Report

Darwin Marine Supply Base Dredging and Dredge Spoil Placement Management Plan

30 JULY 2013

Prepared for

Macmahon Contractors Pty Ltd

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Abbreviations/Glossary

Abbreviation/Definition	Description
AIMS	Australian Institute of Marine Science
ASS	Acid Sulfate Soil
ANZECC & ARMCANZ	Australian and New Zealand Environment Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand
BIMOS	Biodiversity Impact Mitigation and Offsets Strategy
CD	Chart datum
CEMP	Construction Environmental Management Plan
CSD	Cutter Suction Dredge
DCM	Northern Territory Department of the Chief Minister
DDSPMP	Dredging and Dredge Spoil Placement Management Plan
DGPS	Differential Global Positioning System
DGT	Diffusive gradients in thin films
DLP	Northern Territory Department of Lands and Planning
DLPE	Northern Territory Department of Lands, Planning and Environment
DLRM	Northern Territory Department of Land Resource Management
DoI	Northern Territory Department of Infrastructure
DPC	Darwin Port Corporation
EIS	Environmental Impact Statement
EMS	Environmental Management System (Macmahon EMS)
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
HSEQ	Health, safety, environment and quality
INPEX	INPEX Operations Australia Ltd or INPEX Browse, Ltd
JSA	Job safety assessment
KPI	Key performance indicator(s)
LNG	Liquefied Natural Gas
Macmahon	Macmahon Contractors Pty Ltd
Minister	The Commonwealth Minister administering the EPBC Act, including a delegate of the Minister
MSB	Marine Supply Base
NRETAS	Northern Territory Department of Natural Resources, Environment, the Arts and Sport (now NT EPA)
NT EPA	Northern Territory Environment Protection Authority
NTG	Northern Territory Government
NTU	Nephelometric Turbidity Units
PASS	Potential Acid Sulfate Soil
Proponent	Northern Territory Department of Lands and Planning (now part of Department of Lands, Planning and Environment)
QA/QC	Quality assurance/quality control
SEWPaC	Commonwealth Department of Sustainability, Environment, Water, Population and Communities
ShoreASCO	ShoreASCO Pty Ltd
SSI	South Shell Island
TAG	Technical Advisory Group

Introduction

1.1 East Arm Wharf Expansion Project

The proponent for the East Arm Wharf expansion project was the Northern Territory (NT) Department of Lands and Planning (DLP, hereafter 'the Proponent'), now a part of the Department of Lands, Planning and Environment (DLPE). The project comprises an expansion of East Arm Wharf in Darwin Harbour to accommodate the requirements of prospective wharf users through three separate developments:

- A Marine Supply Base (MSB) adjacent to East Arm Wharf, primarily to service the existing and developing oil and gas industries in the Timor Sea, Browse Basin and adjacent areas.
- A barge ramp and hardstand area, including berthing for barges and facilities for loading and unloading.
- An extension to the East Arm Wharf quay, and construction of moorings to accommodate tug boats, customs boats and other smaller vessels.

The expansion requires dredging within Darwin Harbour to provide for effective and efficient vessel access and manoeuvring.

The initial phase of the EAW expansion project comprises the development of the MSB (**Figure 1-1**). In September 2011, the NT Government (NTG) awarded the works to develop the MSB to ShoreASCO, who will be the operator of the MSB facility once constructed. ShoreASCO has engaged Macmahon Contractors Pty Ltd (Macmahon) as a subcontractor, to design and construct the MSB. When and by whom the remaining two developments will be constructed is unknown at this stage.

The MSB will be developed according to a master plan, to service and support the existing and planned offshore oil and gas exploration and production industries. The MSB is to be of international standard and capable of supporting the offshore industry in the region surrounding Darwin, in locations ranging from the Browse Basin to Papua New Guinea.

The MSB will have the capacity to service over 1000 vessels per annum. Initially, one berth at the MSB is planned to be used as a rock load-out facility to service the rock armouring requirements of the INPEX Ichthys LNG project under construction at Blaydin Point in Darwin. The rock load-out facility is scheduled to operate for a duration of 7.5 months. The proposed MSB comprises over 8 ha of land and 19 ha of water licence. Construction works commenced in April 2012, and the project is scheduled to be completed in September 2013.

Dredging is required to construct the berthing areas, a swing basin and access channel from the MSB to existing shipping channels within Darwin Harbour. The approach channel, swing basin and berth areas extend over an area of 15.1 ha, and dredging will be to -7.7 m below Chart Datum (CD), with one berth (Berth 3) dredged to -8.7 m CD, to cater for berthing of vessels with greater than normal draft. A total of 685,000 m^3 of sediment is planned to be removed.

Dredging will be a two-phase project; the first phase commenced 3 October 2012 and ceased 30 November 2012 and the second phase is scheduled to begin 1 May 2013 and run for 25 weeks. Approval is being sought from the Commonwealth Minister administering the EPBC Act (hereafter 'the Minister'), via the Department of Sustainability, Environment, Water, Population and Communities (SEWPaC), to commence dredging during the Wet Season and if this is obtained Macmahon will be able to bring forward the Phase 2 dredge commencement date.

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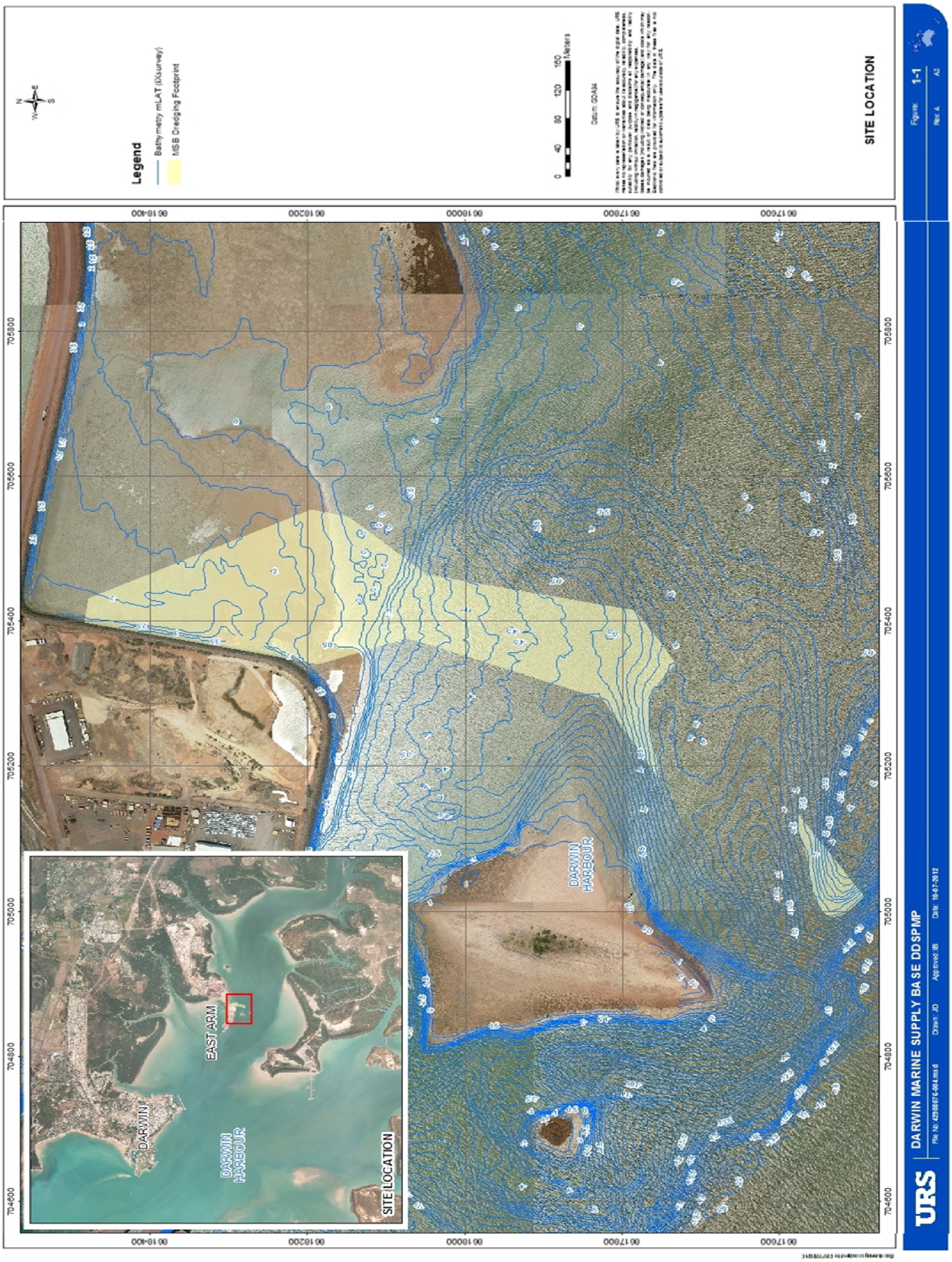
Figure 1-1 Location map of East Arm Wharf and MSB dredging footprint



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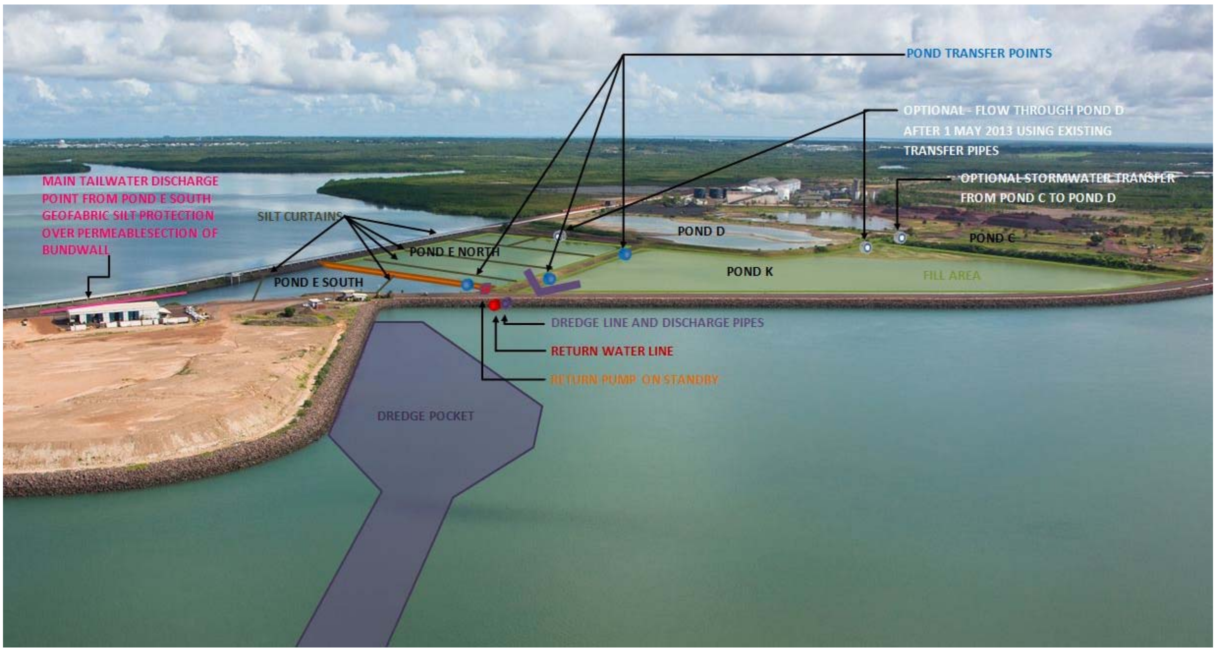
Dredge material is to be placed into the existing East Arm Dredge Spoil Pond K, with the tailwater flowing into Pond E and returned to the receiving environment through a permeable section of the railway bund wall (see **Figure 1-2**). As described in **Section 2.5.5**, a back-up pump will be present in the south-east corner of Pond E to (if required) discharge tailwater into the dredge footprint. Pond D may also be used for tailwater treatment during the Dry Season (after 1 May 2013). The dredging and reclamation methodology is discussed in detail in **Section 2**.

Figure 1-2 Aerial photograph showing dredge spoil placement configuration



1.2 Purpose of this plan

This document relates to the management and monitoring of the dredging operations and onshore disposal of the dredged material. The plan incorporates the requirements stipulated in approval conditions (see **Section 1.7**) pertaining to the preparation of:

- **A Dredging and Dredge Spoil Placement Management Plan** (DDSPMP)
- **A Water Quality Management Plan**

It also incorporates the commitment made by DLP (2011a) in their Draft Environmental Impact Statement (EIS) for the East Arm Wharf Expansion Project to prepare an **Acid Sulfate Soil** (ASS) **Management Plan**. As the management and monitoring of dredging, dredge spoil placement, water quality and ASS are inextricably linked, it was necessary to combine the requirements of the three plans into a single plan.

This DDSPMP demonstrates that reasonable and practicable steps have been taken to manage the risks associated with, and the potential environmental impacts arising from, the dredging and spoil placement activities to be undertaken during the construction phase of the MSB project.

The DDSPMP details how the potential impacts of the dredging and spoil placement activities will be minimised by the identification and implementation of appropriate management and monitoring

1 Introduction

controls. It describes the proposed management, monitoring, reporting, review and auditing requirements for the dredging and spoil placement activities in order to meet the conditions of the various environmental approvals.

The DDSPMP and supporting documentation has been prepared for submission to the East Arm Wharf Expansion Project Technical Advisory Group (TAG) for review and endorsement and to the NT Environment Protection Authority (NT EPA) and, via SEWPaC, to the Minister for approvals.

The development and implementation of this DDSPMP is also a requirement under the Macmahon Environmental Management System (certified under ISO 14001- Environmental Management Systems).

1.3 Relationship to other management plans

The DDSPMP is one of a series of environmental management plans (EMPs) that together form the environmental management system for the Project. It should be read in conjunction with the overarching Macmahon Construction Environmental Management Plan (CEMP) for the project, which details the project background; an overview of the Macmahon Management Systems and how the CEMP addresses all requirements of ISO14001.

The CEMP contains various sub-plans detailing separate environmental issues (excluding dredging and spoil placement activities):

- Erosion & Sediment Control Sub-Plan
- Piling (Land Based) Management Plan
- Flora & Fauna Management Sub-Plan
- Hazardous Substances and Waste Management Sub-Plan
- Air Quality and Dust Management Sub-Plan
- Greenhouse Gas Management Sub-Plan
- Noise Management Sub-Plan
- Fire Management Sub-Plan
- Biting Insects Management Sub-Plan
- Aboriginal and Cultural Heritage Management Sub-Plan.

1.4 Proponent/Primary Contractor

The Proponent of the East Arm Wharf Expansion Project is the NT DLP (now a part of DLPE), which is responsible for developing and providing strategic planning and growth frameworks, strategies and infrastructure plans required to develop the NT.

The Proponent is acting on behalf of the NTG. The Department of the Chief Minister (DCM) has the role of coordinating with the primary contractor. The primary contractor for the project is ShoreASCO.

Proponent's address:

Level 5, Energy House

Cavenagh Street

Darwin, NT 0800

Ph (08) 8999 5511

Primary Contractor's Address:

ShoreASCO Pty Ltd

34 O'Sullivan Cct

Hudson Creek, NT 0828

Ph (08) 8922 9567

1.5 Subcontractor

Macmahon will design and construct the MSB as contractors to ShoreASCO. Sinclair Knight Mertz is the lead design consultant for Macmahon.

Subcontractor's Head Office address:

Level 3

27-31 Troode Street

West Perth, WA 6005

Ph (08) 9232 1000

Subcontractor's Darwin Office address:

170 Coonawarra Road

Winnellie, NT, 0820

Project Contact: Chris Pick

Ph (08) 8943 1000

1.6 Project approvals

The EAW expansion project was initially assessed through an EIS (DLP 2011a), with additional information and responses to stakeholder comments presented in an EIS Supplement (DLP 2011b). Complete details of the environmental assessment process are provided in these documents. The project was assessed jointly by the NTG under the *Environmental Assessment Act 1982* and the Commonwealth Government under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

1.6.1 NRETAS approval recommendations

The NTG approved the project under the *Environmental Assessment Act 1982* in December 2011. Twenty-two recommendations were listed within the Environmental Assessment Report (Department of Natural Resources, Environment, the Arts and Sport [NRETAS] 2011), which have been addressed by the provision of additional information by the Proponent, and commitments made in this DDSPMP and the Macmahon CEMP. A copy of the NRETAS assessment report is available online at http://www.ntepa.nt.gov.au.

1.6.2 Commonwealth approval conditions

The Commonwealth Government awarded conditional approval under the EPBC Act on 5 March 2012 (SEWPaC 2012a), with a variation to the approval issued on 28 May 2012 (SEWPaC 2012b). Forty-nine ministerial conditions of approval were attached to the approval decision, all of which are legally binding to the Proponent. Four conditions (15, 17, 36 and 37) of the original approval were superseded in the variation issued 28 May 2012. A full copy of the Commonwealth approval decision is available online at http://www.environment.gov.au.

SEWPaC will be consulted for approval if any changes or revisions to the DDSPMP or the proposed action occur, as required by Condition 5 (revision/change approvals). The approved DDSPMP is implemented in accordance with Condition 21. These approval conditions are also applicable to all other environmental management plans/strategies associated with the project.

1.6.3 Waste Discharge Licence

A Waste Discharge Licence (WDL187) pursuant to section 74 of the *NT Water Act* was granted to Macmahon on 24 August 2012. The expiry date of the licence is 22 May 2014. The WDL contains

29 conditions with which the licensee (Macmahon) must comply. NT EPA will be consulted for approval if any changes or revisions to the DDSPMP occur, as required by Condition 11 of the licence.

1.6.4 Environmental commitments

Environmental commitments made in the Draft EIS (DLP 2011a) and the EIS Supplement (DLP 2011b) that are relevant to the dredging and spoil placement activities associated with construction of the MSB have been consolidated in a commitments and actions register. This register is separate from this DDSPMP as it is progressively updated to incorporate additional conditions of approval from secondary approvals (e.g. under the NT *Waste Management and Pollution Control Act* and the NT *Water Act*). It also serves as an audit tool.

1.7 Legal requirements and guidelines

This DDSPMP has been developed to meet Commonwealth EPBC approvals conditions (approval 2010/5304), NRETAS Recommendations (Assessment Report 67) and the conditions of WDL 187. The pertinent conditions and recommendations have been incorporated into the commitments and actions register introduced in **Section 1.6.4.**

Other legislative requirements relevant to the dredging activities are presented in **Table 1-1** (Commonwealth) and **Table 1-2** (NT).

International conventions and guidelines relevant to the dredging activities are listed in **Table 1-3**.

A number of government strategy and guideline documents have been developed to provide advice to proponents in the development of environmental management and monitoring programs. In the development of this DDSPMP the documents listed in **Tables 1-4** and **1-5** have been taken into account.

In addition to Commonwealth and NT regulatory guidance, this DDSPMP takes account of the Environmental Assessment Guideline for Marine Dredging Proposals (EAG7) developed by the WA Environmental Protection Authority (EPA) under s16(k) of the *Environment Protection Act* (EPA 2011). The guideline aims to provide guidance for the clear and consistent presentation of predicted impacts of dredging and dredge-generated sediment on benthic habitats. Aspects of these guidelines have been adopted in the absence of dredging and spoil disposal guidelines for the NT.

Table 1-1 Commonwealth legislative requirements

Commonwealth	
Title	**Description**
Aboriginal and Torres Strait Islander Heritage Protection Act 1984	The purposes of this Act are the preservation and protection from injury or desecration of areas and objects in Australia and in Australian waters, being areas and objects that are of particular significance to Aboriginals in accordance with Aboriginal tradition.
Australian Ballast Water Management Requirements 2001	Requirements designed to reduce the risk of introducing harmful aquatic organisms into Australia's marine environment through ships' ballast water. Australian ballast water management requirements are consistent with International Maritime Organization (IMO) guidelines for minimising the translocation of harmful aquatic species in ships' ballast water

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Commonwealth	
Title	**Description**
Environment Protection and Biodiversity Conservation Act 1999	This Act provides a national framework for environmental and heritage protection. It focuses on protecting "matters of national environmental significance" including listed, protected species and marine species.
Hazardous Waste (Regulation of Exports and Imports) Act 1989	An Act to provide for the regulation of the export, import and transit of hazardous waste, and for related purposes.
Hazardous Waste (Regulation of Exports and Imports) Amendment Act 1996	An Act to amend the Hazardous Waste (Regulation of Exports and Imports) Act 1989, and for related purposes. The object of this Act is to regulate the export, import and transit of hazardous waste to ensure that exported, imported or transited waste is managed in an environmentally sound manner, so that society and the environment, both within and outside Australia, are protected from the harmful effects of the waste.
Protection of the Sea (Harmful Anti-fouling Systems) Act 2006	An Act relating to the protection of the sea from the effects of harmful anti-fouling systems. It includes application or use of harmful anti-fouling and the required certificates and anti-fouling declarations.
Protection of the Sea (Prevention of Pollution from Ships) Act 1983	This Act relates to the prevention of pollution (in any form) from ships.
Quarantine Act 1908 and Quarantine Regulations 2000	An Act relating to quarantine, including the quarantine and quarantine procedures of vessels, persons and goods.

Table 1-2 Northern Territory legislative requirements

Northern Territory	
Title	**Description**
Aboriginal Land Act 2010	This Act provides for access to: Aboriginal land, certain roads bordered by Aboriginal land and the seas adjacent to Aboriginal land.
Northern Territory Aboriginal Sacred Sites Act and Regulations 2011	An Act to effect a practical balance between the recognised need to preserve and enhance Aboriginal cultural tradition in relation to certain land in the NT and the aspirations of the Aboriginal and all other peoples of the NT for their economic, cultural and social advancement.
Crowns Land Act 2011	An Act responsible for managing Crown land and facilitating (development consented) land use for economic development.
Dangerous Goods Act 1998 and Amendment Act 2003 (Act No. 20, 2003)	An Act to provide for the safe storage, handling and transport of certain dangerous goods. The goods will be classified and need to be taken care of by specialised persons. This Act will be controlled by competent authorities.
Darwin Port Corporation Act 2005	An Act to provide for the establishment of the Darwin Port Corporation for the control and management of the Port of Darwin and for related purposes.
Environmental Protection (National Pollutant Inventory) Objective 2004	National Environment Protection Measures (NEPMs) are broad framework-setting statutory instruments defined in the *National Environment Protection Council (NEPC) Act 1994*. They outline agreed national objectives for protecting or managing particular aspects of the environment. A NEPM will become law in each participating jurisdiction once it is made by NEPC.
Environmental Offences and Penalties Act and Regulations 2011	This Act establishes penalties for certain offences under prescribed Acts (such as an environmental offence) and for related purposes.

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Northern Territory	
Title	**Description**
Fisheries Act and Regulations 2009	An Act to provide for the regulation, conservation and management of fisheries and fishery resources so as to maintain their sustainable utilisation, to regulate the sale and processing of fish and aquatic life, and for related purposes.
Heritage Conservation Act and Regulations 2008	The principal object of this act is to provide a system for identification, assessment, recording, conservation, and protection of places and object of, amongst other things, historic, social or aesthetic value. This includes geological structure, ruins, buildings, gardens, landscapes and coastlines of the Northern Territory.
Litter Act 2011	An Act relating to litter. It includes that no person shall leave, throw, deposit or abandon litter in, onto or from a public place or land elsewhere than into authorised receptacles.
Marine Act 2011 and Marine (Pilotage) Regulations 2001	This Act regulates shipping within the NT and provides for the application to the NT of the uniform shipping laws code and for related matters such as required qualifications and actions and other related purposes.
Marine Pollution Act 2004 and Marine Pollution Regulations 2010	An Act to protect the marine and coastal environment by minimising intentional and negligent discharges of pollutants (such as oil, garbage, sewage etc.) from ships into coastal waters and for related purposes.
Waste Management and Pollution Control Act 2009 and Waste Management and Pollution Control Regulations 2010	This Act aims to enforce appropriate waste management practices and protection against pollution on the one hand and on the other, to provide the right tools and level of assistance for those wishing to adopt sustainable environmental practices. The Act protects and, where practicable, aims to restore and enhance the quality of Northern Territory environment. The Act facilitates the implementation of NEPM established by the NEPC.
Water Act 1992	This Act covers the investigation, use, control, protection, management and administration of water resources in the NT. The Act prohibits the release of certain restricted substances into watercourses.

Table 1-3 International conventions and guidelines

International Conventions	
Title	Description
Guidelines for the Development of Garbage Management Plans for compliance with Regulation 9(2), Annex V of MARPOL	The use of three complementary techniques to manage garbage: source reduction, recycling and disposal. It must include the person in charge of carrying out the plan, procedures for garbage collection, and procedures for processing garbage, storing garbage and the disposing of garbage.
International Convention for the Prevention of Pollution from Ships (MARPOL 73/78)	The MARPOL Convention is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. It covers the prevention of pollution by oil, chemicals, and harmful substances in packaged form, sewage and garbage.
International Convention for the Control and Management of Ships' Ballast Water and Sediments	The Convention aims to prevent the potentially devastating effects of the spread of harmful aquatic organisms carried by ships' ballast water from one region to another.
The Convention on the Conservation of Migratory Species of Wild Animals	Aims to conserve terrestrial, aquatic and avian migratory species throughout their range. It is an intergovernmental treaty, concluded under the aegis of the United Nations Environment Programme, concerned with the conservation of wildlife and habitats on a global scale.

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International Conventions	
Title	Description
International Convention for the Prevention of Pollution from Ships as modified by the Protocol of 1978 relating thereto and Annex V (Prevention of Pollution by Garbage from Ships) (IMO 1973)	This deals with different types of garbage and specifies the distances from land and the manner in which they may be disposed of. The requirements are much stricter in a number of "special areas" but perhaps the most important feature of the Annex is the complete ban imposed on the dumping into the sea of all forms of plastic.

Table 1-4 Commonwealth Government strategy and guideline documents

Commonwealth
National Assessment Guidelines for Dredging (Commonwealth of Australia 2009)
Guidelines for Fresh and Marine Water Quality - Australia and New Zealand Environment Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) 2000
National Water Quality Management Strategy (Commonwealth of Australia 1992)
Intergovernmental Agreement on a National System for the Prevention and Management of Marine Pest Incursions, April 2005

Table 1-5 Northern Territory strategy and guideline documents

Northern Territory
A Review of Environmental Monitoring of the Darwin Harbour Region and Recommendations for Integrated Monitoring (2005)
A Strategy for the Conservation of Marine Biodiversity in the Northern Territory of Australia, Parks and Wildlife Commission of the NT (PWCNT) (2000)
Declaration of Beneficial Uses and Objectives Darwin Harbour Region (June 2010)
Darwin Harbour Regional Management Strategic Framework 2009–2013 (Draft)
Darwin Harbour Water Quality Protection Plan 2009 (Draft)
Darwin Port Corporation (DPC) Environmental Management System, Environment Policy and OH&S Policy 2002

1.8 Existing management frameworks in Darwin Harbour

The NTG is developing a Water Quality Protection Plan (WQPP) for Darwin Harbour under the National Water Quality Management Strategy. The overall aim of the WQPP is to ensure that water quality objectives are maintained and that the community's values for waterways are protected (NRETAS 2010).

Phase 1 of the development of the WQPP commenced in 2006 and was completed in 2009. This included identifying key risks to water quality, development of interim water quality objectives (based on beneficial use declarations under the *Water Act*), improvements to monitoring activities and evaluation of pollutant loads (NRETAS 2010).

Phase 2 of the development of the WQPP commenced in January 2011 and is scheduled for completion by June 2013 (NRETAS 2012). This phase includes the development of an integrated decision support system for the Harbour catchment and recommended management actions. Hence the WQPP does not yet represent a management framework for the Harbour, though it does provide a basis for the development of such a framework.

Under the WQPP, the dredging activities fall within the Upper Estuary “water type” where beneficial uses, as declared under the NT *Water Act*, are cultural (recreation and aesthetics) and environment (NRETAS 2010).

Performance against the water quality objectives described in the Phase 1 WQPP are assessed by NRETAS on the basis of the annual mean value of the measured parameter (NRETAS 2010). It is noted that the guidelines do not apply during high flow events associated with Wet Season conditions and that the water quality objectives are intended for use in “catchment management and land use planning activities” (NRETAS 2010). Hence the objectives could be considered as representing targets for long-term water quality rather than as limits to be adhered to during the dredging operations. However, they have been taken into account during the development of the environmental management frameworks detailed in **Section 6**. The environmental management frameworks have been developed in a manner that is consistent with the risk based decision framework discussed above.

1.9 DDSPMP review, approval and availability

Macmahon is committed to implementing best practice environmental management in order to operate in an environmentally responsible manner. In keeping with this commitment, Macmahon will review the DDSPMP as required in response to any new information, requirements or identified project-related risks. Reviews will address matters such as the effectiveness of this DDSPMP, changes in environmental risks, changes in business conditions, processes for monitoring environmental performance, and any relevant emerging environmental issues currently not addressed.

Reviews of this DDSPMP are the responsibility of Macmahon. The Proponent is responsible for submitting revisions of this Plan to the TAG and SEWPaC for review and comment with final revisions submitted to SEWPaC for approval by the Minister. Macmahon is responsible for submitting revisions to the NT EPA for approval. Macmahon is also responsible for coordinating all comments received and has created a comment register for the purposes of tracking, managing and closing comments.

The approved DDSPMP is publicly available at: **www.eastarmwharf-eis.nt.gov.au.**

Dredging and Dredge Spoil Placement Methodology - Overview

2.1 Introduction

These sections describe the dredging and spoil placement methodology that will be used by Macmahon in constructing the MSB and the methodology described is the basis for this DDSPMP. While it is considered to be highly developed, the methodology is by no means definitive; it is provided as a basis for development of this Plan. Depending on onsite conditions, some modifications may be required during the dredging execution, with all revisions and reactive management plans being submitted to the NTG for review by the TAG and then onto SEWPaC for approval by the Minister prior to implementation. Macmahon is responsible for submitting all revisions and reactive management plans to NT EPA for review and approval.

It is acknowledged that the DDSPMP is predicated upon there being no blasting undertaken. Should a need for blasting be identified, then it is recognised that it cannot be undertaken without Ministerial approval of a revised DDSPMP. In addition there is no requirement for bottom dumping, rehandling or double handling of dredge material by the dredge and these practices will not be undertaken as part of this project. Pre-cutting and/or pre-treating of the dredge spoil will be undertaken if high strength rock is found that cannot be efficiently removed with the CSD. Pre-cutting is the process of breaking up harder sections of material with a larger CSD, while pre-treatment breaks up the rock with equipment like an excavator on a barge, normally fitted with a rock breaker or ripper attachment, or the use of a backhoe dredge. In both instances once the rock is broken up it is then cut and pumped ashore with the CSD as per the requirements of this plan. Any pre-cutting or pre-treatment undertaken will be subject to the same environmental conditions as the dredging works being undertaken as per this plan in the MSB footprint.

Cyclonic and otherwise bad weather would necessitate the temporary cessation of the dredging activities. The Dredge Master will make ongoing assessments regarding weather conditions to determine if a cessation in dredging is required. If the Port goes into cyclone alert or shut down then the dredging contractor will comply with all directions from the Port Master.

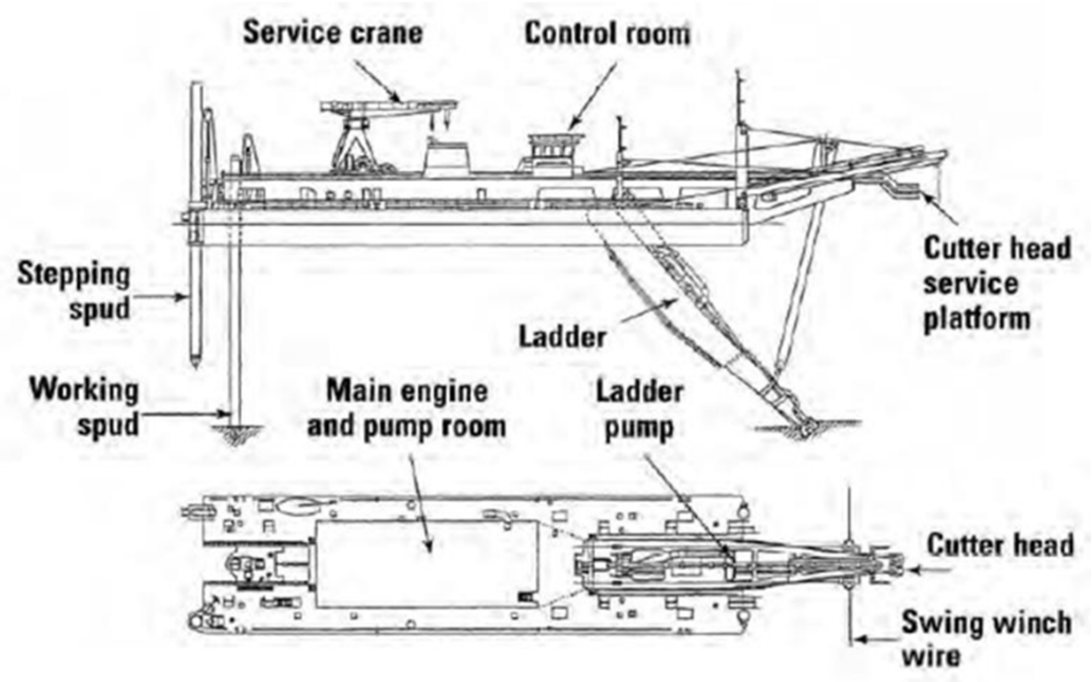
The Darwin MSB dredge works has an estimated total volume of 685,000 m³. The sediment is proposed to be disposed of entirely onshore, with the dredge footprint and reclamation ponds displayed in **Figures 1-1 and 1-2**.

2.2 Equipment

The location of the works within a tidal zone, limited available draught for vessels, the existence of the harder phyllite material to be dredged, and the direct hydraulic placement of the dredged material are determining factors for the selection of the preferred dredge methodology. The current seabed surface levels over the proposed dredging area range from 0.0 m CD to -7.7 m CD. The typical geotechnical profile of the material to be dredged consists of overlaying soft marine sediment up to 2 m thick, and an underlying harder phyllite layer down to maximum dredge depth.

The selected method is cutter suction dredging (**Figure 2-1**) and the selected dredge for this project is the Eastern Aurora (specifications in **Figure 2-2**). The Eastern Aurora completed Phase 1 dredging and is to continue during Phase 2 dredging. However it may be replaced by a smaller CSD sometime during the Phase 2 works, to complete the detailed dredging against the new MSB wharf structure, or replaced with an alternate CSD with a higher cutter head power if hard material is found, but with the dredging process adjusted to deliver the same average tailwater output to maintain the pond management process. A replacement CSD with a higher tailwater output would require a revised DDSPMP to be endorsed by TAG and submitted to the NT EPA and the Minister for approval.

Figure 2-1 Typical cutter suction dredge



2.3 Summary of work method

Dredging is to be completed as outlined in the schedule in **Table 2-1**.

Table 2-1 Proposed dredging schedule for MSB

Phase	Start Date	Estimated Duration	Dredge Volume (m³)
1	3 October 2012	30 November 2012	170 000
2a	ASAP to 30 April 2013*	30 April 2013	515 000
2b	1 May 2013	25 weeks#	
		TOTAL	685 000

* Approval pending from SEWPaC to continue dredging into the Wet Season.

This duration will reduce if Wet Season dredging is approved.

Macmahon has sought a revision to the EPBC Act approval conditions to allow Wet Season dredging, with a decision pending. The timing for recommencement of dredging, including Wet Season dredging will be subject to successful commercial negotiation with the nominated dredging sub-contractor.

2 Dredging and Dredge Spoil Placement Methodology - Overview

Figure 2-2 Eastern Aurora cutter suction dredge

HALL
CONTRACTING PTY LTD
AUSTRALIA | ASIA | PACIFIC
www.hallcontracting.com.au

EASTERN AURORA

IHC CUTTER SUCTION DREDGE (1994—Rebuild 2011 Class GL)

SPECIFICATIONS

Power	7,426kW Total Installed
Ladder Pump Deck Pumps x 2	IHC 1,752kW IHC 3,816kW
Cutter	850kW
Pipe	700mm dia. Suction 700mm dia. Delivery
Length OA Hull Length Beam	116m 80.6m 14.9 metres
Dredging Parameters	27m @ 38 degrees
Maximum Pumping Distance	7,000m (sand and silty materials)
Anchors	2—Anchor Booms plus spud carriage

2 Dredging and Dredge Spoil Placement Methodology - Overview

The duration of dredging may vary, dependent upon the presence of harder quartz veins which may slow the progress made by the Eastern Aurora in removing sediment. Over the duration of the dredging it is expected that the dredge will work on average 20 hours a day over a six day week and this is the basis for the pump flow calculations, however this assumption shall not impose any restriction on the dredge working hours, and it shall be allowed to work 24 hours a day, 7 days a week with movements and downtime planned as required to avoid any potential sedimentation of South Shell Island during low outgoing tides (refer to Water Quality Management Framework, **Section 6.3**).

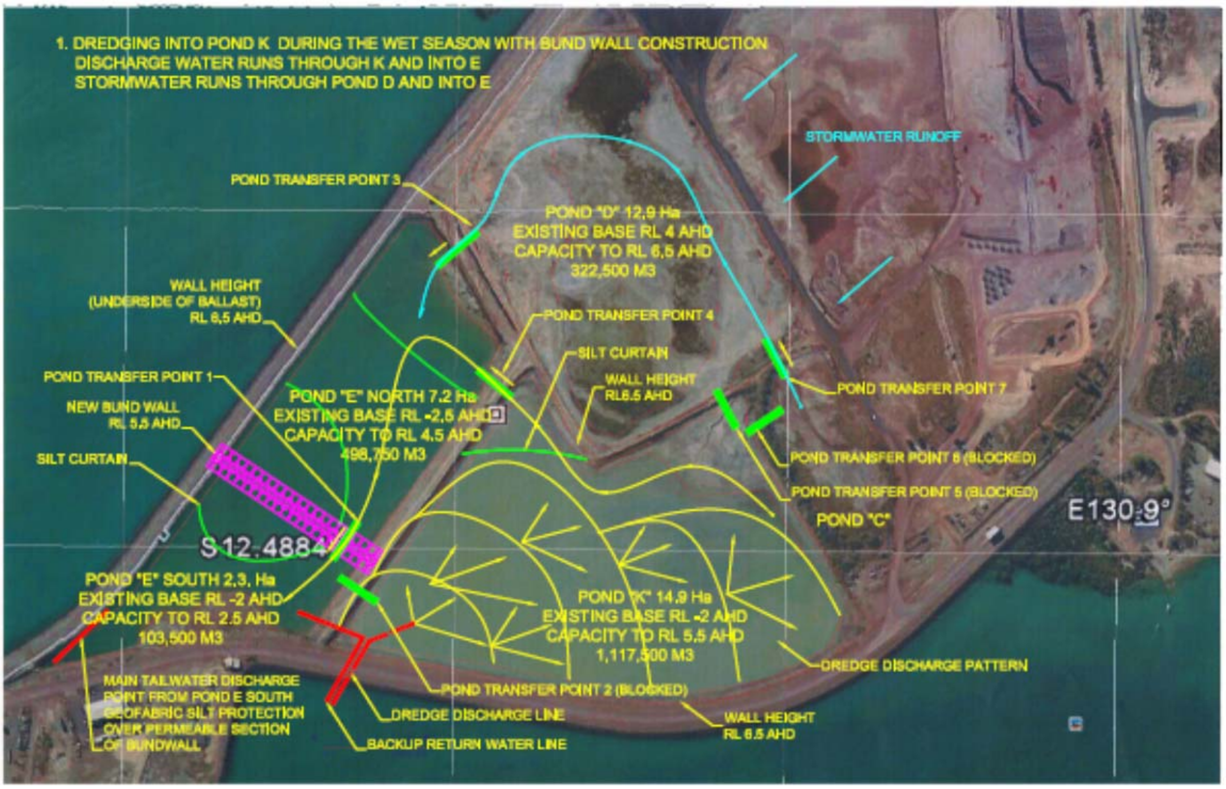
When using the cutter suction dredging technique, dredged material must be sufficiently fluidised to be pumped to its placement site. Material is usually pumped at approximately 12-15% solids (by volume); with production figures to date indicating an average of 5% is being achieved due to harder materials than expected. Overall the volume of water pumped remains the same and only the solids content changes. A sediment loss rate of 1% at the cutter head is typical for cutter suction dredge operations.

Dredge spoil will be pumped from the dredge head through a pipeline to the dredge spoil placement area on East Arm (see **Section 2.4**).

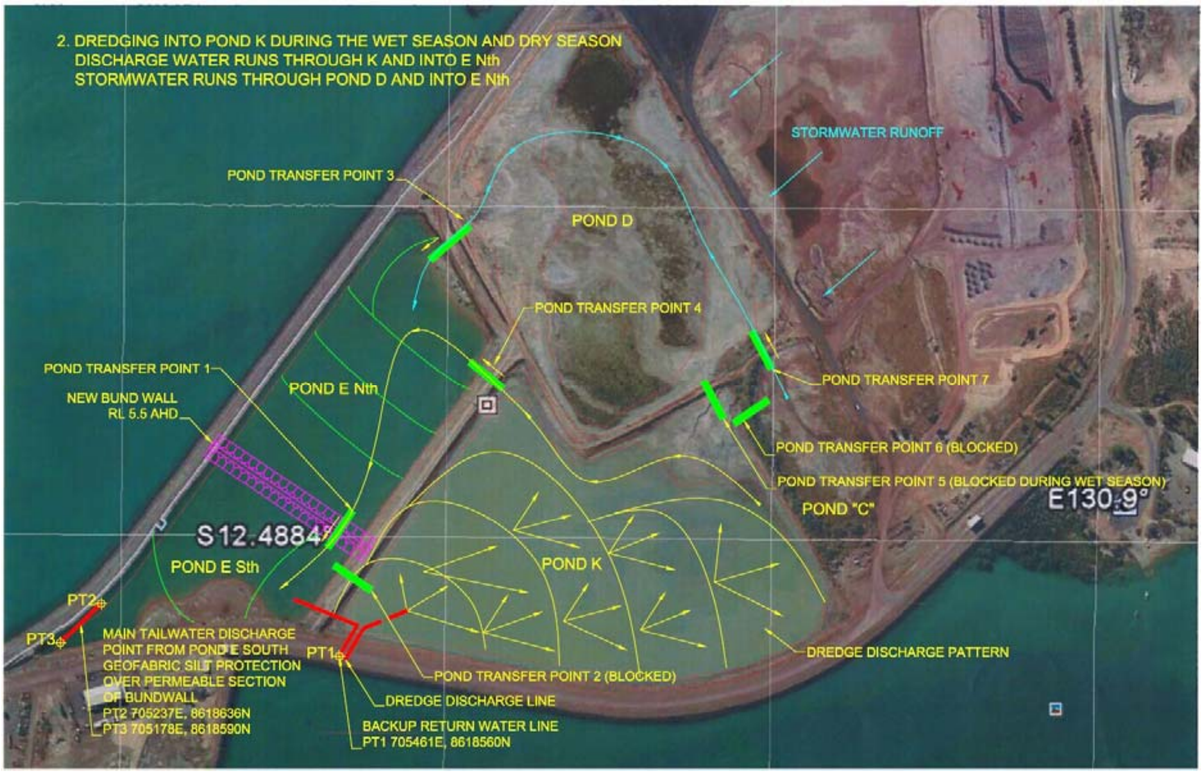
2.4 Dredge spoil placement area

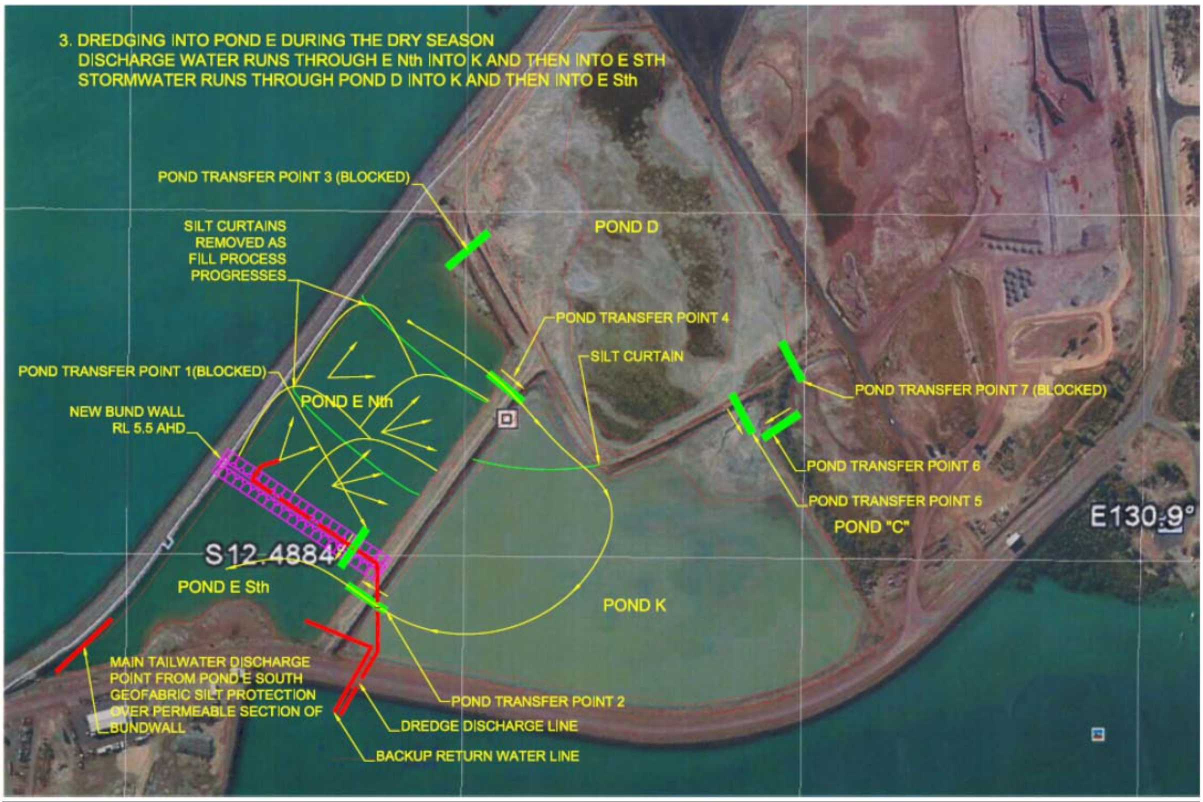
Onshore disposal to existing decant ponds adjacent to the proposed MSB (**Figure 2-3**) is a suitable option as it has been used historically for the disposal of material from capital dredging in East Arm and at the Darwin Waterfront and for disposal of maintenance dredge spoil. Offshore disposal is not part of the current development proposal.

Figure 2-3 Configuration of dredge spoil placement ponds



2 Dredging and Dredge Spoil Placement Methodology - Overview





2 Dredging and Dredge Spoil Placement Methodology - Overview

Dredge spoil placement is discussed in detail in **Section 2.5.4** - the dredged material will be pumped ashore from the dredge area into the existing pond system, where it will be deposited in Pond K or a portion of Pond E divided off by the construction of a new bund wall if all the dredge spoil cannot successfully be placed into Pond K.

Transfer points 1, 2 and 4 will have a reclamation box with an adjustable height weir. The weir boards will be designed to be water tight to ensure sediment does not pass through, thus increasing the likelihood of turbidity trigger event. The design of the reclamation weir boxes and associated weir boards will be submitted to NTG for review and approval.

Dredging during October and November 2012 involved spoil being deposited in Pond K and the tailwater flowing around Pond K and into Pond E, through the silt curtains (**Figure 2-4**), and out of the permeable section of the railway bund wall. Some tailwater was diverted through Pond D which is allowable outside the nominated Wet Season. Tailwater was transferred through Pond D from Pond K and into Pond E, using pipes embedded into the bund wall structures at transfer points 5 and 3, respectively (**Figure 2-5**).

Figure 2-4 Silt curtains in Pond E (installed July 2012)

Figure 2-5 Transfer structures in/out of Pond D

Wet Season dredging will require a new transfer point, noted as Transfer Point 7 in **Figure 2-3**, that will divert stormwater from Pond C, which has been mostly reclaimed, into Pond D so it can pass around Pond K and into Pond E (North). The design of this transfer point will be as per the previously installed pipes in and out of Pond D.

Any dredge activities undertaken during the Wet Season will have the dredge spoil deposited only in Pond K, with Pond E (North) being used from 1 May 2013. In the early stages of reclamation of Pond E (North) the silt curtains will be retained but at some stage they will be obsolete and removed. Silt curtains may be installed in Pond K if required to reduce turbidity levels.

During the remainder of dredging works, regardless of the initial dredge spoil deposition location (i.e. Pond K or Pond E (North), the tailwater will be returned to the environment through the permeable section of the railway bund wall located in the south-west corner of Pond E (South) (**Figure 2-3**).

During the Dry Season it will be allowable to pump high turbidity tailwater from Pond E (North) and Pond K into Pond D to an RL of 6.5 m AHD and hold for sufficient time to allow settlement of fine particles before finally releasing back into Pond E (North). During this operation the outlets of Pond D will be closed off using a steel plate at transfer point 7 and suitable adjustable weir box structures at transfer points 3 and 5. Tailwater will be released in a controlled manner when required at transfer points 3 and 5 using the adjustable weir box structures. The design of the adjustable weir box structures will be submitted to NTG for review and approval.

2.5 Dredge spoil and tailwater management

The dredged material will be placed in the settlement ponds with tailwater stored for sufficient time to allow for settling of fine suspended sediments (residence time) prior to discharge of the tailwater. Water quality management and monitoring is discussed in detail in **Section 6** and **Section 7** of this plan.

2.5.1 Settling ponds system and available volumes

Settlement ponds and internal ponds within the reclamation area are pre-existing ponds constructed during the previous development of East Arm Port.

Pre dredge surveys of the current ponds have shown:

- Pond K: minimum height of the outer bund walls is 5.0 m AHD, with an average pond floor level of -2.0 m AHD; an area of 14.9 ha. A temporary bund wall with a height of 6.5 m AHD has been constructed along the causeway and the bund wall between Pond K & E has also been raised to 6.5m AHD providing a capacity to store coarse sediments of 1,117,500 m^3 based on 5.5 m AHD, and a maximum water capacity of 1,192,000 m^3 with a water level of 6.0 m AHD. During normal dredge operation the water in Pond K will be in the range of 4.5 to 5.0 m AHD. However, during the later stages of dredging when the capacity of Pond K is significantly reduced then the water level will be maintained at 6.0m AHD.
- Pond D (currently isolated from the dredging treatment operations, but may be put back into service after 1 May 2013): minimum height of the outer bund walls is 6.5 m above AHD, with an average pond floor level of 4.0 m AHD; an area of 12.9 ha giving a capacity to 6.0 m AHD of

258,000 m³. It will be allowable to deposit a thick layer of up to 250 mm of solids dropped out of tailwater in Pond D, thus providing 32,250 m^3 of capacity for solids.

- Pond E: minimum height of the outer bund walls is 6.5 m AHD, with an average pond floor level of -2.0 m AHD (-2.5 m AHD in Pond E (North)); an area of 9.5 ha and a fill level of 4.5 m AHD has been set to allow a 2.0 m freeboard to the underside of the rail ballast, as confirmed by stability analysis of the railway bund. Pond E will be divided into two separate ponds with a bund wall (refer **Figure 2-3** and **Section 2.5.3**), using the Southern 25% for stormwater that will be maintained at 2 m AHD, and the Northern 75% will provide capacity to 4.5 m AHD of 498,750 m³. The maximum storage capacity in Pond E (North) with the water level at 5.0 m AHD is 534,375 m^3.

Based on the above and with a modified Pond E, the pond system has a storage capacity of 1,648,500 m^3 for solids.

Prior to Pond E bund wall construction a report by a suitably qualified geotechnical engineer will be provided to the TAG for review, and a subsequent geotechnical investigation will be provided to the TAG prior to filling of Pond E (North) that demonstrates that bund walls (including rail bund) design, stability and seepage has been assessed and proven to be suitable for the application. Ongoing monitoring of stability and seepage of the Railway Bund (E-North) and the new Cross Bund by Macmahon will be performed, as per Pond K bunds (below), especially during periods of low tidal levels.

Geotechnical investigation of the Pond K bund wall structures (including raising the bund walls to 6.5m AHD) has been undertaken to determine that the final solids and interim water retention levels are within safe working limits, and as per the advice received in that report a Macmahon supervisor will undertake daily inspections for cracks and any other indication of movement or change in the walls. In addition, datum points will be established at commencement of pond filling and weekly DGPS survey will be undertaken to record any wall movements. If any weakness or failure is apparent, dredging will cease immediately pending a geotechnical investigation and filling of the ponds will only recommence after a geotechnical investigation has certified that the ponds are structurally sound to proceed.

2.5.2 Required pond volume

The dredge volume for the project is 685,000 m³. Evaluation prior to dredging determined a possible range of bulking factors that would result in final dredge volumes between 1,027,000 m³ and 1,800,000 m³, with a predicted bulking factor of around 1.85 resulting in 1,267,250 m³ of dredge spoil. At the end of November 2012, with 25% of the dredging complete, Macmahon undertook a hydrographic survey of the dredge area to determine the volume dredged, and in Pond K to determine the volume deposited, and compared the results which revealed a higher than expected bulking factor of 2.42 (refer **Table 2-2**).

Table 2-2 Calculated bulking factor

Material	Volume	Bulking Factor	Final Volume (m^3)
Siltstone	342,500 (50%)	170%	582,250
Weathered siltstone	123,300 (18%)	250%	308,250
Marine sediments	219,200 (32%)	350%	767,200
Total	685,000 (100%)	242%	1,657,700

2 Dredging and Dredge Spoil Placement Methodology - Overview

Pond D is isolated from the treatment system over the Wet Season but may be bought back into service after 1 May 2013 if required. Dredge material deposited into Pond D will be limited to 250 mm and compliance with EPBC Condition 17(f) will be maintained.

It has been agreed with NTG that 75% of Pond E may be used for direct dredge spoil placement and storage (during the dry season only) and this approach will be adopted, and is discussed in detail in **Section 2.5.3**. The capacities of the ponds have been surveyed (**Table 2-3**) and the time to fill the ponds from empty (taking into account 5% solids) has been predicted (**Table 2-4)**. The required capacity will come from 100% of Pond K and 75% of Pond E, as per **Table 2-3**.

Table 2-3 Pond capacities

Pond	Total Volume (m^3)	Allowable Percentage	Available Volume (m^3)
Pond K	1,192,000	100%	1,192,000
Pond E	534,375	75%	534,375
Pond D (Dry Season only)	258,000	100%	258,000
Total	1,984,375		1,984,375

Table 2-4 Time to fill ponds before discharge occurs

Pond	Available Capacity (L)	Flow Rate (L/Day)	Time to Fill Ponds (Days)	Time to Fill Ponds Consecutively (Days)
Pond K	1,192,000,000	144,000,000	8.28	8.28
Pond E	534,375,000	117,257,143	4.56	12.84

2.5.3 Pond Capacity Management Measures

As previously discussed, the project will dredge 685,000 m^3 of material and, by applying the calculated bulking factor of 2.42, Macmahon needs pond capacity to store 1,657,700 m^3 of dredge spoil and allow for reasonable residence time as per items 1 to 5 below.

NTG has allowed the division of Pond E with a bund wall, leaving 25% on the Southern end for ongoing stormwater management and providing the remaining 75% for dredge spoil placement.

Once the bund wall is built through Pond E the pond network will have the required capacity for dredge spoil placement available (refer **Table 2-2** and **Section 2.5.1**), and the dredge spoil will be managed in a way to provide sufficient volume for 'residence time' of tailwater to allow suspended sediments to drop out of the tailwater prior to discharge into the environment. This volume will be achieved by implementing to following three management measures,

1. Hydrographic surveys will be undertaken on a monthly basis to confirm the volume of material dredged from the MSB footprint and this will be compared to a survey in the Ponds to confirm the volume of the remaining capacity in the Ponds. Copies of the surveys will be provided to TAG as part of the monthly reports.

2 Dredging and Dredge Spoil Placement Methodology - Overview

2. Remove rocky material from Pond K and truck to another location allowing dredging to continue into Pond K. Although a specific location for this rocky material has not been identified, NTG has advised the material can be accommodated elsewhere at the port or at a nearby location or alternatively a suitable location could be selected by Macmahon. As there is a strong demand for such material, there will not be a difficulty utilising it for port-related needs. The full range of testing described in **Section 7** of this report will be undertaken prior to relocation to ensure contaminants are not removed from the pond network,
3. Remove about 25,000 m³ (pre-dredged volume) of Phase 2 material (along the wharf face) using an excavator and trucking to another location rather than depositing into the ponds system. This material has been imported to site by Macmahon as a temporary piling platform and would be reused as clean fill on another project,
4. Stock piling material in Pond K, with the final height to be confirmed by a geotechnical assessment to ensure stockpile and bund wall integrity is maintained,
5. And, pumping high turbidity tailwater into Pond D for settling. It is expected that up to a 250 mm layer of solids will be deposited into Pond D in this manner, thus removing 32,250 m^3 of solids.

From 1 May 2013 the use of Pond D will be allowed for tailwater processing, thus the remaining volume in Pond E (North) and the use of Pond D will provide plenty of residence time during the last portion of the dredge works, which will be deposited into Pond K. The total capacity in Pond D to assist with residence time is 258,000 m^3.

2.5.4 Pond fill sequence

Dredge spoil will be pumped by the CSD through a floating pipeline, under the causeway road and to the South Western corner of Pond K where it will be diverted into two directions with a Y valve. One branch will go to Pond E (North) and the other will lead into Pond K. Spoil will be pushed out from the pipe discharge point via a D6 size dozer with low ground pressure tracks (‘swamp dozer’) or excavator. The spread direction for the spoil is shown in **Figure 2-3**.

With Pond K half full at the end of November 2012 and dredge spoil effectively requiring the full capacity of both Pond K and Pond E (North), the ongoing placement methodology for dredge spoil is critical to ensure that turbidity levels can be managed in the final stages of dredging. Upon recommencement of dredging, placement will continue into Pond K until the internal bund wall across Pond E is constructed, but not before 1 May 2013. Then the focus will be on filling Pond E (North) prior to coming back to Pond K. After 1 May 2013 the tailwater from Pond K can then be diverted through Pond D and back through Pond E (North) over the top of the dredge spoil for the final stages of dredging. The above method will provide flexibility to dispose into either pond at any time as it is anticipated that as the ponds fill, and turbidity levels increase, each pond may need to be ‘rested’ to allow suspended sediments to drop out, thus the switching from Pond K to Pond E (North) will get more frequent as dredging progresses.

During dredging it may be required to pump down the water levels in Pond E (North) or Pond K lower than the normal operating water heights to enable management of dredge spoil.

As at the end of July 2013, 70% of the dredging has been completed (ie 480,000m3) with 205,00m3 remaining to be dredged which will be rocky material with a low bulking factor. The remaining capacity in Pond K to 5.5m AHD is 250,000m3. It is considered that all of the dredge spoil will be able to be successfully deposited into Pond K by implementing the management measures in Section 2.5.3, especially the stockpiling of materials in Pond K.. The capacity in Pond D & E (North) will provide sufficient residence time for the treatment of tailwater exiting Pond K before being discharged from Pond E (South).

To assist with controlling the water quality of the tailwater being discharged from Pond K the dredge spoil will be deposited into Pond K in a manner to ensure the full capacity of Pond K is utilised for the storage of dredge spoil, especially the northeast corner of Pond K. This will be achieved by:

a) directing the dredge spoil discharge pipe along the southern side of Pond K (ie along the causeway/Port Access Road);

b) constructing mounds out of dredge spoil to assist with diverting the dredge spoil discharge to be directed towards the northeast corner ; and

c) pushing dredge spoils with earthmoving equipment to the northeast corner.

2.5.5 Pond levels (water only)

A summary of pond filling times is presented in **Table 2-4.** Flow rates are presented in **Table 2-5** and are also included in the cross-section of the pond system presented in **Figure 2-6**. Note that the rates in **Table 2-5** are the maximum possible in ideal conditions and the actual flow rates will vary. The information presented in **Table 2-5** and **Figure 2-6** is based on the deposition of dredge material into Pond K with tailwater flowing into Pond E (North) and then into Pond E (South). The values are unchanged during the Dry Season, when the dredge material will be deposited into Pond E (North) and the tailwater will flow through Pond K and into Pond E (South).

A back-up pump will be in place in the south-east corner of Pond E (South) to pump tailwater into the dredging footprint if the flow through the permeable section of the railway bund wall is less than the flow into Pond E (South). The pump will have the capacity to discharge at 600 litres/second.

Pond K will operate between level 4.5 and 5.0 m AHD during normal dredge operation, but may go lower if the dredge is on standby and inflows stop. However, during the later stages of dredging when the capacity of Pond K is significantly reduced then the water level will be maintained at 6.0m AHD.

Table 2-5 Pond flow rates (excluding deposited solids 5%)

Rate	Pond K		Pond E		
	Dredge Discharge Line	Residual Liquids	Pond Connection Pipe	Evaporation	Pond E (South) Rail Bund Outfall Out
L/sec	2,000	1,900	1,357	0.02	1,357
L/min	120,000	114,000	81,429	1	81,427
L/Hr	7,200,000	6,840,000	4,885,714	68	4,885,646
L/Day	144,000,000	136,800,000	117,257,143	1,636	117,255,507
L/Week	864,000,000	820,800,000	820,800,000	11,450	820,788,550

Pond D is isolated from tailwater treatment during the Wet Season period and the water height will be regulated by the transfer pipes into Pond E, ensuring water levels will be as per previous Wet Seasons. If Pond D is bought back into service (allowable outside of the Wet Season) the water level

2 Dredging and Dredge Spoil Placement Methodology - Overview

in Pond D will be maintained at 1.5 m (5.5 m AHD). Some wave action may be induced in Pond D due to wind and it is unknown if this will reduce the effectiveness of sediment removal. Pond D can accommodate a water depth of up to 2 m (6.0 m AHD) and it will be allowable to raise the level to this level to reduce the impact of wind and currents.

Pond E (North) will operate with a water level of 3.5 and 5.0 AHD and be controlled by a reclamation box with an adjustable weir.

A water level between 1.5 and 2.5 m AHD will be maintained in Pond E (South). During the dredging works to date, tailwater has passed through the permeable section of the railway bund (at the South West corner of Pond E, **Figure 2-3**) at a rate which has matched the dredge output; hence this water level has been maintained. As a backup there is a pump discharge outlet located in the South East corner of Pond E (**Figure 2-3**) where a pump system, if required, will return the tailwater to the dredging footprint via an under road pipe system.

Before dredging commenced, the permeable portion of the railway bund wall was lined with a geotextile filter to maximise the quality of the released tailwater. The geotextile filter is held in place with 500 mm diameter rocks to ensure sediments are not drawn out under the filter on an outgoing tide. If signs of blocking of the geofabric are evident then it will be removed and replaced. In the event of an imminent cyclone, and after dredging has stopped because of the same, the geofabric liner will be removed to ensure Pond E (South) outflows are maintained during a significant storm event.

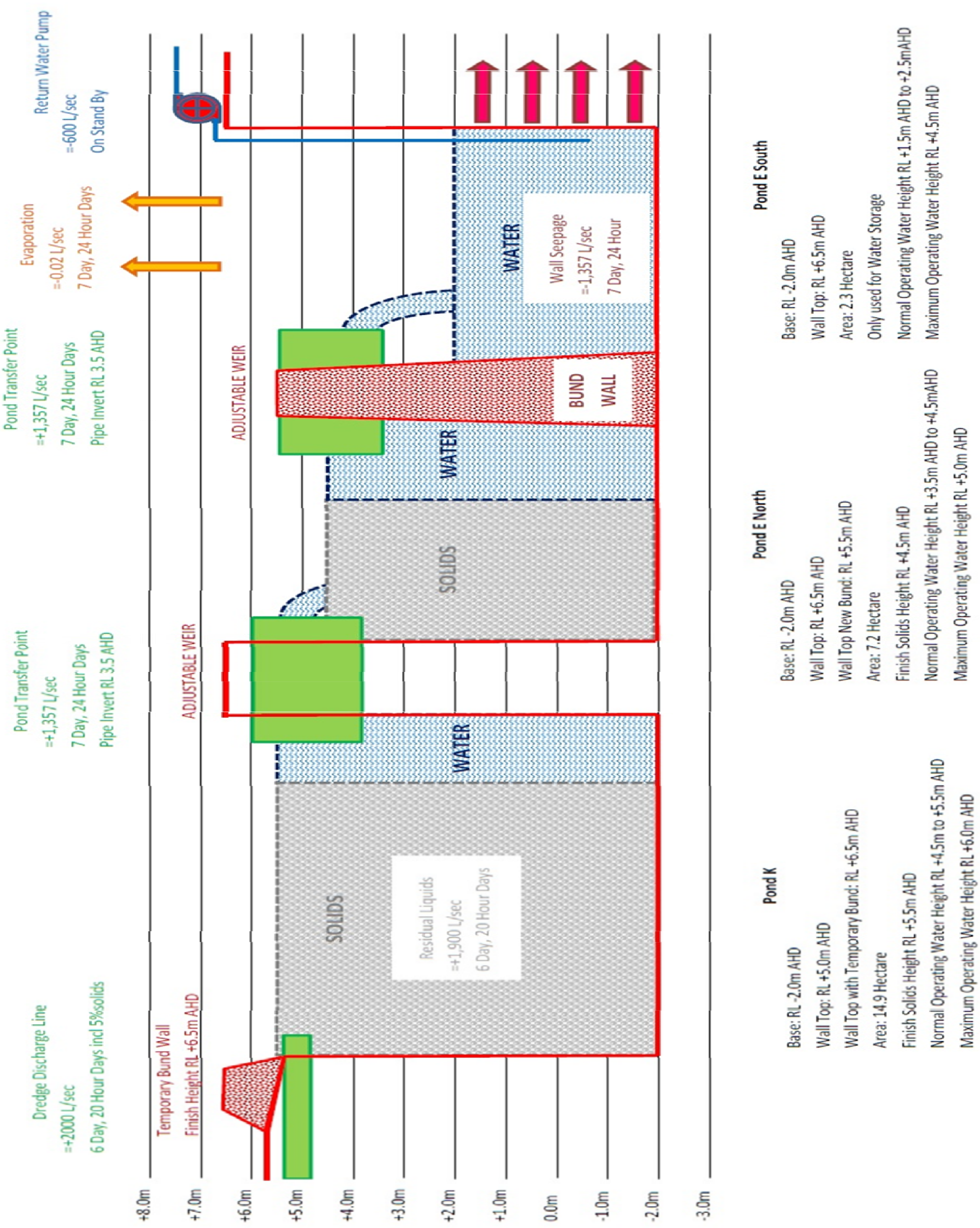
Each pond will operate with a minimum 0.5 m freeboard. To ensure transfer flows equivalent to the dredge output are maintained between ponds, additional pipes may be installed at any transfer point and/or pumps may be used to supplement gravity flows.

The water level of each pond will not vary substantially day to day during dredging and the daily water levels of each pond will be recorded and provided in the weekly reports. Where transfer pipes are fitted, the flow between ponds can be stopped by blocking the pipework between these ponds with steel plates and/or inserting rubber expanding plugs, with both options available on site.

Where a reclamation box is fitted the flow can be stopped by adding drop boards and raising the height of the weir. In both instances flow can be stopped within an hour as a corrective action if required (refer **Table 6-1**).

2 Dredging and Dredge Spoil Placement Methodology - Overview

Figure 2-6 Cross-section of ponds



2.5.6 Stormwater and landform

Stormwater from the pond network and adjacent DPC land ultimately flows into Pond E for return to the harbour via the permeable section of the railway bund wall. Macmahon will be building a bund wall through Pond E and retaining the southern 25% of the pond for the purpose of ongoing stormwater

2 Dredging and Dredge Spoil Placement Methodology - Overview

management, with the permeable section included in the new Pond E (South) (refer **Figure 2-3**). During dredging operations, particularly if dredging is undertaken over the Wet Season, consideration will be given to possible storm events and Macmahon will ensure that a flow path is always available for stormwater to find its way through the ponds, or allow a sufficient catchment to ensure the stormwater can be retained for future release. To ensure these outcomes are achieved, advice will be provided by the project design consultants SKM.

The runoff from DPC land has historically run into both Pond D and Pond K, and it is proposed that the site be modified so that the portion of stormwater that normally runs into Pond K can be diverted into Pond D, thus separating stormwater from the dredge deposition pond which is important if Pond K needs to be blocked off for any reason, or if the stormwater is adding to water quality issues in Pond K. This modification requires a new transfer pipe to be installed between Pond C and Pond D, and the design of this pipe will be as per the existing pipes in and out of Pond D.

Stormwater from the road bund and a catchment area near the gatehouse will continue to run into Pond K. This area is estimated to be 30,000 m^2 and is not a great enough area to overflow Pond K in a 100 year storm event.

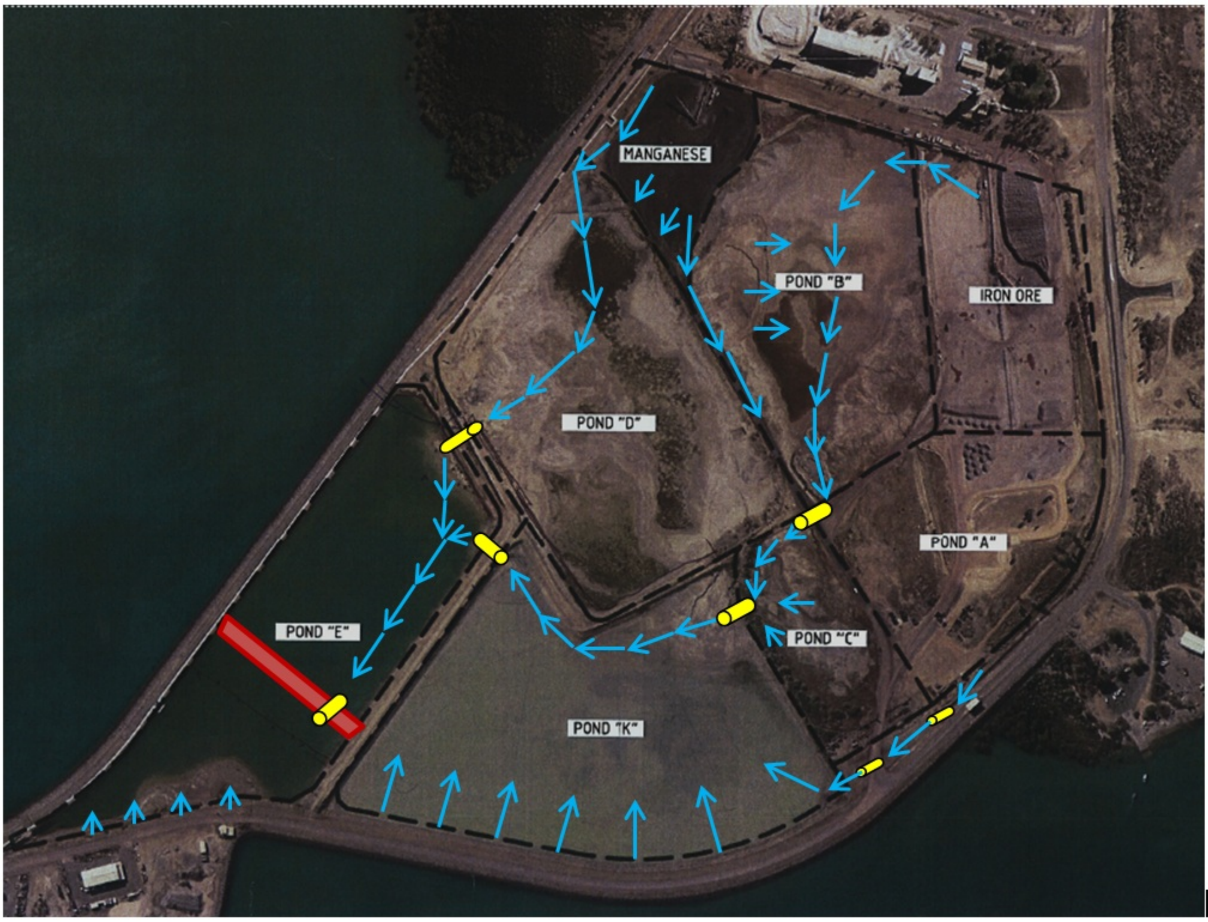
Once the bund wall in Pond E is built, Macmahon will have the option of placing dredge spoil directly into Pond K or Pond E (North) although dredge spoil deposition will be limited to Pond K during the Wet Season to allow stormwater to flow through Pond D and E for settlement and discharge to the environment via the permeable section of the railway bund.

Pond E (North) will be filled with solids to 4.5 m AHD which will allow 0.5 m of capacity for stormwater and tailwater management.

In addition to providing water treatment during the dredging operations, the pond network has the ongoing function of stormwater management, which will be maintained during and after the completion of this project, therefore some of the pipe connections between ponds will be retained for ongoing stormwater management while others will be removed (**Figure 2-7**). When the dredging is complete a surface survey will be completed and a surface profile developed to minimise the risk of ponding against the access road causeway or in areas not forming part of the stormwater system, and the final landform will be effective in directing surface water through Pond E (North) before entering into Pond E (South), then returning to the receiving environment through the permeable portion of the railway bund wall, as per current practice.

2 Dredging and Dredge Spoil Placement Methodology - Overview

Figure 2-7 Stormwater Flowpaths following dredging.



Environmental Project Management and Resourcing

This section describes how environmental management is translated into policies, resources, training requirements and management processes for this project. Reporting and continuous improvement are briefly discussed to provide an understanding of the arrangements in place to fulfil the requirements and commitments of this DDSPMP.

3.1 Macmahon Environmental Management System and Procedures

The Macmahon Environmental Management System (EMS) forms one key component of Macmahon's overall Business Management System and has been third-party certified by NCS International (along with the Quality and Safety Management Systems) as meeting the requirements of:

- ISO 9001 - Quality systems
- ISO 14001 - Environmental management systems
- ISO 18001 - Occupational health and safety management systems.

The ultimate objective of the EMS is to provide a consistent approach to the environmental management of operations, whilst ensuring the required corporate, contractual and legislative requirements are met and environmental impacts are prevented or minimise where possible.

An overview of the EMS to be implemented for the works is illustrated in the flowchart in **Figure 3-1**, and the Macmahon Environment Policy is displayed in **Figure 3-2**.

3.2 Key roles and responsibilities

Resources for this project have been identified by the Project Manager and are detailed in the Project Organisation Chart (DMSB-OC1-C). A current version of this chart is included below in **Figure 3-3** and the latest controlled version of this document is held within the Macmahon Document Library and is available on request.

The responsibilities and authorities of Macmahon personnel are defined in position descriptions, and specific responsibilities of staff in relation to environmental matters are detailed below.

The Macmahon Project Manager is responsible for all responsibilities regarding this plan and will ensure the dredging works are undertaken as per the plan. The dredging contractor directly reports to and takes direction from the Macmahon Project Manager.

3.2.1 Site management responsibilities

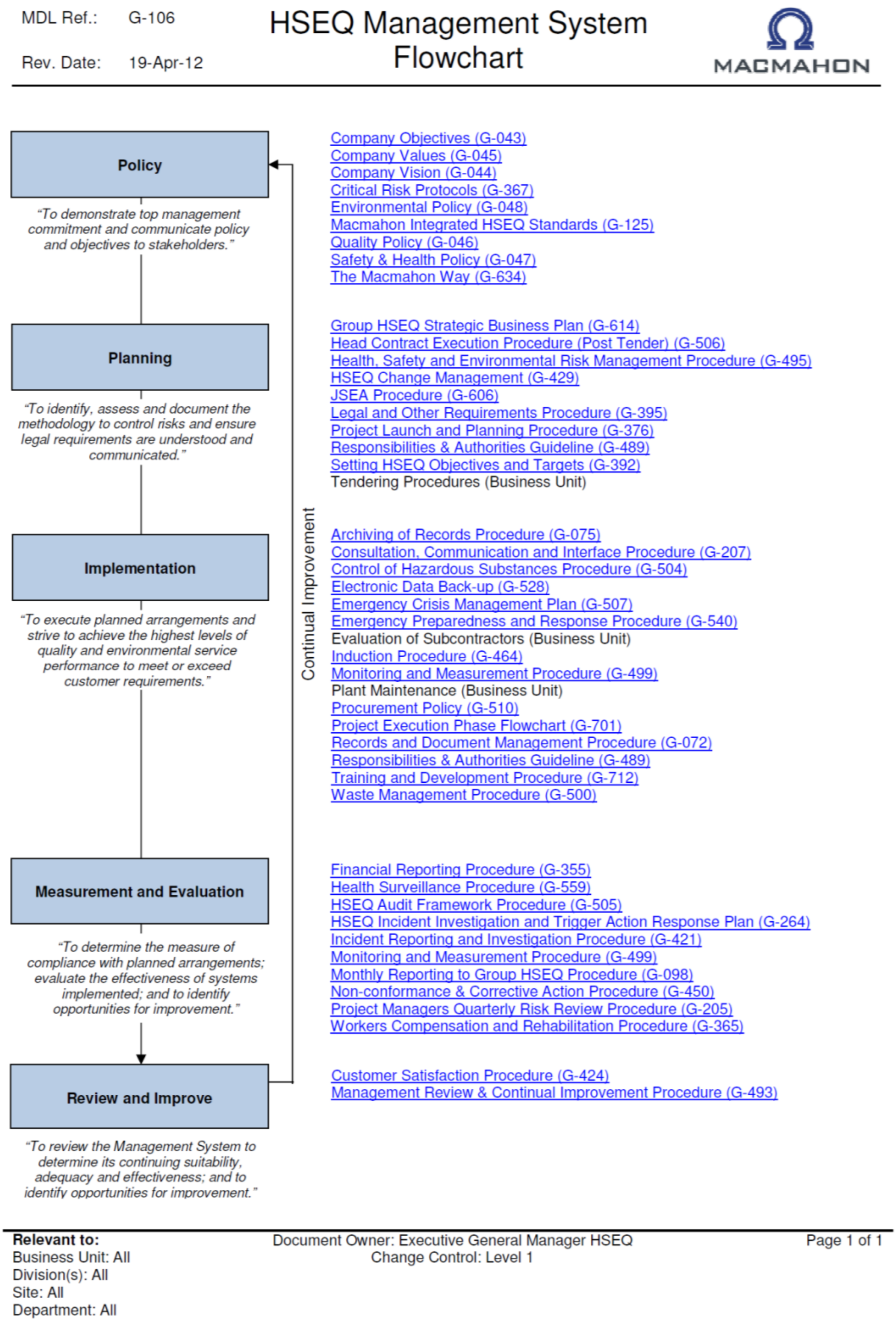
Throughout the dredging works the overall management will be under the supervision of the Macmahon Project Manager and, while day to day control of the dredging activities is being undertaken by the appointed dredging contractor, Hall Contracting, responsibility for all activities on site, including compliance to the DDSPMP rests with the Project Manager. It is the Project Manager that will delegate persons to undertake actions required under the DDSPMP.

Management of the dredge disposal ponds and all water quality management measures will be undertaken by Macmahon.

The Project Manager and the Health, Safety, Environment and Quality (HSEQ) Advisor for the project will report directly to the Project Manager and be the main points of contact in relation to the implementation of this Plan.

3 Environmental Project Management and Resourcing

Figure 3-1 Macmahon Environmental Management System flowchart



3 Environmental Project Management and Resourcing

Figure 3-2 Macmahon environmental policy

ENVIRONMENTAL POLICY

To work effectively in a diverse range of environments and social settings, Macmahon recognises the importance of integral environmental management into how we do business. Our environmental policy objective is to minimise the adverse impact on the environment as a result of our business activities.

To achieve this objective we will:

- Establish and maintain an environmental management system in accordance with AS/NZS ISO 14001.
- Comply with contract conditions, relevant legislation and other criteria to which the company subscribes.
- Regularly review business operations, identify and implement opportunities for improvement.
- Educate our workforce on key environmental issues, management controls and associated responsibilities.
- Establish defined environmental objectives and targets to measure our performance and identify opportunities for improvement.
- Strive to prevent pollution, reduce waste and commit to recovery and recycling where feasible.

Nick Bowen
Chief Executive Officer

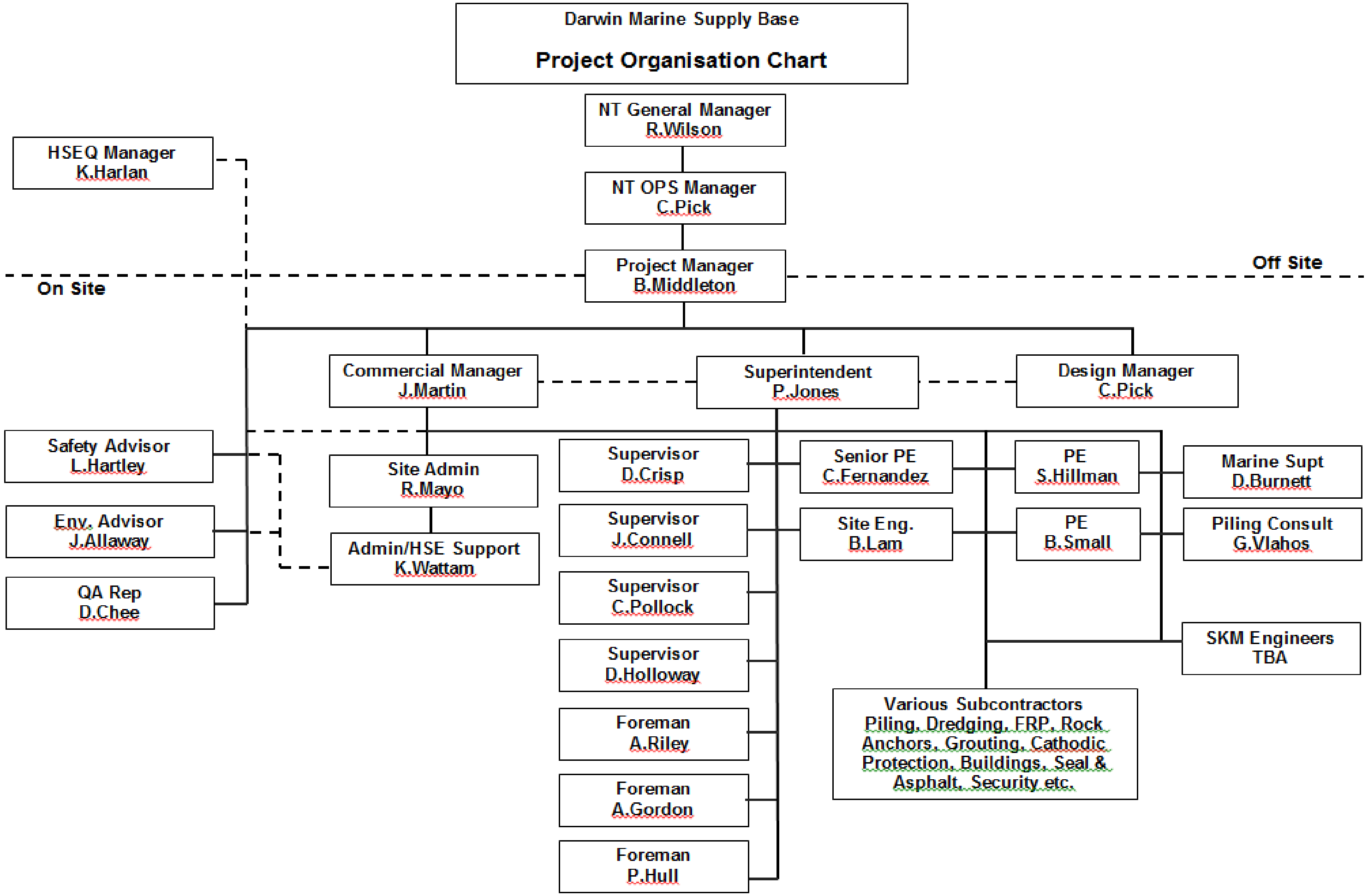
January 2012

MACMAHON

URS

3 Environmental Project Management and Resourcing

Figure 3-3 Project organisation chart



3.2.2 Project Manager

The Project Manager has overall authority in the determination of all matters affecting the implementation and operation of environmental practices on the project. The Project Manager reports to the Regional Manager NT and is responsible for:

- Identifying resources and equipment for environmental purposes
- Ensuring training is provided to improve awareness of environmental issues and responsibilities
- Incorporating environmental management aspects in project planning
- Ensuring project operations are performed in accordance with legal and other requirements
- Formal liaison with the TAG, NT EPA and SEWPaC
- Providing the results of all monitoring programs to the Proponent
- Reviewing the effectiveness of the system for continual improvement
- Reporting of implementation of this DDSPMP.

3.2.3 HSEQ Manager NT

The HSEQ Manager NT reports to the Project Manager and is responsible for:

- Reviewing of the Project Environmental Management Plan
- Auditing the Environmental Management System
- Providing support to the HSEQ Advisors for the duration of the project.

3.2.4 HSEQ Advisor

The HSEQ Advisor has a functional reporting link to the HSEQ Manager NT and reports directly to the Project Manager (and is also the Project Environmental Representative); and is responsible for:

- Preparation of the Project EMP
- Consulting with the Project Manager on environmental matters
- Liaising with employees on environmental matters
- Monitoring and reporting on environmental management system performance
- Conducting site inspections and assisting with audits
- Reviewing inspection reports and ensuring any actions required are executed
- Conduct environmental monitoring such as collection of water samples and noise monitoring and preparing reports
- Facilitate the implementation of environmental improvements and initiatives
- Ensuring the EMP and sub- plans are implemented to meet the requirements for the project
- Arranging the assignment of project staff to perform verification duties
- Ensuring environmental non-conformances and environmental incidents are identified, investigated, reported and suitable corrective actions are determined and completed
- Ensuring subcontractors fulfil their environmental obligations
- Assisting with the updating of various Project Management Plans
- Attending meetings to discuss environmental issues
- Liaising with environmental representatives from the Proponent, other government authorities and community groups.

3.2.5 Supervisors / engineers

The supervisors and engineers for the project report to the Project Manager and are responsible for:

- Implementing and checking the implementation of this plan on site
- Liaising between employees and subcontractors and the HSEQ Advisor regarding environmental matters.

3.2.6 Employees and subcontractors

Employees and subcontractors report to the Supervisor(s) and are responsible for:

- Reporting environmental near-misses, observations and incidents as observed on-site
- Follow instructions given by supervisory personnel in relation to matters that affect the environment
- If trained to do so, conduct initial emergency response activities such as place bunds around spills.

3.2.7 Technical Advisory Group (TAG)

For this Project, the NTG has established an independent TAG to provide advice on management of dredging and disposal works. The TAG is responsible for providing scientific, environmental and technical advice on all aspects of the dredging and disposal works. Where the TAG is required to be consulted on monitoring or corrective actions, a timeframe of three business days has been specified for the initial response.

3.3 Inductions and Training Requirements

This section details the induction and training requirements for the project related to environmental management. Records related to these requirements will be maintained as described in **Section 3.4**.

3.3.1 Environmental inductions

It is the policy of Macmahon to ensure that adequate training and instruction is provided to personnel to allow them to perform their duties whilst ensuring the environmental impacts associated with the Project are prevented or minimised.

All Macmahon and subcontractor personnel must attend a Macmahon site-specific induction prior to commencement of work (in accordance with Macmahon's internal procedure G-464 'Induction') which includes but will not be limited to the following environmental topics:

- Overview of key environmental issues and personnel responsibilities
- Promoting awareness of significant environmental issues and personnel responsibilities
- Reporting of environmental incidents - which will include how an event is reported and to whom the event is reported (all incidents are to be reported, including near misses).
- Emergency procedures - which will cover the procedure for an emergency and for evacuation of the site in the event of a catastrophic situation arising
- Contingency Plans - e.g. for chemical spills, in the event that an unidentified Aboriginal heritage item is uncovered during the works, etc.

Questions relating to environment and heritage matters will be included in the site induction questionnaire to verify employees' understanding of the induction content.

3.3.2 Environmental awareness

Toolbox meetings are held on a fortnightly basis and are mainly aimed at operational staff. All Macmahon and subcontractor personnel are required to attend. Toolbox meetings focus on environmental and safety items relevant for the project during that time, and are used as the main tool to further increase awareness of significant environmental and safety issues, and to communicate the relevant items contained in the Environmental and Safety Management Plans.

Typical items discussed in these toolbox meetings include environmental items such as new procedures or reinforcement of existing procedures relating to erosion control, handling of hazardous chemicals, weeds, clearing boundaries, management of waste/ recycling, biting insect problems, need to report all incidents and hazard/ near misses, etc.

3.3.3 Training

The Macmahon HSEQ Advisor at the project will be trained in Environmental Management (minimum Cert IV or equivalent). Training of site personnel (including subcontractors) involves training in environmental awareness in the induction package and ongoing toolbox meetings. It often includes field instruction on appropriate implementation of environmental controls, which is dependent on the nature of their duties.

Personnel engaged in monitoring for protected marine species and avifauna (as described in **Section 7**) will be required to have evidence of training by an organisation deemed by the TAG to be suitable for this purpose.

3.4 Environmental documents and records management

The integrated Macmahon Document Library is an essential element of our business and serves to meet customer requirements, reduce business risk, improve profitability and demonstrate responsible management to our stakeholders. The Macmahon Document Library contains standard procedures and forms, and also provides for links to Chemwatch and Australian Standards. This document library forms an essential part of the EMS, and will be used to manage the documentation associated with this project.

All requirements for document control, correspondence and filing, superseded documents, and other quality control items are described in detail in the Project Quality Management Plan. Project records, including subcontractor project records, will be maintained to provide evidence of conformity to Proponent requirements, commitments in this DDSPMP and the CEMP, and of the effective operation of the EMS.

Such records include, but are not limited to:

- Correspondence to/from the Proponent and interested parties
- Permits, licenses and approvals
- Induction training records
- Inspection and test documentation (including calibration)
- Non-conformance and corrective action / complaints
- Environmental incidents
- Audits and inspections
- Monitoring Records
- Delivery / waste dockets.

3.5 Performance management

Performance management includes activities to ensure that goals are consistently being achieved in an effective and efficient manner. A key component of the environmental management process is the development and implementation of specific measures to ensure that the environmental risks arising from the dredging and dredge spoil disposal activities are minimised. The success of these objectives is measured with key performance indicators (KPIs) defined for environmental management.

3.5.1 Environmental objectives

The environmental objectives of dredge operations management are to:

- Limit impacts of dredging and dredge spoil management operations on marine life and water quality.
- Ensure that marine protected species, including dolphins, dugongs, turtles and sawfish are not significantly adversely affected by dredging activities.
- Reduce the potential impacts from noise generated by dredging equipment.
- Limit sediment (turbid plume) mobilisation to an extent consistent with protecting the viability of specified communities.
- Ensure migratory bird species that use the dredge spoil deposition ponds are not directly adversely affected by dredge activities.
- Ensure that dredging and dredge spoil placement are undertaken in accordance with regulatory approvals, licenses, permits or authorisations.

3.5.2 Performance criteria

The DDSPMP is the key reference document which identifies actions and commitments to be followed by Macmahon and subcontractor personnel throughout dredging operations. The broad performance criteria of the DDSPMP are as follows:

- Compliance with the DDSPMP by all project personnel and activities
- Adherence to discharge water quality parameters as identified in the Water Quality Monitoring Plan (**Sections 7.2 and 7.3** of this plan)
- No net adverse impacts on corals, mangroves, dolphins, dugongs, turtles, sawfish or migratory birds
- No injuries to protected marine species
- No complaints received in relation to noise, vibration or impacts on protected species as a result of dredging activities
- Response to all registered complaints and completion of Complaint Record and / or Incident Report; appropriate corrective actions taken within three working days.

Where performance criteria are not met, this will form a trigger for review of the Plan, in addition to initiating corrective actions specific to the scenario.

3.5.3 Environmental management KPIs

In the environmental management frameworks detailed in **Section 6** of this plan, specific objectives and targets are set for each significant environmental aspect. KPIs related to the objectives and targets for each of the environmental management frameworks can be found in **Section 6**.

General objectives and targets are:

- All personnel working on site have undergone an environmental induction
- Internal audit score of 100% compliance with the DDSPMP
- Client conducted audit score of 100% for compliance with the DDSPMP
- SEWPaC conducted audit score of 100% for compliance with the DDSPMP
- No activity in breach of the provisions of any environmental legislation
- 100% investigation and reporting of any environmental incident at the site
- 100% compliance required for management measures relating to dredging and dredge spoil management.

3.5.4 Environmental Incident Reporting

All Macmahon and subcontractor site personnel are required to report all environmental incidents immediately to their Supervisor or the HSEQ Advisor. It is the responsibility of the Supervisor to contact the HSEQ Advisor to investigate the incident, with personnel involved in accordance with Macmahon's internal procedure G-421 'Incident Reporting and Investigation Procedure'.

Incidents shall be entered and tracked using InControl® (software), regardless of additional client reporting requirements. Complaints will be investigated by the Project Manager and action taken to enable satisfactory closeout. Any incidents that have caused environmental harm or that have the potential to cause environmental harm will also be reported to the Proponent representative and to NT EPA (Pollution Hotline [1800-064-567] or the compliance contact person [refer **Section 8.5**]) within 24 hours. When in any doubt as to the seriousness of the event, Macmahon will notify the authorities, in liaison with the Proponent. The Proponent will be notified of any notices received from authorities.

3.6 Management review

3.6.1 Inspections / monitoring

The Macmahon checklist C-NT-012 'Northern Territory Environmental & Safety Inspection Checklist' will be completed by the HSEQ Advisors on a weekly basis. Upon commencement of the project, this checklist may be amended to include project-specific requirements. It should be noted that in addition to the weekly checklist, daily visual monitoring is conducted both by site Supervisors and HSEQ Advisors. Any corrective actions resulting from inspections will be entered onto the Macmahon register G-599 'Non-conformance and Corrective Action Register' ("Action Register") and the progress tracked for completion.

3.6.2 Internal audits

Internal audits will be carried out to assess the effectiveness of the DDSPMP in the field and to identify opportunities for improvement. Internal audits will be carried out as detailed in Macmahon procedure G-505 'HSEQ Audit Framework Procedure'. An Internal Audit Plan will be established by the Macmahon Group Quality & Environmental Manager. An internal environmental audit will be completed within the first three months of start-up, and thereafter every 12 months (as a minimum).

Any non-conformance identified during the audit shall be actioned in accordance with Macmahon procedure G-450 'Non-conformance and Corrective Action'. Management personnel responsible for the area shall undertake corrective action on the deficiencies found. Any corrective actions will be entered onto the Project Corrective Action Register and the progress tracked for completion.

3.6.3 External audits

External audits can be conducted by a second party (e.g. ShoreASCO, the Proponent) or third parties, such as other government departments, or a certification audit by NCS International. The NTG may conduct an audit at any time when they believe there is an issue in relation to environmental compliance. SEWPaC can also conduct or direct an external audit. The Macmahon Project Manager would assist with any external audit.

Results from any external audits will be reviewed by the Project Manager, with any necessary corrective actions assigned to project personnel to ensure appropriate and timely closeout. Any corrective actions will be entered onto the Project Corrective Action Register and the progress tracked for completion.

3.6.4 Project Corrective Action Register

Any environmental non-conformance (e.g. incidents, audit-related non-conformance, complaints, government notices, etc.) will be recorded in InControl® (software). InControl® details the non-conformance, allocates corrective action required, responsible persons, timeframes by which the action is to be completed, and the actual completion date. Each non-conformance shall be reviewed and it will be established if there are any actions available to reduce the severity or likelihood of re-occurrence.

3.6.5 Continuous improvement

The mechanisms described in the sections below will be implemented to review performance and to identify opportunities for improvement. Records will be kept and reporting will be done according to internal Macmahon procedures for managing documentation; and observations will be detailed in project reporting to the Proponent.

3.6.5.1 Prestart meetings

Prestart meetings are held on a daily basis for all Macmahon and subcontractor project personnel and are based on operational items for the day, such as tasks to be performed that day, any complaints, any incidents, safety and environmental items to be aware of, etc. Minutes of these daily meetings are kept and filed, using the Macmahon form ‘NT Pre-start Muster Talk’ (C-NT-050).

Prestart meetings are an opportunity for Macmahon and subcontractor project personnel to bring up any items of concern for discussion and resolution, prior to commencing works for the day.

3.6.5.2 Toolbox meetings

Toolbox meetings are held on a fortnightly basis, for all employees and subcontractor personnel. Toolbox meetings focus on environmental and safety items relevant for the project at the time, and are used as the main tool to increase awareness in significant environmental and safety issues and to communicate the relevant items contained in the Environmental and Safety Management Plans.

3 Environmental Project Management and Resourcing

Typical items discussed in toolbox meetings are:

- Any recent incidents & hazard/ near misses, recommendations
- Any complaints received
- Any audit results
- Environmental items such as new procedures or re-enforcement of existing procedures relating to erosion control, handling of hazardous chemicals, weeds, management of waste/ recycling, biting insect problems, need to report all incidents and hazard/ near misses etc.
- Health issues such as dehydration, stretching exercises, healthy eating, and other company initiatives. Regularly, guest speakers are invited such as an exercise physiologist, doctor, senior Macmahon staff, auditors and others
- Safety items such as safety statistics, new procedures, re-enforcement of existing procedures relating to working at heights, working with and around machinery, manual handling, cardinal rules, use of Job Safety Assessments (JSAs), emergency response, etc.
- Items discussed in the Safety Committee (the Safety Committee focuses on safety items however environmental items are also discussed)
- Any changes to the project and new works/ tenders
- Any training conducted or planned
- Any items as brought up by anyone in the meeting.

Issues raised are recorded, and responsibilities assigned to ensure satisfactory close-out of the issues raised. Minutes of these fortnightly meetings are kept and filed and posted on site notice boards, using the Macmahon form 'NT Toolbox Meeting Minutes' (C-NT-020).

3.6.5.3 Monthly progress reporting

The HSEQ Advisors complete a Macmahon 'Project HSEQ Performance Monthly Report' (C-170), in liaison with the Project Manager, which is forwarded to the Perth Head Office via the HSEQ Manager NT. This report covers the preceding month's HSEQ performance covering the following:

- Any training conducted or planned
- Workforce number and man-hours worked (including indigenous participation figures)
- Safety incident statistics including TRIFR
- Any incidents (safety, plant and/ or environmental)
- Drug & alcohol testing results
- Number of audits conducted
- Leading indicator descriptions (e.g. number of hazard/ near misses and safe act observations reported, number of toolbox and safety committee meetings held, subcontractor information, number of inspections and audits, training conducted, JSAs/ procedures developed)
- Details on corrective actions and any outstanding actions
- Inductions
- Quality Non Conformance Statistics
- Waste types and volumes, including recycling
- Any complaints
- Comments by Project Manager
- Other HSEQ Performance / Information for the month (such as training/refresher courses, Proponent audit results/feedback, opportunities for improvement, etc.).

3 Environmental Project Management and Resourcing

3.6.5.4 Group Management System review

In accordance with Macmahon procedure G-493 'Continual Improvement', the Project Manager reviews the management system on a quarterly basis to determine its continuing suitability, adequacy and effectiveness, and to assess and identify opportunities for improvement. The document used for this review is the Macmahon 'Construction Quarterly Project Managers Risk-Based Safety Review' (C-322). Items discussed and reviewed are:

- Any outstanding actions from the previous quarterly risk review
- Any trends resulting from an analysis of incidents and hazard/ near misses over the past quarter
- Safe Act Observations
- Project Risk Register
- Corrective Action Register and any items outstanding
- JSA Register
- Issues discussed at prestart and toolbox meetings
- Any Proponent related issues
- Determination of the top three high risk activities and actions to be taken in the next quarter to reduce the risks
- Communication and understanding of safety requirements by employees (includes subcontractors).
- Any negative response to be itemised for action and follow-up.

3.6.5.5 Senior Management review

Senior Macmahon management personnel regularly visit the project sites to conduct visual inspections of the project works. If any deficiencies are found during these inspections (which can be recorded using a Safe Act Observation or 'Site Visitors Audit' C-226) then these will be recorded on the Corrective Action Register and these will be actioned within three business days.

Existing Environment and Relevant Studies

4.1 Background

The marine environment within the Project area is described in detail in the Draft EIS and EIS Supplement (DLP 2011a, b). This section of the DDSPMP provides a brief overview of those components of the existing environment that are pertinent to the consideration of impacts from dredging and spoil placement during the construction of the MSB. It also provides information on studies that have been undertaken subsequent to the primary approvals process. This information provides the context for determining the management strategies detailed in **Section 6** and the monitoring programs detailed in **Section 7**.

The Darwin Harbour region encompasses 2,417 km² and includes the catchments of the rivers and streams that flow into the harbour, including the Howard River, Elizabeth River, and Blackmore River, as well as the large estuarine/marine water body that is Darwin Harbour. Within the Harbour, shores are characterised by extensive intertidal mud flats and mangroves. Corals exist in several areas within the Harbour.

The MSB is located adjacent to the existing East Arm Wharf, within Darwin Harbour (**Figure 1-1**). Two small islands (South Shell Island and Catalina Island) lie in the vicinity of the project area (south and east respectively).

4.2 Existing physical environment

4.2.1 Meteorological conditions

Darwin Harbour lies in the monsoonal (wet–dry) tropics of northern Australia and experiences two distinct seasons; a hot Wet Season from November to March (when winds are predominantly westerly) and a warm Dry Season from May to September (when winds vary from south-easterly through to northerly). The months of April and October are transitional. Maximum temperatures are defined as hot all year round, but November is the hottest month with a range of 25 °C minimum to 33 °C maximum, while June and July normally experience the lowest average daily temperatures with a range of 19 °C minimum to 30 °C maximum (BoM 2012).

The mean annual rainfall for Darwin is 1735 mm, with rain falling on an average of 113 days, mainly from November to March. A range of monthly rainfall averages received at Darwin International Airport (highest, mean and lowest monthly rainfall) is provided in **Table 4-1** (BoM 2012). Daily mean evaporation ranges from 6 mm in February to 8 mm in October. The mean annual evaporation rate is 2482 mm (BoM 2012).

Table 4-1 Average monthly rainfall for Darwin (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	426	374	317	102	21	2	1	5	16	71	140	252
Max	940	1110	1014	396	299	51	27	84	130	339	371	664
Min	136	103	88	1	0	0	0	0	0	0	17	19

4 Existing Environment and Relevant Studies

Cyclone activity occurs intermittently in the Darwin region, mainly between November and April, with cyclones typically causing the most damage within a distance of 50 km from the coast. Aside from the impacts of strong winds, storm surges can be of concern to vessels and coastal developments surrounding Darwin Harbour. Storm surges (generally 2–5 m higher than normal tide levels), result from strong onshore winds and reduced atmospheric pressure (BoM 2012) and can cause flooding and damage through raised tidal levels and increased wave heights. The height of a storm surge is influenced by many factors, including the intensity and speed of winds within the associated cyclone, the angle at which the cyclone crosses the coast and the bathymetry of the affected area.

4.2.2 Coastal geomorphology and bathymetry

Darwin Harbour is a large ria system, or drowned river valley, formed by post-glacial marine flooding of a dissected plateau. The harbour, which has a surface area of some 500 km^2, was formed by rising sea levels about 6000-8000 years ago. Since the formation of the harbour, surface erosion from the adjoining terrestrial environment has carried substantial quantities of sediment into the harbour. This sediment now forms much of the intertidal flats that which overlie bedrock around the harbour margins. The Elizabeth River flows into the East Arm of the harbour, within which lies the Project area.

The harbour extends for more than 30 km along a north-west to south-east axis. The main channel of the harbour is around 15-25 m CD deep, with a maximum depth of some 36 m. The channel favours the eastern side of the harbour and continues into East Arm, at water depths of more than 10 m CD. The bathymetry in this area has been already previously modified by dredging for the development of the East Arm Wharf.

In 2010, iXSurvey Pty Ltd completed a hydrographic survey in the vicinity of East Arm. **Figure 1-1** shows that the bathymetry falls from approximately 2 m above CD along the northern edge of the MSB dredging area to approximately 10 m below CD at its southern extremity.

4.2.3 Marine sediment quality

The sediment profile for the East Arm of Darwin Harbour consists of Quaternary age intertidal marine alluvium comprising mud, silt, sand and coral remnants, underlain by the Proterozoic metasediments of the Burrell Creek Formation, consisting of meta-siltstone, meta-sandstone and phyllite. The rocks strike close to north-south and are steeply dipping either to the east or west. Quartz veins are widespread within the Burrell Creek Formation.

Approximately 80% of the Darwin Harbour region’s seafloor is estimated to be covered with soft surfaces consisting of mud and fine sand. Soft surfaces containing varying amounts of gravel and sand are found in the main channels around reefs, on beaches and on spits and shoals near the mouth of the harbour (Fortune 2006).

In April/May 2012, URS undertook a geochemical assessment of the sediments within the MSB dredging footprint. The report (URS 2012a) contains a summary of the potential contaminant inputs to the dredging area. Land uses in the Darwin Harbour catchment represent potential sources of contaminants that may accumulate in the MSB dredging footprint. In the mid-1990s, the mean annual contaminant loads contributed to the harbour from the Hudson Creek catchment (upstream of the MSB development) were calculated by Padovan (2001) to be 15 t of nitrogen, 3 t of phosphorous, 40 kg of arsenic, 6 kg of cadmium, 220 kg of chromium, 189 kg of copper, 327 g of lead, 43 kg of nickel and 1,860 kg of zinc.

4 Existing Environment and Relevant Studies

The key findings from the URS (2012) geochemical assessment were:

- Arsenic concentrations in the MSB dredging footprint exceeded guideline criteria levels (Commonwealth of Australia 2009). Elevated levels of arsenic in Darwin Harbour sediments have previously been attributed to local geological influence (e.g. natural weathering of bedrock in the catchment) and are not thought to be attributable to anthropogenic sources (Padovan 2003, Fortune 2006). Bioavailability testing of other samples of Darwin Harbour sediments has found that only a very small proportion of the arsenic may be bioavailable, therefore there would be a low risk of toxic effects from arsenic on the marine environment if the sediments were dredged (URS 2009).
- No other elements or contaminants exceeded guideline criteria levels within the MSB dredging footprint.
- The majority of sediments tested were considered likely to have the potential to generate acidity if they were exposed to oxygen.
- Whilst the arsenic within the sediments discharged into the reclamation area may have low bioavailability under non-acidic conditions, if acid is generated from the exposure of the sediments to air then this may mobilise arsenic from the sediments, leading to elevated arsenic concentrations in the tailwater discharged from the reclamation area.

Management and monitoring of acid generation and contaminants within the reclamation area are described in **Sections 6 and 7** of this DDSPMP.

4.2.4 Metocean conditions

Darwin Harbour has semidiurnal macro-tides (two highs and two lows per day) with a strong diurnal inequality. The highest astronomical tide is 8 m CD. The mean spring tidal range is 5.5 m and the mean neap tidal range is 1.9 m, with a maximum range of 7.8 m. It is a well-mixed system with large volumes of water moving within the harbour with tidal fluctuations. Tidal movement plays an important role in re-suspending material from the harbour floor into the water column.

Williams, Wolanski and Spagnol (2006) investigated the link between hydrodynamics, sediment and nutrient dynamics in the harbour to assist in the management of infrastructure developments. Near headlands and embayments, a complex circulation occurs that includes jets, eddies, separation points and stagnation zones. These currents are different at flood and ebb tides and the asymmetric dispersion of particles results in trapping at headlands and embayments. Sediment is delivered to the upper arms by runoff. Despite being macrotidal the harbour was found to be poorly flushed, with much of the riverine fine sediment remaining trapped in mud flats and mangroves with little escaping to the sea. The residence time of pollutants in the upper reaches of the harbour was found to be in the order of 20 days (Williams, Wolanski and Spagnol 2006).

The MSB is located in an area where the Dry Season flushing is estimated to be around 36 days (**Figure 4-1**) hence it is defined as being in the Upper Estuary Zone.

4.2.5 Marine water quality

Water quality in Darwin Harbour is described as generally high, although naturally turbid most of the time (DLP 2011a). Water quality parameters vary greatly with the tide (spring versus neap), location of sampling point (inner versus outer harbour), and with the season (Wet Season versus Dry Season).

4 Existing Environment and Relevant Studies

Figure 4-1 Dry Season flushing zones in Darwin Harbour

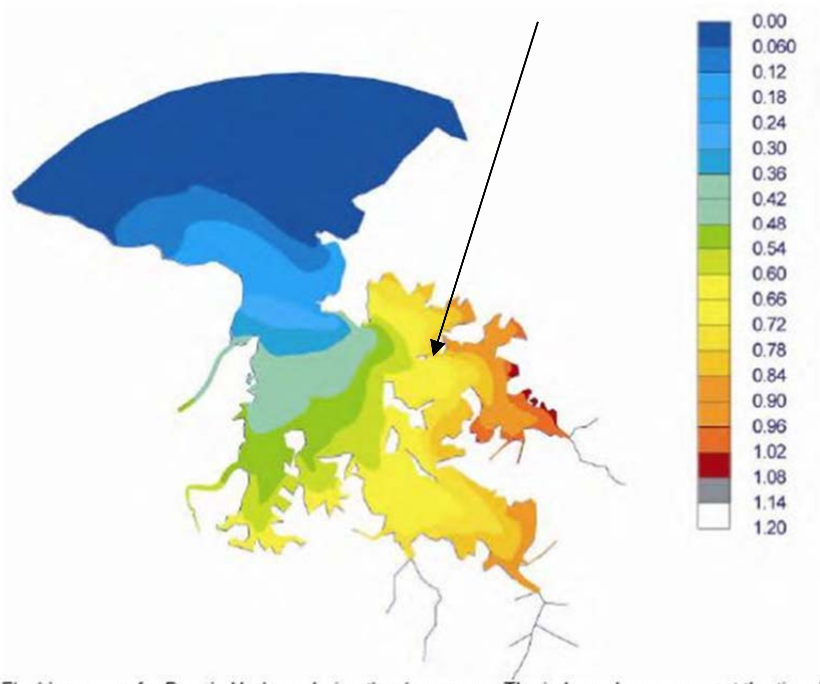


Figure 6: Flushing zones for Darwin Harbour during the dry season. The index values represent the time in days it takes for a conservative constituent to be removed from the harbour by advection / diffusion. Multiply the index values by 60 for the time in days. (*Source: David Williams, in 'Water Quality Guidelines for the Protection of Environmental Beneficial Use of the water resources of the Darwin Region': EMG Paper 1, Dec 2007*).

During the Dry Season the salinity is quite uniform and the estuary well mixed. This contrasts with Wet Season conditions where the saline water of the harbour, is met in the upper estuary by a buoyant plume of freshwater (from the catchment). A strong salinity gradient can persist during and after rainfall events in the upper reaches of the estuary and the tidal creeks. The Wet Season effects on harbour water quality (through high surface runoff from the land) can last until April or May, depending on the amount and duration of rainfall.

Duggan (2006) conducted research on the water quality of Darwin Harbour from 2002 to 2004. Seasonal aspects, rather than spatial or tidal aspects, were found to be the most important determinant of water quality, with rainfall considered to have the greatest impact on water quality (increasing nutrients, suspended solids and chlorophyll a).

There is no evidence of widespread water or sediment pollution in the Harbour, although there some localised pollution has been identified in the past (e.g. Padovan 2003, Water Monitoring Branch 2005, Drewry 2011). Anthropogenic influences to Harbour water quality include the East Arm Wharf port operations, historic industrial activities at Darwin Waterfront, Sadgroves Creek and wastewater outfalls (URS 2004), however there is no evidence of hydrocarbon or pesticide pollution in the harbour (DHAC 2007).

4.2.6 Water quality baseline data

Between 2008 and 2011, a number of water quality investigations were undertaken by URS on behalf of INPEX Browse, Ltd (INPEX) to characterise the existing conditions in East Arm (URS 2009, 2011). **Table 4-2** presents summary statistics for dry and Wet Season water quality, as recorded at a site off the southern tip of South Shell Island (URS 2011a).

These data were collected every 15 minutes over a year-long program. Data were grouped and averaged based on tidal cycle and seasonal variation, allowing seasonal means, medians, and percentiles to be calculated. This gives a robust body of data to compare background levels of turbidity with potential increases associated with various natural and artificial turbidity-generating events in the harbour.

Water quality data from South Shell Island is relevant to the present project as this location is the nearest significant receptor (coral communities) to the dredging location and will also be monitored for biological impact, although modelling does not indicate an impact at this site (refer to **Section 5**). The two other locations identified, Old Man Rock and Catalina Island are located to the east, further from dredging activity and with a lower modelled risk of dredge spoil impact and no well-developed coral communities (refer to **Sections 4.2.2 and 4.2.3**). Accordingly it is appropriate that South Shell Island water quality data have been used to set trigger levels for monitoring, as described in **Section 7** of this DDSPMP.

Table 4-2 Summary of water quality parameters at South Shell Island (URS 2011a)

	Dry Season			Wet Season		
	Mean	Minimum	Maximum	Mean	Minimum	Maximum
Temperature (°C)	28.1	25.3	32.1	30.4	28.1	32.0
Conductivity (mS/cm)	48.7	40.2	52.9	46.2	36.7	49.8
Depth (m)	6.3	2.4	11.0	6.7	2.5	11.3
pH	8.0	7.7	8.5	8.0	7.6	8.2
DO (%)	93.5	73.4	121.1	88.5	67.3	106.4
Turbidity (NTU)	4.4	0.1	46.4	8.3	0.2	68.0
Suspended sediment concentration (SSC) (mg/L)*	10.8	7.1**	46.4	14.1	7.2**	64.7

* Calculated from NTU using relationship in URS (2011a): SSC = 0.848 * NTU + 7.0477

** These values are an artefact of applying a linear equation to the SSC/NTU relationship and the actual SSCs are likely to have been considerably lower. This does not affect the veracity of the trigger levels presented in **Sections 6.2 and 6.3** of this DDSPMP, which are closer to the maximum NTU and SSC values.

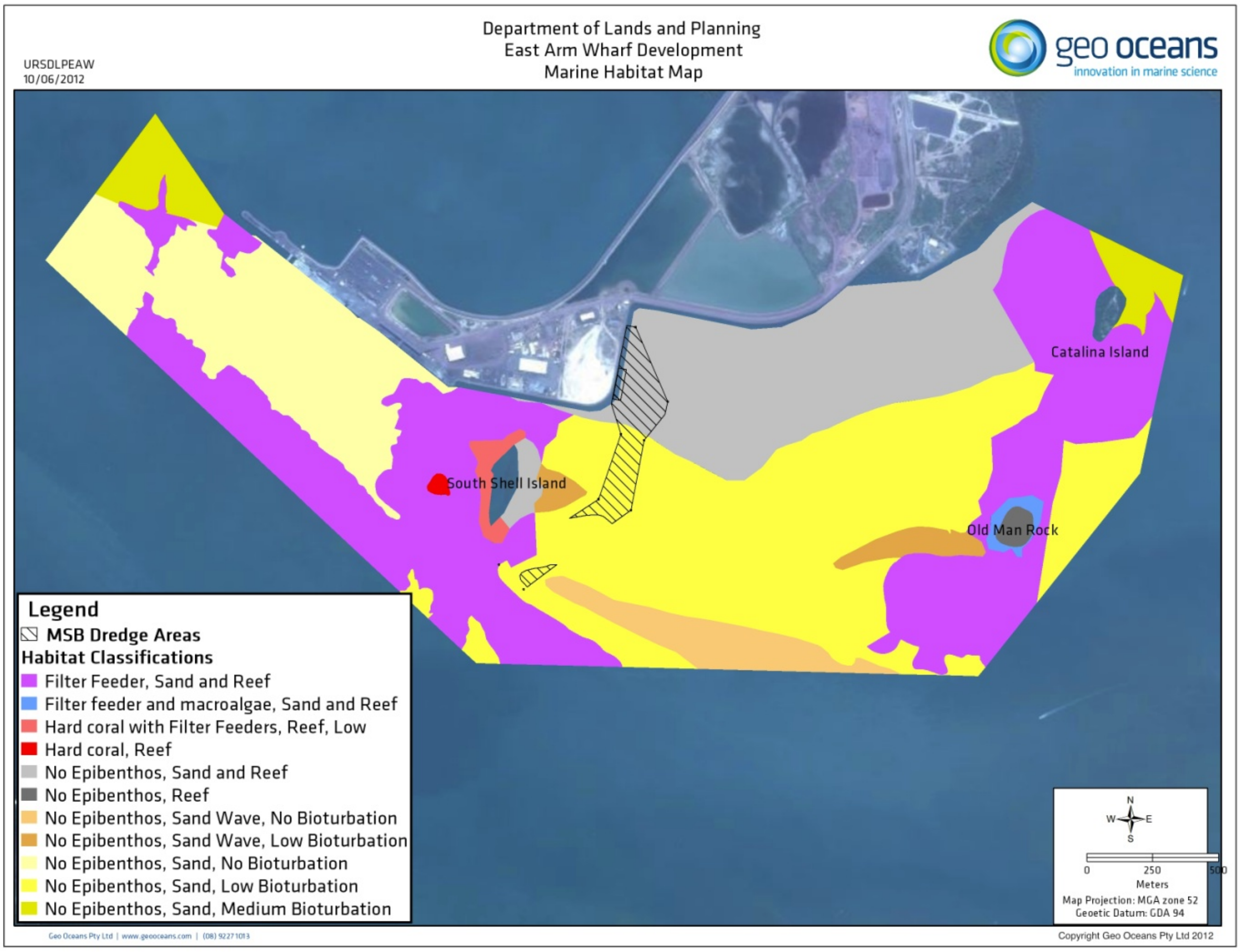
4.3 Environmental receptors

4.3.1 Marine habitats

A comprehensive survey of the marine habitats around South Shell Island, Old Man Rock and Catalina Island was undertaken in May 2012 by Geo Oceans Pty Ltd (Geo Oceans 2012a). A habitat map (**Figure 4-2**) was produced from interpolated substrate and biological community data collected on the survey. The map also incorporated data from previous habitat mapping in the area (Geo Oceans 2011), along with digital imagery and acoustic survey data (including that of iXSurvey [2010]). It should be noted that "no epibenthos" refers to areas in which the cover of epibenthic macrobiota (e.g. corals, filter-feeders, macroalgae) was less than 10%.

The habitat map provided the basis for selection of benthic community monitoring sites in East Arm (see **Section 7.3.3.2**).

Figure 4-2 Benthic habitats, East Arm (Geo Oceans 2012a)



4.3.2 Hard coral communities

Hard coral communities occur in Darwin Harbour where the substrate is rocky in the lower intertidal and shallow subtidal zones and where hydrodynamic conditions permit. Hard corals are dominant within some of the benthic communities around South Shell Island (**Figure 4-2**); mainly on the western side of the island (the opposite side to that directly exposed to the proposed dredging activities at the MSB).

Other well-known hard coral communities in Darwin Harbour include:

- Off the north-east shore of Wickham Point, within 2 km of the proposed MSB dredging works.
- Weed Reef, Plater Rock and Kurumba Shoal, on the western side of the harbour, and Dudley Point at the northern end of Fannie Bay, all more than approximately 10 km from the MSB.
- Channel Island coral community in Middle Arm, on the intertidal platform between Channel Island and the mainland. This is listed on the Register of the National Estate and is a declared Heritage Place under the *NT Heritage Conservation Act 1991*. It is some 15 km (by sea) from the MSB.

With the exception of the coral community off the north-east shore of Wickham Point, all of these communities are sufficiently remote from the MSB that the proposed dredging works pose no credible risk of impact to them. Sediment plume modelling (**Section 5**) predicts that the South Shell Island and north-east Wickham Point hard coral communities are also sufficiently distant from the proposed dredging works to be at no risk of impact. Nevertheless, monitoring of the South Shell Island coral community will be undertaken, as described in **Section 7.3**.

4.3.3 Filter-feeder communities

Filter-feeder communities are those that primarily comprise sponges, gorgonians (sea fans and sea whips) and other soft corals. They primarily occur on intertidal or subtidal hard substrates and may co-occur with hard corals, giving rise to “mixed species” communities. However, they also occur at depths shallower than, and deeper than, those at which hard corals thrive and can be the dominant component of the benthic community in some areas (**Figure 4-2**).

It should be noted that during the environmental approvals process for the East Arm Wharf Expansion project the publications of Hooper, Kennedy and Quinn (2002) and Alvarez, Browne and Horner (2002) were misquoted as indicating South Shell Island is a “biodiversity hotspot” for sponges, soft corals and hard corals. While the first of these publications refers to the region between Darwin and the Wesel Islands (a distance of some 650 km) as being a “biodiversity hotspot”, it makes no specific mention of South Shell Island. The second publication does not present any new data, but simply references the first, indicating that Darwin Harbour is “located in one of the hotspots of sponge diversity within Australia”. Neither publication discusses hard or soft corals.

Notwithstanding this, it is proposed to monitor filter-feeder communities around South Shell Island and Old Man Rock (**Section 7.3**) as their potential to contain species that could be of importance to bio-prospecting is recognised. It is also recognised that, as is evident in **Figure 4-2** and the habitat maps of Darwin Harbour presented in Geo Oceans (2011), large areas of filter-feeder communities are present both within East Arm and across the broader harbour.

4.3.4 Protected marine species

4.3.4.1 Cetaceans

Three species of coastal dolphin occur in Darwin Harbour: the Indo-Pacific humpback dolphin (*Sousa chinensis*), the Indo-Pacific bottlenose dolphin (*Tursiops aduncus*), and the Australian snubfin dolphin (*Orcaella heinsohni*). The Indo-Pacific bottlenose dolphin is the most widely distributed and abundant of the three coastal dolphin species in Darwin Harbour, and occurs all around the Australian coastline. The snubfin dolphin is a recently described species, having previously been considered to be a population of the Irrawaddy dolphin (*Orcaella brevirostris*). *Orcaella heinsohni* occurs across the subtropical and tropical parts of Australia; however there is currently no overall population estimate in Australian waters.

While limited information is available on snubfin and Indo-Pacific humpback dolphins in the north-west of Australia (Allen et al 2012, Bejder et al 2012), there is ongoing research into coastal dolphin species by the NTG in Darwin Harbour and Shoal Bay (e.g. Palmer 2010). These studies, as well as separate repeat transect studies at Cobourg Peninsula and Kakadu, have indicated that there are differences in habitat preferences between the species (INPEX 2011a). The following conclusions can be drawn from the work of Palmer (2010) and INPEX (2011b):

- The Indo-Pacific humpback dolphin was the most commonly sighted species and occurred in its highest density in Shoal Bay. It was also the most common of the three species to occur near East Arm. The density observed in the western parts of the harbour was comparable to that observed near East Arm over the two year period from 2008 to 2010.
- The Indo-Pacific bottlenose dolphin was commonly observed along the north-eastern shorelines of Darwin Harbour, but not near the north-western shorelines or in the shallower parts of Shoal Bay. The density observed in the western parts of the harbour was comparable to that observed in the eastern parts of the harbour but less than that observed in the northern parts of the harbour.
- The Australian snubfin dolphin was the least sighted of the three species and was most often found adjacent to the western shoreline of the Harbour. It was observed infrequently in East Arm.

4.3.4.2 Dugongs

Dugongs are known to occur in Darwin Harbour waters, although in relatively low numbers. Dugongs have been recorded in higher densities at Gunn Point and the Vernon Islands, some 30–50 km to the north-east of the mouth of the Harbour. Dugongs have also been observed in relatively high numbers at Bare Sand Island and Dundee Beach in Fog Bay, 60 km south-west of Darwin Harbour, and are known to travel long distances (Whiting 2008).

In Darwin Harbour, dugongs have been observed foraging on the rocky reef flat between Channel Island and the western end of Middle Arm Peninsula (Whiting 2001). As no seagrass occurs on the reef flat in this area, the dugongs were likely to have been feeding on macroalgae. It has been suggested that this habit of foraging on the algae, sponge and coral communities of macrotidal reefs distinguishes dugongs in the Anson–Beagle Bioregion from conspecifics elsewhere (Whiting 2002).

In general, it is considered that dugongs could occur anywhere in the harbour that could support seagrasses or algae. The only benthic community in the vicinity of the MSB that was found by Geo Oceans (2012a) to supported a notable amount of macroalgae was on the mixed sand and rocky reef habitat around Old Man Rock (**Figure 4-2**). Substantially greater areas of potential foraging habitat for dugong exist elsewhere in the Harbour (INPEX 2011b).

4.3.4.3 Turtles

Six species of marine turtles are known to occur in Northern Territory waters. Of these, the green, hawksbill and flatback turtles use Darwin Harbour regularly, while the Pacific ridley and loggerhead turtles are suspected to be infrequent users. The leatherback turtle is considered to be an oceanic species and is unlikely to occur in Darwin Harbour (Whiting 2003).

The shoreline throughout Darwin Harbour, and particularly in East Arm, consists largely of mangrove forests and mudflats and does not provide suitable nesting habitat for any species of turtle. The nearest nesting beach (used by the flatback turtle) is located in the Casuarina Coastal Reserve near Lee Point on the north-eastern shore of the harbour. Turtles visiting the harbour are more likely to be foraging for food. Flatback and hawksbill turtles forage on the filter-feeder communities which are extensive in the harbour. The hawksbill turtle also forages on seagrass and macroalgal communities in addition to filter-feeders. Green turtles forage amongst seagrass and macroalgal communities (INPEX 2011a).

4.3.4.4 Sawfish

The EPBC protected matters database indicates that dwarf sawfish (*Pristis clavata*), freshwater sawfish (*Pristis microdon*) and green sawfish (*Pristis zijsron*) may potentially inhabit Darwin Harbour. The three species of sawfish are widely distributed throughout Australian tropical waters and are thought to be uncommon within the harbour.

No records have been found of sightings of the freshwater or green sawfish within the harbour. The Atlas of Living Australia (biocache.ala.org.au) contains only two records of the dwarf sawfish in the Darwin Harbour region:

- Buffalo Creek, which discharges into Shoal Bay, outside of the main harbour (MAGNT record)
- An Australian Museum record with an imprecise location, possibly from Rapid Creek which is in the middle harbour approximately 10 km to the north of the MSB.

These are both tidal creeks; quite a different environmental setting from the area to be dredged for the MSB, which is primarily comprised of an intertidal sand flat, with some subtidal sand and pavement habitat.

4.3.5 Migratory bird species

Migratory bird species recorded around East Arm Port area have predominantly been within the mangroves, the saline wetlands and beside the water in the dredge spoil ponds. Although historical counts suggest that migratory shorebird numbers within Darwin Harbour are modest (Chatto [2003] survey Block 4), the East Arm Port does seasonally support nationally significant numbers of some migratory shorebirds (**Table 4-3**).

4 Existing Environment and Relevant Studies

Table 4-3 Numbers of migratory birds that recorded >0.1% fly away population at East Arm Port Ponds K and D (EMS 2011) compared to the general Darwin Harbour Region (Chatto 2003).

Species	Combined Nov 2010 – Jan 2011 (EMS 2011) Pond K numbers	Combined Nov 2010 – Jan 2011 (EMS 2011) Pond D numbers	Recorded Numbers around Darwin Harbour (survey block 4 from Chatto (2003)
Lesser Sand Plover	2	320	1800 (6% Figure 104)
Greater Sand Plover	16	276	3410 (11% Figure 106)
Far Eastern Curlew	0	123	200 (4% Figure 64)
Terek Sandpiper	0	0	1099 (7% Figure 74)
Sharp-tailed Sandpiper	1	249	370 (2% Figure 92)

The criteria for determining the importance of habitat for migratory shorebirds in Australia (EPBC Act policy statement 3.21) rates a site as nationally important habitat if:

- The site is identified as internationally important under Ramsar: or
- The site supports:
  - at least 0.1% of the fly away population of a single migratory shorebird species; or
  - At least 2000 migratory birds; or
  - At least 15 shorebird species.

The East Arm Port area meets the criteria for supporting nationally important migratory shorebird habitat in that:

- Five migratory shorebird species (Lesser Sand Plover, Greater Sand Plover, Far Eastern Curlew, Terek Sandpiper and Sharp-tailed Sandpiper) have been recorded within the East Arm Port area at numbers greater than 0.1% of the fly away population
- At least 2000 migratory birds have been recorded
- Twenty-two migratory shorebird species have been recorded within the study area (EMS 2011).

Very few shorebirds use the intertidal flats associated with the MSB dredging area but nationally significant numbers of some migratory birds listed under the EPBC Act roost on the dredge spoil ponds at East Arm Wharf. Numbers of waterbirds counted varied from 50 to 1333 (EMS 2011). This variation is likely to reflect variation in both time of the year and tidal heights at the time of the survey, given the macrotidal nature of Darwin Harbour and thus the variability in the number and quality of natural roosting sites that might be available. This suggests that alternative roosting sites are both available and currently being used by migratory birds when they are not present at the East Arm Port.

Sediment Transport Modelling and Impact Assessment

5.1 Synthesis of assessment approach

The assessment of potential environmental impacts from the dredging works at the MSB was informed by:

- Two-dimensional hydrodynamic models that incorporated water levels, currents and waves
- Sediment transport models that determined suspended sediment dispersion and sediment accumulation
- GIS analyses to quantify and depict potential impacts on habitats on the basis of tolerance limits.

Two discrete tranches of modelling have been undertaken for the MSB dredging campaign:

- Tranche 1 – modelling undertaken for the Draft EIS (DLP 2011a) and for Rev 0 of this DDSPMP (URS 2012b)
- Tranche 2 – modelling undertaken for this revision of the DDSPMP.

The requirement for two tranches of modelling arose because during Phase 1 of dredging it became apparent that the tailwater entering Pond E was flowing out through the permeable section of the bund wall at a sufficiently high rate that use of the pump to return the tailwater to the dredging footprint was not required. Hence, in preparation for Phase 2 of dredging it was necessary to remodel the tailwater return as flowing out through the bund wall rather than as being pumped into the dredging footprint.

The outputs from Tranche 1 of the modelling have been retained in the DDSPMP as they remain applicable to the generation of turbid plumes from the dredging operation. The areas potentially affected by turbidity in the tailwater returned into the dredging footprint lay within the areas affected by turbidity from the operation of the dredge (refer **Section 5.5**), hence the model outputs are applicable to the consideration of potential effects from dredging (as opposed to tailwater return) during Phase 2.

5.2 Hydrodynamic model

5.2.1 Tranche 1 model

The predicted water quality impacts from a conceptual dredging program were presented in Appendix E of the Draft EIS for the East Arm Wharf Expansion Project (URS 2011b). The dredging methodology presented in this DDSPMP was subsequently modelled by HR Wallingford (HRW); using the same model applied to the INPEX dredging works.

A detailed description of the model is presented in HRW (2010). The key assumptions applied to the model were:

- The tidal oscillations within Darwin Harbour are of such magnitude that it is appropriate to assume that the water column is well mixed at the proposed dredging site, hence the numerical modelling study could be carried out using a 2D model. This refers to the INPEX dredging site, which is immediately adjacent to the MSB dredging site.
- Wave energy entering the harbour from Beagle Gulf is limited and most of the wave energy at Blaydin Point (on the opposite side of East Arm from the MSB site) is generated locally within East Arm.

Following a review of existing data sources, a suite of regional numerical models was developed to cover Beagle Gulf and Darwin Harbour. The model data inputs; calibration and validation of the flow model and wave model; descriptions of the boundary conditions; results of sensitivity analyses; and depictions of the model extent and model mesh resolution are all contained within HRW (2010).

This model was applied to the dredging and tailwater management methods presented in Rev 0 of this DDSPMP (URS 2012b).

5.2.2 Tranche 2 model

The 'Darwin Harbour community model' was used by the Australian Institute of Marine Science (AIMS) for Tranche 2 of the modelling (AIMS 2013). This model was developed for the original East Arm Wharf development and, over a period of 16 years, was applied to many of the dredging campaigns within Darwin Harbour. Over the past four years the model has been further refined and developed by AIMS to assist in understanding the general movement of cohesive and non-cohesive sediments and nutrients in the harbour. It has formed the foundation for the NTG's WQPP for the harbour (refer **Section 1.8**).

Boundary conditions for the model were taken from observations recorded at Buoy 5 at the entrance to Darwin Harbour. Buoy 5 is a DPC channel marker that is equipped with instrumentation to measure wind speed and direction; tidal depth, current and direction; and waves. This model was applied to the dredging and tailwater management method proposed for Phase 2 of the dredging (as described in **Section 2**).

5.3 Sediment transport model

5.3.1 Tranche 1 model

HRW utilised the hydrodynamic model developed for INPEX to predict the dispersion of sediment plumes, and the areas of sediment deposition, for the duration of the MSB dredging program. For the modelling simulations, the following assumptions were made:

- The dredging is undertaken over two separate phases – Phase 1 of 90 days duration (commencing Q3, 2012), Phase 2 of 30 days duration (commencing Q2, 2013).
- 1% loss of sediment from the dredge cutter head. This equates to a total loss in Phase 1 of 1,625 tonnes, and in Phase 2 of 137 tonnes.
- Discharge of tailwater commences five days after commencement of dredging and continues for a period of five days following cessation of each dredging phase.
- Daily average discharge rate for the return pump system (from Pond E into the MSB dredging area) is a constant 5.5 megalitres per hour.
- SSC in return water is a constant 100 mg/L.

The dredging program was modelled in four stages, each of 30 days duration:

- Stage One – dredge located towards the southern end of the approach channel
- Stage Two - dredge located at the confluence of the shipping channel and the turning basin
- Stage Three - dredge located within the central turning basin.
- Stage Four – dredge located in the berths.

The model outputs showed the predicted net effects of turbid plume dispersion during different stages of the indicative dredging program.

5 Sediment Transport Modelling and Impact Assessment

Model outputs are presented as:

- 90th percentile plots of SSC (showing the SSCs that are exceeded within the model less than 10% of the time) for each dredging stage.
- 95th percentile plots of SSC (showing the SSCs that are exceeded within the model less than 5% of the time) for each dredging stage.
- Sediment accumulation at the end of each dredging stage. Note that sedimentation was considered to be accumulative over the first three stages; i.e. sedimentation at the end of Stage Two represents the net accumulation of sediments over Stages One and Two; sedimentation at the end of Stage Three represents the net accumulation of sediments over all three stages. By the commencement of Phase 2 of the dredging, it was assumed that any sediment deposited during Phase 1 would have been redistributed or consolidated during the intervening Wet Season; hence sedimentation at the end of Stage Four represents the net accumulation of sediments over that stage only.

Selected model outputs are presented in:

- **Figure 5-1** - 90th and 95th percentile plots of SSC for Stage One.
- **Figure 5-2** - 90th and 95th percentile plots of SSC for Stage Two.
- **Figure 5-3** - 90th and 95th percentile plots of SSC for Stage Three.
- **Figure 5-4** - 90th and 95th percentile plots of SSC for Stage Four.
- **Figure 5-5** – Net sediment accumulation at the end of Stage One.
- **Figure 5-6** – Net sediment accumulation at the end of Stage Two.
- **Figure 5-7** – Net sediment accumulation at the end of Stage Three.
- **Figure 5-8** – Net sediment accumulation at the end of Stage Four.

In each of the figures, insets have been included to improve the clarity of the SSC concentrations and sediment accumulation depths in the vicinity of the MSB.

In **Figures 5-1** and **5-2**, the two discrete areas of elevated SSC are at the location of tailwater return from Pond E to the dredging footprint (the more northern area) and the location of the dredge (the more southern area). In **Figures 5-3** and **5-4**, the two areas merge into one due to the proximity of the dredge to the modelled tailwater return location.

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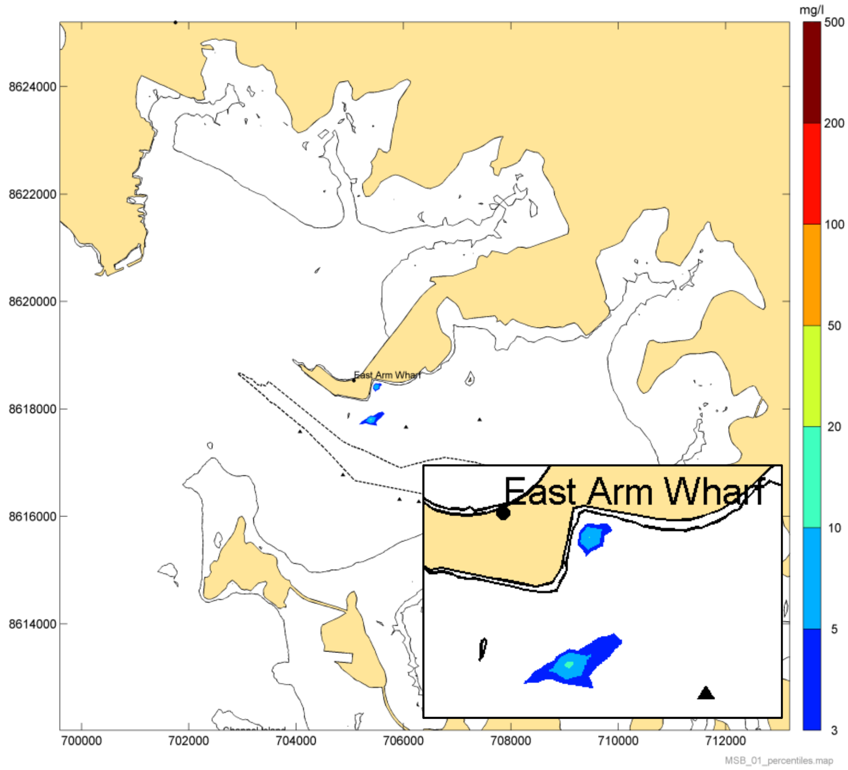
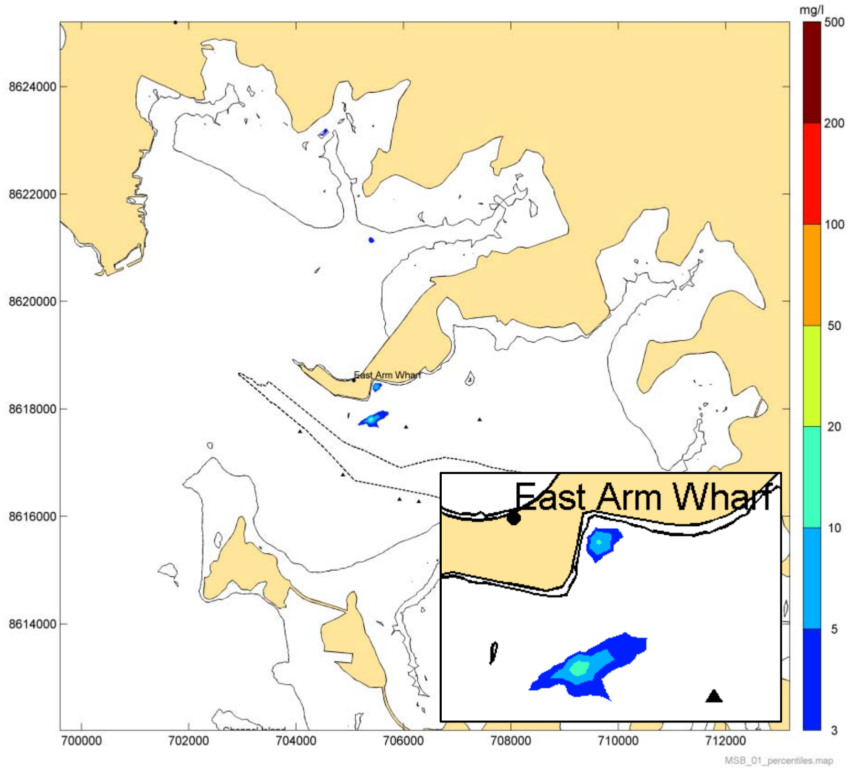
Figure 5-1 90th (top) and 95th (bottom) percentile plots of SSC (mg/L) - Stage One.





5 Sediment Transport Modelling and Impact Assessment

Figure 5-2 90th (top) and 95th (bottom) percentile plots of SSC (mg/L) - Stage Two.

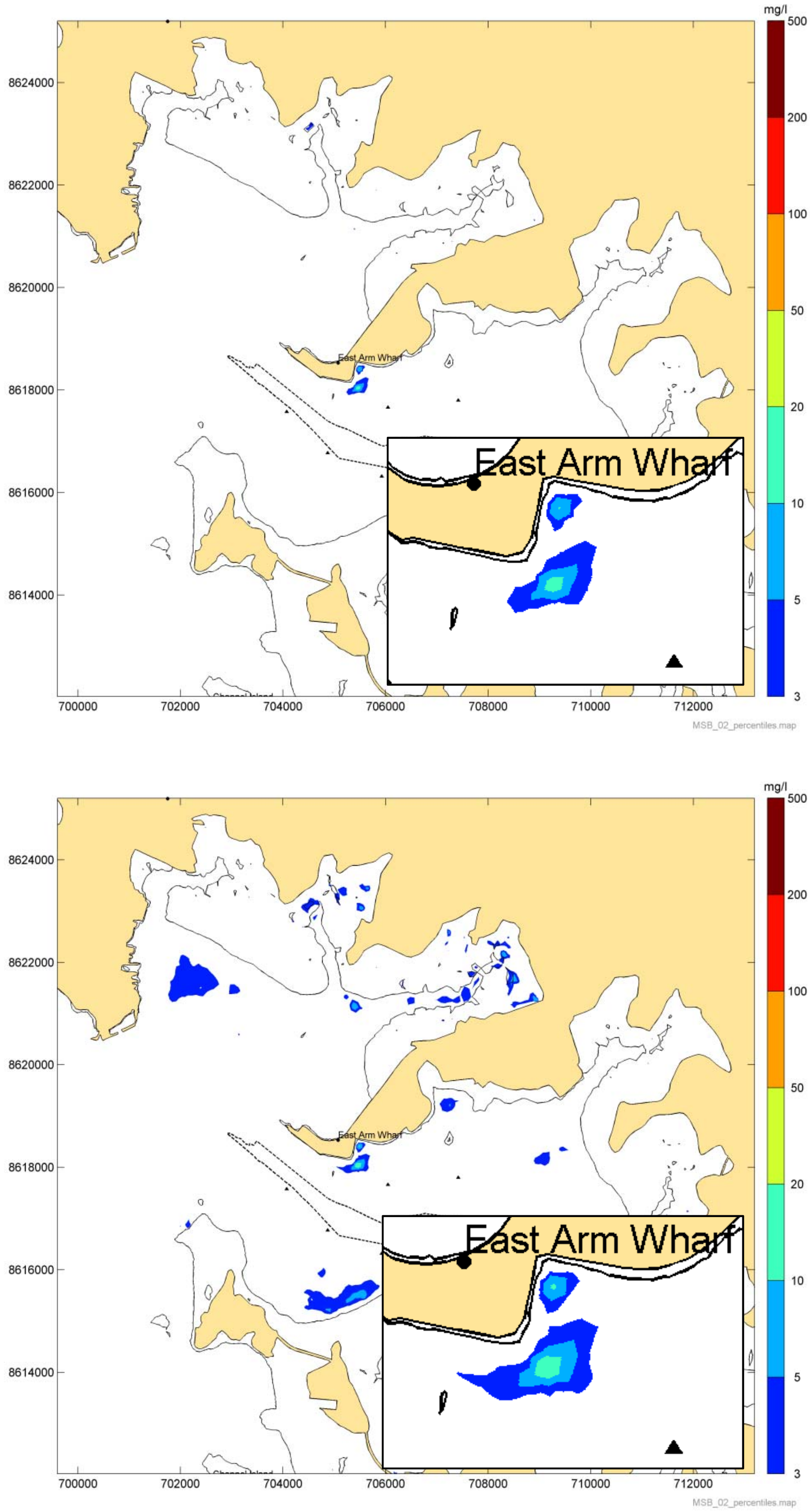


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Figure 5-3 90th (top) and 95th (bottom) percentile plots of SSC (mg/L) - Stage Three.

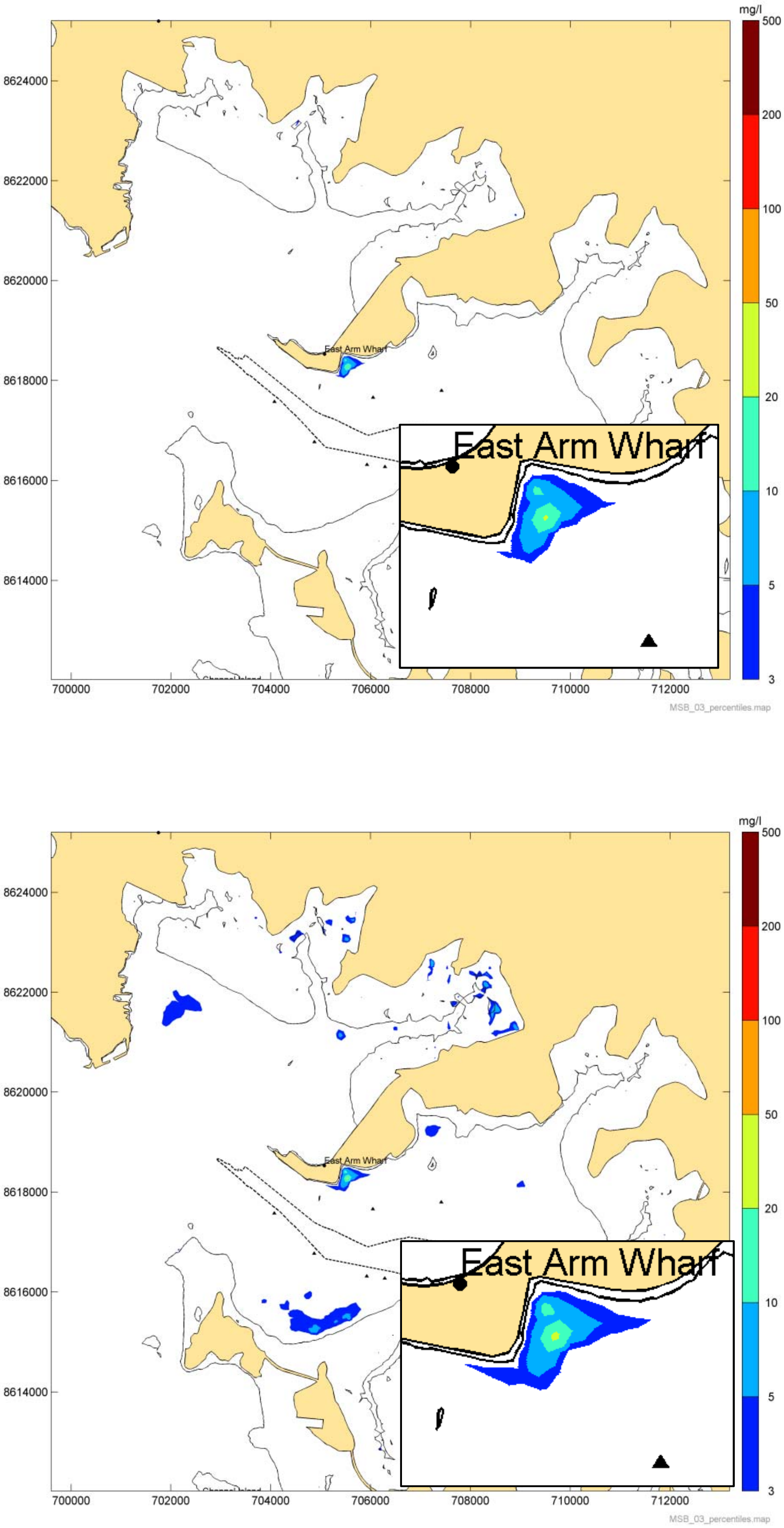

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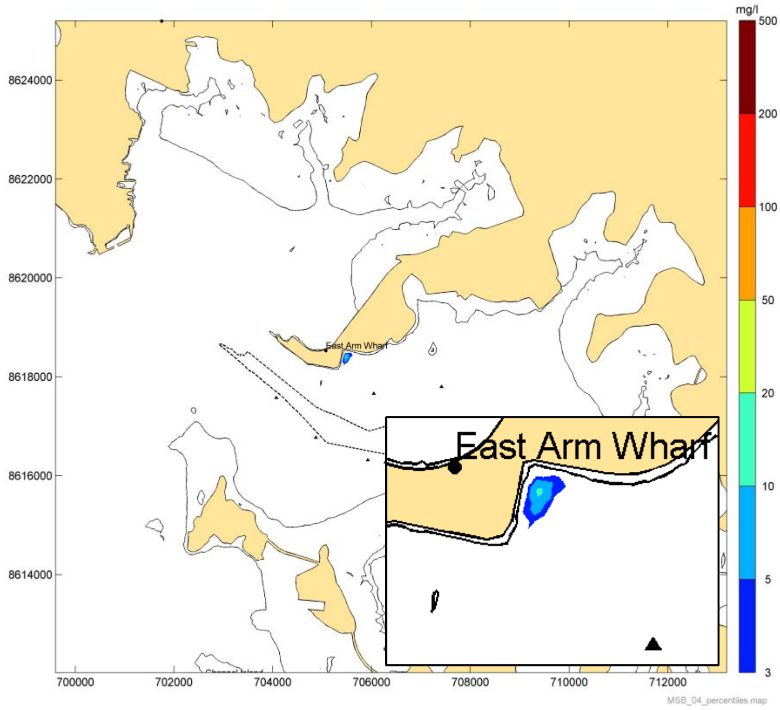
Figure 5-4 90th (top) and 95th (bottom) percentile plots of SSC (mg/L) - Stage Four.



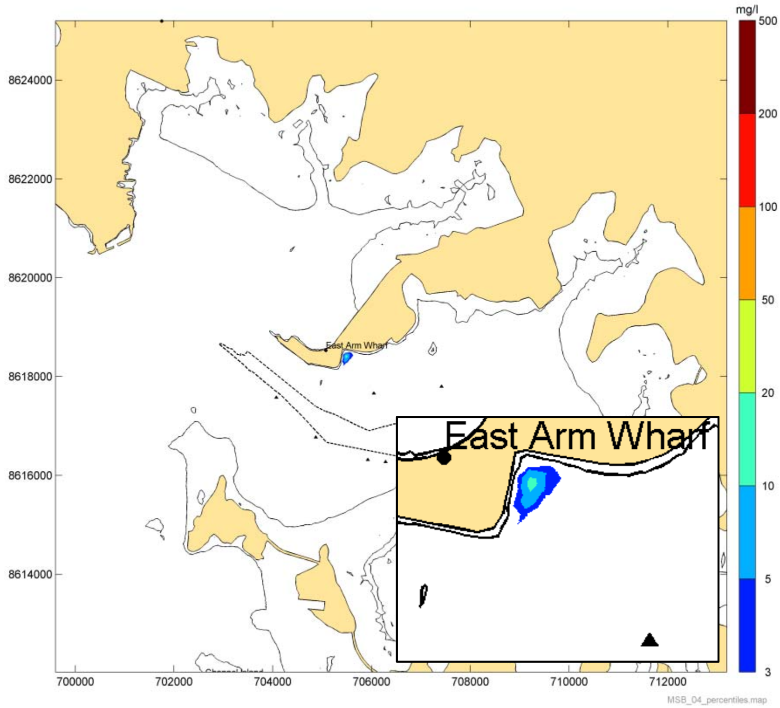


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Figure 5-5 Net sediment accumulation (mm) - end Stage One.

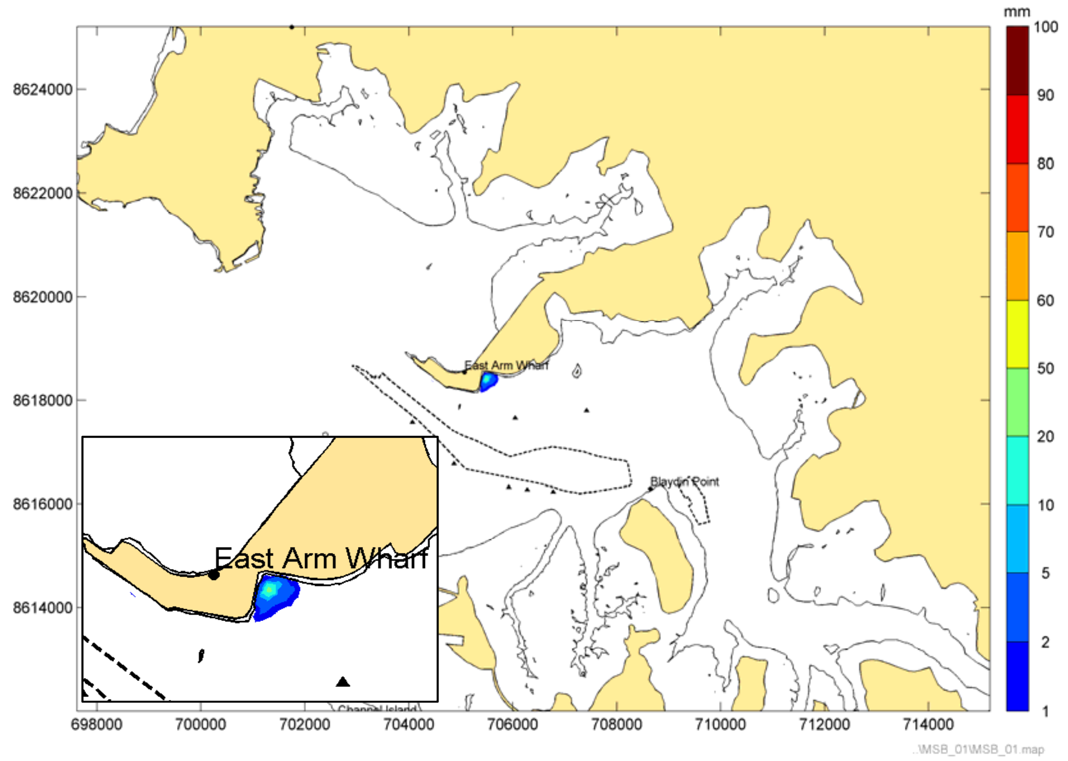

Figure 5-6 Net sediment accumulation (mm) - end Stage Two.

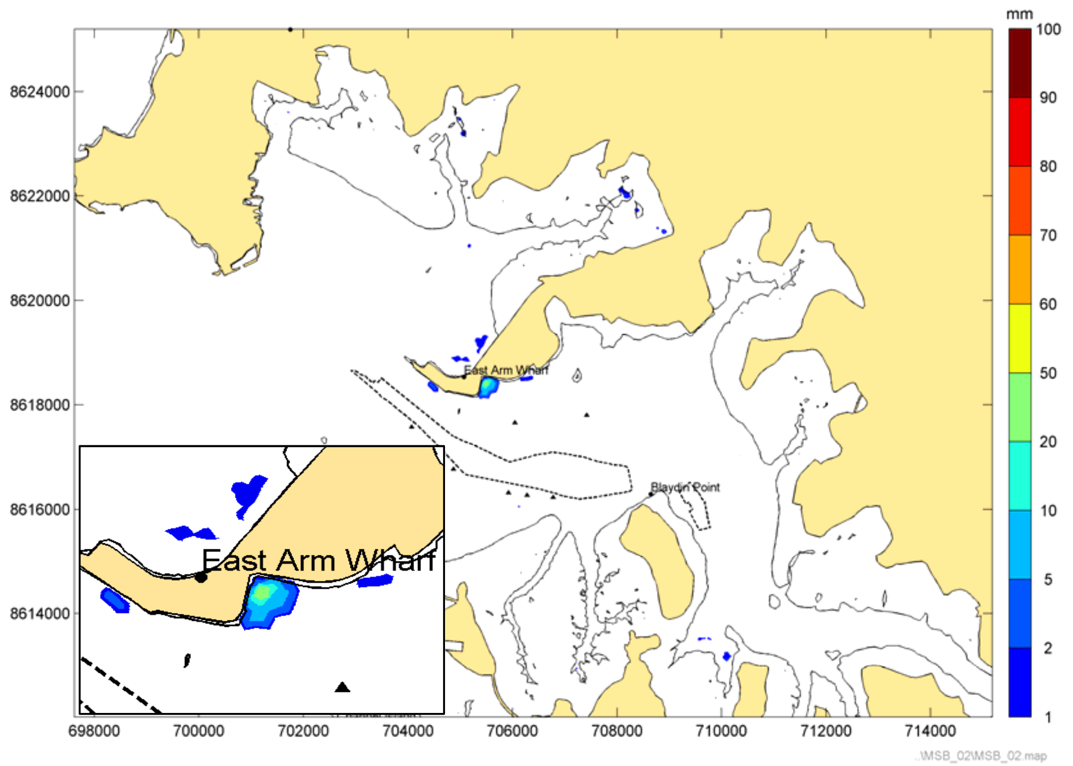

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Figure 5-7 Net sediment accumulation (mm) - end Stage Three.

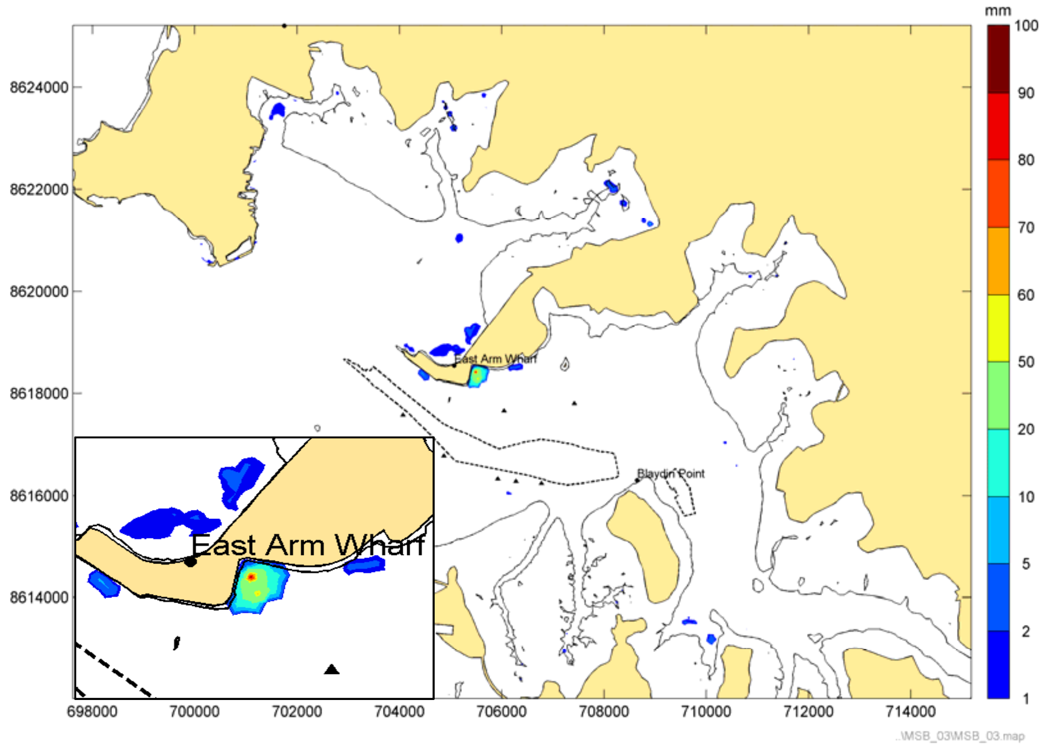
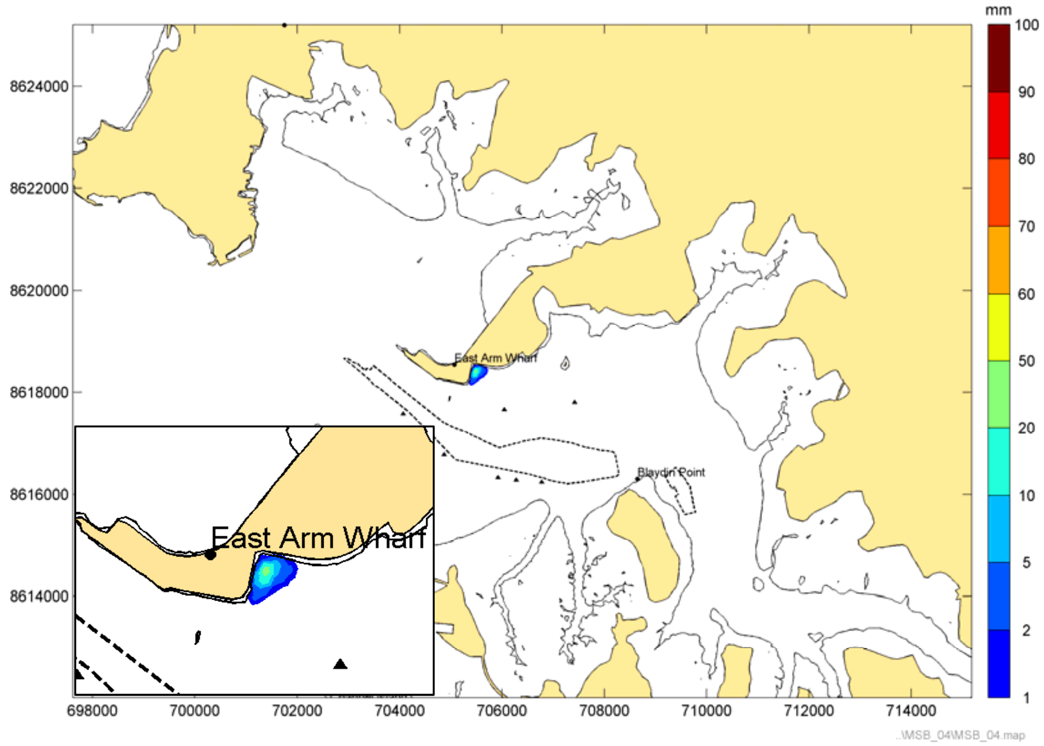


Figure 5-8 Net sediment accumulation (mm) - end Stage Four.



5.3.2 Tranche 2 model

The dredging program as implemented is proposed to include dredging during the Wet Season (Phase 2a), which requires the following considerations with respect to the assumptions in **Section 5.3.1**:

- While Phase 2a would commence in early Q2, rather than mid-Q2, of 2013 HRW (2010) found that wind conditions had only a minor influence on the dispersion of turbid plumes, which was primarily driven by tidal movement. Hence it is considered that the Dry Season modelling of turbid plumes arising from the dredge operation can be considered equally applicable to the Wet Season.
- The assumption of 1% loss of sediment from the dredge cutter head can remain unchanged. For Phase 2, this will equate to a loss of approximately 1,400 tonnes. Hence applying the Phase 1 model outputs to Phase 2 represents a conservative overestimate of the SSC and sedimentation levels predicted to occur during Phase 2.
- Retaining consideration of the discharge from the return pump system (from Pond E into the dredging footprint) adds further to the conservatism as such discharge was not required during Phase 1 and may not be required during Phase 2.

Although the actual dredging program progressed in a different sequence to that modelled in Tranche 1, the model outputs are still informative for the revised Phase 2 of the program as some dredging is still to take place in all areas of the dredging footprint covered by Stages One to Four. During Phase 1 of the dredging, surface sediments were removed from within the dredging footprint; in Phase 2 deeper sediments and consolidated materials will be removed from across the area.

Although the actual Phase 1 dredging progressed in a different sequence to the indicative program modelled in Tranche 1, the total dredge volume is the same for both tranches of modelling; hence the total net sedimentation predicted by Tranche 1 at the end of Phase 2 can be considered to be the sum of the sediment accumulation depths across all four of the stages modelled. This is a conservative consideration as it does not take account of the redistribution and consolidation of deposited sediments which will occur between the end of Phase 1 and the commencement of Phase 2 of the dredging program; these processes will reduce the total sedimentation depths at the sites of accumulation.

As the Tranche 1 modelling of turbid plumes arising from the dredging operation can be applied to Phase 2 of the dredging, Tranche 2 of the modelling was concerned only with the tailwater discharge through the permeable section of the railway bund. The assumptions used for the Tranche 2 modelling of sediment dispersion and sedimentation were:

- SSC of 100 mg/L for the return water. This represents considerable conservatism as the mean SSC recorded during Phase 1 at the southern end of Pond E was only 15.7 mg/L (averaged over 64 readings).
- Discharge of tailwater at a rate of 1,357 L/s (refer **Table 2-5**) for 24 hours per day over a 32 week period commencing one month before the end of the Wet Season. This allows for a period of seven weeks of continued discharge of tailwater from the ponds after the completion of dredging.
- Fall velocity of sediment of 0.06 mm/s, bed shear stress for erosion of 0.10 N/m^2, and bed shear stress for deposition of 0.08 N/m^2. These were based upon field observations taken in East Arm by AIMS for other projects.

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Tranche 2 model outputs are presented as:

- 90th percentile plot of SSC, showing the SSCs that are exceeded within the model less than 10% of the time, and 3 mg/L contour (**Figure 5-9**). The 3 mg/L contour is shown to assist comparison with **Figures 5-1** to **5-4**, on which 3 mg/L is the lowest SSC shown.
- 95th percentile plot of SSC, showing the SSCs that are exceeded within the model less than 5% of the time, and 3 mg/L contour (**Figure 5-10**).
- Sediment accumulation predicted to be attributable to tailwater discharge through the railway bund wall at the end of dredging Phase 2 (**Figure 5-11**). The 1 mm (1000 µm) contour is shown to assist comparison with **Figures 5-5** to **5-8**, on which 1 mm is the smallest deposition depth shown. This figure should be considered in conjunction with **Figure 5-8** as showing the predicted extent of sedimentation from the overall dredging campaign.

Figure 5-9 90th percentile plot of SSC (mg/L) and 3 mg/L contour– Tranche 2 model.

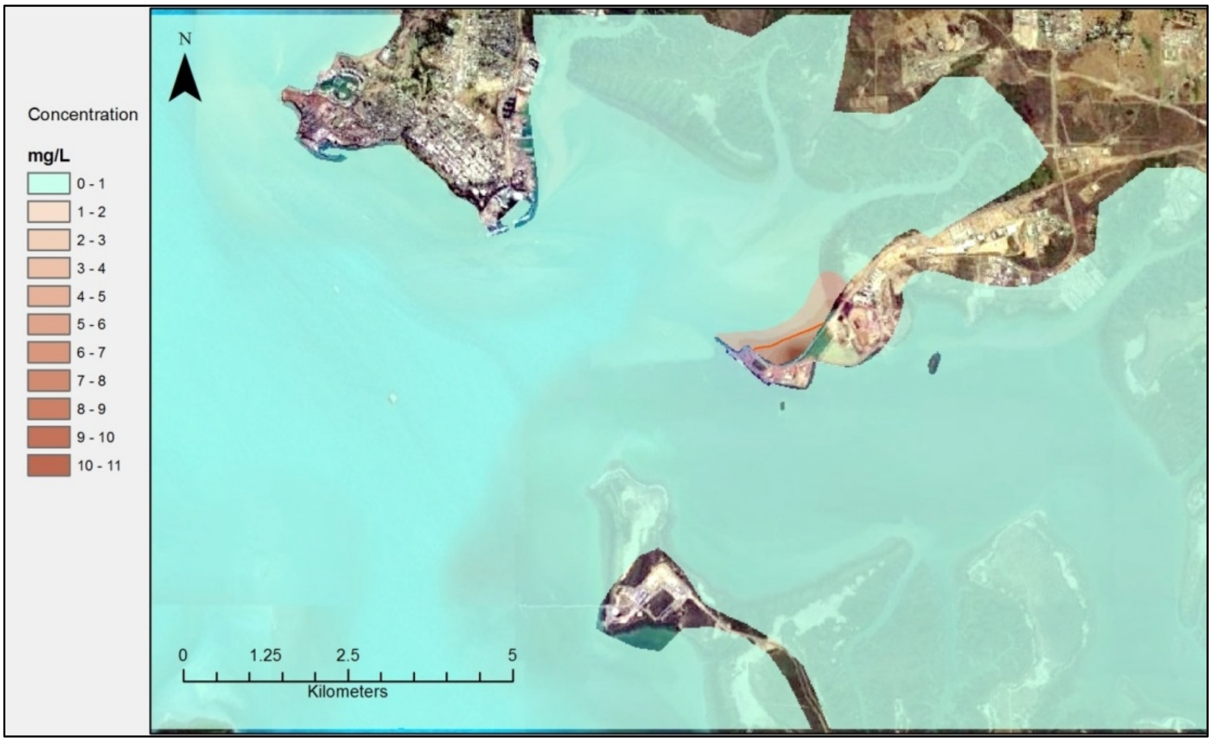

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Figure 5-10 95th percentile plot of SSC (mg/L) and 3 mg/L contour – Tranche 2 model.

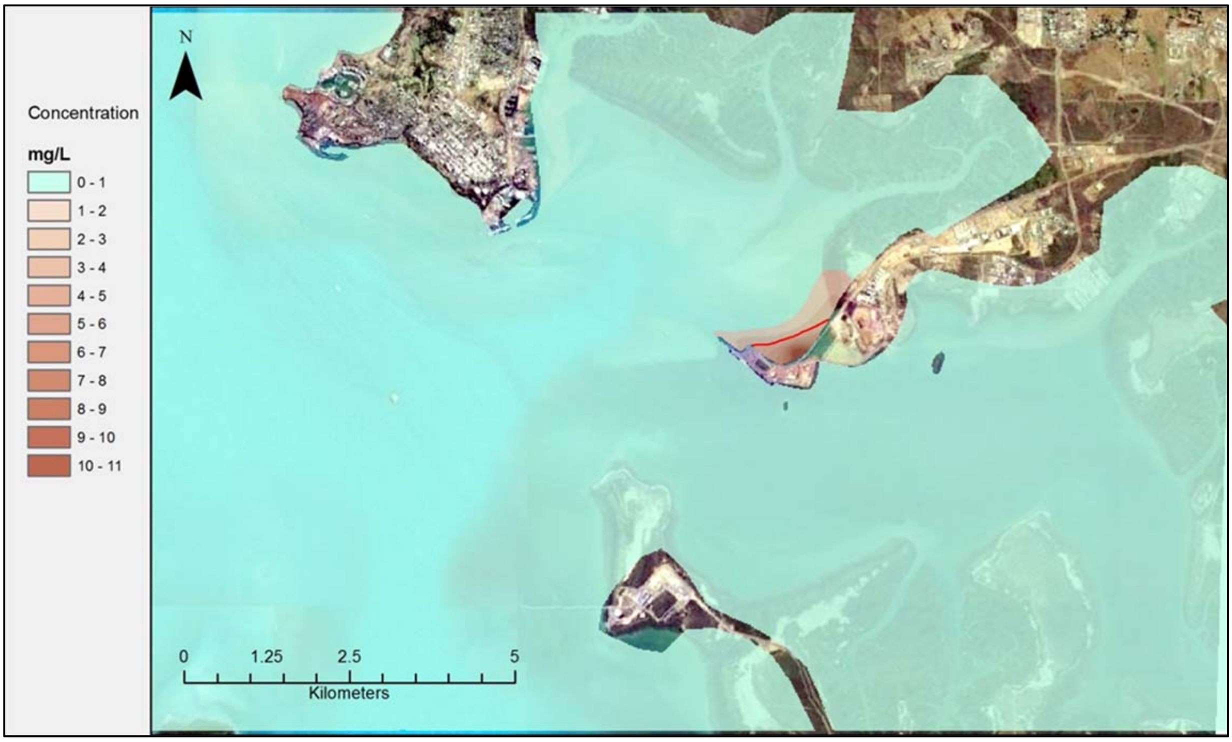
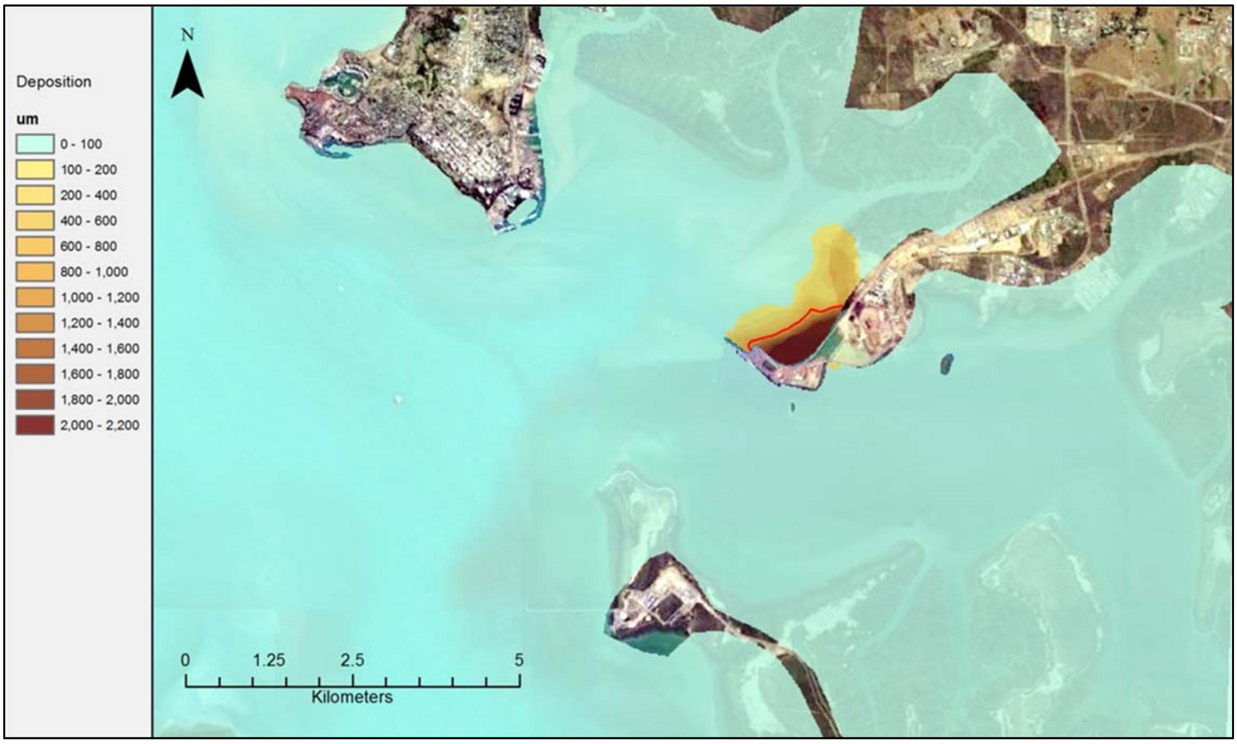


Figure 5-11 Net sediment accumulation (μm) and 1 mm deposition contour at the end of dredging Phase 2 - Tranche 2 model.



5.4 Tolerance limits for biological communities

The tolerance limits for biological communities derived by INPEX (2011a) were adopted to interpret the modelling results and to determine zones of potential impact by the dredging-induced excess turbidity and sedimentation.

For Phase 1 of the dredging program, tolerance limits for **SSC** were derived from the Dry Season subset of a one-year baseline dataset of water quality (URS 2011a), on the presumption that biological communities in East Arm are adapted to local conditions but will be stressed if exposed to conditions that regularly exceed the 95th percentile of normally prevailing background concentrations (calculated from the URS [2011a] Dry Season dataset to be 20 mg/L in East Arm). As the sediment transport model calculates excess (above background) SSC caused by the dredging and tailwater disposal, the median of the background concentrations (calculated from the URS [2011a] Dry Season dataset to be 10 mg/L in East Arm) was subtracted from the 95th percentile of the background concentrations. This yielded a tolerance limit for excess SSC of 10 mg/L in East Arm during the Dry Season.

For Phase 2a of the dredging program, the tolerance limit for excess SSC in East Arm during the Wet Season is calculated (from the URS [2011a] Wet Season dataset) to be 25 mg/L. This is derived using the same approach described above for the Dry Season (i.e. a 95th percentile of 36 mg/L minus a median of 11 mg/L). Phase 2b of the dredging program will be undertaken during the Dry Season and the corresponding tolerance limit will be applicable during this phase.

Tolerance limits for **sediment deposition** on mangroves were derived by INPEX (2010, 2011a) from a review of the outcomes of habitat-specific dose-response experiments and field observations reported in the scientific literature. These tolerance limits have been adopted for the MSB dredging program – i.e. 50 mm accretion may lead to reduced health or mortality; above 100 mm accretion mortality of trees was considered “likely”. For corals and filter-feeder communities, INPEX (2011a) contended that a meaningful sedimentation threshold could not be derived from the literature due to factors such as wide variations in tolerances between species, and between morphologies within species.

5.5 Zones of Impact and Influence

5.5.1 Tranche 1 model

For the assessment of potential dredging-related impacts upon benthic communities, definitions of Zones of Impact and Influence consistent with the EPA (2011) EAG7 (introduced in **Section 1.7.4**) were adopted:

- Zone of High Impact: this zone constitutes the direct footprint of the dredged area and a 20 m wide annulus around the footprints to account for smothering from coarse sediments liberated from the cutter head during dredging. Impacts in these areas are predicted to be severe and often irreversible.
- Zone of Moderate Impact: Within the Zone of Moderate Impact, damage to benthic habitats and mortality of benthic biota may occur, primarily as a result of the indirect impacts from increased turbidity and sedimentation that may occur at times over areas within the zone. Impacts within this zone are predicted to occur, but the disturbed areas may recover (after completion of the dredging and disposal operations). It is expected that there will be no long-term modification of the benthic habitats in this zone. The outer edge of the Zone of Moderate Impact is delineated by the 90th percentile contour plot for SSC, as defined by dredge plume modelling. This delineates the areas

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where, for 90% of the time, the predicted SSC is below the calculated tolerance for benthic communities (dredging related SSC of 10 mg/L for East Arm communities during the Dry Season, 25 mg/L during the Wet Season, refer **Section 5-4**). The 10% of time during which the SSC threshold is predicted to be met or exceeded is likely to represent periods of mid-flow tidal states (particularly during spring tides) and any one exceedance event is not likely to exceed two hours.

- Zone of Influence: this zone includes the areas in which, at some time during the dredging works, benthic communities may experience (detectable) changes in sediment-related environmental quality outside the natural ranges that are normally expected. However, the intensity, duration and frequency of these changes is such that any damage to benthic habitats is likely to be reversible, and no mortality of benthic biota is expected to occur. The outer boundary of this zone is delineated by the 95th percentile contour plot for SSC, as defined by dredge plume modelling. This reflects the area where, for 95% of the time, excess SSC from the dredging will be below the calculated tolerance for benthic communities (10 mg/L in the Dry Season, 25 mg/L in the Wet Season, refer **Section 5.4**). The potential Dry Season Zones of Impact and Influence (for SSC) predicted from the model outputs are presented in **Figure 5-12**. To define the boundaries of the Zones of Moderate Impact and Influence, the maximum distances from the dredge location to the modelled 10 mg/L contours on the 90th and 95th percentile plots were calculated for each dredging stage. These distances were then applied to the perimeter of the dredging footprint in the following manner:
- The distances from the dredge location to the 10 mg/L contour on each of the 90th percentile plots (the top plots in **Figures 5-1, 5-2** and **5-3**) were used to define the boundary of the Zone of Moderate Impact around, respectively, the small southern dredging area; the approach channel; and the turning basin.
- The distances from the dredge location to the 10 mg/L contour on each of the 95th percentile plots (the bottom plots in **Figures 5-1, 5-2** and **5-3**) were used to define the boundary of the Zone of Influence around the three segments of the dredging footprint in the same manner.

It should be noted that in the Tranche 1 modelling the Zones of Moderate Impact and Influence for Stage Four of the dredging, and also the zones associated with the tailwater discharge in all four stages, lay within the zone boundaries associated with the dredge.

From **Figure 5-12**, it is evident that, during Dry Season dredging:

- The Zones of High Impact and Moderate Impact only overlie habitats with less than 10% cover of benthic macrobiota on either sand or mixed sand/rock substrates.
- The Zone of Influence for the southern segment of the dredging footprint encroaches upon small areas of filter-feeder communities on a sand or rock substrate. For the main dredging footprint, the Zone of Influence only overlies habitats with less than 10% cover of benthic macrobiota on either sand or mixed sand/rock substrates.

The Dry Season Zones of Impact and Influence can be conservatively applied to Phase 2a dredging during the Wet Season as the 25 mg/L SSC contours are considerably closer to the dredge than the 10 mg/L contours (refer **Figure 5-3**). The Wet Season zones are therefore considerably closer to the perimeter of the dredging footprint than those shown in **Figure 5-12**. For Stages One, Two and Four of dredging, the 25 mg/L contour is not present on the model outputs (refer **Figures 5-1, 5-2** and **5-4** respectively) and the Zones of Impact and Influence therefore do not extend beyond the Zone of High Impact for these stages. Hence, for Wet Season dredging the Zones of Impact and Influence only

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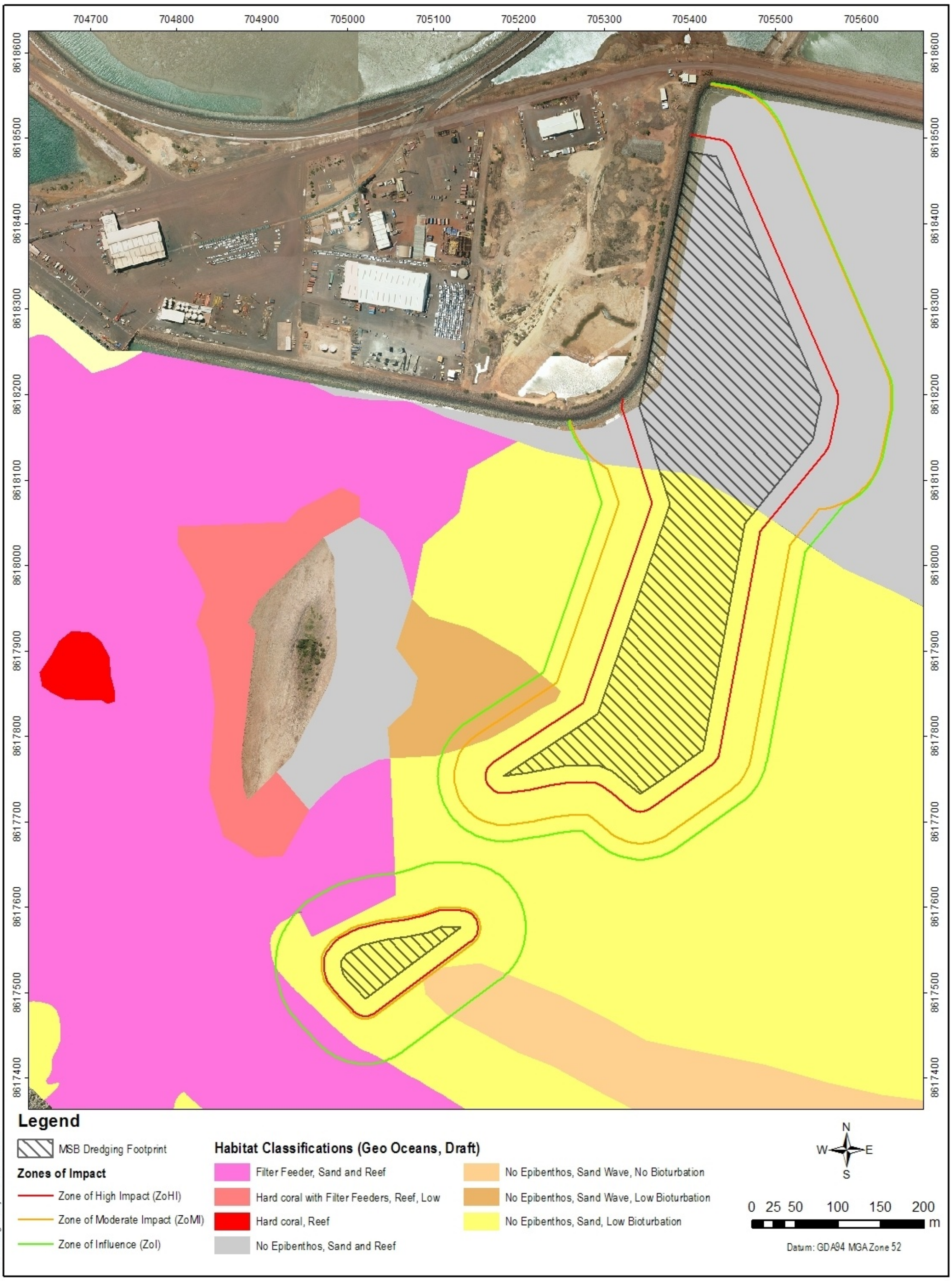
overlie habitats with less than 10% cover of benthic macrobiota on either sand or mixed sand/rock. substrates.

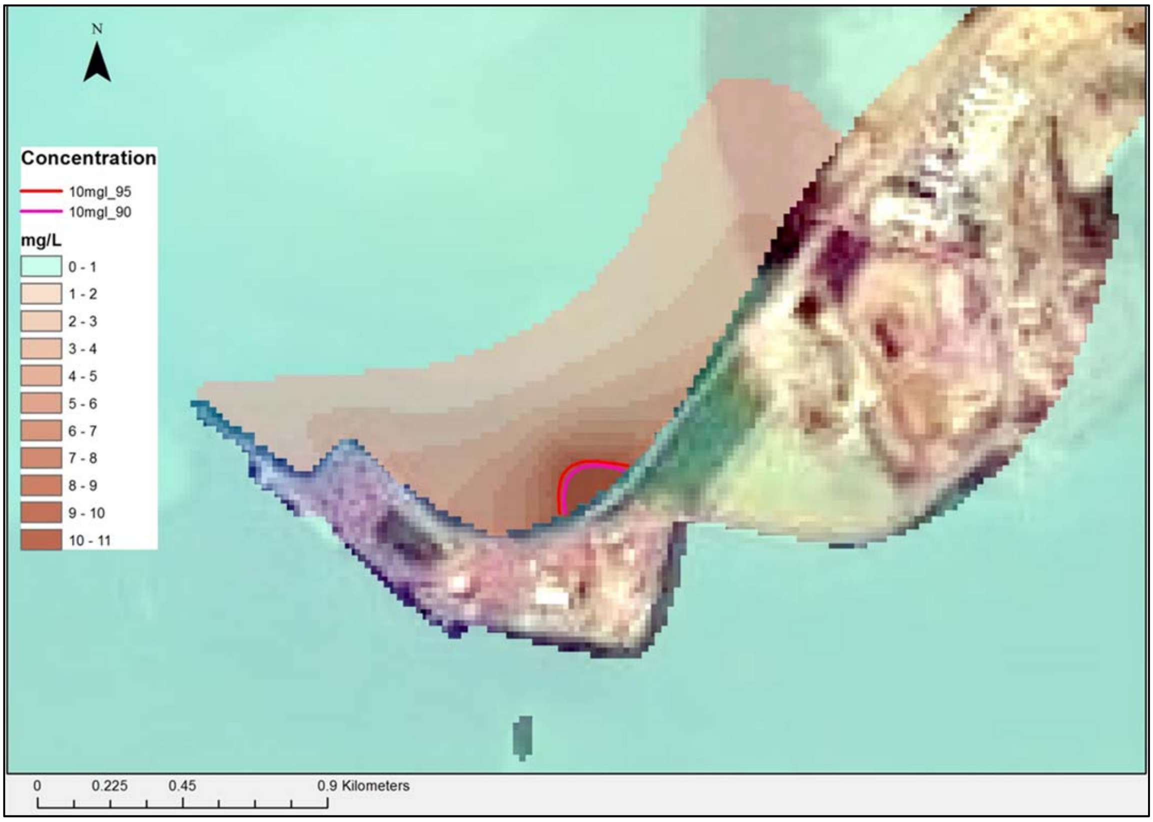
Figure 5-12 Predicted potential Zones of Impact and Influence (SSC) – Tranche 1 model



5.5.2 Tranche 2 model

Zones of impact and influence were derived from the Tranche 2 model outputs in the same manner as for the Tranche 1 model outputs (**Figure 5-13**).

Figure 5-13 Predicted potential Dry Season Zones of Impact and Influence (SSC) – Tranche 2 model.



The following are apparent from **Figure 5-13**:

- There is no physical disturbance to the seabed from dredging activities; hence there is no Zone of High Impact as defined by EPA (2011). If such a zone were to be delineated based upon the smothering of soft bottom benthic communities on the seaward side of the railway bund wall, then it would lie within the Zone of Moderate Impact.
- The outer edge of the Zone of Moderate Impact is delineated by the 90th percentile contour plot for SSC, as defined by the Tranche 2 modelling. This delineates the areas where, for 90% of the time, the predicted SSC is below the calculated tolerance for benthic communities (dredging related SSC of 10 mg/L for East Arm communities during the Dry Season, 25 mg/L during the Wet Season, refer **Section 5-4**). On **Figure 5-13**, the outer edge of the Zone of Moderate Impact for the Dry Season is shown as the purple contour, extending a maximum of approximately 100 m from the railway bund wall. For the Wet Season, there are no areas seawards of the railway bund wall where an SSC of 25 mg/L is exceeded more than 90% of the time; hence no Zone of Moderate Impact can be defined for the Wet Season.
- The outer boundary of the Zone of Influence is delineated by the 95th percentile contour plot for SSC, as defined by dredge plume modelling. This reflects the area where, for 95% of the time,

excess SSC from the dredging will be below the calculated tolerance for benthic communities (10 mg/L in the Dry Season, 25 mg/L in the Wet Season, refer **Section 5.4**). On **Figure 5-13**, the outer edge of the Zone of Influence for the Dry Season is shown as the red contour, extending a maximum of approximately 120 m from the railway bund wall. For the Wet Season, there are no areas seawards of the railway bund wall where an SSC of 25 mg/L is exceeded more than 95% of the time; hence no Zone of Influence can be defined for the Wet Season.

Overall, this indicates that any potential impacts arising from the discharge of tailwater through the permeable section of the railway bund wall are predicted to be limited to within a radius of approximately 120 m from the bund wall. This is predominantly a soft bottom habitat, though some filter-feeder communities and epibenthic biota may be present on the bund wall and these may be adversely impacted by the tailwater discharge. However, any impacts are likely to be reversible and, once the tailwater discharge ceases, the communities could be expected to regain their pre-discharge characteristics over time.

5.6 Conclusions

5.6.1 Suspended sediments

On the basis of the model outputs (**Figures 5-12** and **5-13**), it can be concluded that no impact upon habitats with greater than 10% cover of epibenthic macrobiota is predicted to occur as a result of the MSB dredging program. During Dry Season dredging only, two areas of filter-feeder habitat close to the southern segment of the dredging footprint are predicted to lie within the Zone of Influence, in which, at some time during the dredging works, benthic communities may experience (detectable) changes in sediment-related environmental quality outside the natural ranges that are normally expected. However, the intensity, duration and frequency of these changes is such that any damage to benthic habitats is likely to be reversible, and no mortality of benthic biota is expected to occur. Notwithstanding this conclusion, Macmahon has committed to monitoring the coral and filter-feeder communities of South Shell Island as it is acknowledged that there is a degree of stakeholder concern that they not be adversely impacted by the dredging program (refer **Section 7.3**).

5.6.2 Sedimentation

Figures 5-5 to 5-8 and **Figure 5-11** show that the accumulation of dredging-derived sediment is not predicted to exceed 50 mm in any of the mangrove communities that are potentially reached by the turbid plumes generated by the dredging and tailwater disposal. Hence it is concluded that potential sedimentation effects on mangroves need not be given further consideration in this Plan.

Although it has not been possible to derive reliable sedimentation thresholds for coral and filter-feeder communities, it is noted that, as shown in **Figures 5-5 to 5-8** and **Figure 5-11**, there is no net sedimentation of >1 mm predicted to occur within the coral and filter-feeder communities in East Arm (refer **Figure 4-2**). Hence it is concluded that potential sedimentation effects on these communities need not be given further detailed consideration in this Plan, with the exception that any excessive sedimentation on these communities will be recorded through the benthic communities monitoring program (**Section 7.3**).

5.7 Cumulative effects – INPEX

Recommendation 10 of the NRETAS Assessment Report (NRETAS 2011) recommends that an area of (potential) common impact with the INPEX dredging program should be defined and specific management measures developed. HRW modelled the combined effects on SSC and sedimentation of the MSB and INPEX dredging programs being undertaken concurrently and found that any potential effects from the MSB program were typically imperceptible from those potentially arising from the INPEX program:

- The Zones of Moderate Impact for SSC and sedimentation of the INPEX program were not substantially altered by the presence of the MSB dredging program.
- The MSB program did not contribute sufficient additional sediment to increase the areas of mangroves or benthic communities predicted to be at risk of impact from sedimentation through the INPEX program.

Whilst the Zones of Moderate Impact for SSC of the two programs may overlap, the Zone of Moderate Impact for SSC of the MSB program only overlies habitats with less than 10% cover of benthic macrobiota. Hence it is considered that no specific management measures are required.

As indicated **in Section 5.5**, the Zones of Moderate Impact and Influence are predicted to be smaller in the Wet Season than in the Dry Season, hence the extent of cumulative effects during the Wet Season will be concomitantly smaller.

While concurrent dredging activities are occurring, the cumulative effects of both on SSC at the South Shell Island monitoring site (see **Section 7.3.2**) will be evident. The monitoring to be undertaken by Macmahon at the perimeter of the MSB dredging footprint (**Section 7.3.2**) will inform the TAG's consideration of the extent to which the MSB dredging program is contributing to the SSC levels over the benthic communities around South Shell Island.

In the event that the investigation of attributability is complex due to potential cumulative impacts to the sensitive receptor from dredging programs occurring concurrently in the vicinity of the South Shell Island benthic communities, the proponent will investigate the lines of evidence and coordinate a meeting with the relevant dredging parties (e.g. Van Oord, Boskalis, INPEX and NTG as required) to determine the likely cause and appropriate management measures (if related to Macmahon activities) within five business days following the initial notification.

Environmental Management

6.1 Introduction

This section describes the Environmental Management Frameworks (EMFs) that have been developed for the key risks associated with the dredging works, as identified through the environmental risk assessment process (DLP 2010, 2011). The EMFs are instrumental to effectively manage and mitigate environmental risks to sensitive receptors identified in **Section 4**.

EMFs have been developed for the following aspects:

- Water quality – dredge spoil placement ponds
- Water quality – East Arm
- Protected marine species – physical interaction
- Protected marine species – underwater noise
- Migratory birds

Each EMF states the relevant Project commitments made and objectives to be met, and contains specific, measurable targets to achieve the objectives. It also summarises the management actions required to meet these targets, the relevant KPIs and the monitoring activities to be employed to measure success in meeting the requirements and identify the need for corrective actions.

It should be noted that:

- Management actions are routine tasks that will be undertaken to meet the objectives of each EMF.
- Corrective actions are those tasks that are possible to be undertaken if monitoring indicates that trigger levels have been exceeded.

Where trigger levels are proposed, it should be noted that these are triggers for further investigation and are set well below levels at which significant adverse ecological effects could be anticipated. Monitoring is described in greater detail in **Section 7**. Each EMF also indicates the relevant reporting requirements (detailed further in **Section 8**) and the responsibilities of project personnel.

The Proponent is working closely with INPEX regarding dredge management planning and related monitoring programs so that activities for the two projects consider the temporal and spatial scale of each other's activities and a consistent approach that maximises synergies and learning outcomes can be achieved.

6.2 Water quality – dredge spoil placement ponds

6.2.1 Potential impacts

Potential impacts upon the water quality within the dredge spoil placement ponds (reduced pH) may occur as a result of generation of acid if dredged sediments that contain PASS are exposed to air within the ponds for extended periods. Synergistic impacts may arise if the more acidic water leaches metals (arsenic in particular) from the dredged sediments, or from the existing sediments in the ponds.

If acidic water is pumped from the ponds into East Arm, then impacts around the discharge location could include:

- Injury to, or mortality of, protected marine species, fish, crustaceans, mangroves, etc.
- Reduction of bicarbonates in the receiving water, potentially resulting in deformities in shellfish development.
- Release of contaminants from sediment in the receiving environment.

- Corrosion of metals and weakening of concrete structures, potentially impacting on infrastructure and/or engineering works.

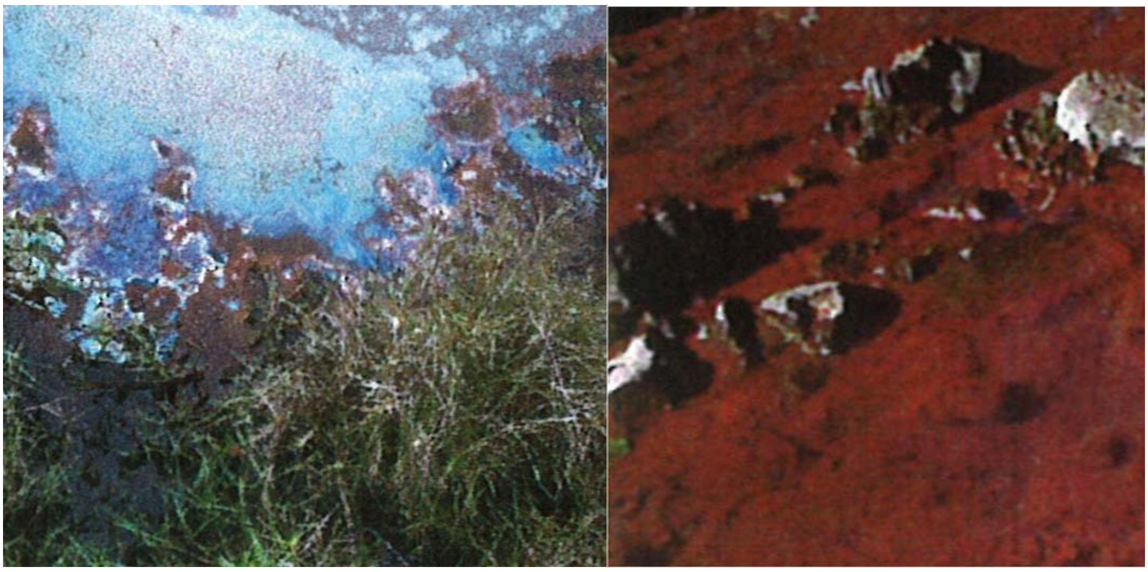
Potential impacts upon the receiving environment from the discharge of tailwater with elevated concentrations of suspended sediments are addressed in **Section 6.3.**

6.2.2 Potential indicators of impact

Some indicators for the presence of acid leachate arising from oxidation of PASS (**Figure 6-1**) are:

- Green-blue water, sometimes cloudy but sometimes extremely clear due to the presence of metals that have leached from the soils (aluminium).
- Rust coloured strains on soils, and rust coloured slime on water (due to iron oxidising bacteria).
- Yellow patches on soils as they dry out ("jarosite").

Figure 6-1 Potential indicators of acid leachate



6.2.3 Water quality criteria for disposal of tailwater

The key water quality guidelines that are relevant to the MSB development are the Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000 (hereafter 'ANZECC Guidelines', ANZECC & ARMCANZ 2000) and the Water Quality Objectives for the Darwin Harbour Region 2010 (hereafter 'Darwin Harbour Region Water Quality Objectives' [Fortune & Maly 2009, NRETAS 2010]). Further discussion of the applicability of these guidelines is presented in **Section 6.3.2**.

The ANZECC Guidelines and Darwin Harbour Region Water Quality Objectives apply to the receiving environment, rather than to the tailwater. However, if the tailwater meets the following criteria then it will be considered suitable for continued disposal:

- The daily mean **pH** of the three water samples collected during monitoring at the discharge point from Pond E (see **Section 7.2.2**) is greater than 6.0 and less than 8.5. This will meet the criterion for an Upper Estuary setting, as presented in the Darwin Harbour Region Water Quality Objectives.

6 Environmental Management

- For **toxicants**[1] (including arsenic) the Darwin Harbour Region Water Quality Objectives defer to the ANZECC Guidelines. Hence concentrations of toxicants will be compared against the ANZECC Guidelines for slightly to moderately disturbed ecosystems (i.e. for 95% species protection) (ANZECC & ARMCANZ 2000, Table 3.4.2). For some toxicants (including arsenic) the ANZECC Guidelines have no criteria levels for marine waters as there are considered to be insufficient data to derive reliable trigger values. In these instances it is proposed to adopt the criteria levels for fresh water. The list of metallic toxicants to be tested (presented in **Section 7.2.3**) is based on the potential presence and toxicity of these metals in Darwin Harbour. It is noted that none of these metals (with the exception of arsenic) were found at concentrations exceeding the ANZECC Guidelines during testing for this project.

Measures to reduce the acidity of the pond system (refer to **Section 6.2.4**) if pH is below 6 or contaminant concentrations exceed ANZECC guidelines, and to improve settlement rates if SSC exceeds the target value at the perimeter of the dredging footprint, will be implemented and confirmed as successful by monitoring before recommencing discharge.

The target **SSC** for the tailwater will be 100 mg/L. As SSC cannot be monitored directly in the environment, turbidity (in Nephelometric Turbidity Units [NTU]) is used as a surrogate measure. A mathematical relationship between the two measures has been derived from water samples collected within the pond system and analysed for both SSC and turbidity. An interim target of 111 NTU, calculated from the SSC/NTU relationship presented in URS (2011a), was applied at the onset of dredging. After the first four weeks of dredging, this target was increased to 135 NTU on the basis of the data collected over that period. The SSC/NTU relationship is now updated as further SSC and NTU data are collected during water quality monitoring in the ponds and the most recent NTU value is applied in the monitoring program (refer **Table 7-1**).

6.2.4 Management of Water Quality

6.2.4.1 Management of potential acid sulfate soil

Macmahon will disturb only the minimum footprint necessary for dredging the channel.

Contingency Potential Acid Sulfate Soil (PASS) management options that will be applied include:

- Neutralisation of PASS using lime (refer to detailed description below).
- Strategic Reburial (without prior lime treatment). Reburial within the ponds at East Arm is likely to be the most suitable management option, at depth and covered with non-PASS materials.

As PASS was located and mapped during the sediment geochemical investigation (URS 2012a), a range of management options were considered (URS 2012a). It is likely that the most suitable option will be strategic reburial, within the existing East Arm ponds that have been constructed in the past for the purpose of receiving fill.

PASS sediments will be dredged into the lower portion of the ponds and sediments that are not PASS can then be deposited on top, allowing for strategic burial of the underlying PASS materials within the ponds. Depending on the %S levels, additional treatment may be necessary; in liaison with the

[1] The ANZECC Guidelines define a toxicant as a chemical capable of producing an adverse response (effect) in a biological system at concentrations that might be encountered in the environment, seriously injuring structure or function or producing death. Examples include pesticides and heavy metals.

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Proponent, NT EPA and SEWPaC, actions such as lime treatment, covering with clean soils or water, etc. may be necessary.

6.2.4.2 Neutralisation of PASS

Physically incorporating neutralising alkaline materials, such as lime, into the soil is a common technique used in managing PASS. It is important that sufficient lime is used to ensure that existing soil acidity and all potential acidity that can be generated is neutralised over time. Lime treatment is an option whereby the soils can be reused as clean fill (noting that the soils are often unsuitable for geotechnical reasons).

The laboratory analysis of the oxidisable sulphur in each soil sample is used to calculate the amount of acid that can be generated if the sulphides are completely oxidised or totally exposed to the air. The results are generally given by the laboratory in %S.

The analytical results from the laboratory chromium reducible sulphur test provide a liming rate (kg lime/tonne of soil). These rates can also be estimated using Table 3 in the Queensland Acid Sulfate Soils Investigation Team guidelines (QASSIT 2008). These include a safety factor of 1.5. An approximate weight can be obtained from volume by multiplying volume (m^3) by bulk density (t/m^3).

It is important to mix adequate neutralising material so that all acid that can be produced is neutralised and to bring the pH of the soil to 5.5 as a minimum. Suggested neutralising agents for the treatment of ASS should be slightly alkaline with low solubility (pH 7–9). Fine aglime ($CaCO_3$) is the preferred neutralising agent for treating ASS, using the purest form available.

The guidelines recommend constructing a treatment pad, including a compacted clay layer, leachate collection system and containment with bunding.

Where excavation and mechanical mixing are not feasible, a more soluble material such as hydrated lime $Ca(OH)_2$ or sodium bicarbonate $NaHCO_3$ can be used.

Soil that has been treated using a neutralising agent such as lime should follow the following performance criteria:

- An excess of the neutralising agent (lime) should be used to allow for potential acidity of the soil
- Post neutralisation of the soil, the pH is to be 5.5 or greater
- The excess lime should remain in the soil until all acid generation reactions are complete.

Validation samples will be collected of the mixed material, at a rate of to be determined. This will determine if the criteria have been met. Soil that has not met the above criteria must be retreated until it meets the performance criteria. Normal turnaround time for samples is two weeks. If needed, additional lime can be mixed in at any time after the sample results have been received.

6.2.4.3 Water quality management (ponds)

The tailwater will be managed within the settling ponds such that the quality of the water discharging through the railway bund wall (or pumped into the dredge footprint if the backup system is utilised) is within the guideline criteria discussed in **Section 6.2.3**. If trigger levels are exceeded within any of the ponds then this will be reported to NT EPA and to the Proponent within 24 hours of the exceedance occurring. The pond in which the exceedance occurred will be isolated from the tailwater management system until corrective actions (**see Table 6-1**) can be implemented to preserve the quality of the receiving waters. It will remain isolated until such time that it can be demonstrated that the pond can

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be reinstated into the tailwater management system without causing the water quality in Pond E (South) to exceed trigger levels.

The frequency of monitoring within the ponds (refer **Section 7.2**) limits the risk of trigger level exceedances within Pond E (South) arising from tailwater effects. Trends identified within the preceding ponds will enable corrective actions to be implemented before exceedances occur within Pond E (South). In this manner Pond E (South) is effectively considered to be the 'receiving environment', with the railway bund wall providing an additional buffer against impacts upon the environment of Frances Bay and Darwin Harbour.

During construction of the bund wall to separate Pond E into 'North' and 'South', suspended sediment concentrations in Pond E will be managed using silt curtains, in a manner that will allow stormwater (and tailwater, if dredging is in progress) to flow around the construction area. If trigger levels are exceeded outside of the railway bund wall during this work, then construction of the bund wall will cease until the water quality within Pond E (South) returns to within the trigger levels.

To manage pond volumes, it may be necessary for Macmahon to move slurries between Pond E (North) and Pond K. Trigger levels within these ponds may be exceeded during these periods and, if so, then the ponds will be isolated from Pond E (South) if trigger levels are also exceeded outside of the railway bund wall. They will remain isolated from the tailwater management system until such time as water quality within Pond E (South) returns to within the trigger levels.

Table 6-1 Water quality EMF – dredge spoil placement ponds

Water Quality Management Framework - dredge spoil placement ponds	
Element	Maintenance of water quality within dredge spoil placement ponds.
Commitments	EPBC 2010/5304 condition 28 WDL 187 conditions 8, 9 and 17-29
Objectives	• No increase in acidity within pond waters to the extent that the tailwater is unacceptable for discharge due to low pH or elevated toxicant concentrations. • No adverse impacts upon migratory birds utilising the ponds. • To protect receiving waters from dredging-related impacts.
Target	1. No occasions when tailwater pH is outside the guideline range (6.0-8.5) within the ponds, or at the point of discharge to the marine environment, as a result of acid leachate generation. 2. No exceedances of ANZECC & ARMCANZ (2000) water quality criteria for arsenic or other bioavailable toxicants within the ponds (refer to **Section 7.2**). 3. 100% of tailwater ready for discharge has SSC less than 100 mg/L (measured as turbidity, refer **Section 6.2.3** and **Table 7-1**). 4. Pond D must not exceed 5.5 m AHD during the Wet Season. 5. No occasions when tailwater discharging from Pond E/Pond E (South): a. Contains floating oil or grease or petroleum hydrocarbon sheen or scum, or litter or other objectionable matter. b. Causes or generates odours which would adversely affect the use of surrounding waters. c. Causes algal blooms. d. Causes visible change in the behaviour of, or mortality of, fish or other aquatic organisms.

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Water Quality Management Framework - dredge spoil placement ponds	
	e. Causes adverse impacts on plants.
Key Performance Indicator(s)	• Number of instances when pH or bioavailable toxicant concentrations are outside of acceptable guidelines (pH <6.0 or >8.5; bioavailable toxicant concentrations >ANZECC Guidelines) within the ponds or at the point of discharge to the marine environment. • Number of instances when SSC in Pond E/Pond E (South) is >100 mg/L (measured as turbidity, refer **Section 6.2.3** and **Table 7-1**). • Number of instances when target criteria 5 (a)-(e) are not met.
Management	• Ensure that all site personnel are aware of potential issues with PASS (via induction and toolbox meetings). • Ensure the Dredging Contractor is aware of the PASS locations identified in the 2012 geochemical assessment (URS 2012a). • The dredged sediments are pumped via pipeline into the ponds, and the sludge is allowed to settle within the ponds. PASS sediments will not be stockpiled or transported to where they may be exposed to the atmosphere. • Placement of dredged PASS material in a designated area, at a deeper level within the dredge spoil disposed in Pond K than the subsequent layers, preventing oxidisation of PASS material. • Ensure control is maintained over discharge into Pond E and it can be stopped within designated timeframes. • During normal dredging operations, Pond K water levels maintained at 4.5 to 5.0 m AHD to ensure sufficient water to facilitate settlement of suspended sediments and to minimise mobilising existing sediments. • During the later stages of dredging, raise the height of the Pond K bund walls to 6.5m AHD to allow the water levels in Pond K to be maintained at 6.0mAHD to ensure sufficient water to facilitate settlement of suspended sediments and to minimise mobilising existing sediments. • During the later stages of dredging, in the event the tailwater being discharged from Pond K is above the nominated SSC/Turbidity trigger levels (ie 100mg/L/135NTU) then ensure the tailwater water quality at the Pond E (North) and Pond E(South) discharge locations are less than the nominated trigger levels. • A geofabric filter was placed over the permeable section of the railway bund wall before dredging commenced. • During the Wet Season, dredge spoil will be deposited only into Pond K.
Monitoring (**Sections 7.2, 7.3**)	• Water quality monitoring within ponds – pH, toxicants, NTU as detailed in **Section 7.2**. • Water quality monitoring at perimeter of dredge footprint, and permeable section of railway bund as detailed in **Section 7.3**. • Visual monitoring of target criteria 5 (a)-(e) outside the permeable section of railway bund (during the water quality monitoring events indicated in **Section 7.3**).
Reporting (**Section 8**)	• Weekly reporting of data to TAG and the Proponent. • Monthly reporting of data to NT EPA. • Monitoring report to NT EPA at conclusion of each dredging phase. • Annual audit and compliance report to NT EPA. • Trigger level exceedances will be reported to the Proponent, and to SEWPaC (on behalf of the Proponent), within 24 hours of the exceedance occurring. The Proponent will also notify the TAG. • Trigger level exceedances will also be reported by Macmahon direct to NT EPA within

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Water Quality Management Framework - dredge spoil placement ponds	
	24 hours of the exceedance occurring and a report on corrective actions implemented to address the cause of the exceedance within five business days of the notification.
Corrective Action(s)	• If pH falls below 6.0 or exceeds 8.5, SSC exceeds 100 mg/L, or bioavailable toxicant concentrations exceed ANZECC Guidelines in Pond K, Pond D (in the Dry Season) or Pond E (North) then flows between ponds (including into Pond E [South] if the exceedance is in the preceding pond) will be blocked (using weirs, steel plates or expanding plugs) within one hour of detection (refer **Section 2.5.5**). • If deemed by Macmahon and the TAG to be potentially effective in returning water quality in Pond K to below criteria levels, the water level will be raised to 6.0 m AHD to mitigate wind and wave actions, allowing more sediment to settle and to reduce mobilisation of existing sediment. • If deemed by Macmahon to be potentially effective in returning the pH of the water in any of the ponds to above 6.0, lime will be applied to discrete areas within the ponds. Lime will also be applied to pond sediments that are exposed to air if it is apparent they are a source of acidification of the water. Water will be recirculated within the affected pond(s) until the pH at the point of discharge into the next pond, or to the receiving environment, is >6.0 (but below 8.5). • If pH is >8.5 in any pond, then the water will not be discharged into Pond E (South) until such time as the pH decreases to below 8.5 (but above 6.0). The elevated pH will add to the buffering capacity of the pond system to neutralise acid that may be generated from the exposure to air of ASS. • If toxicant concentrations exceed ANZECC Guidelines in any of the ponds, the pond will be isolated from the system using the methods described above. The water may be diluted using water with lower toxicant concentrations (either from within the pond system or from within the dredging footprint) until toxicant concentrations are returned to below ANZECC Guideline levels. • If deemed by Macmahon and the TAG to be potentially effective in reducing SSC, the flow path of the water through Pond K will then be increased, using measures such as internal bunds or silt curtains to allow greater settlement of the sediment. • During the later stages of dredging, increase the number of silt curtains in Pond E(North) to assist with increasing the settlement of sediments out of the tailwater passing through Pond E (North) and ensure tailwater passing into Pond E (South) does not exceed the Pond E (South) SSC/turbidity trigger levels (ie 100mg/L/135NTU) • If SSC exceeds 100 mg/L in the Dry Season, tailwater will be diverted through Pond D to allow settlement of sediment, thereby reducing SSC levels.
Term	• For the duration of tailwater disposal.
Responsibility	• Macmahon to ensure Dredging Contractor's documents are compliant with the DDSPMP • Macmahon Project Manager to ensure the Dredging Contractor implements monitoring program and water quality management measures • Dredging Contractor is required to take direction from the Project Manager

6.3 Water quality – East Arm

6.3.1 Potential impacts

The cutter head of the dredge will generate plumes of turbid water containing elevated levels of suspended sediments. The tailwater discharge from the dredge spoil placement ponds will also increase the levels of suspended sediments in the vicinity of the MSB. The plumes of suspended sediments could impact upon marine organisms through clogging of feeding or respiratory structures or through a reduction in light penetration through the water column. As the suspended sediments settle, this could lead to smothering of benthic communities.

6.3.2 Water quality guidelines and objectives

As discussed in **Section 6.2.3**¸ the key water quality guidelines that are relevant to the MSB are the ANZECC Guidelines and the Darwin Harbour Region Water Quality Objectives. The Darwin Harbour Region Report Cards (e.g. Drewry et al. 2011, Aquatic Health Unit 2013) are also relevant as they contain data from ongoing NTG water quality monitoring in Darwin Harbour.

The National Water Quality Management Strategy recommends that “the guidelines for each indicator should be based on locally derived data to reflect local (ambient) conditions. Where derivation of guidelines based on local monitoring is not possible, it is recommended that the national ANZECC Guidelines are used instead (for tropical Australia)”.

Therefore, the most applicable guidelines for this project are Darwin Harbour Region Water Quality Objectives, and in the absence of guidelines for certain parameters, reference will be made to the national ANZECC Guidelines.

The Darwin Harbour Region Water Quality Objectives reports (Fortune & Maly 2009; NRETAS 2010) state that in the case of Darwin Harbour the most stringent water quality criterion is the environmental Beneficial Use category. This is because the intent of environmental beneficial use is to maintain the health of aquatic ecosystems, and a water body that meets an environmental beneficial use will in almost all circumstances also meet the requirements for all other beneficial uses. Human health related guidelines are also provided to protect recreational and cultural values in the region.

NRETAS (2010) has adopted the ANZECC Guidelines approach for physico-chemical indicators for slightly to moderately disturbed systems. The ANZECC guidelines have defined acceptable effect sizes for each level of protection for different indicator types (**Table 6-2**).

Table 6-2 ANZECC Guidelines default effect size for varying levels of protection

Indicator Class	Effect Size or Departure from Reference		
	High Conservation Value Systems	Slightly to Moderately Disturbed Systems	Highly Disturbed Systems
Toxicants in water	No change to natural values	95% of species protected	80-90% spp. protected
Toxicants in sediments	No change to natural values	>90% individuals protected	
Physico-chemical*	No change to natural values	Median lies within $20^{th}/80^{th}$ percentile of reference range*	Locally determined ($10^{th}/90^{th}$ percentile of range)
Biological	No change to natural values	Median lies within $20^{th}/80^{th}$ percentile of reference range	Locally determined ($10^{th}/90^{th}$ percentile of range)

*Applicable to the approach taken with WQOs for the Darwin Harbour region

NRETAS (2010) states that the Darwin Harbour Region Water Quality Objectives can be used as a tool for monitoring water quality and supporting decision making on the management of activities affecting coastal marine waters in the Darwin Harbour Catchment. They apply to ambient waters (i.e. the receiving waters) and should not be regarded as individual discharge criteria. The values include protection of aquatic ecosystems and recreational activities associated with the use of marine waters such as swimming, boating and fishing. Where the values are not being met, planning and management of these areas should move towards achieving the objectives over time.

The Darwin Harbour Region Water Quality Objectives and the ANZECC Guidelines can be used to provide guidance to those undertaking water quality monitoring programs by providing key water quality indicators that can be monitored over time. Measured water quality can be compared with the criteria to determine whether management goals are being achieved or where management action is required.

6.3.3 Trigger levels

6.3.3.1 South Shell Island – water quality

Reactive turbidity trigger levels have been set for the South Shell Island water quality monitoring site; these are based on turbidity data collected by URS (2011a) in a long-term water quality study conducted in Darwin Harbour. The URS data were collected every 15 minutes at two sites in East Arm (South Shell Island and North-east Wickham Point) over a year-long program. Data were grouped and averaged based on tidal cycle and seasonal variation, allowing seasonal means, medians, and percentiles to be calculated. This gives a robust body of data to compare background levels of turbidity with potential increases associated with various natural and artificial turbidity-generating events in the harbour.

The trigger levels have been calculated in accordance with the methodology applied by INPEX (2012), which in turn follows the principles of McArthur, Ferry and Proni (2002). Thus there are separate trigger levels for:

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- Intensity - the 99th percentile (Dry Season) or 95th percentile (Wet Season) of the URS (2011a) data; i.e. the levels below which 99% and 95%, respectively, of background turbidity data values fall. Turbidity levels in excess of these can therefore be identified with a high degree of confidence as being above normal background concentrations; and therefore potentially have an adverse impact on benthic communities.
- Duration – the number of consecutive days over which the four-day rolling average turbidity level is above the 95th percentile (Dry Season) or 90th percentile (Wet Season) of the URS (2011a) data. This recognises that turbidity levels that are lower than the intensity trigger may still be detrimental to benthic communities if there is a prolonged duration of exposure.
- Frequency – the number of days within each seven day period when the four-day rolling average turbidity level is above the 95th percentile (Dry Season) or 90th percentile (Wet Season) of the URS (2011a) data. This recognises that turbidity levels that are lower than the intensity trigger may be still be detrimental to benthic communities if they are frequently exposed to these levels, even if the days of exposure are not consecutive.

The Trigger Levels in INPEX (2012) relate exclusively to Channel Island; no Trigger Levels for South Shell Island were calculated by INPEX (2012) as they have no reactive monitoring associated with South Shell Island. However, the same methodology as that used by INPEX (2012) for Channel Island has been applied to South Shell Island in this DDSPMP. The East Arm subset of the URS (2011a) dataset was used for this DDSPMP.

The duration and frequency trigger levels were derived from the frequency distribution of the number of days on which, in the baseline dataset (URS 2011a), mean turbidity levels exceeded the 90th percentile level. The higher number of consecutive days, and the higher number of days within a seven day period, for the Wet Season than the Dry Season reflect the incidence of longer-duration elevations of background turbidity levels during the Wet Season. This can be due to factors such as turbidity generated from stormwater runoff entering the harbour from creeks and rivers entering East Arm. The lower 90th percentile level at South Shell Island (**Table 6-3**) than at Channel Island (INPEX 2012) reflects the lower turbidity levels in East Arm than at Channel Island in the baseline Wet Season dataset (URS 2011a).

The trigger levels for turbidity (in NTU) are shown in **Table 6-3**.

Table 6-3 Turbidity trigger levels for South Shell Island for the MSB Dredging Program

Trigger category	Level	
	Dry Season	Wet Season
Intensity	>12 NTU (99th percentile)	>35 NTU (95th percentile)
Duration	>10 NTU (95th percentile) over 4 consecutive days	>23 NTU (90th percentile) over 7 consecutive days
Frequency	>10 NTU (95th percentile) for >4 days per 7 day period	>23 NTU (90th percentile) for >6 days per 7 day period

If any of the trigger levels in **Table 6-3** are exceeded by the four-day rolling average NTU level at the South Shell Island monitoring site (**Section 7.3**), this will be reported by Macmahon to NT EPA, the

Proponent and SEWPaC (on behalf of the Proponent) within 24 hours of the exceedance occurring. The Proponent will also notify the TAG. Also within 24 hours, corrective actions (**Table 6-4**) will be trialled to determine which have the greatest potential to reduce the dispersion of plumes from the dredging and tailwater discharge operations to reach the South Shell Island monitoring site.

Concurrently, an attributability assessment will be initiated by Macmahon to determine whether or not the exceedance was likely to have been caused by dredging or tailwater discharge activities. This assessment will be completed and sent to the TAG for review within three business days of the exceedance occurring. It will include consideration of information such as:

- Changes in water quality at the reference sites (which would indicate whether there were regional increases in turbidity due to natural factors such as storm activity)
- Periodic water quality data collected at the perimeter of the dredging footprint.
- Observations of turbid plumes emanating from other sources (such as INPEX dredging operations) within East Arm.
- Wind, wave, current direction and tidal data.

If it is deemed by the TAG that the exceedance is potentially due to the MSB dredging or tailwater discharge operations, then those corrective actions (**Table 6-4**) that the trials have shown to be effective in adequately reducing turbidity emanating from these activities will continue to be implemented until such time as the turbidity levels fall to below all of the trigger levels in **Table 6-3.** Reactive benthic community monitoring (refer **Section 7.3.3**) will be initiated on the following neap tide.

If there is evidence that the exceedances may be due to INPEX dredging operations, then the attributability assessment period will be extended by a further two business days to incorporate the input of parties to those operations (refer **Section 5.7**). In the event that clear attributability cannot be ascribed, increasingly stringent corrective actions will be applied to the MSB dredging works until it can be demonstrated to the TAG that the exceedences cannot be attributed to the MSB works.

6.3.3.2 South Shell Island – benthic communities

In addition to the routine monitoring of coral and filter-feeder communities around South Shell Island (**Section 7.3.3**), these benthic communities will be monitored in the event of an exceedance of any of the water quality trigger levels at the South Shell Island water quality monitoring site (**Table 6-3**), if the exceedance is deemed to have been due to the MSB dredging or tailwater discharge activities. The monitoring will be conducted over a two day period once tidal currents are sufficiently low to permit safe deployment of the monitoring equipment (described in **Section 7.3.3.3**).

Data analysis will occur over the five day period following completion of the monitoring survey. A reactive trigger level of 10% decrease in seabed cover has been set for the benthic communities; this is the smallest change that can be reliably detected by the monitoring technique (**Section 7.3.3.3**).

In the event of a net decrease in seabed cover of >10% (of the baseline cover), this will be reported to the Proponent and the Proponent will notify the TAG and SEWPaC within 24 hours of the exceedance being detected through the data analysis. If the corrective actions applied after exceedance of the water quality trigger levels have not been effective in returning the four day rolling average NTU value to below all trigger levels, then further corrective actions (refer **Section 6.3.4**) will be implemented within the same timeframe. At any site where the benthic communities trigger is exceeded, monthly monitoring of the communities will continue during the remainder of the MSB dredging campaign, unless it can be demonstrated that the water quality at the site is being affected by turbid plumes from other sources within East Arm (e.g. the INPEX dredging campaign) and not the MSB dredging works.

6.3.3.3 Dredging footprint and railway bund

Whilst the primary water quality triggers relate to the South Shell Island monitoring site, monitoring of turbidity at the perimeter of the dredging footprint and at the permeable section of the railway bund wall (**Section 7.3**) will assist in the management of the dredging and tailwater discharge operations to reduce the potential for trigger level exceedance at the South Shell Island site.

The initial turbidity trigger level at the perimeter of the dredging footprint and at the permeable section of the railway bund wall was 52 NTU (equivalent to 50 mg/L based upon the relationship established by URS [2011a]). A value of 50 mg/L was agreed upon by the NTG and the TAG as a suitable trigger level to apply at these locations. As described in **Section 7.3.2.3**, the value of the trigger level in NTU is determined in accordance with the SSC/NTU relationship, which is updated as further SSC and NTU data are collected during water quality monitoring in East Arm.

Any exceedances of the trigger level at the monitoring locations around the perimeter of the dredging footprint, or on the seaward side of the railway bund wall (**Section 7.3**), will be reported to the Proponent, and the Proponent will notify the TAG and SEWPaC, within 24 hours of the exceedance occurring.

Concurrently, an attributability assessment will be initiated by Macmahon to determine whether or not the exceedance was likely to have been caused by MSB dredging or tailwater discharge activities. This assessment will be completed and sent to the TAG for review within three business days of the exceedance occurring.

The attributability assessment will include, but not be limited to, consideration of information such as:

- Background turbidity levels in the waters around the perimeter of the dredging footprint (outside of the plumes from the operating dredge and tailwater discharge point) or in Frances Bay (if the exceedance is seaward of the railway bund).
- Observations of turbid plumes emanating from other sources within East Arm or Frances Bay.

If it is deemed by the TAG that the exceedance is potentially due to the MSB dredging or tailwater discharge activities, or to tailwater return through the railway bund, then corrective actions (refer **Section 6.3.4**) will be implemented within 24 hours.

Any pre-cutting or pre-treatment processes used on dredge material will be subject to the same allowable conditions indicated for dredging in this section and elsewhere.

6.3.4 Management measures

The following inherent characteristics of the dredging operation are anticipated to minimise the generation of turbid plumes:

- Most of the dredging operation is situated close to shore, at a location which is afforded some protection from the effects of tidal currents.
- The dredge operation involves a single, static cutter suction dredge unit.
- The suction pipe is directly behind the cutter head.
- The cutter on *Eastern Aurora* is a Vosta type cutter, which is designed to maximise feed to the suction pipe and minimise the release of sediment into the water column surrounding the dredge.

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- Cutter speed will be as low as possible while dredge pumps are at the maximum speed possible whilst soft material (i.e. sand and silt) is being removed.
- In harder material (phyllite) there will be slower slewing across the cut face, and shallower depth of cut reducing volumes liberated at the face to less than the capacity of the pumps and suction pipe to remove the material. Material is expected mostly to be cut into large pieces of approximately 100 mm and possibly up to 450 mm. Sediment liberated in this cutting process will be captured by the suction pipe.

Throughout the dredging campaign, water quality data will be collected within East Arm (see **Section 7.3.2**). Consideration of trends in the water quality data, and observations made during monitoring at the perimeter of the dredging footprint, and at the permeable section of the railway bund wall, will be used to adaptively manage the MSB dredging and tailwater discharge operations to minimise the potential for water quality trigger levels to be exceeded. In particular, the daily recalculation of the four day rolling average turbidity value will provide advanced warning of any impending trigger level exceedances, allowing precautionary corrective actions (refer **Table 6-4**) to be implemented before the trigger level is exceeded. For example, observations during monitoring will indicate the times within the tidal cycle when the migration of dredge plumes towards South Shell Island is highest; maintenance or relocation of the dredge can then be scheduled to coincide with those times. If tailwater discharge is shown to be contributing to the turbidity levels at South Shell Island during certain periods within the tidal cycle, then the discharge could also be reduced or temporarily suspended at these times.

Table 6-4 Water quality EMF – East Arm

Water Quality Management Framework – East Arm	
Element	Maintenance of water quality within East Arm.
Commitments	EPBC 2010/5304 condition 28 WDL 187 conditions 8, 9, 16 and 18-29
Objectives	• To minimise impacts upon the hard coral and filter-feeder communities at South Shell Island from dredge generated turbidity and release of toxicants.
Target	• No adverse impacts upon the hard coral and filter-feeder communities at South Shell Island as a result of dredging and tailwater disposal. • No instances of exceedance of turbidity trigger levels at the telemetered South Shell Island monitoring site. • Less than a 10% net reduction in benthic cover of corals or filter-feeders at South Shell Island monitoring sites.
Key Performance Indicator(s)	• Number of instances of exceedance of reactive water quality monitoring criteria (trigger levels) at South Shell Island requiring dredge management measures to be implemented to return water quality in East Arm to an acceptable level. • Percentage net reduction in benthic cover of corals or filter-feeders at South Shell Island monitoring sites.
Management	• Dredge cutter head speed varied in accordance with material being dredged, to minimise dispersion of fine sediments from the cutter head into East Arm. • Amount of sediment in tailwater discharged back into the receiving environment

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Water Quality Management Framework – East Arm	
	managed as per **Table 6-1**.
Monitoring (**Section 7.3**)	• Reactive water quality monitoring – South Shell Island • Benthic community monitoring – South Shell Island and reference sites. Routine and in response to water quality criteria exceedances.
Reporting (**Section 8**)	• Weekly reporting of data to TAG and the Proponent. • Monthly reporting of data to NT EPA. • Monitoring report to NT EPA at conclusion of each dredging phase. • Annual audit and compliance report to NT EPA. • Trigger level exceedances will be reported to the Proponent, and to SEWPaC (on behalf of the Proponent), within 24 hours of the exceedance occurring. The Proponent will also notify the TAG. • Trigger level exceedances will also be reported by Macmahon direct to NT EPA within 24 hours of the exceedance occurring and a report on corrective actions implemented to address the cause of the exceedance within five business days of the notification. • Notification to stakeholders (the Proponent, TAG and SEWPaC) of outcome of investigation into attributability of exceedance to dredging within 24 hours of completion of investigation.
Corrective Action(s)	• Slowing the cutter head or slew speed on the dredge, reducing the flow of water and sediment to the reclamation area • Reducing the rate of tailwater discharge (if back-up facility to pump tailwater from Pond E to the dredging footprint is being utilised) • Deploying additional silt curtains within Pond E to increase sediment settlement rates. • Reducing or suspending dredging activity during tidal periods when the migration of dredge plumes towards South Shell Island is highest. • Moving the dredge to an alternate workface away from South Shell Island • Undertake TAG review to investigate whether additional Corrective Actions are possible and whether trigger values should be modified (noting that changes to this Plan need to be approved by NT EPA and the Minister).
Term	• For the duration of dredging and tailwater discharge activities
Responsibility	• Macmahon HSEQ Advisor to ensure Dredging Contractor's documents are compliant with the DDSPMP • Macmahon HSEQ Advisor to ensure implementation of monitoring program and water quality management measures

The trigger and response procedures for the monitoring of South Shell Island, the perimeter of the dredging footprint and the permeable section of the railway bund wall are summarised in **Table 6-5** and **Table 6-6**. A flowchart depicting the framework for the monitoring and management of water quality in East Arm and Frances Bay, and of the South Shell Island benthic communities, is presented as **Figure 6-2**.

Table 6-5 South Shell Island monitoring – triggers and responses

Components	Water Quality Trigger	Benthic Community Trigger
Trigger value	*Dry Season*: Four day rolling average NTU at South Shell Island monitoring site exceeds: Intensity: >12 NTU Duration: >10 NTU over 4 consecutive days Frequency: >10 NTU for >4 days per 7 day period *Wet Season:* Four day rolling average NTU at South Shell Island monitoring site exceeds: Intensity: >35 NTU Duration: >23 NTU over 7 consecutive days Frequency: >23 NTU for >6 days per 7 day period Triggers will be reviewed and possibly adjusted (in consultation with the TAG and with the approval of SEWPaC) to ensure that they can be practicably implemented and that they are relevant as early indicators of potential impacts upon the health of the South Shell Island coral and filter-feeder communities.	Coral/Filter-feeder mortality: >10% net reduction in benthic cover of corals or filter-feeders
Trigger Description	Turbidity levels are monitored in real time via a telemetered probe at South Shell Island. On a daily basis, data are quality checked and the rolling four day average NTU calculated. An exceedance will be deemed to have occurred if any one of the three triggers listed above (i.e. intensity, duration or frequency) is exceeded. Trigger level exceedances will be reported to the Proponent, and the Proponent will notify the TAG and SEWPaC, within 24 hours of the exceedance occurring.	Benthic transects established pre-dredging will be recorded over a two day period at the commencement of the first neap tide period following the exceedance of the water quality trigger. The transect data will be analysed (within five days of the completion of the survey) to assess whether the benthic community mortality trigger has been exceeded at any of the South Shell Island monitoring sites. An exceedance will be deemed to have occurred if the net reduction in benthic community cover at any of the monitoring sites (relative to the baseline survey, minus mean mortality at reference sites) is greater than 10%. Trigger level exceedances will be reported to the Proponent, and the Proponent will notify the TAG and SEWPaC, within 24 hours of the exceedance being detected by analysis of the monitoring data.
Attributability Assessment	If a trigger value is exceeded, then an assessment will be undertaken to determine whether or not the exceedance is attributable to dredging. This assessment will be completed within three business days of the exceedance occurring. The assessment will include consideration of information such as: • Changes in water quality at the reference sites. • Periodic water quality data collected at the perimeter of the dredging footprint. • Observations of turbid plumes emanating from other sources within East Arm.	Not applicable

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Components	Water Quality Trigger	Benthic Community Trigger
Monitoring Response	Implement monitoring of benthic community cover at South Shell Island and reference sites (**Section 7.3.3**) at the commencement of the first neap tide period following the exceedance of the water quality trigger.	If the benthic community trigger is exceeded at any of the South Shell Island monitoring sites, then monthly monitoring of benthic community cover will be undertaken at the site to inform an assessment of the effectiveness of the corrective action(s) implemented. This monitoring will continue for the remainder of the MSB dredging campaign, unless it can be demonstrated that turbid plumes from other sources within East Arm, and not the MSB dredging works, are impinging upon the site.
Management Response	Implement corrective action(s) (**Table 6.4**) to reduce turbidity attributable to dredging and tailwater return that impinges upon the South Shell Island benthic communities within 24 hours of exceedance of the water quality trigger.	Implement further corrective action(s) (**Table 6.4**) to reduce turbidity attributable to MSB dredging or tailwater return that impinges upon the South Shell Island benthic communities within 24 hours of exceedance of the benthic community trigger.
	Reports detailing the monitoring data collected and corrective action(s) implemented will be submitted to the Proponent (for distribution to stakeholders) within five business days of data collection or corrective action implementation.	

Table 6-6 Dredging footprint and railway bund – triggers and responses

Components	Dredging Footprint Perimeter Monitoring	Railway Bund Monitoring
Trigger value	Mean SSC in water column exceeds 50 mg/L (measured as NTU, with conversion as described in **Section 7.3.2.3**).	Mean SSC in water column exceeds 50 mg/L (measured as NTU, with conversion as described in **Section 7.3.2.3**).
Trigger Description	Turbidity levels are monitored twice daily in real time, using a hand-held probe, at a number of locations 50 m from the perimeter of the dredging footprint (refer **Section 7.3.2**). An exceedance will be deemed to have occurred if the mean turbidity through the depth of the water column at any location exceeds the trigger value listed above.	Turbidity levels are monitored in real time, using a hand-held probe, at a number of locations on the seaward side of the permeable section of the railway bund wall (refer **Section 7.3.2**). An exceedance will be deemed to have occurred if mean turbidity through the depth of the water column at any location exceeds the trigger value listed above.
	Trigger level exceedances will be reported to the Proponent, and the Proponent will notify the TAG and SEWPaC, within 24 hours of the exceedance occurring.	
Attributability Assessment	If a trigger value is exceeded, then an assessment will be undertaken to determine whether or not the exceedance is attributable to MSB dredging, tailwater discharge, or the passage of water through the permeable section of the railway bund wall. This assessment will be completed within three business days of the exceedance occurring.	
	The assessment will include consideration of information such as: • Background turbidity levels in the waters around the perimeter of the dredging footprint (outside of the plumes from the operating dredge and tailwater discharge point). • Observations of turbid plumes emanating from other sources within East Arm.	The assessment will include consideration of information such as: • Background turbidity levels in the receiving waters outside of the plume from the railway bund. • Observations of turbid plumes emanating from other sources within Frances Bay.

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<table>
<tr><th>Components</th><th>Dredging Footprint Perimeter Monitoring</th><th>Railway Bund Monitoring</th></tr>
<tr><td rowspan="2">Monitoring Response</td><td>During daylight hours, undertake hourly real time turbidity monitoring, using a hand-held probe, at locations 50 m from the perimeter of the dredging footprint where the plume from dredging or tailwater discharge is observed to be most turbid.
Correlate these data with telemetered turbidity data from South Shell Island to ascertain whether trigger value exceedances at the perimeter of the dredging footprint lead to elevations of turbidity at the South Shell Island benthic communities.
Continue hourly monitoring until:
a) the mean turbidity levels through the depth of the water column at these locations return to below the trigger value; or
b) it can be demonstrated (to the satisfaction of the TAG) that trigger value exceedances at the perimeter of the dredging footprint do not lead to elevations of turbidity at the South Shell Island benthic communities.</td><td>Undertake hourly real time turbidity monitoring, using a hand-held probe, at locations on the seaward side of the railway bund wall where the plume from the permeable section is observed to be most turbid.
Continue hourly monitoring until:
a) the mean turbidity levels through the depth of the water column at these locations return to below the trigger value; or
b) it can be demonstrated (to the satisfaction of the TAG) that the exceedance poses no risk of significant impact to the receiving environment in Frances Bay.</td></tr>
<tr><td colspan="2">In the event that either trigger value is exceeded, all turbidity data collected will be presented to the TAG for their consideration within 24 hours of the exceedance. The TAG will provide an assessment of whether there is justification to alter trigger values, or frequency of monitoring, within three business days of receiving the data. Any proposed changes to the monitoring program will be submitted to SEWPaC for approval.</td></tr>
<tr><td rowspan="2">Management Response</td><td>Implement initial corrective action(s) (Table 6.4) to reduce turbidity (attributable to dredging and tailwater return) at the perimeter of the dredging footprint within 24 hours of exceedance of the trigger value.
The corrective action(s) will continue to be applied:
a) until the mean turbidity levels through the depth of the water column at the monitoring locations (50 m from the perimeter of the dredging footprint where the plume from dredging or tailwater discharge is observed to be highest) return to below the trigger value; or
b) unless the TAG determines, with the agreement of SEWPaC, that trigger value exceedances at the perimeter of the dredging footprint do not pose a risk of significant impact to the South Shell Island benthic communities.</td><td>Implement corrective action(s) (Table 6.1) to reduce the turbidity of the water leaving Pond E through the permeable section of the railway bund wall within 24 hours of exceedance of the trigger value.
The corrective action(s) will continue to be applied unless the TAG determines, with the agreement of SEWPaC, that trigger value exceedances at the permeable section of the railway bund wall do not pose a risk of significant impact to the receiving environment in Frances Bay.</td></tr>
<tr><td colspan="2">Reports detailing the monitoring data collected and corrective action(s) implemented will be submitted to the Proponent (for distribution to stakeholders) within five business days of data collection or corrective action implementation. Any proposed changes to the monitoring program will be submitted to SEWPaC for approval.</td></tr>
</table>

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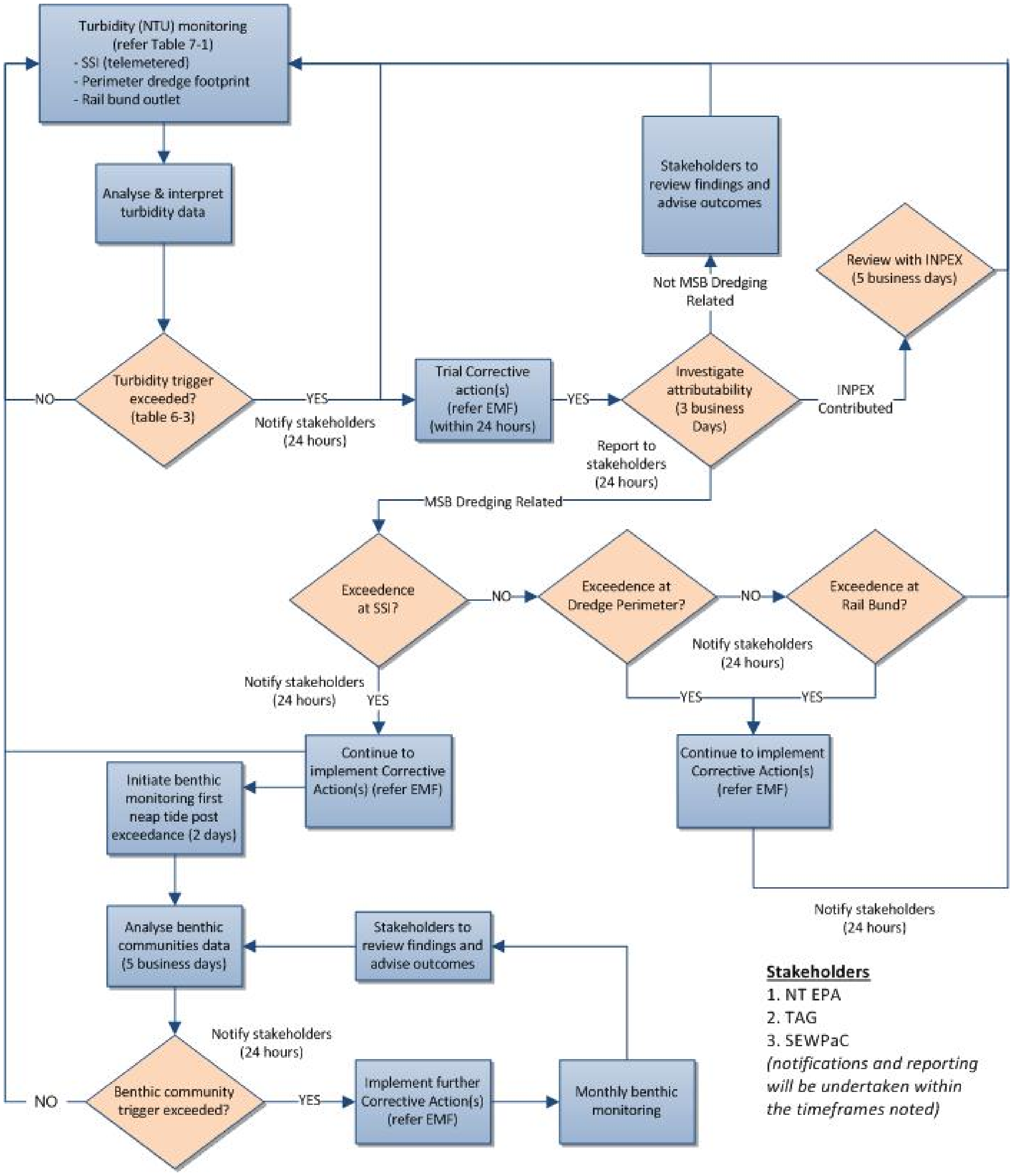
Figure 6-2 Water quality and benthic habitat monitoring and management framework



6.4 Protected marine species – physical interaction

The main risk of physical interaction with protected marine species will be in relation to the movement of dredge support vessels (e.g. crew transfer vessel, tender vessel). The risk of direct impact to protected marine species from the operating dredge is considered to be very low. As the dredge will be stationary during most of the works, with the most mobile part of the equipment (the cutter head) generating noise and vibration which is likely to discourage any species that may be present from approaching sufficiently close to the dredge for them to be exposed to the risk of impact. When moving between or within the dredging footprint, the dredge will transit at low speeds (<5 kn) and only over small distances (hundreds of metres).

It should be noted that physical interactions between dredging vessels and marine species are a higher risk when mobile dredges such as Trailer Suction Hopper Dredges are used and when dredged material is disposed offshore. Neither of these scenarios is applicable to the MSB dredging.

Nevertheless there will be monitoring (refer **Section 7.4**) and management measures implemented to reduce the risk of physical interaction with protected marine species, as described in the following EMF and depicted in **Figure 6-4**. These measures will apply to the operation of the dredge and also to any other vessels engaged in the works (e.g. crew transfer vessels). Night-time dredging will be subject to the same management measures as for dredging during daylight hours. These will be facilitated with the use of spotlights/vessel searchlights to increase visibility for Marine Fauna Observers (MFOs).

Table 6-7 Protected marine species EMF – physical interaction

Protected Marine Species Management Framework – physical interaction	
Element	Vessel interaction with protected marine species.
Commitment	EPBC 2010/5304 condition 17(e)
Objective	• Minimise the risk of injury to, or mortality of, protected marine species • Develop and maintain awareness of the need to protect marine species.
Target	• No incidents of vessel interaction with protected marine species. • All dredging personnel to complete an HSE induction, including protected marine species awareness and management requirements. • All vessel masters competent in protected marine species interaction procedures. • At all times that the dredge is operational, at least one crew member is a trained MFO.
Key Performance Indicator(s)	• Number of audits and incident reports. • Number of reported sightings of live, injured or dead marine fauna. • Number of personnel completing an HSE site induction. • Availability of MFO trained dredge operator
Management	• Training of Vessel Masters in interaction procedures and specified crew as MFOs. • A trained Marine Fauna Observer must be on duty, above deck with good visibility, during all dredging operations. • On each occasion that the dredge has been non-operational for a period exceeding 30 minutes, a visual assessment shall be undertaken of the 150 m radius Observation Zone by the MFO for a period of 10 minutes. Dredging will not recommence until no protected marine species have been sighted within the 150 m radius Observation Zone for a period of 10 minutes. • The assessment of the Observation Zone will be made from an elevated position on the dredge, where a clear line of sight is achievable to the edge of the zone.

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Protected Marine Species Management Framework – physical interaction	
	• The MFO shall not be engaged in any other activities during the 10 minute assessment period. • The MFO will maintain ongoing visual scanning of the Observation Zone for protected marine fauna and, every 30 minutes, will dedicate a period of five minutes for observation (from an elevated position) for protected marine fauna. • Night observations will be carried out with aid of spotlights/vessel searchlights. • Respond in accordance with vessel interaction procedures if protected marine species are sighted within the Observation Zone. Cease dredging if turtles, dugongs or dolphins enter within 50 m of the cutter head, or dolphins with calves enter within 150 m of the cutter head. • Rotation of the dredge cutter head will only start when it is positioned near the seafloor, and rotation will be stopped before the cutter is raised through the water column. • Vessels to adhere to DPC speed restrictions. • Follow SEWPaC guidelines (**Figure 6-3**). • Do not approach, circle or wait in front of wildlife for the purposes of casual viewing. • Maintain watch for stranded, injured or dead marine fauna and contact the Department of Land Resource Management (DLRM) Marine Wildwatch (1800-453-941) for retrieval, treatment or post-mortem. • Install propeller guards on all dredge support vessels with propellers extending below the keel beam.
Monitoring (**Section 7.4**)	• Regular monitoring for the presence of stranded, injured or dead marine fauna • Marine fauna observations (refer to management section)
Reporting (**Section 8**)	• Daily submission of marine fauna observations sheets (**Figure 7-4**). • Weekly summary reporting of number of sightings, incidents and corrective actions. • Monthly reporting of data to NT EPA. • Monitoring report to NT EPA at conclusion of each dredging phase. • Annual audit and compliance report to NT EPA. • Any vessel interaction incidents and protected species injury or mortality will be reported to the Proponent, and to SEWPaC (on behalf of the Proponent), within 24 hours of the incident occurring. The Proponent will also notify the TAG. Incidents will also be reported by Macmahon direct to NT EPA within 24 hours of the incident occurring.
Corrective Action(s)	• In the event that an incident or near miss occurs between vessels and protected marine species, the incident will be investigated and discussed to further improve awareness to reduce risk of collision. • In the event of any impacts to protected marine species from vessel strikes, a dedicated marine fauna observer will be required on watch on all vessels while underway. • For mobile vessels, a 5 kn vessel speed limit will be applied in areas where frequent sightings (an average of >1 per day in any one week) are made of protected marine species. • If protected marine species approach within the Caution Zone (**Figure 6-3**), vessels that are under way will proceed at a “no wash” speed.
Term	• For the duration of dredging activities.
Responsibility	• Macmahon HSEQ Advisor to ensure Dredging Contractor’s documents are compliant with the DDSPMP • Macmahon HSEQ Advisor to ensure Dredging Contractor implements protected marine species management and monitoring program • Macmahon Project Manager to liaise with DLRM on response to stranded, injured or dead marine fauna and potential recovery, treatment or post-mortem

6 Environmental Management

Figure 6-3 SEWPaC guidelines on approach distances for dolphins

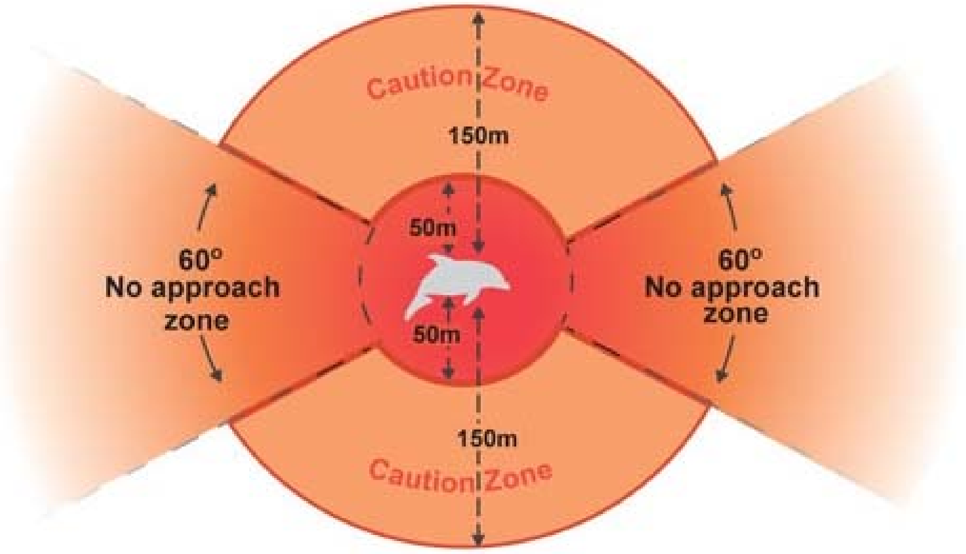
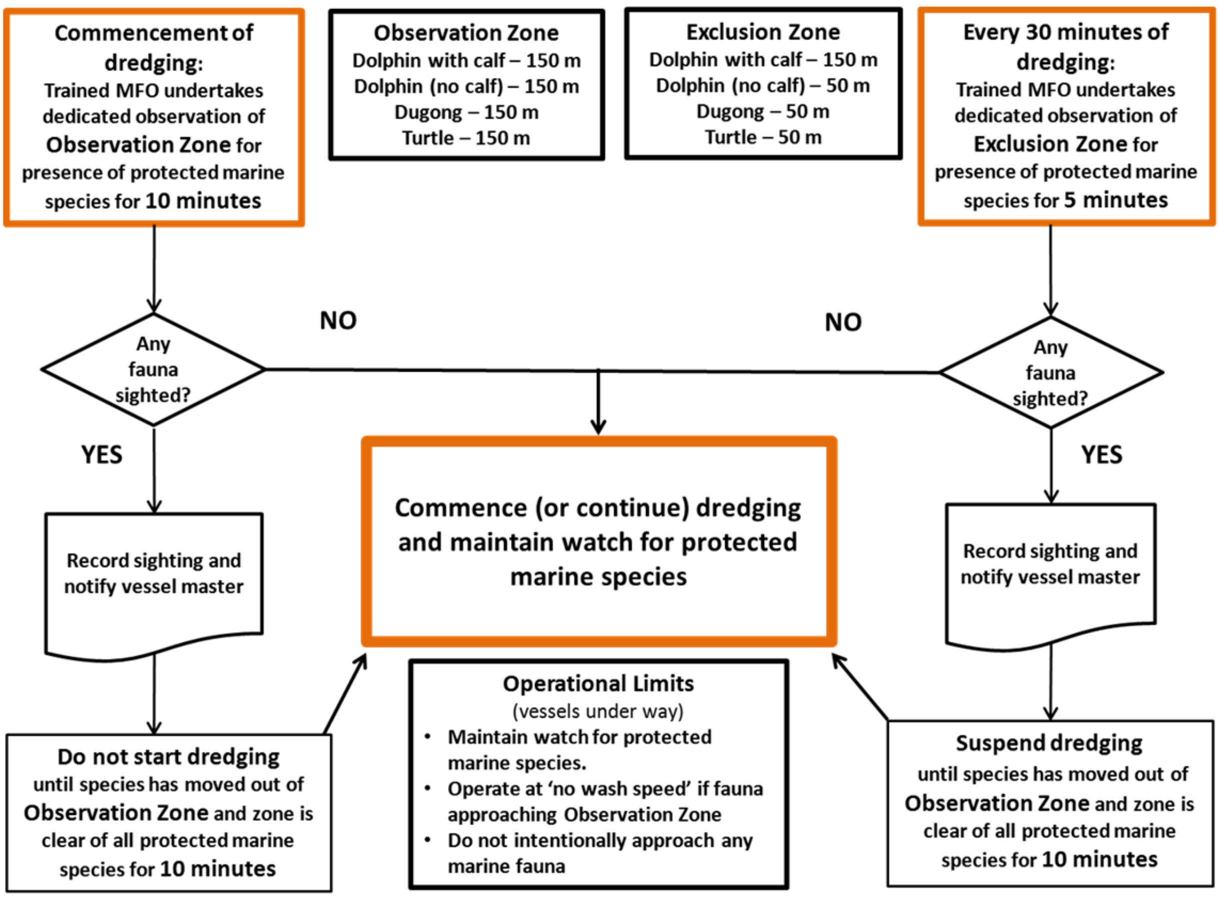


Figure 6-4 Vessel interaction management flowchart



6.5 Protected marine species – underwater noise

Dredging for construction of the MSB is creating additional underwater noise in various forms and intensity above current ambient levels in Darwin Harbour.

Coastal **dolphins** use sound for navigation, feeding and avoiding predators (through echo location) and also for communication (through narrow band frequency modulated sound). The ability of dolphins to communicate, navigate and echo locate can be compromised by sound generated by human activity. While the ocean is naturally noisy, marine mammals are well adapted to natural levels of ambient noise. However, anthropogenic noise can cause masking (i.e. the blocking of the perception stimulus due to the presence of another stimulus in the same range) to occur (Jensen et al. 2009). Dolphins may be temporarily displaced from the vicinity of the MSB by the increase in noise levels. Alternatively the dolphins may adapt (dolphins are known to frequent busy harbours such as Singapore) or may tolerate the increased noise to feed on fish attracted to the operating dredge in search of food.

Turtle auditory morphology is adapted for hearing in water. They hear largely in the low frequency range (<1000 Hz), though the bandwidth and peak sensitivity varies between species. The use of sound by turtles is little understood. Experimentally, turtles have initially shown avoidance behaviour, then eventually habituating to the noise (Moein Bartol & Musick 2003). Observation of dredge activities around Australia is that turtles largely avoid coming in close proximity to the dredge. In part this is attributed to the sound of the dredge.

Little information is available on the auditory systems of **dugongs** and little research has been undertaken to investigate the sensitivity of dugongs to noise. There are only anecdotal reports of dugongs avoiding areas with high boat traffic.

Monitoring of protected marine species is described in **Section 7.4**. Management measures implemented to reduce the risk of disturbance of protected marine species by underwater noise generated by the dredging works are listed in the following EMF.

Table 6-8 Protected marine species EMF – underwater noise

Protected Marine Species Management Framework – underwater noise	
Element	Impact of underwater noise on protected marine species.
Commitments	EPBC 2010/5304 condition 17(e)
Objectives	• Minimise the risk of disturbance to protected marine species from underwater noise. • Establish and maintain awareness of the importance of protecting marine species.
Target	• No avoidable disturbance to protected marine species as a result of noise generated during dredging activities. • All dredging personnel to complete an HSE induction • At all times that the dredge is operational, at least one crew member is a trained MFO.
Key Performance Indicator(s)	• Number of audits and incident reports. • Number of reported sightings of live, injured or dead protected marine species. • Number of personnel completing an HSE site induction. • Availability of MFO trained dredge operator
Management	• Ensure that all equipment is maintained in good operating condition (balancing, greasing, etc.) and have proper noise control systems in place. • Ensure all noise minimisation measures such as mufflers, special enclosures and sound-

Protected Marine Species Management Framework – underwater noise	
	insulation mounts are fitted and working • Ensure revolving equipment such as propellers and drive shafts are balanced to reduce vibration. • Minimise the noise generation of equipment (thrusters and auxiliary plant) by switching them off when not used (i.e. avoid running on standby mode).
Monitoring (**Section 7.4**)	• Marine fauna observations • Regular monitoring for stranded, injured or dead marine fauna.
Reporting (**Section 8**)	• Daily submission of marine fauna observations sheets (**Figure 7-4**). • Weekly summary reporting to the Proponent of number of sightings of protected marine species. • Monthly reporting of data to NT EPA. • Monitoring report to NT EPA at conclusion of each dredging phase. • Annual audit and compliance report to NT EPA. • Any suspected noise related incidents will be reported to the Proponent, and to SEWPaC (on behalf of the Proponent), within 24 hours of the incident occurring. The Proponent will also notify the TAG. Incidents will also be reported by Macmahon direct to NT EPA within 24 hours of the incident occurring. • Any corrective actions implemented in response to suspected noise related incidents will be detailed in the monthly report to NT EPA and in the weekly report to the Proponent. The latter report will be sent by the Proponent to the TAG and SEWPaC.
Corrective Action(s)	• In the event that noise related impact is suspected, the incident will be investigated to confirm a noise related impact has occurred and identify the most appropriate action(s) to reduce the impact. This may include one or more of the following: noise reduction measures, soft-start start-up procedures, restriction on vessel movements/activities, increase the radius of the Observation Zone to 200 m.
Term	• For the duration of dredging activities
Responsibility	• Macmahon HSEQ Advisor to ensure Dredging Contractor's documents are compliant with the DDSPMP • Macmahon Project Manager to ensure Dredging Contractor implements noise management aboard vessels

6.6 Migratory birds

6.6.1 Pond system characteristics

The filling of the dredge spoil placement ponds will reduce the pond area at East Arm Wharf, particularly Pond K and 75% of Pond E which it is intended to fill to capacity with dredge spoil. However most of the bird observations during the bird surveys conducted by EMS (2011) were at Pond D (2169 individuals observed out of 3722 observed at 14 sites in total).

Pond D is subject to disturbance from surrounding industrial activities associated with the East Arm Wharf, such as bulk mineral stockpiling and rail operations. This pond fills to capacity during the Wet Season as a result of storm water inundation and dries out completely by the end of the Dry Season. When dry the site is unattractive for roosting shorebirds. Ongoing settlement of the fine dredge spoil currently contained in Pond D is contributing to a gradual change in the surface profile of the pond, leading to an increase in water depth of the pond at the end of the Wet Season and decreasing the duration of the period for which it is dry.

As noted by NRETAS, it is anticipated that the birds that currently roost on the banks of Pond K in small numbers will use Pond D instead, or roost at the natural habitat types within Darwin Harbour that they used before East Arm Wharf was constructed, and continue to use under many tidal and seasonal conditions.

The most likely reasons Pond D is chosen by migratory shorebirds for roosting is that it:

- is in close proximity to the coast
- is fenced from disturbance
- is sufficiently open so that aerial predators are readily detected
- contains shallow water, allowing thermoregulation through the legs while roosting.

During the Wet Season Pond D will operate as it normally would during any other Wet Season, and storm water will flow though into Pond E.

The regular wetting and drying of the edge of this pond will keep it free of vegetation and thus retain its attractiveness to roosting shorebirds. Although not envisaged due to Pond D being isolated from the treatment system, any remedial work that may be required in Pond D will be undertaken during the latter part of the 2013 Dry Season when the pond is at its driest and before migratory birds have arrived.

6.6.2 Triggers for corrective actions

6.6.2.1 Pond water height

Pond D (refer **Section 7.5.2.1**) will not be used for tailwater treatment during the Wet Season and the water height will be maintained as per previous Wet Seasons.

6.6.2.2 Migratory birds

Monitoring of migratory birds is described in **Section 7.5**. To comply with EPBC approval Condition 15, monitoring of migratory birds will be implemented throughout the dredging. Condition 15 requires additional management measures to minimise turbidity impacts and disturbance to migratory birds from 1 November onwards. Macmahon has adopted these additional measures (increased monitoring and corrective actions, as detailed below) across the entire dredging duration.

Two triggers are to be adopted for management actions with reference to migratory birds during dredging.

The first action (to analyse causation and to implement targeted management responses) will be taken should the total number of shorebirds counted fall by greater than 50% from one week to the next. The figure of 50% is adopted because these counts cannot be compared with baseline surveys and are being used only to attempt to detect sudden changes in pond suitability during dredging.

Action will also be taken should the maximum number of shorebirds counted during any month fall below 60% of maximum baseline numbers in total for that month, or for any of the four species which have been recorded at Pond D in nationally significant numbers, or have fewer than 60% of the number of species recorded during baseline surveys. The figure of 60% is adopted as being a threshold that allows for the high levels of daily and seasonal variation expected and the megatidal environment of Darwin Harbour, while still demonstrating that the site retains its value to migratory shorebirds.

6.6.3 Responses to trigger exceedances

If any of the triggers described in **Section 6.6.2** are exceeded, Macmahon will notify the Proponent within 24 hours of the exceedance being determined and will provide all monitoring data relevant to the pond systems to the TAG for consideration within three business days of the relevant count. The TAG will investigate in conjunction with Macmahon to determine whether changes detected are attributable to the condition within the ponds or the management of the ponds (e.g. water levels too high, water quality, roost area) or whether changes are more likely to be caused by extrinsic factors (e.g. condition of the tide, on-migration, local rainfall). The changes will be compared to any counts under the auspices of the Australian Wader Studies Group at other sites in the Darwin region and elsewhere in Australia to determine if they are part of a larger trend. A review of the conditions at the site will also be undertaken to determine if any local habitat variables have altered, particularly whether water has been available, whether the potential roost sites have become excessively vegetated or any other matters that might have discouraged birds from roosting at the site.

Where the variation is considered by the TAG to be site specific, a more detailed investigation of all of the pond monitoring and environmental data will be undertaken. If the cause can be identified as relating to pond management or dredge spoil placement and handling practices, the TAG will advise the contractor of required corrective actions. The TAG will ensure that analysis and consideration of relevant contributing factors is undertaken within a period of 15 business days of its receipt of initial trigger exceedance data from the contractor.

Management measures to be implemented to reduce the risk of adverse impacts upon migratory birds are listed in the following EMF (**Table 6-9**). If required due to trigger exceedances, corrective actions will be considered. During the Wet Season Pond D will be removed from the settling pond system and water quality will therefore not be affected by tailwater. As a result, water quality monitoring will be reduced to weekly intervals in order to maintain data to support consideration of potential changes in migratory bird numbers as described in **Table 6.9**.

Table 6-9 Migratory birds EMF

Migratory Birds Management Framework	
Element	Impact of spoil placement on protected migratory birds.
Commitments	EPBC 2010/5304 condition 17(e)
Objectives	• Minimise the risk of adverse impacts upon migratory birds from the operation of the dredge spoil placement ponds. • Establish and maintain awareness of the importance of protecting migratory birds and their habitat.
Targets	• No adverse impacts upon migratory birds from placement and management of dredge spoil. • Maintenance of Pond D at normal Wet Season water level (5.5 m AHD) from 1 November to 30 April. • During dredging, total number of shorebirds counted during monitoring does not fall by

6 Environmental Management

Migratory Birds Management Framework	
	>50% between weeks. • Maximum number of shorebirds counted during any month does not fall below 60% of the maximum total baseline numbers for that month. • Maximum number of shorebirds counted during any month does not fall below 60% for any of the four species that have been recorded at Pond D in nationally significant numbers. • The number of shorebird species present during any month does not fall below 60% of the number of species recorded during baseline surveys. • All personnel engaged in the operation of the pond system to complete an HSE induction, including migratory bird awareness and management requirements.
Key Performance Indicators	• Number of audits and incident reports. • Water height in Pond D. • Number of migratory birds utilising the pond system as habitat. • Number of personnel completing an HSE site induction.
Management	• Minimise the area of mangrove, salt pan and tidal mudflat areas disturbed for any works or reclamation. • Control sedimentation or other impacts that may impact shorebird feeding sites. • Protect the high tide roost site in Pond D. • Control activities or facilities that might cause additional disturbance to feeding and roosting birds (e.g. excessive noise, additional nocturnal lighting). • Continue restricted access to the public and animals (dogs) to areas where migratory shorebirds roost and feed. • Where access allows, non-PASS residual silt in Pond D will be mounded to a small island for greater security for roosting migratory shorebirds. • The NTG is developing a Migratory Shorebird Management Plan in consultation with SEWPaC to compensate for residual detriment of Project activities on migratory bird species. • Ensure the water level in Pond D does not exceed the normal Wet Season level (5.5 m AHD) for the period between 1 November and 30 April inclusive.
Monitoring (**Section 7.5**)	• Monitor shorebirds at East Arm Wharf in accord with SEWPaC recommendation • Pond D will be monitored throughout the dredging to measure changes in water depth and sediment deposition with reference to the potential to explain migratory bird habitat impacts (only while Pond D is being used). • An adapted monitoring approach will be considered in consultation with the TAG (approved and directed by SEWPaC) if significant decline in bird use is observed. • Ongoing Migratory Bird monitoring for five years post-dredging undertaken to satisfy EPBC approval condition 17(f)(i).
Reporting (**Section 8**)	• Monthly reporting of data to NT EPA. • Monitoring report to NT EPA at conclusion of each dredging phase. • Annual audit and compliance report to NT EPA. • In the event of an exceedance of a bird abundance trigger (**Section 6.6.2**), the Proponent and NT EPA will be notified within 24 hours. All relevant pond monitoring data will be provided to the TAG within three business days of the relevant count. A report on corrective actions implemented to address the cause of the exceedance will be submitted by Macmahon to NT EPA within five business days of the notification. • Any mortality of protected migratory birds from dredge spoil placement activities will be reported to the Proponent, and to SEWPaC (on behalf of the Proponent), within 24 hours

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Migratory Birds Management Framework	
	of the mortality occurring. The Proponent will also notify the TAG. Mortality will also be reported by Macmahon direct to NT EPA within 24 hours of mortality occurring.
Corrective Action	• Reducing the water level in Pond D.
Term	• For the duration of dredging activities, continuing into operations phase.
Responsibility	• Macmahon Project Manager to ensure Dredging Contractor's documents are compliant with the DDSPMP. • Macmahon HSEQ Advisor to ensure Dredging Contractor implements monitoring program and water quality management measures.

Environmental Monitoring

7.1 Overview

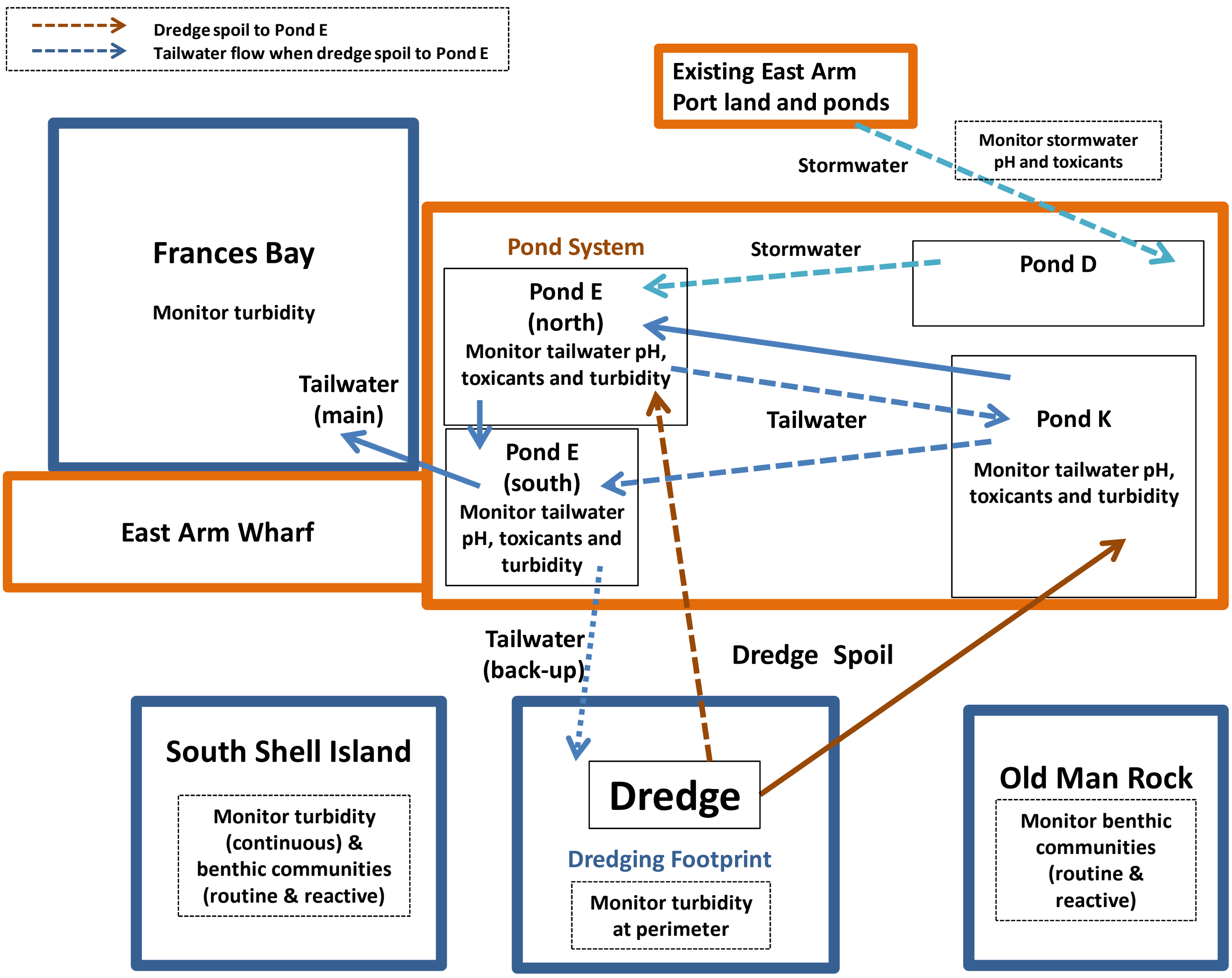
The environmental monitoring program to be implemented as a part of this DDSPMP comprises the following:

- Monitoring of water quality within the dredge spoil placement ponds (**Section 7.2**).
- Monitoring of water quality and benthic communities within East Arm (**Section 7.3**).
- Monitoring for presence of protected marine species in the vicinity of the MSB dredging works (**Section 7.4**).
- Monitoring of migratory birds around the dredge spoil placement ponds (**Section 7.5**)

Key aspects of each of the monitoring programs are summarised in **Table 7-1**. The testing frequencies noted are applicable if the dredge is working, inclusive of any dredging activities over the Wet Season. Altered frequencies are noted for monitoring when the dredge is no working.

The schematic in **Figure 7-1** shows the inter-relationship between the water quality monitoring conducted within the dredge spoil placement ponds (**Section 7.2**) and the water quality and benthic communities monitoring conducted within the East Arm receiving environment (**Section 7.3**). The water quality and benthic communities monitoring locations are shown in **Figure 7-2.**

Figure 7-1 Pond and receiving environment water quality and benthic communities monitoring



7 Environmental Monitoring

Table 7-1 Summary of environmental monitoring programs

Locations	Parameter	Methods	Frequency	Triggers	EMF
DREDGE SPOIL PLACEMENT PONDS					
Section 7.2 Location 1 - 20 m from dredge spoil discharge point into Pond K or Pond E (North). Locations 2,3,11 & 13 - At all pond outlets where tailwater is flowing, including Pond D if used during Dry Season. *If required:* Stormwater from existing Port land.	pH	Hand-held probe	Three times per day from the commencement of each dredging phase, reduced to once per day if TAG concurs that observed trends indicate no likelihood of trigger exceedance over a 14 day period. Once weekly between dredging phases (over Wet Season).	pH<6.0 pH>8.5 Discharge from pond discontinued if either trigger exceeded (**Section 6.2.3**)	
	Toxicants	Laboratory	Sample collected once per day from the commencement of each dredging phase, reduced to once per week if TAG concurs that observed trends indicate no likelihood of trigger exceedance over a 14 day period. If trends subsequently indicate a potential for trigger exceedance, revert to daily sample collection until trend is reversed. DGT units removed for analysis every four days whilst establishing relationship between dissolved and bioavailable toxicant concentrations. Once weekly between dredging phases (over Wet Season).	Discharge from pond discontinued if any ANZECC Guidelines trigger levels exceeded. (**Section 6.2.3**; trigger levels detailed in **Section 7.2.3**)	Water Quality Management - Dredge Spoil Placement Ponds
Section 7.2 Location 1 - 20 m from dredge spoil discharge point into Pond K or Pond E (North).	Turbidity (NTU)	Hand-held probe	Three times per day from the commencement of each dredging phase, reduced to once per day if TAG concurs that observed trends indicate no likelihood of trigger exceedance over a 14 day period. Once weekly between dredging phases (over Wet Season).	Use project specific SSC/NTU relationship (**Section 6.2.3**) to determine NTU trigger based on 100 mg/L SSC.	
Section 7.2 Locations 13 - Pond E (north) outlet	Turbidity (NTU)	Hand-held probe	Three times per day from the commencement of each dredging phase, reduced to once per day if TAG concurs that observed trends indicate no	Use project specific SSC/NTU relationship (**Section 6.2.3**) to determine NTU trigger based on	

7 Environmental Monitoring

Locations	Parameter	Methods	Frequency	Triggers	EMF
			likelihood of trigger exceedance over a 14 day period. Once weekly between dredging phases (over Wet Season).	100 mg/L SSC. Discharge from Pond E (North) discontinued if trigger exceeded (**Table 6-1**).	
Section 7.2 Locations 2, 3, 11 & 13 - At all pond outlets where tailwater is flowing, including Pond D if used during Dry Season.	SSC (mg/L)	Laboratory	Three times per day for first 14 days, further sampling on a weekly basis to extend range of values and strengthen SSC-NTU relationship.	100 mg/L. Also used to establish the relationship between SSC and NTU in the tailwater, to enable NTU to be used as surrogate measure of SSC. (**Section 6.2.3**)	Water Quality Management - Dredge Spoil Placement Ponds
Section 7.2 Location 4 - Pond E (South) prior to discharge (after the construction of the bund wall)	pH	Hand-held probe	Three times per day from the commencement of each dredging phase, reduced to once per day if TAG concurs that observed trends indicate no likelihood of trigger exceedance over a 14 day period. Returned to three times per day if Pond E (North) required for dredge spoil disposal. Once weekly between dredging phases (over Wet Season).	pH<6.0 pH>8.5 Discharge into Pond E discontinued if either trigger exceeded. (**Section 6.2.3**)	
	Toxicants	Laboratory	Once per day from the commencement of each dredging phase, reduced to once per week if TAG concurs that observed trends indicate no likelihood of trigger exceedance over a 14 day period. If trends subsequently indicate a potential for trigger exceedance, revert to daily monitoring until trend is reversed. DGT units removed for analysis every four days whilst establishing relationship between dissolved and bioavailable toxicant concentrations. Once weekly between dredging phases (over Wet Season).	Discharge into Pond E discontinued if any ANZECC Guidelines trigger levels exceeded. (**Section 6.2.3**; trigger levels detailed in **Section 7.2.3**)	
	Turbidity (NTU)	Hand-held probe	Three times per day from the commencement of each dredging phase, reduced to once per day if TAG concurs that observed trends indicate no likelihood of trigger exceedance over a 14 day period. Returned to three times per day if Pond E	Use project specific SSC/NTU relationship (**Section 6.2.3**) to determine NTU trigger based on 100 mg/L SSC. Discharge into Pond E (South)	

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Locations	Parameter	Methods	Frequency	Triggers	EMF
			(North) required for dredge spoil disposal. Once weekly between dredging phases (over Wet Season).	discontinued if trigger exceeded (**Table 6-1**).	
Section 7.2 Location 4 - Pond E (South) prior to discharge (after the construction of the bund wall)	SSC (mg/L)	Laboratory	Three times per day for first 14 days, further sampling on a weekly basis to extend range of values and strengthen SSC/NTU relationship (including if Pond E [North] required for dredge spoil disposal)	100 mg/L. Also used to establish the relationship between SSC and NTU in the tailwater, to enable NTU to be used as surrogate measure of SSC. (**Section 6.2.3**)	Water Quality Management - Dredge Spoil Placement Ponds
Section 7.5 Pond D	Pond water level	Install water height marker in pond	Daily, commencing at start of dredge spoil disposal	Pond water level above 1.5 m (from 1 November to 30 April only)	
Section 7.5 Ponds D and K	Migratory birds: species presence, abundance, mortality	Observation by trained observer	Weekly during dredging, commencing at start of dredge spoil disposal. 3 x monthly in: December 2012 January 2013 February 2013	Fall in numbers >50% between weekly counts. 60% below monthly maximum levels for total numbers, number of four key species, total number of species (See **Section 7.5.2.2** for details)	Migratory birds management
EAST ARM					
Section 7.3 South Shell Island (SSI) *Reference sites*: Old Man Rock Weed Reef	Turbidity (NTU)	INPEX data logger (SSI)	Daily, integrated 15 minute data commencing at start of dredging and continuing for duration of tailwater discharge.	*Dry Season*: Four day rolling average NTU exceeds: *Frequency*: >10 NTU for >4 days of 7. *Duration*: >10 NTU over 4 consecutive days *Intensity*: >12 NTU Benthic community monitoring initiated if any trigger exceeded (**Section 7.3.3**)	Water Quality Management – East Arm

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Locations	Parameter	Methods	Frequency	Triggers	EMF
Section 7.3 South Shell Island (SSI) *Reference sites*: Old Man Rock Weed Reef Mandorah (benthic communities only)	Turbidity (NTU)	INPEX data logger (SSI)	Daily, integrated 15 minute data commencing at start of dredging and continuing for duration of tailwater discharge.	*Wet Season:* Four day rolling average NTU exceeds: *Frequency*: >23 NTU for >6 days of 7. *Duration*: >23 NTU over 7 consecutive days *Intensity*: >35 NTU Benthic community monitoring initiated if any trigger exceeded and exceedance is attributable to MSB dredging program. (**Section 7.3.3**)	
	Benthic communities - % cover	ROV survey	*Scheduled*: Baseline. End Phase 1. Start Phase 2. (conditional) End Phase 2. 12 weeks post- Phase 2. (conditional) *Triggered*: As required by SSI turbidity data.	10% decline in benthic community cover at impact sites. Trigger exceedance, if deemed to be potentially due to MSB dredging, will necessitate implementation of management measures for dredging and tailwater disposal (**Section 6.3.4**)	Water Quality Management – East Arm
Section 7.3 Locations 5, 6 & 7 - 50 m from perimeter of dredging footprint (leeward side of tidal flow) And Locations 8, 9 & 10 - on seaward side of railway bund permeable section	Turbidity (NTU)	Hand-held probe	Twice daily, commencing at start of dredging: 1-2 hours after High Water 1-2 hours before Low Water. If plume is > calculated trigger and extends beyond 50 m from the perimeter of the dredge footprint, or further than 50 m from the bund wall, then hourly monitoring until mean turbidity at each monitoring location is < calculated trigger.	Use project specific SSC/NTU relationship (**Section 7.3.2.3**) to determine NTU trigger based on 50 mg/L SSC at 50 m from perimeter of dredge footprint. In the event of exceedance of turbidity triggers at SSI monitoring site, data will inform TAG's assessment of the likelihood that exceedance was due to MSB dredging program. (**Section 6.3.3**)	

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Locations	Parameter	Methods	Frequency	Triggers	EMF
Section 7.3 Locations 5, 6 & 7 - 50 m from perimeter of dredging footprint (leeward side of tidal flow) And Locations 8, 9 & 10 - on seaward side of railway bund permeable section	SSC (mg/L)	Laboratory	Samples collected over first 14 days of dredging.	n/a: To establish the relationship between SSC and NTU in the plumes emanating from the dredge and from the railway bund permeable section, to enable NTU to be used as surrogate measure of SSC. (**Section 7.3.2.3**)	Water Quality Management – East Arm
Section 7.4 Observation Zone and Exclusion Zone around dredge head	Protected Marine Species - presence	Observation by trained observers (MFOs)	1. On each occasion that the dredge has been non-operational for a period exceeding 30 minutes, a visual assessment will be undertaken of the 150 m radius Observation Zone by the MFO, for a period of 10 minutes prior to the recommencement of dredging. 2. Every 30 minutes, the Observation Zone will be assessed by the MFO for a period of five minutes.	Trigger – entry of protected marine species into the Exclusion Zone: • 150 m for dolphin with calf • 50 m for all other protected marine species, including dolphin without calf. 1. Dredging shall not commence until no protected marine species have been sighted within the Observation Zone for a period of 10 minutes. 2. If protected marine species enter into the Exclusion Zone, then dredging will cease until such time as there have been no protected marine species sighted within the Observation Zone for a period of 10 minutes. (**Section 6.4**)	Protected Marine Species Management – physical interaction and underwater noise

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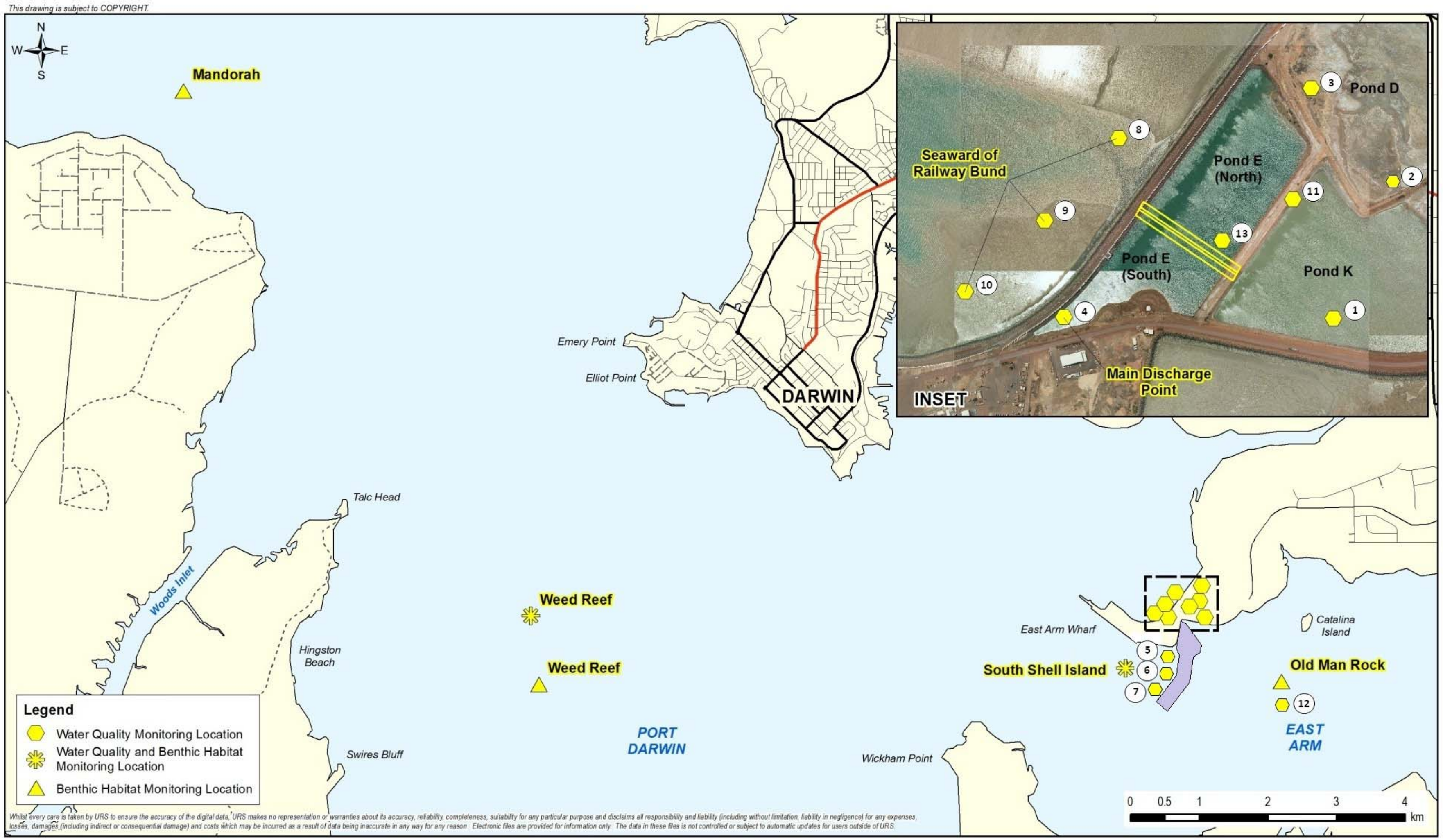
Figure 7-2 Water quality and benthic community monitoring locations



Z

7.2 Dredge spoil placement ponds – water quality

7.2.1 Objectives

The objectives of monitoring water quality within the dredge spoil placement ponds are to:

- Detect trends in tailwater pH that may indicate the generation of acid from dredged PASS material pumped into the ponds.
- Detect trends in toxicant concentrations within the ponds that may indicate the mobilisation of toxicants from the dredged sediments, or from material placed in the ponds during past dredging programs (East Arm Wharf development, Darwin City Waterfront, etc.).
- Confirm the physico-chemical properties (pH, toxicants and SSC) of the tailwater are suitable for discharge from the ponds to the harbour waters.

7.2.2 Monitoring locations

The pH, turbidity and toxicant concentrations of the tailwater are monitored:

- Within 20 m from the dredge spoil discharge point into Pond K or into Pond E (North).
- At any pond discharge point where dredge tailwater is flowing.
- Within Pond E (or Pond E [South] when created).

In the event that stormwater enters Ponds D, E or K from existing reclamation areas or ponds within East Arm Port, then pH and toxicants will be monitored weekly by the NT Department of Infrastructure (DoI) unless the results of such monitoring, in the view of TAG, require more frequent sampling and analysis. This will inform the assessment of potential causes of any trends in pH and toxicant concentrations that may become evident in Ponds D, E or K. It is noted that there are no controls on entry into the dredge spoil placement ponds of stormwater from the Port areas to the north of the ponds. However, if there is a need to transfer stormwater from Pond F (at East Arm Wharf) into Pond E, then this would be done by a pump system; hence the water in Pond F shall be tested to assess its suitability for transfer prior to pumping.

7.2.3 Methodology

Over the course of dredging Phase 1:

- Tailwater **pH** was monitored by extracting water samples three times per day from each monitoring location and testing the water with a hand-held pH meter.
- **Turbidity** was monitored at each location using a hand-held probe.
- One water sample per day was collected from each of the monitoring locations and sent to a NATA-accredited laboratory for analysis of **toxicant** concentrations (including arsenic). Prior to analysis, the samples were filtered to remove particles >45 µm in diameter; reducing the potential for sediment-bound toxicants to be included in the analyses. Results were typically received from the laboratory within seven working days.

Details of instrument calibration, sample collection and processing methods, etc., are presented in Macmahon's water quality sampling procedure. Since the completion of Phase 1 of the dredging, monitoring has continued at a reduced frequency (once per week, as per **Table 7-1**). The Phase 1 sampling frequency will be applied at the commencement of Phase 2 of the dredging.

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For the two week period prior to the commencement of Phase 2 dredging and during the first four weeks of Phase 2 dredging, DGT ('diffusive gradients in thin films') equipment will be deployed within the pond system. DGT technology is widely used to assess the bioavailability of toxicants in both fresh and marine waters (e.g. Munksgaard & Parry 2003, Ferreira et al. 2008, Sherwood et al. 2009, Davison & Zhang 2012, Osterlund et al 2012).

DGT units are typically deployed for periods of days to weeks; hence they provide a time averaged (i.e. integrated over a period of time) measure of bioavailable toxicant concentrations. The DGT units in the pond system will be retrieved and analysed every five days as biofouling in tropical marine waters can become a problem after 4-5 days (I. Poiner, TAG Chair, pers. comm. 2013). This is considered an appropriate frequency for analysis, as data from the daily water samples collected to date have shown isolated spikes in toxicant concentrations (typically of copper) that are present only on individual days. Integrated concentrations over four day periods will provide more useful data.

During each deployment period, daily water samples will be collected in the immediate vicinity of the DGT units, filtered and analysed for toxicants. This will enable an assessment of relative trends in dissolved and bioavailable toxicant concentrations.

Based on potential toxicity and presence within Darwin Harbour sediments, the metallic toxicants to be monitored through collection of water samples are displayed below. The toxicant trigger levels are set at the 95% level of protection (% of species) within the ANZECC Guidelines. Where marine water quality triggers are not available due to insufficient data, freshwater trigger levels applicable to slightly–moderately disturbed systems are adopted[2].

Arsenic (AsIII)	24 µg/l (freshwater)
Arsenic (AsV)	13 µg/l (freshwater)
Cadmium	5.5 µg/l
Chromium (CrIII)	27.4 µg/l
Chromium (CrVI)	4.4 µg/l
Copper	1.3 µg/l
Lead	4.4 µg/l
Mercury (inorganic)	0.4 µg/l
Nickel	70 µg/l
Selenium (total)	5 µg/l (freshwater)
Zinc	15 µg/l

Speciated toxicants (arsenic and chromium) will be analysed for total values, and if any total exceeds the trigger level of one of the species, then the samples will be reanalysed for the individual species.

If the TAG considers that a sufficiently robust relationship exists between dissolved toxicant concentrations and the DGT-derived bioavailable concentrations (see above) then, in the event that the concentration of any dissolved toxicant in the daily water sample exceeds its trigger level:

[2] It is recognised that freshwater trigger levels are not strictly applicable to marine ecosystems. However, as noted in **Section 6.2.3** the ANZECC Guidelines indicate that there are insufficient ecotoxicity data for these toxicants to set reliable trigger levels. Similarly, the available dataset for concentrations of these metals within Darwin Harbour waters is insufficient for the determination of reliable 'natural background levels'. It is noted that, for toxicants, the Darwin Harbour Region Water Quality Objectives (Fortune & Maly 2009; NRETAS 2010) defer to the ANZECC Guidelines.

- The relationship will be applied to determine the equivalent bioavailable concentration.
- The bioavailable concentration will be compared against the trigger level.

The management response to the outcome of this comparison is detailed in **Section 6.2.4** and **Table 6-1.**

It is noted that the DGTs will not provide a quantitative measure of arsenic, chromium or selenium (I. Poiner pers. comm. 2013). If concentrations of these metals in the collected water samples approach their respective trigger levels, then an appropriate frequency of sample collection within the ponds will be agreed with the TAG (and NT EPA and SEWPaC will be advised of the outcome).

The frequency of sampling is periodically reviewed and, if approved by the TAG, will be reduced to daily (for pH and turbidity) or weekly (for toxicants) if there is no trend towards decreasing pH or increasing turbidity or toxicant concentrations over a 14 day period. Depending on the results from the initial DGT deployment at the commencement of Phase 2 dredging (see above), TAG may also consider the suitability of approving the use of DGTs on a reduced deployment frequency in lieu of water sampling for toxicant concentrations. Such an approval by TAG would be provided to NT EPA and SEWPaC. Monitoring frequencies for all parameters will be increased to the start-up frequency in the event that relevant guideline exceedances are detected.

7.2.4 Data analysis

Trends in **pH** are considered at each monitoring location over time (i.e. is pH decreasing at any of the locations over time?) and also between locations (e.g. is pH lower at the discharge point from Pond E than at the pipes leading from Pond K to Pond E?). To date there have been no trends towards reduced pH levels (i.e. increased acidity). However, if such trends were to occur then the data would inform an assessment of whether the acidification was arising from acid generated from the material dredged from the MSB or from previously dredged material in the pond system.

Trends in **turbidity** are considered at each monitoring location over time (i.e. is turbidity decreasing at any of the locations over time?) and also between locations (e.g. is turbidity lower at the discharge point from Pond E than at the pipes leading from Pond K to Pond E?). Turbidity has been highly variable over the course of the dredging program to date and no clear trends have been apparent. If trends were to become apparent, then they would inform an assessment of whether turbidity is reducing at a rate which will continue to allow tailwater to continue to be discharged to the harbour from Pond E, or whether extended settlement times would be needed before discharge could occur.

Trends in **toxicant** concentrations are considered at each monitoring location over time (i.e. are the toxicant concentrations increasing at any of the locations over time?) and also between locations (e.g. are the toxicant concentrations higher at the discharge point from Pond E than at the pipes leading from Pond K to Pond E?). As indicated in **Section 7.2.3**, there have been no overall trends observed in toxicant concentrations. If ongoing monitoring indicates that there is an increasing trend in any toxicant concentrations, either over time or between locations, then the trend analysis will assist in the assessment of whether the increasing concentrations are due to liberation of toxicants from the material dredged from the MSB; from toxicants mobilised from previously dredged material in the pond system (possibly abetted by increased tailwater acidity, if present); or from toxicants in stormwater entering the pond system from the developed areas of East Arm Port. DoI monitors stormwater entering into the pond system.

7.2.5 Outcomes

The data outputs from the monitoring enable ongoing assessments to be made of the need to implement further tailwater (or stormwater) management measures to maintain water quality parameters within the pond system below trigger levels and to render the water suitable for disposal from Pond E (see **Section 6.2.4**).

7.3 East Arm - water quality and benthic communities

7.3.1 Overview

The East Arm water quality and benthic communities monitoring program aims to gather information on the state of the marine environment near the MSB dredging footprint before, during, and post-dredging. Specifically, the objectives of the program are to:

- Provide baseline benthic community health data prior to the commencement of dredging
- Utilise water quality data during dredging to monitor the potential for dredging impacts
- Perform benthic community monitoring during dredging to monitor dredging impacts
- Provide post-dredging benthic community habitat data to identify impacts that may have occurred as a result of dredging.

It is intended that the program be flexible as required by the conduct, field observations and outcomes of the monitoring events, and the data evaluation process will be revised (in consultation with the TAG) as required through the monitoring program.

The water quality monitoring program uses data from the INPEX water quality monitoring program to provide Macmahon with water quality information relevant to the MSB dredging. Access to these data has been secured for the duration that it is required for this purpose.

If additional information needs are identified during or post-dredging, these will be addressed as required and the program will be updated to reflect the changes. Likewise, changes in control site location, timing of dredging program execution, equipment, or other variables that may affect the implementation of this program will be evaluated (in consultation with the TAG) and the plan updated as necessary.

7.3.2 Water quality monitoring

7.3.2.1 Objectives

The water quality monitoring program aims to provide information on water quality in the project area, with the specific purpose of informing reactive habitat monitoring if required by the exceedance of water quality trigger levels. The water quality program will:

- Utilise existing INPEX water quality data as a pre-dredging baseline
- Monitor water quality during dredging
- Trigger benthic community monitoring events (if water quality data indicate potential impacts from dredging)
- Inform reporting on benthic community monitoring if changes in benthic community health are observed.

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7.3.2.2 Monitoring locations

Water quality monitoring within East Arm will comprise:

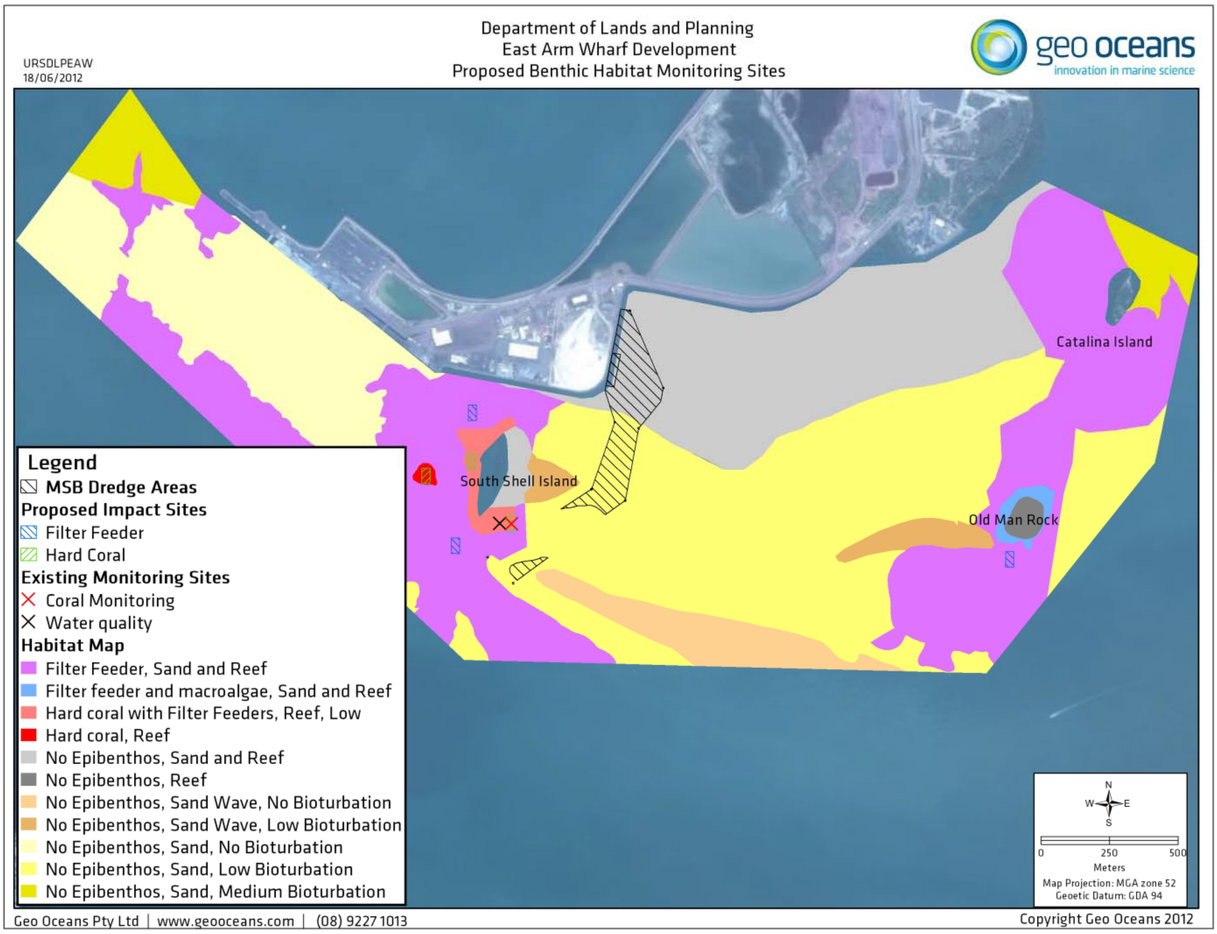
- Receipt of turbidity data from water quality loggers deployed and maintained by INPEX as a part of their monitoring program for the Ichthys development dredging program.
- Monitoring by Macmahon of turbidity at locations around the perimeter of the dredging footprint and on the seaward side of the permeable section of the railway bund wall.

The use of the **INPEX** water quality monitoring program as a data source to monitor the MSB dredging project is a cost-effective way to obtain consistent water quality data, reducing duplication in field programs and increasing compatibility of data collected.

The locations from which INPEX water quality data are received (**Figures 7-2** and **7-3**) are a subset of the sites monitored for the Ichthys development dredging program:

- South Shell Island (putative impact)
- Weed Reef (control).

Figure 7-3 Locations for water quality and benthic community monitoring in East Arm



The rationale for selection of the South Shell Island monitoring location as the putative impact site included consideration of its proximity to the dredging footprint, the model outcomes and the benthic habitats survey. In addition, it is considered that the water quality at that location will be adequately representative of the water quality at the benthic communities monitoring sites around South Shell Island. It is also a location that is immediately “downstream” of the dredging footprint on ebb tides, which is when there is the greatest likelihood of turbid plumes from the dredging works and tailwater discharge impinging upon the benthic communities.

Data from the control sites are required in the event that it is necessary to assess whether changes in water quality at the South Shell Island site are due to the dredging program, or to the influence of harbour-wide changes in water quality (e.g. due to a period of high rainfall or elevated wave action).

The locations for turbidity monitoring around the perimeter of the **dredging footprint** and on the seaward side of the permeable section of the railway **bund wall** are dependent upon the observed distribution of the plumes emanating from the dredge cutter head, and from the permeable section of the bund, at the time that the monitoring is conducted. In turn, this varies in accordance with the prevailing tidal conditions. The monitoring targets those locations 50 m “downstream” from the perimeter of the dredging footprint, and from the seaward side of the permeable section of the railway bund wall, at which turbidity is visibly the highest.

The number of locations required to comprehensively characterise the plume also varies between days, though a minimum of three locations are monitored around the perimeter of the dredging footprint and a minimum of three locations are monitored on the seaward side of the railway bund wall.

If turbidity levels in the waters passing through the railway bund wall from Pond E (South) are lower than the turbidity levels in Frances Bay, then these observations will be taken into consideration if it is necessary to investigate the attributability to tailwater discharge of turbidity trigger level exceedances at the South Shell Island site.

7.3.2.3 Methodology and data analysis

The **INPEX** water quality monitoring program includes the use of bed-mounted water quality loggers, which are currently in place at the nominated sites recording turbidity (NTU) data. Data will be available throughout the duration of the MSB dredging program. Raw water quality monitoring data are received from INPEX on a daily basis from the South Shell Island logger. Data from the logger at the control site is available fortnightly; with the potential for more frequent downloads if required. Upon receipt of the water quality data from INPEX, it is subjected to a QA/QC check and, if deemed acceptable, the calculated statistic (four day rolling mean NTU) is compared against the turbidity trigger level in **Table 7-1**. If no exceedance is evident, then the data are added to the database and monitoring continues. If an exceedance has occurred, then the response described in **Section 6.3.4** is initiated.

The Proponent will submit the TAG’s advice and proposed actions to SEWPaC in all instances of exceedance, in accordance with approvals.

The **Macmahon** monitoring of the perimeter of the dredging footprint, and on the seaward side of the permeable section of the railway bund wall, is undertaken using a hand-held multi-parameter probe. Data are fed to a display and data storage unit on the monitoring vessel and downloaded for archiving (and further analysis, if required) once ashore. The real-time water quality data are viewed aboard the monitoring vessel, enabling immediate feedback to be provided to the TAG with respect to whether the target turbidity level (see **Table 7-1**) is being exceeded. This takes account of the background turbidity levels in the vicinity of the dredging operation and the tailwater discharge locations.

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As well as dictating the monitoring locations (see **Section 7.3.2.2**), the changes over the tidal cycle in distribution of the plume from the operating dredge determine the times at which monitoring takes place. As the dredging footprint is “upstream” from South Shell Island, monitoring takes place on the ebb tide. During the first two weeks of dredging, the changing distribution of the plume was recorded to determine the most appropriate times (after High Water) for routine monitoring to occur. On each ebb tide, the main times of interest are when:

- The plume is most dense (typically within 1-2 hours after High Water), though it is in close proximity to the dredge.
- The plume extends furthest from the dredge (typically within 1-2 hours before Low Water), though it is less dense as it is dispersed by the tidal flow.

Similar variability has been observed in the distribution of the plume emanating from the seaward side of the permeable section of the railway bund wall. During the first two weeks of tailwater discharge through the bund wall, the changing distribution of the plume was recorded to determine the most appropriate times for routine monitoring to occur.

As indicated in **Table 7-1**, if the trigger level is exceeded 50 m from the perimeter of the dredging footprint, or 50 m from the permeable section of the bund wall, then hourly monitoring will be undertaken until mean turbidity at each monitoring location is below the trigger level.

Also during the first two weeks of dredging, water samples were collected from within the dredging and tailwater plumes in East Arm and filtered to remove the suspended sediments. Turbidity measurements (in NTU) were taken concurrently at the water sampling points. The filter papers, with the sediments removed from the water samples, were sent to an appropriately accredited laboratory for accurate weighing. The field-measured turbidity and laboratory-measured SSC enabled relationships to be established between NTU (turbidity) and SSC for the plume emanating from the dredge cutter head and for the tailwater plumes. The relationships differ for the different turbidity sources as they vary with the predominant sizes of particles within the water column. These relationships have enabled a more accurate determination to be made of the target NTU level (as a surrogate for the 50 mg/L SSC target) at the perimeter of the dredging footprint and on the seaward side of the permeable section of the railway bund wall. The relationships are updated upon receipt of any further SSC and NTU data collected from the monitoring locations and the current target NTU levels are included within the weekly monitoring summary report (**Section 8.1.1**).

7.3.3 Benthic communities monitoring

7.3.3.1 Objectives

This component of the monitoring program aims to provide information on the health of benthic communities in the project area on a regular basis throughout the duration of the dredging project; and on an as-required basis if water quality trigger levels are exceeded. Specifically, the habitat monitoring program will:

- Provide a baseline of benthic habitat health pre-dredging
- Monitor benthic community health during dredging
- Include triggered habitat monitoring events if water quality monitoring indicates the potential for impacts from dredging
- Monitor the potential cumulative effects of the MSB and INPEX dredging programs

- Inform the need for implementation of dredging management measures
- Provide a post-dredging assessment of benthic community health in the project area.

7.3.3.2 Monitoring locations

In May 2012, Geo Oceans conducted a habitat mapping exercise in the project area, the results from which (Geo Oceans 2012a) were used to identify potential locations for ongoing monitoring of benthic communities during the dredging works. The locations selected are detailed in **Table 7-2**, with the East Arm sites shown in **Figure 7-3**.

Table 7-2 Habitat monitoring locations

Site	Type	Habitat
South Shell Island	Putative Impact	Corals, filter-feeders
Old Man Rock	Reference	Filter-feeders
Weed Reef	Reference	Corals, filter-feeders

The South Shell Island monitoring sites were selected on the basis of:

- The presence of coral and filter-feeder communities (about which stakeholders have expressed concern of impacts) with benthic cover amongst the highest recorded in the vicinity of South Shell Island.
- Lateral separation of the sites to assess potential impacts across the breadth of communities off the western side of South Shell Island.

The rationale for the inclusion of a filter-feeder community monitoring site at Old Man Rock is to assess potential impacts from turbid plume dispersion from INPEX's dredging works upstream in East Arm. Data from the Weed Reef reference sites are required in the event that it is necessary to assess whether changes in benthic communities at the South Shell Island site are due to the dredging program, or to broader scale impacts (e.g. physical impacts or harbour-wide degradation of water quality due to storm activity, bleaching [hard corals], disease outbreak).

7.3.3.3 Methodology

The habitat monitoring methodology was developed by Geo Oceans, and the design of the program specifically seeks to provide comparable data to assess benthic community health through time. Towed cameras and mini-ROVs will be used to collect video footage and high resolution still images of the benthic habitats at the monitoring sites. This imagery will then be analysed using point overlay software (Coral Point Count with Excel extensions software) to provide a quantitative data set of the composition and biota percent cover.

This data set will be statistically analysed using a 'Before, After, Control and Impact' (BACI) design (Underwood 1994) with replication within each site and between different sites (i.e. reference and impact sites). This survey design involves repeated measurements over time being made at reference sites and potentially impacted sites (**Table 7.2**), both before and after the potential impact has occurred. The design relies on data from reference sites to compare results against natural variation or other activities that could cause an influence on the impacted site.

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Reference sites have been selected for the survey from outside the Zone of Influence, to reduce (as much as possible) the chance they will be impacted by the MSB dredging program. Impact sites have been selected based on their proximity to the development, their environmental sensitivity, and their consistency within a survey area for ongoing statistical comparison.

The survey area at each site will be 50 m by 50 m. The transects will be spatially accurate to within 5 m of the pre-defined transect line to minimise variance within the site, with transect start and end points will be determined using a highly accurate differential global positioning system (DGPS).

A baseline survey conducted by Geo Oceans (2012b) between 29-31 July 2012 produced a dataset upon which a statistical power analysis was undertaken. The minimum detectable difference (change) varied between sites, from 2% to 14%. This variability was primarily due to the typically patchy distribution of benthic biota along the transects and to the high variability in cover between transects. Given these characteristics of the benthic communities, it is considered that it is only feasible to detect (with sufficient statistical confidence) a change of 10% in biota cover at the monitoring sites.

To detect a 10% change in biota cover with a power of at least 0.8 and a statistical confidence of 5%, the power analysis showed that analysis was required of 50 still images per transect, with 5 points analysed per image. The recommended number of replicate transects (each 50 m long) required per site varies between monitoring sites from five to nine transects. A plan presenting the results of the power analysis and a final monitoring design (Geo Oceans 2012b) will be submitted to the TAG for consideration prior to the conduct of surveys during dredging (if required) or post-dredging.

The East Arm water quality and benthic habitat monitoring and management framework is depicted in **Figure 6-2**. The schedule of routine benthic community monitoring is included in **Table 7-3**. Additional monitoring will be required if the turbidity trigger levels presented in **Table 6-3** are exceeded.

Table 7-3 Schedule for habitat monitoring surveys

Survey type	Timing
Scheduled monitoring event – baseline	Prior to Phase 1
Triggered monitoring event(s)	None required during Phase 1
Scheduled monitoring event	End of Phase 1 (conducted 6-7 December 2012)
Scheduled monitoring event	Prior to Phase 2
Triggered monitoring event(s)	As required by water quality exceedance
Scheduled monitoring event	End of Phase 2
Contingency monitoring event – post-dredging	Twelve weeks after end of Phase 2

As indicated in **Table 7-3**, there were no triggered monitoring events during Phase 1 of the dredging. Hence any changes in benthic community characteristics at South Shell Island between the end of Phase 1 and the commencement of Phase 2 will either reflect natural changes or be attributable to the ongoing INPEX dredging campaign.

The post-dredging contingency monitoring event is included in recognition that if a benthic community does experience a dredging-related increase in turbidity levels, then any potential impacts may only become evident some time after the increase has occurred (refer **Section 6.3.3**). However, if there are no triggered monitoring events during dredging Phase 2, and if there are no detectable declines in biota cover between the monitoring events at the end of Phase 1 and the commencement of Phase 2, then it is considered that the post-dredging contingency monitoring event will not be required.

If at any stage during the monitoring program, new data or changes in the timing of the dredging program execution, equipment or other variables are identified that may affect the implementation and effectiveness of the habitat monitoring program, this DDSPMP will be evaluated, revised and resubmitted for NT EPA and Ministerial approval as necessary.

7.4 Protected marine species

At all times that the dredge is operational, the crew will include at least one member that is trained (by a training provider whose capability is recognised by the TAG) as an MFO. As described in **Table 7-1**, the MFO will be responsible for undertaking visual assessments (for protected marine species) of the 150 m radius Observation Zone around the cutter head. The assessment of the Observation Zone will be made from an elevated position on the dredge, where a clear line of sight is achievable to the edge of the zone. The MFO will not be engaged in any other activities during the dedicated assessment periods.

During dredging, at 30 minute intervals the designated MFO will check the Observation Zone for a period of five minutes. If any protected marine species are present within the zone, the sighting will be recorded (including details of the time and results of observation) and the management measures described in **Section 6.4** will be implemented.

The Dredging Contractor has provided awareness training to selected crew members to inform them about the protected marine species which may occur within Darwin Harbour; to provide a description of the record form to be used for recording protected marine species sightings; and to explain how to apply appropriate avoidance mitigation measures to minimise potential impacts or collisions with marine fauna. The purpose of the training was to raise awareness; to encourage recording and reporting of protected marine species sightings, and to emphasise the requirement to report stranded, injured or dead marine species regardless of what caused the injuries or deaths.

The Dredging Contractor undertakes observations for protected marine species and reports all positive sightings by the MFO to the Project Manager who ensures sightings are logged and information is provided to the NTG. All sightings of protected marine species are recorded by the MFO on marine fauna observation forms (**Figure 7-4**) which are available on all Project vessels. These records are then logged into the Project marine fauna sighting register.

Macmahon will be responsible for reporting sightings of any EPBC-listed marine fauna to the relevant authorities within 24 hours. This includes the requirement under EPBC condition 17(g) to report to the relevant Minister, within one business day, where there is injury or mortality to a listed threatened or migratory species that may be attributable to the dredging activity. The report will include details of the individual species observed, the frequency, location and timing of observations, and photos (if available). The objective of these reports is to identify potential interaction areas which will be incorporated by the Dredging Contractor into pre-starts, toolboxes, marine fauna awareness training, or other general awareness sessions as required.

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Figure 7-4 Marine fauna observations form

Library Ref: N109

Revision Date: 13-Jul-12

Marine Fauna Observations
Marine Supply Base

MACMAHON

Name :

Employer :

Date :

Day or Night Shift :

Time	Reported Observations & Actions							Initial
	Species[1]	No.	Calves (Y/N)	Distance (m)	Mitigation response[2]	Beaufort state	Comment	

[1] Record the species as accurately as you can. If unsure, use the general terms "dolphin", "turtle", "sawfish", etc.
[2] If no mitigation response is required, you should still record this.
Take photos if possible.

Relevant to:
Business Unit: Maintenance Services
Division(s): Workshop
Site: All
Department: Plant Maintenance

Document Owner: HSEQ Superintendent
Change Control: Level 3

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7.5 Migratory birds

7.5.1 Recent monitoring

The NTG has already conducted a 10 month survey, monitoring shorebirds and wetland birds within East Arm Port, mainly at the dredge spoil ponds. In a 2011 report by EMS, it was recommended that monitoring be continued and expanded to include the saline flats/tidal mudflats and a Dry Season survey conducted. It was also recommended that monitoring should be continued to determine whether the migratory birds can and do use other nearby areas once the dredge spoil ponds are filled.

The aim of the surveys would be to substantiate the assumption that migratory and shorebirds will utilise alternative habitat types within Darwin Harbour. These issues are currently being considered in the development of the Biodiversity Impact Mitigation and Offsets Strategy (BIMOS) between the NTG and SEWPaC, under which the NTG has agreed to undertake monitoring of the migratory birds at an appropriate frequency.

7.5.2 Planned monitoring

7.5.2.1 Pond water height

Pond water height measurements will be taken daily throughout dredging, and used to reference current pond height against natural high water levels.

7.5.2.2 Migratory bird monitoring

In the first year, counts at East Arm Wharf ponds will be conducted (during daylight hours) within two hours of high tide in line with the SEWPaC significant impact guidelines for 36 migratory shorebird species policy statement. During the dredging phase until the end of November, counts will be undertaken weekly. For this period it is anticipated that the extra water supplied to Pond D may attract migratory shorebirds when normally they would not be present at the site because it is dry. The weekly counts are therefore likely to exceed baseline levels. Nevertheless the counts will be undertaken in order to determine whether any sudden changes occur that cannot be accounted for otherwise (e.g. the counted waders are in transit).

Further counts will be undertaken (during the 3-5 days of the highest tide of each of the following months:

- December 2012 (three counts)
- January 2013 (three counts)
- February 2013 (three counts).

Ongoing Migratory Bird monitoring will be undertaken for five years post-dredging to satisfy EPBC approval Condition 17(f)(i). After the Migratory Bird Management Plan has been implemented by the NTG these surveys will continue and also satisfy condition 36 of the above approval.

Results will be analysed to compare the total numbers, numbers of species and numbers of four species (i.e. those previously identified to have used Pond D for roosting in numbers exceeding the threshold for national significance) with the mean value in baseline surveys, allowing for the month of survey.

Reporting

8.1 Routine reporting

8.1.1 Weekly monitoring data

Each week during the dredging and tailwater discharge activities, a weekly summary report of monitoring data will be submitted to the Proponent for dissemination to the TAG and to other stakeholders that may be designated by the TAG. The report will include:

- pH and turbidity (NTU) data within the dredge spoil placement ponds, from the commencement of dredging and spoil placement (**Section 7.2**).
- Toxicants and SSC data for pond waters, once available from the laboratory (**Section 7.2**).
- Comments on any apparent trends in the data, both over time and between ponds (**Section 7.2.4**).
- Daily averages and four day rolling averages of turbidity data from the telemetered data logger at South Shell Island (**Section 7.3.2**).
- Turbidity data from monitoring at the perimeter of the dredging footprint and seaward of the permeable section of the railway bund wall (**Section 7.3.2**).
- SSC data for water samples collected at the perimeter of the dredging footprint, once available from the laboratory (**Section 7.3.2**).
- Records of sightings of protected marine species (**Section 7.4**).
- Dredge daily logs showing work area and availability.

8.1.2 Monthly report

Each month during dredging and tailwater discharge, a monthly summary report will be provided to the Proponent and to NTEPA which details:

- Status of dredging operations (**Section 8.1.3**).
- Summary of weekly data reports (**Section 8.1.1**).
- Discussion of any trigger level exceedances (**Section 8.2**).
- Corrective actions taken to address exceedances (**Section 6**).
- Summary of daily observation data for migratory birds (numbers and species) (**Section 7.5**).
- Details of any injuries to, or mortalities of, turtles, dugongs, dolphins or migratory birds as a result of dredging activities or pond water management (**Section 8.3**).
- A summary of environmentally significant equipment failures or events and an outline of corrective actions taken, or proposed, to reduce environmental harm arising therefrom (**Section 8.3**).
- Details of any complaints received, including investigations undertaken, conclusions formed and actions taken (**Section 8.4**).
- Details of the dredge hydrographic survey findings.

8.1.3 Dredge operation records and reporting

The Dredging Contractor will maintain daily records of areas dredged, the volumes of material removed and dredge availability. These records will be provided to TAG weekly, and the findings from the hydrographic survey will be included in the Macmahon monthly report to the Proponent (see **Section 8.1.2**). Copies of the daily environmental inspection checklists and other relevant environmental records will be provided by the Dredging Contractor to Macmahon, and these will be provided to the Proponent for circulation as appropriate.

8.1.4 End of dredge phase reporting

In accordance with Condition 28 of WDL 187, within one month of the conclusion of each dredging phase Macmahon will submit a monitoring report to NT EPA which includes, but will not be limited to, a trend analysis and interpretation of analytical data collected under the conditions of the licence. The report will also be made available on Macmahon's website.

8.1.5 Compliance reporting

The NTG, as the holder of the EPBC approval, will report to the Commonwealth Government on a yearly basis (by 30 March of each year after the commencement of the Action). Macmahon will provide information to the NTG as required to facilitate this reporting requirement, including:

- Summaries of all monitoring program outcomes
- Summaries of any monitoring exceedances
- Details of corrective actions implemented to dredging and tailwater discharge methods in response to monitoring exceedances
- Details of triggered habitat monitoring surveys and results (if any)
- Recommendations for dredge program conduct for the next period.

As licensee under WDL 187, each year Macmahon will submit to NT EPA an annual audit and compliance report as specified in Condition 29 and Appendix 2 of the licence. This report will be submitted a minimum of 20 business days prior to the anniversary of the commencement date of the licence (24 August 2012).

During dredging, Macmahon will notify NT EPA of any non-compliances with WDL 187, as required under Condition 22 of the licence.

8.2 Exceedance notification and reporting

The following notifications of exceedances will be made to the Proponent, TAG, DLPE and SEWPaC, within 24 hours of the exceedances occurring:

- Within the dredge spoil placement ponds, exceedance of –
  - pH, toxicant or SSC (measured as NTU) trigger levels (**Section 6.2.3**)
  - triggers for Pond D water levels (**Section 6.6.2.1**)
  - triggers for reduction in numbers of migratory birds (**Section 6.6.2.2**).
- Within East Arm, exceedance of –
  - intensity, duration or frequency trigger for turbidity at the South Shell Island telemetered monitoring site (**Section 6.3.3.1**)
  - trigger for reduction in live benthic cover at South Shell Island benthic community monitoring sites (**Section 6.3.3.2**)
  - turbidity trigger levels at the perimeter of the dredging footprint and on the seaward side of the permeable section of the railway bund wall (**Section 6.3.3.3**).

Exceedances will also be reported to NT EPA in accordance with Conditions 24.1 and 25 of WDL 187 and as and when required under the *Waste Management and Pollution Control Act* and the *Water Act*.

For each exceedance, Macmahon will provide NT EPA with a report on the corrective actions implemented to address the cause of the exceedance. In accordance with Condition 24.2 of WDL 187, this report will be submitted within five business days of the notification provided in accordance with Condition 24.1.

For each exceedance, or suite of related exceedances, a report will also be prepared by Macmahon (and submitted to the Proponent) that summarises the nature of the exceedance(s) and the corrective action(s) implemented. For exceedances of the turbidity trigger levels at the South Shell Island telemetered monitoring site the report will include the outcomes of the assessment of attributability of the MSB dredging program (conducted within three business days of the exceedance notification, or within five days if it is apparent that the exceedance may be due to cumulative impacts arising from the INPEX dredging program, refer **Figure 6-2**). These reports will be updated with further monitoring results (e.g. of benthic community monitoring) and with comments on the effectiveness of the corrective action(s) once this has been determined; the timeframe for these updates will be dependent upon the length of time that is required for the additional monitoring to be undertaken (and data processed) and for the effectiveness of corrective action(s) to be assessed.

8.3 Environmental incident notification and reporting

In the event of the following environmental incidents, the Proponent will be notified and the Proponent will notify the TAG and SEWPaC, within 24 hours of the incident occurring:

- Vessel interaction with protected marine species, including details of injury to, or mortality of, individuals in accordance with EPBC approval Condition 17(g) (**Section 6.4**).
- Suspected disturbance of protected marine species related to noise generated by MSB dredging activities (**Section 6.5**).
- Mortality of protected migratory birds in dredge spoil placement ponds (**Section 6.6**).

Other environmental incidents (spills, etc.) will also be recorded. If the incident is a notifiable incident under the *Waste Management and Pollution Control Act*, then NT EPA will also be notified within 24 hours.

All incidents will be investigated and recorded on a Macmahon ‘Incident Report Form’ (G-228), and/or an ‘Environmental Incident Details Form’ (G-051), in accordance with procedure G-421 ‘Accident Investigation and Reporting’. Preventative and corrective actions will be established and these will be recorded on Macmahon’s ‘Non-conformance and Corrective Action Register’ (G-599), and the progress tracked for completion.

8.4 Complaints reporting

In the event of a complaint received as a result of dredging activities, they will be entered and tracked using InControl® (software). Details recorded include:

- Date, time and method of complaints
- Description of complaint
- Complainant details
- Cause, action and proposed action, including allocation of a person to action the complaint and an action date
- Follow-up and close-out.

Corrective action in response to valid complaints is to occur within 48 hours following receipt of the complaint. Records will be made available to the Proponent and authorities upon request, taking into account any privacy issues of the complainant as appropriate.

8.5 Reporting and notification summary

The Proponent will report as required to the Commonwealth Government under the EPBC approval. The Proponent will publish the results on the following web site, in accordance with EPBC Condition 17(h):

Website **www.eastarmwharf-eis.nt.gov.au**

Reporting and notifications will be sent to the following stakeholders as per the requirements detailed within **Section 6** this DDSPMP.

Proponent ken.gardner@nt.gov.au and Stephen.Hoyne@nt.gov.au

NT EPA environmentops@nt.gov.au

SEWPaC post.approvals@environment.gov.au

The reporting and notification requirements for the Project are summarised in **Table 8-1**.

Table 8-1 Reporting and notification summary

Reporting Type	Time	Reporting to	Content/Comments
Routine reporting			
Start up	14 days 1 month (from commencement)	Proponent, SEWPaC Websites	Notice of dredging commencement as per EPBC approval Condition 1 Post DDSPMP on Proponent website as per EPBC approval Condition 8 as on Macmahon's website as per WDL 187 Conditions 10 and 19
Protected marine species sightings (**Section 7.4**)	24 hours (from sighting)	Proponent	Marine Fauna Observations sheet (**Figure 7-4**)
Weekly monitoring reports (**Section 8.1.1**)	Weekly	Proponent, TAG	Water quality data from monitoring within the dredge spoil placement ponds, at South Shell Island, at the perimeter of the dredging footprint and seaward of the permeable section of the railway bund wall. Protected marine species sightings (summary from daily observations sheets).
Monthly reports (**Section 8.1.2**)	Monthly	Proponent, TAG, NT EPA, SEWPaC	Dredge production. Pond levels. Summary of weekly monitoring reports. Trigger level exceedences and resultant corrective actions implemented. Numbers and species of migratory birds observed in ponds. Summary of notifications, non-compliances, complaints, and

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Reporting Type	Time	Reporting to	Content/Comments
			environmental emergencies or incidents and measures implemented to address these.
End of dredging phase reports (**Section 8.1.4**)	Within one month of conclusion of each dredging phase	NT EPA, Macmahon website	Monitoring report as per Condition 28.1 of WDL 187.
Yearly compliance and monitoring reports (**Section 8.1.5**)	30 March 2013 30 March 2014	Proponent, SEWPaC, Website	Compliance report as per EPBC approval Condition 3. All monitoring as per EPBC approval Condition 17(h).
	29 July – 23 August 2013	NT EPA	Audit and compliance report as per Condition 29 of WDL 187.
Exceedance reporting			
Water quality exceedance – initial notification (**Section 8.2**)	24 hours (from occurrence)	Proponent, TAG, NT EPA, SEWPaC	Location and value of exceedance.
Water quality exceedance – attributability review (**Section 8.2**)	24 hours (from end of three day attributability review period)	Proponent, TAG, SEWPaC	Details of determination and logic used to support the conclusions.
Water quality exceedance – corrective actions (**Section 8.2**)	Five business days (from notification)	NT EPA	As per Condition 24.2 of WDL 187.
Benthic communities monitoring (**Section 8.2**)	24 hours (from end of benthic survey data analysis period)	Proponent, TAG, SEWPaC	Detailed report from GeoOceans quantifying any effects on benthic communities.
Migratory bird and Pond D water level monitoring – initial notification (**Section 8.2**)	24 hours (from occurrence)	Proponent, TAG, NT EPA, SEWPaC	Nature of exceedance.
Migratory bird monitoring – pond monitoring data summary (**Section 8.2**)	Three business days (from trigger exceedance)	Proponent, TAG, SEWPaC	Daily numbers and species of migratory birds sighted in pond network (**Section 7.5.3.2**)
Migratory bird monitoring - corrective actions (**Section 8.2**)	Five business days (from notification)	NT EPA	As per Condition 24.2 of WDL 187.
Environmental incident reporting			
Injury to, mortality of, or disturbance of, a protected species (**Section 8.3**)	24 hours (from occurrence)	Proponent, TAG, NT EPA, SEWPaC	Time, location and photos.

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Reporting Type	Time	Reporting to	Content/Comments
Other environmental incidents (**Section 8.3**)	24 hours (from occurrence)	NT EPA	Report generated from InControl® (software)
Complaints reporting			
Complaints (**Section 8.4**)	48 hours (from occurrence)	Proponent	Report generated from InControl® (software)
Ongoing monitoring reporting			
Migratory bird monitoring (**Section 7.5.2.2**)	Ongoing	SEWPaC	Ongoing survey with reporting as per EPBC approval Conditions 17(f)(i) and 36.
TAG advice reporting			
TAG advice relating to EPBC approval Condition 13(a)	1 week	SEWPaC	A copy of all advice and recommendations made by the TAG and an explanation of how this advice and recommendations will be implemented or an explanation of why the person taking the action does not propose to implement certain recommendations
TAG advice relating to EPBC approval Condition 13(b)	48 hours	SEWPaC	

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