Report

East Arm Wharf Dredging Sampling and Analysis Plan

26 APRIL 2012

Prepared for

Department of Lands and Planning

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Abbreviations

Abbreviation	Description
ANC	Acid neutralising capacity
ASS	acid sulphate soils
CD	Chart Datum
COC	contaminants of concern
DHAC	Darwin Harbour Advisory Committee
DLP	Northern Territory Department of Lands and Planning
DPC	Darwin Port Corporation
EAW	East Arm Wharf
EPBC	Environment Protection and Biodiversity Conservation
ha	Hectares
HSEP	Health, safety and environment plan
ISQG – Low	Interim Sediment Quality Guidelines – low
kg	kilogram/s
km	kilometre/s
LNG	liquefied natural gas
m	metre/s
mg	milligram/s
MSB	Marine Supply Base
NAGD	National Assessment Guidelines for Dredging
NATA	National Association of Testing Authorities
PAH	Polycyclic aromatic hydrocarbons
PCB	Polychlorinated biphenyls
PQL	Practical quantification limit
PSD	Particle size distribution analyses
PSV	Platform support vessel
PWC	Power and Water Corporation
QA/QC	Quality assurance/quality control
RPD	Relative percent difference
RSD	Relative standard deviation
SAP	Sampling and Analysis Plan
SCr	Chromium reducible sulphur
SEWPaC	Commonwealth Department of Sustainability, Environment, Water, Population and Communities
SPOCAS	Suspension Peroxide Oxidation Combined Acidity and Sulfate [Suite]
TAA	Total actual acidity
TBT	Tributyltin
TPH	Total petroleum hydrocarbons
URS	URS Australia Pty Ltd

Introduction

1.1 Background

The Northern Territory Department of Lands and Planning (DLP) has proposed an expansion of the East Arm Wharf (EAW) in Darwin Harbour to accommodate the requirements of prospective wharf users, including commercial users and the Department of Defence. The expansion will require dredging within Darwin Harbour to provide for effective and efficient vessel access and manoeuvring. The proposed expansion also involves the development of additional land at EAW by reclamation. The major features of the project are as follows:

- Developing a Marine Supply Base (MSB) adjacent to EAW, primarily to service the existing and developing oil and gas industries in the Timor Sea, Browse Basin and adjacent areas.
- Constructing a barge ramp and hardstand area, including berthing for barges and facilities for loading and unloading.
- Extending the EAW quay, and construction of moorings to accommodate tugs, customs boats and other smaller vessels.

Dredging as part of the expansion project will be undertaken at three locations:

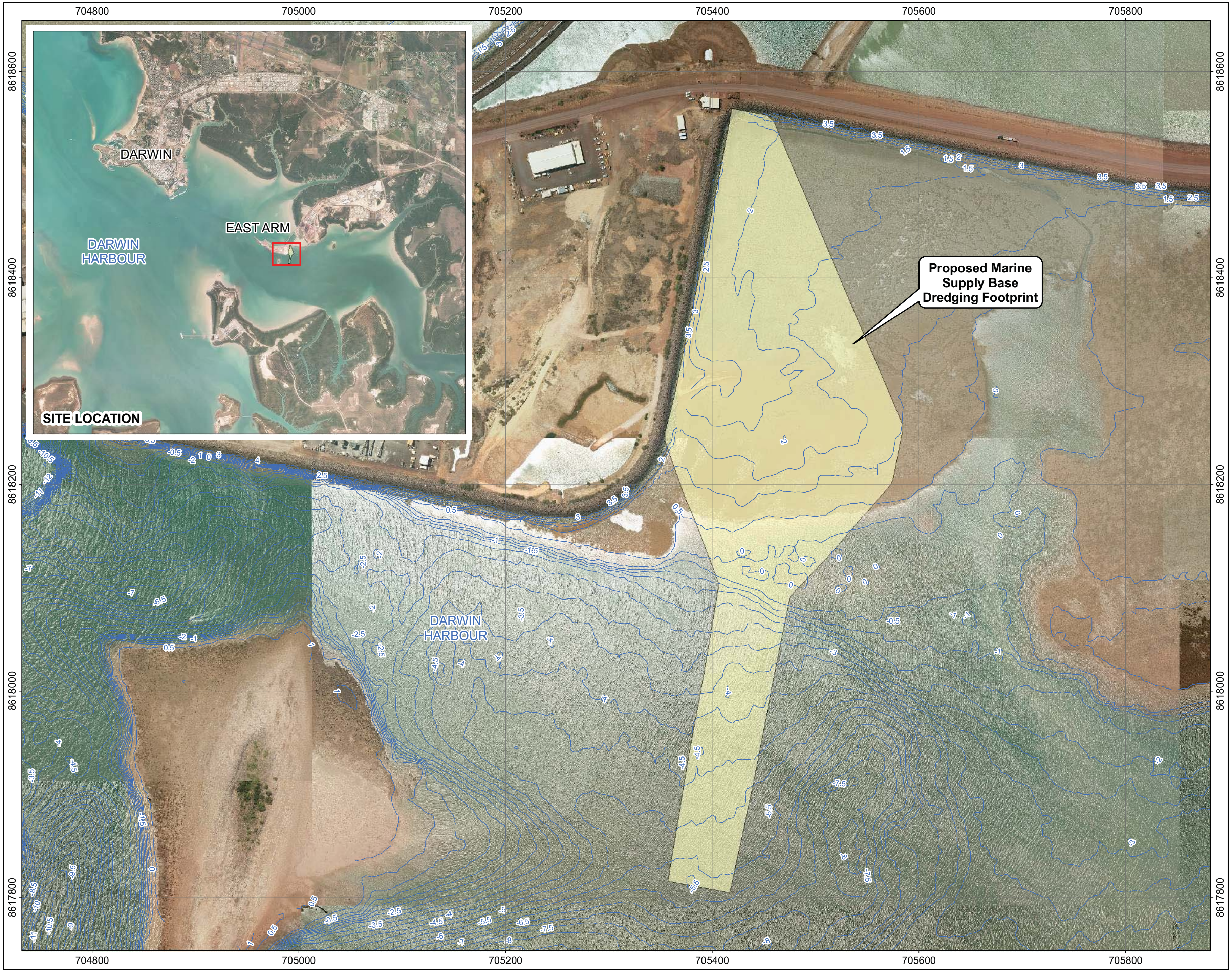
- The MSB
- The barge ramp
- The tug and small vessel berth areas.

These locations are identified in Figure 1-1. This sampling and analysis plan (SAP) has been prepared for the dredging of the MSB area; the barge ramp and small vessel berth areas are to be developed at a later time, and will be addressed in a separate SAP. No capital dredging will be undertaken outside of the MSB dredging area on works under the current Northern Territory and Commonwealth approvals until an updated SAP, updated Water Quality Management Plan and updated Dredging and Dredge Spoil Placement Management Plan are approved by the pertinent regulators.

This SAP addresses the requirements set out in Conditions 24 and 25 of the Commonwealth project approval (EPBC 2010/5304) issued by the Department of Sustainability, Environment, Water, Population and Communities (SEWPaC) under sections 130(1) and 133 of the *Environment Protection and Biodiversity Conservation Act 1999*.

1.2 Proposed Marine Supply Base

The oil and gas industry offshore from Darwin is expanding, and is currently serviced to a significant extent by the EAW. A dedicated MSB is required to efficiently service the offshore oil and gas industry into the future. Initially the MSB wharf will be used for approximately 133 days of rock load-out (RLO) as part of the INPEX Ichthys LNG project (INPEX 2010). The core business of the MSB will be the provision of logistics services to the offshore petroleum industry, including loading and unloading platform support vessels (PSVs), intermodal transfer and freight consolidation. The MSB will also provide laydown, loading, refuelling and victualing services for vessels and docking for vessels requiring maintenance.



N
W E
S

Legend

Bathymetry mLAT (iXsurvey)

Proposed Marine Supply Base Dredging Footprint

0 40 80 120 160 Meters

Datum: GDA94

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EAST ARM WHARF SAP

SITE LOCATION

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Figure: 1-1

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The proposed MSB will be located east of the existing EAW (refer Figure 1-1). The MSB concept design incorporates the following features:

- A dredged channel and berths to -7.7 m CD (Chart Datum) to provide access for deep-draft vessels
- A large hardstand area on existing reclaimed land. This area will be used for storage of supplies, and will also include an administrative building. A rock load-out facility (stockpile and wharf) and a truck path will also feature.
- A wharf adjacent to the hardstand for the accommodation of drilling mud and brine tanks and supply systems, potable water supply services, and fuel storage and supply systems.
- Power and fire-fighting water systems, and waste disposal facilities.

The final configuration of the proposed MSB is currently under development by the consortium engaged by the Northern Territory Government to construct and operate the facility.

1.3 Proposed dredging

At the time of writing, the planned dredging for the MSB approach channel and berths is to be conducted by the cutter suction dredge "Eastern Aurora". The work plan is proposed to be undertaken over two campaigns; an initial 60 days commencing in May 2012, and a secondary campaign of 37 days in April 2013 (if required). The features of the program are detailed in Table 1-1 below.

Table 1-1 Planned MSB dredging campaign details.

Feature	
Vessel type	Cutter suction dredge "Eastern Aurora"
Dredge depth	- 7.7 m CD
Estimated dredge footprint	86,054.6 m²
Estimated dredge volume	640,000 m³
Estimated 'soft' materials volume	200,000 m³
Average discharge rate – soft sediment	750 m³ per hour
Average discharge rate – consolidated material	450 m³ per hour
Pumping details	Approximately 12% solids
Fine material discharge loss	Approximately 1%

Geotechnical investigations have shown that the sediments to be dredged will be unconsolidated sediments (muds, clays and sand), underlain with low strength phyllite and low – medium strength meta-siltstone (AECOM 2011). Due to the close proximity to the operational port, all unconsolidated sediments are considered to be potentially contaminated. All dredged material will be pumped into dredge ponds in the reclamation area at EAW, and "evaporators" used to reduce the required pond volume. No material will be disposed offshore.

1.4 Proposed investigation

URS Australia Pty Ltd (URS) has been commissioned by DLP to develop a Sampling and Analysis Plan (SAP) with reference to the *National Assessment Guidelines for Dredging* (NAGD) (Commonwealth of Australia 2009). The SAP assesses the proposed dredging program and available historical data on the physical and chemical characteristics of sediments in the vicinity of the MSB and access channel (Phase I assessment). In addition, the sampling and analysis of sediments for contaminants listed on the Contaminants List (Section 3.2) and a comparison to Screening Levels (Phase II assessment) are detailed in the SAP (Section 5).

Elutriate and bioavailability testing (Phase III) and assessment of toxicity and bioaccumulation (Phase IV) may not be required, depending on the outcomes of the Phase II assessments. However, if necessary, Phase III and Phase IV assessments will be undertaken in the event that the upper 95% confidence limit of mean concentrations of contaminants in sediment exceed NAGD Screening Levels.

Geochemical testing of sediments in the dredge areas is proposed to assess the distribution and variability of contaminant concentrations and to compare these concentrations to Screening Level values in the NAGD (Commonwealth of Australia 2009). The primary use of the sediment data will be to characterise the contaminant status of sediment and assist in the selection of disposal options. The new data, together with limited historic data (where current and appropriate), will be used to classify the sediments in a single dredge management unit, or if required, assess several distinct dredge management units.

1.5 Objectives

The purpose of this SAP is to describe the location and number of seafloor sediment samples, the sampling methodology, analytical and sample transport procedures to confirm the chemical characteristics of the sediments proposed to be dredged and to assess their suitability for use at the proposed reclamation area in EAW.

Specifically, investigations to support the proposed dredging program at EAW have the following objectives:

- Complete a field sampling and analytical program of sediment proposed for dredging in accordance with guidance provided in the NAGD (Commonwealth of Australia 2009).
- Determine whether the quality and quantity of (previous and current) data gathered are sufficient to adequately characterise the contamination status of the sediments to assess disposal and re-use options.
- Classify the sediment as acceptable, or otherwise for re-use within the reclamation area.

Data quality objectives for the program are:

- To collect and retain, in accordance with the SAP procedures, the required number of cores and samples to assess contamination levels in accordance with the NAGD (Commonwealth of Australia 2009).
- To collect and retain, in accordance with the SAP procedures, the required number of quality assurance/quality control (QA/QC) samples to assess data quality in accordance with the NAGD (Commonwealth of Australia 2009).
- For analysis of the samples to be undertaken at a NATA-accredited laboratory (National Association of Testing Authorities) in accordance with laboratory QA/QC procedures and in accordance with the NAGD analysis procedures.

- For the SAP report to undergo independent detail checks and technical reviews before the results are provided to SEWPaC and utilised in the Water Quality Management Plan for the project, as detailed in Conditions 26 and 28 of the Commonwealth project approval (EPBC 2010/5304).

1.6 SAP Review and Approval

This SAP has been reviewed and approved for release to the client by Ian Baxter of URS, who is a member of the Consultancy Panel for SEWPAC, for whom reviews are undertaken of documents submitted in support of applications for the disposal of dredged material (under the *Environment Protection [Sea Dumping] Act 1981*).

For ease of review of this SAP by SEWPaC, Appendix A of the SAP details in which sections of the SAP that the relevant guidance provided in Appendix B of the NAGD (Commonwealth of Australia 2009) has been addressed.

Environmental Setting

2.1 Darwin Harbour

2.1.1 Physical characteristics

Darwin Harbour is a large ria system, or drowned river valley, formed by post-glacial marine flooding of a dissected plateau. The harbour was formed by rising sea levels about 6000-8000 years ago and has a surface area variously described as between 500 and 1,000 km^2, depending upon the boundaries applied (e.g. Padovan 2001, Darwin Harbour Advisory Committee [DHAC] 2003; INPEX 2010; DLP 2011). In its southern and south-eastern portions, the harbour has three main components: East, West and Middle Arms which merge into a single unit, along with the smaller Woods Inlet, before opening into Beagle Gulf to the north.

The harbour extends for more than 30 km along this north-north-east – south-south-westerly oriented axis. The Elizabeth River flows into East Arm, while the Darwin and Blackmore rivers flow into Middle Arm. During the dry season (May to September) the estuary is typically well mixed, but freshwater inflow from rivers during the wet season can lead to stratification of salinity in the water column in the arms of the harbour (Drewry et al. 2010).

The Darwin Harbour catchment is some 2,417 km^2, which is relatively small when compared to its estuary area of some 810 km^2 (DHAC 2003; Wolanski et al. 2005). The relatively low catchment to estuary ratio (when compared to other major Australian estuaries) was considered by DHAC (2003) to indicate that there is less potential for disturbance from runoff to the estuary than in estuaries with proportionally larger catchments.

2.1.2 Land use and contaminant loads

DHAC (2003), based on the data of Owen and Meakin (2003), determined that there was a wide diversity of land uses within the Darwin Harbour region, though almost 70% of the region was occupied by non-polluting uses (e.g. remnant native vegetation, surface water supply, conservation areas).

The Elizabeth River has the second largest catchment of the rivers entering Darwin Harbour [the largest is the Blackmore River that enters Middle Arm (Padovan 2001)]. In the late 1990s, rural land use accounted for approximately 75% of the catchment area. This is likely to have increased over the past decade, being primarily comprised of rural residential areas and small-scale horticultural developments in the upper reaches of the river. Undeveloped land (predominantly mangrove communities) fringes the river over a distance of some 25 km between the rural land use areas and East Arm, has the potential to act as a buffer to reduce the amounts of contaminants reaching East Arm from sources in the upper catchment. Padovan (2001) calculated the mean annual contaminant loads contributed to the harbour from the Elizabeth River catchment in the mid-1990s to be 69 tonnes of nitrogen, 3.5 tonnes of phosphorous, 70 kg of arsenic, 14 kg of cadmium, 156 kg of chromium, 373 kg of copper, 132 kg of lead, 138 kg of nickel and 1,638 kg of zinc.

Approximately 6 km upstream of EAW, the Palmerston Wastewater Treatment Plant discharges treated effluent into Myrmidon Creek, which enters the lower reaches of the Elizabeth River where it enters East Arm. The mass loadings of the release from the Plant in 2005/06 were 40 tonnes of ammonia, 69 tonnes of Kjeldahl nitrogen and 18 tonnes of phosphorus (Power and Water Corporation [PWC] 2006).

Some 4 km upstream of the MSB dredging area is Hudson Creek, which supports livestock export facilities and other light industrial uses. The Hudson Creek catchment also includes rural and urban land. All of these land uses represent potential sources of contaminants that may accumulate in the MSB dredging area. In the mid-1990s, the mean annual contaminant loads contributed to the harbour from the Hudson Creek catchment were calculated by Padovan (2001) to be 15 tonnes of nitrogen, 3 tonnes 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.

2.1.3 Distribution of contaminants

Environmental factors that may potentially affect the distribution of contaminants within Darwin Harbour, and hence could influence the concentrations of contaminants in the sediments of the MSB dredging area, include:

- Strong tidal currents that readily mobilise seafloor sediments on flood and ebb tides, especially during spring tide periods.
- Eddies in water flows that enhance the settlement of sediments from the water column in certain areas (such as at the eastern end of EAW, within the MSB dredging area).
- Wind-driven water circulation that can redistribute large amounts of seafloor sediments, particularly during tropical storms and cyclones.

Each of these factors would primarily influence the distribution of fine sediment fractions, to which metals are typically bound at higher densities (Batley 1995).

2.2 East Arm Port

EAW is located approximately 4.5 km south east of the Darwin Central Business District (CBD). Opened in 2000, the existing wharf has a continuous 754 m berth face located parallel to the main shipping channel, and incorporates a dry bulk materials handling facility featuring a ship loader designed to load Panamax class vessels and is currently used to export iron ore, manganese, and copper concentrate. EAW occupies a land area of approximately 18 ha of sealed hard stand surface with 4,000 m^2 of undercover cargo handling facility, and a further 18 ha of bunded area for future reclamation. A single rail spur from the Austral Asia Railway runs over a 16 m wide railway causeway, linking to three rail lines to the wharf (including a 4 ha intermodal container terminal), with road access provided over the causeway from Berrimah Road (NTG 2011).

The primary role of EAW is to facilitate the movement of goods via rail, road and shipping to international markets. EAW currently services vessels handling general cargoes, live cattle exports, dry bulk imports, containerised / break bulk and specialised heavy lift cargoes, plus offshore rig tender service vessels (AECOM 2009). It is utilised by oil and gas, mining, agriculture, horticulture and construction industries [Darwin Port Corporation (DPC) 2010].

The types and tonnages of cargo exported from Darwin Port in 2010/2011 are detailed in Table 2-1 (DPC 2010). Of note with reference to potential impacts on sediment quality are the ores, minerals, chemicals and petroleum exports. These have historically influenced the sediment quality in the EAW area, most notably after copper concentrate spills occurred while loading in 2010 (AIMS 2010).

2 Environmental Setting

Table 2-1 Trade through Darwin Port in 2010/2011

Commodity	Export tonnage	Import tonnage
Iron ore and concentrates	1,288,658	
Manganese	882,804	
Copper ores and concentrates	201,962	
Petroleum (Total)	69,853	773,387
• *Automotive distillates*		*493,705*
• *Motor spirits*		*117,072*
• *Aviation gasoline*		*161,902*
• *Other petroleum*		*709*
Livestock	129,133	
Chemicals	22,749	109,570
Machinery and equipment	13,157	12,186
Livestock feed	9,101	
Metal Waste	8,873	2,277
Metal Products	2,579	24,626
Uranium and thorium	608	
Paper	378	2,006
Building supplies	356	
Motor Vehicles and Parts	67	
Timber	39	90

Existing Data

3.1 Previous investigations

The NAGD (Commonwealth of Australia 2009) state that existing chemical or toxicity data for the sediments of the area to be dredged have a maximum currency of five years, where there is no reason to believe that the contamination status has changed significantly, after which new data are required. The EAW area was subject to copper concentrate spills in 2010 (AIMS 2010), so in accordance with the guidelines, all data from 2010 and earlier are to be used for historical comparison only and cannot be used to characterise the current contaminant status of the sediments to be dredged.

Previous investigations that were conducted in the vicinity of EAW include the following:

- AIMS 2010, Investigation of Copper Concentrate Loadout at East Arm Port: Water and Sediment Quality, prepared for Northern Territory Government Department of Natural Resources, Environment, the Arts and Sports, Darwin, Northern Territory.
- URS, 2009. Ichthys Gas Field Development Project: Nearshore Marine Water Quality and Sediment Study. Prepared for INPEX Browse, Ltd, 11 August 2009.
- Fortune, J, 2006. The grainsize and heavy metal content of sediment in Darwin Harbour. Report No. 14/2006D of the Aquatic Health Unit, Environmental Protection Agency, Department of Natural Resources, Environment and the Arts, Darwin, Northern Territory.

The findings of the previous investigations will assist in consideration of the potential sources of contaminants to the EAW area. Selected findings (sediment quality exceedances only) from these studies are summarised in Table 3-1 below.

Table 3-1 Sediment sampling results from selected previous studies in the East Arm Wharf area

Study	Analyte	Screening Level (mg/kg)	95% UCL	Comment
AIMS 2010	Arsenic	20	Not calculated	Screening Level exceeded at some sites near EAW
	Copper	270	Not calculated	Exceeded at some sites near EAW. One site exceeded ANZECC bioavailability criteria.
URS 2009	Arsenic	20	37.2	Bioavailability = low
	Chromium	80	45.1	Screening Level exceeded at some sites near EAW
	Mercury	0.15	0.018	
	Nickel	21	5.9	
Fortune 2006	Arsenic	20	Not calculated	Screening Level exceeded at two sites near EAW

These studies found that although the NAGD Screening Levels were exceeded at some individual sites, the only 95% UCL level to exceed a Screening Level was arsenic in the URS (2009) study (in which elutriate testing showed that arsenic was present in a form with only low bioavailability). Other analytes investigated in these studies did not exceed Screening Levels at any site.

URS

3.2 Contaminants list

Taking into consideration port activities, potential catchment inputs and data from previous sediment sampling programs in East Arm, Table 3-2 presents a list of contaminants which it is considered could be present at elevated levels in the sediments within the MSB dredging area. In addition to the listed contaminants, samples will also be tested for acid sulfate soils potential, as required by the conditions of the Commonwealth project approval.

Table 3-2 Contaminants list for sampling in MSB dredging area

Analytical Parameter	Rationale for Analysis
Particle Size Distribution Analysis (PSD)	Standard sediment analysis tool.
Total Organic Carbon (TOC)	For normalisation of organics
Antimony	Potentially found at ore export loading facilities
Aluminium	Useful for normalising elements
Arsenic	Known to be naturally high background levels
Cadmium	Common pollutant in port areas
Chromium	Elevated concentrations detected by URS (2009)
Copper	AIMS (2010) indicated the presence of elevated concentrations in port sediments
Iron	Exported from EAW
Lead	Common pollutant in port areas
Manganese	Exported from EAW
Mercury	Elevated concentrations detected by URS (2009)
Nickel	Elevated concentrations detected by URS (2009)
Silver	Common pollutant in port areas
Zinc	Common pollutant in port areas
Total polycyclic aromatic hydrocarbons (PAHs)	Common pollutant in port areas
Total petroleum hydrocarbons (TPHs)	Common pollutant in port areas
Total nitrogen	Palmerston wastewater treatment outfall located upstream
Total phosphorus	Phosphate rock exported from EAW
Tributyltin (TBT)	No longer used as an antifoulant, but still potentially present in port environments.
Radionuclides	Uranium and thorium exported from EAW

3 Existing Data

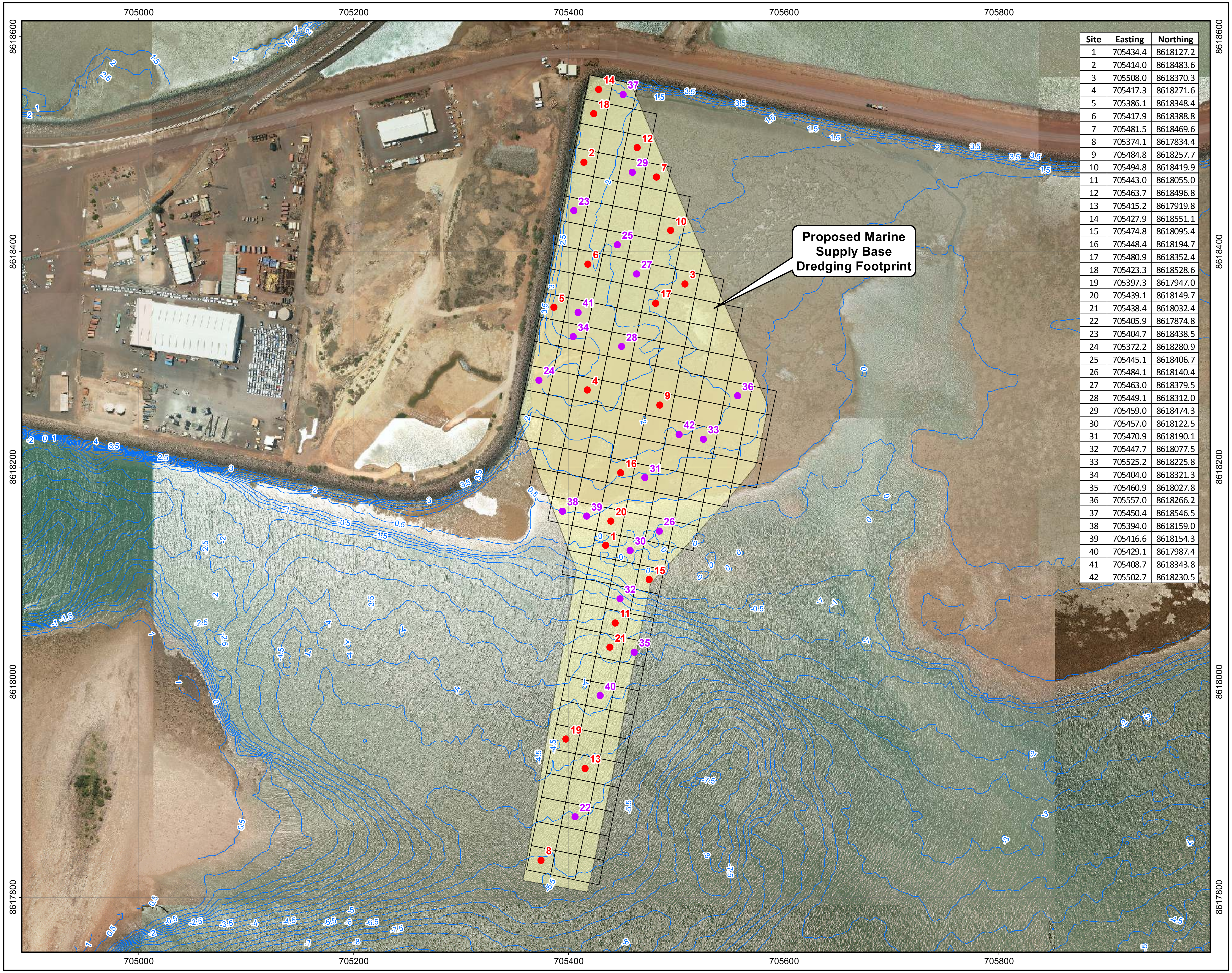
It should be noted that not all of the “typical sediment contaminants” listed in Table 1 of the NAGD (Commonwealth of Australia 2009) appear in Table 3-2 of this SAP. Contaminants for which there are considered to be no significant sources of input to the MSB dredging area (e.g. from imports or exports, or from the surrounding catchment) have been excluded from Table 3-2. For example, while organochlorine pesticides (mainly dieldrin) were detected in some samples of Darwin stormwater in the mid-1990s by Padovan (2001), these pesticides have been progressively phased out over the subsequent decades. Therefore it is considered that the potential for organochlorine pesticides to be present in the MSB dredging area sediments is sufficiently low to justify their exclusion from the contaminants list.

Sampling Locations

The required number of sample locations, calculated in accordance with Appendix D of the NAGD, is 21. This calculation is based on the estimated volume of unconsolidated sediment within the MSB dredging footprint (200,000 m^3). The estimated volume of unconsolidated sediment was derived by the EAW expansion project construction contractor from consideration of geotechnical borehole data contained in reports including Douglas Partners (2010), Seas Offshore (2010) and Aurecon (2011).

As indicated in Appendix D of the NAGD, "contaminants… will rarely penetrate far into the underlying, undisturbed geological materials, especially if these are clay or rock". Hence it is not proposed to sample these materials, which are estimated to comprise the remaining 440,000 m^3 of the dredging volume.

The locations were selected by overlaying a 23 x 23 m grid over the dredging area (to provide a total of 165 cells, more than the 105 cells [5 x 21 sample locations] needed to meet the requirements of Appendix D of the NAGD), then generating random numbers to determine the cells within which samples are to be collected. The sampling locations and coordinates (in geodetic datum GDA94) are shown in Figure 4-1. An additional 21 locations and coordinates are also shown; these will be sampled as required in the event that any of the initial 21 locations do not have a surface layer of unconsolidated sediments.



Site	Easting	Northing
1	705434.4	8618127.2
2	705414.0	8618483.6
3	705508.0	8618370.3
4	705417.3	8618271.6
5	705386.1	8618348.4
6	705417.9	8618388.8
7	705481.5	8618469.6
8	705374.1	8617834.4
9	705484.8	8618257.7
10	705494.8	8618419.9
11	705443.0	8618055.0
12	705463.7	8618496.8
13	705415.2	8617919.8
14	705427.9	8618551.1
15	705474.8	8618095.4
16	705448.4	8618194.7
17	705480.9	8618352.4
18	705423.3	8618528.6
19	705397.3	8617947.0
20	705439.1	8618149.7
21	705438.4	8618032.4
22	705405.9	8617874.8
23	705404.7	8618438.5
24	705372.2	8618280.9
25	705445.1	8618406.7
26	705484.1	8618140.4
27	705463.0	8618379.5
28	705449.1	8618312.0
29	705459.0	8618474.3
30	705457.0	8618122.5
31	705470.9	8618190.1
32	705447.7	8618077.5
33	705525.2	8618225.8
34	705404.0	8618321.3
35	705460.9	8618027.8
36	705557.0	8618266.2
37	705450.4	8618546.5
38	705394.0	8618159.0
39	705416.6	8618154.3
40	705429.1	8617987.4
41	705408.7	8618343.8
42	705502.7	8618230.5

N S E W

Legend

- Primary Sample
- Secondary Sample
- Bathymetry mLAT (iXsurvey)
- Sampling Grid (23 x 23m)
- Proposed Marine Supply Base Dredging Footprint

0 40 80 120 160 m

Datum: GDA94 MGA Zone 52

EAST ARM WHARF SAP

SAMPLING LOCATIONS

Sampling Methods

5.1 Sterilisation procedures

Prior to commencement of sampling operations, an area on the vessel will be designated for sample handling. Potential contaminant sources in the vicinity of this area (e.g. galvanised or oily surfaces) are to be covered to reduce the potential for sample contamination.

Field personnel will wear sterile disposable nitrile gloves during sampling to minimise the potential for sample contamination by residues (e.g. hydrocarbons, sunscreen, etc.). Gloves will be changed between samples. Sterile plastic and stainless steel spatulas will be used where direct contact with the sediment sample is necessary (e.g. during splitting of the cores): stainless steel will be used for samples to be analysed for organic compounds, and plastic for samples to be analysed for metals. Smoking is not permitted in the vicinity of, or upwind from, the designated sample processing area. Sample processing will be undertaken upwind of generators and any other engines that are unable to be turned off for safety reasons.

The polycarbonate core tubing to be used for sample collection (see Section 5.2) will be cleaned with dilute acid, then rinsed with deionised water and a suitable solvent before the commencement of the sampling program. Sampling equipment will be decontaminated between sites by thorough cleaning in seawater. If clayey sediments are encountered, then a Decon solution will be used to clean the cores, with the cores rinsed in seawater prior to use at the next site.

5.2 Sampling methods

Two sampling methods will be used:

- diver coring of surface sediments (0-1.0 m)
- vibrocore sampling of subsurface sediments (1.0 m+).

Diver-driven cores will be attempted at each sampling location. Where unconsolidated sediment extends below 1.0 m depth, and where penetration of the cores is limited by the gravel content of the sediment, vibrocore samples will be taken. Vibrocoring will also be used if environmental conditions (e.g. strong currents, minimal visibility) render diver coring operations unsafe or impractical.

For **diver coring**, samples will be collected in polycarbonate tubes (50 mm diameter, 1,200 mm length) by divers wearing nitrile gloves to prevent sample contamination by materials (such as sunscreen) on the divers' hands. At each site, a single core tube will be driven into the sediment to refusal using a specialised coring device. An assessment will be made by the diver as to the reason for refusal (e.g. due to reaching consolidated material, gravel or stiff clay). The top of the tube is then capped, the tube withdrawn from the seabed and a cap secured to the bottom of the tube, which is then placed into a weighted basket, in which vertical orientation of the tube is maintained as it is recovered to the surface.

A **vibrocore** will be installed on a vessel fitted with appropriate lifting equipment, power generation, deck space, shallow draft, adequate station-holding capability and other specifications to be finalised by the coring equipment supplier. The equipment will be manned by suitably qualified and experienced personnel, and the field operations supplemented by geotechnical staff from the contractor. The cores, with polycarbonate liners, are driven into the seabed from the vessel, then recovered to the vessel.

Aboard the support vessel, the sediment will be extruded from the core and photographed. The depth and visual descriptions of the sediment will be recorded, including colour, predominant grain size, presence of shell fragments and depth of any distinct horizons (changes in colour or grain size).

Composite samples will be taken from every 0.5 m horizon, i.e. 0–0.5 m; 0.5–1.0 m, etc. Any intermediate horizons of soft sediments >0.5 m in thickness will be sampled separately.

5.3 Sample handling, preservation and transport

Table 5-1 details the containers, holding times and possible analysing laboratories for each analyte. Sediment samples will be placed in 250 ml laboratory supplied glass jars (for hydrocarbons and TBT analyses) and plastic whirlpak bags (for metals, PSD and acid sulfate soils analyses). The use of plastic, rather than glass, storage containers is recommended for metals, as metals tend to adsorb onto glass surfaces, potentially leading to underestimates of metal concentrations. An additional whirlpak of sediment will be retained at each site for archiving purposes.

All samples (whirlpaks and jars) will be placed inside labelled plastic self-seal bags for protection, stored on ice or refrigerated in the field and frozen at the earliest opportunity. Samples will be delivered, with accompanying Chain of Custody forms, to Australian Laboratory Services (ALS) in Darwin. ALS will forward the samples, under appropriate Chain of Custody procedures and preservation conditions, to their NATA-accredited laboratories in other capital cities.

Table 5-1 Practical Quantification Limit (PQLs) and analytical methods

Analyte	PQL	Method	Container / sediment weight	Holding time	Lab
Total Petroleum Hydrocarbons (TPH)	2 – 100 mg/kg	GC-FID-EP071	Teflon Lined 250 ml Glass Jar 100-250 g	14 days chilled to 4°C Extended if frozen	ALS -Perth
Total Polycyclic Aromatic Hydrocarbons (PAH)	0.004-0.005 mg/kg	USEPA 3640/8270	Teflon Lined 250 ml Glass Jar 100-250 g	14 days	ALS Perth
Metals					
Antimony	0.5mg/kg	USEPA 6020 ICP/MS and EG020SDH	Whirlpak 10-100 g	180 days chilled to 4°C Extended if frozen	ALS –Perth
Arsenic	0.5 mg/kg				
Cadmium	0.1 mg/kg				
Chromium	0.5 mg/kg				
Copper	0.5 mg/kg				
Lead	1 mg/kg				
Nickel	1 mg/kg				
Zinc	0.5 mg/kg				
Iron	2 mg/kg				
Aluminium	5 mg/kg				
Mercury	0.01 mg/kg	APHA 3112 Hg-B CV/FIMS			
Tributyltin (TBT)	1 µg Sn/kg	GCMS-EP090	Teflon Lined 250 ml Glass Jar 100-250 g	14 days chilled to 4°C 120 days if frozen	ALS – Brisbane
Total Organic	0.1%	LECO after acid	Teflon Lined	Undetermined-	

5 Sampling Methods

Analyte	PQL	Method	Container / sediment weight	Holding time	Lab
Carbon (TOC)		treatment – EP005	250 ml Glass Jar 10-50 g	extended storage if frozen	
Particle Size Distribution (PSD)	-	Wet sieving and laser diffraction	Whirlpak 50-200 g	No specific holding time – chilled to 4°C	ALS Perth
Radionuclides	500 bq/kg	ISO9696 & ISO9697	Teflon Lined 250ml Glass Jar 50-200 g	6 months	ALS Perth
Total Nitrogen	20 mg/kg	NT-11	Teflon Lined 250ml Glass Jar 50-200 g	6 months	ALS Perth
Total Phosphorus	2 mg/kg	NT-11	Teflon Lined 250ml Glass Jar 50-200 g	6 months	ALS Perth
Acid sulfate soils	Action criteria dependent on clay content.[1]	Chromium suite: Total actual acidity (TAA), Chromium Reducible Sulfur (SCr) and Acid Neutralising Capacity (ANC).[2]	Whirlpak 100-250 g	Lab in 24 hours and frozen as soon as possible	ALS-Perth/ Brisbane/ Sydney

1 Refer to Section 8.1 in Identification and Investigation of Acid Sulfate Soils and Acidic Landscapes, WA Department of Environment and Conservation Acid Sulfate Soils Guideline Series May 2009.
2 10 % of samples will also be analysed using the Suspension Peroxide Oxidation Combined Acidity and Sulfate (SPOCAS) Suite.

5.4 Sample numbers

The total number of samples to be collected cannot be calculated at this juncture, as the number of samples from each location will depend on the depth of unconsolidated sediment at that location.

Following Quality Assurance / Quality Control (QA/QC) practice recommended in the Guidelines, the following samples will be collected:

- Field triplicate samples of sediments at 10% of locations (typically those with plentiful unconsolidated sediments). These will involve collecting and processing three separate samples at each of two locations.
- Field splits at 5% of locations (i.e. one location). The sample will be homogenised and split into three subsamples, two of which will be processed separately by the primary analysing laboratory, with the third subsample sent to an alternate (reference) laboratory for analysis.

Field triplicate samples and splits will be labelled so as to be identifiable by the field environmental contractor, yet unrecognisable as replicates by the analysing laboratory.

As sediment samples will be collected over a number of days, samples will potentially be sent to the receiving laboratory in batches. If this occurs, one sample from the previous batch, an inter-batch duplicate, will be re-sampled to determine analytical variation between batches.

5.5 Laboratory analysis of samples

Analysis of sediments will be undertaken by NATA accredited laboratories (ALS). The methods and analytical PQLs for the analyses are provided in Table 5-1; the latter are at or below those recommended in Table 1 of the NAGD.

Laboratory QA/QC procedures will be consistent with those described in Appendix F of the NAGD. That is, for each batch (10-20 samples) or part batch, the following samples will be analysed.

- One laboratory blank sample.
- For metals, one Standard Reference Material, i.e. a sample of certified composition such as MESS-1 or BCSS-1, or BEST-1 (for mercury), or a suitable internal laboratory standard calibrated against a Standard Reference Material. The laboratory standard will be a ground sediment sample, not a liquid sample, to test both the recovery of the extraction procedure and the analysis.
- For organics, one sample spiked with the parameters being determined (or a surrogate spike for certain organics) at a concentration within the linear range of the method being employed. This will determine whether the recovery rate of the analytical method is adequate or not (i.e. that all the chemicals present in the sample are actually being found in the analysis.
- One replicate sample to determine the precision of the analysis; the standard deviation and coefficient of variation will be documented.

Recoveries of surrogate spikes will be documented and daily calibration data reviewed. The laboratory will review the quality control data and quality assurance documentation and a statement will be made in their report that the data meet the quality objectives specified by the method for that analysis. These will be presented in the laboratory analytical report - i.e. the acceptable recovery range for spikes and Standard Reference Materials and the acceptable range of RPDs on duplicates. All of the quality assurance data (blanks, laboratory duplicates, spikes and Standard Reference Materials) will be reported with the analytical data for each batch of samples analysed. As soon as the analyses are completed the results will be emailed to URS for review so that any unusual values can be queried and, if necessary, reanalysis carried out before the holding time for the samples has expired.

The laboratory QA/QC procedures will be appropriate for the low concentrations expected in marine sediments, which are frequently lower than those required for contaminated site investigations. A clear statement will be made on the Chain of Custody forms accompanying the samples that they are comprised of marine sediments.

5.6 Field records

Field notes will include the manual recording of field conditions (weather, tides and currents), site locations, sampling methods and handling and storage methods, field sample numbers, date, time and identity of sampler.

Field description of sediments will include the physical appearance, texture, colour, and presence of foreign material, presence of shell fragments and or biota and stratification. Where multiple samples are collected at a site, notes will be made on the variability between samples. Records will also be made detailing the unique sample identifier for each sample collected.

Chain of Custody forms accompany all samples to the analysing laboratories. Each sample will appear as a separate line item on the form, with the required analyses clearly identified. The consignments will be checked against the Chain of Custody forms by the laboratories and their completeness confirmed by return e-mail.

5.7 Health, safety and environment

Prior to the start of fieldwork, a scope specific risk-based health, safety and environment plan (HSEP) will be prepared and reviewed by key project personnel to address potential risks to the health and safety of project personnel and to their operating environment. Factors specific to East Arm include:

- Low visibility
- Strong currents
- Large tidal variations (potential vessel grounding)
- Marine wildlife (e.g. crocodiles, stingers)
- Vessel traffic (commercial and recreational)

These factors will be considered with reference to both sampling efficiency and potential health and safety risks. The HSEP will also include issues such as handling and storage of chemicals used in fieldwork, and management of waste.

Safety planning will include job hazard analyses to identify the personnel and equipment requirements of all survey tasks, vessel navigation duties and responsibilities, the use of routine and emergency communication channels, and the development of an Emergency Response Plan to be followed in the event of a serious accident. On-site vessel inductions and other 'tool-box' safety meetings will be conducted before the start of each sampling task.

5.8 Contingency plan

In the event of adverse weather conditions or critical equipment failure rendering the sampling programme unsafe, there will be a downtime contingency. If the sampling programme has commenced, then the survey team will return to shore and assess the likely duration of the adverse weather conditions or equipment repair/replacement times. Alternative equipment/vessel suppliers will be identified in Darwin (in addition to the selected contractor) prior to works commencing, so that if possible, equipment/vessels can be replaced in the event of equipment/vessel issues.

5.9 Data management and reporting

Validation of analytical data will be undertaken as soon as results are received from the analytical laboratory. The relative standard deviation (RSD) will be determined for field triplicates and duplicates and the relative percentage difference (RPD) will be determined for laboratory duplicates. In accordance with the NAGD (Commonwealth of Australia 2009) laboratory duplicates that have a RPD of greater than ± 35% will be reanalysed, if possible, prior to the expiry of the analytical holding time. Likewise, field triplicates and duplicates that have an RSD of greater than ± 50% will be reanalysed. An interpretive quality control report will be provided by the analysing laboratory, highlighting any outliers to quality control procedures.

ProUCLT statistical software will be used to analyse the data. The reporting of the field and analytical data will comprise:

- Documentation of all field procedures and data including core photographs and logs.
- Data validation.
- Comparison of the 95% UCL of contaminant concentrations in sediment in the dredge area with NAGD Screening Levels (as per Appendix A of the NAGD (Commonwealth of Australia 2009)).
- If NAGD Screening Levels are exceeded, mean sediment contaminant concentrations will be compared with background concentrations.

5.10 Sampling and Analysis Plan Report

A SAP report will be submitted to SEWPaC to comply with Condition 25 of the Commonwealth project approval (EPBC 2010/5304). The report will be used by DLP as input into the Water Quality Management Plan (in accordance with the approval conditions detailed in Section 1.4).

The report will include a description of actual sampling locations and numbers, results including QA/QC assessment of both field and laboratory data, and an assessment of the results in accordance with the NAGD. The original laboratory certificates will also be included.

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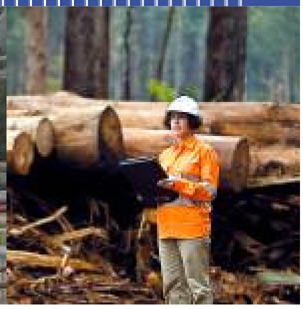
Appendix A Cross reference of Sampling and Analysis Plan to NAGD Appendix B

NAGD Guidance	SAP Section
The objectives of the SAP, including data quality objectives.	1.5
A brief description of the dredging proposal, including the planned dredging area or areas, the dredging depths, the types of sediments involved and the final volume of material to be removed (in cubic metres) for sea disposal.	1.3
An evaluation of the history of the dredge area and its catchment, and available data on the sediments to be dredged.	2.1.2 2.2 3.1
A table showing the amounts to be dredged for each separate dredge area, as well as differentiating between clean, contaminated and potentially contaminated materials.	1.3
The *Contaminants List*, based on the history of the catchment and any previous sediment sampling.	3.2
Consideration of environmental factors potentially affecting contamination in the sediments (such as currents, bathymetry, grain-size) or which may limit or hinder the sampling program (for example depth, currents or waves, rocky bottom, weather, wildlife such as sharks, crocodiles or stingers, remoteness).	2.1.3 5.7
A rationale for the proposed sampling design, including maps showing the dredging area/s and the proposed sampling locations.	4
A contingency plan in case of adverse weather or critical failure of equipment.	5.8
The equipment (vessel, sampling, sub-sampling and testing gear, positioning equipment, sample containers, reports, charts and data forms) and personnel needed to implement the SAP, and a list of field measurements to be carried out.	5.2
A list of sample numbers, including field replicates and quality assurance samples, the approximate sampling locations and details of the position-fixing method, the proposed length of cores and depths of sub-samples from cores.	4 5.2 5.4
Step-by-step procedures for sampling and sub-sampling consistent with Appendix D of the Guidelines; the volume of sample required for analysis and the types and numbers of containers; procedures to ensure that samples are not contaminated from pollution sources on the survey boat.	5.1 5.2 5.3
Step-by-step procedures for sample handling, preservation, storage and QA/QC.	5.3
The laboratories to be used, a list of analyses required, the proposed analytical methods, the detection limits of the proposed methods, whether the methods will achieve the specified Practical Quantitation Limits (PQLs) in Table 1 of the Guidelines, laboratory replicates, certified reference materials, and QA/QC procedures.	5.3 5.5
Procedures for data management, data quality validation and any statistical routines proposed used.	5.9







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