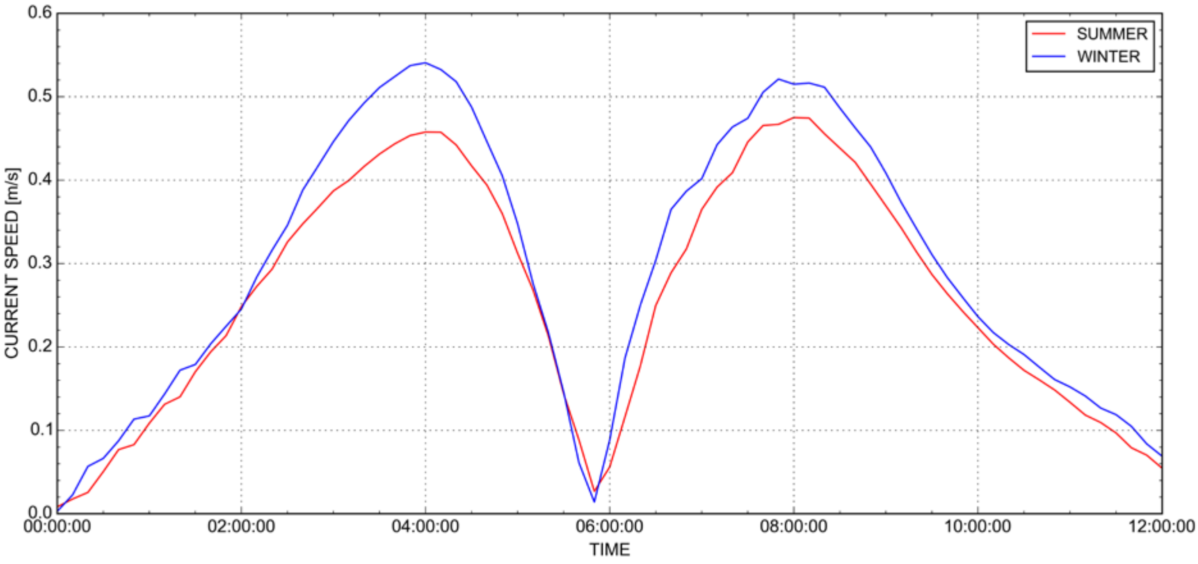


Figure 4- 1: Summer and winter current speed comparison over one tidal cycle from Flood to Ebb.

4.1.3 Representative current field

The typical representative current field pattern plots are shown in Figure 4-2 (Base Case), Figure 4-3 (Test Case). These plots compare the flow regime for peak ebb and flood currents for the different scenarios. The current field pattern plots for both ebb and flood show no changes including current speed and direction outside of the project area. Changes within the project area, with plots zooming in on the project area, are discussed in the following.

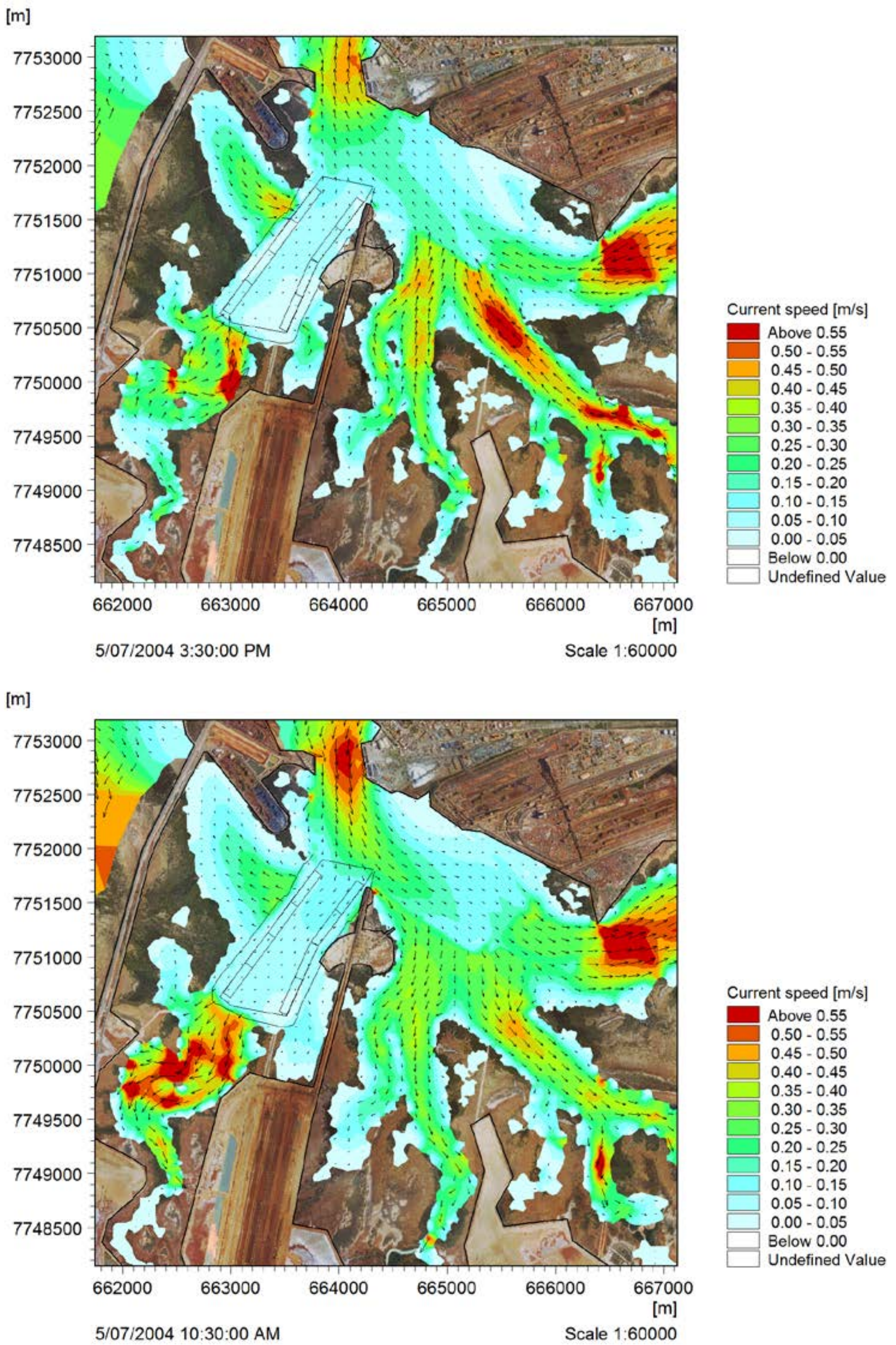
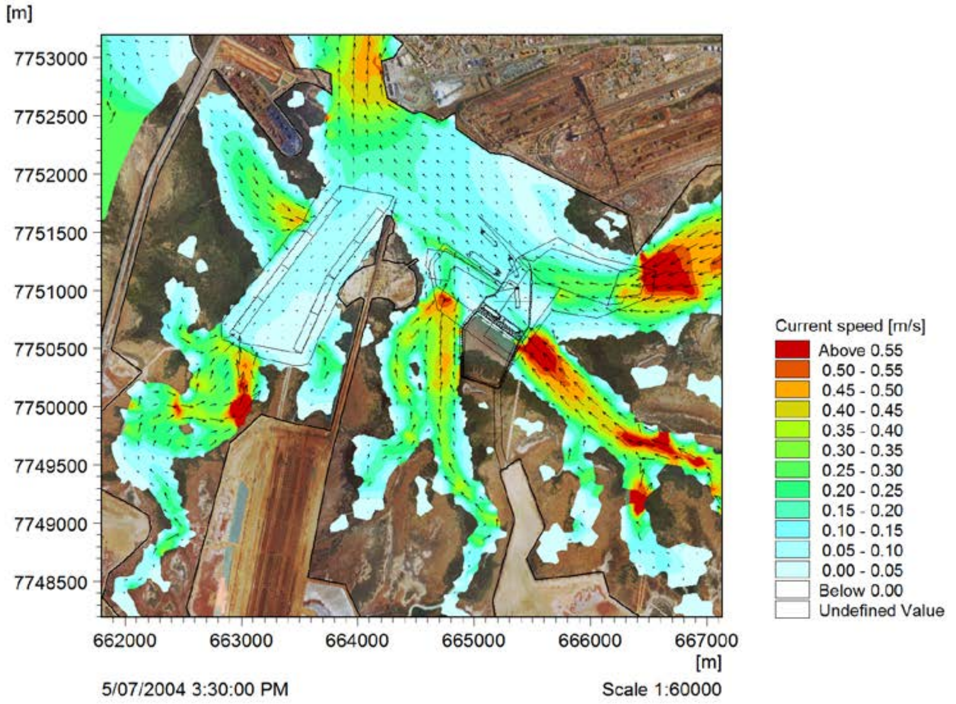


Figure 4-2: Base Case representative current field for Ebb (top) and Flood (bottom) cycles.



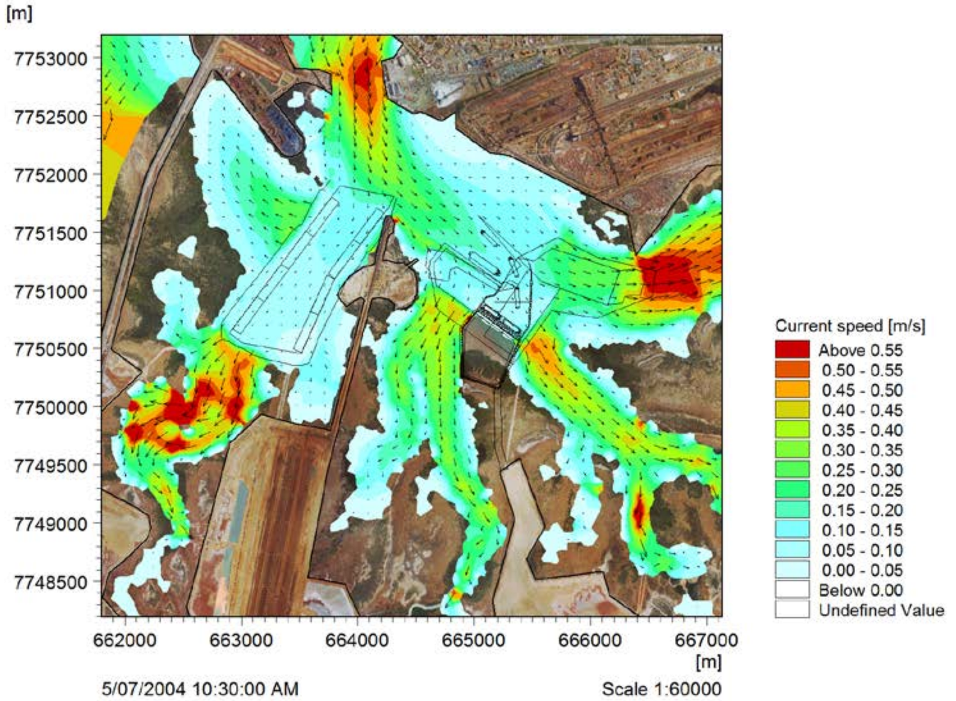


Figure 4- 3: Test Case representative current field for Ebb (top) and Flood (bottom) cycles.

4.1.4 Impact on maximum current velocity

Maximum current velocity difference plots, showing change in maximum current speed between the Test Case and Base Case are provided in Figure 4-4 for both flood and ebb tides.

These plots highlight the impact on maximum current patterns (flood and ebb) of the proposed development (Test Case versus Base Case) across the proposed construction area as predicted in the modelled scenarios.

The plots indicate:

- A negligible difference in maximum current velocity outside of the project area of the proposed development;
- A reduction in flow velocity in the immediate vicinity of the proposed development (up to 0.2 m/s). This is accentuated over the pre-development by the inclusion of both Stingray Creek and the Lumsden Point developments in the Test Case modelling scenario – an average depth change relative to CD of around 6 m through the inclusion of Lumsden Point, and a further 2 m from the present development;
- The flow velocity is very similar for both Flood and Ebb tides with the exception of Smith Point, where the Ebb tide shows in increase of around 0.05 m/s – 0.10 m/s;
- Upstream of South West Creek shows the largest difference in maximum flow velocity in the vicinity of the development area – up to 0.2 m/s;
- The most prominent feature is the large spatial difference in flow velocity at the south east boundary of the Stingray Creek development (alternatively the eastern most boundary of the Lumsden Point reclamation area). For the ebb tide, the spatial difference in current velocity is in the order of 0.4 m/s over 50 m;
- In the region to the west of Nelson Point, the post-development indicates a slight decrease in flow velocity by at most 0.1 m/s – this is relatively insensitive to Flood or Ebb tide.

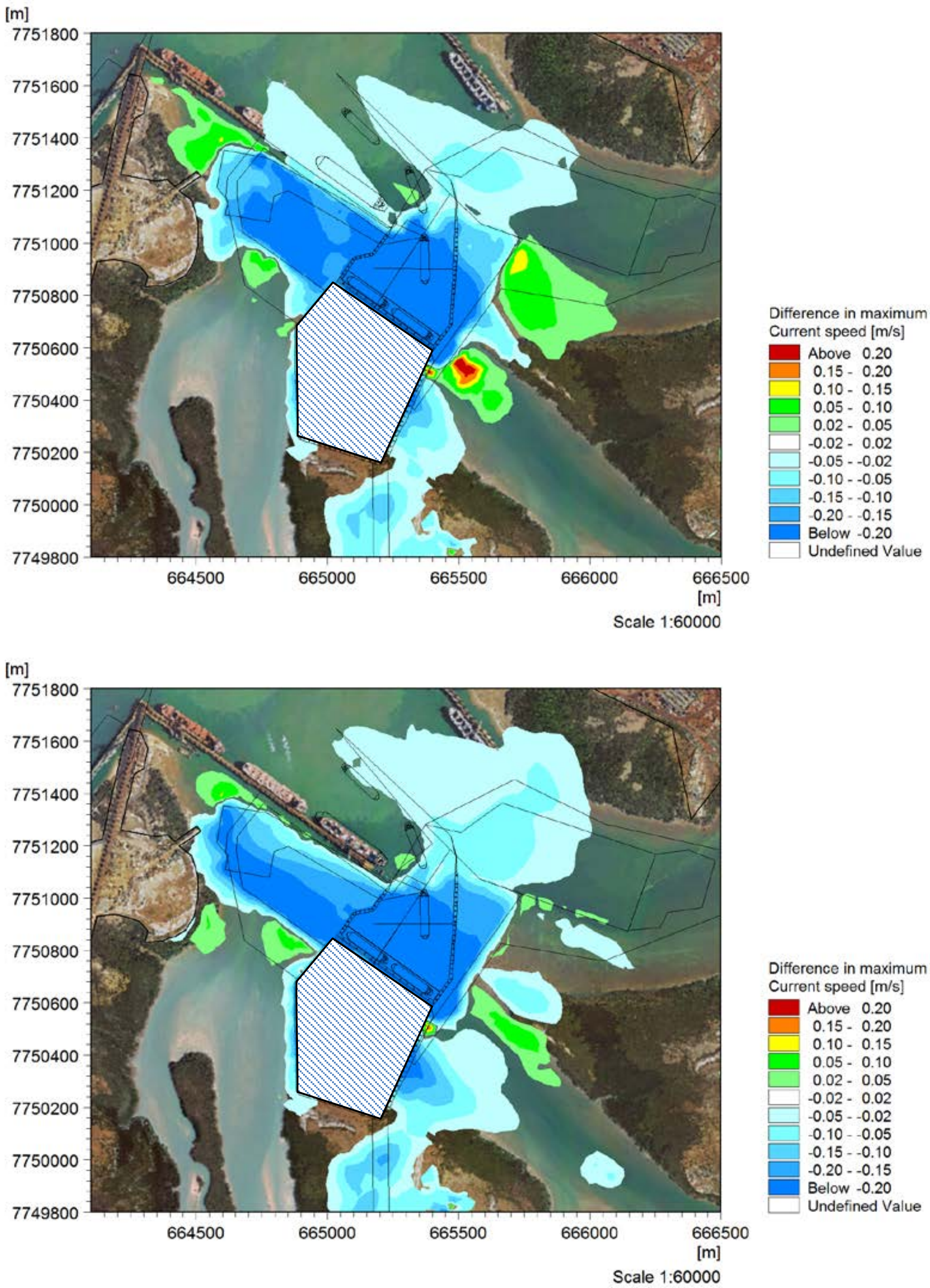


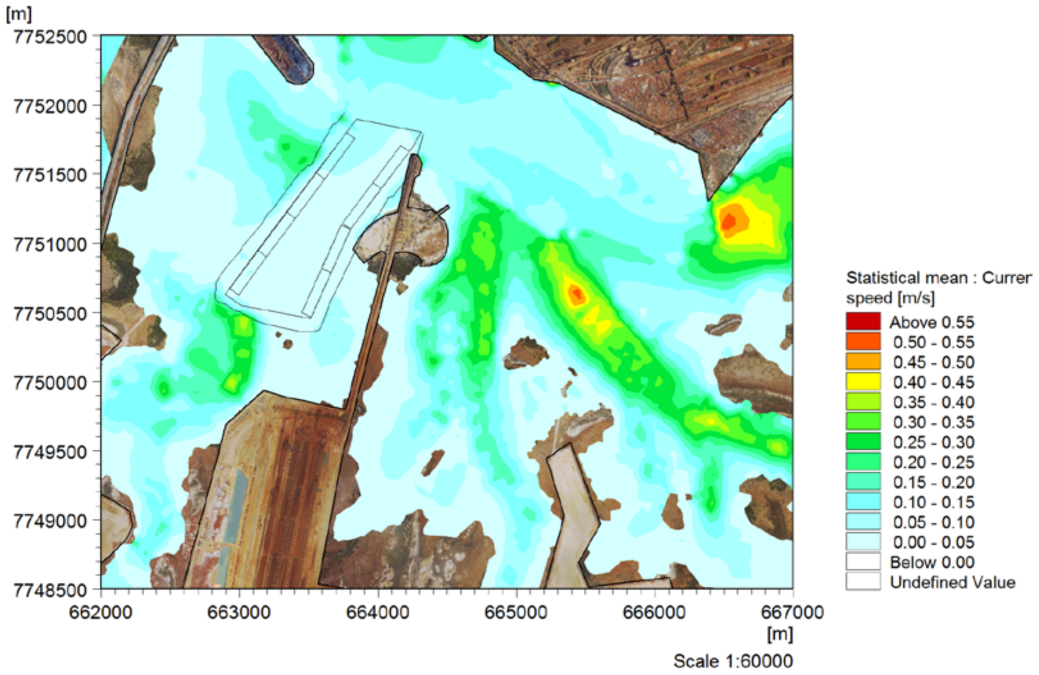
Figure 4-4: Difference in maximum current speed (Test Case) – (Base Case) over Ebb (top) and Flood (bottom) tidal cycles. Hatched area implies no inundation.

4.1.5 Impact on mean flow velocity

Velocity plots showing the mean flow velocity for ebb and flood tidal cycles are presented in Figure 4-5 and Figure 4-6 for the base case and test case respectively. Difference plots, focused on the project area, are shown in Figure 4-7 for the flood and ebb tidal cycles.

The results indicate:

- For both the flood and ebb tide cycles, there is no change in the mean flow velocity outside the immediate post development area;
- There is a slight decrease in the mean flow velocity to the north east of the project area by at most 0.1 m/s;
- In the immediate vicinity of the project area, the mean flow velocity over both tidal cycles is affected by the development by at most ±0.2 m/s – the results are consistent with the maximum flow velocity comparisons (see Section 4.1.4);
- A large spatial differential in mean flow velocity over the ebb tidal cycle is shown just south east boundary of the Stingray Creek development – a spatial velocity differential of at most 0.4 m/s. This is consistent with the maximum flow velocity comparisons.



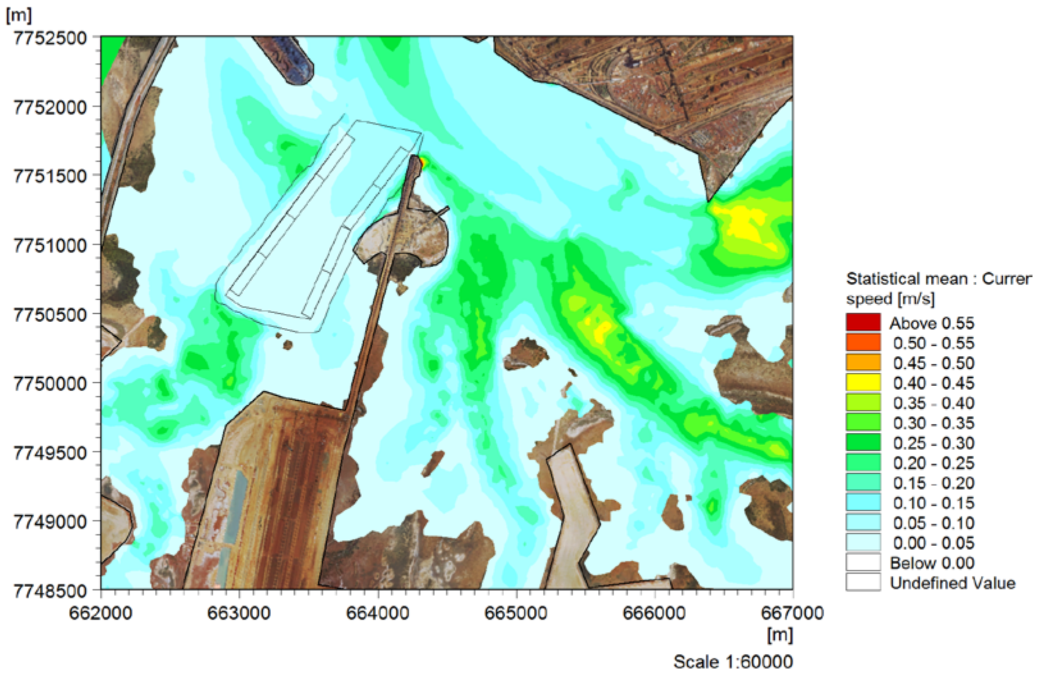
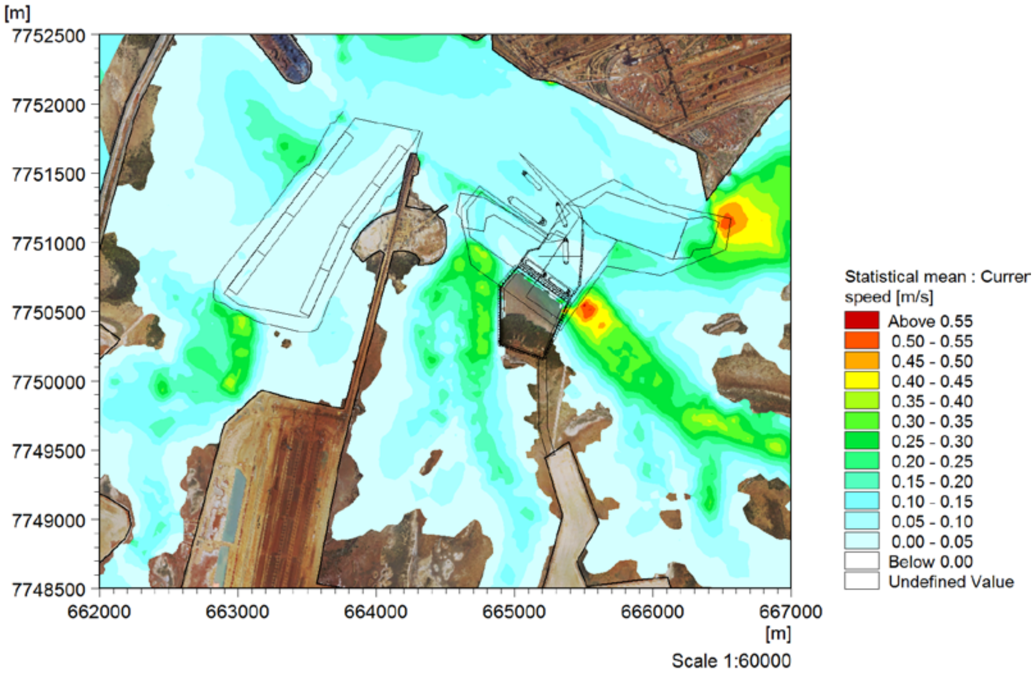


Figure 4- 5: Base Case mean current speed over Ebb (top) and Flood (bottom) cycles.



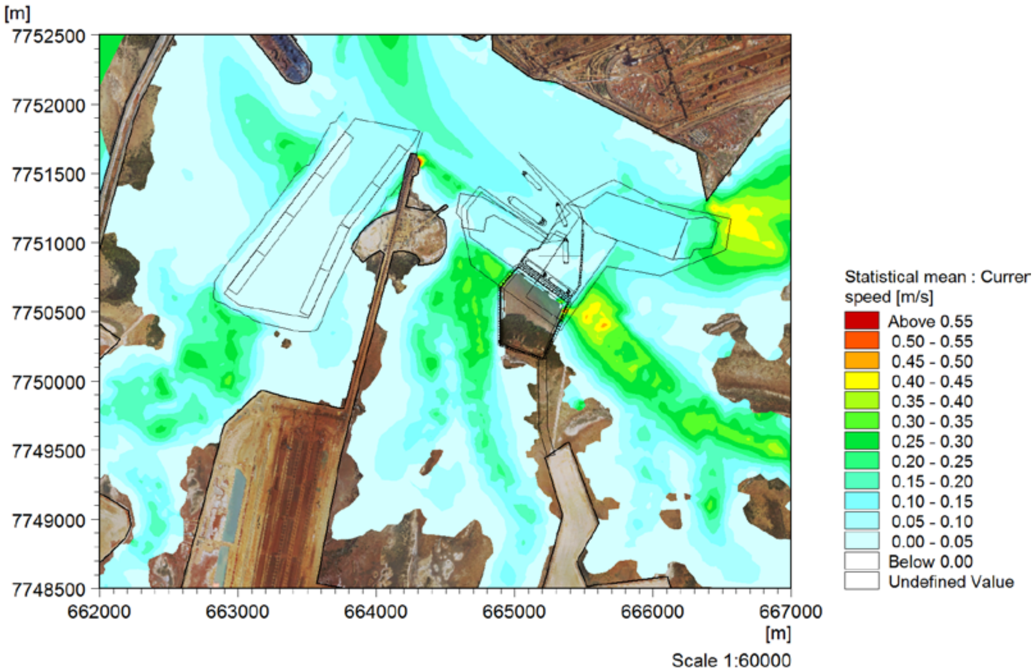


Figure 4- 6: Test Case mean current speed over Ebb (top) and Flood (bottom) cycles.

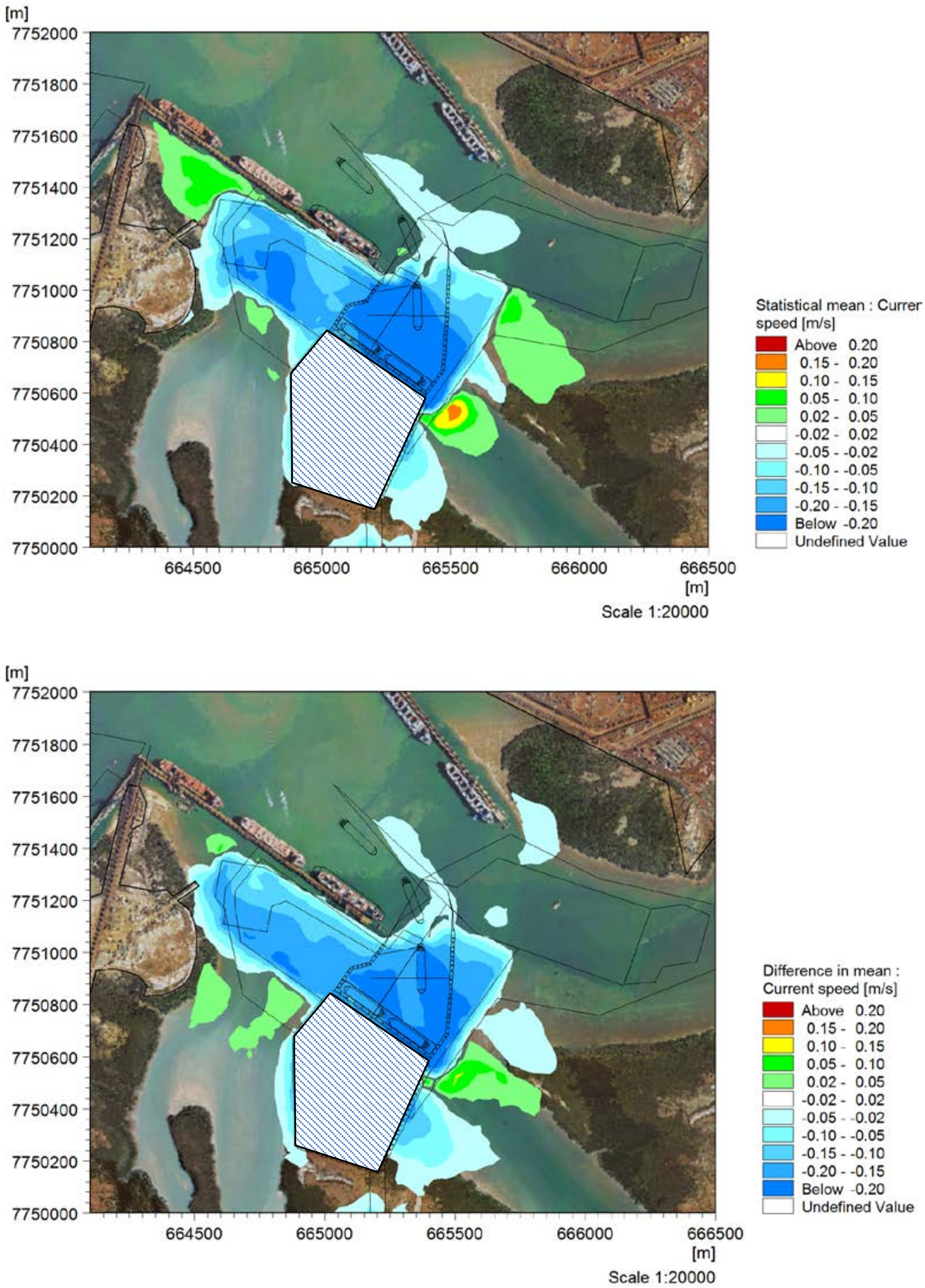


Figure 4- 7: Difference in mean current (Test Case) – (Base Case) for Ebb (top) and Flood (bottom) tide cycles. Hatched area implies no inundation.

4.2 Analysis at key output locations

A point location analysis was carried out to assess the impact of the development on hydrodynamic conditions at locations of sensitive environmental receptors near the development area. Seven key output locations, which have different seabed and creek features (eg. divergence, bends, creek ends) in the vicinity of the project area, were selected for the analysis as shown in Figure 4-8. Key output locations 6 and 7 are situated directly east and south of the proposed dredge area respectively. Coordinates of each point and their elevation relative to the CD are provided in Table 4-1.

At each key output location the current speed and direction were extracted and plotted for the 14-day tidal cycle simulated. Time series plots showing the magnitude of the current velocity and direction during a winter 14 day cycle are provided in Figure 4-9 to Figure 4-15.

A summary of the co-ordinates of each key output location and the predicted impact of the development on peak current speeds is given in Table 4-1 and Table 4-2 for chosen summer and winter tidal cycles respectively.

The following observations regarding this location data can be made:

- Current velocities are slightly more energetic for the Base Case during the winter tidal cycle – by approximately 6%;
- Current velocities are slight more energetic for the Test Case during the winter tidal cycle – by approximately 7%;
- Current directions are left relatively unaffected between the Base Case and Test Case;
- There is a negligible difference in the maximum current velocity between the Base Case at Test Case for all locations apart from 7 – on average less than 1%;
- For location 7, the Test Case clearly demonstrates a reduction in the maximum current velocity during both summer and winter tidal cycles – on average 27%.

The primary reason for the disparity between the Base Case and Test Case in the maximum current velocities at location 7 is the inclusion of both the Stingray Creek and Lumsden Point developments.

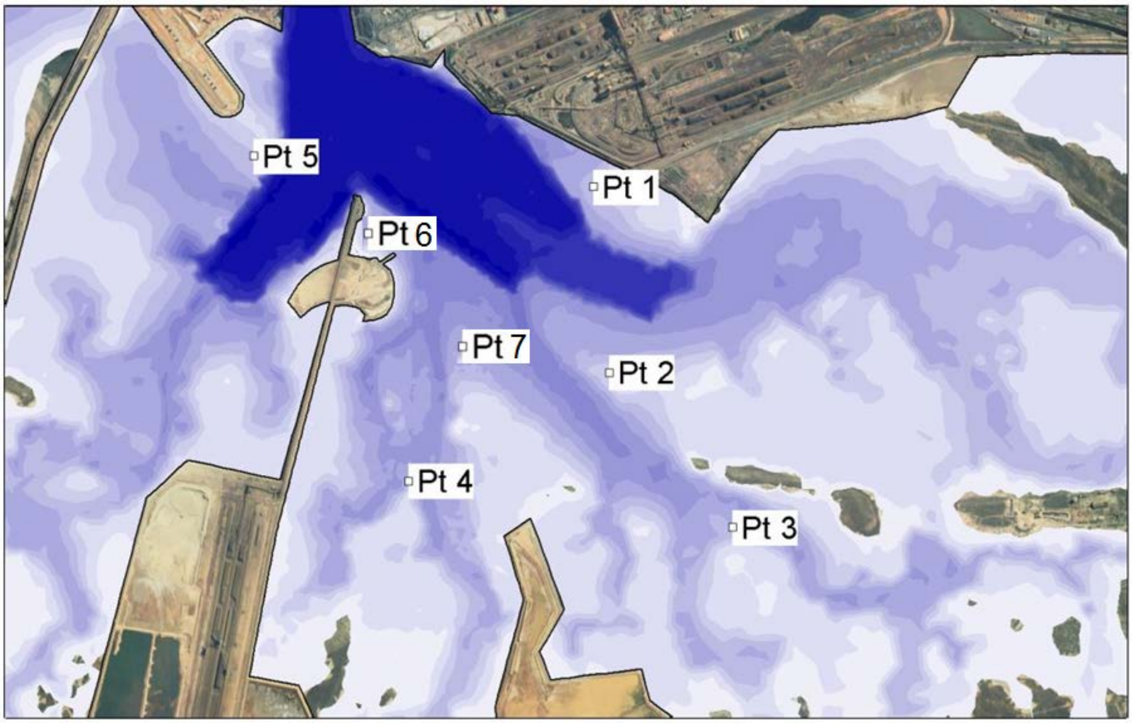


Figure 4- 8: Seven key output locations near the development area.

Table 4- 1: Summary of peak current velocities at the 7 target locations during Summer (see Figure 4- 8).

Location	Easting [m]	Northing [m]	Elevation [mCD]	Base Case MAX U [m/s]	Test Case MAX U [m/s]	Difference (Base Case) –(Test Case)	
						U [m/s]	%
1	665800	7751700	4.4	0.14	0.14	<0.01	<0.1
2	665900	7750500	5.8	0.07	0.06	-0.01	-14
3	666700	7749500	3.9	0.36	0.36	<0.01	<0.1
4	664600	7749800	3.5	0.2	0.2	<0.01	<0.1
5	663600	7751900	4.9	0.17	0.17	<0.01	<0.1
6	664400	7751400	4.4	0.15	0.15	<0.01	<0.1
7	664900	7750750	3.3	0.46	0.33	-0.13	-28

Table 4- 2: Summary of peak current velocities at the 7 target locations during Winter (see Figure 4- 8).

Location	Easting [m]	Northing [m]	Elevation [mCD]	Base Case MAX U [m/s]	Test Case MAX U [m/s]	Difference (Base Case) –(Test Case)	
						U [m/s]	%
1	665800	7751700	4.4	0.13	0.13	<0.01	<0.1
2	665900	7750500	5.8	0.09	0.08	-0.01	-11
3	666700	7749500	3.9	0.41	0.41	<0.01	<0.1
4	664600	7749800	3.5	0.23	0.22	-0.01	-4
5	663600	7751900	4.9	0.13	0.13	<0.01	<0.1
6	664400	7751400	4.4	0.15	0.16	0.01	7
7	664900	7750750	3.3	0.5	0.38	-0.12	-24

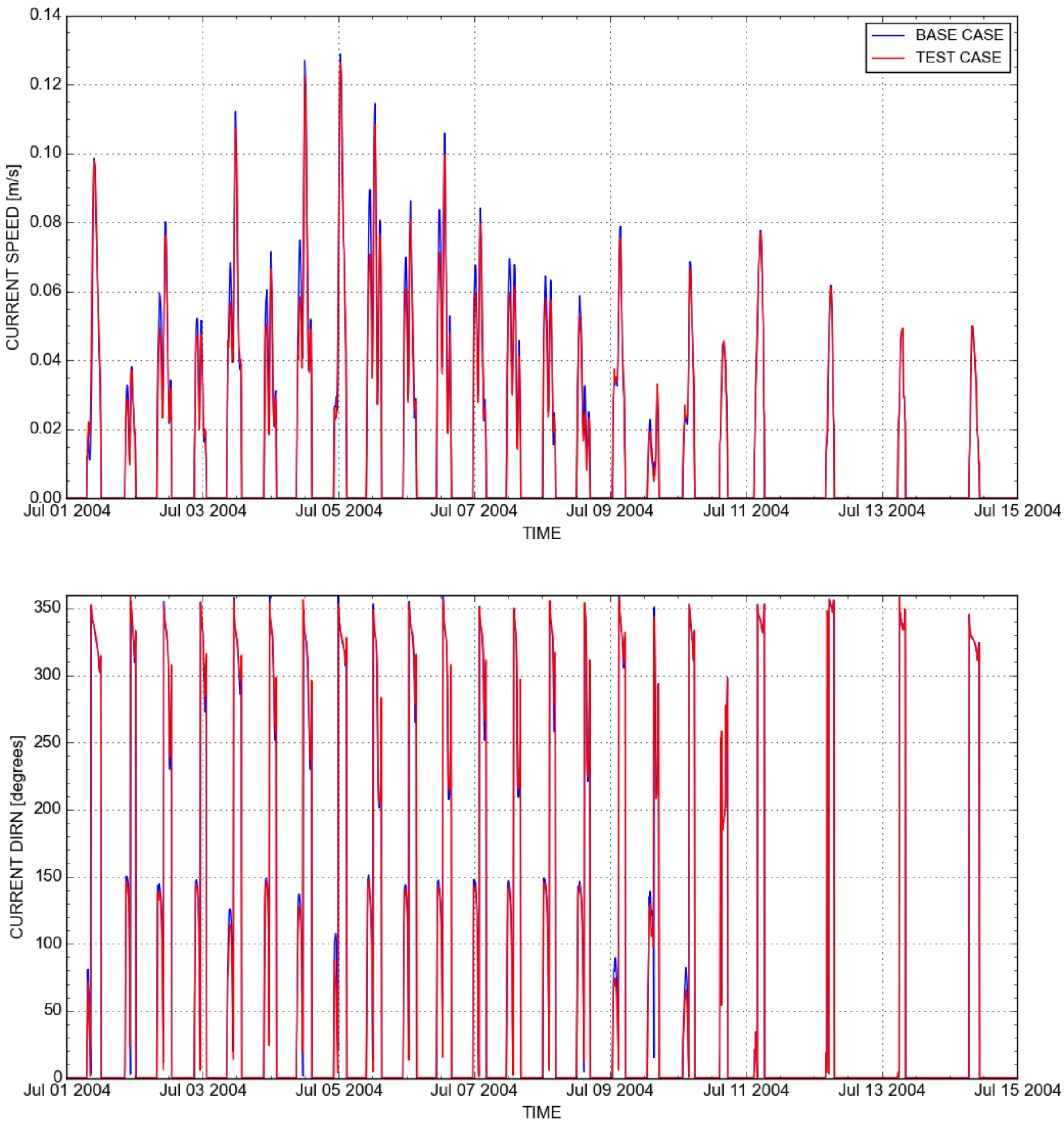


Figure 4- 9: Comparison of current speed and direction between the Base Case and Test Case for output location 1.

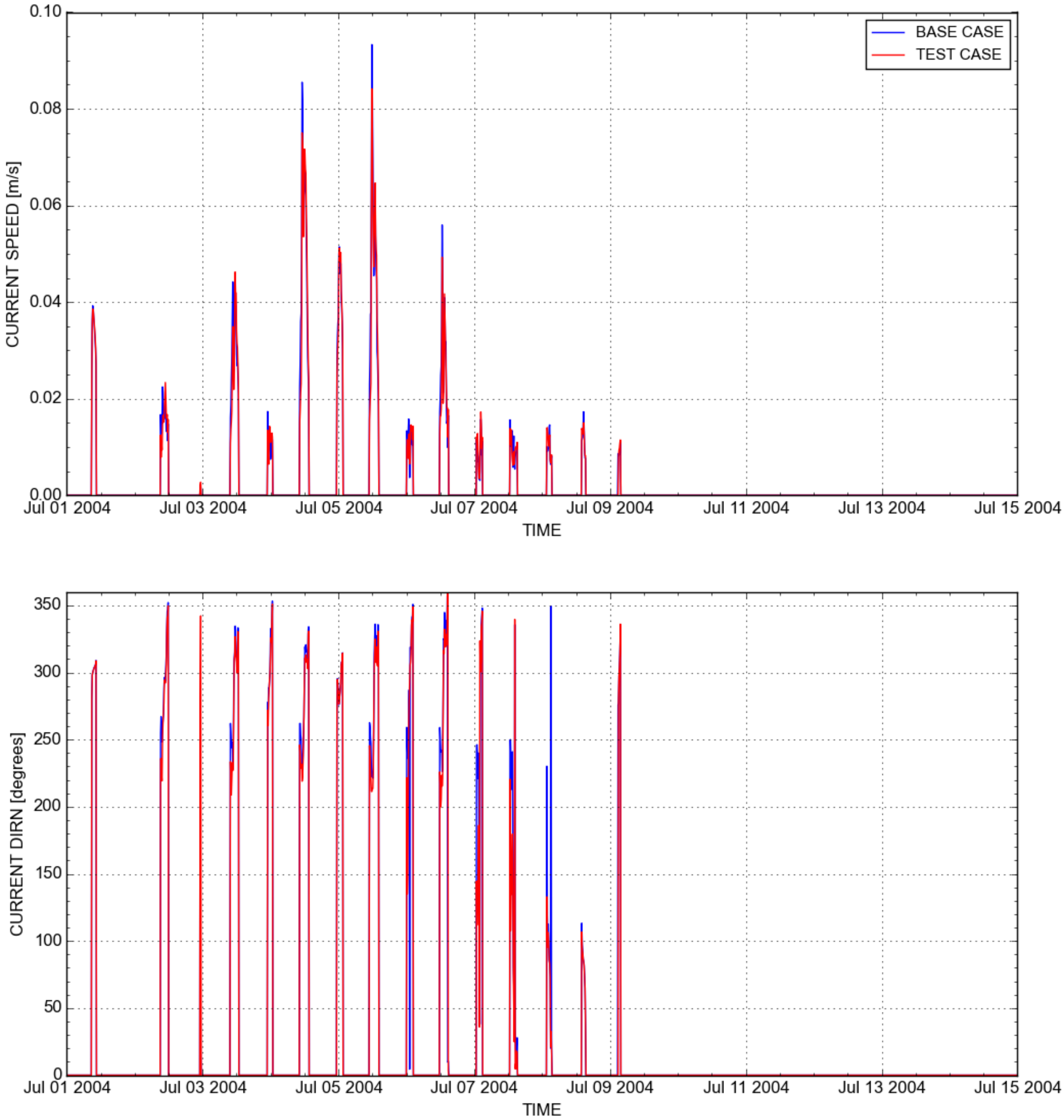


Figure 4- 10: Comparison of current speed and direction between the Base Case and Test Case for output location 2.

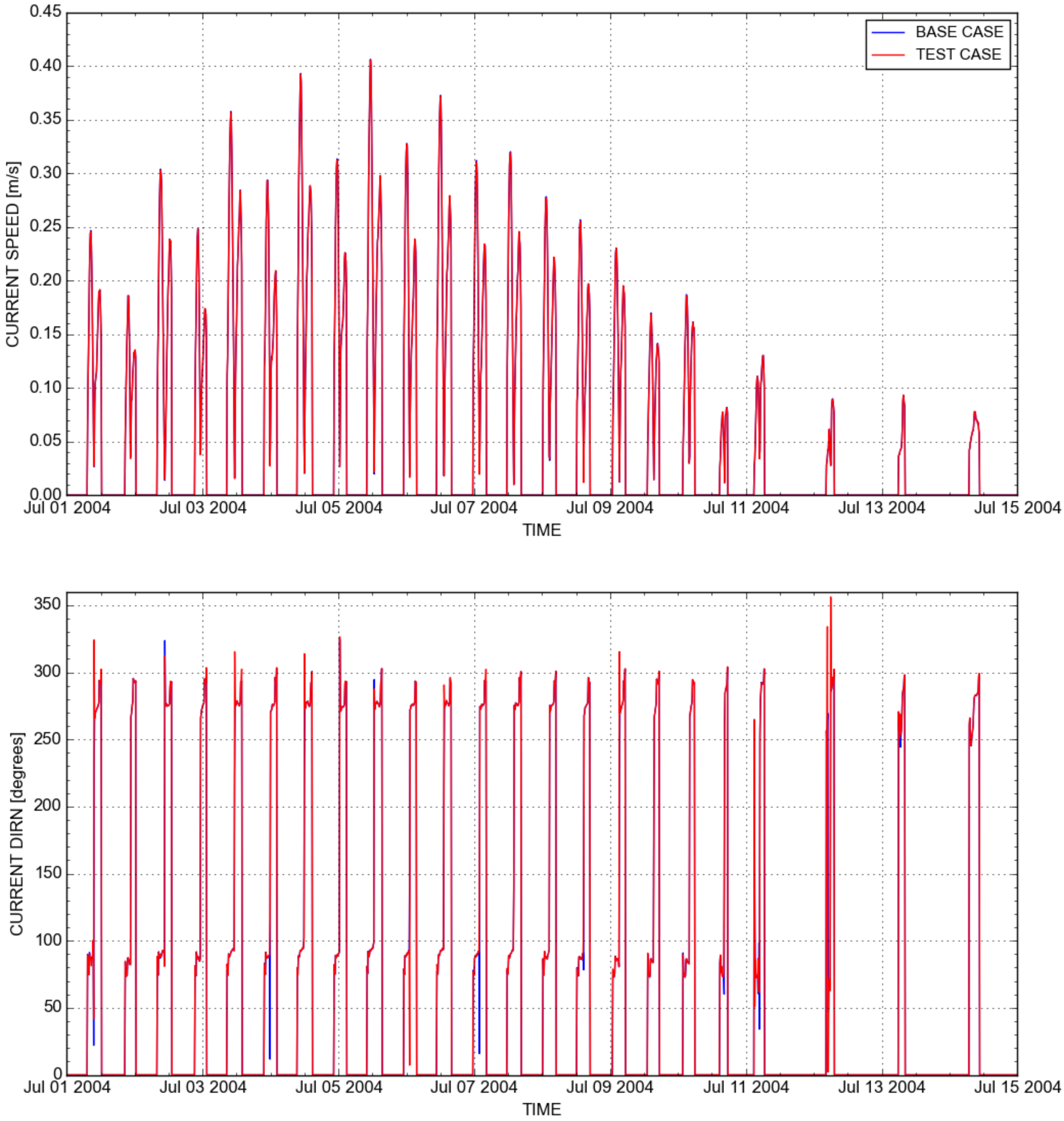


Figure 4- 11: Comparison of current speed and direction between the Base Case and Test Case for output location 3.

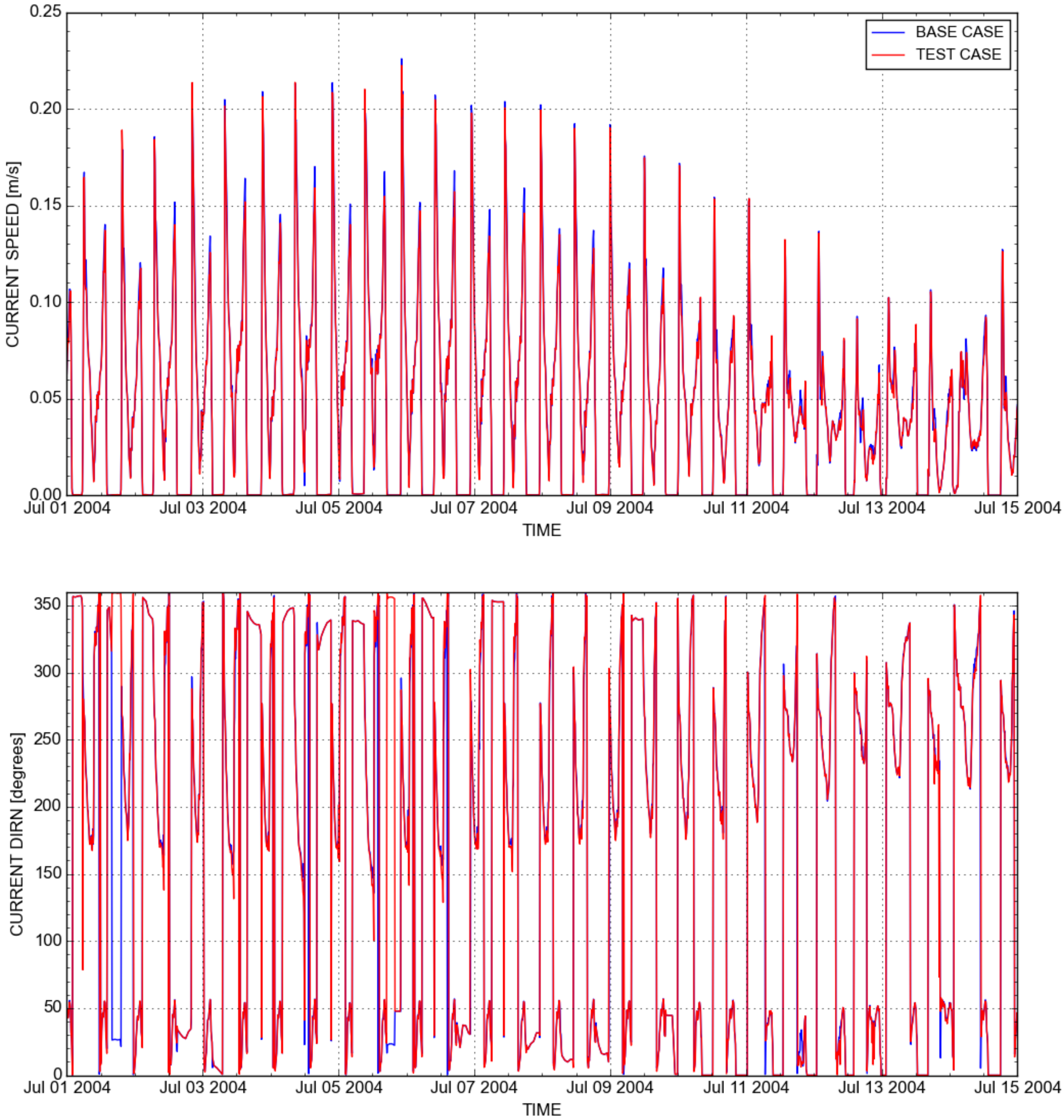
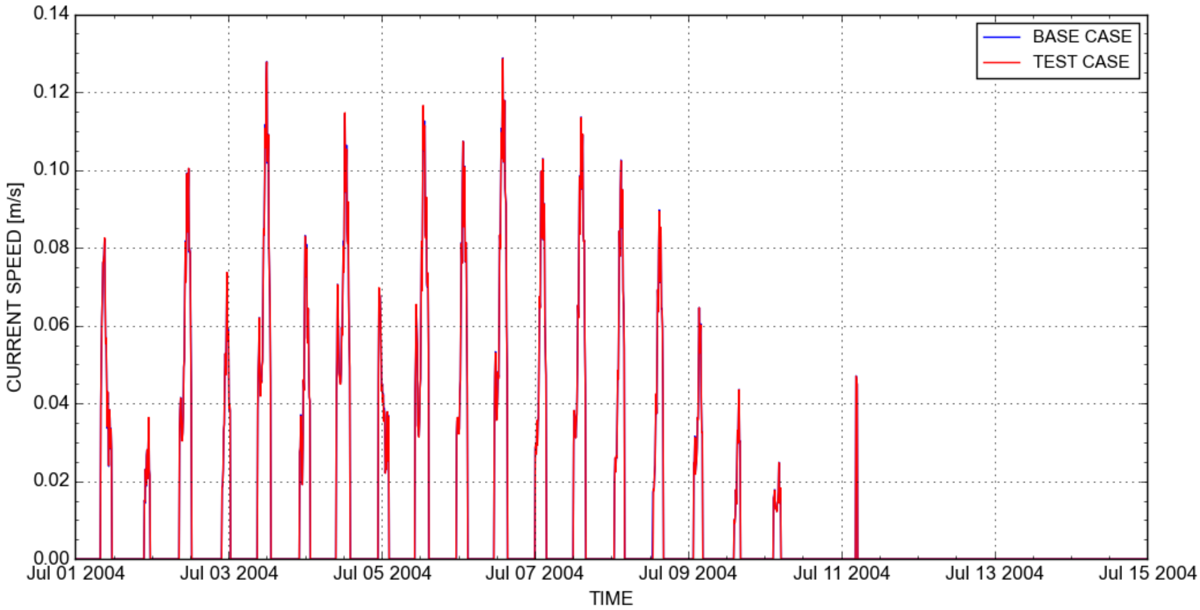


Figure 4- 12: Comparison of current speed and direction between the Base Case and Test Case for output location 4.



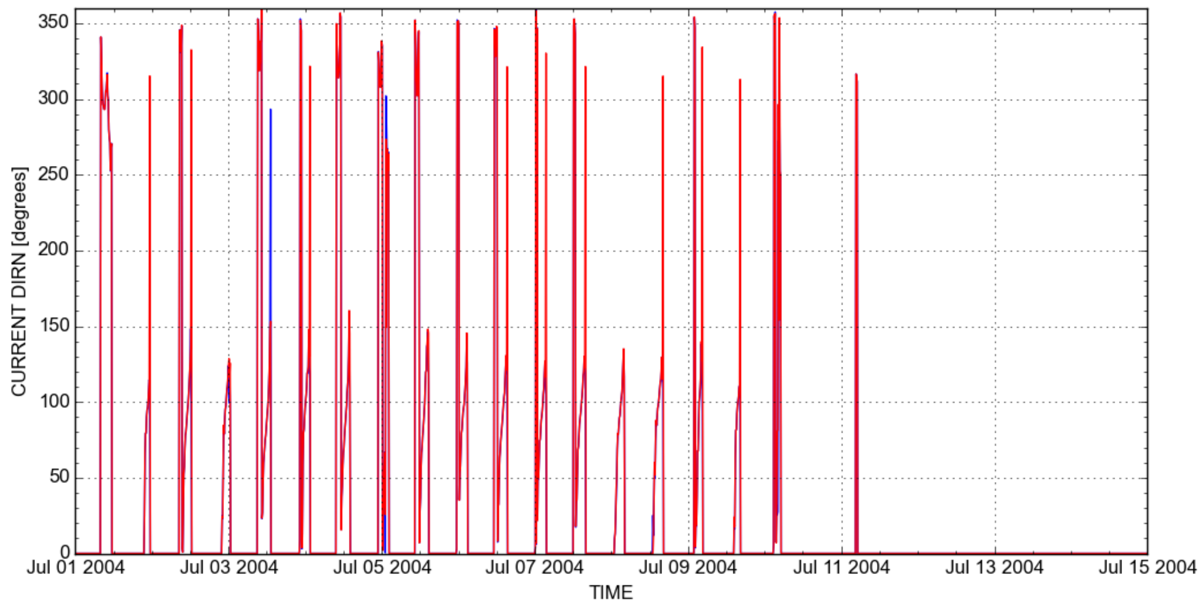


Figure 4- 13: Comparison of current speed and direction between the Base Case and Test Case for output location 5.

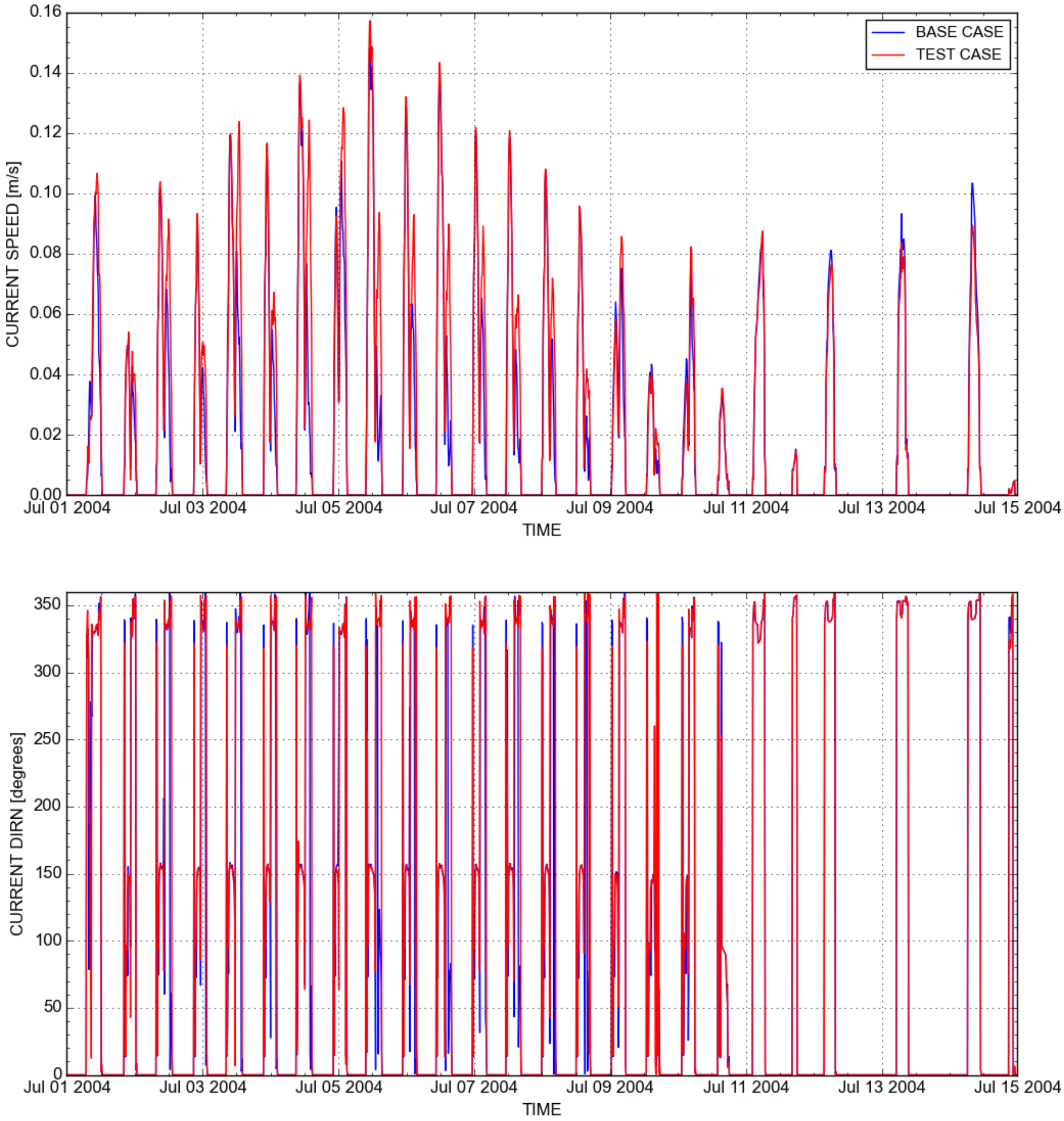


Figure 4- 14: Comparison of current speed and direction between the Base Case and Test Case for output location 6.

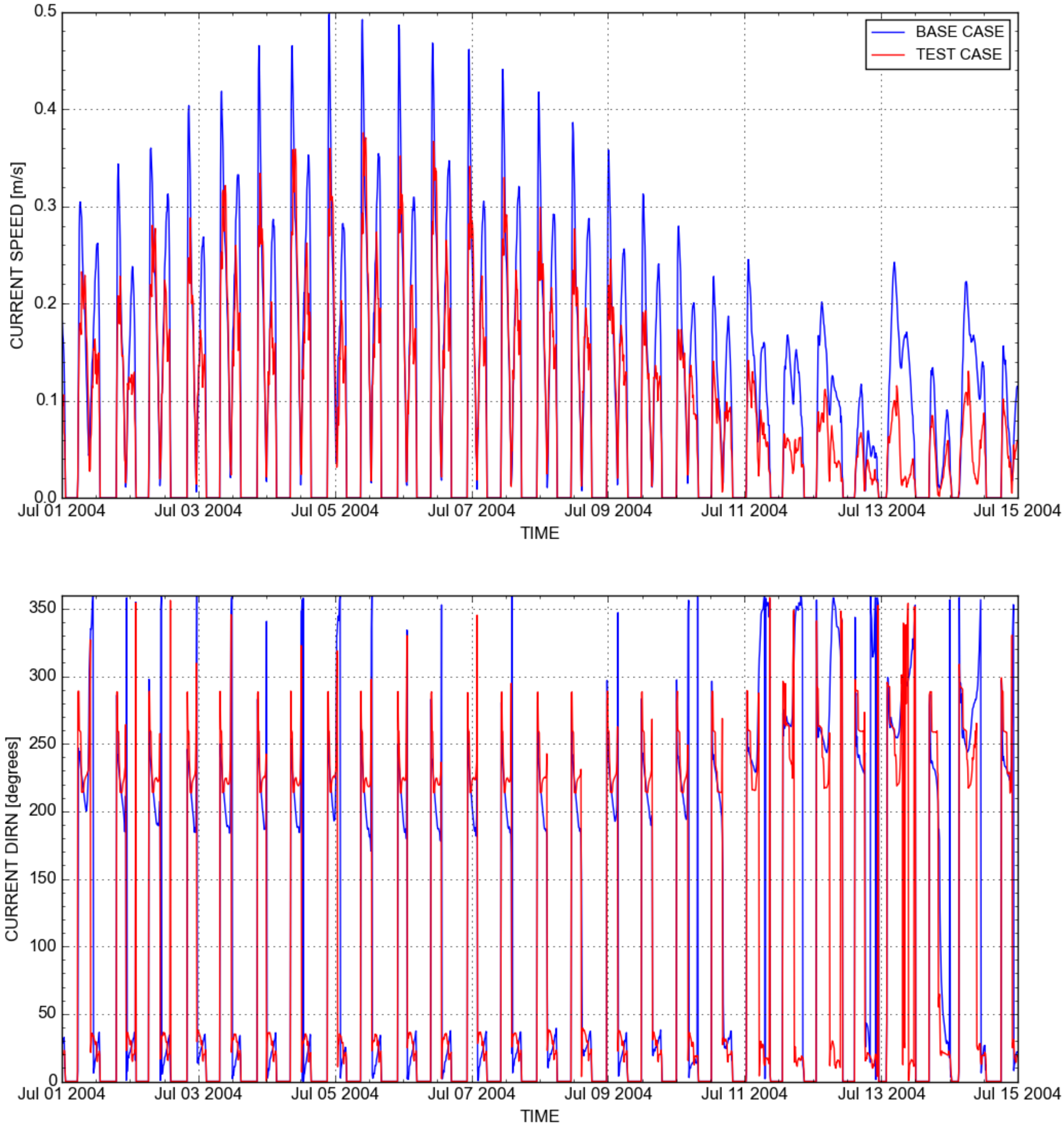


Figure 4- 15: Comparison of current speed and direction between the Base Case and Test Case for output location 7.

4.2.1 Impact on inundation patterns

The effect of the proposed development on water levels was assessed in terms of predicted changes at seven key output locations. The results of this assessment are shown in Figure 4-16 and Figure 4-17 over 14 day summer and winter tidal cycle respectively.

Results are presented as a series of submergence curve plots, showing the percentage of time during a spring-neap tidal cycle (horizontal axis) that water levels remain below a given height above chart datum (vertical axis). Note that these output locations are dry for part of the tidal cycle, hence submergences at low water are not shown.

This assessment illustrates that, for the seven key output locations during both a typical summer and winter spring-neap tide cycle, there is a negligible difference in inundation patterns between the Base Case and Test Case bathymetries.

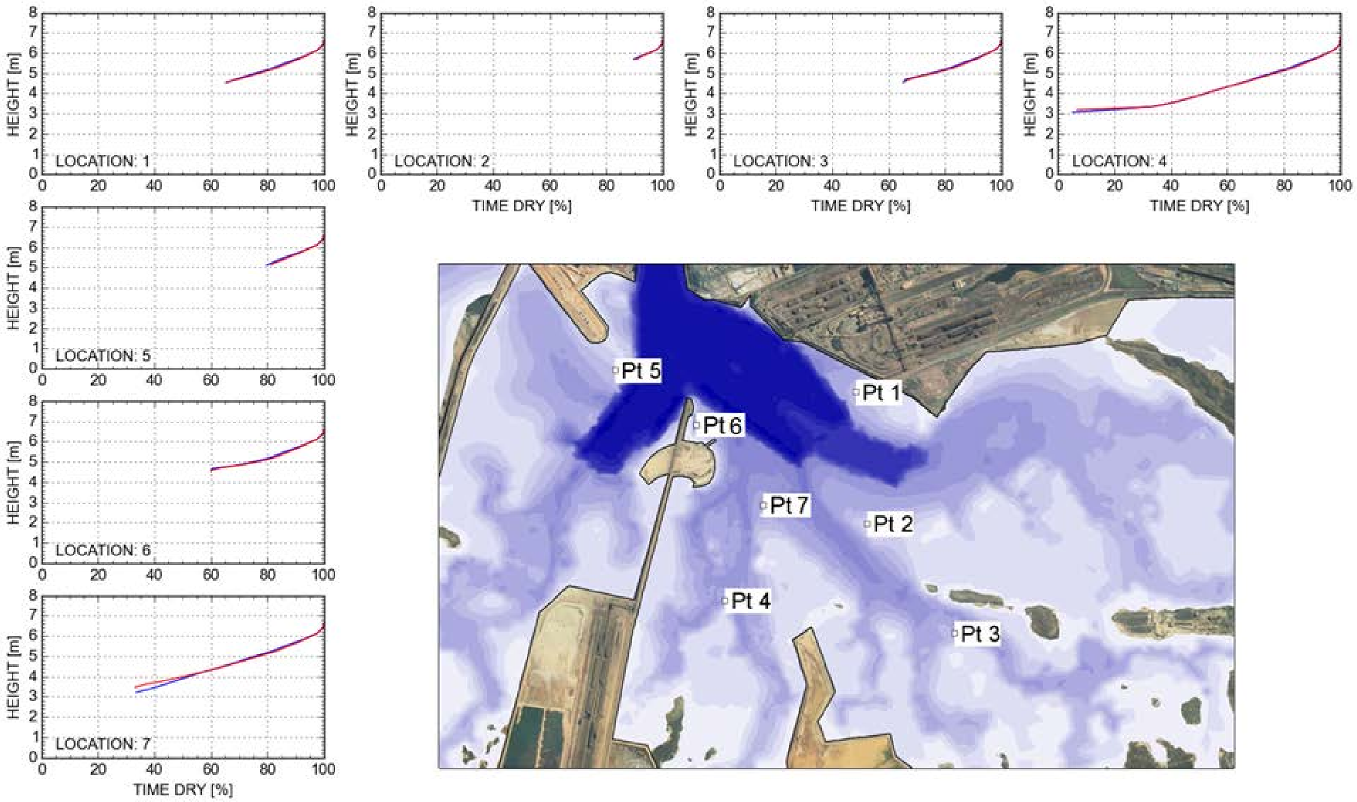


Figure 4- 16: Submergence curves during the selected summer tidal cycle at seven locations; Base Case (blue) versus Test Case (red).

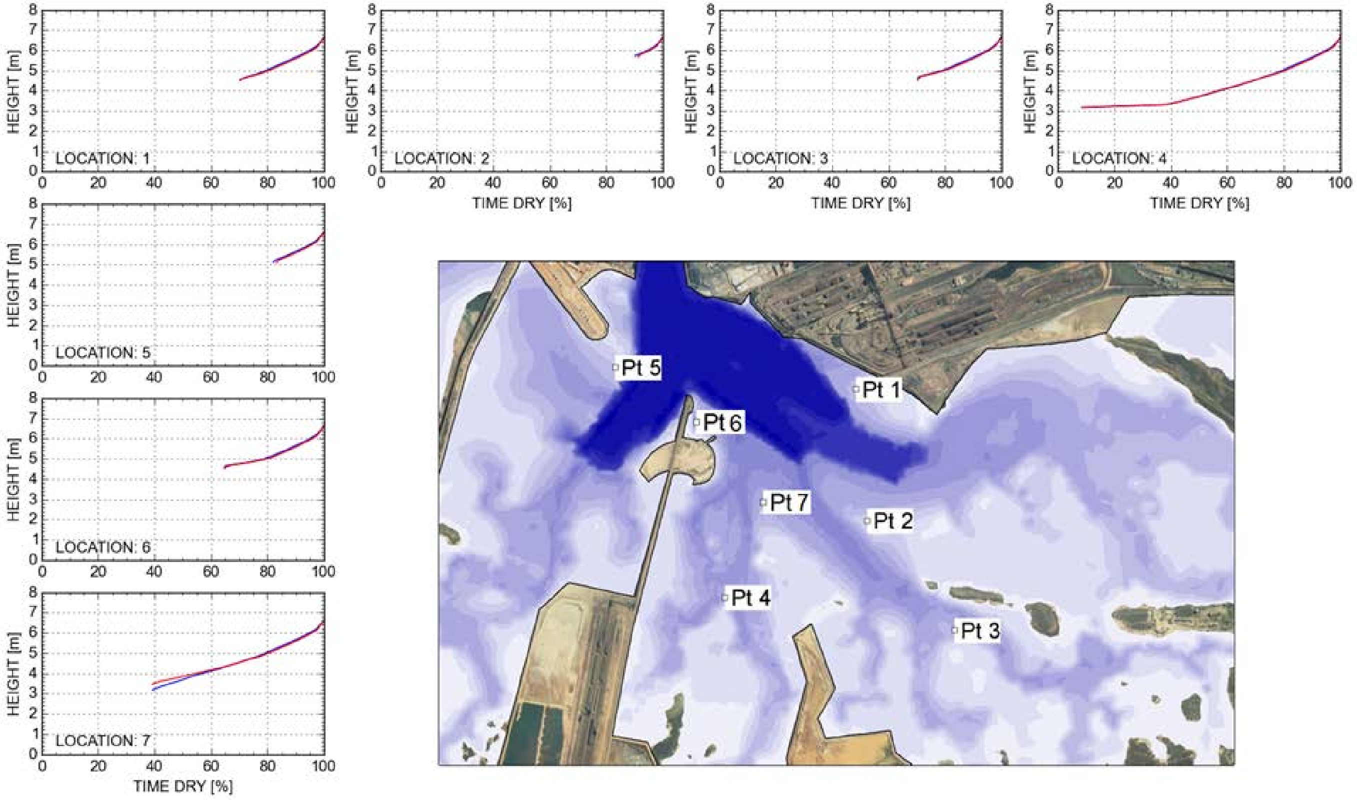


Figure 4- 17: Submergence curves during the selected winter tidal cycle at seven locations; Base Case (blue) versus Test Case (red).

5. CONCLUSIONS

The hydrodynamic modelling undertaken for the FMG tug haven has enabled the potential change in current conditions and water levels associated with the proposed development to be investigated and quantified. This was achieved using a validated MIKE 3 HD model that was used to simulate hydrodynamic changes associated with the pre-development case (Base Case) and the proposed development (Test Case) by undertaking a peak flow, mean flow, point location and inundation analysis.

Comparing the hydrodynamic results from the Base Case and Test Case modelling scenarios predict the following potential changes in current velocity and water level:

- For both flood and ebb tides, post-development flow velocity changes will be negligible outside of the immediate vicinity of the project area;
- There is a slight decrease in the mean flow velocity to the north east of the project area by at most 0.1 m/s;
- In the immediate vicinity of the project area, the mean flow velocity over both tidal cycles is reduced by 0.2 m/s (over the proposed dredge area including Lumsden Point and Stingray Creek);
- A large spatial differential between the base and test case in mean flow velocity of 0.4 m/s over the ebb tidal cycle is shown just south east of the Stingray Creek development (alternatively the eastern most boundary of the Lumsden Point reclamation area).

An examination of flow velocity, direction and inundation analysis was conducted at seven key output locations. This study showed:

- Current velocities are slightly more energetic for both the Base Case and Test Case during the Winter tidal cycle – by approximately 6-7%;
- On average, there is a 1% difference in the maximum current velocity between the Base Case at Test Case for all locations apart from location 7;
- For location 7, the Test Case clearly demonstrates an average reduction of 27% in the maximum current velocity; largely due to the inclusion of Lumsden Point and Stingray creek developments;
- Current directions are relatively unaffected by the development;
- Differences in inundation patterns are negligible.

Based upon the modelling and analysis presented in this report, the development will have negligible impact on flow velocities and inundation patterns outside the immediate vicinity of the project area. Although there are subtle differences between flood and ebb tides, the effect is consistent across both mean and maximum flow velocities.

REFERENCES

Australian Hydrographic Service (AHS) 2012, *Australian National Tide Tables 2013*, Australian Hydrographic Office, Commonwealth of Australia.

Danish Hydraulic Institute (DHI) 2011, *MIKE C-MAP*, release 2011 SP7.

Environmental Protection Authority (EPA), 2009, Environmental Assessment Guidelines No. 3

Fugro Pelagos Inc. 2012, Port Hedland Outer Harbour Survey, 23.00002013

WorleyParsons 2015, FMG Tug Haven Marine Studies, Sediment Plume Dispersion Modelling, 201320-08579-CS-REP-0001

Appendix 3: Sediment Plume Dispersion Modelling

This page has been left blank intentionally

FMG

FMG Tug Haven Marine Studies

Sediment Plume Dispersion Modelling

201320-08579 – CS-REP-0001

FMG Document 560PO-4347-RP-EN-003

11 January 2016

Level 7, QV1 Building,
250 St. Georges Terrace
Perth WA 6000
Australia
Telephone: +61 8 9278 8111
Facsimile: +61 8 9278 8110
www.worleyparsons.com
ABN 61 001 279 812

WorleyParsons Consulting

FMG
FMG TUG HAVEN MARINE STUDIES
SEDIMENT PLUME DISPERSION MODELLING

Disclaimer

This report has been prepared on behalf of and for the exclusive use of FMG, and is subject to and issued in accordance with the agreement between FMG and WorleyParsons. WorleyParsons accepts no liability or responsibility whatsoever for it in respect of any use of or reliance upon this report by any third party.

Copying this report without the permission of FMG or WorleyParsons is not permitted.

PROJECT 201320-08579 - FMG TUG HAVEN MARINE STUDIES

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CUSTOMER APPROVAL	DATE
A	Internal Review	B Heijlen	D Hansen		11-11-2015		
B	Client Review	B Heijlen	D Hansen	H Houridis	11-11-2015		
0	Issued for use	B Heijlen	D Hansen	H Houridis	15-12-2015		
1	Issued for use	B Heijlen	D Hansen	H Houridis	11-01-2016		

CONTENTS

EXECUTIVE SUMMARY

Fortescue Metals Group (FMG) requires capital dredging to be conducted for the proposed port towage services tug infrastructure facility at Anderson Point in Port Hedland. WorleyParsons has been commissioned by FMG to assess hydrodynamic and sediment plume dispersion impact due to proposed dredging works.

This report describes the Sediment Plume Dispersion Modelling that was performed to investigate the fate of the sediment plume generated by dredging activities associated with the project.

The Sediment Dispersion Modelling was carried out using WorleyParsons Port Hedland Sediment Dispersion model, which consists of hydrodynamic module (HD), mud transport module (MD) and spectral wave module (SW). The impact of dredging on sediment plume dispersion was assessed by applying the model to the dredging program in a summer and a winter scenario. For modelling purposes, the pre-development case was defined by the port layout and bathymetry as of May 2014, updated with projects approved by the Environmental Protection Authority (EPA) in January 2015. The post-development case was based on the proposed dredging layout. The model simulations incorporated all changes in bathymetry related to the proposed dredging footprint.

The results have been analysed to predict:

- suspended sediment concentration (SSC); and
- total sedimentation due to deposition of the dredge plume at completion of the dredging program.

Key findings are:

- SSC is expected to be less than 20 mg/L around the project area for 50% of the time.
- SSC is expected to be less than 50 mg/L around the project area for 80% of the time.
- SSC is expected to be less than 10 mg/L near the harbour entrance for at least 80% of the time.
- SSC throughout the harbour is expected to be lower in summer than in winter.
- Sedimentation due to deposition of the dredge plume of up to 200 mm is expected at localized areas within mooring basins AP2 and AP3.
- Average sedimentation due to deposition of the dredge plume of 115 mm is expected within the dredging area.

- Sedimentation due to deposition of the dredge plume in South Creek is expected to be generally less than 10 mm with sedimentation up to 50 mm in localised areas within the mangroves.
- Outside the areas discussed above, sedimentation due to the dredge plume is expected to be less than 5 mm.

ACRONYMS

BoM	Bureau of Meteorology
CD	Chart Datum
DHI	Danish Hydraulic Institute
DMMA	Dredged Material Management Area
EPA	Environmental Protection Authority
FMG	Fortescue Metals Group
GDA	Geocentric Datum of Australia
HAT	Highest Astronomical Tide
HD	Hydrodynamic
H_s	significant wave height
LAT	Lowest Astronomical Tide
MGA	Map Grid of Australia
MHWN	Mean High Water Neap Tide
MHWS	Mean High Water Spring Tide
MLWN	Mean Low Water Neap Tide
MLWS	Mean Low Water Spring Tide
MSL	Mean Sea Level
MT	Mud Transport
PHPA	Port Hedland Port Authority
SI	International System of Units
SSC	Suspended Sediment Concentration
SW	Spectral Waves
T_p	peak wave period
TPXO	TOPEX/Poseidon Global Tidal model

1. INTRODUCTION

Fortescue Metals Group (FMG) requires capital dredging to be conducted for the proposed port towage services tug infrastructure facility at Anderson Point in Port Hedland. The dredging area is located to the north of South West Creek and the proposed dredging works consist of:

- dredging of approach channel and tug pens to -8.0mCD. The total dredge volume is approximately 800,655m^3;
- onshore dredge spoil disposal to existing Dredged Material Management Areas (DMMA).

The proposed dredging footprint is shown in Figure 1-1 and Figure 1-2. Coordinates of the dredging set out points are shown in Table 1-1.

In order to support the required Marine Studies; two numerical modelling studies are required to identify potential environmental impacts resulting from the proposed dredging work. These studies include:

- a Hydrodynamic Modelling and Impact Assessment (WorleyParsons 2015) to quantify any potential change in current conditions and water levels as a result of the proposed project; and
- a Sediment Plume Dispersion Modelling to investigate the transport and fate of the sediment plume generated by dredging.

This report presents the Project's Sediment Plume Dispersion Study.

Figure 1-1: Proposed dredging location

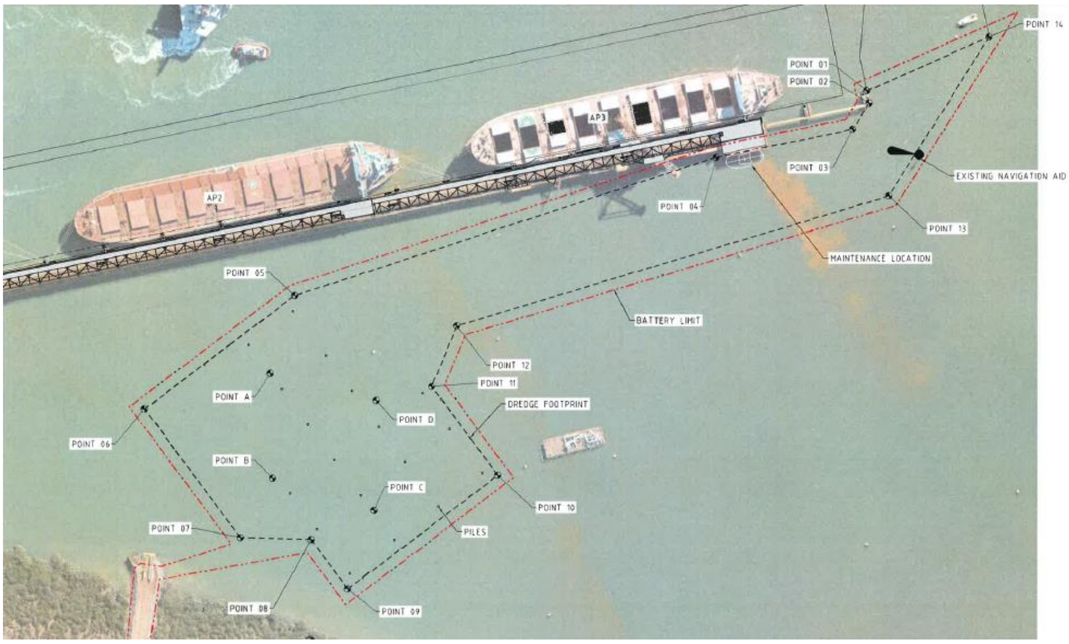


Figure 1-2: Proposed dredging layout

Table 1-1: Proposed dredging set out points

Point Number	Easting [m]	Northing [m]
01	665260.10	7751071.56
02	665253.51	7751062.29
03	665226.06	7751057.11
04	665123.17	7751130.27
05	664771.09	7751324.36
06	664603.67	7751353.88
07	664578.53	7751211.28
08	664620.82	7751163.20
09	664611.24	7751108.85
10	664778.65	7751079.33
11	664796.02	7751177.81
12	664851.54	7751198.56
13	665204.99	7750992.08
14	665371.08	7751023.41

1.1 Scope of work

This Sediment Plume Dispersion Study was undertaken to quantify the expected movement and concentration of material suspended during dredging operations over the approximately 12-week dredging program. The study's primary aim was to understand the distributions and intensities of suspended sediment plumes and sedimentation that the proposed dredging program might potentially generate. This was achieved by using the WorleyParsons in-house calibrated and validated Port Hedland Models hydrodynamic model, spectral wave model and sediment plume dispersion model.

For the purpose of sediment plume dispersion study, a sensitivity analysis was performed to determine which of the two bathymetries results in a "worst case" scenario for potential sediment plume impacts. The study investigated potential seasonal variations in the migration of the suspended material and sedimentation patterns for the "worst case". The model was run over both a summer and winter seasons.

Specifically, the scope of work included:

- Obtain and review the necessary dredging information related to the project, confirming dredging area and quantities. Determine expected material characteristics for the dredging program;
- run the existing WorleyParsons' wave model to develop the wave conditions to couple into the sediment plume model;
- simulate the dredging program for summer and winter seasons using the 'worst case' design option for the sediment plume model simulation; and
- generate spatial and temporal SSC and sedimentation maps from the sediment plume modelling results.

Discharged dredged material is assumed to stay confined within the limits of the DDMA and is excluded from this study.

The results of the study are described in Section 4, with conclusions of the findings presented in Section 5.

1.2 Modelling strategy

As the sediment transport model represents the integration of numerous modules with physical site data, it is necessary to clarify the overall strategy employed in the modelling process. To aid in this, the diagram shown in Figure 1-3 illustrates the integration of the various elements employed in the modelling process and their relation to the sediment plume dispersion modelling results.

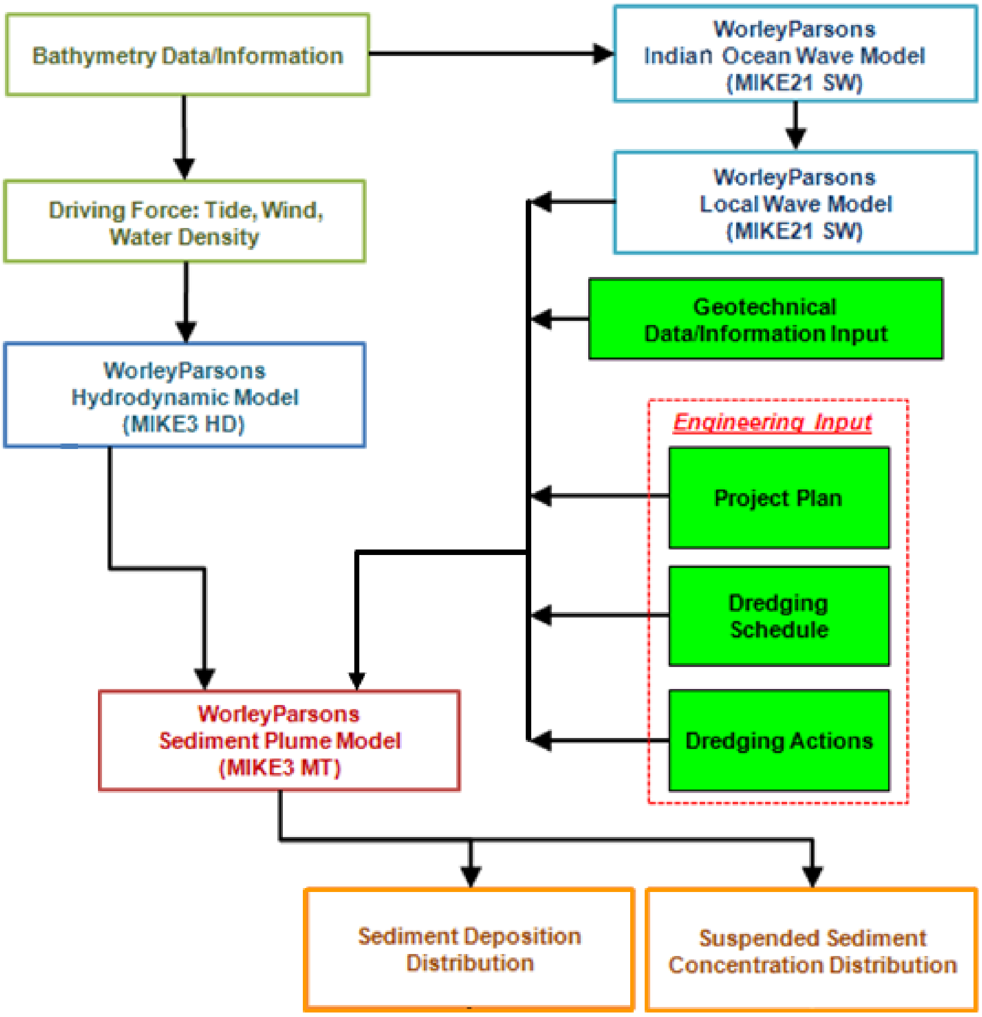


Figure 1-3: Schematic of the sediment dispersion modelling process

As illustrated in the schematic, the sediment dispersion study involves using wave and three-dimensional hydrodynamic models within the oceanographic setting of a tide-dominated estuary. The Port Hedland estuary has a complex bathymetry, with tidal flats and inter-tidal regions dissected by deep channels that contain strong tidal currents. As such, the models need to resolve the complex bathymetry and be capable of representing the strong tidal currents in the channel regions. Wetting and drying of the inter-tidal flats and flow into fringing mangrove areas also need to be properly represented in the model.

Sediment plume modelling studies must have a model domain that sufficiently encompasses the total area affected by the sediment plumes arising from the proposed dredging. The total affected area includes the initial extent of the sediment plume and deposition, as well as those areas affected by the reworking of sediments (which occurs through re-suspension and subsequent transport). As such, it is necessary to ensure that accurate wave and hydrodynamic inputs are used to force the sediment plume movement and sediment re-suspension. For correct characterisation of the wave and hydrodynamic climate, the study's domain must be large enough to properly capture wind energy transfer to the sea surface over long fetches, of about 50 to 100 km.

The sediment plume dispersion model must account for particle-size-specific sinking, sedimentation and re-suspension of sediments given the range of current and wave conditions indicated for the area, as derived by the hydrodynamic and wave models. The model must also account for the effects of sediment cohesion (i.e. clumping) on sinking rates of fine particles and the effects of sedimentation history, burial and armouring on re-suspension rates. In consideration of this, detailed site-specific geotechnical information is a necessary input for the sediment transport model.

The sediment plume dispersion model simulates any possible hydrodynamic changes as a result of morphology variation during the simulation. Changes to the hydrodynamics in an area such as Port Hedland, where tidal currents dominate the marine dynamics, will undoubtedly have an impact on plume behavior.

The sediment plume dispersion model simulates the full dredging program, from the start of dredging to completion. This allows the full extent of the dredge plume to be predicted by simulating its continuous movement away from the spill area throughout the dredging program. This approach avoids the potential risk of underestimating of the final plume extent that can be associated with other common approaches, such as scaling of a limited (eg one month) simulation.

Other necessary inputs are specific to the Project and relate to the dredging operation itself. These include details of the dredge vessel to be used, transport and disposal plans for the removed material, schedule and production rates.

All of these requirements have been considered in selecting the optimal models, parameters, and inputs employed in this study.

1.3 Study datum

Water depths and levels presented in this report are referenced to Port Hedland Chart Datum (CD), unless otherwise stated, and are in units of metres.

Geographical positions are provided in the Map Grid of Australia, zone 50 (MGA50) coordinate system, which employs the Geocentric Datum of Australia (GDA94) Geodetic Datum, unless stated otherwise.

All units are in standard International System of Units (SI) unless otherwise stated, with all bearings and directions provided in degrees relative to True North.

2. CLIMATE DESCRIPTION

2.1 General Oceanography

The coastal regions of the North West Shelf near Port Hedland experience a tropical arid climate, with a quasi-monsoonal seasonal shift in wind direction and rainfall patterns.

The hydrodynamics of the coastal waters near this site, and within the Port Hedland estuary, are dominated by a large tidal range that drives strong flood and ebb tidal currents. These currents are of scales of about 1 m/s in the near shore region, and more than 1 m/s in the estuary entrances and deeper channels in the tidal creeks during peak ebb and flood tides. The tidal currents are typically aligned along local bathymetric contours. Substantial areas of drying mudflats occur along the coastline and within the Port Hedland estuary. The bathymetry is flat and shallow, typical of intertidal flats in the region.

In this region wind forcing is secondary to tidal forcing for local currents, although wind forcing drives residual flows along the coastline, which is an important transport mechanism for suspended sediments. The winds in summer are quite persistent from the west/north-west and typically result in a long-term drift towards the north and east, following the coastline. Weaker and less persistent current reversals occur during times of northerly and easterly winds during autumn and winter.

2.2 Tidal levels

Tides at Port Hedland are semi-diurnal and macro-tidal with a mean spring tidal range of 5.5 m (AHS 2012). Standard tidal levels are given in Table 2-1.

Table 2-1: Port Hedland tidal planes (AHS 2012)

Tidal plane	Elevation above CD (m)
HAT (highest astronomical tide)	7.5
MHWS (mean high water springs)	6.7
MHWN (mean high water neaps)	4.6
MSL (mean sea level)	4.0
MLWN (mean low water neaps)	3.3
MLWS (mean low water springs)	1.2
LAT (lowest astronomical tide)	0.0

A typical spring-neap cycle is shown in Figure 2-1 (first two weeks in April 2004), determined from harmonic analysis using the published constituents for Port Hedland (AHS 2012).

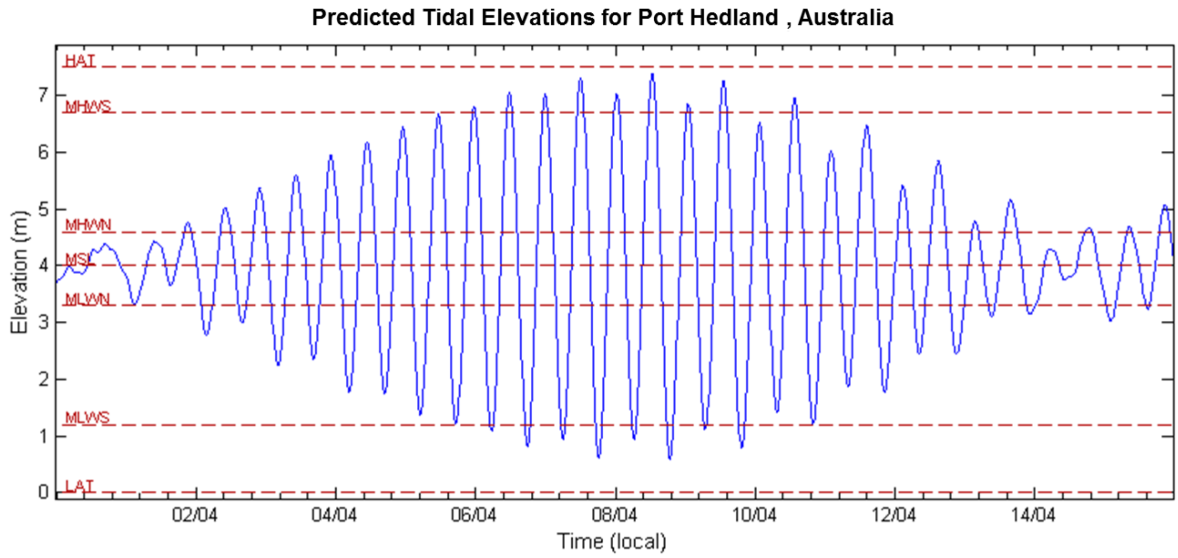


Figure 2-1: Typical spring-neap tidal cycle at Port Hedland

2.3 Winds

Wind roses presenting the seasonal variation in wind conditions at the onshore Bureau of Meteorology (BoM) weather station at Port Hedland Airport and the offshore Pilbara Ports Authority buoy at Beacon 15 are given in Figure 2-2. The roses show the wind speed and proportion of time that winds occur from each direction sector during each season. A comprehensive long-term series of data is available at each site, with the roses based on an 18-year record (1993–2011) at Port Hedland Airport, and a 10-year record (2000–2009) at Beacon 15.

The wind roses for Port Hedland Airport show the onshore wind climate is dominated by north-westerly onshore winds and south-easterly offshore winds. Offshore at Beacon 15 (approximately 20 km north-west of the Project site), the north-westerly onshore winds and south-easterly offshore winds are also evident, with a moderately higher occurrence of westerly winds and more consistent directionality to these dominant wind directions than that at Port Hedland Airport. Recorded wind speeds at Beacon 15 are also approximately 10 to 15% higher than those measured at the airport station in most cases.

The highest winds at Port Hedland are associated with the passage of a tropical cyclone, which affect the region from November to April. High wind gusts may also be associated with thunderstorms and squalls. These can occur with limited warning but are short-lived localised events, generally lasting less than an hour.

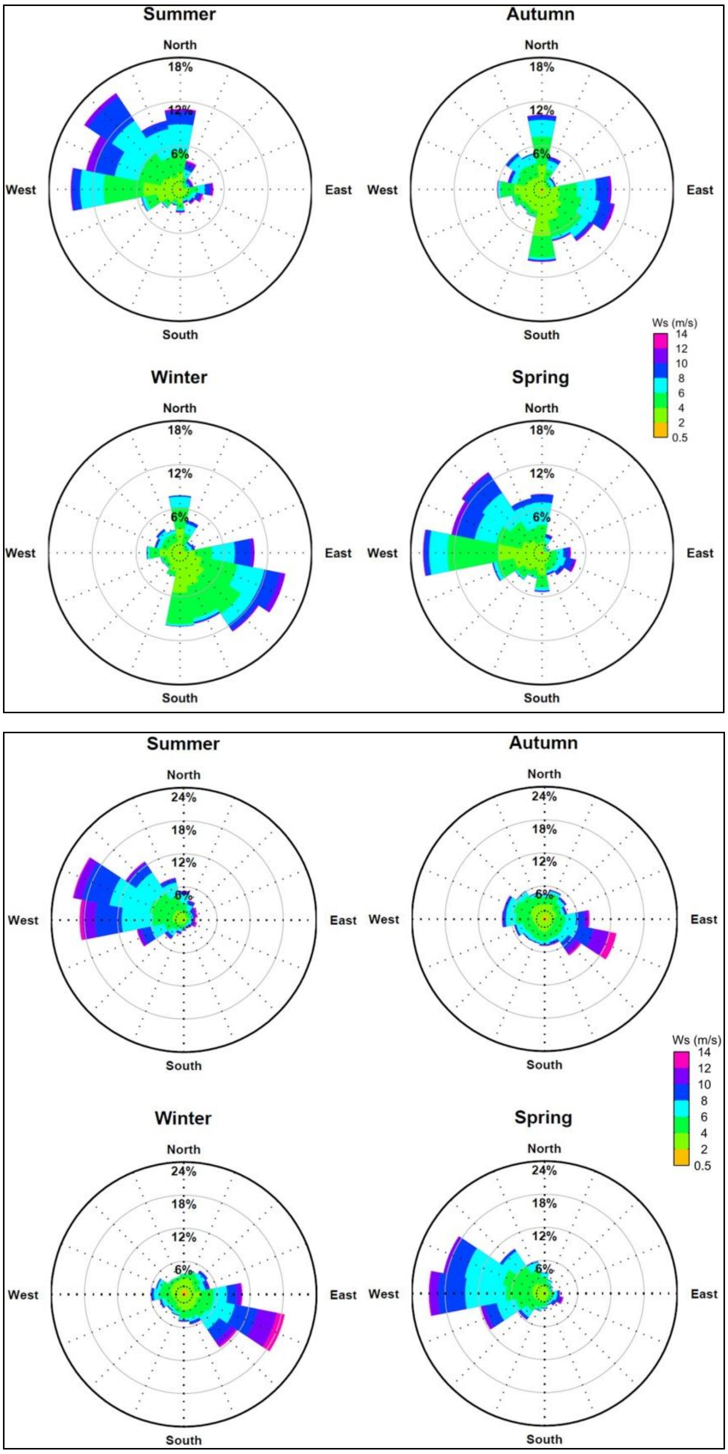


Figure 2-2: Seasonal wind roses at Port Hedland Airport (top) and Beacon 15 (bottom)

2.4 Waves

Seasonal wave roses, based on five years of measured wave data offshore at the Beacon 15 buoy, are shown in Figure 2-3. Wave heights (H_s) at Beacon 15 are below 2 m for 99.5% of the record, with this increasing to 99.8% of the time during winter and decreasing to 98.5% of the time during summer, when larger waves are more prevalent on account of the stronger onshore winds. Waves are from the north-west quadrant for approximately 92% of the record, with a low occurrence of waves from the east generated by easterly winds that prevail in winter at times when the oceanic swell is very low. The oceanic swell tends to be present all year with a peak energy period (T_p) typically between 13 and 17 seconds.

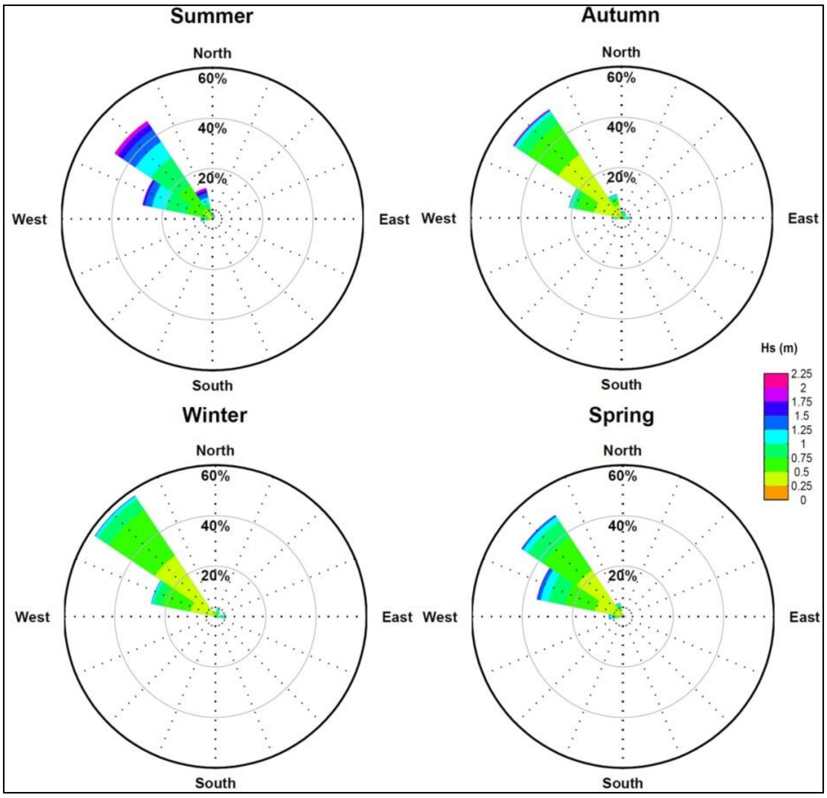


Figure 2-3: Seasonal wave height and direction roses at Beacon 15

Within the Inner Harbour waves are influenced by local bathymetry and sheltering and are predominantly generated by the local winds. Waves are an important consideration in the simulation of long-term sediment rate since given wave action affects re-suspension potential at the seabed.

3. SEDIMENT PLUME DISPERSION MODEL

3.1 Introduction

The dispersion and deposition of sediment from the proposed dredging activities was simulated with WorleyParsons' existing sediment plume dispersion model, coupled with WorleyParsons' validated hydrodynamic model for Port Hedland and the local wave model. The MIKE3 MT module was considered the most suitable given its accurate representation of wetting and drying effects (of particular importance in the Port Hedland Inner Harbour) and its ability to dynamically change the flow regime as sedimentation and erosion changes during the dredging program.

3.2 Model description

The sediment plume modelling is based on the MIKE3 MT multi fraction cohesive sediment transport model. The MIKE3 MT module describes erosion, transport and deposition of mud or sand/mud mixtures under the action of currents, wind and waves. The bed is described as layered and characterised by the density and critical shear strength for erosion. For the sediment plume study, a one layer approach has been applied.

The MIKE3 MT module, which calculates the combined transport of cohesive sediments (silt/clay; with grain size diameter ≤ 75μm) and non-cohesive sediments (sand; diameter > 75μm), is basically a solution of the advection dispersion equation. For a selected water layer, the equation can be represented as:

$$\frac{\partial c}{\partial t}+v_x\frac{\partial c}{\partial x}+v_y\frac{\partial c}{\partial y}=\frac{1}{h}\frac{\partial}{\partial x}\left(hD_x\frac{\partial c}{\partial x}\right)+\frac{1}{h}\frac{\partial}{\partial y}\left(hD_y\frac{\partial c}{\partial y}\right)+Q_LC_L\frac{1}{h}-S$$

where: c= suspended sediment concentration; $v_x, v_y =$ current speed in the x and y directions; h water layer thickness; D_x, D_y dispersion coefficients in x and y directions; Q_L=source discharge rate; C_L=source discharge sediment concentration and S= deposition / erosion rates.

3.3 Model domain and bathymetry

The large domain extent of the WorleyParsons Port Hedland Sediment Transport Model captures the full effects of wind and tidal-induced forcing on the circulation within the coastal region near and within Port Hedland estuary. The offshore extent covers an area 60 km offshore from Port Hedland, to a water depth of approximately 30 m, and between Depuch Island in the west and Larrey Point in the east. The size of the domain allows an accurate representation of the tides offshore from Port Hedland within the model, which is integral to ensuring that tidal hydrodynamics within the Inner Harbour are correctly characterised. The model domain's extent is presented graphically in Figure 3-1.

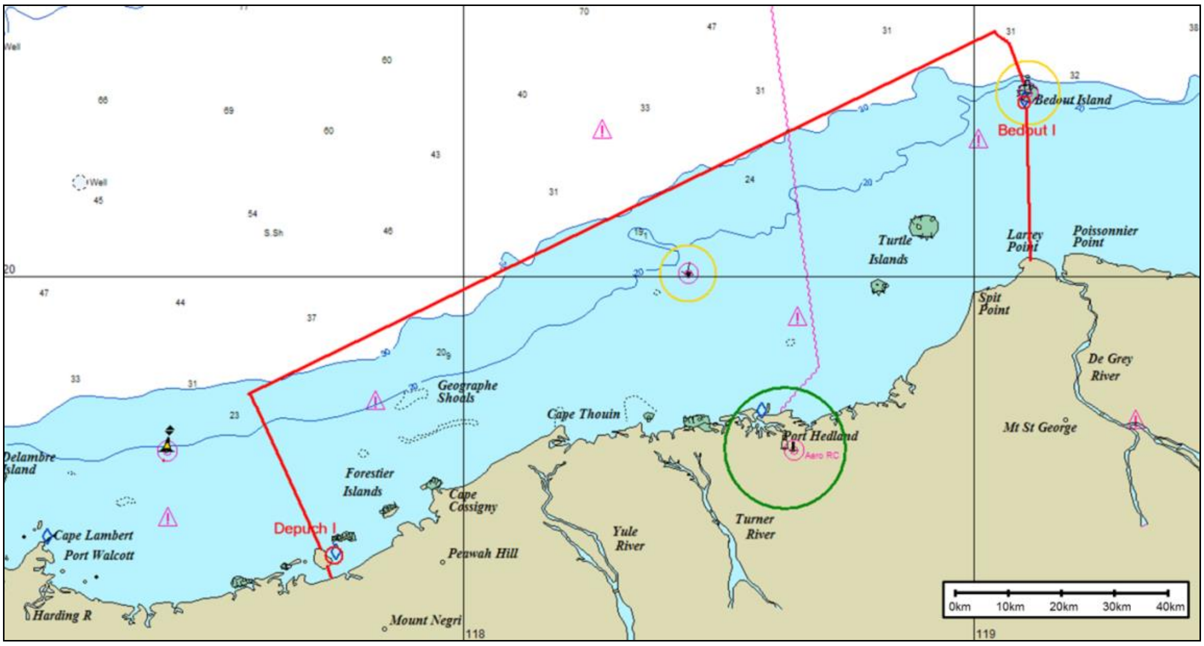


Figure 3-1: Mike 3 HD model domain (inside red boundary)

3.3.1 Project Layout

Two cases were set up i.e. pre-development and post development conditions as specified in the modelling specification (WorleyParsons 2015b):

- **Base Case (Pre-development)** – As a base case to represent the existing condition. This case includes the existing bathymetry updated with future stages of approved developments,

  The model's "Pre-development" (Base Case) local bathymetry is based on a series of hydrographic and LIDAR surveys, with dredging and developments included between 2000 and May 2014 including but not limited to:

  1. Channel and harbour maintenance dredging
  2. BHP Hunt Point CLOF (survey JDN, 2012)
  3. Utah Point dredging and development
  4. Anderson Point dredging and development (AP1, AP2, AP3)
  5. Harriet Point dredging and development
  6. Nelson Point dredging and development

7. South West Creek dredging and development: AP4, AP5 (FMG), and SP1, SP2 (Roy Hill)
8. Stingray Creek dredging (Eastern part of the Stingray creek dredged for BHP tugboats cyclone mooring)
9. Near shore – Offshore outer harbour survey
10. Outer Harbour Bathymetric LIDAR survey

Future approved developments, have been added onto the existing bathymetry in their full extent of approval as described below:

1. BHPBilliton, Hunt Point Marine Precinct (Tug Harbour)
2. PHPA, South West Creek Dredging and Reclamation

- **Test Case for Sediment Dispersion Study (Post-development) –** Proposed tug haven dredging included as shown in Section 1. Not all future approved developments that were included in the hydrodynamic impact assessment's test case (WorleyParsons 2015a) are included in the sediment plume dispersion model because both studies aim to provide a conservative assessment of the both dredge plume and the cumulative hydrodynamic impact.

Outside the area covered by available surveys, bathymetry data is extracted from the C-MAP digital chart database (DHI 2011).

The Sediment Dispersion Model uses an unstructured computational mesh which allows for higher resolution around areas of specific interest or that have complex bathymetries or morphologies. Computational length scales of the triangles range from 2000 m at the coarsest scale down to 10 m at the finest scale, to minimise run time while still giving a suitable level of accuracy in results for the assessment. To maintain computational accuracy, it is ensured that the mesh traversed this length scale range by no more than a factor of two across the entire computational domain (i.e. smaller cells are no smaller than 50% of the larger adjacent cell). A mesh showing the test case bathymetry is shown in Figure 3-2.

A sensitivity analysis was carried out to determine which of the two cases (base case or test case) results in a "worst case" scenario for potential sediment plume impacts. It was found that modelling the dredge plume with the base case bathymetry resulted in higher suspended sediment concentrations around the project area. Therefore, only results of the base case have been presented in order to provide a conservative analysis.

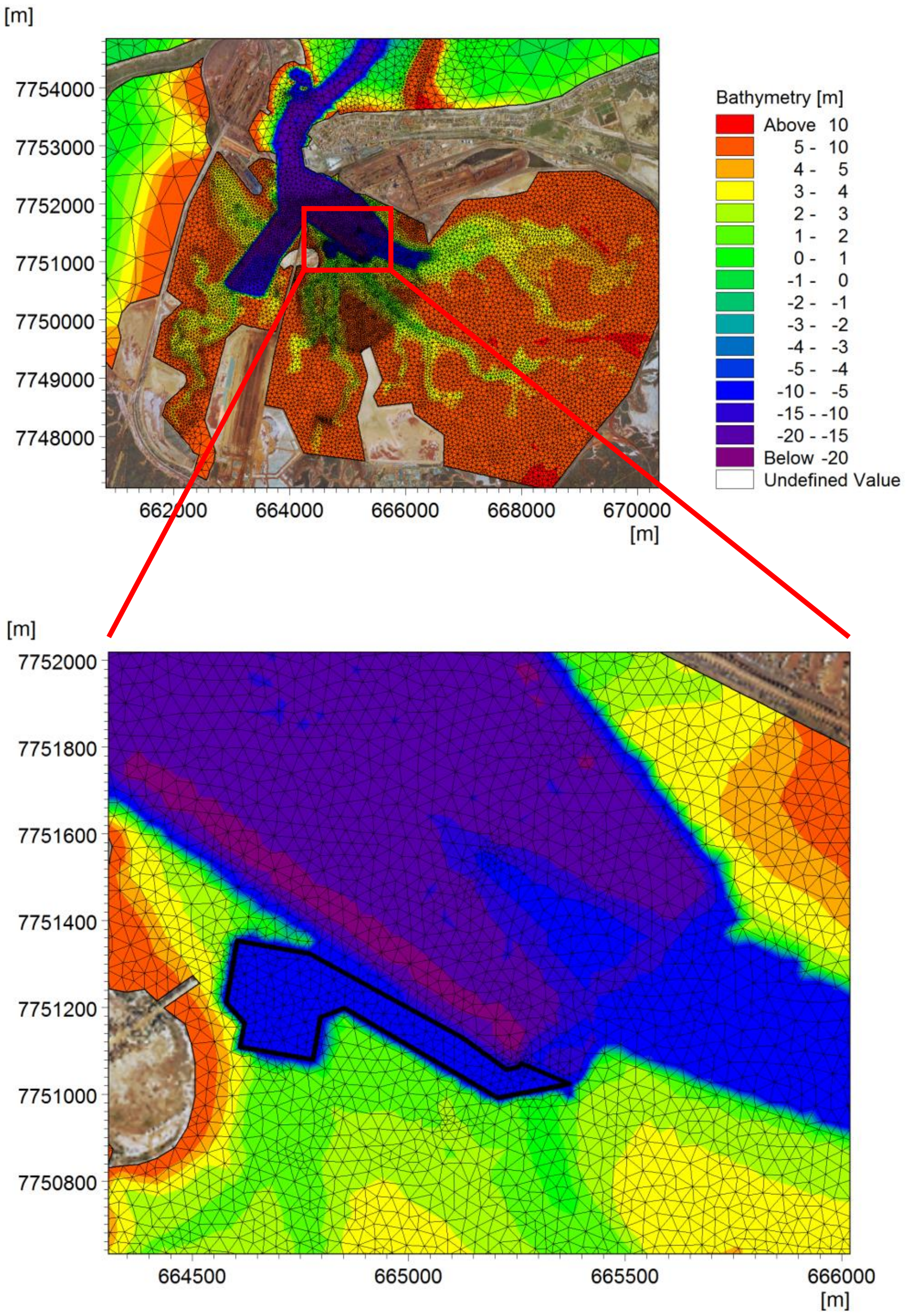


Figure 3-2: Model mesh showing post development model bathymetry and dredging footprint

3.4 Geotechnical conditions

A literature review on available sediment data has been carried out to determine appropriate input into the sediment dispersion model. Several geotechnical investigations have been carried out previously in the vicinity of the proposed dredging area for several projects. These include geotechnical investigations for the The Heng Shan project (2008), Lumsden Point Tug Harbour project (WorleyParsons 2010), Inner Harbour Cyclone Moorings project (WorleyParsons 2011), Lumsden Point Development project (WorleyParsons 2013). In addition, geotechnical investigations have been conducted within the proposed dredging area as part of the present project development.

3.4.1 Percentage of fines

Twelve representative samples at four locations in the vicinity of the proposed dredging area from previous geotechnical investigations and nine representative samples at four locations from the present geotechnical investigations were used to determine the percentage of fines in the material to be dredged. The borehole locations are shown in Figure 3-3. The relevant projects of which the samples are taken and sediment data for these boreholes are summarised in Table 3-1 and Table 3-2. The average percentage of fines (median grain size < 75 μm) of all samples in the dredging area was calculated as the average percentage of fines of all boreholes in tables Table 3-1 and Table 3-2, as shown in Table 3-3. This percentage fines, namely 28%, was implemented in the model as the representative fraction of fines.

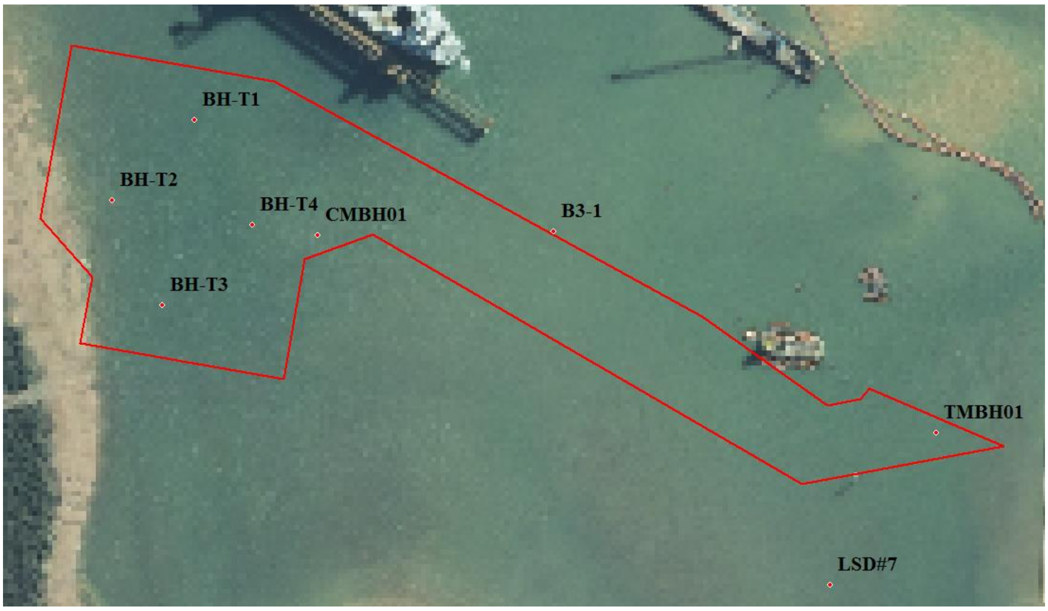


Figure 3-3: Borehole locations

Table 3-1: Silt and clay percentage at proposed dredging area from geotechnical investigations for the present project

Borehole number and coordinates (MGA_50)	Near surface marine sediment sample depth interval (m below seabed)	Silt and clay percentage (<75 µm)	Fine sand percentage (75 µm to 150 µm)
BH-T1 (664704.9E 7751292.66N)	0.0 to 0.45	4.0%	2.0%
	4.5 to 5.0	44.0%	14.0%
	7.0 to 7.5	34.0%	10.0%
BH-T2 (664637.4E 7751226.62N)	3.5 to 4.0	42.0%	15.0%
	6.33 to 7.0	20.0%	7.0%
BH-T3 (664679.1E 7751139.73N)	0.45 to 0.85	43.0%	8.0%
	9.5 to 10.0	22.0%	6.0%
BH-T4 (664752.6E 7751205.78N)	0.0 to 0.45	20.0%	4.0%
	3.2 to 3.5	20.0%	5.0%
Average over 0 to 0.5 m below seabed		**22.3%**	**4.7%**
Average over 3.0 to 6.0 m below seabed		**31.5 %**	**10.3%**
Average over 7.0 to 10.0 m below seabed		**28.0 %**	**8.0%**

Table 3-2: Silt and clay percentage at proposed dredging area from previous geotechnical investigations

Borehole number and coordinates (MGA_50)	Near surface marine sediment sample depth interval (m below seabed)	Reference Project	Silt and clay percentage (<75 µm)	Fine sand percentage (75 µm to 150 µm)
B3-1 (665001.1 E, 7751200.75 N)	0.0 to 0.15	The Heng Shan Project (WorleyParsons 2008)	10.0%	5.0%
	0.15 to 0.45		37.0%	8.0%
	5.5 to 5.65		44.0%	16.0%
	12.6 to 12.76		34.0%	7.0%
THBH01 (665315.8 E, 7751034.6 N)	4.0 to 4.4	Lumsden Point Tug Harbour project (WorleyParsons 2010)	30.0%	10.0%
CMBH01 (664806.3 E, 7751197.7 N)	2.5 to 2.7	Inner Harbour Cyclone Moorings project (WorleyParsons 2011)	30.0%	20.0%
LSD#7 (665228.8E 7750908.8N)	0.00 to 0.30	Lumsden Point Development project (WorleyParsons 2013)	9.0%	4.0%
	3.40 to 3.70		30.0%	12.0%
	5.25 to 5.50		30.0%	9.0%
	7.00 to 7.30		35.0%	8.0%
Average over 0 to 0.5 m below seabed			**18.7 %**	**5.7%**
Average over 3 to 6 m below seabed			**32.8 %**	**13.4%**
Average over 7 to 13 m below seabed			**34.5 %**	**7.5%**

Table 3-3: Summary of percentage fines (<75 µm) as used in the sediment plume model

	Average percentage fines from geotechnical investigation for present project (Table 3-1)	Average percentage fines from Previous geotechnical investigations (Table 3-2)
Average over 0 to 0.5 m below seabed	22.3%	18.7 %
Average over 3.0 to 6.0 m below seabed	31.5 %	32.8 %
Average over 7.0 to 10.0 m below seabed	28.0 %	34.5 %
Average of all samples	28.0 %	

3.4.2 Settling velocity

Ideally, the fractions and their corresponding settling velocities should be identified through site measurement when the real dredging activities begin. However, before the project starts the sediment parameters can be predicted through analysing the settling velocities of the geotechnical measurements taken at the Project site.

A site sediment plume monitoring program (WorleyParsons 2012) was carried out for the PHPA South West Creek Dredging and Reclamation Project: based on the sediment plume samples taken from the Cutter Suction Dredger (CSD) operation, the site settling velocity measurement indicated the lowest 40 to 50% of the plume material (by weight) produced a settling velocity of approximately 0.02 mm/s and the highest 10% (by weight) produced a settling velocity of 1 to 3 mm/s. It is stressed that the fine percentage of the dredged material over the South West Creek dredging area is approximately 19% which is lower than the 28% at the FMG Tug Haven and the samples normally were taken 100 m away from the CSD cutting locations.

For the current study, a total of four fractions were used for the finer component (diameter < 75 µm), with an additional fraction to address the finer sand component (75 µm < D_{50}< 150 µm). The additional finer sand included in the model is to ensure the entire plume generated by the spilled material is captured in the model. The proportions of the five components used in the model are summarised in Table 3-4. The high percentage of the fine fines (44.8%) and associated lower settling velocity imply that the spilled material at this site will have a high SSC and take longer to settle on the seabed.

Table 3-4: Particle size distribution and associated settling velocities as used in the model.

Mud type	Description	Average particle size represented (µm)	% Contribution to total spill volume	Settling velocity (mm/s)
Fraction 1 (fine fines)	Regularly transported large distances, generally will not settle out and contributing largely to suspended sediment migration	5	44.8	0.02
Fraction 2 (medium fines)	Can be transported large distances during spring tide, prime cause of remote sedimentation	15	18.0	0.2
Fraction 3 (fines)	Settles outside of the work area and can easily re-suspend under wave and current action	43	13.9	1.7
Fraction 4 (coarse fines)	Settles quickly outside of the work area	66	6.7	3.8
Fraction 5 (fine sands)	Settles quickly within and outside the work area	111	16.6	9.9

3.5 Marine forcing functions

The main hydrodynamic driving forces at the sites can be divided into tidal and non-tidal processes. Compared with the tidal and wind forcing, the hydrology of the adjacent watershed (e.g. river discharge) plays a minor role in ambient currents. The local meteorological conditions (e.g. wind) are expected to contribute to surface currents, with these effects having more influence during slack and neap tide periods. Waves are expected to influence the re-suspension of sediments. Not included are ocean currents, which are unlikely to significantly affect the hydrodynamic and morphological processes within the Inner Harbour.

3.5.1 Tides

Tidal data at the hydrodynamic model's ocean boundaries are taken from the TPXO7.0 dataset. This is a global database of harmonic tidal constituents published by the US National Climatic Data Center derived from the 10-year TOPEX/Poseidon satellite mission. The astronomical tides are included on all the open boundaries by spatial interpolation of the tidal constituent data (amplitude and phase) provided by the TOPEX/Poseidon global tidal altimetry data (TPXO7.0). The eight dominant semi-diurnal and diurnal tidal constituents are used in the simulations, in addition to the yearly constituents (Sa and Ssa), given they account for most of the tidal amplitude.

At the model coastal boundaries, the TOPEX tidal data is supplemented with predictions at local tide stations, available in the Australian tide tables. Constituents derived from the Depuch Island tidal station, located on the western boundary, are included in conjunction with the TPXO7.0 model data to generate an interpolated tide forcing along the western boundary. Tidal forcing on the eastern boundary will be generated by interpolation of the Bedout Islet tidal constituents and the TPXO7.0 data.

On all the open boundaries, the predicted water levels are site specific and vary in local time and along the boundary line. At the points along the boundary where water is flowing into the model domain, the flow is forced perpendicular to the boundary orientation, while at points where the water is flowing out of the model domain, the flow direction is extrapolated from the nearest points inside the model domain.

The model boundaries and location of the Bedout Islet and Depuch Island tidal stations are shown in Figure 3-1.

3.5.2 Ambient winds

Ambient wind conditions are analysed using offshore wind measurements at the Beacon 15 buoy, as well as land-based measurements from the Port Hedland Airport BoM station, 6 km inland of the Project site. All datasets have been interrogated and it appears that the consistent measurements at Beacon 15 during the selected simulation period are the most appropriate for hydrodynamic model forcing because they better represent local wind conditions over water.

While the dataset may capture some cyclone events, an independent assessment of hydrodynamic conditions during an extreme cyclone event was not in the scope of work.

3.5.3 Waves

The MIKE21 SW Wave Model was used to model the wave climate for the period of one year. The model was based on the existing WorleyParsons Port Hedland Wave Model but included the future approved projects in the bathymetry, as described in section 3.3.1. The domain covers the harbour area and output includes values every 10 minutes for significant wave height (H_s) and peak wave period (T_p) for the simulation period.

The SW Wave Model was forced at offshore boundaries by a wave energy spectrum, extracted from simulations previously undertaken by WorleyParsons, as well as by wind measured at Beacon 15 offshore Port Hedland for the year 2004.

Spatial output of the SW model, representing wave conditions in the region for the simulation period, was used as input for the MT module.

3.6 Model set-up and parameters

3.6.1 Spill rate from cutter suction dredge operations

Spill rates are defined as the fraction of dredged material that is suspended as spill in the water column.

Spill Volume = Spill rate * dredged volume

Published spill rates (SR) for hydraulic dredgers give a wide range of values from 0.00% to 5.14% of the production rate with an average of 0.73%. (Anchor Environmental 2003).

Doorn-Groen & Foster (2007) suggested an empirical formula to calculate the spill rate for CSD dredging methods:

Spill rate = Percentage of Fines * Spill Fraction

With the percentage of fines defined as fraction of the sediment with a median grain size diameter ≤ 75μm and the Spill Fraction equal to 25%.

For CSD operations in Port Hedland, WorleyParsons (2012a), based on site measurements, suggests a spill rate of 1% for CSD operations as appropriate. The percentage of fines in this study was 19%, which results in a spill fraction of 5.3%.

By assuming this spill fraction of 5.3% as more appropriate in the present study for the Port Hedland area for CSD operations and with a percentage of fines of 28% (Section 3.4.1), this gives formulas of spill rate and spill volume:

Spill Rate = 5.3% * 28% = 1.5%

Spill Volume = 1.5% * dredged volume

This spill rate of 1.5% is within the expected range (0.00% to 5.14%) but larger than the averaged 0.73% spill rate (Anchor Environmental 2003).

3.6.2 Dredging operation inputs

An indicative dredging methodology plan was provided to WorleyParsons as an approximate plan of the dredge operations, outlining the dredging methods and expected production rates. Dredge depths and volume in the modelling were based on the Dredging and Spoil Disposal Management Plan (FMG 2015).

The dredging operational inputs and assumptions used in the sediment plume dispersion model are summarised below:

1. The 7500kW CSD would operate from Northeast to Southwest, from the channel towards the Tug Haven Basin, dredging immediately to depth along this path in each sweep.
2. Dredge volume of the tug haven is estimated at 800,655 m^3 (FMG 2015).
3. An average hourly production rate of 680 m^3/hour (68,000 m^3/week on efficiency rate of 100 hours production per week) of material would be removed by the CSD. In total this represents approximately 12 weeks of dredging for the 800,655 m^3 of material to be dredged.
4. For the present assessment, the dredger is modelled in terms of dredging time and location with the material being introduced as a suspended sediment source. It was assumed the approximate dredging/filling time for each day will last for 14 hours. This includes a daily downtime allowance for maintenance during central daylight hours and produces an overall estimated efficiency of 60%, consistent with the expected production rates.
5. The spill rate associated with CSD operations is about 1.5% of the total material content returning to the water column, as specified in Section 3.6.1, with all material assumed to be released across the bottom of the water column.
6. Dredge plumes generated by the spilled fine material were run at 46 release positions (shown graphically in Figure 3-4) within the proposed dredged area to provide realistic spatial variability into the discharge from the dredger across the project site.
7. Propeller wash affecting the sediment plume due to CSD movement was also included in the model. It is assumed the propeller wash due to the movement from one location to another location lasted for 10 minutes (twice every day).
8. Dredged material would be transported by pipelines to DMMA. The DMMA was assumed to be a confined area and therefore discharge to the DMMA was not included in the model.

Figure 3-4: Proposed dredge footprint with spill locations as implemented in the sediment plume model.

3.6.3 Erosion and deposition

In the model, the deposition rate is formulated as a function of the settling velocity, the near-bed concentration and the actual critical bed shear stress for deposition. The settling velocity in this formulation depends on two key parameters, namely the grain size and an estimation of the level of flocculation, with larger grain sizes (i.e. those associated with sands) containing much higher settling velocities than finer materials. As such, sands are more readily deposited in the model than the fine silt and clay materials, which tend to remain suspended and transport greater distances in the model.

The erosion rate depends on the seabed properties; that is, whether the seabed is dense and consolidated or soft and only partly consolidated. In the present model, the bed is described as one layer with the material suspended and re-deposited due to wave and current action. A critical shear stress is usually set to determine whether the deposition material is re-suspended or not. The criterion for erosion is exceeded corresponding to the driving forces exceeding the sediment stabilising forces.

For the present study, a variable critical bed shear stress for deposition was employed. The critical shear stress for erosion was assumed constant. An overview of shear stress parameters is shown in Table 3-5.

One layer composed of five fractions of fine sediment was assumed in the MT model as described in section 0. The mud layer was assumed to be evenly distributed within the harbour at the beginning of the simulation.

Table 3-5: Critical shear stress parameters for all sediment fractions

Fractions	Critical shear stress for deposition (N/m^2)	Critical shear stress for erosion
1 (fine fines)	0.07	0.6 N/m^2 for mangrove area within Inner Harbour, 0.3 N/m^2 elsewhere
2 (medium fines)	0.07	
3 (fines)	0.2	
4 (course fines)	0.3	
5 (fine sands)	0.3	

3.6.4 Parameters summary

Key hydrodynamic and sediment transport model parameters and formulations are shown in Table 3-6.

Table 3-6: Key Hydrodynamic and Sediment Transport Model parameters and formulations

Parameter	Description	Value
Time step	Maximum computational time step	600 seconds
	Minimum computational time step	0.01 seconds
Eddy viscosity	Smagorinsky formulation, constant	0.4
Bed resistance	Roughness Height	Mangrove area: 0.3 m Remainder area: 0.065 m
Approximate spatial resolution	Open boundaries	2000 m
	Offshore and coastline >10 km from project site	500–2000 m
	Shoal areas and offshore <10 km from site	100–600 m
	Development site, navigation channel and Inner Harbour	10–120 m
Bed parameters	Density of bed layer	400 kg/m^3
	Bed roughness	0.0687 m
Critical shear stress	For deposition	See Table 3-5
	For erosion	0.3 N/m^2, except of 0.6 N/m^2 for mangrove area within Inner Harbour
Dispersion coefficient	Horizontal dispersion coefficient	1.0
	Vertical dispersion coefficient	0.1
Sigma layers	Number of vertical sigma layers	5 (equal layers each spanning 20% of the depth)

3.7 Simulation scenarios

Selection of an appropriate simulation year is required to ensure that the simulations were representative of typical conditions likely to be experienced at the proposed project site. WorleyParsons has selected this typical year based on analysis of a 10 year wind dataset at Beacon 15, on account of the influence of wind on drift currents at the project site.

A seasonal analysis of the winds during each of the years that were representative of the typical range of wind speed and direction of an entire 10 year dataset at Beacon 15 (2004, 2007, 2008 and 2009) concluded that 2004 was the most representative (i.e. closest to the average), with the seasonal wind roses for this year shown in Figure 3-5. The roses show the same dominance of Westerly and North-Westerly winds during summer, with winds tending towards Westerly during spring. Autumn and winter also replicate the dominance of the South-Easterly winds observed at the Beacon 15 offshore site. As such, 2004 was selected as the appropriate year for the Sediment Plume Dispersion Modelling.

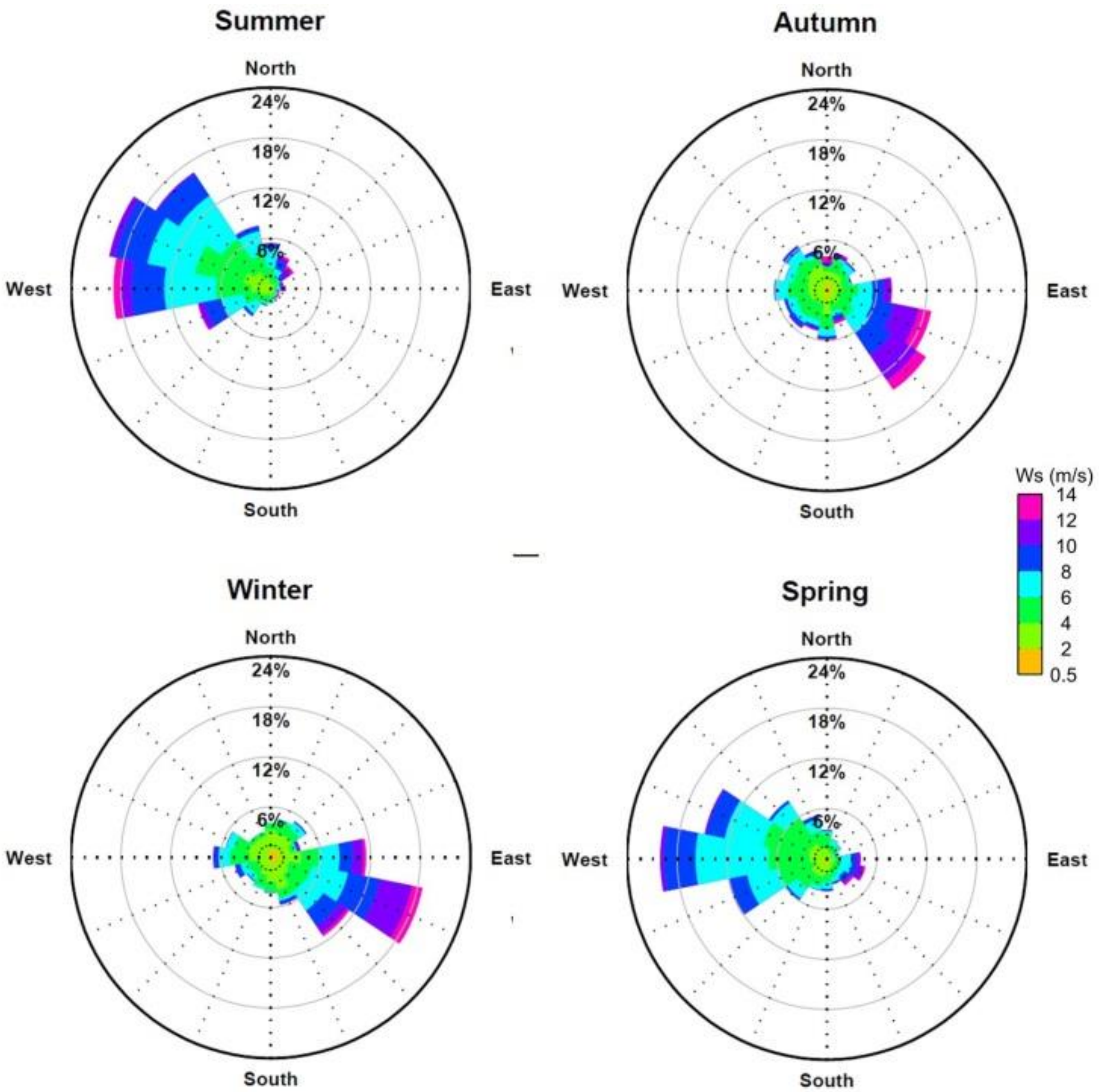


Figure 3-5: Seasonal wind roses for Port Hedland at Beacon 15 for January to December 2004

The model was run for a 12- week period over both summer and winter scenario in 2004. This enabled seasonal effects present in the forcing dataset to be included in the model and hence allowed for a shift in the dredging operation start date. Table 3-7 presents the simulations periods. All scenarios were run for an additional week to ensure long-term migration and accumulation effects were captured.

Table 3-7: Sediment Plume Dispersion Model Simulation Scenarios

Simulation	Period of simulation (excluding warm-up period)	Scenario
1	01/01/2004 to 06/04/2004	Base case, Summer
2	01/07/2004 to 06/10/2004	Base case, Winter
3	01/01/2004 to 06/04/2004	Test case, Summer
4	01/07/2004 to 06/10/2004	Test case, Winter

4. SEDIMENT DISPERSION MODEL RESULTS

4.1 Introduction

Predictions of the sediment plume dispersion and deposition patterns have been extracted from the sediment dispersion model for the summer and winter scenarios.

Results are presented for the entire simulation period representing the 12-week dredging program, as:

- Spatial plots of SSC;
- Point output of SSC; and
- Total sediment deposition in thickness at completion of the dredging program.

The spatial images of percentiles were selected as the most appropriate means of presenting the results as they clearly indicate the scale and magnitude of the dredging operation's environmental footprint.

The background SSC and sedimentation rates were not included in the analysis. Further analysis of the predicted plume behaviour was performed through analysis of SSC exceedance curves at five sites selected at key locations across the model domain. The location of each of these sites is provided in Table 4-1,

All values presented here for SSC and sedimentation rates represent concentrations above background levels.

Table 4-1: SSC exceedance curve analysis sites

Location	Mangrove location description	Easting (MGA 50)	Northing (MGA 50)
Point 1	Near Nelson Point	665800	7751700
Point 2	Near Smith Point	665900	7750500
Point 3	Upstream of South East Creek	666700	7749500
Point 4	South Creek near dredging area	664600	7749800
Point 5	Near Utah Point	663600	7751900
Point 6	Near Andersen Point	664400	7751400
Point 7	Upstream of SW Creek	664900	7750750

4.2 Suspended Sediment Concentration

Predictions of the suspended sediment dispersion and concentration over the course of the dredging operation have been illustrated in Figure 4-1 to Figure 4-6 which present the 50th (median) and 80th percentile SSC concentrations. These maps were derived using the integrated depth-averaged SSC values as they were the most indicative of the overall level of light loss in the water column which was of particular concern to corals and aquatic biota in the affected waters.

In the context of the results presented in this report, the percentiles represent the percentage of time during the dredging at which SSC levels are predicted to be below the given thresholds. For example, the 80th percentile is the SSC value below which 80% of the model predicted SSC values may be found. It is important to note that each model grid point will be associated with a different distribution of SSC values with time. Thus, a spatial plot of percentiles is a composite plot and does not represent a SSC distribution predicted to occur at a particular point in time.

The term SSC has been used in this report instead of total suspended sediment concentration as background values were not included in the model results. As such, SSC is defined here as the suspended sediment concentration, throughout the water column, resulting from the dredging and propeller wash associated with the project.

4.2.1 Summer scenario

Analysis of the summer scenario, shown in Figure 4-1, Figure 4-2 and Figure 4-3, indicate dredging over the summer season is expected to result in a general plume migration near the Project area within the Inner Harbour with the highest plume concentrations occurring in South Creek and Southeast Creek.

The 50th percentile plot (Figure 4-1), shows high concentrations (typically 10 to 20 mg/L) along the South East Creek near the dredging area. SSC within the Inner Harbour away from the dredging area are predicted to range between 2 to 10 mg/L.

The higher concentrations of the 80^{th} percentile (Figure 4-2) are the result of episodic re-suspension of fine material during spring tides and energetic wave conditions within the shallow water. In the immediate vicinity of the project site, maximum concentrations in the 80th percentile were between 20 and 50 mg/L, down to below 10 mg/L at distances over 1.0 km north east of the site.

Higher concentrations in the 80th percentile are also noted along Stingray Creek as a result of dredged material being transported to this area. These high concentrations, of up to 20 mg/L for the 80th percentile in some areas are as shown in Figure 4-2.

Outside the Inner Harbour, only low concentrations were produced, with SSC concentrations predicted to be < 5 mg/L and <10 mg/L near the outside of the main shipping channel as illustrated in the 50th and 80th percentile maps, respectively.

Further analysis of the predicted plume behaviour was performed through analysis of SSC exceedance curves at five sites selected at key locations across the model domain. The location of each of these sites is shown, along with the exceedance curves themselves, in Figure 4-3. Statistics of depth averaged SSC at these locations are summarised in Table 4-2.

It is worth noting that while locations 1,2,3,4, and 7 have 50th percentiles SSC values in the same range, the 80th and 95th percentiles are significantly higher for points 3, 4, and 5. This represents a higher SSC plume more often sweeping past these locations than at locations 1 and 2.

Point 5 and 6 have lower SSC exceedance curves, indicating that the sediment plume does not sweep through these locations in its full extent.

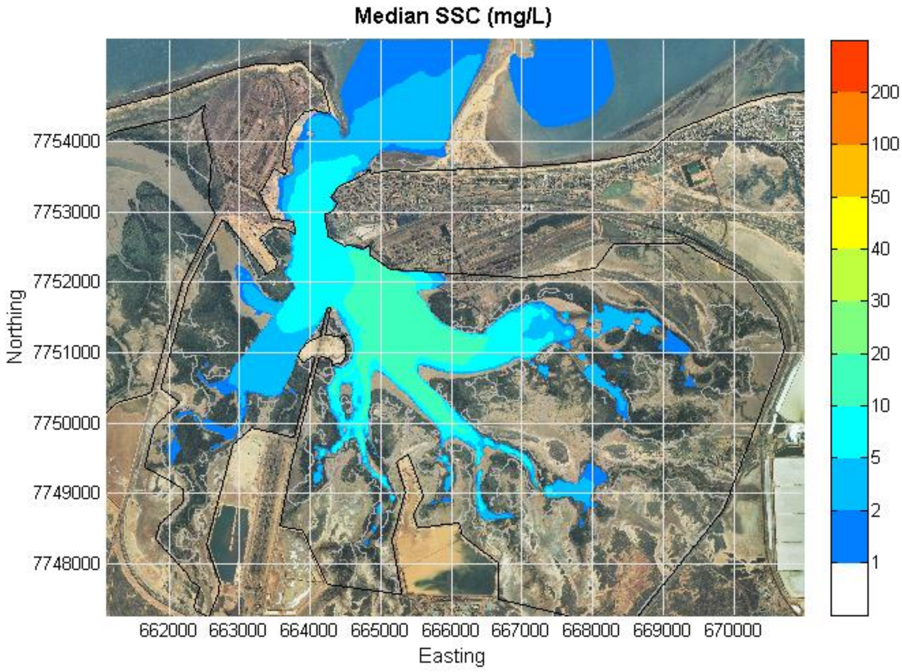


Figure 4-1: Predicted 50th percentile depth-averaged SSC in the Inner Harbour: summer scenario

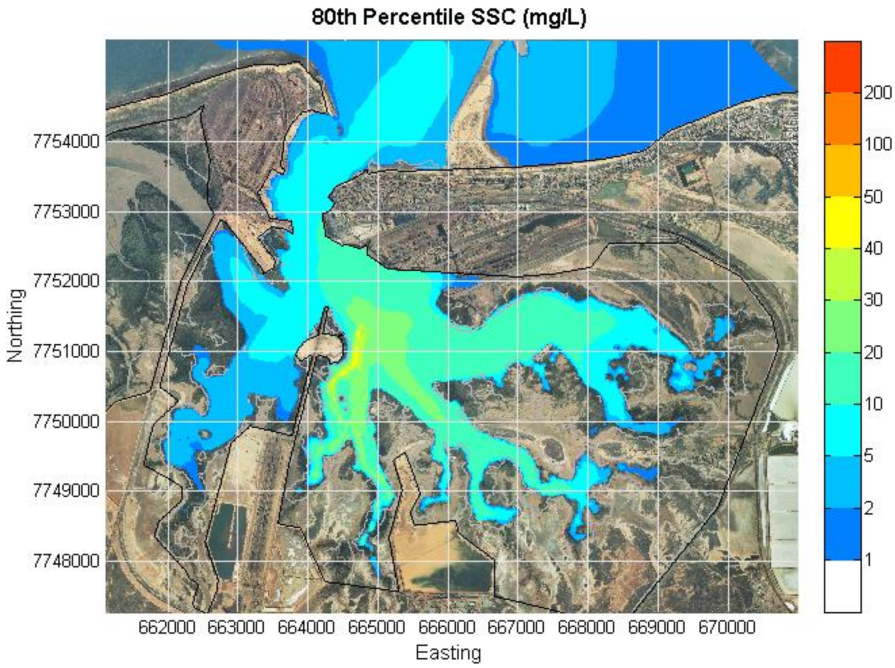


Figure 4-2: Predicted 80th percentile depth-averaged SSC in the Inner Harbour: summer scenario

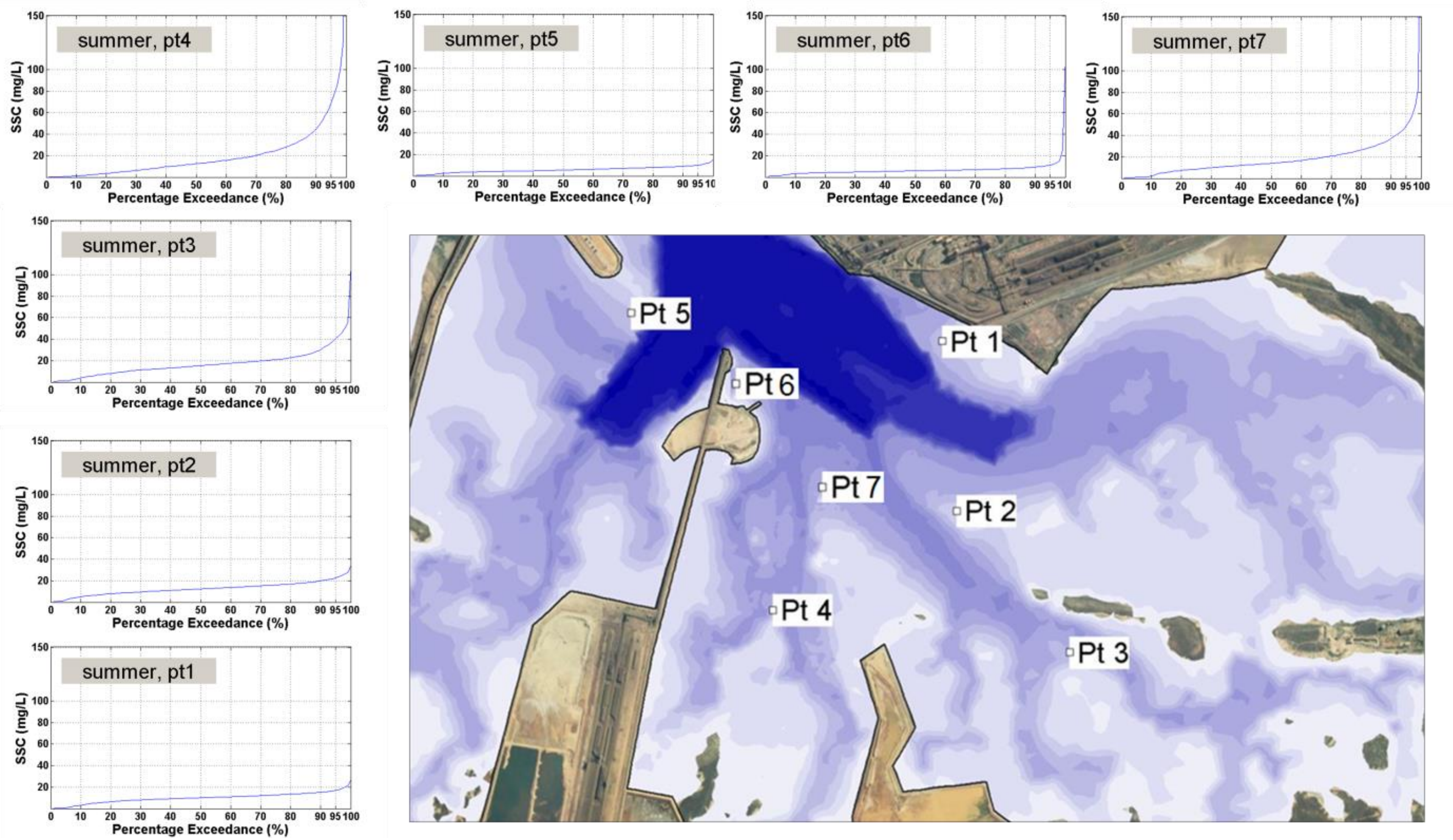


Figure 4-3: Predicted exceedance curves of depth-averaged SSC at key locations in the Inner Harbour: summer scenario

Table 4-2: Statistics of depth averaged SSC at key locations, Summer Scenario

Point	50th percentile (mg/L)	80th percentile (mg/L)	95th percentile (mg/L)
1	10	13	17
2	12	17	23
3	15	23	40
4	13	28	69
5	5	8	10
6	6	8	11
7	14	26	48

4.2.2 Winter scenario

Analysis of the winter scenario, shown in Figure 4-4, Figure 4-5 and Figure 4-6, indicate dredging over the winter season is expected to result in a general plume migration near the Project area within the Inner Harbour with the highest plume concentrations occurring in South Creek and Southeast Creek.

The 50th percentile plot (Figure 4-4), shows high concentrations (typically 10 to 20 mg/L) along the South East Creek near the dredging area. SSC within the Inner Harbour away from the dredging area are predicted to range between 2 to 10 mg/L.

The higher concentrations of the 80th percentile (Figure 4-5) are the result of episodic re-suspension of fine material during spring tides and energetic wave conditions within the shallow water. In the immediate vicinity of the project site, maximum concentrations in the 80th percentile were generally between 20 and 50 mg/L, down to below 10 mg/L at distances over 1.5 km north east of the site.

Higher concentrations in the 80th percentile are also noted along Stingray Creek as a result of infrequent re-suspension of material transported to this area from the dredging activities. These high concentrations, of up to 20 mg/L for the 80th percentile in some areas are as shown in Figure 4-5.

Outside the Inner Harbour, only low concentrations were produced, with SSC concentrations predicted to be < 5 mg/L and <10 mg/L near the outside of the main shipping channel as illustrated in the 50th and 80th percentile maps, respectively.

Further analysis of the predicted plume behaviour was performed through analysis of SSC exceedance curves at five sites selected at key locations across the model domain. The location of each of these sites is provided in Table 4-1, and shown, along with the exceedance curves themselves, in Figure 4-6. Statistics of depth averaged SSC at these locations are summarised in Table 4-2.

It is worth noting that locations 1,2,3,4, and 7 have 50th percentiles SSC values in the same range, but the 80th and 95th percentiles are significantly higher for points 3, 4, and 5. This represents a higher SSC plume more often sweeping past these locations than at locations 1 and 2.

Points 5 and 6 have lower SSC exceedance curves, indicating that the sediment plume does not sweep through these locations in its full extent.

Table 4-3: Statistics of depth averaged SSC at key locations, Winter Scenario

Point	50th percentile (mg/L)	80th percentile (mg/L)	95th percentile (mg/L)
1	10	14	18
2	11	16	21
3	14	19	25
4	19	37	75
5	7	11	13
6	8	12	27
7	18	30	61

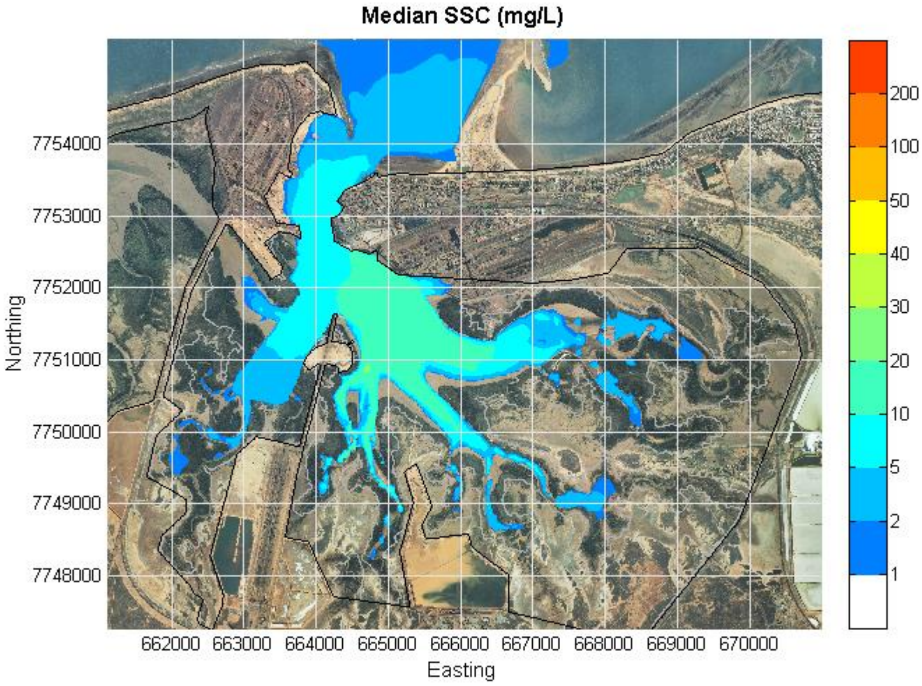


Figure 4-4: Predicted 50th percentile depth-averaged SSC in the Inner Harbour: winter scenario

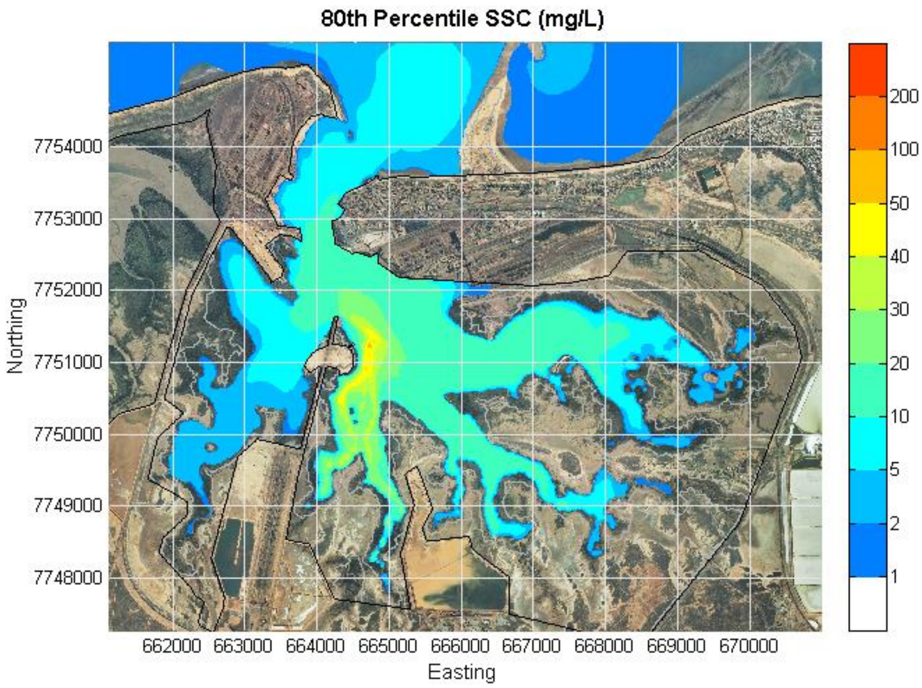


Figure 4-5: Predicted 80th percentile depth-averaged SSC in the Inner Harbour: winter scenario

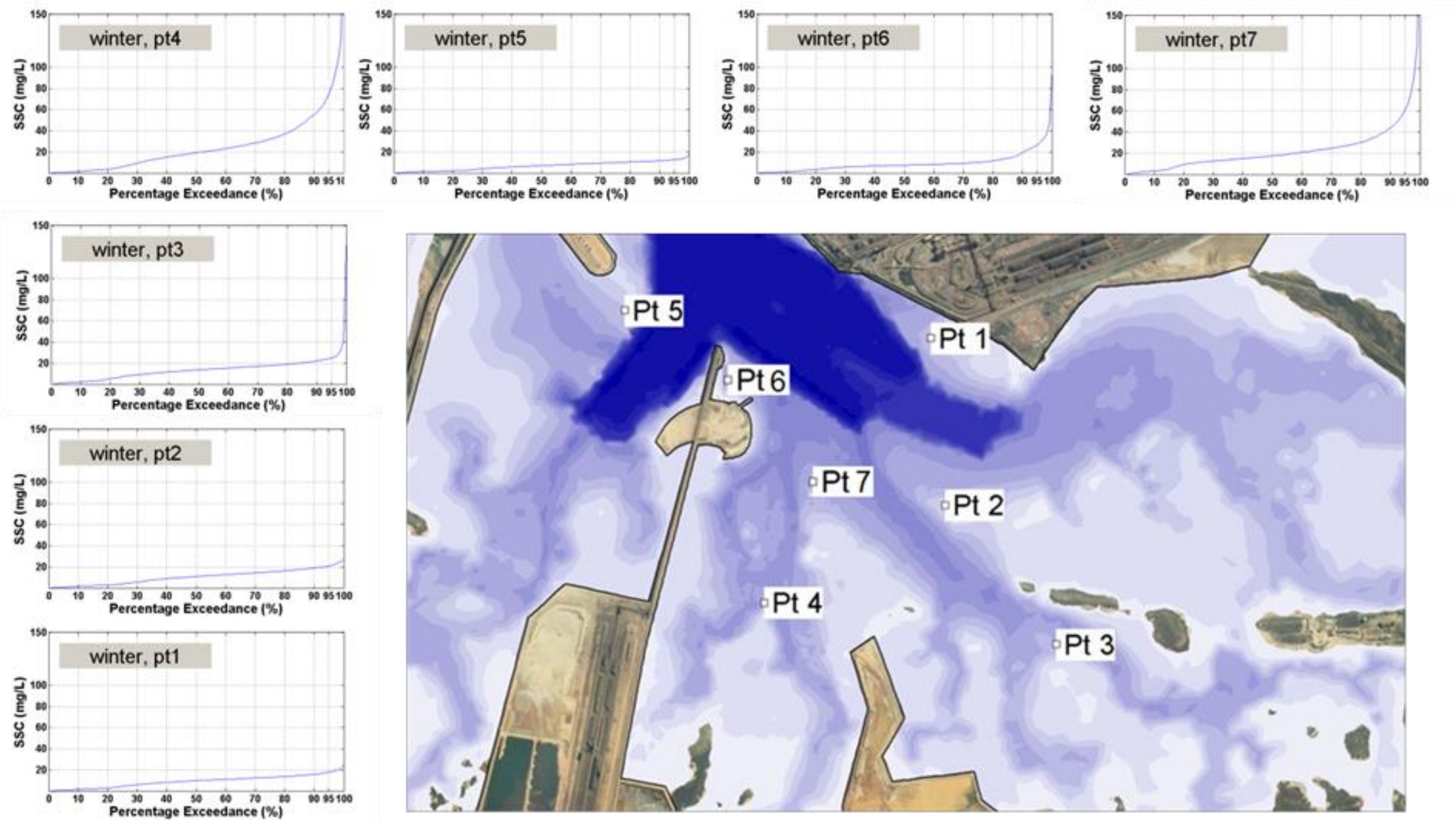


Figure 4-6: Predicted exceedance curves of depth-averaged SSC at key locations in the Inner Harbour: winter scenario

4.2.3 Seasonal effects

The sediment plume SSC near the dredge site in the winter scenario shows a higher SSC compared with the SSC in the summer scenario, as more of the plume is retained within the spill area and along South East Creek. This is likely due to the seasonal tidal flow rather than the seasonal wind conditions, given the dominant wind direction in winter is south-easterly - which will drive the plume north-west towards the harbour entrance. Figure 4-7 presents the extracted tidal flux across the section between Anderson Point and Nelson Point. The tidal flux is estimated to be approximately 15% higher in summer than in winter.

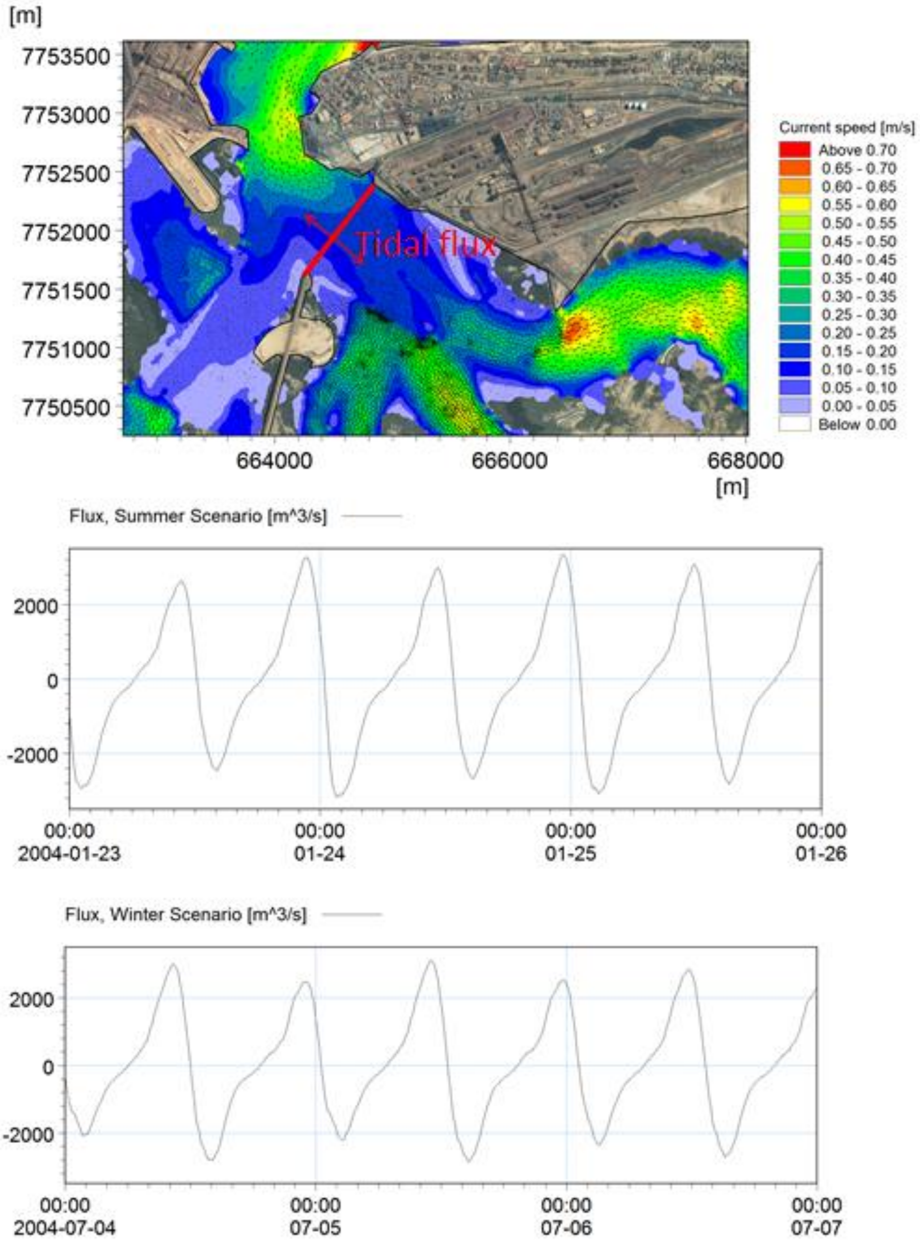


Figure 4-7: Extracted tidal flux across section between Anderson Point and Nelson Point (base case)

4.3 Total sedimentation

Sedimentation by settling of the dredge plume was assessed through analysing the total seabed thickness change at the end of the model simulation. Total sedimentation across all particle size fractions is analysed and presented.

The predicted net sedimentation thickness over a short timescale (less than two weeks), can be taken directly from the seabed thickness change results from the model. Over longer timeframes in excess of one to two months, the sedimentation consolidation effect from the dredging should be taken into account (Young & Townsend 1986). Consolidation is the volume change in sediment material over time and as such, the fully consolidated volumes of fine sediments are often only a fraction of their initial deposited volumes. Whitehouse & Soulsby (2000) concluded that the dry density of soft soil due to dredging under consolidated deposits could increase from 200 kg/m^3 near the surface to 500 kg/m^3 at a depth of 1m. Typical surface dry densities of intertidal mudflats are in the range 500 to 1000 kg/m^3. Underneath recent deposits, the dry density (especially in clays) may be as high as 1000 to 1600 kg/m^3 at a depth of 1 m.

In view of the dredging program's long time scale (approximately 3 months), the consolidation effects have been taken into account in the total seabed thickness change images, with a final density of approximately 1000 kg/m^3 assumed to ensure a conservative estimate of the seabed thickness. The resulting total seabed thickness change from the model, post-consolidation, is presented in Figure 4-8 for the summer scenario, and Figure 4-9 for the winter scenario.

Deep basins close to the source of the sediment spill tend to catch most of the sedimentation due to the decreasing current speed in deeper areas. This is can be seen in Figure 4-8 and Figure 4-9, where the largest sediment deposition occurs in the AP2 and AP3 mooring basins. Within these basins, sedimentation is expected to result in a 10 to 200 mm change in the seabed thickness. Expected sediment deposition in the turning basin north of AP2 and AP3 is generally less than 10 mm. Over 1 km away from the dredging area, the level of expected sedimentation is minimal (<2 mm). Along South Creek, the deposition thickness generally varies from 2 to 10 mm with some higher spots of up to 50 mm (Figure 4-8 and Figure 4-9).

Changes to bed thickness in mangrove zones are minimal, with most of the Inner Harbour mangroves expected to show less than 5 mm over the summer and winter scenarios apart from localised thickness changes of 5 to 50 mm in the mangroves immediately adjacent to the Andersen Point along the South Creek side, as shown in Figure 4-8 and Figure 4-9.

Seasonal variation on the thickness changes is not obvious; however winter simulation results generally show slightly more sediment deposition than summer simulation results.

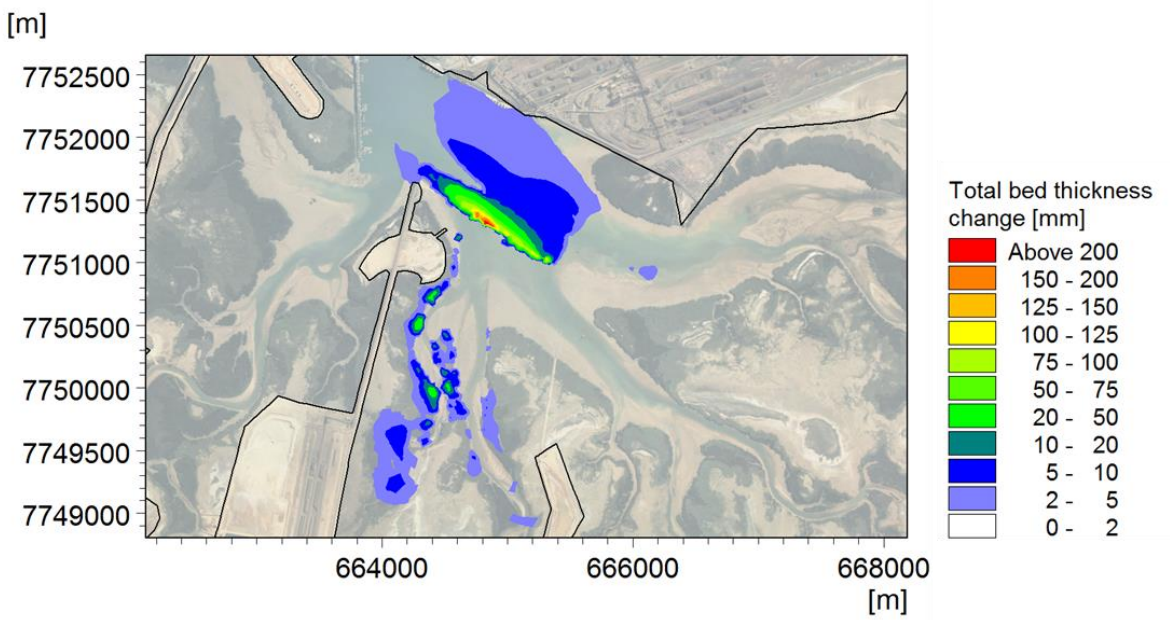


Figure 4-8: Total seabed thickness change after completion of dredging in the Inner Harbour: summer scenario

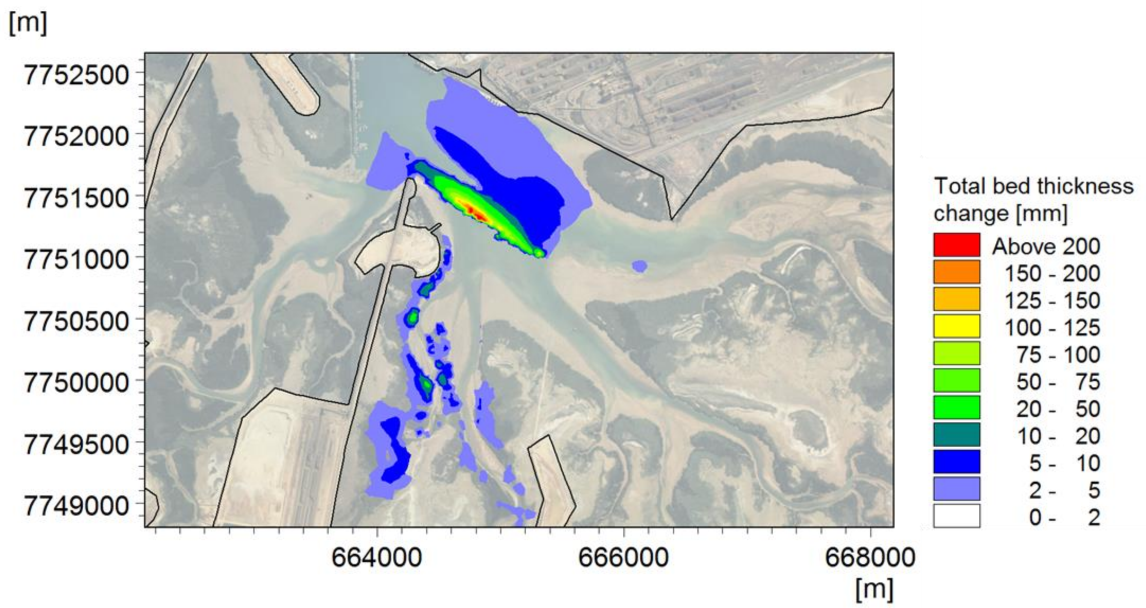


Figure 4-9: Total seabed thickness change after completion of dredging in the Inner Harbour: winter scenario

5. CONCLUSIONS

5.1 Suspended sediment concentration

The SSC was characterised through analysis of the 50th and 80th percentiles of the integrated depth-averaged SSC throughout the water column.

The main findings of the sediment plume dispersion model are listed below.

- Suspended sediments from the dredging operations are predicted to be 50 mg/L or less for 80% of the time in the summer scenario and increasing to 55 mg/L in the winter scenario at locations immediately outside of the proposed development site;
- the SSC drops down quickly beyond 1km from the dredging site, with the SSC below 30 mg/L for 80% of the time;
- along South Creek, south of the dredging area, the highest SSC was predicted to be up to 55 mg/L (at least 80% of the time) in the winter scenario;
- the plume dispersion at the harbour entrance is expected to be similar in both the summer and winter scenarios with the concentration below 10 mg/L for at least 80% of the time; and
- seasonal variation shows higher SSC near the dredging area and a larger extent of the dredge plume upstream of South Creek, South East Creek, and Stingray Creek for the winter scenarios when compared with the summer scenarios.

5.2 Total sedimentation

Sedimentation predicted in the dredge dispersion model was assessed by analysing the total seabed thickness change at the end of the model simulation.

Key findings were:

- average sedimentation in the proposed dredging area due to the dredge plume is expected to be around 115 mm, as a result of the fine sand component settling quickly from the spilled material;
- the highest sedimentation across the AP Berth 3 and its turning basin, in both the summer and winter scenarios, was predicted to be up to 200 mm;
- localised sedimentation in South Creek during in the winter and summer scenarios were predicted to be generally less than 10 mm with sedimentation up to 50 mm in localised areas.

- Outside the areas discussed above, sedimentation due to the dredge plume is expected to be less than 5mm.

REFERENCES

Anchor Environmental C.A. L.P. 2003, Literature review of effects of resuspended sediments due to dredging operations. Prepared for Los Angeles Contaminated Sediments Task Force, Los Angeles, CA

Australian Hydrographic Service (AHS) 2012, *Australian National Tide Tables 2013*, Commonwealth of Australia

Danish Hydraulic Institute (DHI) 2011, *MIKE C-MAP*, release 2011 SP7

Doorn-Groen, S.M. and Foster, T.M. 2007, Environmental Monitoring and Management of Reclamation Works Close to Sensitive Habitats, Proceedings of the XVIII World Dredging Congress. Orlando, USA (27 May 2007)

FMG 2015, Dredging and Spoil Disposal Management Plan, 22 July 2015, 560PO-C0001-4320-PL-MA-0001

Whitehouse, R. & Soulsby, R.L., 2000, Dynamics of Estuarine Muds- A Manual for Practical Applications, Chapter 9, Published by Thomas Telford, Great Britain

WorleyParsons 2008, FMG, Heng Shan Project, Anderson Point Bert 3 (AP3) Geotechnical Investigation – Factual Report, 00093-P-12044-RP-GE-00010

WorleyParsons 2010, Port Ore Handling – Lumsden Point – Environmental – Implementation of the environmental sampling programme Tug Harbour – Inner Harbour Geotechnical Investigation, PREP-080-G-12/166/0, prepared for FAST

WorleyParsons 2011, Inner Harbour Geotechnical Investigation, Quantum Cyclone Moorings – Geotechnical Factual Report, 301012-01234 – RP-GE-005 Rev1

WorleyParsons 2012, PHPA South West Creek Dredging and Reclamation Project, Sediment Plume Monitoring During Back actor and Cutter Suction Dredge Operations, 301012-01406 Rev 0, March 2012

WorleyParsons 2013, Lumsden Point Development, Port Hedland – Near shore Geotechnical Investigation Factual Report Environmental Impact Assessment – Geotechnical Investigation, prepared for PHPA, 301012-01677-GT-REP-0001, April 2013

WorleyParsons 2015a, FMG Tug Haven Marine Studies, Hydrodynamic Impact Assessment, 201320-08579-CS-REP-0002

WorleyParsons 2015b, FMG Tug Haven Marine Studies, Hydrodynamic Impact Asessment and Sediment Plume Dispersion Modelling Specification

Young, R. N. & Townsend, F. C. 1986, Consolidation of Soils: Testing and Evaluation: A Symposium, ASTM Committee D-18 on Soil and Rock. Published by ASTM International, 1986

Appendix 4: Benthic Primary Producer Habitat Survey and Impact Assessment

This page has been left blank intentionally

Advisian
WorleyParsons Group

Client Name

Tug Haven Marine Studies

Benthic Primary Producer Habitat Survey and Impact Assessment

January 2016

Advisian is a global advisory firm that provides project and business solutions to clients who develop, operate and maintain physical assets in the infrastructure and resources sectors.

560PO-4347-RP-EN-0005

Advisian Pty Ltd
Level 2
235 Georges Terrace
Perth WA 6000
Australia

P +61 8 9278 8111
F +61 8 9278 8110
Advisian trading as WorleyParsons Services Pty Ltd
ABN: 61 001 279 812

Advisian
WorleyParsons Group

Disclaimer

This report has been prepared on behalf of and for the exclusive use of Client Name, and is subject to and issued in accordance with the agreement between Client Name and Advisian.

Advisian accepts no liability or responsibility whatsoever for it in respect of any use of or reliance upon this report by any third party.

Copying this report without the permission of Client Name and Advisian is not permitted.

PROJECT NO 201320-08244– TUG HAVEN MARINE STUDIES: BENTHIC PRIMARY PRODUCER HABITAT SURVEY AND IMPACT ASSESSMENT

Rev	Description	Author	Review	Advisian Approval	Date
0	Issued for Use	N Claydon	H Houridis	P Shipley	13-Jan-16

Advisian
WorleyParsons Group

Table of Contents

List of Appendices

List of Figures

List of Tables

1 Introduction

1.1 Background

Pilbara Marine Infrastructure Pty Ltd is proposing to develop a tug haven adjacent to the existing Herb Elliott Port Facility, where there are existing shipping berths managed by the Fortescue Metals Group (Fortescue) Pilbara iron ore operation. Pilbara Marine Pty Ltd (Pilbara Marine) is seeking the second licence for tug operation to support their iron ore operations in Port Hedland.

The Tug Infrastructure will support the safe mooring of tugs with safe access and the provision of service facilities. To provide access to the facility, Pilbara Marine is proposing to undertake capital dredging over an area of 90,830 m^2 to a maximum depth of -8.0m Chart Datum (CD) within the vicinity of Anderson Point. It is also proposed that dredge material will be disposed into an existing onshore containment area.

1.2 Structure of report

This BPPH impact assessment report will address the following objectives:

- Section 2.1 will review the relevant Western Australian EPA guidelines for assessment of BPPH and apply the recommended approach to impact assessment.
- Section 2.2 will describe the benthic communities and habitats within the proposed disturbance area and their context within the Port Hedland LAU to determine their ecological significance
- Section 2.3 will describe the proposal and previous design options and justify the site selected.
- Section 2.4 will define the direct and indirect impact and determine the spatial extent of impact for the proposed development.

1.3 Scope of work

This report provides results of the desktop BPPH study and the impact assessment based on the preferred design and construction for the Tug Haven works. This impact assessment will be used to address the requirements of the guidelines and bulletins published by the OEPA, and to identify the potential direct and indirect impacts on BPPH associated with the proposed development.

2 BPPH Loss Assessment

2.1 Environmental Assessment Guidelines

In order to assess the impacts of the proposal on BPPH in Port Hedland, the EPA has published several State based guidelines which are outlined below.

2.1.1 Guidance Statement No. 1 (EPA 2001)

Guidance Statement No. 1 is the "Guidance Statement for the Protection of Tropical Arid Zone Mangroves along the Pilbara Coastline". This Guidance Statement specifically addresses the protection of tropical arid zone mangroves, habitats and dependent habitats along the Pilbara coastline.

The four types of management areas are:

- Guideline 1: Regionally significant mangroves - Outside designated industrial areas and associated port areas.
- Guideline 2: Other mangrove areas – Outside designated industrial areas and associated port areas
- Guideline 3: Regionally significant mangroves – Inside designated industrial areas and associated port areas
- Guideline 4: Other mangrove areas – Inside designated industrial areas and associated port areas.

Guideline 4 is applicable to Port Hedland Harbour. The EPA's expectations for this category are that impacts of development on mangrove habitat and ecological function of the mangroves in these areas to be reduced to the minimum practicable level.

The EPA would consider the significance of the environmental impacts but would expect that the proposal in these zones is likely to be capable of being made environmentally acceptable. Accordingly, proposals in these areas will not be subject to a presumption against finding the proposal environmentally acceptable providing that:

- A high priority is placed on protecting tropical arid zone mangroves, habitat and dependent habitats, and
- Any development being planned and designed to keep impacts on mangroves, habitats and dependent habitats to a minimum practical level.

An assessment of the proposed development confirms that no direct or indirect impacts are expected on any mangrove habitat within Port Hedland harbour.

2.1.2 Environmental Assessment Guideline No. 3

EAG3 specifically addresses protection of BPPH in Western Australia's marine environment. The EAG defines BPPH as seabed communities within which algae (e.g. macroalgae, turf and benthic microalgae), seagrass, mangroves, corals or mixtures of these groups are prominent components (EPA 2009). The EPA recognises the fundamental ecological importance of BPPHs and the potential consequences of their loss. It is also acknowledged that almost all marine development proposals will results in the loss of some of these important habitats (EPA 2009).

For the purposes of this study, the following definitions were adopted:

- BPPs are primarily marine plants such as macroalgae, seagrasses, mangroves, turf algae and benthic microalgae, but also include the scleractinian corals (which gain a large proportion of their energy from internal symbiotic microalgae); and
- BPPHs are a combination of the BPPs and the substrata that can support them. BPPHs not only include areas of existing BPPs, but also areas that previously supported them or may be colonised by them in the future. Examples of BPPHs include coral reefs, seagrass meadows, mangrove forests, intertidal mud flats and seabed where macroalgal, coral or seagrass communities have grown and could grow.

Other benthic habitats such as those dominated by sessile organisms (eg. Soft corals, sponges and ascidians) area recognised as being important, but the loss of or damage to these habitats would be treated separately as part of the environmental impact assessment process.

The only BPPH likely to be affected by the proposed development is the habitat within the dredge footprint which is predominantly bare substrate. In accordance with the *Environmental Protection Act 1986* (EP Act), all proposals that may result in disturbance to or loss of marine BPPH should adhere to the principles and guidelines recommended within EAG3 (EPA 2009).

This impact assessment was conducted to achieve the goals of the overarching principles given in EAG3 for the environmental protection of BPPH. These overarching principles are:

1) All proponents should demonstrate consideration of options to avoid damage/loss of BPPH, by providing the rationale for selection of the preferred site and broad project design for example.

2) Where avoidance of BPPH is not possible, then design should aim to minimise damage/loss of BPPH (e.g. through iterative design and demonstratable application of Principle 3 below). Proponents will be required to justify that design in terms of operational needs and environmental constraints of the site.

3) Proponents will need to demonstrate 'best practicable' design, construction methods and environmental management aimed at minimizing further damage/loss of BPPH through indirect impacts and minimizing potential for recovery.

4) The EPA's judgement on environmental acceptability with respect to damage/loss of BPPH and the risk to ecological integrity will be based primarily on its consideration of the proponent's application of principles 1 to 3 and calculations of cumulative loss of each BPPH type within a defined LAU (the most 'realistic' scenario), together with supporting ecological information, and expert advice, as required.

The design options considered by Fortescue in order to address the first three principles are discussed in Section 4. As described in Principle 4, the impacts need to be defined spatially and compared with the Port Hedland LAU, which is described in Section 5. The BPPH loss assessment is presented in Section 6.

2.1.3 Environmental Assessment Guideline No. 7

The Environmental Guidelines for Marine Dredging Proposals (EAG7) is 'designed to ensure that predicted extent, severity and duration of impacts to benthic habitats associated with significant dredging activities, which are subject to formal environmental impact assessment by the EPA, are presented in a clear and consistent manner' (EPA 2011a). EAG7 provides specific guidance on the layout and presentation of predicted impacts associated with dredging activities on benthic communities and habitats.

In particular, EAG7 focuses on direct loss of benthic habitats and communities by removal or burial and indirect impacts on benthic habitats and communities from the effects of migration of sediment plumes by dredging. This guidance should be followed in conjunction with EAG3.

EAG7 also describes a spatially-based zonation scheme to describe the predicted extent, severity and duration of the impacts associated with dredging. The three zones of impact are:

- Zone of High Impact (ZoHI): the area where impacts on benthic organisms are predicted to be irreversible. These areas would include the zones within and directly adjacent to the proposed dredge area.
- Zone of Moderate Impact (ZoMI): the area within which the predicted impact on benthic organisms are sub-lethal, and/or the impact are recoverable. This zone would be located immediately outside of the ZoHI
- Zone of Influence (ZoI): the area within which changes in environmental quality associated with dredge plumes are predicted and anticipated during the project, but where these changes would not results in a detectable impact on benthic biota.

In the ZoHI, it is predicted that a 100% loss of the benthic communities due to the dredging activities will occur, either from the habitat being removed and disposed of, or due to chronic stress from turbidity or sedimentation.

In the ZoMI it is predicted that sub-lethal impact to benthic communities will occur, such as reduced photosynthetic activity or increased mucous production (in corals).

In the ZoI the dredging activities may have some influence, however the impacts would not be sub-lethal and no detectable loss or impact would be present.

2.1.4 Environmental Protection Bulletin No. 14

An LAU is 'a specific geographical area which provides the most effective boundaries for management of cumulative environmental impacts on marine habitats' (EAG3, EPA 2009). The guidance for assessing BPPH in and around Port Hedland provides a set LAU boundary to aid proponents to comply with EAG3 for proposals in Port Hedland. Historically, the EPA has noted that different proponents have defined different LAUs for assessing the cumulative losses of BPPH associated with their proposals in Port Hedland. This inconsistency in application of EAG No. 3 resulted in the development of EP Bulletin No 14 which provides a clear definition of the LAU for proposals in Port Hedland. All assessments within the area are expected to use this LAU (shown in Figure 2-1) for evaluating cumulative losses of BPPH from the date of issue in August 2011 (EPA 2011b).

The Port Hedland LAU is 15,102.5 ha in area and is used for development related cumulative losses associated with the inner harbour, tidal creek, barrier islands and the adjacent intertidal zone within the inner Port Hedland area. The northern boundary has been based on existing coastline data and inshore mangrove extent, while taking into account the temporal variation of the soft erodible coastlines and the spoil ground located immediately east of the harbour entrance.

The LAU shown in Figure 2-1 forms the basis of the cumulative loss assessment for the proposed Tug Haven.

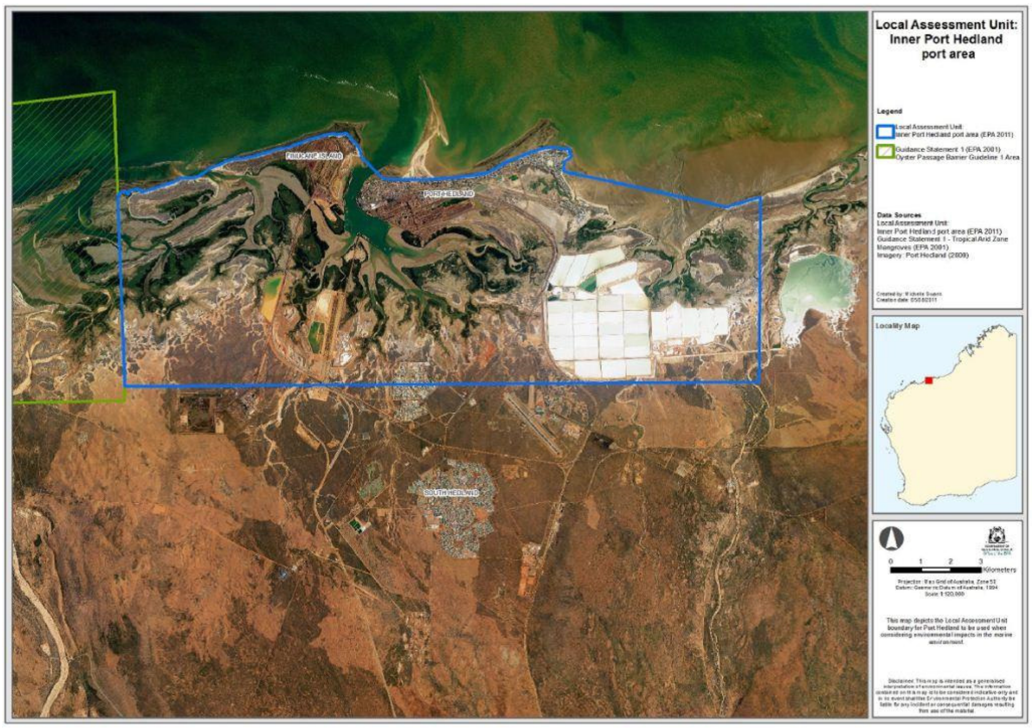


Figure 2-1: Port Hedland Local Assessment Unit

2.2 Existing Habitat

2.2.1 Benthic habitat in the Port Hedland LAU

The BPPH ecology of the Port Hedland LAU was assessed previously during the cumulative loss assessment for the South West Creek dredging project (WorleyParsons 2012). Data was collected through literature review and compilation of existing data, raw data collected from baseline investigations, ground truthing surveys, sonar surveys and satellite imagery analysis.

Mangrove extent was adapted from the EPA report and recommendations for the Port Hedland Outer Harbour Development (EPA 2012). More recently, BPPH surveys were undertaken for the Lumsden Point General Cargo Facility within the project footprint at Lumsden Point (WorleyParsons 2013). All of this information has been compiled to produce an updated map of the BPPH within the Port Hedland LAU. This is presented in Figure 2-2.

The marine habitat found in Port Hedland is typical of those found along the arid coastlines of the Pilbara region. The BPPH present in the Port Hedland LAU includes mangroves, corals, seagrass, turfing algae, macroalgae, reef habitat and sandy (benthic microalgal) habitat. The dominant habitat within the LAU is bare sediment. Mangroves include the species *Avicennia marina*, *Rhizophora stylosa*, and a small proportion of *Ceriops australis*.

All of these species are found elsewhere in Port Hedland and the Pilbara region. None are listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999 or the Wildlife Conservation Act 1950

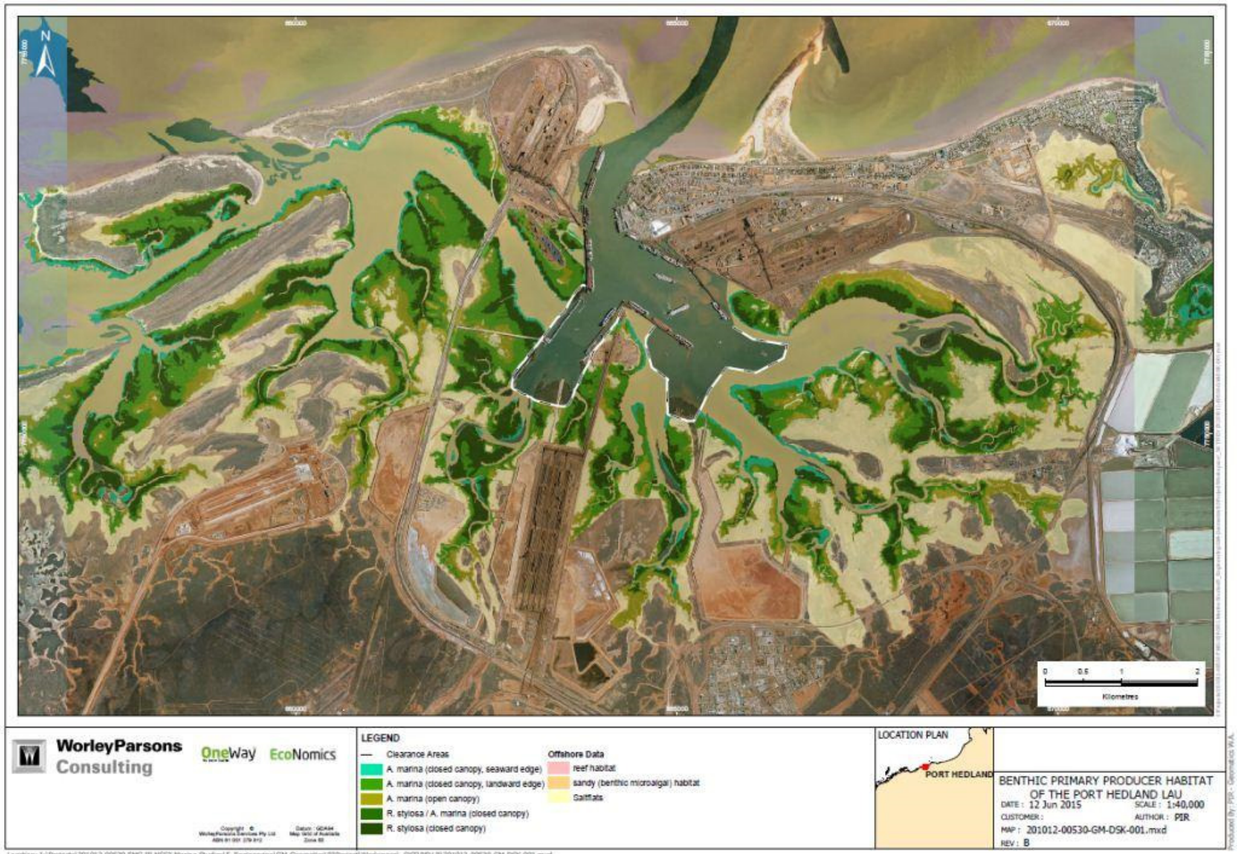


Figure 2-2: Updated BPPH map within the Port Hedland LAU

2.2.2 Benthic habitat at the Tug Haven site

The benthic habitat at the proposed Tug Haven site has been assessed previously during the mapping of the Port Hedland LAU (WorleyParsons 2012). Images were also taken at low tide during the recent sediment sampling campaign for the implementation of the sampling and analysis plan (Advisian 2015). The images below (Figure 2-3 and Figure 2-4) show bare substrate, with some shell grit but no presence of benthic primary producers such as seagrass, corals or macroalgae.

Figure 2-3: Tug Haven site facing east from Australia Island, with AP3 on the left.

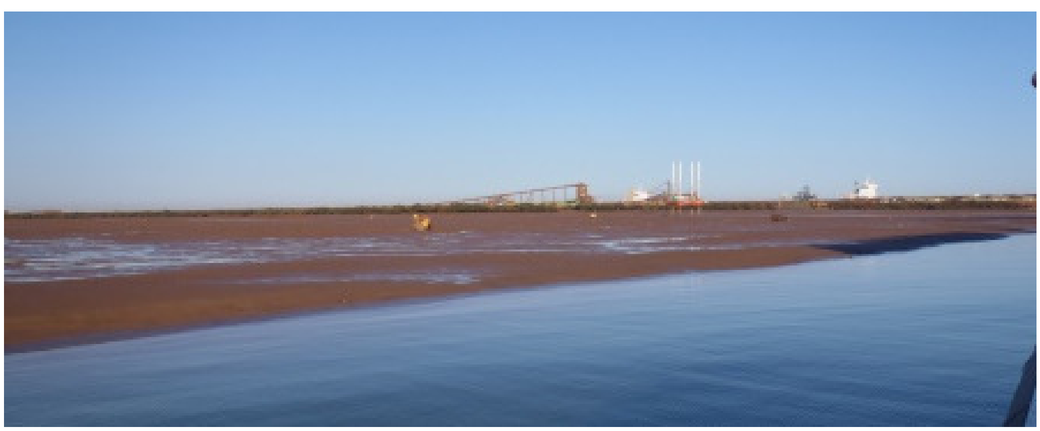


Figure 2-4: Tug Haven site facing west back towards Australia Island.

The proposed Tug Haven construction footprint will impact a total of 9.02 ha of existing subtidal marine seabed. Of this area, 6.83 ha has been previously approved as part of other project assessments, in particular, the Stingray Creek Cyclone Mooring Facility which has been previously assessed as not containing any BPPH. The remaining 2.19 ha was identified as sandy soft bed habitat which has the potential to contain MPB (microphytobenthos) or benthic microalgae (Figure 2-5)

Figure 2-5: BPPH within the tug haven proposed footprint

2.3 Site Selection and alternatives considered

The tug haven dredging, construction and infrastructure being assessed in this BPPH survey and impact assessment includes the following:

- Capital dredging of over an area of 90,830 m^2 to remove approximately 800,655 m^3 of dredge spoil to a maximum depth of -8.0m Chart Datum (CD);
- Disposal onshore to an existing Dredged Material Management Areas (DMMA); and
- Construction of an access corridor between the tug pen and the onshore facilities, which is likely to be a piled structure approximately 150m in length and 1.8m wide.

2.3.1 Analysis of Options

FMG considered a number of options to determine a cost-effective and environmentally acceptable development outcome. In order to address Principle 1 and 2 of EAG3, several design alternatives were considered and assessed by FMG in consultation with the Pilbara Ports Authority (PPA) and key stakeholders including Department of State Development (DSD). Design alternatives that were evaluated included:

- Five options and configurations adjacent to Anderson Point
- Four options and configurations adjacent to South West Creek

The options were evaluated against a number of criteria including:

- maritime safety, in particular conflict with existing port operations;
- volume of material to be dredged and environmental impacts;
- minimising disturbance to mangrove and other BPPH habitat;
- potential to expand the tug pen configuration to allow for future demand; and
- the cost of construction and operation of the facility.

The options adjacent to South West Creek, although optimal in terms of minimising distance between the Tug Haven and the onshore facilities, resulted in significantly larger dredge volumes and a larger construction footprint over the BPPH intertidal habitat including mangroves.

The options adjacent to Anderson Point and the Herb Elliott Port Facility were of different orientations and configurations including placing the Tug Haven in deeper water and then parallel to the AP3 berth, perpendicular to the AP3 berth or immediately adjacent to the intertidal area behind the AP3 berth (Appendix A). All options involved much smaller dredge volumes and had a relatively smaller potential impact on the BPPH habitat.

The preferred concept design as shown in Figure 2-6 was chosen to minimise the dredge footprint and volume and also allow safe navigation around the Herb Elliot Port Facility. It is also noteworthy that more than 75% of the total proposed construction footprint is already within an approved area of cumulative loss and will therefore avoid any significant increase in cumulative losses within the Port Hedland LAU. Landside disturbance is also being undertaken on pre-disturbed Stage A footprint

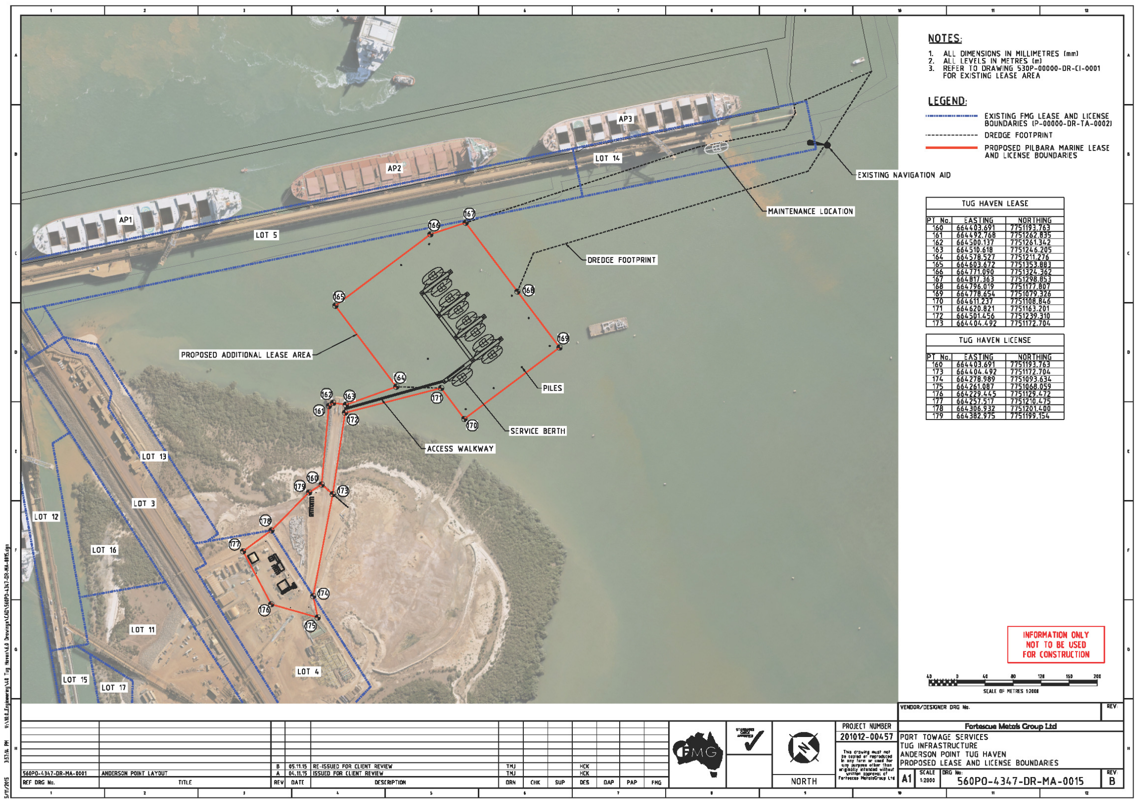


Figure 2-6: Preferred Conceptual Layout for Proposed Tug Haven, Andersen Point

2.4 BPPH Loss assessment

2.4.1 Historical loss of BPPH

BPPH cumulative loss for the Port Hedland LAU has been calculated from historic aerial photographs from 1964 which was used to create a baseline image of the area before major development and other anthropogenic activities. The total areas and estimated percentage impacts are presented in Table 2-1, based on the information given in the EPA Report 1503 (EPA 2014) and the Lumsden Point General Cargo Facility Cumulative Impact Assessment (WorleyParsons 2013).

Table 2-1: BPPH extent within the Port Hedland LAU as of December 2015

BPPH type	Historical area (ha)	Estimated cumulative loss including approved projects (including those not yet started) (ha)	Resultant extent of habitat (ha)	Percentage impact (%)
Mangroves	2,676	389.98	2286.02	14.57
Coral	19	0.1	19	0.7
Macroalgae	73	49	23	68
Sandy Habitat (potential MPB)	2349	261.34	2087.66	11.13
Saltmarsh (potential)	3394	1623	1771	48
Saltmarsh (actual)	628	327	301	52
Cyanobacterial mats (potential)	4274	1849	2425	43
Cyanobacterial mats (actual)	299	129	170	43

Within EAG3, six categories of marine ecological protection are identified based on the area type. These include high protection areas, development areas or designated areas. Associated with these are cumulative loss guidelines, which are tools to identify the risk to ecological integrity based on the cumulative loss within an area type.

Cumulative loss limits for development areas (Category E) are 10%. However, EPA has previously described the Port Hedland LAU as a Category F area (EPA2009b), where cumulative loss guidelines have been significantly exceeded (>10%). EAG3 also states that cumulative loss guidelines are not intended to be applied as rigid limits and acceptability of any irreversible loss of, or serious damage to, benthic primary producer habitat in all cases, will be based on judgement of the EPA.

2.4.2 Direct loss of BPPH

The disturbance footprint of the Tug Haven proposal is limited to the dredging and construction area within the subtidal marine environment. There is no habitat loss associated with onshore construction activities and the project footprint indicates no direct loss of mangroves will occur within the battery limits of the Tug Haven onshore infrastructure.

As summarised in Table 2-2, the BPPH proposed to be removed for this proposal due to dredging is 2.19 ha. This loss of sandy habitat will lead to a cumulative loss of 263.53 ha within the LAU, which is a total 11.24% cumulative loss. The overall percentage cumulative loss of sandy habitat within the LAU directly attributable to the proposal is 0.11%.

Table 2-2: Estimated BPPH loss within Port Hedland LAU.

BPPH type	Benthic habitat area predicted loss due to project (ha)	Cumulative loss area of LAU from historic and proposed loss (ha)	Estimated percentage loss of habitat category within LAU due to proposal	Estimated cumulative loss within LAU (%) (current loss and proposed loss)
Sandy Habitat (potential MPB)	2.19	(Current loss is 261.34) Proposed loss is 263.53	0.11	11.24

2.4.3 Indirect loss of BPPH

Suspended sediment concentrations are predicted to increase during dredging throughout the zones of high impact (ZoHI), zone of moderate impact (ZoMI) and zone of influence (ZoI). These zones are defined in Section 2.4.7, based on the results of the sediment plume modelling and the ability for BPPH to tolerate elevated suspended sediment and sedimentation during the period of dredging. BPPH such as corals and algae communities present in the Port Hedland LAU depend on light reaching the seabed in order for photosynthesis to occur. It is generally acknowledged and understood (through experience with previous dredging campaigns) that existing communities present within Inner Harbour are resilient and tolerant to high sediment loads.

2.4.4 Sediment plume modelling

Sediment plume modelling was undertaken to quantify the expected movement and concentration for material suspended during dredging operations (WorleyParsons 2015). The results from this modelling are used here to determine the zones of impact, and the likelihood of impacts on sensitive receptors due to sedimentation and suspended sediment.

The study investigated potential seasonal variations in the migration of the suspended material and sedimentation patterns for the "worst case", and therefore the model was run over both summer and winter seasons. The modelling approach and methods are described in the Sediment Plume Dispersion Modelling report (WorleyParsons 2015).

The summer scenario results for predicted suspended sediment concentration (SSC) are presented in Figure 2-7 and Figure 2-8, and the winter scenario results are shown in Figure 2-9 and Figure 2-10. It is predicted that dredging over either season is expected to result in a general plume migration near the Project area within the Inner Harbour, with the highest plume concentrations occurring in South Creek and South East Creek. Outputs for both seasons were very similar, though the winter scenario shows a slightly higher SSC compared with the SSC in the summer scenario, with more of the plume more likely to be retained within the spill area and along South East Creek. This is likely due to the seasonal tidal flow rather than the seasonal wind conditions, given the dominant wind direction in winter is south-easterly - which will drive the plume north-west towards the harbour entrance. The tidal flux is also estimated to be approximately 15% higher in summer than in winter.

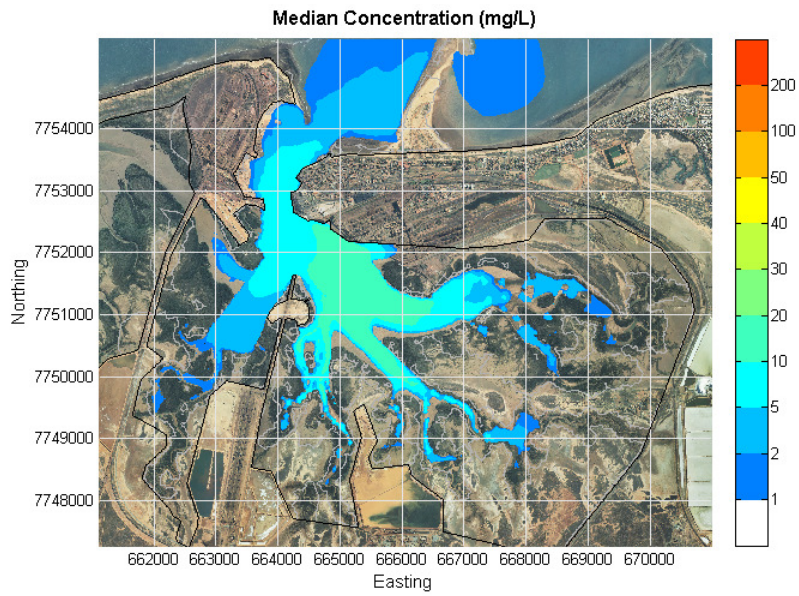


Figure 2-7: Predicted 50th percentile depth-averaged SSC in the Inner Harbour: summer scenario

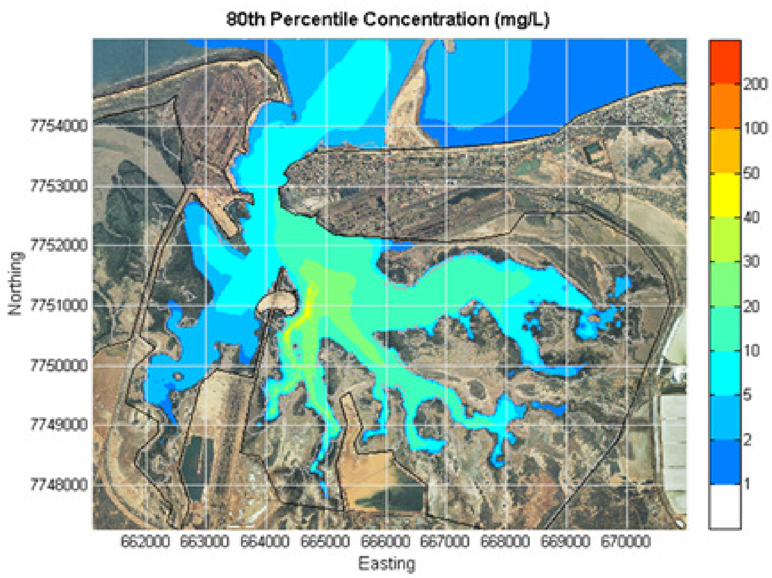


Figure 2-8: Predicted 80th percentile depth-averaged SSC in the Inner Harbour: summer scenario

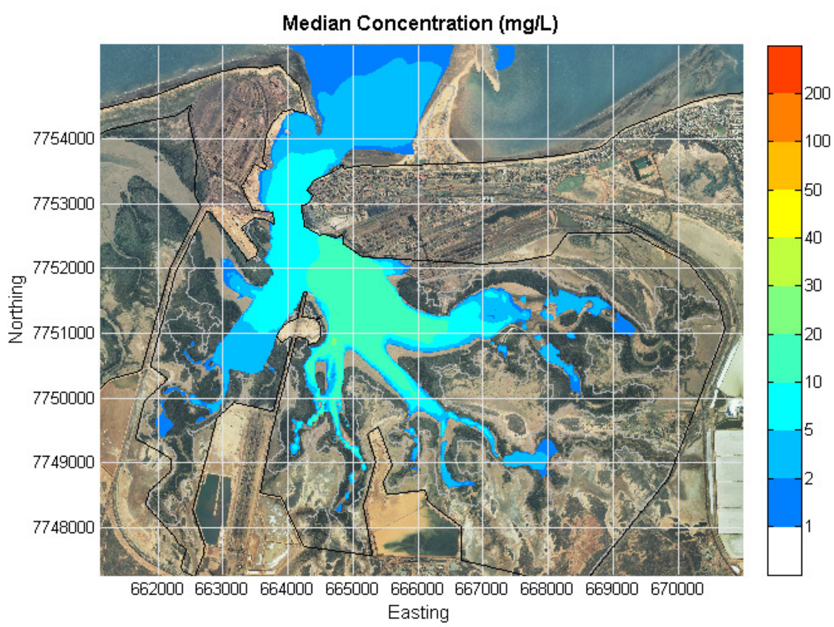


Figure 2-9: Predicted 50th percentile depth-averaged SSC in the Inner Harbour: winter scenario

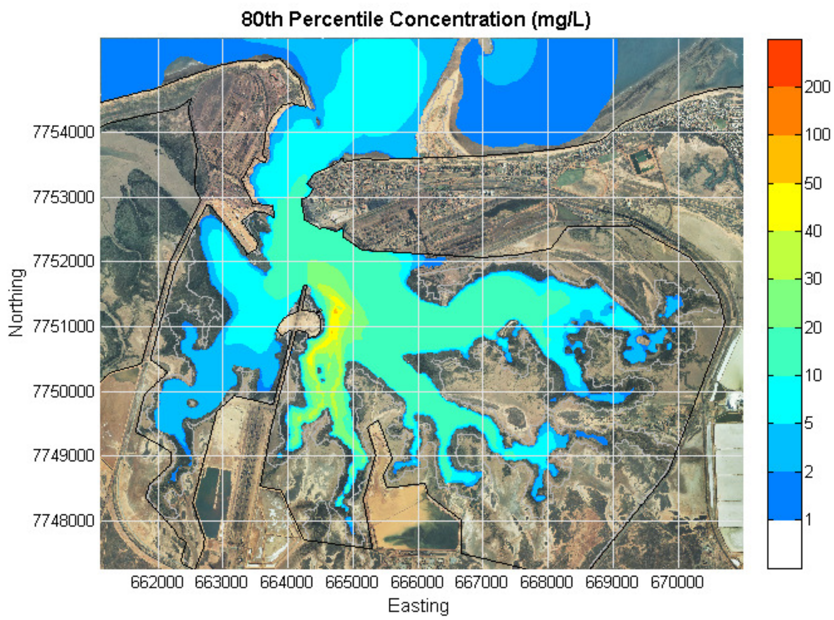


Figure 2-10: Predicted 80th percentile depth-averaged SSC in the Inner Harbour: winter scenario

2.4.5 Impacts from sedimentation

During the sediment plume modelling, sedimentation modelling was also undertaken to predict the resulting total seabed thickness change. According to the modelling results, areas where possible sedimentation of 100 mm or more may occur are in the ZoHI, where direct loss of existing habitat will already occur due to the direct impact of dredging (Figure 2-11 and Figure 2-12). Areas of moderately high sedimentation (between 50-100 mm) are limited to the ZoMI whereas most of the remaining section of Inner Harbour (including the areas of mangrove) are expected to experience less than 10 mm of consolidated total seabed thickness change over the summer and winter scenarios. There are no areas within the harbour, where mangroves occur, that are likely to experience sedimentation above the 5 to 50 mm range. This is well below the mortality threshold of 100mm that was adopted in previous projects for mangrove species present in Port Hedland (WorleyParsons 2010). Overall, no indirect or irreversible loss of coastal intertidal BPPH is predicted to occur from sedimentation.

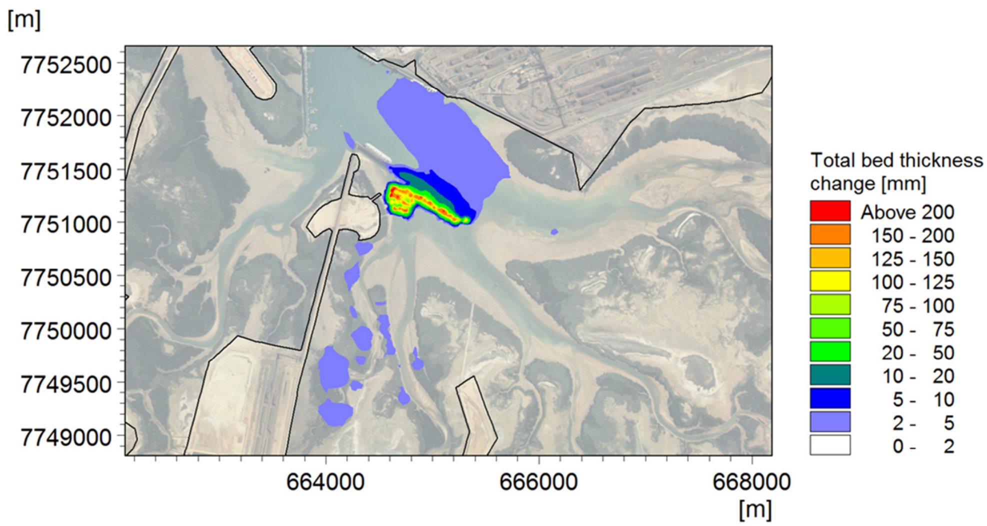


Figure 2-11: Total seabed thickness change after completion of dredging in the Inner Harbour: summer scenario.

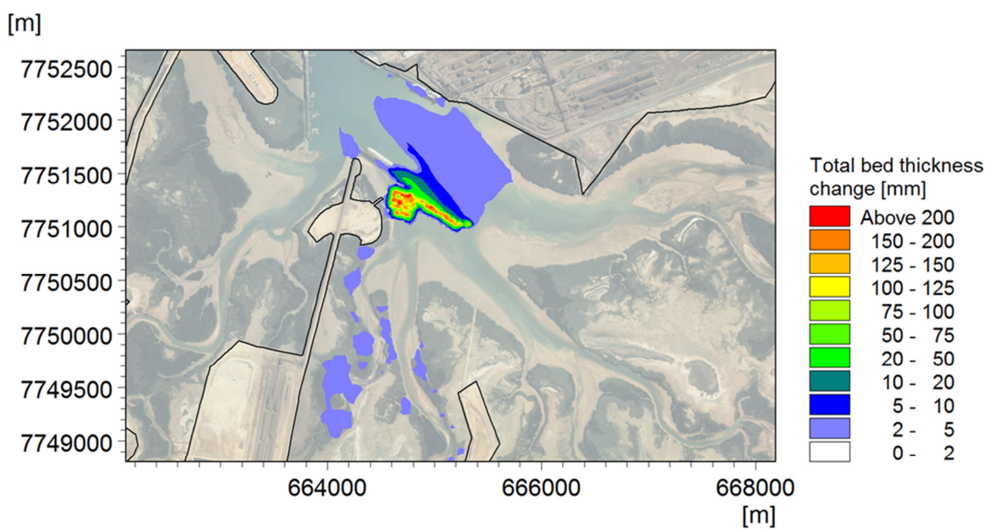


Figure 2-12: Total seabed thickness change after completion of dredging in the Inner Harbour: winter scenario.

2.4.6 Surface water impact assessment

In addition to the sediment plume modelling, a surface water impact assessment was also undertaken to determine the estimate the impacts from surface water flow into the marine environment. Comparison of the estimated pre and post development peak flows, volumes and hydrographs suggests the following:

- There is no significant change in the total volume of run-off from the site under post-development conditions; as a result there is not expected to be a significant impact on the tidal creeks or surrounding mangrove habitat;
- The peak flow entering the tidal creeks is reduced through flow detention in the sedimentation basin, producing a slower release of water into the tidal creeks and surrounding mangrove habitat;
- Post development run-off is discharged to the same tidal creek systems as under the current conditions and the drainage system and site earthworks avoid restricting tidal movements that could adversely impact the mangrove vegetation; and
- It was demonstrated that the sedimentation basin could effectively remove suspended sediment prior to discharge of run-off water to the environment.

By directing surface run-off flows via a sediment basin to the proposed discharge area at the tidal creek, it has been shown that potential surface water related risks, particularly those associated with sediment transport, can be effectively managed.

These results also confirm that surface water runoff will have not indirect impacts on BPPH.

2.4.7 Impact zonation

The spatial extent of the ZoHI, ZoMI and ZoI have been mapped in accordance with EAG7 to integrate the predicted extent, severity and duration of impacts associated with the proposed dredging (Figure 2-13).

The ZoHI is confined to the area of dredging where direct removal of sediment and BPPH will occur. The loss of habitat associated with the dredging is not considered significant as the seabed has existing ministerial approval to be disturbed. The total area of the ZoHI is 9.02ha (of which 6.83 ha has been previously approved for dredging).

The ZoMI is confined to the immediate area around the ZoHI. Based on the modelling of SSC and sedimentation, there is very little likelihood that mangroves or other benthic primary producers will be impacted beyond the ZoMI. Predictions relating to potential impacts from SSC are based on previous experience and extensive monitoring of these habitats as part of previous dredging assessments within Port Hedland (WorleyParsons 2013). The ZoMI is therefore based on areas likely to experience greater than 50 mm sedimentation, which may result in sub-lethal impacts to benthic microalgae. The total area of the ZoMI is 3.9 ha.

The ZoI has been defined as the area where a SSC threshold of 5mg/l is exceeded for more than 50% of the time. Water quality data from a range of sites within the harbour confirm that TSS (and turbidity) is naturally high and that 5 mg/l is a much more realistic concentration than 1 or 2 mg/l in trying to discern a visible plume. The total area of the ZoI is 552 ha.

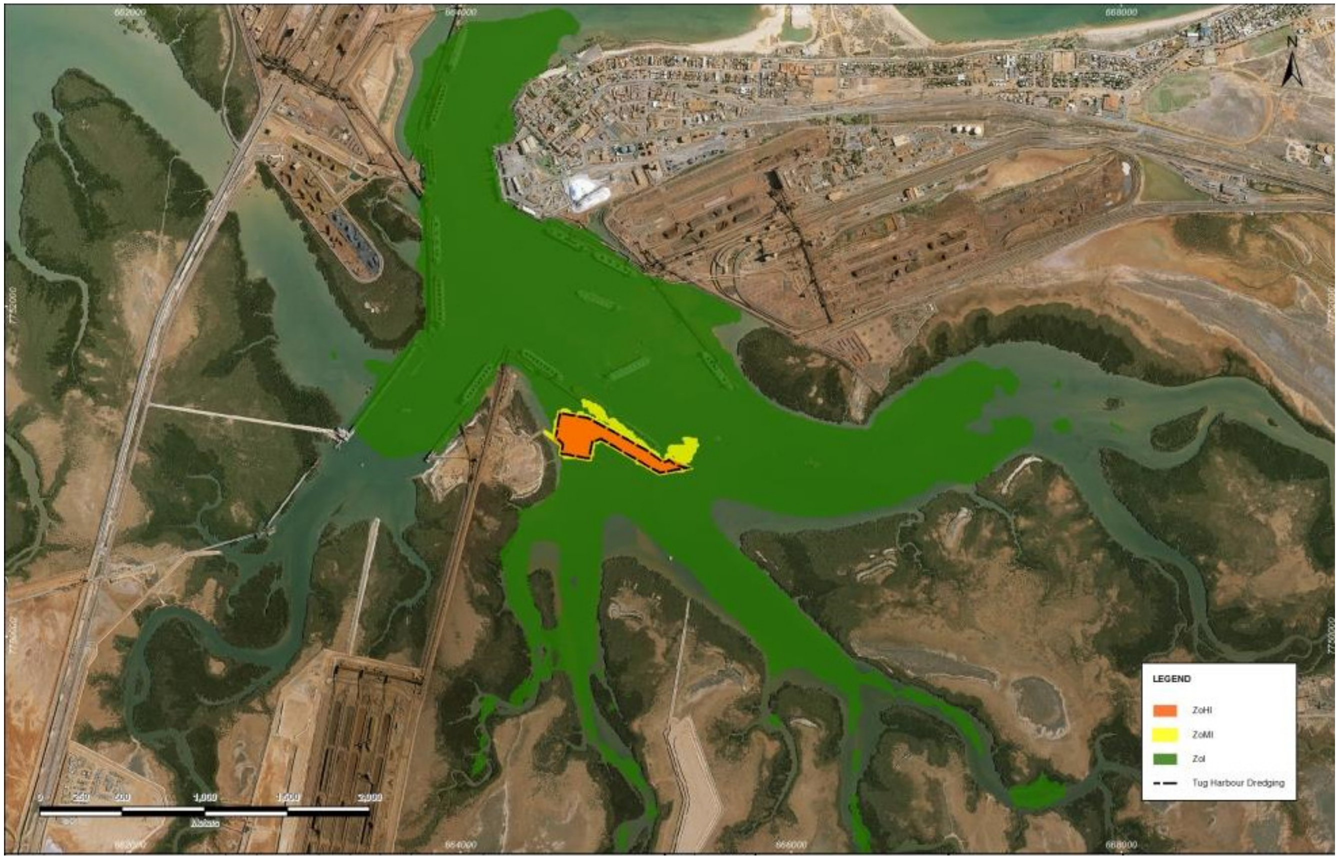


Figure 2-13: Zones of Impact/Influence from Proposed Dredging Program

2.5 Benthic habitat loss assessment summary

2.5.1 Irreversible BPPH losses

Irreversible losses will be confined to the disturbance footprint, and will include the sandy (benthic microalgal) habitat within the dredging area.

Table 2-3: Summary of estimated BPPH loss within the Port Hedland LAU

Benthic habitat category	% loss of habitat category within LAU due to proposal	Estimated cumulative loss within LAU (%)
Sandy habitat	0.11	11.24

2.5.2 Predicted impacts on BPPH

Predicted impacts in the ZoMI and ZoI were analysed using sediment plume modelling for SSC and sedimentation. The assessment of impact also draws on much of the previous project dredging experience from Port Hedland where extensive and intense monitoring of a range of indicators has confirmed that the ecosystem is resilient to the periodic exposure of elevated levels of suspended sediment and sedimentation (WorleyParsons 2013).

Figure 2-14 provides a summary of baseline and modelled surface irradiance changes from historical dredging projects. At sites SC1, SC2 and SEC 1 for example, light levels are naturally low and resident BPP communities have survived previous dredging campaigns. Therefore it can reasonably be assumed they will also survive/recover from disturbance associated with the current project, which involves a much shorter construction campaign than the previous projects.

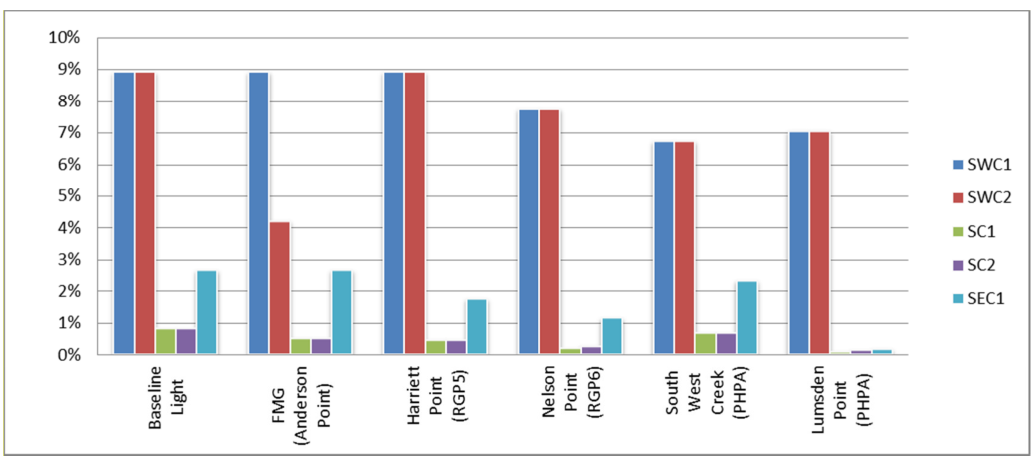


Figure 2-14: Percentage of surface irradiance at BPPH locations from predictive modelling from previous major dredging campaigns

Sedimentation was also compared with previous projects and also adopted a chronic trigger level of 100 mm to determine indirect impacts (WorleyParsons 2010). The sediment plume modelling predicted that sedimentation levels of 100 mm would only occur within the disturbance footprint with no direct or indirect impact to mangroves. Sedimentation elsewhere in the Harbour is likely to be less than 10 mm with the exception of sections of South Creek where up to 50 mm is possible in localised areas.

It is therefore predicted that no irreversible impacts will occur outside the disturbance footprint or zone of high impact. The ZoMI which is primarily sandy soft bed habitat and has the potential to contain MPB (microphytobenthos) or benthic microalgae will be affected by the higher sedimentation but will recover rapidly following cessation of the dredging activity. No impact is expected on any BPPH or associated species in the ZoI.

2.5.3 Ecological significance of losses

Based on the assessment of historical data and observations recorded during the most recent field assessment for sediment sampling for this project, no unusual, unique or highly significant habitat complexes were identified in the disturbance footprint.

The direct loss of subtidal BPPH due to the dredging and construction activities associated with this proposal also represent a very small proportion of the total BPPH found in Port Hedland and will have a negligible impact on the ecological integrity of the broader Port Hedland LAU. The ecological significance of estimated benthic community losses are also minimal as over 75% of the total proposed construction footprint is already within an approved area of cumulative loss.

3 Conclusion

The Tug Haven proposal assessed in this BPPH assessment has considered the impacts relating to capital dredging works and disposal of dredge material to existing Dredged Material Management Areas (DMMA). The proposal also includes construction of an access corridor between the tug pen and the onshore facilities which is likely to be a piled structure.

The preferred concept design for the Tug Haven has been selected to minimise the dredge volume and construction footprint and to also allow safe navigation around the Herb Elliott Port Facility. Over 75% of the total proposed construction footprint is already within an approved area of cumulative loss and will therefore avoid any significant additional contribution to cumulative losses within the Port Hedland LAU.

The desktop survey has confirmed that a maximum of 2.19 ha of bare substrate would be removed within the construction and dredging footprint representing only 0.11% cumulative loss within the Port Hedland LAU, which would increase the total cumulative loss of this habitat type from 11.13% to 11.24%.

The ecological significance of the losses of BPPH arising from the Tug Haven proposal is considered minimal as the direct losses of habitat associated with the proposal are negligible and unlikely to affect the ecological integrity of the broader Port Hedland LAU.

4 References

EPA (2001) Guidance Statement for the Protection of Tropical Arid Zone Mangroves along the Pilbara Coastline; EPA Guidance Statement No. 1

EPA (2009). Environmental Assessment Guideline 3 (EAG3): Protection of Benthic Primary Producer Habitats in Western Australia's Marine Environment. Perth, WA, Environmental Protection Authority.

EPA (2011a) Environmental Assessment Guideline for Marine Dredging Proposals no. 7 (EAG7).

EPA (2011b). Environmental Protection Bulletin No.14: Guidance for the assessment of benthic primary producer habitat loss in and around Port Hedland, Environmental Protection Authority, Western Australia.

EPA (2012) Report and recommendations of the Environmental Protection Authority: Port Hedland Outer Harbour Development for BHP Billiton Iron Ore. In. Environmental Protection Authority

WorleyParsons (2010) South West Creek Tug & Small Vessel Cyclone Mooring Facility Benthic Habitat Dredging Tolerances and Implications for this Project, Report by WorleyParsons for Port Hedland Port Authority

WorleyParsons (2012) South West Creek Dredging and Reclamation Project. Benthic Primary Producer Habitat Survey and Cumulative Loss Assessment: Port Hedland Local Assessment Unit (in draft). Prepared for Port Hedland Port Authority.

WorleyParsons (2013) Lumsden Point General Cargo Facility: Ecosystem and Cumulative Impact Assessment. Prepared for Port Hedland Port Authority.

WorleyParsons (2015) FMG Tug Haven Marine Studies: Sediment Plume Dispersion Modelling. 560PO-4347-RP-EN-003. Prepared for Fortescue Metals Group

Appendix A

Tug Haven Options

Appendix 5: Surface Water Impact Assessment

This page has been left blank intentionally

Advisian
WorleyParsons Group

Fortescue Metals Group Ltd

Fortescue Towing Services

Tug Haven Marine Studies Surface Water Impact Assessment

13 November 2015

Advisian is a global advisory firm that provides project and business solutions to clients who develop, operate and maintain physical assets in the infrastructure and resources sectors.

560PO-4347-RP-EN-0001

Advisian
Level 2
235 Georges Terrace
Perth WA 6000
Australia

P +61 8 9278 8111
F +61 8 9278 8110
Advisian trading as WorleyParsons Services Pty Ltd
ABN: 61 001 279 812

Advisian
WorleyParsons Group

Fortescue
The New Force in Iron Ore

Synopsis

This report presents the results of a surface water impact assessment of works proposed for expansion of tug operations at Anderson Point, within the Port Hedland harbour, referred herein as the Tug Haven Project. The report is intended to support the second license application for tug operations. It identifies the potential impacts associated with the proposed development and presents mitigation and management measures.

Disclaimer

560PO-4347-REP-EN-0001 – FORTESCUE TOWING SERVICES : TUG HAVEN MARINE STUDIES SURFACE WATER IMPACT ASSESSMENT

Rev	Description	Author	Review	Advisian Approval	Date
A	Issued for internal review	S Ripley	I Weaver	P Shipley	N/A
B	Issued for client review	S Ripley	I Weaver	P Shipley	19-Oct-15
0	Issued for use	S Ripley	I Weaver	P Shipley	13-Nov-15

Table of Contents

List of Appendices

1 Executive Summary

Advisian (WorleyParsons Group) was engaged by Fortescue Metals Group Ltd to undertake a surface water impact assessment for the proposed supply and construction to support a second license application for tug operations at Anderson Point.

This report presents the results of a surface water impact assessment, identifies the potential impacts associated with the proposed development and presents mitigation and management measures. The results suggest that:

- There is no significant change in the total volume of run-off from the site under post development conditions; as a result there is not expected to be a significant impact on the tidal creeks or surrounding mangrove habitat;
- The peak discharge rate of run-off entering the tidal creeks may be significantly decreased due to flow compensation through the use of sedimentation basin controls. The basin controls allow a slower release of surface water discharged to the tidal creeks and surrounding mangrove habitat;
- Post development run-off is discharged to the same tidal creek systems as under the current conditions with the proposed drainage and site earthworks arranged to avoid restriction of tidal actions or uncontrolled ponding that would adversely impact the mangrove vegetation; and
- The existing sedimentation basin can be rehabilitated to effectively remove suspended sediments >200μm prior to discharge of surface run-off to the marine environment.

The conceptual approach presented in this report has been shown to effectively manage the potential surface water related risks associated with the Tug Haven onshore infrastructure and to minimise impacts to the tidal creek and mangrove habitat. The management measures are also consistent with those presented in the Fortescue: Surface Water Management Plan, Environment (Fortescue 2014) and drainage systems at Fortescue's existing port facility at Anderson Point.

2 Introduction

2.1 Background

WorleyParsons was engaged by Fortescue Metals Group Ltd (FMG) to undertake a Surface Water Impact Assessment for the proposed infrastructure required to support the second license application for tug operations at Anderson Point. The proposed onshore infrastructure required to support the second tug license application is located at Anderson Point, in Port Hedland (at location 664267 m E, 7751146 m N, MGA94 Zone 50), as shown by Figure 2-1. The proposed infrastructure will be referred to as the Tug Haven Project for the remainder of this report.

Figure 2-1 Location of Tug Haven onshore infrastructure at Port Hedland

Figure 2-2 Aerial of the proposed onshore infrastructure for the Tug Haven Project

2.2 Objectives

The objective of this surface water impact assessment is to identify surface water related risks associated with the proposed supply and construction of infrastructure and to recommend surface water management measures and associated designs to mitigate risk and minimise potential impacts on the environment.

The management measures will be consistent with those presented in the Fortescue: Surface Water Management Plan, Environment (Fortescue 2014).

2.3 Scope of Work

The scope of work for this impact assessment includes:

- Identify surface water related risks associated with the proposed development;
- Identify surface water management measures to mitigate risk and potential impacts on the environment;
- Validate the performance of proposed mitigation measures, specifically:
  - Assess the existing sedimentation basin and evaluate if it can effectively remove suspended sediment from site stormwater run-off prior to discharge to the environment; and
  - Confirm that the quantity and quality of run-off flow to downstream mangrove habitats, located in tidal creeks, are similar under pre and post development conditions.
- Complete an impact assessment for the site with the proposed surface water management measures in place.

3 Methodology

The following methodology was adopted for this surface water impact assessment:

- Literature review and gap analysis;
- Characterisation of the existing site conditions;
- Identification of sensitive receptors in the project area and the surface water risks associated with the Project;
- Development of surface water management measures to mitigate risk;
- Use of LiDAR data (2015) and design layout and levels of earthworks and infrastructure to delineate contributing catchment areas under both pre (current) and post development conditions;
- Estimation of run-off peak flows, hydrographs and flow volumes under current development conditions using regional estimation methods presented in Australian Rainfall and Runoff (AR&R 1987) and from stormwater modelling (via XP-Storm hydrological and hydraulic modelling software);
- Testing and confirmation of the hydraulic performance of the existing sedimentation basin using XP-Storm modelling software;
- Estimation and comparison of modelled peak flows, hydrographs and flow volumes under pre (current) and post development conditions; and
- Completion of an impact assessment with proposed surface water management measures in place.

The hydrological analysis presented in this report has adopted methods consistent with those presented in Australian Rainfall and Runoff (AR&R 1987).

4 Literature Review and Gap Analysis

4.1 Literature Review

A literature review was conducted to identify reference documents that are relevant to this study. The reference documents referred to when preparing this Surface Water Impact Assessment are listed in Table 4-1 along with their relevance.

Table 4-1: Reference Documents and Relevance to this Study

Reference	Relevance
North Star Stage 2, Port Expansion Environmental Marine Studies, Surface Water Impact Assessment (201012-00530-RP-HY-0002)	This report was used as the primary reference for the Tug Haven Surface Water Impact Assessment. A surface water impact assessment was completed for the North Star Stage 2 Port Expansion studies located to the south of the Tug Haven Project. A similar methodology was adopted for this assessment.
Benthic Primary Producer Habitat Survey and Impact Assessment (201012-00530-EN-REP)	This report was used to identify significant sensitive surface water ecosystems within the Port Hedland Local Assessment Unit. The study indicated the only significant sensitive ecosystem surrounding the project area are the mangrove habitats.
Port Towage Services – Tug Infrastructure – Marine Structure (560POC002-4347-BD-MA-0001)	This document assisted with the development of the Basis of Design for this study.
Fortescue: Surface Water Management Plan, Environment (100-PL-EN-1015)	This document presents legislative requirements and objectives for surface water management at all Fortescue sites and also presents the potential direct and indirect environmental impacts to surface water arising from Fortescue's activities. The potential impacts relevant to this study include: • Alteration of surface water volume and flow regimes; • Reduction in water quality; • Fauna and habitat loss; • Increased turbidity and downstream sedimentation caused by excessive erosion; • Increased risk of storm surge and flooding. This Surface Water Impact Assessment Report addresses these risks and presents management measures and engineering designs that are consistent with Fortescue's Surface Water Management Plan.
Western Australian Water in Mining Guideline published by the Department of Water (DoW, 2013)	This guideline ensures the consideration of mining activities on surface water dependent ecosystems, including surface water dependent coastal vegetation such as mangroves. An objective from the guidelines that is particularly relevant to this Surface Water Impact Assessment is to:

	• Minimise the adverse effects of the discharge of water from the site on environmental, social and cultural values. This Surface Water Impact Assessment Report achieves this objective.
T155: Port – Flood Risk Assessment and Drainage Design (515P-10029-RP-HY-0001)	The surface water management measures presented in this report were designed to: • Manage surface water run-off to minimise impacts on port operations and protect key infrastructure from flooding; and • Minimise surface water impacts on tidal creeks and mangrove habitats associated with the expansion of FMG's port facility. The objectives of this previous study were similar to the objectives of the current study, therefore a similar methodology was adopted when assessing the surface water impact of the Tug Haven Project. The results of the previous study were used also to confirm the soil types and parameters for modelling and to evaluate the risk posed by flooding in upstream catchment areas. The study showed that the FMG port development protects the proposed Tug Haven onshore site from floodwaters passing from upstream catchment areas and that floodwater levels in the vicinity of the Tug Haven study area are influenced mostly by tide and storm surge levels (tailwater conditions).
T155: Port – Basis of Design for Earthworks, Roads and Drainage (510P-00000-BD-CI-0001)	This document assisted with the development of the Basis of Design for the current study.
The Heng Shan Project South West Creek Flood Study (00093-R-05029-RP-HY-0001)	The results of this study were used to characterize the existing hydrological conditions; particularly to evaluate the risk that flooding in South West Creek poses to the Tug Haven Project. The study showed that the FMG port development protects the proposed site from floodwaters passing from upstream catchment areas.
Oceanic Storm Surge Study at Anderson Point, Port Hedland Harbour (07519-06010-EN-RP-0002)	The results of this study were used to set tail water conditions when developing the concept drainage.

4.2 Gap Analysis

The literature review shows significant existing surface water and environmental information and data is available to support this impact assessment. This information is considered sufficient to characterise the existing site hydrology, to identify potential environmental risks and receptors and to develop appropriate mitigation and management measures for the Project.

No significant information gaps were identified.

5 Existing Site Conditions

5.1 Climatic conditions

The Pilbara region is classified as arid to semi-arid with average annual rainfall between 200-350mm. The region is a climate of extremes with considerable variability controlled by the tropical cyclones during the summer months, predominantly January to March. Flooding is usually associated with cyclonic events, decreasing with distance from the coast.

Rainfall and evaporation data recorded from the Bureau of Meteorology (BoM) Port Hedland Airport monitoring station (4032) are shown in Figure 5-1 and Figure 5-2.

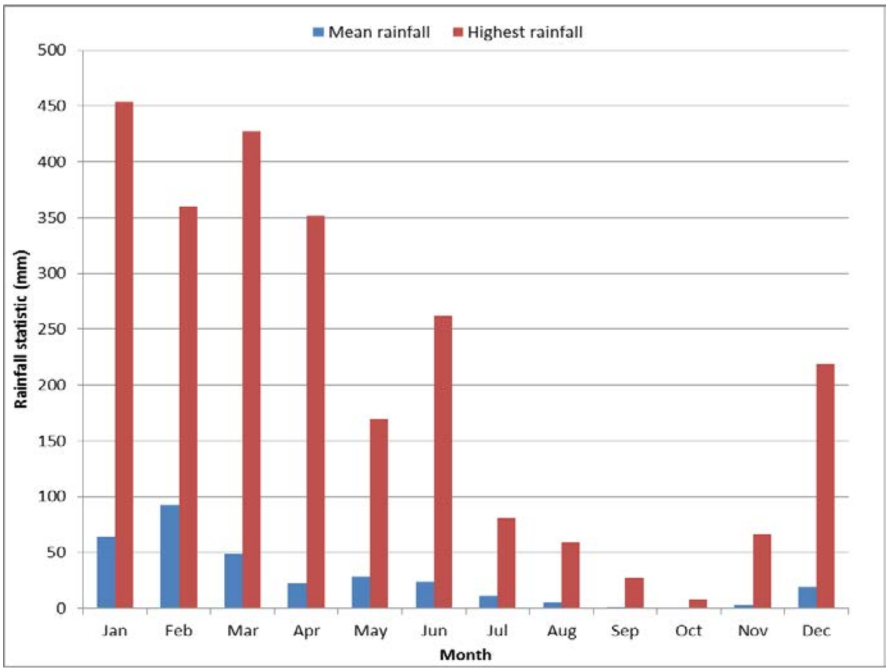


Figure 5-1 Average monthly rainfall statistics for Port Hedland Airport (BoM 2015)

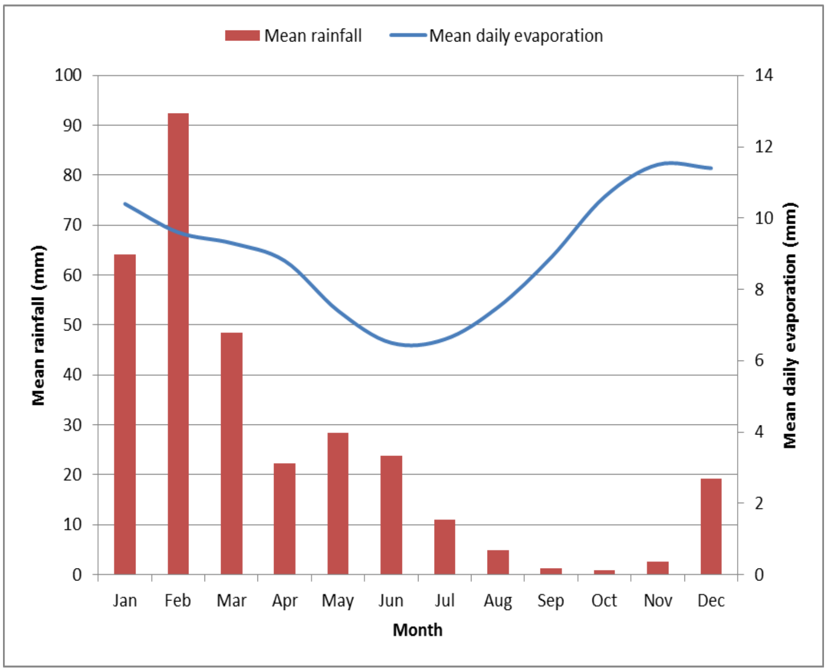


Figure 5-2 Mean monthly rainfall and daily evaporation statistics (BoM 2015)

5.2 Intensity Frequency Duration Curves

Design rainfall Intensity-Frequency-Duration (IFD) data for the Project was obtained from the BoM online IFD tool. IFD Data for the Tug Haven Project (664267 E, 7751146 N, MGA94 Zone 50) is shown in Figure 5-3.

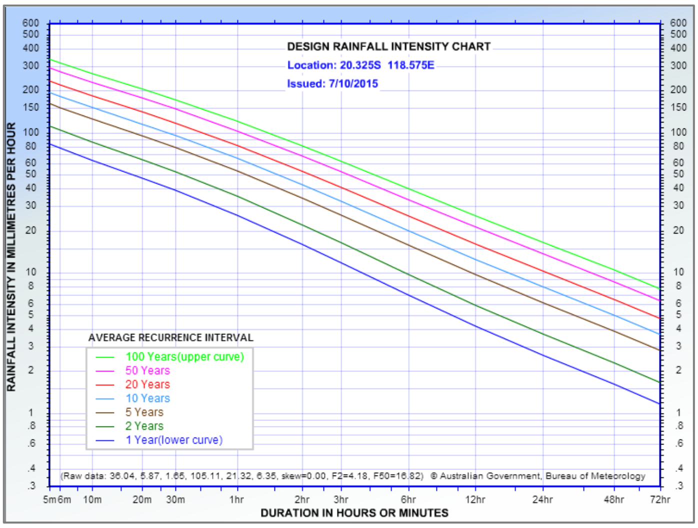


Figure 5-3 IFD Curve for Tug Haven Project (BoM 2015)

5.3 Topography

The Project lies within the floodplain of South Creek and South West Creek, within the Port Hedland coastal zone. Much of the surface water flow in the catchment is in the form of overland/sheet flow (WorleyParsons 2004) generated from rainfall run-off.

5.4 Hydrology

The Project area is located at the existing Anderson Point Port development. It is protected from flood waters originating from South Creek and South West Creek, the two major watercourses in the area by existing port infrastructure (WorleyParsons 2011 T155: Port – Flood Risk Assessment and Drainage Design). Run-off flows impacting on the project area therefore are limited to rainfall run-off. Under the existing conditions, rainfall run-off appears to be distributed across the existing drainage network, with a portion passing through the existing sedimentation basin prior to discharge to the tidal creeks.

5.5 Tides

Port Hedland experiences large tidal range (>7 m) as shown in Table 5-1 .

Table 5-1 Standard Tide Levels from the 2013 Australian National Tide Tables

Tide	m CD	m AHD
Highest Astronomical Tide (HAT)	+7.56	3.66
Mean High Water Springs (MHWS)	+6.69	2.79
Mean High Water Neaps (MHWN)	+4.62	0.72
Mean Sea Level (MSL)	+3.95	0.05
Mean Low Water Neaps (MLWN)	+3.28	-0.62
Mean Low Water Springs (MLWS)	+1.21	-2.69
Lowest Astronomical Tide (LAT)	-0.02	-3.92

*Measurements are referenced in m CD. In Port Hedland the conversion between AHD and CD is based on the following equation: 0.0m AHD = +3.9m CD (Fortescue Metals Group 2015).

5.6 Storm Surge

Storm surge is a rise in normal sea water level along the shore as a result of strong onshore winds and/or low reduced atmospheric pressure. A storm surge accompanies a tropical cyclone as it comes ashore. Storm surges can also be formed by intense low-pressure systems in non-tropical areas.

The storm surge water level adopted by the BoD for the Tug Haven Marine Structures is+9.1m CD (5.2m AHD) (Fortescue Metals Group 2015). The storm surge water level is a function of the following:

Storm Surge Water Level (SSWL) = Still water level (SWL) + Sea water rise + Setup

*Still water level (SWL) = Surge + Tide

A previous study of Oceanic Storm Surge at Anderson Point, Port Hedland Harbour by WorleyParsons (2004) concluded the following:

- 100 year ARI storm surge water level reaches +6.1m AHD (still water level) at Anderson Point; and
- 50 year ARI storm surge water level of 5.4m AHD.

The study showed the design peak flood levels developed by the modelling vary through the harbour area and are shown to be highest over the mudflats and sandy lowland areas where the high ground elevation tends to lift the storm surge water level.

5.7 Tailwater Levels

The modelling undertaken as part of the Greater Port Hedland Storm Surge Study (Global Environmental Modelling Systems 2000) provided catchment response times for South West Creek. For the 50 year and 100 year ARI design floods, the times to peak flood generally varied between 8 to 12 hours, depending on the rainfall pattern being modelled. The results demonstrate that the river flood peak discharge generally occurs well after any ocean storm surge. Consequently, the probability of the two events occurring at the same time is low. The joint probability of occurrence is less than 1% yielding an equivalent ARI in excess of 100 years.

In line with the above results and with the hydrological and hydraulic model simulations of previous studies, a minimum high tailwater condition of 3.66m AHD (equivalent to Highest Astronomical Tide [HAT]) was adopted as a basis for concept design.

6 Sensitive Receptors, Surface Water Risks and Management Measures

6.1 Sensitive Receptors

The project footprint indicates no direct loss of mangroves will occur within the battery limits of the Tug Haven onshore infrastructure.

The Benthic Primary Producer Habitat surveys undertaken for the Port Hedland Local Assessment Unit (LAU) indicate the significant sensitive surface water ecosystems surrounding the Tug Haven Project area are the mangrove habitat. The surrounding mangrove habitat must be protected from the Project surface water run-off through effective surface water management. Measures must be implemented to ensure the quantity and quality of surface water from the site under pre and post development conditions are similar. The Mangrove Monitoring and Management Plan, as referenced in the Dredging and Spoil Disposal Management for Anderson Point Towage Infrastructure and Services (560PO-C0001-4320-PL-MA-0001_B) will be used to monitor the health of mangroves and mangrove habitat during the construction and operation works.

The surface water management measures presented in this section have been developed to minimise impacts to the mangrove habitat.

6.2 Surface Water Risks

6.2.1 Sediment Loads

The main risk posed by the proposed development to the environmental receptors is the mobilization and transport of sediment laden run-off from the development area. Run-off from the disturbed port site areas will transport sediment during significant flood events.

The risk posed by sediment in run-off is also high during construction where the ground is disturbed and prone to erosion.

6.2.2 Hydrocarbon discharge

There is potential for adverse change to the surface water quality entering the creeks due to the mobilization of spilled or leaked hydrocarbons stored, handled or transported on site.

6.2.3 Alteration of surface water volume and flow regimes

The development of the site has the potential to alter surface water run-off volumes and flow regimes to the tidal creek mangrove habitat.

Alterations to the run-off volumes and flow regimes can occur if the characteristics of the catchment areas contributing run-off to the creeks are significantly changed.

6.2.4 Increased turbidity caused by erosion

Construction activities will disturb areas of the site which will potentially increase the risk of erosion by wind and rain and lead to increased turbidity in the receiving tidal creek and mangrove habitat.

6.2.5 Storm surge and flooding

The site is located in an area which is subject to the effects of storm surge during extreme storm events, which poses a flood risk to the site.

Rainfall run-off also poses a potential flood risk to the site. Previous investigations (Section 4), suggest that Fortescue's existing port facility provides adequate protection from floodwaters passing from South Creek and South West Creek. Flood levels in the vicinity of the Tug Haven onshore infrastructure are influenced mostly by tide and storm surge.

Direct rainfall run-off on the site must be managed to minimise the risk of localized flooding of infrastructure.

6.3 Surface Water Management Measures

The following surface water management measures are consistent with Fortescue's Surface Water Management Plan (Fortescue 2014) and drainage systems at Fortescue's existing port facility at Anderson Point.

6.3.1 Sediment Loads

Run-off from the site during operations will be captured in the existing surface drainage network and treated using the existing sedimentation basin or alternative sediment trapping methods to remove suspended sediment prior to discharge to the tidal creek and mangrove habitat.

Run-off generated during construction from disturbed areas on site will be managed to trap sediments prior to discharge to the tidal creek.

6.3.2 Hydrocarbon discharge

Hydrocarbons will be managed to avoid leaks and spills. Fuel handling areas will be bunded to capture any spills for remediation and will be either located outside of the floodplains or appropriately elevated to avoid the risk of flood inundation. Bunded areas must be capable of containing the combined volume of run-off from a 20 year ARI 72 hour duration design flood event and 110% of the tank contents in accordance with the Water Quality Protection Guidelines No 6. (Water and Rivers Commission 1999).

Stormwater run-off from workshop pavements, fuel unloading and storage areas and from vehicle wash down areas shall be directed to grit and oil interceptors to remove pollutants prior to discharge of the water. Accidental spills outside controlled areas must be remediated to avoid contamination of groundwater or surface water.

6.3.3 Alteration of surface water volume and flow regimes

The site drainage network will collect run-off on the site, treat and discharge back to the same tidal creek as under natural conditions. The catchment area contributing run-off to the tidal creek under pre (current) and post development conditions will remain the same to minimise impacts on the volume of run-off and flow regime.

6.3.4 Increased turbidity caused by erosion

Run-off generated during construction from disturbed areas on site will be managed to remove sediment prior to discharge back to the tidal creek.

The drainage system should limit flow velocities generally to less than 2 m/s for the design event to reduce the risk of scour and erosion under more regular run-off events. Scour protection is recommended to prevent erosion in those areas where design velocities exceed 2 m/s.

The finished earthworks level of the onshore infrastructure will remain, nominally at or above 7.0m AHD as reflected by the existing Anderson Point development. For drainage purposes, the finished earthworks level was assumed to gently grade to trapezoidal drains at a nominal surface gradient of 0.5%, to limit overland flow velocities and to reduce risk of scour and erosion from earthworks surfaces by rainfall run-off.

6.3.5 Storm surge and flooding

The civil design for the site has taken into consideration tide levels and storm surge to protect the site from flooding by storm surge.

A drainage system is proposed to protect the site infrastructure from flooding caused by direct rainfall run-off. The drainage system must also prevent sustained ponding in mangrove areas, allowing exposure to the mangroves of the normal cycles of tidal action.

7 Drainage Strategy

7.1 Rainfall run-off modelling

The pre (current) and post development hydrological conditions at the site were examined using XP-STORM hydrologic and hydraulic modelling software. XP-STORM was used to estimate peak flows and hydrographs within the modelled system. XP-STORM's modelling methods and parameters are consistent with those presented in AR&R (1987) and were adopted for design of the FMG T155 port drainage systems (WorleyParsons 2011).

The model calculates rainfall run-off for delineated catchment areas and routes the run-off to the outlet. The software can account for storage effects and infiltration losses based on soil type and is able to estimate run-off from both pervious and impervious areas.

For this project, infiltration losses were estimated using the Green Ampt Method consistent with those adopted for the T155 study. The representative soil parameters shown in Table 7-1 were adopted for the various pervious areas assigned to the modelled catchment.

Table 7-1: Adopted Green-Ampt Infiltration parameters (SWMM Run-off Variables)

Classification / Land Use *	Average Capillary Suction (mm)	Saturated Hydraulic Conductivity (mm/hr)	Initial Moisture Deficit
Bare Earth / Fill	218.5	3.0	0.250

* Soil types selected from available list in XP-Storm, and considered representative of the materials at site.

7.2 Basis of Design

The Water Quality Protection Guidelines (DoW 2000) provides guidelines for stormwater management, with stormwater drainage to be designed in accordance with Australian Rainfall and Runoff (AR&R 1987). Stormwater management on site shall provide for the collection, storage and disposal of water, with run-off carrying high sediment loads diverted to a sedimentation basin for treatment prior to discharge to the environment, in accordance with these guidelines.

The minor / major design approach recommended in AR&R (1987) was adopted for this Project. This approach requires all "minor" run-off from the 10 year ARI design storm event to be captured and treated by the stormwater drainage system at the site prior to discharge to the tidal creek. All site rainfall run-off, from the 100 year ARI major design storm event, is assumed to report to the central area of the site before draining into the sedimentation basin for discharge to the tidal creek. Infrastructure designs should be developed with existing pad levels set above 6.1m AHD, the 100 year ARI design flood level.

A single drainage network was modelled capturing run-off from both pervious and impervious areas of the catchment. Collected run-off was directed to a sedimentation basin, located outside the catchment boundary prior to discharge to the tidal creek.

A nominal finished earthworks level of 7.0m AHD was adopted for Tug Haven onshore infrastructure in line with the existing levels at the site. The surface level was adopted for pre (current) and post condition modelling and was assumed to gently grade to at an average gradient of 0.5 % prior to discharge to the sedimentation basin.

7.2.1 Open Drains

Trapezoidal open drains were adopted to control scouring and sedimentation and to minimize sudden changes in velocity. The designs had side slopes no steeper than 1V:3H. The drains were generally unlined except where scour protection was required:

- where design velocities exceeded 2m/s;
- where drain materials had high scour potential;
- at all culvert inlets and outlets;
- at substantial changes in direction of open channels and drains; and
- at abrupt changes in invert levels at falls along any open drain alignment.

7.2.2 Sedimentation Basin

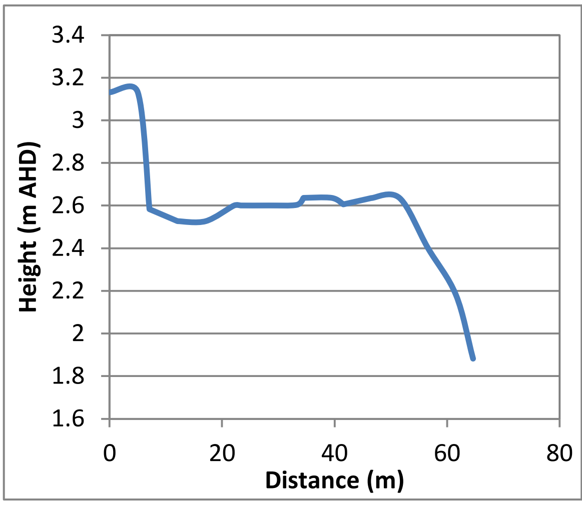
The run-off from the Project will be directed into the existing unlined sedimentation basin located outside the Tug Haven Project area. The run-off will be directed offsite into the sedimentation basin for treatment prior to discharging, via a spillway and outlet drain, to the tidal creek. The 10 year ARI design storm was modelled to verify that the basin provided sufficient detention to settle out of suspension sediment particles of size greater than or equal to 75µm (fine sand/silt).

The sedimentation basin was modelled based on its existing size, measuring 38m width x 26m length and effectively 0.5 m depth, shown by Figure 7-1. Figure 7-2 shows a profile from upstream of the basin within the inlet channel, through the basin and outlet channel to discharge at the mangroves. A section through the sedimentation basin is shown in Figure 7-3.

The existing outlet from the basin comprised a breach in the northern bund nominally 4m wide. Supplementary storage in the upstream area between the basin and the causeway embankment was ignored.

For post development conditions a controlled outlet was assumed comprising a low level piped outlet to handle base flows and an elevated overflow weir to pass the larger storm flows. A 300 mm diameter reinforced concrete pipe was selected for the base flow pipe with an inlet invert level of 2.6 m AHD, nominally the base level of the basin. The overflow weir adopted for evaluation had a 4 m wide crest set at 2.9 m AHD, 0.3 m above the basin base. The inflowing channel also appeared to have an invert level of 2.6 m AHD. Elsewhere, the bunds of the basin were assumed to be rehabilitated to a minimum crest level of 3.3 m AHD. Furthermore, a potential bypass to the north west, at location 664,323 m E, 7,751,230 m N (MGA94 zone 50 coordinates) was assumed to be closed off with appropriate earthworks to a minimum level of 3.3 m AHD also, forcing all run-off from this area through the sedimentation basin.

Figure 7-1 Approximate sedimentation basin dimensions (ArcMap 2015)



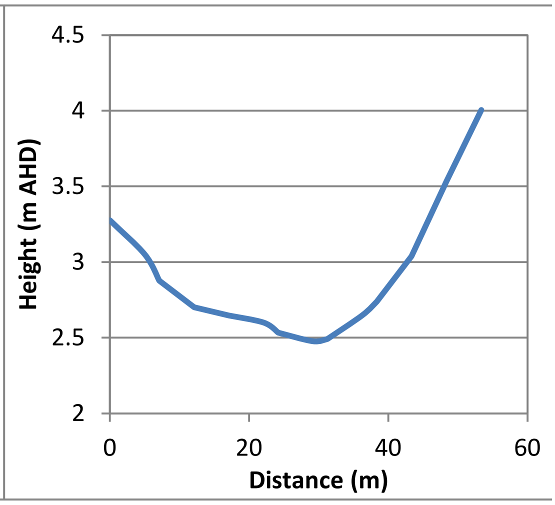


Figure 7-2 Flow path profile through inlet channel, basin and outlet channel

Figure 7-3 Section through sedimentation basin

8 Pre and Post Development Models

8.1 Model Assumptions

The following assumptions were adopted for evaluation of the system using the XP-Storm model:

- Drain the Tug Haven Onshore development area from the south and west towards the north east (towards the existing sedimentation basin) at an average grade of 0.5%. This grade was assumed sufficient to direct run-off to surface drains and to reduce risk of scour and uncontrolled discharge of surface water run-off to the tidal creek;
- Impervious fractions were assigned to catchment areas based on current and planned infrastructure;
- Trapezoidal drains were nominally 1 m deep with 1:3 (V:H) side slopes;
- Existing ground surface levels were used to model the current scenario;
- Run-off was collected from the site and discharged to the existing sedimentation basin for removal of suspended sediment prior to discharging the treated water to the tidal creek; and
- The catchment boundary for the pre (current) and post development models will extend to the middle of the causeway to accommodate possible sheeting.

8.2 Catchment Delineation

The proposed development catchment contributing rainfall run-off to the tidal creeks under pre (current) and post development conditions is depicted by Figure 8-1. The total catchment area is 12.1 Ha.

Impervious fractions were assigned based on the pre (current) and proposed development to model the catchment rainfall run-off.

Run-off was estimated from rainfall excess after infiltration was assessed using the Green Ampt soil parameters in Table 7-1.

Figure 8-1 XP-Storm model catchment boundary

8.3 Hydrological Modelling

8.3.1 Model Scenarios

A range of durations for 10 year ARI design storms were tested using the XP-Storm Model to identify the critical duration (the duration producing the largest peak flows). The following 10, 15, 20, 30, 45, 60, 90, 120-minute duration rainfall events were tested and the critical duration was identified as 60 minutes.

8.4 Pre (current) development scenario

The pre development scenario inflow and outflow hydrograph at the sedimentation basin for the 10 year ARI design storm of 60 min duration is presented in the following figure.

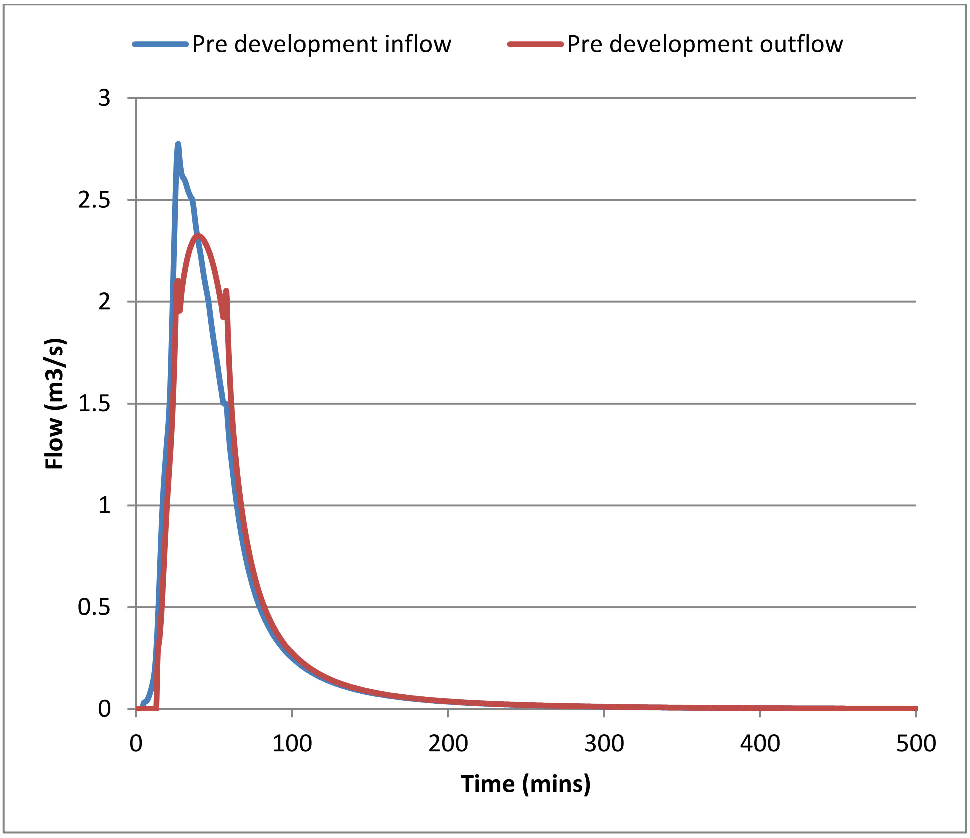


Figure 8-2 Pre (current) development inflow and outflow hydrographs

8.5 Post development scenario

The resulting post development inflow and outflow hydrographs at the sedimentation basin for the 10 year ARI design storm of 60 min duration are presented in the following figures.

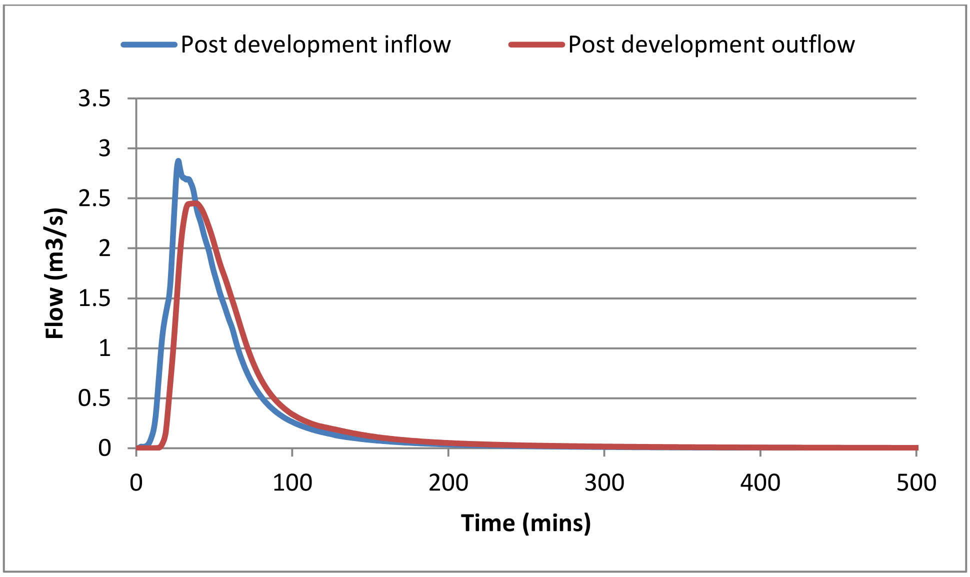


Figure 8-3 Post development inflow and outflow hydrographs

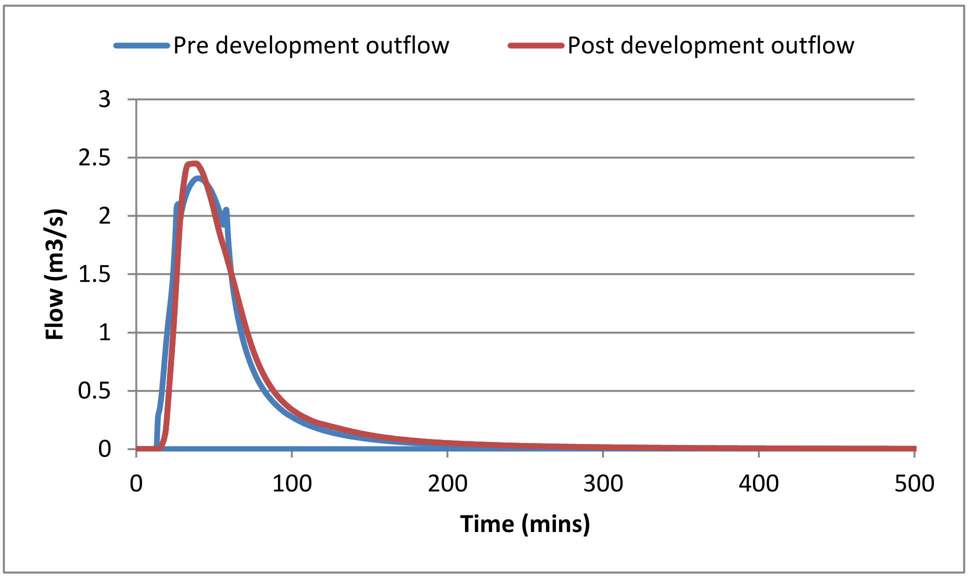


Figure 8-4 Pre and post development outflow hydrographs

Results from the XP-STORM modelling suggest the 10 year ARI design flows can be contained within the drainage system albeit with minimal freeboard. The peak flows leaving the sedimentation basin are similar under the both the pre (current) and post development scenarios.

The run-off is passed through the sedimentation basin for treatment prior to discharge to the tidal creek.

Note that the limited bund height of the sediment basin allows for only 400mm weir depth (depth of weir crest below the top of the embankment that it is protecting). Additional bund height appears unwarranted as storage depth is limited by topography to the north west of the basin.

A summary of the design flow characteristics is presented in Table 8-1 indicates times to peak and peak flows for inflows and outflows under both pre and post development conditions with an estimate of the peak storage developed.

Table 8-1 Flow characteristics resulting from the 10yr ARI design rainfall of 60-minutes duration

	Inflow		Developed Storage	Outflow	
Condition	**t_p (mins)**	**Q (m^3/s)**	**S (m^3)**	**t_p (mins)**	**Q (m^3/s)**
Pre-development (current)	27	2.78	7,535	40	2.35
Post development	27	2.87	7,551	36	2.45

*t_p - time to peak

8.6 Sedimentation Basin

The existing sedimentation basin was modelled to evaluate its effectiveness to remove sediment transported in run-off from storms up to the 10 year ARI design event. The Fair and Geyer (1954) method was used to calculate the fraction of initial solids removed based on the estimated design flows and sedimentation basin characteristics.

Table 8-2 Sedimentation basin 'fraction removed' based on Fair and Geyer theory

Particle Diameter (D) (µm)	Settling Velocity (V_s) (m/s)	Time to Settle 1 metre Vertically (secs)	Fraction Removed
10	3.82E-05	26212	0.01
20	1.53E-04	6553	0.05
50	9.54E-04	1048	0.27
75	**2.15E-03**	**466**	**0.48**
100	3.82E-03	262	0.65
200	1.53E-02	66	0.94
500	9.54E-02	10	1.00

The results contained in Table 8-2 show that 48% of particles of 75 micron can be removed from run-off at the peak of the 10-year ARI design flood. Almost all particles greater than 200µm are removed.

Changes to basin size and shape will affect the fraction of sediment removed. Inclusion of the extended basin area to the west of the sedimentation basin (Appendix B Dwg: 560PO-4347-DR-CI-0003_A) will improve both basin capacity and removal efficiency. Based on likely efficiency improvements alone, reduction by 75% of the 75 micron sediment fraction could be achieved from the 10-year ARI peak flow.

Higher rates of sediment reduction can be expected from the lower flows occurring during the rising and recession legs of the flood hydrograph and from run-off flows generated by the more frequent, lesser storms.

These sediment removal rates are based on the endemic soil types of the area (reflected in the materials likely to be used in the earthworks and unsealed pavements). Any transported haematite or magnetite particles, which have much higher density, will settle out even more readily.

9 Impact Assessment

Comparison of the estimated pre and post development peak flows, volumes and hydrographs as summarized in Table 8-1 suggest the following:

- There is no significant change in the total volume of run-off from the site under post development conditions; as a result there is not expected to be a significant impact on the tidal creeks or surrounding mangrove habitat;
- The peak flow entering the tidal creeks is reduced through flow detention in the sedimentation basin, producing a slower release of water into the tidal creeks and surrounding mangrove habitat;
- Post development run-off is discharged to the same tidal creek systems as under the current conditions and the drainage system and site earthworks avoid restricting tidal movements that could adversely impact the mangrove vegetation; and
- It was demonstrated that the sedimentation basin could effectively remove suspended sediment prior to discharge of run-off water to the environment.

By directing surface run-off flows via a sediment basin to the proposed discharge area at the tidal creek, it has been shown that potential surface water related risks, particularly those associated with sediment transport, can be effectively managed.

10 References

Bureau of Meterology, 2015. http://www.bom.gov.au/

WorleyParsons, 2015. North Star Stage 2 Benthic Primary Producer Habitat Survey and Impact Assessment (Rev B) Iron Bridge Joint Venture, WorleyParsons Pty Ltd, Perth, WA.

WorleyParsons, 2015. North Star Stage 2 Mangrove Protection Management Plan (Rev B) Iron Bridge Joint Venture, WorleyParsons Pty Ltd, Perth, WA.

Fortescue, 2015. Dredging and Spoil Disposal Management Plan, Anderson Point Towage Infrastructure and Services (560PO-C0001-4320-PL-MA-0001), Fortescue Metals Group, Perth, WA.

Fortescue. 2015. Port Towage Services Tug Infrastructure – Marine Structure Basis of Design (560POC0002-4347-BD-MA-0001), Fortescue Metals Group, Perth, WA.

Fortescue, 2014. Surface Water Management Plan, Environment. Document Number 100-PL-EN-1015.

Department of Water, 2013. *Western Australian Water in mining guideline*, Department of Water, Government of Western Australia. http://www.water.wa.gov.au/PublicationStore/first/105195.pdf

Pilgrim, DH, (ed). 1987. *Australian Rainfall & Runoff – A Guide to Flood Estimation*, Institution of Engineers, Australia, Barton, ACT, 1987 (2001 reprint).

Water and Rivers Commission, 1999. *Water Quality Protection Guidelines (No. 6 Mining and Mineral Processing: Minesite Water*, Water and Rivers Commission.

Wong, T. H. F and Engineers Australia, 2006. *Australian Runoff Quality: A Guide to Water Sensitive Urban Design*, N.S.W. : Engineers Media for Australian Runoff Quality Authorship Team 2006.

WorleyParsons, 2011. T155: Port Basis of Design for Earthworks, Roads and Drainage (510P-00000-BD-CI-0001).

WorleyParsons, 2011. T155: Port – Flood Risk Assessment and Drainage Design (515P-10029-RP-HY-0001).

WorleyParsons, 2009. The Heng Shan Project South West Creek Flood Study (00093-R-05029-RP-HY-0001).

WorleyParsons, 2007. Pilbara Iron Ore and Infrastructure Project: South West Creek and Rail Loop Flood Study (11098-06100-CI-RP-0002).

WorleyParsons, 2004. Oceanic Storm Surge Study at Anderson Point, Port Hedland Harbour (07519-06010-EN-RP-0002).

Appendix A

Sedimentation Basin Calculations

Particle Diameter (m)	Settling Velocity (m/s)	Time to Settle 1 metre Vertically (secs)	Fraction Removed
1.00E-05	3.82E-05	26212	0.01
2.00E-05	1.53E-04	6553	0.05
5.00E-05	9.54E-04	1048	0.27
7.50E-05	2.15E-03	466	0.48
1.00E-04	3.82E-03	262	0.65
2.00E-04	1.53E-02	66	0.94
5.00E-04	9.54E-02	10	1.00

Stokes Law:

$$V_s = \frac{(\rho_m - \rho_w) g D^2}{18\mu}$$

Fair and Geyer Theory:

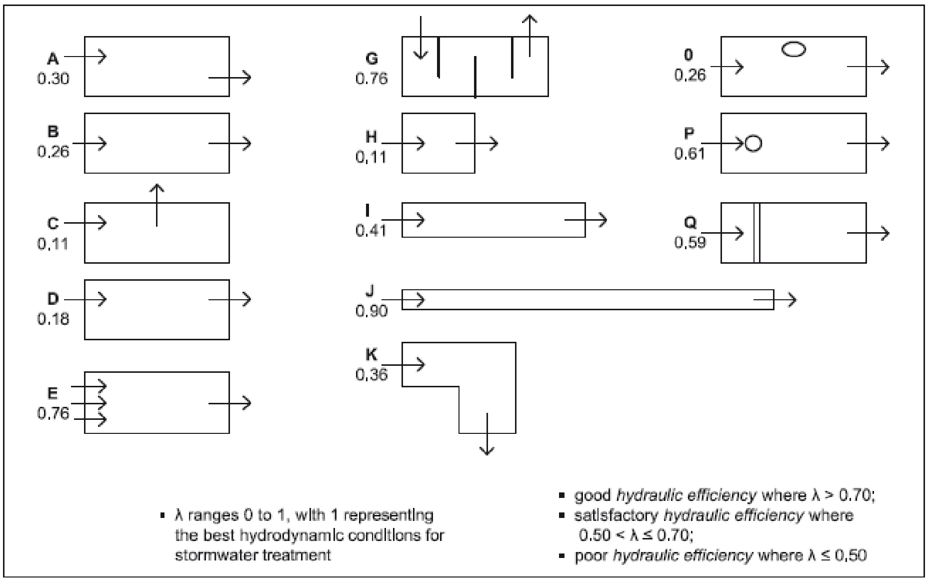
$$R = 1 - \left(1 + \frac{1}{n}\frac{V_s}{Q/A}\right)^{-n}$$

Basin Dimensions:

Width	38m
Length	26m

Where:

ρ_m	Density of Bare Earth / Fill	1700	kg/m^3	
ρ_w	Density of Water	1000	kg/m^3	at 20 degrees
m	Viscosity of Water	0.001	kg/ms	at 20 degrees
g	Gravity	9.81	m^2/s	
A	Basin Surface Area	988	m^2	
A	Basin Cross Sectional Area	19	m^2	
Q	10yr ARI Design Inflow	2.87	m^3/s	
V	Ave Velocity of flow	0.15	m/s	
d	Depth of flow in basin (m)	0.50	m	
l	Hydraulic efficiency	0.59		
n	Turbulence parameter	2.439		

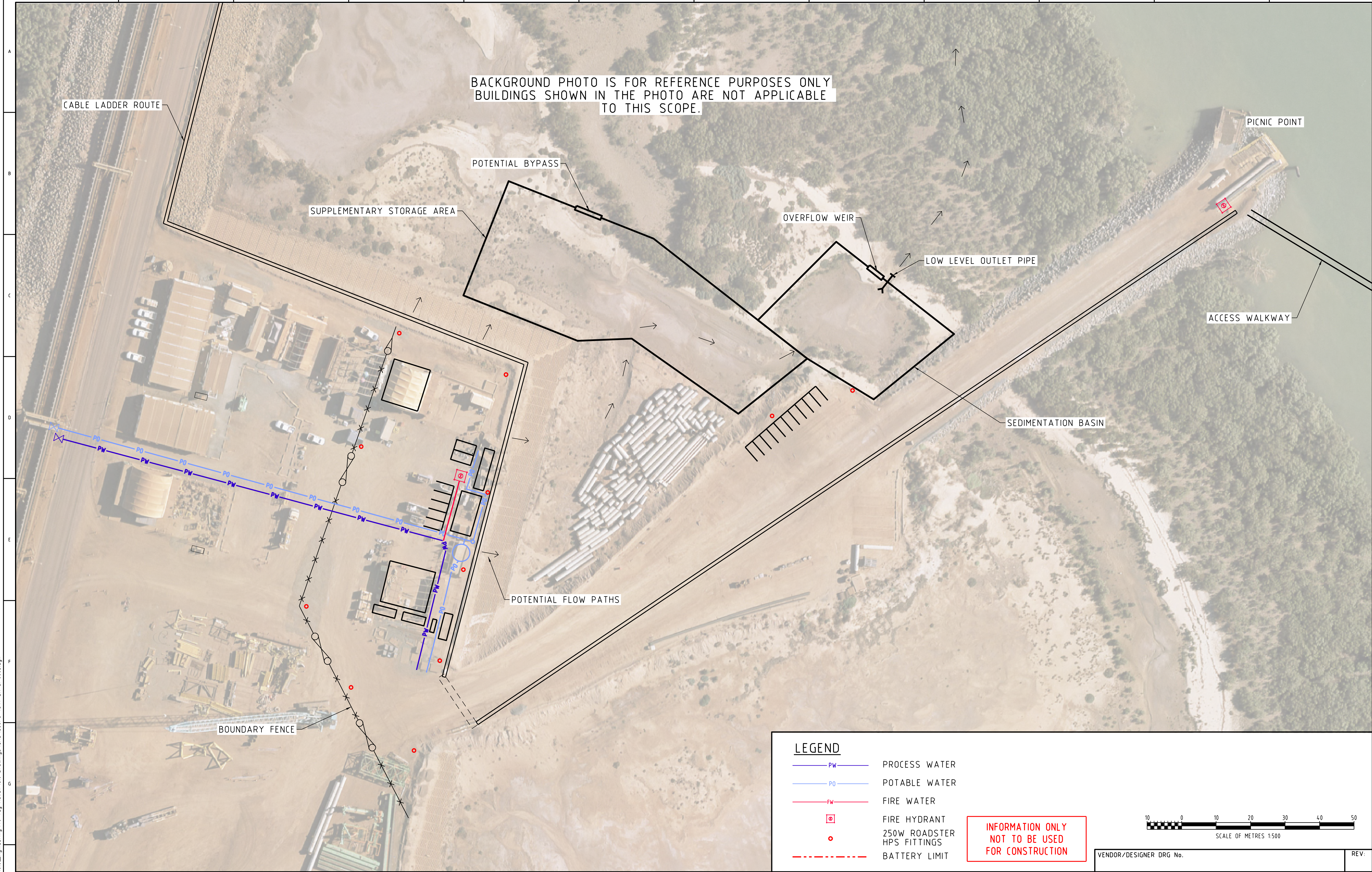


Notes:

1. Settling velocities based on Stokes law for the settling of spherical particles - this applies only to small particles in non-turbulent systems with low Reynolds number.
2. 'Fraction Removed' based on Fair and Geyer theory recommended in Australian Runoff Quality (2006).

Appendix B

Stormwater Drainage Conceptual Drawing



LEGEND

- PW — PROCESS WATER
- PO — POTABLE WATER
- FW — FIRE WATER
- FIRE HYDRANT
- 250W ROADSTER HPS FITTINGS
- BATTERY LIMIT

INFORMATION ONLY
NOT TO BE USED
FOR CONSTRUCTION

10 0 10 20 30 40 50
SCALE OF METRES 1:500

VENDOR/DESIGNER DRG No. | REV:

REF DRG No.	TITLE	REV	DATE	DESCRIPTION	DRN	CHK	SUP	DES	DAP	PAP	FMG
		A	22.10.15	ISSUED FOR INTERNAL REVIEW	TMJ		HCK	HCK			
		-	22.10.15	COMMENCED	TMJ		HCK	HCK			

FMG

STANDARDS CHECK APPROVED

WorleyParsons

NORTH

PROJECT NUMBER
560PO

This drawing must not be copied or reproduced in any form or used for any purpose other than originally intended without written approval of Fortescue MetalsGroup Ltd

Fortescue Metals Group Ltd
PORT TOWAGE SERVICES
TUG INFRASTRUCTURE
ANDERSON POINT TUG HAVEN
STORMWATER DRAINAGE INDICATION

A1 | SCALE 1:500 | DRG No: 560PO-4347-DR-CI-0003 | REV: A

22/10/2015 3:15:59 PM V:\10.0_Engineering\4.0 Tug Haven\6.0 Drawings\CAD\560PO-4347-DR-CI-0003.dgn

Appendix 6: Dredging and Spoil Disposal Management Plan

This page has been left blank intentionally

Plan

Dredging and Spoil Disposal Management Plan

Anderson Point

Towage Infrastructure and Services

January 2016
560PO-C0001-4320-PL-MA-0001

Fortescue
The New Force in Iron Ore

	Dredging and Spoil Disposal Management Plan		**560PO-C0001-4320-PL-MA-0001**
Revision Number	**D**		**11/01/2016**
Status	**IFR - ISSUED FOR REVIEW**		
Author	Nadene Claydon	Signature	11/01/2016
Checked	Harry Houridis	Signature	13/01/2016
Approved	David Aston	Signature	11/01/2016
Confidentiality	**FORTESCUE STAFF & CONTRACTORS**	**Publish on Extranet**	☐ Yes ☐ No
Review Date	11/1/2016		

Revision History *(to be completed for each version retained by Document Control)*					
Author	**Checker**	**Approver**	**Rev No.**	**Status**	**Issued Date**
Cormac Collins	Clayton Brandwood	David Aston	A	Draft	03/07/2015
Cormac Collins	Clayton Brandwood	David Aston	B	IFR	13/11/2015
Cormac Collins	Clayton Brandwood	David Aston	C	IFR	20/11/2015
Nadene Claydon	Harry Houridis	David Aston	D	IFR	13/01/2016

TABLE OF CONTENTS

List of Tables

LIST OF FIGURES

LIST OF APPENDICES

1. INTRODUCTION

Pilbara Ports Authority (PPA) is responsible for marine transport operations in Port Hedland and they have identified the need for additional towage services to facilitate trade and to ensure that vessels receive towage services of the highest standard.

Pilbara Marine is proposing to construct infrastructure required for the provision of additional towage services at Anderson Point in Port Hedland.

The Anderson Point Towage Services Project (the Project) includes for the construction of a tug haven to support the safe mooring of tugs. The tug haven will comprise of:

- Tug pens;
- Cyclone moorings;
- Pontoons;
- Service wharf; and
- Walkways, stairs and access bridges or other means of access between the structures within the facility.

Dredging for the tug haven and approach channel and construction of onshore support infrastructure also form part of the Project.

Dredging and spoil disposal works (the Works) will entail dredging of material within the tug haven and approach channel, onshore reclamation of the dredged material as well as the handling of fine dredging materials generated by the dredging process. The management of these works is the subject of this Dredging and Spoil Disposal Management Plan (DSDMP).

The Project location and layout is shown in the site diagrams included in Appendix 1.

1.1 Proponent

Pilbara Marine is a wholly owned subsidiary of Fortescue Metals Group Limited (Fortescue). All works associated with the Project will be undertaken in accordance with Fortescue's Environmental Management System (EMS) and all relevant Fortescue Policies, Standards and Management Plans.

Pilbara Marine will engage separate Contractors for each of the three main construction work packages:

- Dredging works;
- Marine Infrastructure; and

- Onshore Infrastructure.

1.2 Purpose

This Dredging and Spoil Disposal Management Plan (DSDMP) has been developed to outline the Contractors and Pilbara Marine's environmental management obligations in relation to dredging and spoil disposal.

This DSDMP provides details of environmental roles and responsibilities, management actions, monitoring programs and inspections. It also provides detailed descriptions of the dredging works, plant and equipment, and methodology that will be utilised for undertaking the dredging works.

The environmental factors and objectives adopted by the EPA are listed in the Environmental Assessment Guideline for Environmental factors and objectives (EAG8), (EPA, 2013), which should be used when developing an environment management plan under Part IV of the Environmental Protection Act 1986 and EAG17 (EPA 2015).This DSDMP specifically addresses the marine environmental factors which relate to the Sea theme listed in EAG8.

2. DESCRIPTION OF WORKS

A channel and basin is required to be dredged to allow for the installation of the tug haven. The area to be dredged will be designed to meet the manoeuvring and berthing requirements for up to 13 tug vessels. Approximately 0.80 million cubic metres (m^3) of material is proposed to be dredged to a minimum design depth of -8.0 m Chart datum (CD), (subject to confirmation from dynamic mooring analysis of design tug).

Dredging and disposal will be undertaken by cutter suction dredging (CSD) with onshore disposal of dredge material into an existing reclamation area.

The extent of the proposed dredge area is illustrated in Drawing 560PO-4347-DR-MA-0006 (Appendix 1).

2.1 Anderson Point Tug Infrastructure Project Drawings

A list of the drawings prepared for the Project is provided in Table 1. Copies of these drawings are also provided in Appendix 1.

Table 1: Project Drawings

Drawing Number	Drawing Title
560PO-4347-DR-MA-0010	Project Location
560PO-4320-DR-MA-0008	Survey Area
560PO-4347-DR-MA-0006	Dredging and Piling Footprint
560PO-4347-DR-MA-0007	Tug haven Layout
560PO-4347-DR-MA-0009	Battery Limit of Proposed Works
560PO-4347-DR-CI-0002	Onshore Infrastructure Layout
560PO-4320-DR-MA-0002	Reclamation Area Layout
560PO-4320-DR-MA-0009	Dredging and Spoil Disposal Pipelines

2.2 Key Elements of the Anderson Point Tug Infrastructure Project

The key elements of the dredging component of the Project are summarised in Table 2. The dredged area footprint is shown on Drawing No. 560PO-4347-DR-MA-0006 (Appendix 1).

Table 2: Key Elements of the Project

Component	Description
Berth Pocket	Dredged to a depth of R.L of – 8.0 m CD
Departure Channel	Dredged to a depth of R.L of -8.0 m CD
Benched Areas	Dredged to a depth of R.L of -8.0 m CD
Total Volume of material dredged to design depth	Approximately 800,655 m^3
Design batters	1: 2.5 m in marine sediments 1:1.5 m in other materials
Over dredging allowance	0.3 m
Design Tolerances	Horizontal Over Dredging Tolerance Limits On the toelines and on side slopes a distance of zero (0.0) metres inside of the toeline in navigable areas and two (2.0) metres horizontal outside of the toeline of the navigable area.
Disposal of Dredged Material	All dredged material will be initially pumped into Dredge Material Management Area (DMMA) A. Fines and tail water from DMMA A will then be collected in a pumping pit and conveyed to DMMA B.
Dredged Material Disposal Volumes	The gross dredged volume consists of : • 114,380 m^3 of marine sediments and • 686,275 m^3 of material suitable for reclamation. Dredged material fine/non –fines % splits adopted: For marine sediment fraction: • 25% fines • 75% grits For non-marine sediments fraction; • 17% fines • 83% grits

Component	Description
	Adopting these %'s volumes split into fines and grits disposed of are: • Fines Volume = 145,262 m^3 • Grits volume = 655,393 m^3 Bulking factors adopted: • Fines = 5.5 • Grits = 1.0 Total volumes placed in DMMA A and DMMA B are: • DMMA A =655,393 m^3 (Grits) • DMMA B (ESA/SESA)=798,940 m^3 (Fines)
Disposal Area Capacities	The available remaining capacity of DMMA A is 1,560,000 m^3 The available remaining capacity of DMMA B is 2,800,000 m^3 (Based on calculation to reference height of RL =9.5 m AHD The available fines capacity of ESA/SESA is: • ESA = 1,240,000 m^3 • SESA = 1,560,000 m^3
DMMA A Reclamation	The total of the 655,393 m^3 to be reclaimed in DMMA A will primarily be placed in NSA. The majority of the material will be available to be stockpiled for use as surcharge or future borrow.
Disposal into Fines Deposit areas	The total of 798,940 m^3 of fines will be directed into ESA SP1 with discharge through SESA. SESA has an existing capacity of 1,560,000 m^3 (based on calculation to a Capacity Height of RL + 9.5 m AHD).

2.3 Dredging and Reclamation Works

Dredging is required directly south of the existing Fortescue AP1, AP2 and AP3 wharves for the construction and use of the tug haven. The dredging works comprise dredging of the tug haven area and the approach channel as illustrated in Drawing 560PO-4347-DR-MA-0006 (Appendix 1). Dredging will be undertaken by CSD.

Material dredged will be initially pumped to DMMA A for removal of coarse material and then to DMMA B for removal of fine material. The reclamation areas will be trimmed to profile. No additional compaction is required other than the loose placement of fill material.

Further details regarding proposed dredging, reclamation, stockpiling, fines handling and disposal are provided below.

2.3.1 Pre-Dredging Works

The area to be dredged contains various ground types including overlying sediment, and upper and lower red beds.

Pre-dredge surveys will be undertaken of the dredge footprint area. Survey lines will be run at a spacing of 20 m. The area to be surveyed will extend to a distance of not less than 100 m beyond the extent of the top of slopes or toelines where physically practicable for the survey vessel to access. The survey will extend to cover areas outside of the dredged footprint in accordance with the area shown on 560PO-4320-DR-MA-0008 (Appendix 1). A magnetometer survey will also be undertaken of the proposed dredge footprint area.

In addition to undertaking a pre-dredging survey of the dredge footprint, a pre-fill survey will also be undertaken of the reclamation, fines deposit and drainage areas.

2.3.2 Dredging Methodology

All dredging is to be undertaken by a CSD capable of achieving the design dredged depths and the pumping capacity required. The CSD will also have the cutter capacity to dredge all materials found in the dredging area.

The materials to be dredged generally consist of fine to coarse and sharp angular grained siliceous and carbonate silt, sands, gravel, cobbles, clay mixtures overlying stiff to hard clay, rocklike materials and rock, some of which may be in block and slab forms. The clay and rocklike portions are expected to form clay balls, boulder, cobble and gravel sized material. Clay balls and remnants of clay balls, gravel, cobbles and boulder sized material are expected to survive transport and be deposited in the reclamation areas. The materials to be dredged are expected to create a significant quantity of fines during dredging and transport.

It is envisaged that dredging will be undertaken to a depth of -8.0 m CD and commence in deep water near the end of the existing AP3 wharf and terminate at the tug haven. Details of the proposed CSD cut and sequence plan will be provided as part of the Construction Licence application.

The side slopes of the dredged area will be box cut. The stability of the side slopes will be monitored during dredging works. Dredging works will immediately cease if it has been detected that the stability of the slopes are collapsing or are being impacted upon by the dredging activities.

Progress surveys and monitoring will be undertaken to ensure materials generated from the dredging operations do not interfere with port areas in use by others.

2.3.3 Disposal Pipeline Route

All dredged material shall initially be pumped by the CSD to DMMA A. The pipeline required to convey dredged material to DMMA A will consist of a floating pipeline from the CSD to a submerged pipeline riser located at the shore. Sufficient anchors will be deployed to keep the floating pipeline in position, with the location of these to be marked with yellow buoys and marker lights. From the shore, a section of submerged pipeline will be installed to transition from the floating pipeline to a shore pipeline. The shore pipeline will run across Australia Island East along the shoulder of the causeway road, then turn West along the Northern end of the stockyards and enter DMMA A at its Northern end. The proposed pipeline route is illustrated in Drawing 560PO-4320-DR-MA-0009 (Appendix 1).

2.3.4 Reclamation Area Methodology

Management of dredged material will be undertaken in DMMA A where grit and other coarser material will be reclaimed. Fines and tailwater from DMMA A will then be conveyed to DMMA B where the finer material will be reclaimed

DMMA A is divided into two cells to promote removal of grit and coarse material. These cells are known as the Northern Settlement Area (NSA) and Southern Settlement Area (SSA). DMMA B is split into cells to encourage maximum settlement of fines. DMMA B comprises of the Eastern Settlement Area (ESA) and the South Eastern Settlement Area (SESA). The layouts of DMMA A and DMMA B are illustrated in Drawing 560PO-4320-DR-MA-0009 and Drawing 560PO-4320-DR-MA-0002 (Appendix 1).

Reclamation will be undertaken to minimise the deposition of fines within DMMA A and to direct fines and tail water to a pumping pit for further reclamation in DMMA B. To minimise the deposition of fines in DMMA A, reclamation will be carried out such that fines and tail water have an un-impeded path and sufficient grade to allow water and fines materials to reach and be collected in the pumping pit located at the Southern end of SSA. NSA will be reclaimed first in a north to south direction with SSA then being filled and also reclaimed in a north to south direction.

Filling shall be undertaken in a manner that ensures maximum tail water velocity to channel the fines generated in a southerly direction. The thickness and rate of advance of layers will be managed to avoid structural failure of the underlying materials or peripheral bunds, and also to avoid the congregation or entrapment of fines within the reclaimed dredged materials. The pipe outlet shall be set so the dredged material flows to a distribution fan and no ponding of water behind the advancing reclamation will be allowed. To aid in the reclamation works, dozers, excavators and loaders will also be used.

The rate of reclamation in the vicinity of pressure sensitive areas will be kept within safe limits and be adjusted to avoid any excessive build-up of pore pressure in the underlying materials so as to prevent bund failure. If any part of the bunds, berms or reclamation become unstable or a slip appears to be imminent, reclamation will be diverted to other areas.

Fines and tail water resulting from the reclamation activity in DMMA A will be directed and captured in a purposely designed and constructed pumping pit. From the pumping pit, the fines and tailwater will be pumped to the ESA cell of DMMA B.

Filling of ESA will occur in a north to south direction, with pipelines being added as reclamation proceeds. Sufficient pipelines, valves, bends, Y-pieces and blanks will be incorporated to allow dredged materials to be progressively placed across ESA.

The ESA/SESA reclamation plan is shown on 560PO-4320-DR-MA-0002 provided in Appendix 1.

2.3.5 Potential Acid Sulphate Soils in Dredged Material

Acid sulfate soil (ASS) tests undertaken on dredged sediments located within the proposed dredge footprint confirmed that only a small number of samples were PASS. Due to the increased neutralising capacity from the calcareous materials present in the sediments, no samples exceeded the DEC (2013) Action Criteria for net acidity – requiring no active ASS management measures to be implemented for this campaign.

To confirm that no treatment of dredged material is required, water quality monitoring will be carried out at:

- The return water discharge point (in accordance with the Water Quality Monitoring Program).

2.3.6 Methodology for Disposal of Fines & Tail Water into SESA

Dredge spoil will be pumped from the pumping pit to ESA. From here the dredge spoil will be managed so that a fines/water mixture will flow via gravity into SESA. The fines/water mixture will follow a path in SESA towards the final weir box where the supernatant water will be discharged into South Creek.

2.3.7 Early Works to ESA / SESA

Early works to the existing external bunds of ESA and SESA where repair is required will be carried out by Fortescue before dredging commences.

The Contractor shall carry out other works that will be required to ensure the areas are filled to required levels and discharge water is managed. These works will include fitting valves to the discharge pipes and adjusting the invert levels of the existing pipes where required.

2.3.8 Maintenance and Protection of Bunds

The internal and external surfaces of all bunds shall be maintained and protected from weather, sea conditions, current, cyclone conditions and hydraulic erosion from reclamation operations. The bunds may also need to be reinforced with additional material where required.

During the reclamation works the Contractor shall be required to:

- Physically inspect all bunds during each shift;
- Monitor stability and undertake analysis and assessment of the condition of the bunds;

- Repair and maintain the integrity of the bunds;
- Maintain the outer slope from erosion; and
- Undertake any other inspection or *works* required to maintain the integrity of the peripheral and internal bund structures.

2.3.9 Tail Water Control

Reclamation works shall be undertaken so that the tail water flow is directed through DMMA A and DMMA B in a manner that ensures efficient reclamation and completion of required reclamation areas to required levels.

To ensure reclamation works are undertaken to meet the above, the Contractor shall be required to:

- Make sure erosion flows are not allowed to develop;
- Ensure the water is allowed to rest for sufficient time without undue movement in order to allow any fine material and colloidal particles to rest and settle;
- Adjust the level of discharge pipes between SESA and the discharge channel to achieve the desired control of tail water within the Fines Deposit Area; and
- Monitor and manage the removal of the supernatant water such that the discharge meets the requirements of Table 18.

3. OTHER REQUIREMENTS

3.1 Health and Safety Requirements

The Dredging Works shall be carried out in accordance with the Project Contractor HSE Specification (560PO-40000-SP-SA-0001) and Project Health and Safety Management Plan (560PO-4000-PL-SA-0001).

These set out the minimum requirements in relation to resourcing, deliverables and compliance standards for health, safety and environmental matters for the Project.

3.2 Quality Assurance Requirements

The Contractor shall have a Quality System in place which complies with ISO 9001 and shall provide evidence of third party assessment and endorsement. Quality records shall be generated for dredging, field surveys, survey data reduction, data editing, data plotting and chart presentation. All Quality records shall be traceable from the Inspection and Test Procedures to the deliverable set.

3.3 Survey Requirements

The Contractor shall be responsible for carrying out all survey work, which shall include a Pre Dredge Survey, Progress Surveys and Post Dredge Clearance Surveys. Survey works shall be carried out in accordance with the following:

Survey works shall be carried out in accordance with:

- Survey Specifications as mentioned in the Scope of Work;
- IHO SP44 5th Edition (special order); and
- Ports Australia Survey Principles – Version 1.5 (November 2012).

Further details regarding the survey works and requirements are provided in Section 6.3.

3.4 Port Activity

The dredging works will be carried out in an operating Port with ongoing operations occurring at the adjacent Fortescue AP1, AP2 and AP3 berths. PPA Port Regulations and Procedures shall be adhered to during the dredging works.

Interface meetings with AP1, AP2 and AP3 shipping operations will occur as required to manage the interface activities.

4. WORK METHOD STATEMENTS

Work Method Statements (WMS) shall be developed by the Contractor for the works required, and approved by Fortescue prior to the works proceeding. WMS shall cover all the requirements as set out in the Dredging and Spoil Disposal Scope of Works and provide details of all construction activities including:

- Dredging Works;
- Disposal pipeline supply installation and operation;
- Reclamation and spoil disposal activities;
- Environmental monitoring and management;
- Health and Safety Management; and
- Survey and survey control of the Works.

5. RESOURCES

5.1 Main Equipment Vessels

5.1.1 Cutter Suction Dredger

The execution of the dredging and spoil disposal works requires the mobilisation of a robust CSD with sufficient ladder weight, ladder length, cutter, side winch power, spud weight, penetration and pumping power. The CSD vessel proposed to undertake the dredging works has not yet been finalised. Specifications for the proposed CSD vessel will be provided in the Construction Licence application. A general arrangement drawing of the proposed CSD will also be provided in the Construction Licence application.

5.2 Auxiliary Equipment

5.2.1 Reclamation and Spoil Disposal Shore Based Equipment

A list of the reclamation and spoil disposal equipment likely to be used is provided in Table 3 below.

Table 3: Reclamation and Spoil Disposal Equipment

Plant	Type
Dozers x 2	D6 LGP
Excavators x 2	30 T and 24 T
Loader	988
Crane	Franna
All Terrain Crane	As Needed

5.2.2 Self-Propelled Auxiliary Vessels

For support of the CSD operations, anchor handling, handling of submerged and floating pipelines, cyclone moorings, transport between the dredge and the shore and further general marine assistance for the project a multipurpose workboat will be required. The specific workboat has not yet been finalised. Details of the proposed workboat will be provided in the Construction Licence application.

5.2.3 Other Floating Auxiliary Equipment

The following marine auxiliary vessels may also be required:

- Survey boat; and
- Crew boat.

5.3 Pipelines

The pipeline required for the conveyance of dredged material from the CSD to DMMA A and then onto DMMA B will comprise of three distinct sections. These are:

- Floating pipeline;
- Submerged pipeline; and
- Shore pipeline.

Further details of each of these pipelines are provided below. The proposed route is illustrated in Drawing 560PO-4320-DR-MA-0009 (Appendix 1).

5.3.1 Floating Pipeline

A floating pipeline shall be used for the conveyance of dredged material from the CSD to the shore. Approximately 400 m of self floating pipeline with an inner diameter of 750mm is proposed for this section. The pipes shall be connected in a string using male and female ball joint connections.

On some pipes, an extra pontoon with bollards may be installed for additional buoyancy and easy anchoring and towing. The pipeline shall be connected to one side of the dredge with a swivel pipe without floaters. The other end shall be connected in a similar way to the submerged pipeline.

Pipe thickness will be measured throughout the duration of the works with an ultrasonic thickness tester to ensure they are of sufficient thickness. Where pipes are deemed not to be of a sufficient thickness they will be replaced.

Sufficient anchors will be deployed to keep the floating pipeline in position. The location of the anchors will be typically marked with yellow buoys and marker lights.

5.3.2 Submerged Pipeline

The section of pipeline between the shore and the end of the floating pipeline will be bridged by a submerged pipeline. The submerged pipeline will consist of approximately 250 m of steel pipe with an inner diameter of 750 mm. Pipe lengths will be welded together.

5.3.3 Shore Pipeline

The shore based pipeline (inner diameter 750 mm) will run across Australia Island East, along the shoulder of the causeway road, then turn West along the North of the Stockyards and enter DMMA A at its Northern end. A further section of shore pipeline is also required to connect DMMA A to DMMA B. This section of pipeline shall run Eastwards along the Southern end of the Stockyards and enter ESA at its Western side. Approximately 3,000 m of shore based pipeline is required to be installed in total. The pipes will be either welded or bolted together and Y-pieces will be included with valves which allow for branching.

During reclamation within DMMA A there may not be sufficient time to extend the pipeline by means of bolted flanges, and therefore quick coupling pipes may be used. These types of pipes allow for a fast coupling and uncoupling of pipeline and shall be used primarily in the vicinity of the discharge mouth. The pipes have a male end on one side (discharge direction) and a female end on the opposite side. A rubber seal in the female end ensures a closed connection.

Pipe thickness will be measured throughout the duration of the works with an ultrasonic thickness tester to ensure they are of sufficient thickness. Where pipes are deemed not to be of a sufficient thickness they will be replaced.

5.4 Workshop and Spare Parts Yard

Workshop and laydown areas (Drawing 560PO-4320-DR-MA-0009) will be required in support of the dredging and reclamation activities. Welding capability will be required to maintain and repair the floating pipeline, cutters and other equipment. Laydown and storage areas (on and offsite) will be used for storage of spare parts, pipes for reclamation, valves and other reclamation related equipment.

On the reclamation area, a laydown area will be required for the temporary storage of reclamation pipes, valves and other reclamation related equipment.

6. PROJECT EXECUTION

6.1 Mobilisation

Mobilisation activities shall be planned and carried out in accordance with PPA Port Regulations and Procedures and the requirements of the Project Scope of Works.

6.1.1 Vessel Inspection

The CSD vessel will undergo an underwater inspection witnessed by an inspector authorised by the Department of Fisheries (DoF), as well as underwater hull cleaning (as required) prior to mobilisation to Port Hedland. Australian Quarantine Inspection Service (AQIS) and DoF inspections and clearance will be organised at location prior to mobilisation.

Any auxiliary vessels that are not from Port Hedland shall also undergo inspection by AQIS and DoF on arrival. Pumps for fines and tail water may also require inspection and clearance depending on where they are mobilised from.

All planning for inspections, reporting of the results in a timely manner and communication with the Principal shall be the responsibility of the Contractor.

6.1.2 Vessel Condition

All vessels mobilised to site shall be under class registration and have all certificates up-to-date including a certificate of anti-fouling if required.

The CSD and the auxiliary vessels shall follow a regular maintenance program to keep them in good working order and ready for the task throughout the duration of the dredging and reclamation works. Sufficient spare parts, including the important wear and tear parts shall be mobilised and regular maintenance periods shall be scheduled.

Hazardous materials shall carry a Material Safety Data Sheet (MSDS) and procedures for storage and handling. Materials which are not planned to be used during the execution of the works will not be mobilised.

6.2 Dredging Operations

The proposed dredging and reclamation works have been described in Section 2.3.

Details of any additional dredging and reclamation works over and beyond that described in Section 2.3 are provided below.

6.3 Survey and Survey Controls

Survey works are to be undertaken in accordance with;

a) IHO SP 44 5th Edition (special order);

b) Ports Australia Survey Principles – Version 1.5 (Nov 2012); and

c) Survey Specifications as outlined in the Scope of Works.

A pre dredge survey shall be carried out by the Contractor with the area to be surveyed to extend to a distance of not less than one hundred (100) metres (m) beyond the extent of the top of slopes or toelines where physically practicable for the survey vessel to access. The pre dredge survey shall also extend to cover areas outside of the dredged footprint in accordance with the area shown on Drawing 560PO-4320-DR-MA-0008. Survey lines shall be run at a spacing of 20 m.

Progress surveys shall be carried out at regular intervals to establish dredging progress and to quantify volumes for progress payment claim purposes. A weekly progress survey will also be carried out to cover areas outside of the dredged footprint. Progress surveys shall be carried out with a maximum line spacing of 20 m.

The post dredge clearance survey shall be carried out over the same area as the pre dredge survey. Survey line spacing shall be such so as to give 100% bottom coverage and 100% overlap. Long lines shall also be run along the *toe lines* in addition to cross lines.

Pre fill, interim fill and a post fill survey of the reclamation sites shall also be carried out. A pre fill survey shall be completed for each reclamation or fines deposit area before any dredging work commences. Interim fill surveys shall be run at calendar monthly intervals for each reclamation site used during that month. A post fill survey shall be carried out when a reclamation area is no longer required and at the end of the dredging works. Survey lines shall be run at 25 metre centres with bottoms, tops, inverts and banks of bunds and drains located.

6.4 Port Waters Depth Reduction

The Contractor's dredging and spoil disposal works must not reduce the maintained navigable depth of the Port as at the date of the pre dredge surveys. The Contractor shall survey the area of any impact of its operations as required to ensure that the maintained navigable depth is never reduced.

If the maintained navigable depth of the Port within the area of impact is reduced by the Contractor's Works, the Contractor shall remedy the reduction in depth immediately and shall provide 24 hour survey spread availability to demonstrate to the Harbour Master that the maintained navigable depth has been restored. All costs associated with such depth remedy and survey work shall be to the Contractor's account.

7. ROLES AND RESPONSIBILITIES

Fortescue personnel will act to direct, guide and support the Project construction to meet environmental performance requirement. Table 4 identifies the responsibilities associated with the key management positions during the life of the Project.

Table 4: Roles and Responsibilities of Key Personnel

Position	Responsibilities
• Project Manager / Site Construction Manager	• Overall responsibility for implementation of the DSDMP. • Overall responsibility for complying with all relevant legislation, standards and guidelines. • Ensures dredging activities are conducted in a safe environment to both site personnel and the public.
• Dredge Contractor	• Prepares and implements an environmental management plan in accordance with the requirements of the DSDMP. • Implements the management actions of the DSDMP. • Ensures adequate training of all staff within their area of responsibility. • Ensures all equipment is adequately maintained and correctly operated.
• HSE Advisor	• Complies with the requirements of the DSDMP. • Provides advice on dredging and dredge material management related environmental issues. • Overseas implementation of environmental controls, monitoring programs, inspections, audits and management actions in the DSDMP. • Completes compliance reporting requirements. • Coordinates the training and induction process. • Responsible for the implementation of the environmental monitoring programs and inspections. • Prepares environmental monitoring reports. • Provides advice with respect to environmental issues as required. • Responsible for reporting all Level 3 or above incidents to PPA within 24 hours.
• All persons involved in project	• Comply with the requirements of the DSDMP. • Comply with all legal requirements under the approvals documents and relevant Acts.

Position	Responsibilities
	• Exercise a Duty of Care to the environment at all times. • Report all environmental incidents

8. ENVIRONMENTAL STUDIES AND EXISTING ENVIRONMENT

The existing environment has been studied, including baseline surveys and sampling in order to understand the potential impacts of the Works.

8.1 Marine parks and reserves

There are no marine parks or reserves in the vicinity of Port Hedland. The proposed Dampier Archipelago Marine Park is the nearest but is 225 km to the west, and the recently approved Eighty Mile Beach is 250 km to the north. Both marine parks are well outside the predicted zone of influence of proposed dredging activities.

8.2 Previous capital dredging projects

Several dredging projects have been undertaken adjacent to the proposed disturbance footprint and more widely within Port Hedland inner harbour. These include capital dredging at Anderson Point, Nelson Point and within South West Creek. The history of capital dredging in Port Hedland since 1986 is summarised in Table 5.

Table 5: Approved dredge volumes for capital dredging project undertaken in Port Hedland Inner Harbour

Year	Dredge Volume	Proponent
1986	13,600,000	BHPBIO
2002	460,000	BHPBIO
2006-07	5,000,000	FMG
2008	3,400,000	FMG
2009	3,900,000	BHPBIO
2010	6,000,000	BHPBIO
2010	50,000	FMG
2011	17,000,000*	PHPA
2012	1,700,000*	BHPBIO
2012	5,880,000*	PHPA
2015	800,000	PPA (AP5 Project)

*Staged development, dredging partially completed

8.3 Physical marine environment

8.3.1 Seabed morphology and geology

The Port Hedland area is a limestone barrier coast with a large tidal range that has evolved into a mosaic of coastal landforms inclusive of offshore limestone ridges, protected embayments (such as the inner harbour), sandy substrates with mangroves, mud flats, salt flats and a number of islands and associated reefs.

Within the inner harbour marine sediments are described primarily as Archean basement rock overlain by a sequence of Pleistocene-aged sediments (Hickman and Gibson 1982). The majority of the Pleistocene deposits consist of accumulations of terrigenous sediments including clays, silt, sands and gravels with varying degrees of cementation. A thin veneer of Holocene sediments occurs on the seabed surface within the inner harbour that are relatively homogenous across the harbour and consist of unconsolidated fine material ranging from clays and silts to fine sands that extend to a depth of 3 m.

8.3.2 Bathymetry

The inner harbour has been substantially modified by dredging and reclamation activities since development of the port in 1965, to accommodate changes in vessel size and expansion of the port in response to increasing iron ore production in the region. The inner harbour has an average depth of -14.6 m CD and berth pockets in the port range in depth from -11.2 to -19 m CD (PHPA 2010).

8.3.3 Hydrodynamic

Currents within Port Hedland are dominated by tidal flows due to a combination of the large tidal range that exists in the area; the narrow entrance to the port; shelter from wind and swell-driven wave currents provided by Finucane Island; and shallow, narrow creek systems that flow into the port area. The highest astronomical tide is approximately 8 m CD, with tides typically ranging from 1.5 m CD during neaps to 5.8 m CD at springs, and are predominantly semi-diurnal.

During neap tidal conditions, waters within the port are generally well mixed. Even so, some areas experience stratification due to lower current velocities and reduced mixing efficiency. During spring tides increased current velocity and movement of water in a counter-clockwise direction within the turning basin causes reduced mixing within some of the deeper areas of the turning basin (Halpern Glick Maunsell 1997). The natural littoral drift process moves sediment from west to east and the natural current direction in the local area is north-westerly to south-easterly (GHD 2007).

8.3.4 Sediment quality

Environmental sediment sampling was undertaken for this Project to understand the quality of the sediment being dredged and disposed of into the DMMA, and the possible impacts to the water quality due to discharge from the DMMA. This aids to address the EPA objective for marine environmental quality, “to maintain the quality of water, sediment and biota so that the environmental values, both ecological and social, are protected”.

Sediment results from four boreholes found that the material was suitable for onshore disposal within a DMMA, with most metals being below the NAGD screening level and soil guidelines.

Only chromium and nickel were above the NAGD screening level in a few of the samples, however they were below the ANZECC (2000) assessment levels and the NEPM HIL, and therefore suitable for onshore disposal.

Acid sulphate soil analysis was also undertaken, and it was found that although the net acidity (as calculated for the comparison to the action criteria) in the sedimentary layer was above the action criteria, it is considered likely that the stored neutralising capacity within the dredge material will neutralise any acidity generated.

Therefore the dredging and spoil disposal activities related to the Project are unlikely to have a significant impact on the quality of water and sediment.

8.3.5 Sediment plume modelling

Sediment plume modelling was undertaken to quantify the expected movement and concentration for material suspended during dredging operations (WorleyParsons 2015). The study investigated potential seasonal variations in the migration of the suspended material and sedimentation patterns for the “worst case”, and therefore the model was run over both summer and winter seasons. The modelling approach and methods are described in the Sediment Plume Dispersion Modelling report (WorleyParsons 2015).

This modelling addresses the EPA objectives which apply to two factors::

- Coastal processes (to maintain the morphology of the subtidal, intertidal and supratidal zones and the local geophysical processes that shape them), and
- Marine Environmental Quality (to maintain the quality of water, sediment and biota so that the environmental values, both ecological and social, are protected)

The summer scenario results are presented in Figure 1 and Figure 2, and the winter scenario results are shown in Figure 3 and Figure 4. It is predicted that dredging over either season is expected to result in a general plume migration near the Project area within the Inner Harbour, with the highest plume concentrations occurring in South Creek and South East Creek. Both seasons were very similar, though the winter scenario shows a slightly higher SSC compared with the SSC in the summer scenario, with more of the plume more likely to be retained within the spill area and along South East Creek. However, these plumes are considered low.

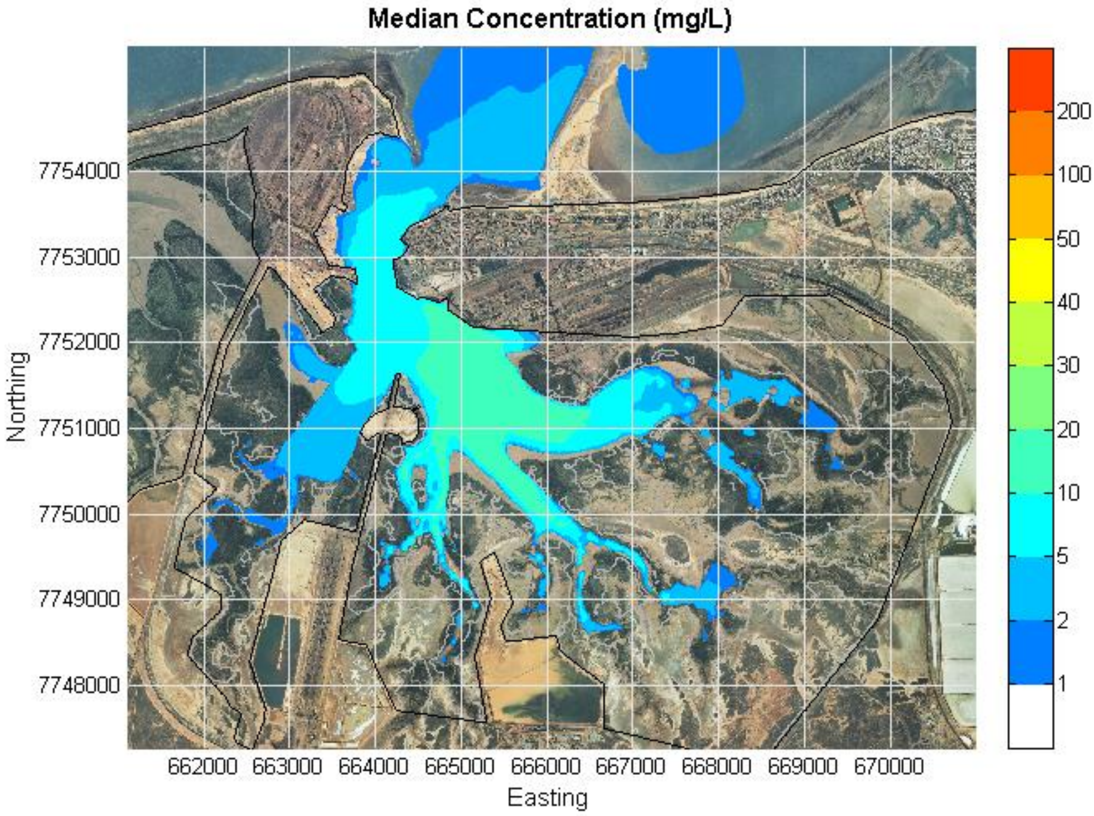


Figure 1: Predicted 50th percentile depth-averaged SSC in the Inner Harbour: summer scenario

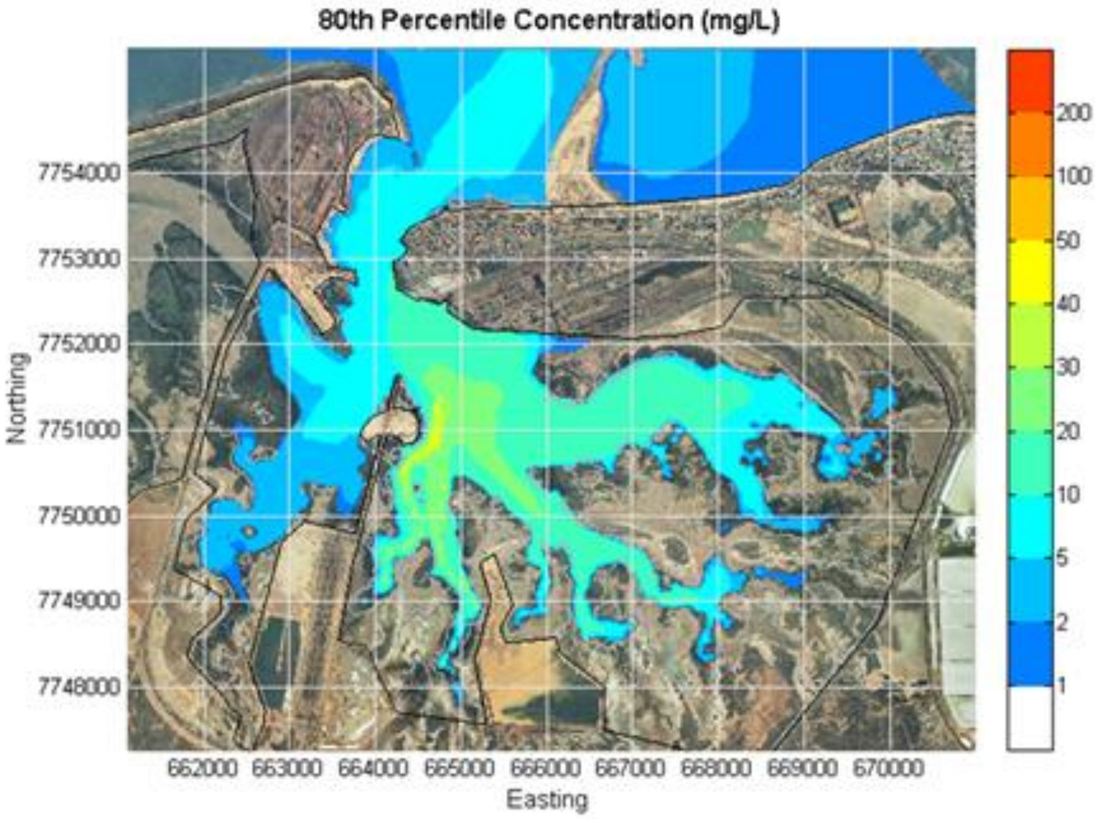


Figure 2: Predicted 80th percentile depth-averaged SSC in the Inner Harbour: summer scenario

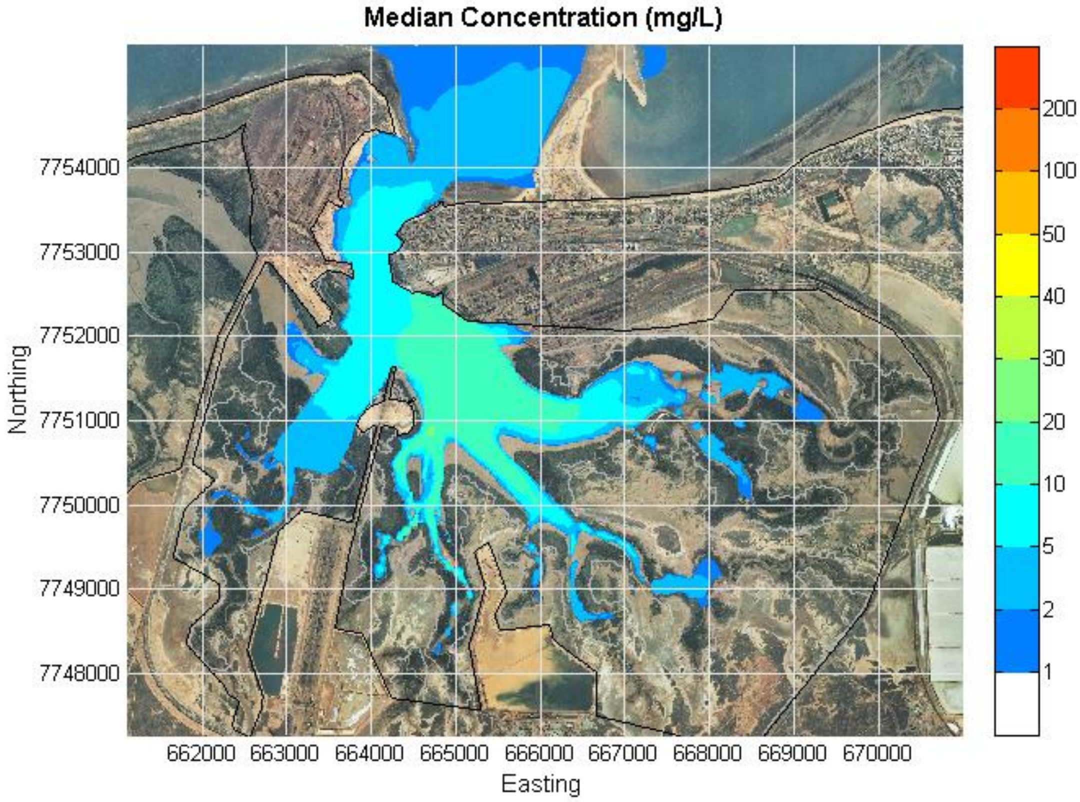


Figure 3: Predicted 50th percentile depth-averaged SSC in the Inner Harbour: winter scenario

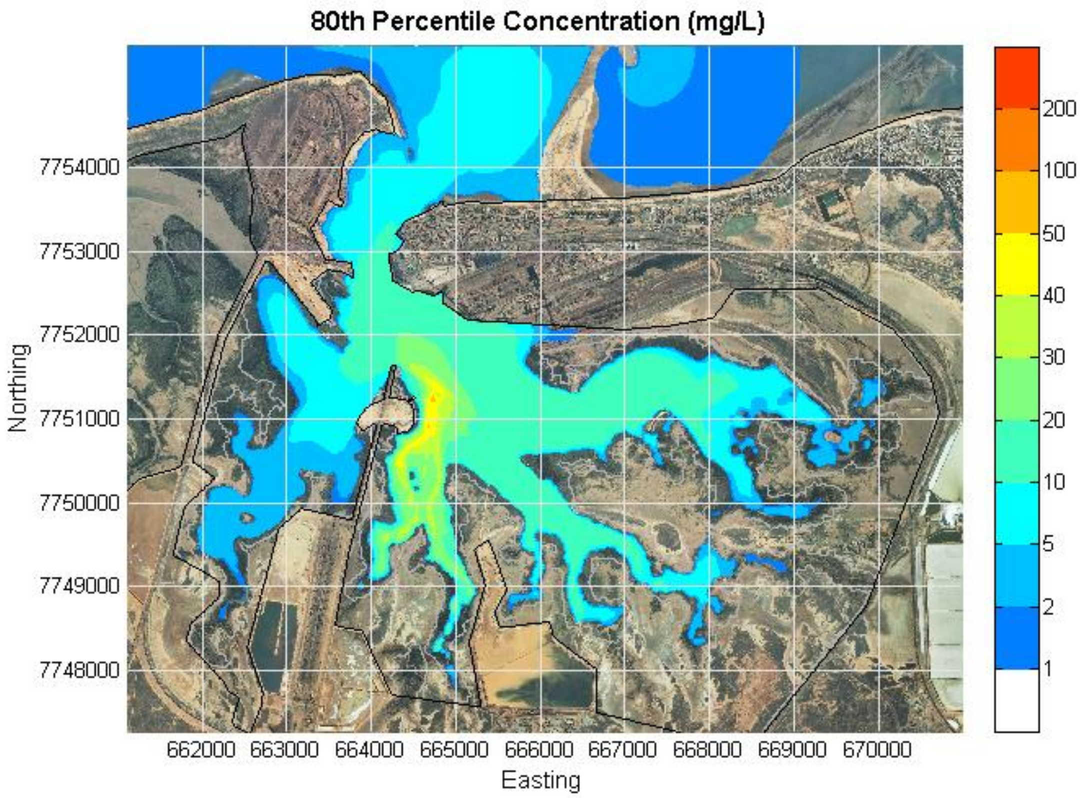


Figure 4: Predicted 80th percentile depth-averaged SSC in the Inner Harbour: winter scenario

Sedimentation modelling was also undertaken to predict the resulting total seabed thickness change. According to the modelling results, areas where possible sedimentation of 100 mm or more may occur are limited to the ZoHI, where direct loss of existing habitat will already occur due to the direct impact of dredging. Areas of moderately high sedimentation (between 50-100 mm) are limited to the ZoMI whereas most of the remaining section of Inner Harbour (including the areas of mangrove) are expected to experience less than 2-5 mm of consolidated total seabed thickness change over the summer and winter scenarios (WorleyParsons 2015). Further discussion of the zones and a figure are provided in Section 9.1. There are no areas within the harbour, where mangroves occur, that are likely to experience sedimentation above the 5 to 50 mm range. This is well below the mortality threshold of 100mm that was adopted in previous projects for mangrove species present in Port Hedland (WorleyParsons 2010). Overall, no indirect or irreversible loss of coastal intertidal BPPH is predicted to occur from sedimentation.

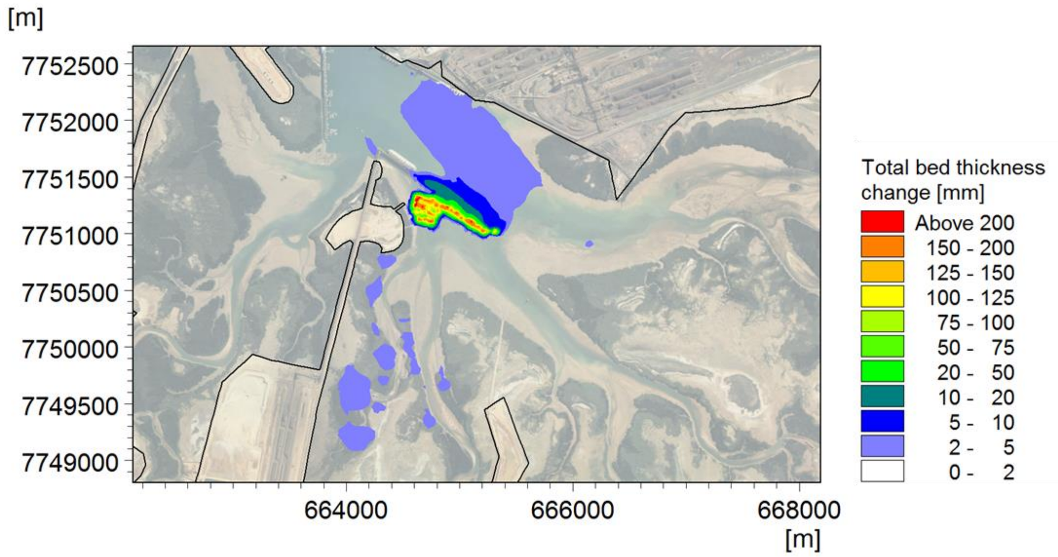


Figure 5: **Total seabed thickness change after completion of dredging in the Inner Harbour: summer scenario**

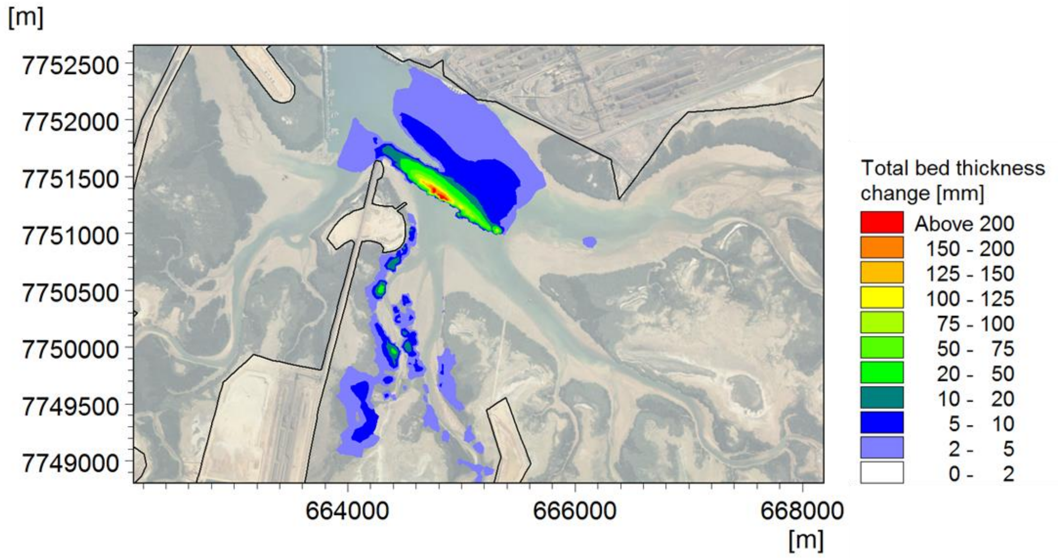


Figure 6: Total seabed thickness change after completion of dredging in the Inner Harbour: winter scenario

8.4 Marine water quality

8.4.1 Physico-chemical

Due to extensive operational and construction activities occurring on a continuous basis within the inner port area, water quality data that can be considered ‘baseline’ can be difficult to collect. Due to the port’s rapid expansion in recent years, water quality throughout the inner port has been affected by dredging and dewatering activities – causing changes to physico-chemical water quality.

The most recent relevant study undertaken to define baseline physico-chemical water quality was undertaken in 2012 for the Stingray Creek Cyclone Mooring Facility (WorleyParsons 2012a) for the inner harbour, and during the South West Creek Dredging and Reclamation Project Phase I and Phase II for the discharge sites in the upper creeks (WorleyParsons 2011, 2014). The Phase II part of the project relates to deepening for AP5. Physico-chemical water quality data was collected from five sites located within the inner harbour to determine baseline conditions between December 2010 and March 2012 between dredging activities during for the Stingray Creek project. For the South West Creek project, data was collected at three different sites within the creeks between January and February 2014.

Turbidity was generally found to be higher in creeks compared with the more exposed sites located at the mouths of the creeks in the inner harbour, most likely due to an increase in fine sediments and reduced flushing from the open ocean. Sites located adjacent to the inner harbour displayed median turbidity of <7 NTU, while sites located upstream displayed median turbidity of 9.5 to 31.2 NTU (WorleyParsons 2014).

The pH was found to be similar between sites located in or adjacent to the operating port area, while pH at sites located within the creeks was slightly lower (WorleyParsons 2011, 2012). Within each site pH was found to show low variation.

Due to the shallow bathymetry observed at each site, temperature was found to vary depending on air temperature variation as a consequence of seasonal change. Median temperatures at each site ranged between 21.21 °C and 31.63 °C.

Higher dissolved oxygen concentrations were found in areas exposed to the open ocean compared with sites located within the creeks (WorleyParsons 2011, 2012).

8.4.2 Chemical

Baseline water quality investigations undertaken in South West Creek as part of PHPA’s dredging and reclamation project (WorleyParsons 2010b) found that all metals reported concentrations below (ANZECC/ARMCANZ 2000) for 99% ecological protection, with the exception of copper and cobalt due to the laboratory limit of reporting being above the (ANZECC/ARMCANZ 2000) guidelines. Nutrients and hydrocarbons in the same study were below the 99% level of ecological protection guidelines at the monitored sites.

Baseline water quality investigations for RGP5 and RGP6 were undertaken between August 2008 and December 2009. All parameters reported concentrations below ANZECC & ARMCANZ guidelines (2000) for 99% ecological protection, with the exception of copper, cobalt zinc and nickel. Copper, zinc and cobalt exceeded the 95% species protection (ANZECC/ARMCANZ 2000) trigger values and nickel exceeded the 99% species protection (ANZECC/ARMCANZ 2000) trigger value (BHPBIO 2010).

More recently, as part of the South West Creek dredging project, nickel concentrations in return water were monitored during dewatering activities. The monitoring program measured intermittent exceedances in of the trigger value for nickel (7 µg/L) however similar exceedances were noted in reference areas unaffected by dredging (WorleyParsons 2012b).

The Pilbara Coastal Water Quality Consultation Outcomes Environmental Values and Environmental Quality Objectives suggest using the ANZECC guidelines 90% level of ecological protection for Port Hedland Port within 250 m of existing, new and approved facilities and infrastructure (DoE 2006).

In accordance with these objectives, the 90% level of ecological protection should logically be extended to within 250m of the proposed dredge footprint and infrastructure boundary as has most recently occurred for the South West Creek dredge footprint and the Small Vessel Cyclone Mooring Facility dredge footprint in Stingray Creek. All other marine environments within state waters of the Port Hedland region are suggested to fall within a 99% ecological protection level.

8.4.3 Surface water assessment

In addition to the sediment plume modelling, a surface water impact assessment was also undertaken to determine the estimate the impacts from surface water flow into the marine environment. This assessment addresses two of the EPA objectives which apply to two factors, which are:

- Coastal processes (to maintain the morphology of the subtidal, intertidal and supratidal zones and the local geophysical processes that shape them), and
- Marine Environmental Quality (to maintain the quality of water, sediment and biota so that the environmental values, both ecological and social, are protected)

Comparison of the estimated pre and post development peak flows, volumes and hydrographs suggests the following:

- There is no significant change in the total volume of run-off from the site under post-development conditions; as a result there is not expected to be a significant impact on the tidal creeks or surrounding mangrove habitat;

- The peak flow entering the tidal creeks is reduced through flow detention in the sedimentation basin, producing a slower release of water into the tidal creeks and surrounding mangrove habitat;
- Post development run-off is discharged to the same tidal creek systems as under the current conditions and the drainage system and site earthworks avoid restricting tidal movements that could adversely impact the mangrove vegetation; and
- It was demonstrated that the sedimentation basin could effectively remove suspended sediment prior to discharge of run-off water to the environment.

By directing surface run-off flows via a sediment basin to the proposed discharge area at the tidal creek, it has been shown that potential surface water related risks, particularly those associated with sediment transport, can be effectively managed.

These results also confirm that indirect impacts on BPPH are unlikely due to surface water runoff.

8.5 Biological marine environment

8.5.1 Benthic Primary Producer Habitat (BPPH)

One of the EPA objectives to be taken into account for this Project is to maintain the structure, function, diversity, distribution and viability of benthic communities and habitats on local and regional scales (EAG8, EPA 2013).

A benthic primary producer habitat (BPPH) desktop survey and cumulative impact assessment was undertaken in December 2015 (Advisian 2015) to calculate the area of direct and indirect losses of BPPH due to the project. It was found that only 2.19 ha of bare substrate would be removed due to the Project. This loss only represents 0.11% of the bare substrate within the LAU, and would result in a cumulative loss of 11.24%. No other indirect losses or impacts were predicted. These impacts were not considered to be significant.

The area of benthic loss within the dredge footprint yet to be approved is shown in Table 7 and clearly shows that a significant proportion of the dredge area already falls within an approved disturbance footprint

Figure 7: Benthic habitat map of the dredge footprint and the Stingray Creek approved benthic loss area.

8.5.2 Introduced marine species

The Port of Port Hedland is at high risk of marine pest colonisation, and routine monitoring of marine species is undertaken within the harbour by PPA. Settlement arrays are placed around the harbour, and samples are collected quarterly and sent to the Department of Fisheries (DoF) for analysis.

8.6 Social and regional planning

8.6.1 Planning context

The Project is located within the administrative boundary of the Port of Port Hedland. The Port Hedland Port Authority (now Pilbara Ports) released the Port Hedland Port Authority Port Development Plan 2012-2016 for mapping sustainable development for the future. The plan addressed social, employment, environmental and heritage impacts of the future developments.

Any proposed works is planned in consultation with PPA, other government authorities and industry. This Project is consistent with the outcomes of this Port Development Plan.

8.6.2 Recreation and tourism

Coastal recreational activities, such as sailing, fishing and diving are popular in the Port Hedland area. There are two major boat-launching areas in Port Hedland at the north-western end of Finucane Island and to the north of the PHPA's berths (WAPC 2003). The PHPA also has a jetty near the existing port area which allows commercial fishing boats access to the coast when commercial wharves are unavailable (WAPC 2003).

The marine aspects of the Project area are known to provide some recreational fishing value, although the area is not considered to be used extensively. It is likely some recreational fishers may be restricted to certain areas of South Creek and South East Creek during construction and dredging as a result of exclusion zones that may be required in accordance with safety requirements. No commercial fishing is undertaken in the area.

8.6.3 Heritage

Indigenous heritage

Fortescue intends to seek ministerial approval under Section 18 of the Aboriginal Heritage Act 1972 to enable construction of infrastructure within the Project footprint for the purpose of transport, storage, import and export of general cargo. Any concerns raised by MPL would be considered by Fortescue in its management of environmental impacts as they affect heritage matters.

Fortescue is committed to on-going consultation with the MPL and to developing the Project in accordance with the requirements of the Aboriginal Heritage Act 1972.

European heritage

While the Database of Heritage Places lists 32 places of European heritage significance within the Port Hedland local government area, only four places are listed on the Register of the National Estate (with no formal assessment) and only two places are registered on the State Register of Heritage Places, being Dalgety House and the former District Medical Officer's Quarters. Both places are located within the Port Hedland township and therefore do not form part of the assessment for the Project.

9. IMPACT ASSESSMENT AND ENVIRONMENTAL MANAGEMENT

A series of environmental management objectives have been developed to mitigate environmental impacts from the proposed dredging operations and undertake the Project within the EPA's objectives. These Project specific objectives include:

EPA Factor (EAG8)	EPA Objective (EAG8)	Project Specific Objective
Marine Environmental Quality	To maintain the quality of water, sediment and biota so that the environmental values, both ecological and social, are protected.	• Water Quality - To minimise the generation and migration of turbid plumes during dredging activities which may cause impacts to coral and mangrove communities through sedimentation or increases in turbidity. • Hydrocarbon Spills - To ensure hydrocarbons are handled and stored in a manner that minimises the potential impact on the environment through leaks, spills and emergency situations; • Waste Management - To ensure best practice management for the handling and storage of all waste and hazardous materials related to the dredging; and • Onshore Dredge Disposal - To manage dredge spoil disposal so as to meet discharge water quality requirements.
Benthic Communities and Habitat	To maintain the structure, function, diversity, distribution and viability of benthic communities and habitats at local and regional scales.	To limit the direct or indirect loss of BPPH associated with the dredging and dredged material management activities

For each objective, management actions have been developed to minimise the risk of unacceptable impacts from the dredging and spoil disposal, and appropriate monitoring, reporting and corrective actions are to be implemented to support the successful achievement of the objectives.

Table 6: Description of Key Elements of Environmental Management Process to Achieve Identified Objectives

Element	Definition/Description
Objective	What is intended to be achieved?
Management Action	Tasks undertaken to enable the objective to be met.
Responsibility	Responsible for ensuring the Management Action is completed.
Timing	Period during which the Management Action should be undertaken.
Measures	Metrics for evaluating the outcomes achieved by Management Actions.
Reporting/Evidence	Demonstrates that the Management Action has been applied and the outcome evaluated.
Target	Thresholds identified beyond which different management actions must be undertaken.
Contingency	Actions to be undertaken in the event that targets are not being met.

Standard environmental management system practices also apply to the activities and are briefly discussed in the sections on monitoring, systems and reporting. Fortescue Environmental Policy, standards and procedures are also applicable.

9.1 Water Quality

The potential impacts to water quality include:

- Increased Total Suspended Sediment (TSS) levels – caused by suspended sediments released into the water column during dredging and resuspended following deposition;
- Increased sedimentation rates – caused by particles settling out of the water column during dredging and disposal and excess water discharge from DMMA B;
- Acidification of discharge water due to Potential Acid Sulphate Soils (PASS) in the dredged material disposed of onshore;
- Mobilisation of potential contaminants through the disturbance of sediments by the dredge, and through discharge water from DMMA B;
- Altered physical parameters in the discharge water;
- Introduction of dust from construction, operation and completion of activities at DMMA A and DMMA B; and
- Introduction of waste and hydrocarbons into the water from dredges and associated machinery.

The generation of a turbid plume is one of the most likely adverse environmental effects associated with dredging operations. The generation of dredge-induced turbid plumes generally results from suspension of fine sedimentary material from the seabed during dredging and the mobilisation of fine sedimentary material during disposal.

As discussed in Section 8.3.5, sediment plume modelling was undertaken to identify potential impacts associated with proposed dredging activities. The results were used to predict the extent of impacts on water quality and BPPH. This section presents the results of winter modelling because this was considered 'worst case' with respect to the predicted behaviour and dispersion of the sediment plume.

The results have been interpreted to identify the zones of impact and influence, following the guidance of EAG7 (EPA 2011). These zones were defined in the BPPH Survey and Impact Assessment report (Advisian 2015), and presented in Figure 8.

The zone of high impact (ZoHI) covers an area of 9.02 ha and is confined to the area of dredging and surrounding battery limit where direct removal of sediment and BPPH will occur. The loss of habitat associated with the dredging is not considered significant as the seabed has existing ministerial approval to be disturbed.

The zone of moderate impact (ZoMI) covers an area of 3.9 ha and is confined to the immediate area around the ZoHI. This zone is based on areas likely to experience greater than 50 mm sedimentation. Based on the modelling of suspended sediment and sedimentation, there is very little likelihood that mangroves or other benthic primary producers will be impacted beyond the ZoMI. These predictions are based on previous experience and extensive monitoring of these habitats as part of previous dredging assessments within Port Hedland (WorleyParsons 2013).

The zone of influence (ZoI) which covers an area of 552 ha has been defined as the area where a SSC threshold of 5mg/l is exceeded for more than 50% of the time. Water quality data from a range of sites within the harbour confirm that TSS (and turbidity) is naturally high and that 5 mg/l is a much more realistic concentration than 1 or 2 mg/l in trying to discern a visible plume.

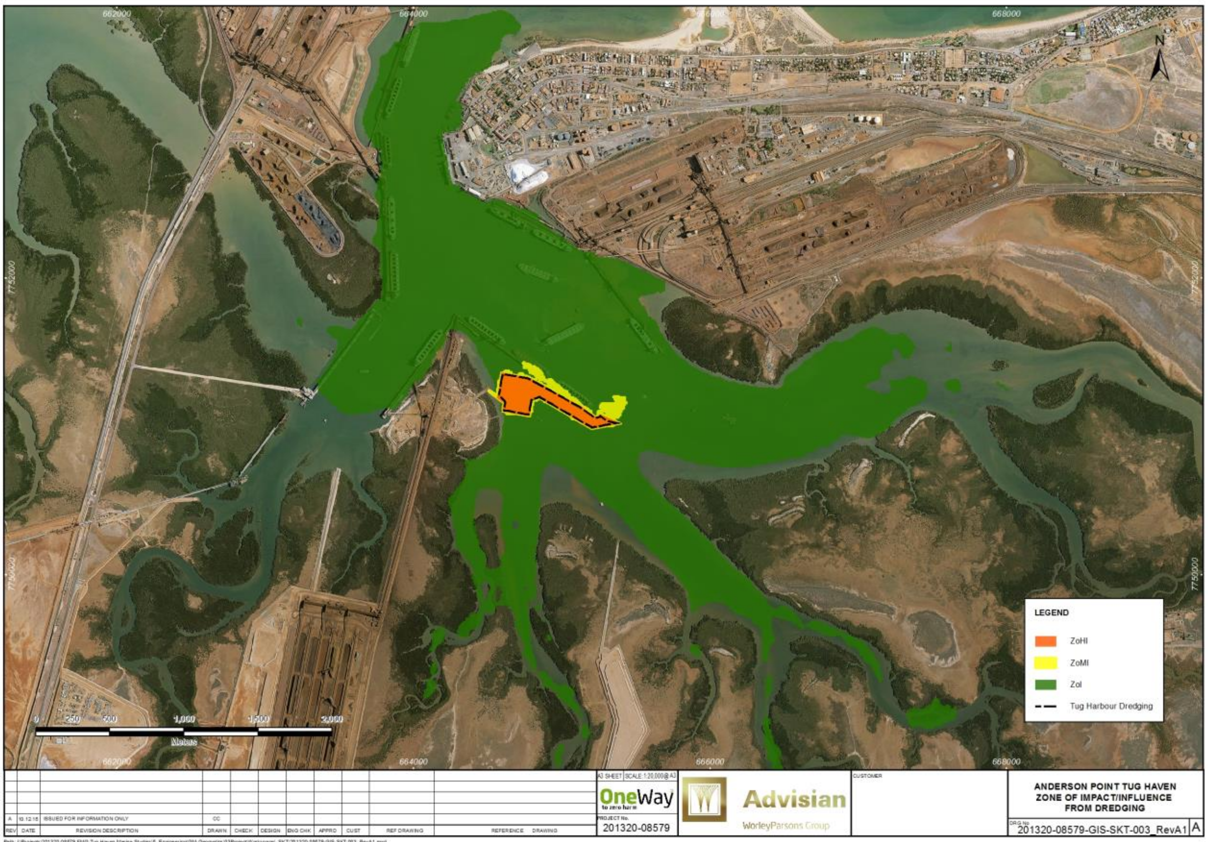


Figure 8: **Zones of impact and influence for the proposed dredging program.**

It should also be noted that there is significant overlap between the ZoHI and ZoMI modelled in this assessment and the previous approved assessment for the Lumsden Point General Cargo Facility Project (WorleyParsons 2013).

Table 7: Environmental Management Actions for Water Quality

Objective 1:	**To manage the generation and migration of turbid plumes during dredging activities to reduce the risk of impacts to coral and mangrove communities through sedimentation or turbidity.**		
	Management Action	**Timing**	**Responsibility**
1.1	Installation and use of a satellite-based vessel monitoring system on the dredge, allowing a track plot analysis to ensure maximum efficiency of the dredging effort and that no dredging occurs outside the required area.	Prior to mobilisation on site.	Contractor
1.2	Maintaining calibration of the hydrographic survey systems onboard the dredge.	For the duration of dredging	Contractor.
1.3	HAZID and CRAW (Fortescue requirements) risk assessment activities to include turbidity risks	Prior to dredging	Contractor
1.4	Implement Marine Water Quality Monitoring Plan.	Two weeks prior to & for the duration of dredging Post dredging – until water quality levels return to pre-dredging levels, or at least one month post dredging	Pilbara Marine/Contractor
1.5	Maximise the residence time in DMMA B to reduce the turbidity plume of the tail water discharge. Suitable controls (e.g. weir boxes) will be used at the discharge point to control the water level and the rate of discharge.	Construction	Contractor
1.6	Cease dewatering or move tail water within reclamation cells when turbidity is excessive.	Construction	Contractor
1.7	Regular inspection and maintenance of erosion, sediment control and drainage structures particularly following heavy or prolonged rainfall.	For the duration of dredging	Contractor.
1.8	Ensure no alterations are made to existing on site drainage infrastructure that could lead to potential water quality impacts off site	For the duration of dredging	Contractor
1.9	Stabilise uncovered areas of soil promptly.	Ongoing	Contractor.
1.10	Install scour protection measures such as gabions where scouring is likely to occur.	Ongoing	Contractor.
1.11	Monitor the operation on a continual basis and report any incidents (to the requirements of the Fortescue	For the duration of	Contractor.

Objective 1:	To manage the generation and migration of turbid plumes during dredging activities to reduce the risk of impacts to coral and mangrove communities through sedimentation or turbidity.		
	Management Action	**Timing**	**Responsibility**
	HSE incident management system) that are likely to cause substantial changes to water quality.	dredging	
1.12	Submit dredge tracking reports to the appointed Fortescue supervisor.	For the duration of dredging	Contractor.
1.13	Use suitable dredging plant and equipment to minimise turbidity, including well maintained floating pipelines to minimise leakage of turbid water during pumping of material to DMMA and DMMA B.	For the duration of dredging	Contractor

Table 8: Environmental Performance Measures and Contingencies for Water Quality

Objective 1:	To minimise the generation and migration of turbid plumes during dredging activities and therefore cause no impacts to coral and mangrove communities through sedimentation or increase in turbidity.		
Measurement	**Target**	**Reporting / Evidence**	**Contingency**
Dredging area.	No dredging occurs outside of the required dredging area.	Tracking reports by satellite-based vessel monitoring system.	Cessation of dredging and relocation of dredges. Maintenance of tracking system.
Dredge plume range water quality.	No exceedance of the predicted range of turbidity in the dredge plume.	Dredge plume monitoring program (DPMP) results. Routine Marine Water Quality Monitoring Program	Revision of dredging strategy, including potential relocation of the dredge(s) and alterations to operational mode. Implement the Tiered Monitoring Framework (Appendix 2) following a water quality trigger breach
BPPH health.	No substantial impacts to BPPH health.	Dredge plume monitoring program (DPMP) results. Routine Marine Water Quality Monitoring Program.	Revision of dredging strategy, including potential relocation of the dredge(s) and alterations to operational mode. Implement reactive coral monitoring following a water quality trigger

9.2 Benthic Primary Producer Habitat

9.2.1 Predicted impacts – direct

The total maximum area of BPPH that stands to be lost from the Project is 2.19 ha of bare substrate. An additional 6.83 ha of footprint has been previously approved as part of other project assessments, in particular, the Stingray Creek Cyclone Mooring Facility which has been previously assessed as not containing any BPPH. None of the 2.19 ha of bare substrate is considered unique or rare within the Port Hedland locality and all types of BPP are well represented in neighbouring and adjacent areas within the Port Hedland LAU.

9.2.2 Predicted impacts – indirect

As discussed in Section 9.1, sediment plume modelling was conducted to predict potential increases in suspended sediment and sedimentation within the Inner Harbour, which could cause indirect impacts on BPPH outside of the ZoHI. The modelling has shown that the predicted increase in SSC (suspended sediment concentrations) and sedimentation is low outside the ZoHI and ZoMI, and within the range of concentrations modelled during previous dredging projects where BPPH data collected after the completion of post dredging surveys showed the BPPH predicted to be influenced by the Project were not impacted. SSC and sedimentation levels were found to be below levels previously predicted for other projects, which had no impact on BPPH within the Inner Harbour (WorleyParsons 2013). It is also concluded there will be no impact to mangroves within the Port Hedland LAU.

Table 9: Environmental Management Actions for BPPH

Objective 2:	To limit the direct or indirect loss of BPPH associated with the dredging and dredged material management activities.		
	Management Action	**Timing**	**Responsibility**
1.1	In consultation with Fortescue, provide all information required for the development of a valid Ground Disturbance Permit (GDP) for proposed dredging activities.	At least four weeks prior to commencement of dredging activities.	Contractor.
1.2	Develop a GDP for the proposed construction activities.	Four weeks prior to construction activities.	Fortescue.
1.3	Assess and approve GDPs if compliant with approval requirements.	Prior to construction activities.	Fortescue.
1.4	Ensure all construction activities are carried out within the GDP boundary and according to GDP conditions.	Project duration.	Contractor.
1.5	HAZID and CRAW (Fortescue requirements) risk assessment activities to include mangrove risks.	Prior to construction	Contractor
1.6	Workforce management including briefings and instructions regarding clearing procedures and information on the ecological significance of mangroves in environmental awareness training.	Project duration.	Contractor to facilitate, attend and keep records. Fortescue to deliver.
1.7	Prohibit access into BPPH areas outside the immediate disturbance area by education and signs.	Construction and dredging.	Contractor.
1.8	Report incidents (to the requirements of the Fortescue HSE incident management system) with the potential to impact on BPPH	Project duration.	Contractor.
1.9	Delineation of clearance boundaries through the use of flagging (to Fortescue requirements) prior to site clearing activities to avoid unnecessary disturbance of mangroves.	Construction.	Contractor.
1.10	Visual monitoring of mangroves to ensure early detection of potential impacts on mangroves.	Project duration.	Contractor

Table 10: Environmental Performance Measures and Contingencies for BPPH

Objective 2:	To limit the direct or indirect loss of BPPH associated with the dredging and dredged material management activities.		
Measurement	**Target**	**Reporting / Evidence**	**Contingency**
Area of BPPH cleared.	No unauthorised clearing of BPPH outside the approved GDP boundary. (Compliance with the GDP).	GDP and post-clearing report. Results of site inspections and audits.	Apply for additional clearing approval if unavoidable. Report any over clearing as an environmental incident (to the requirements of the Fortescue HSE incident management system), carry out incident investigation and implement recommendations. Revision of dredging strategy, including potential relocation of the dredge(s) and alterations to operational mode. Cease dredging if impacts on BPPH exceed the triggers identified in the Reactive BPPH Monitoring Program
BPPH health.	No indirect impacts to BPPH outside the ZoHI or ZoMI.	Dredge plume monitoring program (DPMP) results. Routine Marine Water Quality Monitoring Program. Reactive BPPH monitoring	Report any impacts to BPPH health as an environmental incident (to the requirements of the Fortescue HSE incident management system), carry out incident investigation and implement recommendations. Revision of dredging strategy, including potential relocation of the dredge(s) and alterations to operational mode.

9.3 Introduced Marine Pests

Introduction of non-indigenous species could lead to irreversible detrimental impacts to the composition and function of the natural ecosystem, through changes in competition and predation or through habitat modification. Dredging and construction vessels associated with the Project provide the potential for the establishment of Introduced Marine Pests (IMPs).

Of the seven pest species designated as the basis for management of domestic ballast water movements, none is currently listed as present in Port Hedland, which means that water taken up as ballast or entrained in Port Hedland is deemed low risk for discharge in other Australian ports and coastal waters. The proposed dredge vessel that will be used during dredging has not yet been identified. Quarantine measures will have already been undertaken before dredging takes place.

Table 11: Environmental Management Actions for Introduced Marine Pests

Objective 3:	Minimise the risk of introduction of marine pests.		
	Management Action	**Timing**	**Responsibility**
4.1	Comply with AQIS requirements, and State and Federal legislation. Fortescue and any contractors under their management must submit and obtain PPA approval for any construction vessels prior to arrival.	Project duration.	Contractor.
4.2	Any vessels coming to Port Hedland for the project from other Australian locations that carry ballast or entrained water are required to have the risk status of that water assessed, considering the location of uptake and time of year, and to manage the water in accordance with the requirements of the National System for the Prevention and Management of Marine Pest Incursions, if it is deemed to be high risk.	Project duration.	Contractor.
4.3	Any vessels coming to Port Hedland for the project shall be subject to a biofouling risk assessment following guidance within the National Biofouling Management Guidance for Non-Trading Vessels document and PPA requirements. Vessels assessed as posing a risk should be inspected to ensure they are free of biofouling and dry-docked if needed for cleaning and repair/renewal of the antifouling system immediately prior to departure for Port Hedland.	Prior to vessel departing port of origin	Contractor.
4.4	Monitor and carry out surveillance of the dredge vessel and barges in accordance with AQIS and PPA quarantine requirements.	Project duration.	Contractor
4.5	Inspect all vessels upon arrival to confirm vessel hygiene and provide a vessel report to Fortescue and the PPA Project Manager.	Project duration.	Contractor

Table 12: Environmental Performance Measures and Contingencies for Introduced Marine Pests

Objective 3:	Minimise the risk of introduction of marine pests.		
Measurement	**Target**	**Reporting / Evidence**	**Contingency**
Incidents of noncompliance with AQIS and PPA requirements.	No incidents of noncompliance with AQIS and PPA requirements.	Dredge vessel and barge inspection results and reports. IMP monitoring results within Port Hedland	Implementation of contingency measures as required by PPA and DoF quarantine requirements. Notification to DotE and the DER in the event of an introduction of a marine pest species.

9.4 Hydrocarbon Spills

The hydrocarbons that will be used during the dredging works include diesel and smaller amounts of lubricating oil and grease for maintenance of the dredging equipment.

Potential hydrocarbon spills are expected to have only localised environmental impacts. Land based activities including construction and management of the DMMA could result in a minor hydrocarbon spillage from plant and equipment.

Table 13: Environmental Management Actions for Hydrocarbon Spills

Objective 4:	To ensure hydrocarbons are handled and stored in a manner that minimises the potential impact on the environment through leaks, spills and emergency situations.		
	Management Action	**Timing**	**Responsibility**
5.1	HAZID and CRAW (Fortescue requirements) risk assessment activities to include hydrocarbon spillage risks	Prior to construction	Contractor
5.2	Dredge vessels: tanks and machinery shall be equipped with measurement and overflow protection (i.e. flow and level meters, relief valves, overflow protection valves and emergency shut-off).	Project duration.	Contractor
5.3	Land based plant and equipment shall be appropriately maintained and serviced in accordance with industry standards and stored away from the marine environment where practicable.	Project duration.	Contractor
5.4	Industry standards, port authority and pollution prevention regulations shall be adhered to during: • Refuelling; • Fuel transfer; • Fuel storage; and • Handling of hazardous materials (e.g. bunding, level gauges, overflow protection, drainage systems and hardstands).	Project duration.	Contractor
5.5	Volumes of stored fuels and chemicals shall be limited to day-use. Use of appropriately licensed mini-tankers for refuelling.	Project duration.	Contractor
5.6	Hydrocarbons (including hydrocarbon wastes) shall be stored in accordance with AS1940-2004. Hydrocarbons shall be stored in appropriately labelled drums, or tanks and in bunded areas that can contain 110% of the volume of the largest container, or 25% of the total volume stored within.	Project duration.	Contractor
5.7	Equipment shall be designed and operated to prevent spills and leaks through the provision of in-built safeguards such as relief valves, overflow protection, and automatic and manual shut-down systems.	Project duration.	Contractor
5.8	All personnel will be trained in spill management procedures.	Project duration.	Contractor
5.9	Appropriate type and quantity of spill control equipment/materials commensurate with the risk of the activity being performed, must be available at all times.	Project duration.	Contractor
5.10	The Dredge Contractor shall undertake regular maintenance and systematic inspection of vessels, plant and equipment with particular attention to hydrocarbon storage areas and bunding to reduce likelihood of equipment failure, spills and leaks.	Project duration.	Contractor
5.11	The Dredge Contractor shall keep maintenance and inspection logs/records for all vessels, major	Project duration.	Contractor

Objective 4:	To ensure hydrocarbons are handled and stored in a manner that minimises the potential impact on the environment through leaks, spills and emergency situations.		
	Management Action	**Timing**	**Responsibility**
	plant and equipment and. Records may be requested by PPA at any time.		
5.12	All incidents trends to be reviewed monthly.	Project duration.	Contractor

Table 14: Environmental Performance Measures and Contingencies for Hydrocarbon Spills

Objective 4:	To ensure hydrocarbons are handled and stored in a manner that minimises the potential impact on the environment through leaks, spills and emergency situations.		
Measurement	**Target**	**Reporting / Evidence**	**Contingency**
Number of hydrocarbon management inspections and audits.	To be agreed between Fortescue & Contractor	Inspection and audit results	Review need for further preventative activities in relation to risks.
Number of hydrocarbon spills.	No uncontrolled hydrocarbon spills with potential to cause significant impact on the marine environment.	Incident reports and monthly incident trends. Maintenance and inspection results. Discrepancy in records of volumes of hazardous materials received, stored and dispensed indicating that there could be a leak.	Hydrocarbon spills will be managed in accordance with the requirements of PPA's Marine Oil Pollution Management Plan. Notify the PPA immediately of any hydrocarbon spill with potential marine impacts. Report all spills of hydrocarbon or chemical to water and spills > 10 L to land as an environmental incident (to the requirements of the Fortescue HSE incident management system), carry out incident investigation and implement recommendations.

9.5 Waste

Solid and liquid wastes generated during dredging activities and construction of the DMMA could potentially negatively impact on the surrounding environment if appropriate waste management measures are not implemented. Solid and liquid wastes that may be generated by the Project include:

- Packaging material (plastic wrapping, pallets, etc);
- Concrete;
- Scrap metal;
- Waste oil, hydrocarbons and hazardous materials;
- Recyclable materials (paper, cardboard, aluminium);
- General food packaging and scraps; and
- Domestic sewage.

The potential also exists for accidental discharges of small quantities of solid or liquid wastes to the marine environment. Accidental waste discharges arising from dredge vessels and land based activities (not including hydrocarbons) could include:

- Deck drainage, which may comprise primarily rain water and wash down water, but may include small amounts of waste material;
- Potentially contaminated drainage, including drainage from machinery spaces and bilges; and
- Engine cooling water.

The accidental discharge of waste material (without appropriate dilution or treatment) to the marine environment may:

- Contaminate food sources for marine organisms;
- Result in additional nutrients and pathogens in the water column, potentially leading to algal blooms or toxicity; and
- Cause death, or injury of marine fauna if ingested, or entangled.

Table 15: Environmental Management Actions for Waste Management

Objective 5:	**To ensure best practice management for the handling and storage of all waste and hazardous materials related to the dredging.**		
	Management Action	**Timing**	**Responsibility**
6.1	HAZID and CRAW (Fortescue requirements) risk assessment activities to include waste management risks.	Prior to construction.	Contractor
6.2	All personnel to be educated in Fortescue waste management requirements.	Prior to commencement of work on site.	Fortescue to provide training. Contractor to facilitate, ensure attendance and keep records.
6.3	Controlled wastes shall be managed as per the Environmental Protection (Controlled Waste) Regulations 2004 (WA).	Project duration.	Contractor
6.4	Chemicals carried in packaged, solid or bulk form will comply with the regulations of Part A of Safety of Life at Sea (SOLAS) Chapter VII and the International Maritime Dangerous Goods (IMDG) Code regarding the classification, packing, marking, labelling and placarding, documentation, stowage, handling and emergency response action of dangerous goods.	Project duration.	Contractor
6.5	All waste designated as hazardous/dangerous requiring disposal shall be packaged, stored and transported in accordance with IMDG requirements. Vessel documentation shall include Material Safety Data Sheets (MSDS) for each substance carried.	Project duration.	Contractor
6.6	All vessels will comply with the compulsory insurance and insurance certificate requirements of the International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances (HNS) by Sea 1996.	Project duration.	Contractor
6.7	Vessels of 24m or more in length but less than 400 gross tonnage engaged in international voyages will carry a Declaration on Antifouling Systems (prohibiting the use of harmful organotins in antifouling paints) in compliance with the International Convention on the Control of Harmful Antifouling Systems on Ships.	Project duration.	Contractor
6.8	All sewage and grey water treatment systems shall be checked prior to arrival to the port and maintained to ensure systems are efficient, fully operational and discharging treated water in accordance with MARPOL 73/78 Convention Annex IV (sewage) and Annex V (garbage).	Project duration.	Contractor
6.9	No residues containing noxious substances will be discharged within 12 nautical miles (nm) of the nearest land, in compliance with MARPOL 73/78 Convention Annex II.	Project duration.	Contractor
6.10	Waste management requirements shall be communicated to personnel (i.e. through inductions, pre-starts and/or Job Hazard Analyses (JHAs)).	Project duration.	Contractor

Objective 5:	To ensure best practice management for the handling and storage of all waste and hazardous materials related to the dredging.		
	Management Action	**Timing**	**Responsibility**
6.11	Communication systems on vessels shall be capable of handling the volumes generated and maintained regularly so they efficient and fully operational at all times.	Project duration.	Contractor
6.12	Solid and liquid wastes and hazardous materials shall be stored in appropriately labelled drums or tanks.	Project duration.	Contractor
6.13	Hazardous material storage areas shall be engineered and designed to handle the volumes and operating conditions (both normal and upset conditions) specifically required for each substance, including product identification, transportation, storage, control and loss prevention (e.g. bunding and drainage).	Project duration.	Contractor
6.14	Hazardous substances handling is to be carried out by suitably trained personnel only.	Project duration.	Contractor
6.15	Incompatible products will not be stored together.	Project duration.	Contractor
6.16	Empty liquid waste containers shall be segregated from other wastes and stored in designated areas.	Project duration.	Contractor
6.17	Uncontained waste to be reported as an environmental incident (to the requirements of the Fortescue HSE incident management system), carry out incident investigation and implement recommendations.	Project duration.	Contractor

Table 16: Environmental Performance Measures and Contingencies for Waste Management

Objective 5: To ensure that the potential for adverse impacts on marine water quality from construction activities associated with the Project are reduced as far as practicable			
Measurement	**Target**	**Reporting / Evidence**	**Contingency**
Number of incidents of waste entering the marine environment.	No waste entering the marine environment.	Incident reports.	Implementation of contingency measures as required by PPA's waste management guidelines and PPA's Marine Oil Pollution Management Plan.
Proportion of personnel educated in waste management requirements.	All personnel to be educated in Fortescue waste management requirements.	Training records.	Specially convened training sessions. Review record management.

9.6 Onshore Dredge Material Management

Land-based construction activities related to the onshore disposal of dredge materials is restricted to DMMA A and DMMA B and have limited potential to cause environmental impacts. The following factors are considered relevant to the disposal of dredge spoil into DMMA A and DMMA B:

- Acid Sulphate Soils (ASS) and/or PASS; and
- Discharge water quality.

The management framework for water quality outlined in Section 9.1 of this DSDMP will address discharge water quality related to onshore dredge material disposal.

Table 17: Environmental Management Actions for Onshore Disposal of Dredge Material

Objective 6:	**To manage dredge spoil in a manner that minimises any potential impacts to the receiving environment**		
	Management Action	**Timing**	**Responsibility**
7.1	HAZID and CRAW (Fortescue requirements) risk assessment activities to include discharge water quality and DMMA management risks	Prior to construction	Contractor
7.2	Develop and implement a DMMA water quality monitoring program (DMMA WQMP) to the satisfaction of the Fortescue Environment Superintendent.	Prepare prior to commencement of dredging Implement for the duration of dredging	Contractor Contractor
7.3	DMMA A and DMMA B will be utilised to dispose of all dredge spoil according to the requirements of this DSDMP.	For the duration of dredging	Contractor
7.4	Inspect the dredge spoil disposal pipe upon start up and on a regular basis (as agreed with Fortescue) to detect any leaks.	For the duration of dredging	Contractor
7.5	Dredge spoil discharge water quality will be monitored for the presence of PASS in the DMMAs. If results indicate a need, treatment will be carried out as outlined in Section 2.3.5 of this DSDMP.	For the duration of dredging	Contractor
7.6	Surface water run-off from DMMA A and DMMA B will be contained where appropriate and discharge controlled to meet discharge water quality outlined in Table 18	For the duration of dredging	Contractor
7.7	Discharge tail water from ESA into South Creek will be monitored to ensure water quality parameters are maintained within trigger limits outlined in Table 18 of this DSDMP. Monitoring must be recorded daily during discharge for all parameters (with the exception of metals which will be monitored weekly for the first four weeks)	For the duration of dredging	Fortescue
7.8	Implementation of the Tiered Management Framework if any water quality parameter trigger is exceeded.	For the duration of dredging	Contractor/Fortescue
7.9	Accidental hydrocarbon spills shall be managed in accordance with the measures described in Section 9.4 of this DSDMP and Fortescue Chemical and Hydrocarbon Spills Procedure (45-PR-EN-0014).	For the duration of dredging	Contractor

Table 18: Environmental Performance Measures and Contingencies for Onshore Disposal of Dredge Material

Objective 6:	**To manage dredge spoil disposal so as to meet discharge water quality requirements**		
Measurement	Target	Reporting / Evidence	Contingency
Discharge water quality	• Turbidity: Median < 80th percentile of baseline data • Temperature, pH & conductivity: Median > 20th percentile and < 80th percentile of baseline data • Dissolved Oxygen: >60% saturation • Nickel < 7ug/L	Monitoring data	Investigate causes and amend discharge management practices. Amend DMMA WQMP. Cease discharge from ESA into South Creek.
Number of spills and leaks from the dredge spoil pipeline	No spills or leaks	Inspection and incident reports	Cease discharge if significant spillage. Activate spill response actions (control drainage, clean up) as required. Implement recommendations from incident investigations.

*ANZECC and ARMCANZ (2000)

**Proposed alternatives need to be supported with relevant baseline information including sampling and analysis methodologies

10. MONITORING

A Tiered Monitoring Framework (TMF) has been developed to monitor potential environmental impacts resulting from the Project. This framework will be implemented by Pilbara Marine/Contractor and includes:

- A Marine Water Quality Monitoring Plan; and
- Reactive Coral Health Investigation Program (where trigger is exceeded).

This framework is presented in **Figure 9**.

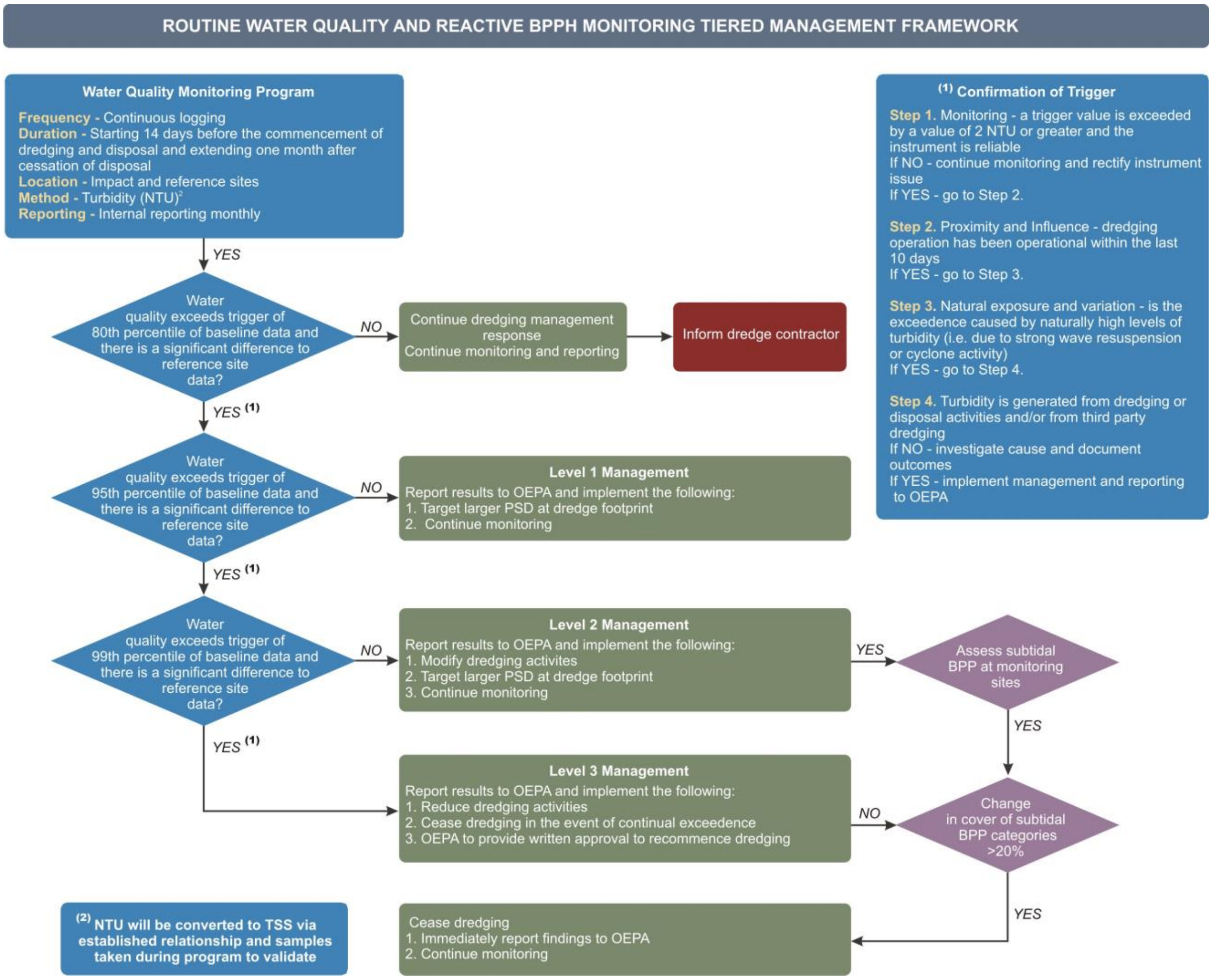


Figure 9: **Water quality and reactive coral monitoring Tiered Management Framework**

10.1 Marine Water Quality Monitoring Plan

The Marine Water Quality Monitoring Plan will monitor the turbidity, temperature, pH, dissolved oxygen and conductivity of the water using telemetered continuous data loggers. These parameters will be measured daily at four impact sites and two reference sites, with monitoring commencing two weeks prior to the start-up of dredging and dewatering activities. Additionally, during dredging activities, water samples will be collected from dewatering discharge points once every two weeks to analyse for nickel concentrations.

The Contractor will also be required to develop and implement a DMMA Water Quality Monitoring Program as part of the Work Method Statement. The intention of this monitoring program is to ensure that the activities are effectively managed to ensure compliance with regulatory requirements. The program is therefore expected to provide “early warning” of any water quality issues in sufficient time to enable management changes to be made to address the risk of non-compliance. Water quality at the point of discharge will also be monitored as part of the Marine Water Quality Monitoring Plan.

10.1.1 Monitoring locations

Two impact monitoring sites - Stingray Creek (SRC) and South East Creek (SEC) have been identified within the predicted area to be influenced by dredging activities within the Inner Harbour. One impact monitoring site – South Creek Discharge (SCD) has been proposed within the predicted area to be influenced by the discharge from DMMA B in South Creek. One reference location has also been identified to provide comparison of data to monitoring locations during dredging activities.

Table 19 provides the geographic coordinates for each site, data to be collected at each site and the site’s function adjacent to the dredge footprint. The locations are also shown in Figure 10.

Table 19: Proposed water quality monitoring sites for dredging

Site	Easting	Northing	Water Quality Data Collection
SEC (dredging)	666086	7749980	Telemetry and logging
SRC (dredging)	666449	7751169	Telemetry and logging
SOL (reference)	661272	7751257	Telemetry and logging
SCD (dewatering)	664417	7748194	Telemetry and logging

10.1.2 Parameters and procedures

Physico-chemical analysis

Turbidity will be measured at monitoring locations associated with dredging activities. At all locations turbidity data will be collected using in situ water quality loggers with telemetry capability. Logging systems at the inshore sites will be located approximately 1 m above the seabed on a steel frame at each specified monitoring location.

For inshore sites, the logger units associated with dredging will be set up to measure turbidity every 30 minutes.

Data will be downloaded daily using the telemetry system deployed with the logger. Loggers will be calibrated monthly to ensure accurate datasets are acquired.

Correlation of TSS and NTU

Correlation of TSS and turbidity is undertaken to validate whether predicted zones of impact from modelling are a true representation of the plume extent during dredging activities. Water samples will be collected with a 1 L Van Dorn bottle and measured for NTU and TSS for a single event during the dredging program. Two sites will be selected in the immediate vicinity of the dredge. Replicated samples will be collected from the surface, mid and bottom of the water column at each site and analysed for:

- TSS (samples sent to the laboratory);
- NTU (measured both onsite and with samples being sent to the laboratory); and
- particle-size distribution (samples sent to the laboratory).

Samples will be sent to a National Association of Testing Authorities (NATA) accredited laboratory for quantitative analysis. Results may also be used to compare measured turbidity values and those predicted in the numerical model (i.e. indication of modelling accuracy).

10.1.3 Data analysis

Water quality data collected daily during the dredge monitoring program will be used to provide early warning of potential water quality deterioration at the monitoring sites. The likelihood of a link between dredging and water quality decline will be assessed in terms of the following factors:

- Locations of and status of dredging activities in relation to the site(s) at the time of the exceedence
- Hydrodynamic conditions, for example wind, tide, wave and swell state at the time of the exceedence
- Effects of extreme weather event in the region
- Spatial extent of water quality decline.

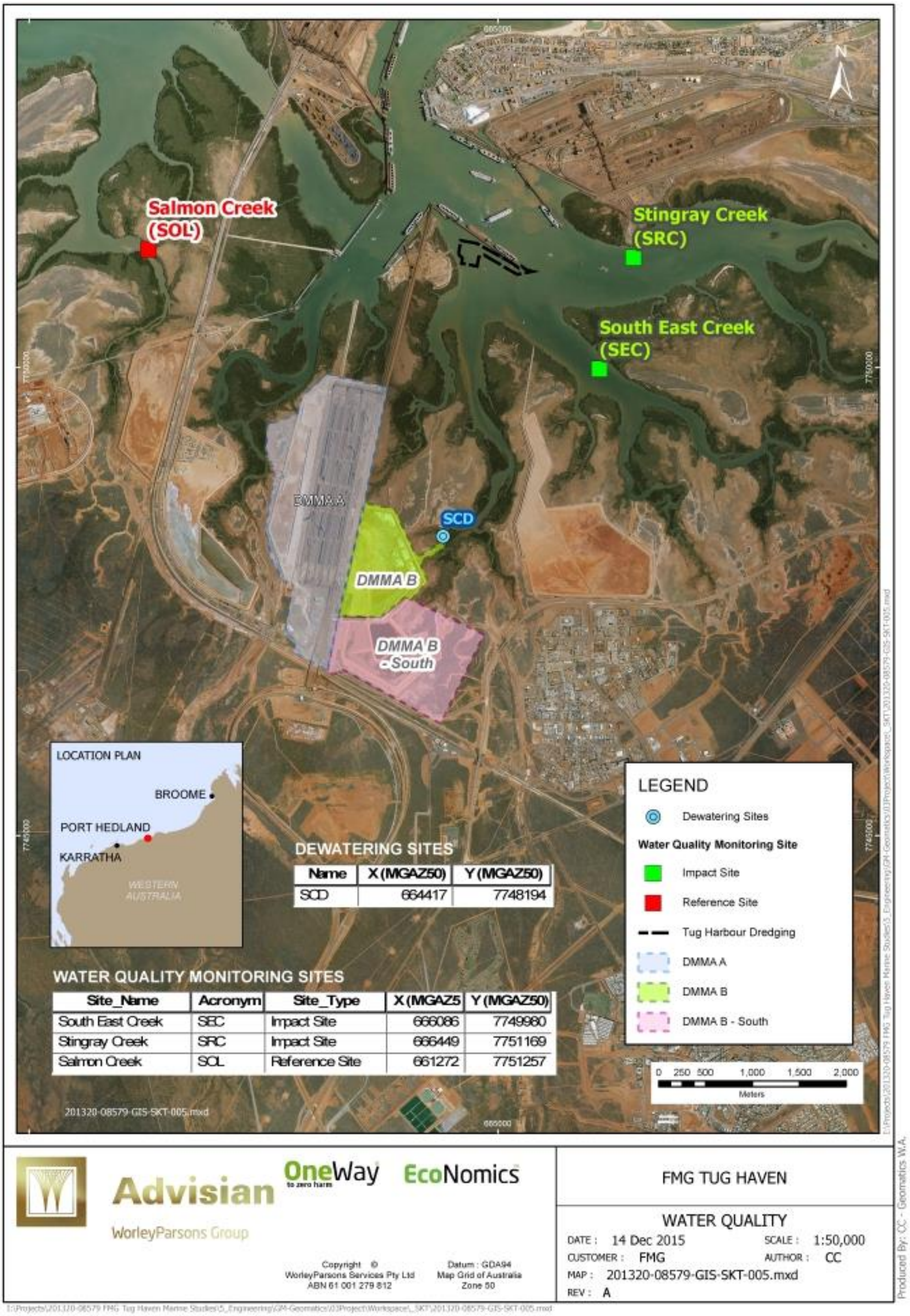


Figure 10: Water Quality monitoring sites associated with dredging and disposal activities

10.2 Reactive BPPH Quality Monitoring

The Coral Health Investigation Program will be implemented should water quality trigger levels be exceeded at selected monitoring sites during dredging activities.

10.2.1 Monitoring locations

Monitoring will occur at three 'impact' sites and one reference site and the coordinates are presented in **Table 20** and **Figure 11**. The impacts sites are also within the 99% level of ecological protection zone from DoE (2006). All of these sites have already been established as monitoring sites for previous projects and therefore results can also be compared to baseline data.

Table 20: Proposed coral monitoring sites for dredging

Site	Easting	Northing
SEC (dredging)	666086	7749980
SRC (dredging)	666449	7751169
OSC (reference)	657244	7749715

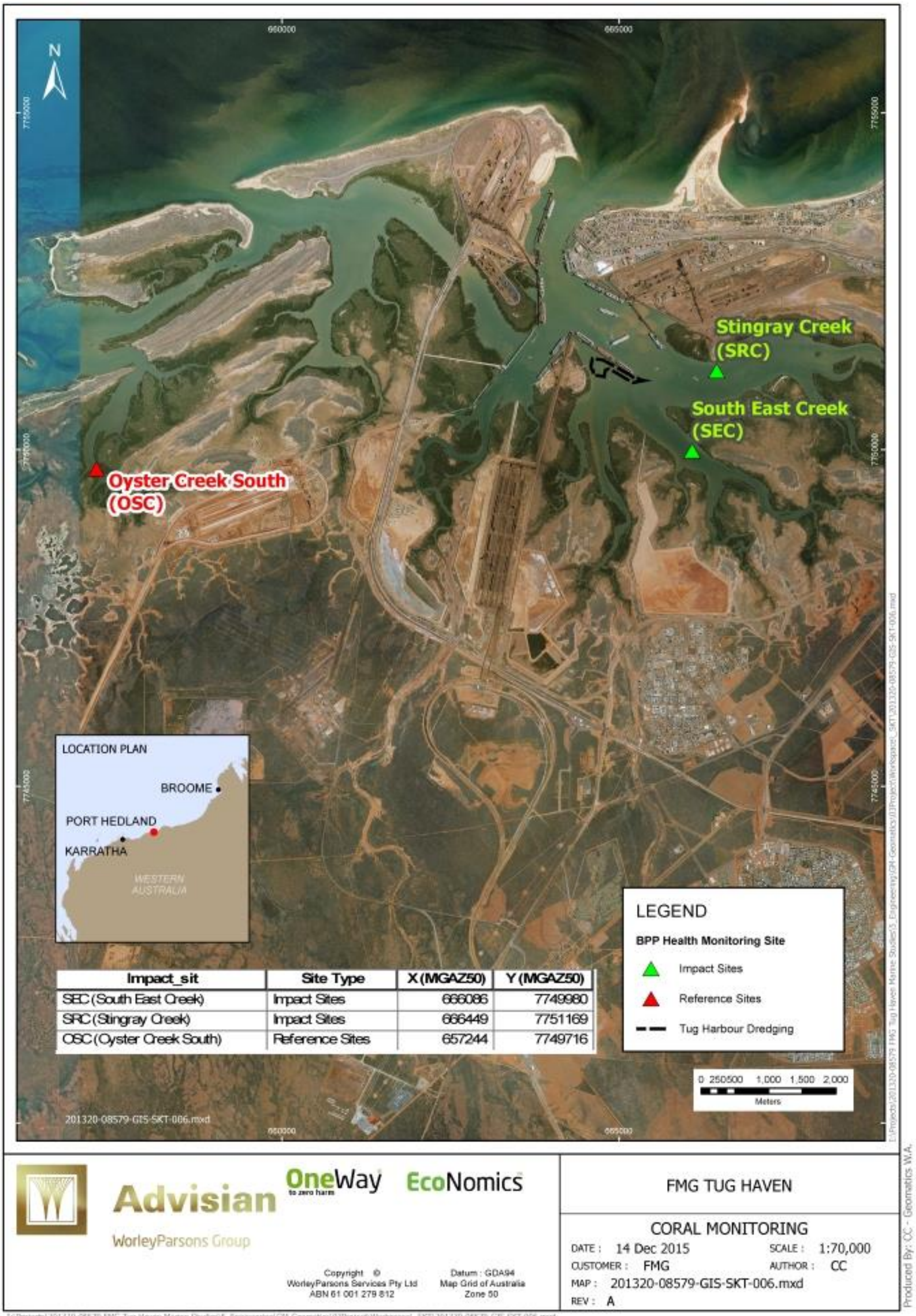


Figure 11: **BPPH health monitoring sites associated with dredging activities**

10.2.2 Parameters and procedures

Pre and post dredging surveys will be undertaken to quantify the composition and mean percent coverage of BPP communities at each site.

Line-intercept surveys

Abundance surveys of the subtidal BPP communities will be made at each site. Four 20 m, haphazardly positioned, line-intercept transects will run within an area of substratum. Approximately 50 x 10 m will be recorded at each site to measure cover of the major benthic organisms in the area of maximum BPP abundance. The transects will be permanently marked with 12 mm reinforcing rod stakes driven into the bottom at 5 m intervals. To measure BPP cover, survey tapes will be stretched tightly between the stakes close to the substratum and the length of the intercept (with the tape of all benthic organisms directly beneath it) will be measured. Intercept lengths for all colonies of a species along each transect will then be totalled and converted to a percentage cover measurement.

These techniques have been used in many other surveys of subtidal BPP communities (Mapstone, Choat et al. 1989; Ayling and Ayling 1995; Ayling and Ayling 2006).

The bleaching status of all coral intercepts will be noted during these surveys in three categories; Not bleached, Partially bleached, and Totally bleached.

A permanent record will be made of the BPP community along each transect by taking an overlapping series of high-resolution digital still photographs of a 33 cm wide strip down the shoreward side of each tape.

Sediment deposition on subtidal BPP (corals)

In addition to measuring the approximate percentage of each BPP colony covered in sediment, measurements of the maximum depth of sediment will be taken, if present, on the surface of each tagged BPP colony using a set of callipers.

Wider measures of subtidal BPP health (corals)

Although line-intercept transects give a good estimate of coral cover, the sample size of BPP colonies immediately beneath the transect lines is not sufficient to encounter relatively rare community events such as BPP disease or to assess small-scale changes in BPP health. Similarly, the health assessment using 50 tagged corals has only a limited sample size of colonies. To sample a wider area and a larger number of corals, the following components will also be measured along a 20 x 2 m strip centred on each transect line:

- Counts of the total number of coral colonies in each major coral group or species.
- Counts of bleached or partially bleached colonies.

- Counts of all sediment-damaged colonies. Many coral colonies have dead patches from a variety of causes and colonies will not be recorded as damaged if there is an actively growing edge encroaching into the dead patch.

- Counts of all diseased colonies. As for sediment damage, if there is an actively growing edge reclaiming a disease-caused dead patch that colony will not be recorded as diseased for that survey.

- Counts of all colonies showing recent partial mortality.

- Counts of all colonies suffering recent total mortality.

Coral sub-lethal stress

During the baseline, changes in the colour and hence zooxanthellae density of the tagged corals were used to assess sub-lethal stress. Colour was measured using the underwater BPP colour chart developed by Siebeck et al. (2006). Colour intensity scores for each tagged coral were recorded during each survey and these measures will be continued by the current monitoring team. A shift toward lighter colour intensity would indicate a more stressed state.

Coral size

The area of each tagged colony was measured during the baseline surveys from the colony photographs and these measures will be repeated during all ongoing surveys. This will give some indication of coral growth and hence a measure of the age of the communities. If the communities are young then this suggests that the habitat is marginal for coral growth and that colonies suffer regular mortality due to natural causes or past port development impacts.

10.2.3 Data analysis

Data will be collected within one week of completion of each BPP health investigation. The significance of any changes in the benthic abundance surveys will be tested using a repeated measures analysis of variance after each survey. Similar repeated measures tests will also be used to check the significance of changes in sediment depth on coral colonies and in the density of damaged BPP colonies.

11. SYSTEMS AND REPORTING

Fortescue operates an environmental management system that includes key elements such as:

- Environmental policy;
- Environmental management plans;
- Standards and procedures; and
- Management processes.

Key items relevant to the activities undertaken under this DSDMP are:

- The Ground Disturbance Permit process that is designed to ensure that ground disturbance is limited to approved areas (Section 11.1); and
- The Incident Event Management Procedure (Section 11.2.

Both of these processes are identified in the Contractors HSE Specification (560PO-40000-SP-SA-0001). Adherence to all of the HSE specifications is mandatory.

Environmental reporting is also to be undertaken regularly, as outlined in Section 11.3.

11.1 Ground Disturbance Permit Process

Any ground disturbance works related to the Project must be undertaken in compliance with the Fortescue Ground Disturbance Permit (GDP) process to ensure all necessary approvals are in place. The GDP process in relation to the Project is outlined in Figure 12.

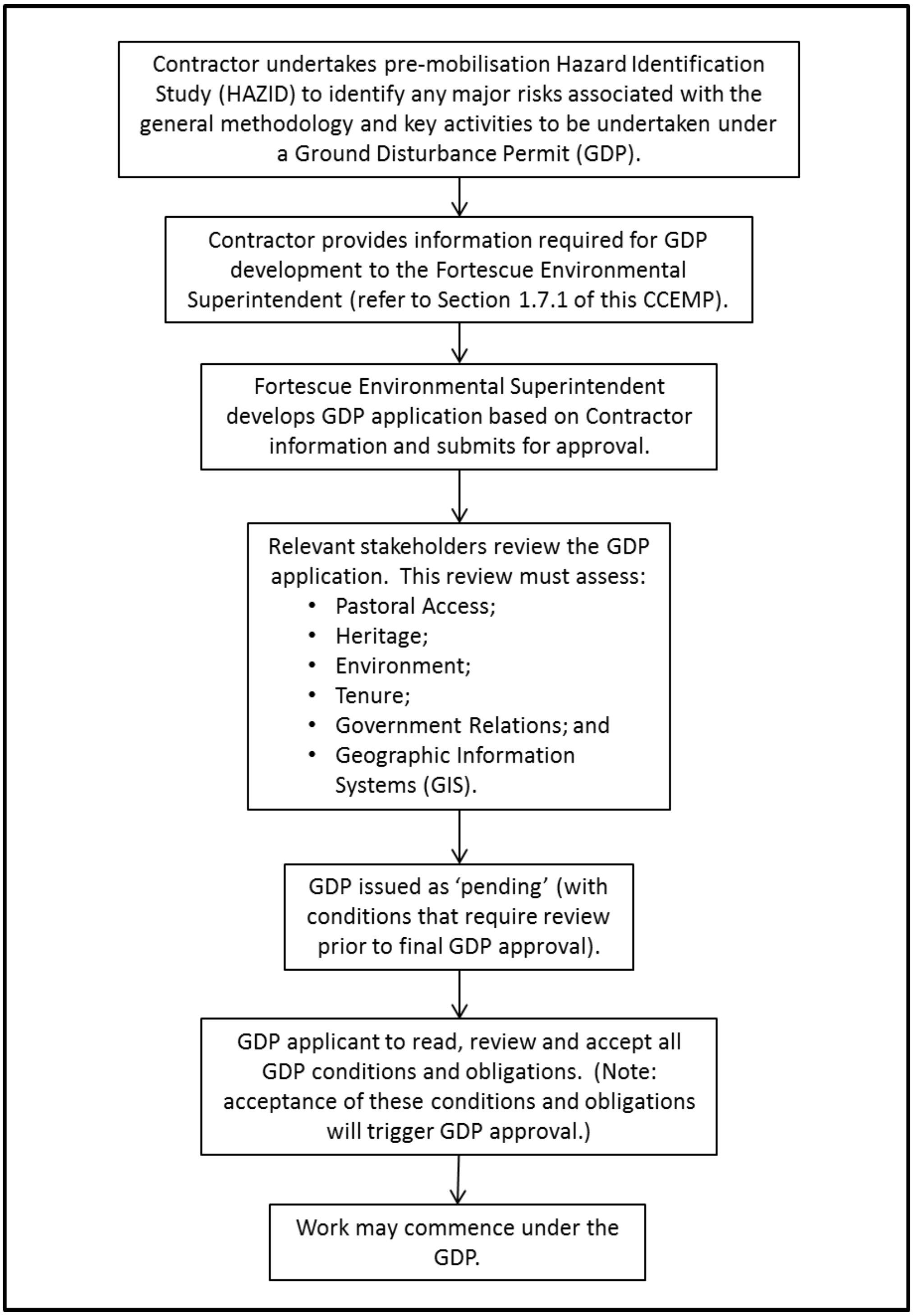


Figure 12: GDP Process

11.2 Incident Management Procedure

The Contractor will be required to report any incidents that occur in accordance with the Fortescue Incident Event Management Procedure. The incident reporting process is summarised in Figure 13 with further detail provided in the Contractor HSE Specification (560PO-40000-SP-SA-0001).

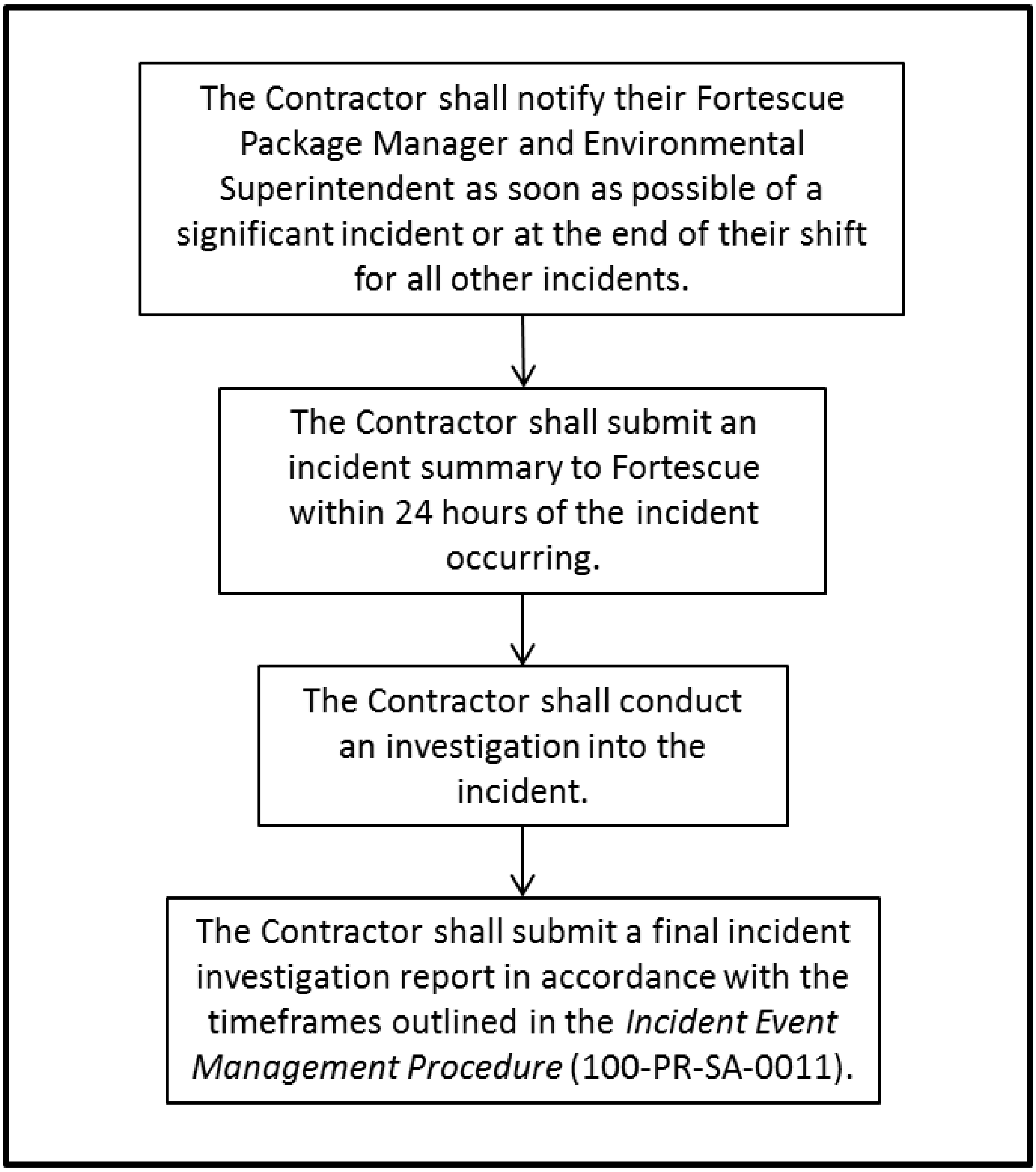


Figure 13: Incident Management Procedure

11.3 Environmental reporting

Sections 9 and 10 have identified the monitoring and management commitments that Pilbara Marine will put in place to minimise environmental impacts during the dredging and disposal activities.

A summary of the environmental reporting requirements as part of this DSDMP is given in **Table 21**.

Table 21: Reporting requirements to be undertaken during dredging and disposal

DSDMP reference	Report name	Contents	Recipient	Frequency/ schedule
Marine Water Quality				
Section 10.1	Water quality monitoring report	Results of the daily monitoring of turbidity at impact and reference locations as specified in 10.1.1	EPA	Pre, during (bi-monthly) and post dredging
Section 9.4	Hydrocarbon spill monitoring	Incident report on hydrocarbon spills to marine waters (>20 litres) including response	DER	Following event
Introduced marine Pests				
Section 9.3	Marine pest inspection checklist	Checklist of vessel components checked during vessel inspection. Statement from lead inspector on marine pest status of the vessel.	DoF	Within 72 hours of inspection
Section 9.3	Vessel quarantine report	Checklist of vessel components checked during vessel inspection. Statement from lead inspector.	DoF	Within 14 days of inspection or risk assessment
Waste management				
Section 9.5	Hazardous records register	Records of hazardous materials received, stored and dispensed shall be maintained and reconciled.	Fortescue	As required
Section 9.5	Incident reporting	The dredge contractor shall report any incident of wastes entering the marine environment to PHPA as soon as possible (but within 48 hours) and implement appropriate clean-up procedures.	Fortescue	As required

12. REVIEW

It is important that plans and procedures are frequently reviewed and revised as Fortescue's operations change and opportunities for improved management practices are identified.

This DSDMP relates to a short term construction activity and hence any review and amendment processes will be more rapid than for operations. This plan is to be reviewed if significant additional information comes to hand or environmental risks or incidents require its review and amendment. Upon review, the document will be revised where appropriate and the revision status will be updated in accordance with Fortescue's document control procedures.

Review and amendment of this plan will be Fortescue's responsibility.

13. GLOSSARY

Term	Definition
AP1	Anderson Point Berth 1
AP2	Anderson Point Berth 2
AP3	Anderson Point Berth 3
AS	Australian Standard
CCEMP	Contractor Construction Environmental Management Plan
DA	Development Application
DSD	Department of State Development
DSDMP	Dredging and Spoil Disposal Management Plan
EMS	Environmental Management System
EPA	Environmental Protection Authority
ESA	Eastern Settlement Area
Fortescue	Fortescue Metals Group
km	Kilometres
m	Metre
MS 967	Ministerial Statement 967
OEPA	Office of the Environmental Protection Authority
PPA	Pilbara Ports Authority
SESA	South Eastern Settlement Area
SSC	Suspended sediment concentrations
TPI	The Pilbara Infrastructure Pty Ltd
WA	Western Australia

14. REFERENCES

Advisian (2015). Port Towage Services – Tug Infrastructure: Geotechnical Factual Report. Report prepared for Fortescue Metals Group. 2 November 2015.

ANZECC/ARMCANZ (2000). Australian and New Zealand Guidelines for Fresh and Marine Water Quality.

Ayling, A. M. and A. L. Ayling (1995). A preliminary survey of benthic communities on fringing reefs in the middle Cairns Section. Unpublished report submitted to the Great Barrier Reef Marine Park Authority.

Ayling, A. M. and A. L. Ayling (2006). The dynamics of Cairns and Central Section Fringing Reefs. Unpublished report submitted to the Great Barrier Reef Marine Park Authority.

BHPBIO (2010). RGP6 Definition Phase Inner Harbour Geotechnical Investigation. Implementation of the Environmental Sampling Programme - Hunt Point Load Out Facility, Prepared for BHPBIO by WorleyParsons.

DoE (2006). Pilbara Coastal Water Quality Consultation Outcomes: Environmental Values and Environmental Quality Objectives. Western Australia.

EPA (2011a) Environmental Assessment Guideline for Marine Dredging Proposals no. 7 (EAG7).

EPA (2013) Environmental Assessment Guideline for Environmental Factors and Objectives. (EAG8) Environmental Protection Agency, June 2013.

EPA (2015) Environmental Assessment Guideline for Preparation of management plans under *Part IV of the Environmental Protection Act 1986* Environmental Protection Agency, August 2015.

GHD (2007). Long Term Dredge Material Management Plan.

Halpern Glick Maunsell (1997). Port Hedland Port Developments Environmental Study. Report prepared for Port Hedland Port Authority.

Hickman, A. and D. Gibson (1982). Explanatory notes on the Port Hedland - Bedout Island Geological Sheet (Second Edition). Bureau of Mineral Resources, Australia and Geological Survey of WA.

Mapstone, D. D., J. H. Choat, et al. (1989). The fringing reefs of Magnetic Island: Benthic biota and sedimentation – a baseline survey. Unpublished report to the Great Barrier Reef Marine Park Authority.

PHPA (2010). Port Hedland Port Authority - South West Creek Tug and Small Vessel Cyclone Protection Mooring Facility - Referral Information, Report prepared by WorleyParsons on behalf of Port Hedland Port Authority.

Siebeck, U., N. Marshall, et al. (2006). "Monitoring coral bleaching using a colour reference card." Coral Reefs 25: 453-460.

WAPC (2003). Western Australian Planning Commission Port Hedland Area Planning Study.

WorleyParsons (2010a) South West Creek Tug & Small Vessel Cyclone Mooring Facility Benthic Habitat Dredging Tolerances and Implications for this Project, Report by WorleyParsons for Port Hedland Port Authority

WorleyParsons (2010b) South West Creek Water Quality Monitoring, Report prepared for Port Hedland Port Authority.

WorleyParsons (2011) South West Creek Dredging and Reclamation Project: Baseline Water Quality Report. Report prepared for Port Hedland Port Authority.

WorleyParsons (2012a). Stingray Creek Small Vessel Cyclone Mooring Facility Project - Baseline Water Quality Report.

WorleyParsons (2012b). South West Creek Dredging and Reclamation Project: Water Quality Monitoring Report 7: 29 May - 20 June 2012.

WorleyParsons (2013) Lumsden Point General Cargo Facility: Ecosystem and Cumulative Impact Assessment. Prepared for Port Hedland Port Authority.

WorleyParsons (2014) South West Creek Dredging and Reclamation Project Phase II: Baseline Water Quality Report. Report prepared for Port Hedland Port Authority.

WorleyParsons (2015) FMG Tug Haven Marine Studies: Sediment Plume Dispersion Modelling. 560PO-4347-RP-EN-003. Prepared for Fortescue Metals Group

Appendix 1: Drawing

Appendix 7: Construction Environmental Noise Management Plan

Management Plan

Port Facility: Construction Environmental Noise Management Plan

Pilbara Iron Ore and Infrastructure Project

2 February 2016
P-PL-EN-0016

Fortescue
The New Force in Iron Ore

	Port Facility: Construction Environmental Noise Management Plan		**P-PL-EN-0016**
Revision Number	**REVISION 6**		**2/02/2016**
Status	**IFU - ISSUED FOR USE**		
Author	Andrew Winzer	Signature	
Checked	Matthew Dowling	pp. Signature	
Approved	Sean McGunnigle	pp. Signature	2/2/16
Confidentiality	**PUBLIC USE (ACCESS TO ALL)**	**Publish on Extranet**	☒ Yes ☐ No
Review Date	**14/04/2014**		

Revision History

Author	**Checker**	**Approver**	**Rev No.**	**Status**	**Issued Date**
D Rowe	**NA**	**NA**	a	DRAFT	5/05/2005
D Ginger	**NA**	**NA**	b	DRAFT	14/07/2006
NA	**NA**	**DEC**	0	IFU	13/10/2006
D Page	**A Meyer**	**D Dowdell**	1	IFU	1/10/2008
R Sharp	**NA**	**S McGunnigle**	2	IFU	23/11/2011
D. Lloyd	**R. Sharp**	**S. McGunnigle**	3	IFU	19/03/2012
D. Lloyd	**R. Sharp**	**S. McGunnigle**	3a	IFR	25/05/2012
R. Sharp	**NA**	**S. McGunnigle**	4	IFU	15/06/2012
G. Pryce	**A. Winzer**	**S. McGunnigle**	5	IFU	15/04/2014
A. Winzer	**M.Dowling**	**S. McGunnigle**	6	IFU	2/2/2016

TABLE OF CONTENTS

List of Tables

List of Figures

List of Appendices

1. INTRODUCTION

This report outlines the assessment methods and management of potential construction noise impacts associated with construction work for the expansion of the Fortescue Metals Group (Fortescue) Herb Elliott Port Facility (the Port). Pilbara Marine, a 100% owned subsidiary of Fortescue proposes to construct a Tug Haven Facility within the Herb Elliott Port Precinct at Anderson Point.

Construction will generally be limited to between 7 am and 7 pm, Monday to Saturday only; however due to time constraints and equipment availability, construction outside these hours will occur for activities including pile driving.

Fortescue proposes to undertake piling activities within the following times:

- 7 am to 7 pm, Monday to Saturday
- 7 am to 7 pm, two Sundays per month plus public holidays
- 7 pm to 9 pm on piling days, when required, in order to safely finish driving of piles. No new piles will be commenced after 7 pm.

Dredging activities to construct the Pilbara Marine Tug Haven Facility will be completed in early 2017. General construction activities to support the Tug Haven Facility will continue at the Port until mid-2017.

To determine the potential impact to noise sensitive receivers from construction noise, the following methodology has been used:

- identify which activities have the potential to result in noise impacts
- obtain manufacturer or measured data from equipment to quantify the noise impacts to noise sensitive premises
- using noise prediction modelling, calculate the predicted noise levels resulting from specific construction activities
- develop strategies to minimise impacts as far as reasonably practicable
- develop procedures to monitor noise levels and identify specific machinery that may result in unacceptable noise impacts.

2. NOISE LEVEL CRITERIA

Noise associated with construction activities carried out between 7 am and 7 pm on any day that is not a Sunday or Public Holiday is not required to satisfy the prescribed standards of the *Environmental Protection (Noise) Regulations 1997*, but rather management practices as defined in Regulation 13. These management practices must show that:

(a) the construction work was carried out in accordance with control of environmental noise practices set out in section 6 of AS 2436-1981 Guide to Noise Control on Construction, Maintenance and Demolition Sites

(b) the equipment used on the premises was the quietest reasonably available

(c) if the occupier was required to prepare a noise management plan under sub regulation (4) in respect of the construction site –

(i) the noise management plan was prepared and given in accordance with the requirement, and approved by the Chief Executive Officer

(ii) the construction work was carried out in accordance with the management plan.

If construction work is to be carried out outside of the hours stated above, then Regulation 13 requires that a noise management plan is to be prepared 7 days before the commencement of the construction works and is to be approved by the Chief Executive Officer. The plan is to include:

- details of, and justification for construction work on the construction site that is likely to be carried out other than between 0700 hours and 1900 hours on any day which is not a Sunday or public holiday
- details of, and the duration of, activities on the construction site likely to result in noise emissions that fail to comply with the standard prescribed under Regulation 7
- predictions of noise emissions from the construction site
- details of measures to be implemented to control noise (including vibration)emissions
- procedures to be adopted for monitoring noise (including vibration) emissions
- complaint response procedures to be adopted.

In addition to the above, it is a requirement to provide written notice to the occupiers of all premises that are likely to exceed the prescribed standards under Regulation 7. This notice must be provided at least 24 hours before work commences. The prescribed standards under Regulation 7 for premises in close proximity to the construction works is provided below.

'Normal' environmental noise (non-construction noise activities) is required to comply with the prescribed standards of the *Environmental Protection (Noise) Regulations 1997* (the Regulations) and specifically, Regulations 7, 8 & 9. Regulations 7 & 8 stipulate maximum allowable external noise levels determined by the calculation of an influencing factor, which is then added to the base levels shown below. The influencing factor is calculated for the usage of land within two circles, having radii of 100 m and 450 m from the premises of concern.

Table 1: Baseline Assigned Outdoor Noise Levels

Premises Receiving Noise	Time of Day	Assigned Level		
		$L_{A\,10}$	$L_{A\,1}$	$L_{A\,max}$
Noise sensitive premises within 15 metres of a dwelling	0700 - 1900 hours Monday to Saturday	45 + IF	55 + IF	65 + IF
	0900 - 1900 hours Sunday and Public Holidays	40 + IF	50 + IF	65 + IF
	1900 - 2200 hours all days	40 + IF	50 + IF	65 + IF
	2200 hours on any day to 0700 hours Monday to Saturday and 0900 hours Sunday and Public Holidays	35 + IF	45 + IF	55 + IF

Note: L_{A10} is the noise level exceeded for 10% of the time.

L_{A1} is the noise level exceeded for 1% of the time.

$L_{A\,max}$ is the maximum noise level.

IF is the influencing factor.

Based on previous assessments, Table 2 shows the calculated influencing factor for key noise sensitive premises and Table 3 shows the assigned levels after incorporating these influencing factors.

Table 2: Assigned Noise Levels for Key Noise Sensitive Receivers

Identification	Land Uses	Influencing Factor
Port Hedland – Esplanade Hotel	Industrial Land within 100m = 50%, Commercial Land within 100m = 50% Industrial Land within 450m = 60%, Commercial Land within 450m = 12%	14
Port Hedland – McKay Street	Industrial Land within 100m = 0%, Commercial Land within 100m =50% Industrial Land within 450m = 30%, Commercial Land within 450m = 30%	7
Port Hedland – Crowe Street	Industrial Land within 100m = 0%, Commercial Land within 100m = 0% Industrial Land within 450m = 30%, Commercial Land within 450m = 0%	3
Wedgefield	Industrial Land within 100m = 50%, Commercial Land within 100m = 0% Industrial Land within 450m = 40%, Commercial Land within 450m = 0%	N/A
South Hedland – Parker Street (Lawson)	Industrial Land within 100m = 0%, Commercial Land within 100m = 0% Industrial Land within 450m = 0%, Commercial Land within 450m = 0%	0

Table 3: Assigned Noise Levels incorporating Calculated Influencing Factors

Identification	$L_{A\,10}$	$L_{A\,1}$	$L_{A\,max}$
Port Hedland – Esplanade Hotel	44	54	64
Port Hedland – McKay Street	37	47	57
Port Hedland – Crowe Street	33	43	53
Wedgefield	44	54	64
South Hedland – Parker Street	30	40	50

3. JUSTIFICATION FOR OUT OF HOURS WORK

There is currently a very high demand for piling equipment and the availability of such equipment is limited for large infrastructure projects in Western Australia. As such, Fortescue is required to compress the construction schedules to ensure work is completed within the equipment availability times. These constraints will necessitate out of hours work, however, to minimise noise impacts to sensitive receivers, this out of hours work will be limited as far as practicable.

Safety is also an important factor for pile driving. Piles which have been commenced but not completed can become unstable, and as such, Fortescue requests that piles which have been commenced prior to 7pm can be completed, up to 9 pm. No new piles would be commenced after 7 pm.

Extending allowable hours for piling and general construction activities will allow Fortescue to optimise the construction schedule, thereby shortening the duration of the construction project.

For the construction phase of this project, Fortescue proposes to undertake construction activities within the following times:

Pile Driving

- 7 am to 7 pm, Monday to Saturday
- 7 am to 7 pm, two Sundays per month plus public holidays 7 pm to 9 pm on piling days, when required, in order to safely finish driving of piles. No new piles will be commenced after 7 pm.
- The current pile driving campaign, to support the construction of the Pilbara Marine Tug Haven Facility, is expected to run from June 2016 until September 2016.

Earthworks and General Construction Activities

- 24 hours - Monday to Sunday.

Dredging

- All dredging activities to support currently approved expansions have been completed.

Fortescue will continue to evaluate the need for out of hours work as the project progresses.

4. NOISE PREDICTION METHODOLOGY

Noise modelling for the Port has been undertaken for Fortescue by Lloyd George Acoustics. The computer modelling programme SoundPlan 7.0 has been utilised to predict the noise propagation from the construction activities to the surrounding areas. This programme was developed by Braunstein + Berndt, GmbH, a European company and is endorsed by the Department of Environment Regulation. The programme was selected to use the CONCAWE algorithms, which require the following input data:

- meteorological information
- topographical data
- ground absorption
- source sound power levels.

4.1 Meteorological Information

Meteorological information utilised was in accordance with the default conditions nominated in the draft EPA Guidance for the Assessment of Environmental Factors No. 8 as shown below in Table 4.

Table 4: Modelling Meteorological Conditions

Parameter	Value	
	Day (0700 – 1900)	Night (1900 – 0700)
Wind Speed (m/s)	4	3
Pasquil Stability Factor	Type E	Type F
Temperature (°C)	20	15
Relative Humidity (%)	50	50

4.2 Topographical Data

Topographical data was 3-dimensional and supplied electronically by Fortescue.

4.3 Ground Absorption

Ground absorption varies from a value of 0 to 1, with 0 being for an acoustically reflective ground (e.g. water or bitumen) and 1 for acoustically absorbent ground (e.g. grass). In this instance, all ground has been set to a value of 0.70.

4.4 Sound Power Data

Fortescue advised the equipment which would typically be used during construction operations. Source sound power level data for this equipment has been obtained from the manufacturers or from in-house data derived from measurements carried out on similar equipment. The sound power levels used in the noise prediction modelling are listed below in Table 5.

Table 5: Source Sound Power Levels, dB(A)

Parameter	Octave Band Centre Frequency (Hz)								Overall dB(A)
	31.5	63	125	250	500	1000	2000	4000	
Front-end Loader (based on Cat 916)	64	79	93	96	103	106	103	98	110
Dozer (Based on Cat 518C)	66	82	97	103	107	107	104	99	112
Grader (based on Cat 16G)	66	89	94	98	106	108	107	102	113
Pile Driver Impact Hammer (based on 12T Diesel operated Drop Hammer)	85	85	103	102	118	123	127	122	136
	85	88	104	113	124	124	126	126	
	85	94	101	116	127	124	126	126	

5. NOISE PREDICTION RESULTS

Predicted noise levels have been calculated by Lloyd George Acoustics as part of the AP4 dredging campaign in South West Creek. This modelling is seen as being an appropriate estimate of predicted noise levels for construction of the Tug Haven Facility as the AP4 berth is located a similar distance south of sensitive receptors. The results of the noise predictions to key noise sensitive premises are presented in Table 6 . The noise sources at each location are ranked in order of importance.

Table 6: Predicted Noise Levels and Noise Source Ranking

Receiver Location	Combined Noise Level from all Noise Sources	Noise Source Ranking
Esplanade Hotel – Port Hedland	L_{A1} 60 dB L_{A10} 34 dB	Pile Driving – 60 dB(A) Dozer – 33 dB(A)
McKay Street – Port Hedland	L_{A1} 54 dB L_{A10} 29 dB	Pile Driving – 54 dB(A) Front-End Loader – 28 dB(A)
Crowe Street – Port Hedland	L_{A1} 54 dB L_{A10} 29 dB	Pile Driving – 54 dB(A) Dozer – 28 dB(A)
Wedgefield	L_{A10} 34 dB	Dozer – 28 dB(A) Grader – 29 dB(A) Front-End Loader – 26 dB(A)
South Hedland (west side)	L_{A10} 20 dB	Front-End Loader – 20 dB(A)

5.1 DISCUSSION OF RESULTS

From the results presented in Table 6, it can be seen that there is a potential for construction noise to exceed Regulation 7 assigned levels (Table 3), especially in Port Hedland.

The noise from piling is likely to be impulsive in nature and a +10 dB penalty is applicable to the predicted noise levels. Therefore the noise from the piling activities is predicted to exceed the L_{A1} assigned levels in Port Hedland.

The noise from the remaining construction activities are not expected to exhibit any annoying noise characteristics at the receiver locations, due to the masking effect of high background noise levels experienced in Port Hedland and Wedgefield. Therefore, the noise from the remaining construction activities are predicted to comply with the L_{A10} assigned levels at all times.

In accordance with Regulation 13, construction noise will therefore require management, particularly as the proposed construction activities will occur outside of normal working hours.

6. NOISE CONTROL MEASURES

To satisfy the Regulations, the following practices will be followed.

6.1 Sourcing Equipment and Control Measures

Fortescue will source the quietest equipment that is practicably available. However, the following specific noise control measure will also be undertaken to satisfy the Regulations if construction activities are conducted outside the hours of 7am to 7pm, or on a Sunday or Public Holiday.

Impact hammers will be shrouded around the hammer mechanism

6.2 Equipment Auditing

As part of the ongoing management of construction noise, all equipment similar to that listed in Table 5 will undergo a noise assessment at commencement of the construction work (or when it is first used) and at regular intervals throughout the contract. Acceptable noise levels will be based on data provided in Australian Standard *AS 2436-1981 Guide to Noise Control on Construction, Maintenance and Demolition Sites*. A noise auditing form with the allowable noise level at a prescribed distance will be developed. Any equipment found not to comply with the noise levels detailed in *AS 2436-1981* will not be permitted to be used during any night-time operations until compliance is achieved.

7. NOISE MONITORING

It is envisaged that noise monitoring will occur over a period of 2 weeks during the piling phase of the project. It is envisaged that the monitoring will occur within one month of the commencing of piling.

Noise monitoring would be predominately undertaken using un-manned statistical noise data loggers, capable of storing audio files for identification of noise sources if required. This monitoring would be supplemented by personnel undertaking noise measurements at specific locations to calibrate the noise model or where there is a potential noise issue or complaint.

8. COMPLAINT RESPONSE

Should a complaint be received about construction noise it will be investigated with the following procedure, and outcomes documented:

- The nature of the noise complaint will be determined and in particular, whether it is a result of general work hours or a specific construction operation.
- All equipment being used close to where the complaint originated will be identified.
- The identified equipment in use at the time of the complaint will be subjected to a noise audit test to determine if it is compliant with the *Construction Noise Management Plan*.
- Any equipment found not to comply with the NMP will not be permitted to commence operation until the noise levels are compliant. If all equipment is compliant, consideration will be given to a change in work practices to reduce further noise impact where practicable.
- The outcome of the investigation will be conveyed to the complainant within a reasonable time period. Details of any complaints received resulting from construction noise will be reported to the Department of Environment Regulation regional office on a monthly basis.

9. NOTIFICATION OF OUT-OF-HOURS WORK

Noise sensitive premises likely to be affected by out-of-hours construction work will be notified by way of an advertisement in the local community newspaper two weeks prior to the out-of-hours work commencing. The notification will include:

- intended hours of operation
- expected duration of the works
- types of activities
- complaints telephone number and email

10. AUDITING AND REVIEW

The Plan has been developed through the extensive use of external consultants (Lloyd George Acoustics).

Minor changes to the Plan are to be made as required to meet the requirements of the project and to comply with all relevant legislation. Major revisions are to be submitted to the Department of Environment Regulation regional office and the Town of Port Hedland for comment.

The Plan is to be reviewed at least annually or where major changes to the project area are made.

Performance and compliance against the actions of the Plan are to be assessed annually, with results presented in the Annual Environmental Report.

11. GLOSSARY OF TERMS

The following is an explanation of the terminology used throughout this document.

A-Weighting

An A-weighted noise level has been filtered in such a way as to represent the way in which the human ear perceives sound. This weighting reflects the fact that the human ear is not as sensitive to lower frequencies as it is to higher frequencies. An A-weighted sound pressure level is described by the symbol dB(A).

$L_{A\ slow}$

This is the noise level in decibels, obtained using the A frequency weighting and the S time weighting as specified in AS1259.1-1990. Unless assessing modulation, all measurements use the slow time weighting characteristic.

$L_{A\ fast}$

This is the noise level in decibels, obtained using the A frequency weighting and the F time weighting as specified in AS1259.1-1990. This is used when assessing the presence of modulation only.

L_{Amax}

An L_{Amax} level is the maximum A-weighted noise level measured during the measurement period.

L_{A1}

An L_{A1} level is an A-weighted noise level which is exceeded for one percent of the measurement period and is considered to represent the average of the maximum noise levels measured.

L_{A10}

An L_{A10} level is an A-weighted noise level which is exceeded for 10 percent of the measurement period. An L_{A10} level is considered to represent the "intrusive" noise level.

L_{Aeq}

The equivalent steady-state A-weighted sound level ("equal energy") which, in a specified time period, contains the same acoustic energy as the time-varying level during the same period. It is considered to represent the "average" noise level.

L_{A90}

An LA90 level is the A-weighted noise level which is exceeded for 90 percent of the measurement period and is considered to represent the “background” noise level.

L_{Amax} assigned level

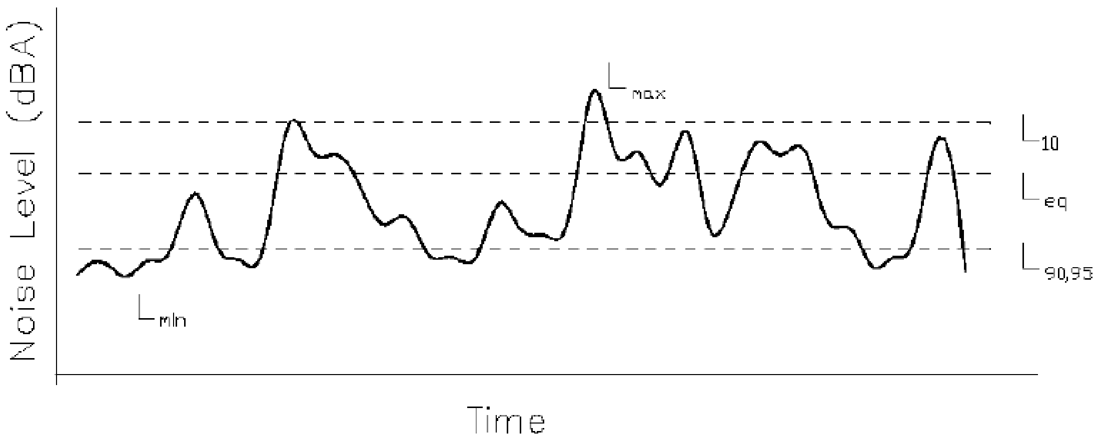
Means an assigned level which, measured as a LA Slow value, is not to be exceeded at any time.

L_{A1} assigned level

Means an assigned level which, measured as a LA Slow value, is not to be exceeded for more than 1% of the representative assessment period.

L_{A10} assigned level

Means an assigned level which, measured as a LA Slow value, is not to be exceeded for more than 10% of the representative assessment period.



Decibel

Decibel (dB) describes the sound pressure level of a noise source. Decibel units are measure on a logarithmic scale referenced to the threshold of hearing.

Impulsive Noise

An impulsive noise source can be described as a source that has a banging noise emission. An example would be hammering or impact piling.

Impulsiveness

Means a variation in the emission of a noise where the difference between L_{Apeak} and L_{Amax} Slow is more than 15 dB when determined for a single representative event

Modulation

Means a variation in the emission of noise that –

(a) is more than 3dB $L_{A\ Fast}$ or is more than 3 dB $L_{A\ Fast}$ in any one-third octave band;

(b) is present for more at least 10% of the representative assessment period; and

(c) is regular, cyclic and audible;

One-Third-Octave Band

Means a band of frequencies spanning one-third of an octave and having a centre frequency between 25 Hz and 20 000 Hz inclusive.

Tonality

Means the presence in the noise emission of tonal characteristics where the difference between:

(a) the A-weighted sound pressure level in any one-third octave band; and

(b) the arithmetic average of the A-weighted sound pressure levels in the 2 adjacent one-third octave bands,

is greater than 3dB when the sound pressure levels are determined as $L_{Aeq,T}$ levels where the time period T is greater than 10% of the representative assessment period, or greater than 8dB at any time when the sound pressure levels are determined as $L_{A\ Slow}$ levels.

Sound Power Level (L_w)

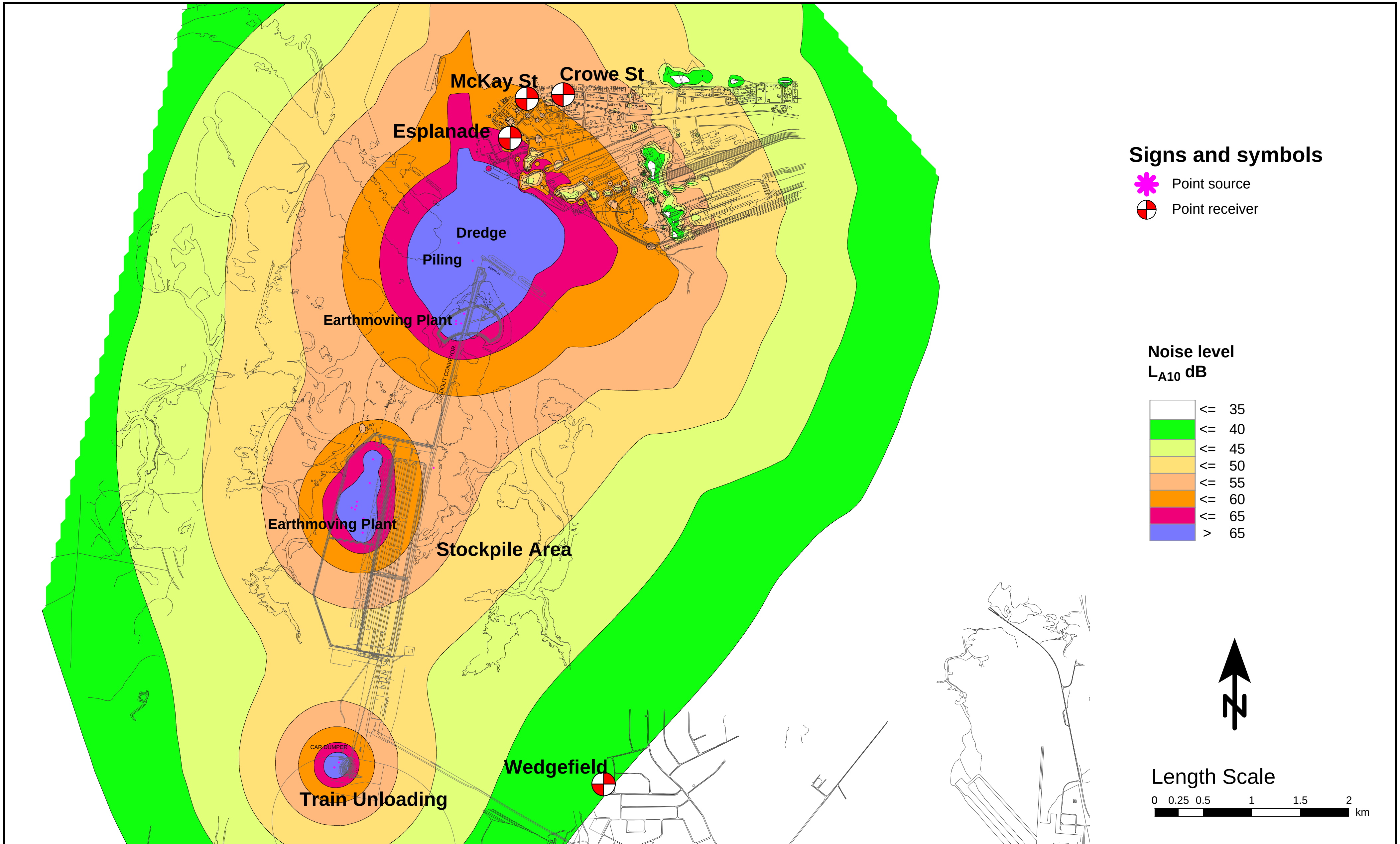
Under normal conditions, a given sound source will radiate the same amount of energy, irrespective of its surroundings, being the sound power level. This is similar to a 1kW electric heater always radiating 1kW of heat. The sound power level of a noise source cannot be directly measured using a sound level meter but is calculated based on measured sound pressure levels at known distances. Noise modelling incorporates source sound power levels as part of the input data.

Sound Pressure Level (L_p)

The sound pressure level of a noise source is dependent upon its surroundings, being influenced by distance, ground absorption, topography, meteorological conditions etc. and is what the human ear actually hears. Using the electric heater analogy above, the heat will vary depending upon where the heater is located, just as the sound pressure level will vary depending on the surroundings. Noise modelling predicts the sound pressure level from the sound power levels taking into account ground absorption, barrier effects, distance etc.

This page has been left blank intentionally

Figure 1: $L_{A\ 10}$ Construction Noise Levels



Fortescue Metals Group - Port Hedland Expansion

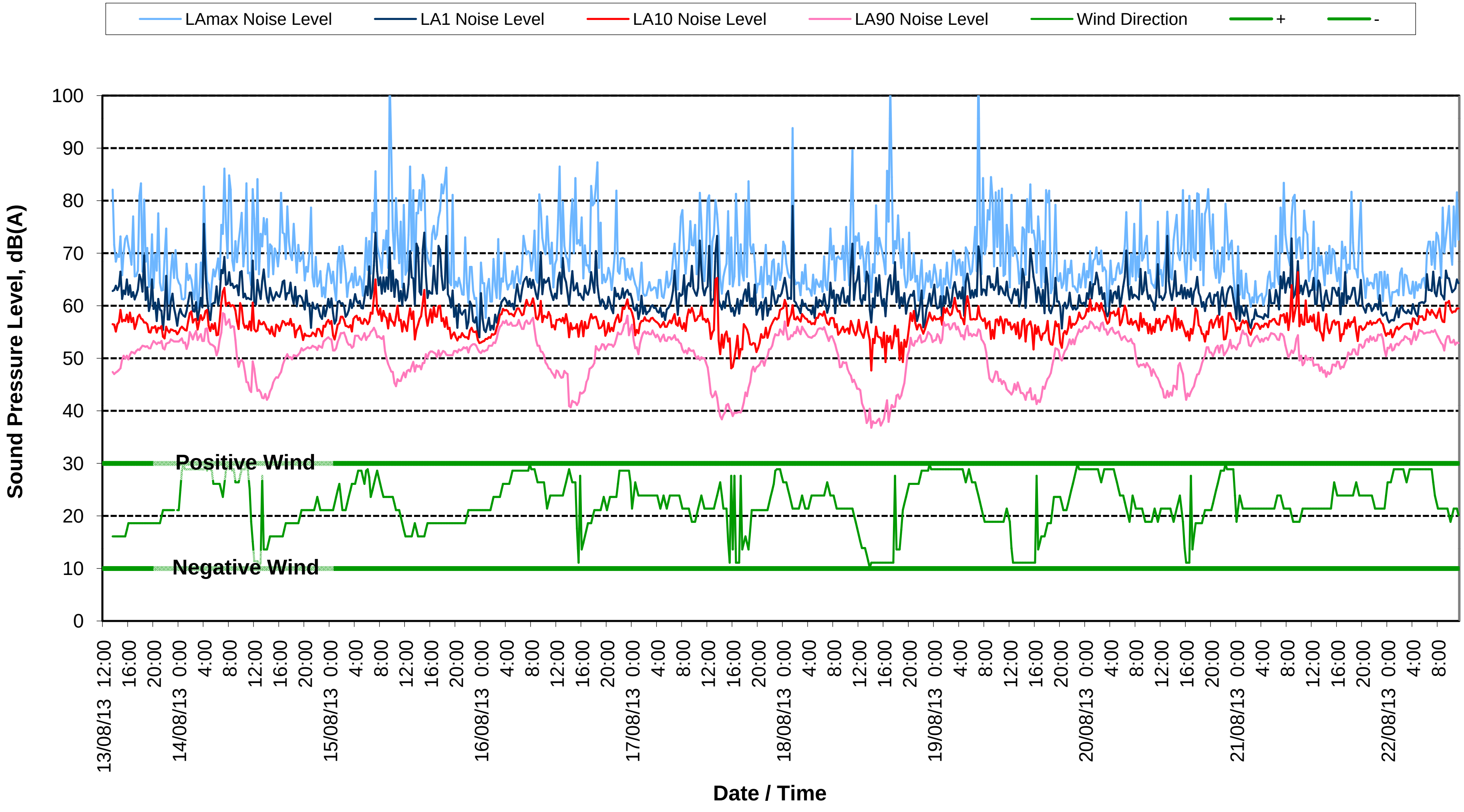
L_{A10} Construction Noise Levels Assuming Piling and Wind from All Directions

Lloyd George Acoustics
by Daniel Lloyd
daniel@lgacoustics.com.au
(08) 9300 4188

Appendix 1: Measured Noise Levels in Port Hedland

This page has been left blank intentionally

FMG Anderson Point - Environmental Noise Measurements
Location 8 - 19 Kingsmill Street, Port Hedland
13 to 22 August 2013



This page has been left blank intentionally