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Draft : Environmental Impact Statement

Chapter B4 Marine Sediment Quality

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Relevance of the Project to Marine Sediment Quality

The Cairns Shipping Development Project (the Project) involves capital dredging for an upgrade of infrastructure for the Port of Cairns, to accommodate larger cruise ships (see **Part A, Overview** of the EIS for details). The Project involves an expansion of the existing shipping channel and swing basins.

It is anticipated that a total capital dredge volume of 4.4 million m³ will be required for the channel and swing basin upgrades. The main component of the dredge volume is related to dredging of the Outer Channel. The future maintenance dredging quantity is estimated to increase by 30 percent due to siltation in the Outer Channel, taking the current 320,000 to 420,000 m³ of in-situ material for the Outer Channel. The inner harbour area is not predicted to be subject to such an increase in siltation and remain at around 30,000 m³ of in-situ material. The expected volume of material from these two areas would give rise to a future annual maintenance amount of 450,000 m³ of in-situ material. Placement of the dredge material is proposed to be at a new marine Dredge Material Placement Area (DMPA) adjacent to the existing DMPA.

Sediments in ports adjacent to urbanised and industrialised areas such as the Port of Cairns may contain contamination from metals and/or synthetic organic compounds. These sediment contaminants, if at levels of environmental concern, may adversely affect marine organisms in sediment and water column during dredging and dredge material placement operations.

Therefore, the State Government's Terms of Reference (TOR) for an Environmental Impact Statement and the Australian Government's EIS Guidelines for the Project require an assessment of sediments in accordance with the following:

Queensland Government - Terms of Reference requirements:

- Provide baseline information on marine sediments and sediment quality in the area likely to be disturbed by dredging or vessel movements including contaminants (such as heavy metals, nutrients and pesticides), the presence of fines and/or indurated layers and acid sulfate potential. Present this information as a map of sediment types based on their physical and chemical properties and include depth profiles
- Assessment of marine sediments should be undertaken in accordance with the National Assessment Guidelines for Dredging (Commonwealth of Australia 2009) NAGD.

Australian Government EIS Guideline requirements:

- Assessment of sediment according to the NAGD 2009. This must include an assessment of the suitability of this material for land deposition and offshore disposal at any proposed dredged material disposal ground
- Assessment of the risk and potential impacts of acid sulfate soils (ASS) and potential acid sulfate soils (PASS).

This chapter provides:

- Baseline information on the key environmental values of marine sediments and sediment quality in areas of potential direct disturbance for the Project. This baseline information includes a summary of findings from Phase II sediment quality testing undertaken as part of the approved Sampling and Analysis Plan (SAP) for the Project. These findings, along with sampling methodology and locations, are detailed in **Appendix D2, Sediment Quality Report**
- An assessment of the potential for values to be affected by the Project. This takes in account the capital and maintenance dredging works and proposed marine placement of dredge material
- The measures proposed to manage and mitigate potential impacts to marine sediment quality, such that sediment quality is maintained to nominated quantitative standards in the Project Area and surrounds, particularly where placement at sea may be required.

B4.1 Assessment Framework and Statutory Policies

B4.1.1 Applicable Legislation and Policies

The following policy and guidelines are relevant to the dredging and placement of marine sediment associated with the Project.

- **1996 Protocol to the Convention to the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972 (as amended in 2006) (the London Protocol)** – Disposal of dredged material at sea is managed under the London Protocol, which aims to have less and cleaner material placement at sea. Annex 2 to the London Protocol sets out the assessment process that must be followed by countries assessing proposals for ocean disposal. These processes are reflected in Australia's regulatory framework, namely the *Environmental Protection (Sea Dumping) Act 1981* and National Assessment Guidelines for Dredging (2009)
- **Environmental Protection (Sea Dumping) Act 1981** – The Sea Dumping Act provides the framework against which the Australian Government regulates the disposal of wastes and other materials at sea. It is through the Sea Dumping Act that Australia also implements its obligations and commitments under the international London Protocol.
- **GBRMPAs Dredging and Spoil Disposal Policy (2004)** – The intent of this policy is to provide a transparent, consistent and contemporary approach to environmental impact management of dredging and spoil disposal in the Great Barrier Reef Marine Park
- **National Assessment Guidelines for Dredging (NAGD) (2009)** – These guidelines provide an approach for assessing the quality of sediments and their suitability for ocean placement (DEWHA, 2009a). They do this through a regulatory framework, which is applied to ensure the impacts of dredged material loading and disposal are adequately assessed and, when ocean placement is permitted, that impacts are managed responsibly and effectively, and that contaminated dredge material is not placed at sea. These guidelines also require alternatives to marine placement to be considered. GBRMPA and the State and Commonwealth Governments are required to adhere to these guidelines when assessing applications under the legislation which references the NAGD
- **Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act)** – The EPBC Act provides for the protection of matters of national environmental significance. The Act requires a proposal must be referred to the Australian Department of Environment (DoE) if the Cairns Shipping Development Project has the potential to have a significant impact on matters of national environmental significance. Matters of national environmental significance triggered for this Project include world heritage properties, national heritage places, wetlands of international importance, nationally listed threatened species and communities, migratory species, Commonwealth marine areas and the Great Barrier Reef Marine Park
- **Guidelines for Sampling and Analysis of Lowland Acid Sulfate Soils in Queensland 1998 (Ahern et al. 1998)** - These guidelines provide a State-wide standardised sampling and analysis regime for characterising acid sulfate soils. These guidelines are relevant to any proposal to place dredged material on land. Sediments destined for offshore placement will remain waterlogged during dredging, transport and placement, and are not considered to be of concern
- **Environmental Protection Act 1994** – This Qld Govt Act and associated policies and regulations provide for sustainable resource development, while protecting ecological processes, by regulating environmentally relevant activities including dredging (ERA 16)
- **Sustainable Planning Act 2009** – This Act provides the framework against which the State Government regulates works undertaken in, on over or through tidal waters, including dredging of material, construction of reclamation area and breakwaters
- **Coastal Protection and Management Act 1995** – This Act provides the framework against which the State Government regulates the dredging and placement of dredged material (i.e. allocation of quarry material and sea dumping in a coastal management district). Requirements for dredging and placement of dredged material at sea that relate to the *Coastal Protection and Management Act 1995* also appear in the State Development Assessment Provisions (2013) under Module 10 – Coastal Protection.

B4.1.2 Methodology

B4.1.2.1 Assessment Approach

Disposal Alternatives and Waste Minimisation

The objectives of the London Protocol and the Sea Dumping Act include considering alternatives to and minimising impacts caused by ocean placement of dredge material.

All alternatives to ocean placement need to be evaluated, including the environmental, social and economic impacts of each disposal option. Furthermore, opportunities for preventing or minimising material placement should be identified during the project design stage

The assessment of dredge material placement alternatives and approaches for waste minimisation are described in detail in **Part A, Overview** of the EIS.

Assessment of Sediment Quality

NAGD (DEWHA, 2009a) sets out the approach to determine the suitability of dredge material for unconfined ocean placement. NAGD provides a decision-tree approach for assessing potential contaminants, comprised of five phases as summarised in **Figure B4.1.2.1a**.

This chapter includes an assessment of existing data, in accordance with Phase I of the NAGD assessment framework. Furthermore, a Phase II assessment of the current contamination status of the Port of Cairns sediments was undertaken (**Figure B4.1.2.1a**). The Phase II process includes:

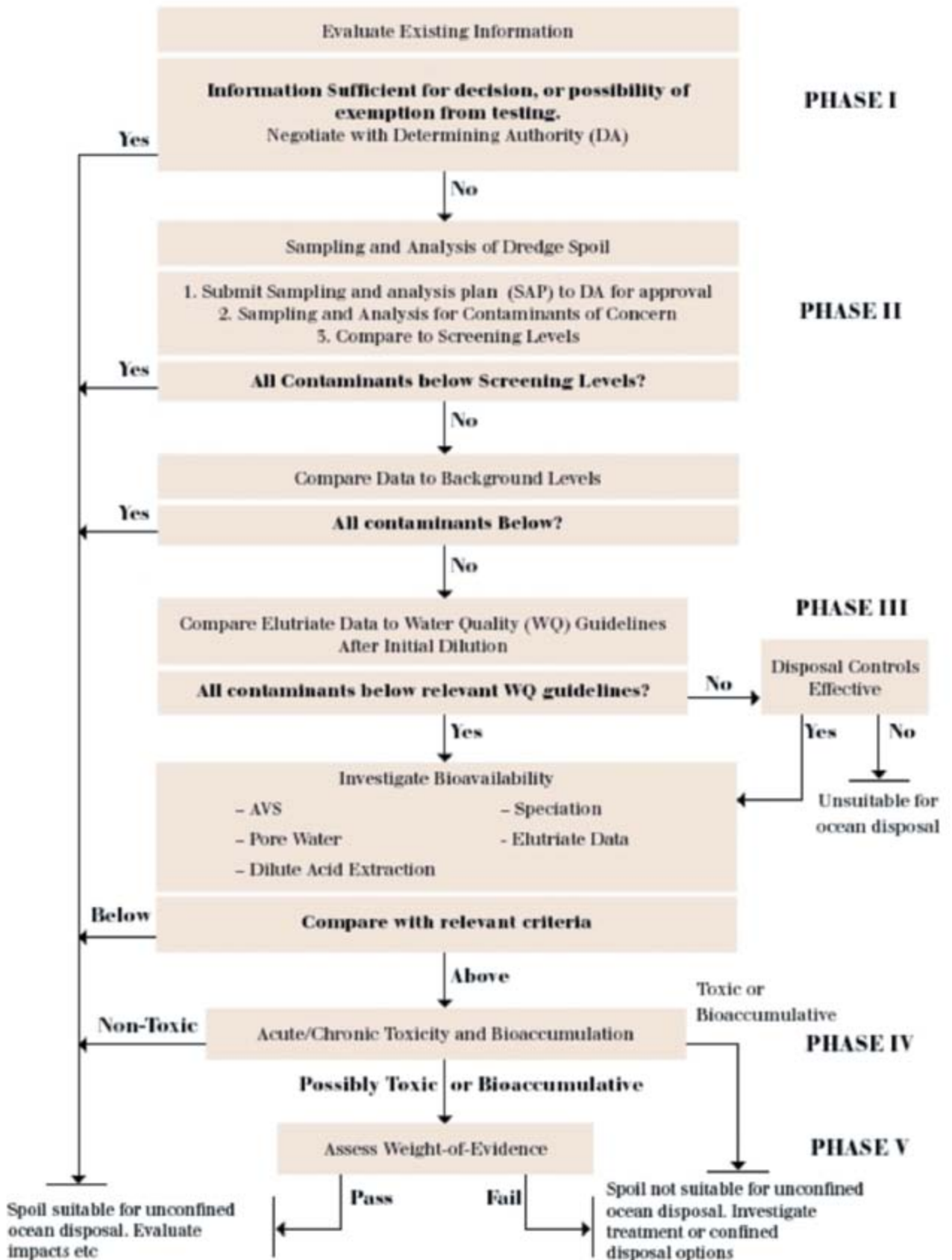
- Preparation and submission of a Sampling and Analysis Plan (SAP) to the Determining Authority
- Sampling and Analysis for Contaminants of Concern (COCs¹) and Contaminants of Potential Concern (COPCs¹)
- Comparison of sediment data against screening levels and background levels.

The findings of this Phase II sediment testing is detailed in **Appendix D2, Sediment Quality Report**, and summarised in this chapter. The Phase II assessment indicated that sediments are suitable for ocean disposal as per NAGD. As part of the Sea Dumping Application and State Government approvals for the dredging and dredge material disposal, the suitability of dredge material for unconfined ocean disposal will be confirmed as part of the approvals process.

Further Phase III testing of sediments may be required at a later stage depending on the outcomes of the Phase II testing (**Figure B4.1.2.1a**). The potential Phase III testing would include elutriate and bioavailability analyses.

¹ In accordance with NAGD, COPCs are those contaminants that exceed the background concentrations and the Screening Level (or elevated concentrations of contaminants for which guidelines do not exist). COCs are those contaminants which exceed the background concentrations and the Screening Level and for which the bioavailability, bioaccumulation or toxicity assessments indicate that significant effects from the contaminants are likely. For COCs, definite actions are required. For COPCs, no immediate action may be required

Figure B4.1.2.1a NAGD Tiered Assessment Approach



B4.1.2.2 Review of Existing Information

A review of relevant literature and existing data, together with targeted sampling of marine sediments, were undertaken in order to:

- Describe the physical properties of sediments in the Project's disturbance footprints
- Characterise the chemical properties of sediments in the disturbance footprints, in terms of current and/or known recent concentrations of trace metals/metalloids, nutrients and other analytes relevant under the applicable legislation
- Identify contaminants of potential concern (COPC) in the Project's disturbance footprints.

Key sediment quality information sources include:

- GHD (2000) HMAS Cairns – Report on Dredge Spoil Disposal Options. Report prepared for the Department of Defence
- Carter et al 2001 Sedimentology of Trinity Bay
- Golder Associates (2012) Preliminary Investigation – Sediment Sampling and Analysis. Common User Barge Facility, Tingira Street Cairns. Report prepared for Ports North
- WorleyParsons (2010) Cairns Port Long Term Management Plan – Dredging and Dredge Spoil Management. Report prepared for Ports North
- WorleyParsons (2010) Cairns Port 2010 Annual Sampling and Analysis Plan – Sediment Characterisation and Introduced Marine Pest Survey Report. Report prepared for Ports North
- WorleyParsons (2011) Port of Cairns Maintenance Dredging: 2011 – Sediment Characterisation Report. Report prepared for Ports North
- WorleyParsons (2012) Port of Cairns Maintenance Dredging: 2012 – Sediment Characterisation Report and Introduced Marine Pest Survey Report. Report prepared for Ports North
- WorleyParsons (2013) Port of Cairns Maintenance Dredging: 2013 – Sediment Characterisation Report and Introduced Marine Pest Survey Report. Report prepared for Ports North.

It is noted that Worley Parsons (2010) includes a comprehensive review of existing sediment quality data collected between 1995 and 2009.

B4.2 Existing Values, Uses and Characteristics

B4.2.1 Background

The Port of Cairns is located in Trinity Inlet, which is fed by numerous freshwater creeks draining small catchments, including Smiths, Skeleton Creek, Redbank Creek, etc. The Barron River feeds into the northwestern region of Trinity Bay.

The catchments immediately adjacent to Trinity Inlet and the wider Cairns Harbour area are largely developed with the exception of broad mangrove areas to the eastern boundary. While mangroves within Trinity Inlet provide a substantial buffer between a mixed urban and agricultural land use spectrum to the south, the Port itself is bounded by mixed industrial, commercial and recreational land uses to the north and west.

Carter *et al.* (2002) noted that sediment input to the shelf off Cairns comes from three main sources; terrigenous sand and mud supplied by rivers; carbonate detritus derived from benthic organisms and from fringing and offshore reefs; and mixed material derived by erosion of the seafloor.

Being located within a heavily urbanised catchment, the system is likely exposed to a range of nutrient and pollutant inputs associated with adjacent and upstream agricultural, residential, commercial and industrial land uses as well as waste water treatment plant inputs. Carter *et al.* (2002) noted that meidu pollution by heavy metals and other industrial contaminants does occur adjacent to the Port of Cairns. However, the port area appears to be well flushed by daily, ebb-tide dominated water movements, and the majority of sediment samples Carter *et al.* (2002) collected from throughout Trinity Bay and Inlet were within recommended environmental limits for pollutants.

Since development of the Port of Cairns over 100 years ago, maintenance dredging has been an ongoing annual requirement to maintain navigable depths within the port navigation areas. Maintenance dredging is typically undertaken using a trailing suction hopper dredge (TSHD *Brisbane* in recent years) for the 9.78 km long Outer Channel and also for the Inner Port shipping channel and swing basins extending another 2.54 km in length. A clam shell dredger is typically used to dredge areas in the Inner Port that are inaccessible to the TSHD *Brisbane*.

Dredged material has been placed at different Dredge Material Placement Areas (DMPA) in the past. The existing DMPA has been in use since 1991 and is located approximately 14.6 km north of the Cairns Port entrance. It has a diameter of one nautical mile and covers approximately 269 ha. Between 1978 and 1990, the DMPA was located approximately 2 km to the south-west of the existing DMPA. Prior to 1978, dredge material was placed at a DMPA approximately 8 km to the south-east of the DMPA used from 1978 to 1990.

B4.2.2 Historic Sediment Quality Data

Detailed sediment quality studies have been undertaken within the Port of Cairns since 1995. A comprehensive review of all sediment data collected between 1995 and 2009 is provided in WorleyParsons (2010). Sediment testing results are compiled on an annual basis due to requirements of the Sea Dumping Permit G10/33155.1 and the Long Term Dredge Spoil Disposal Management Plan (LTDSMP), and content is provided in Worley Parsons (2010, 2011, 2012 and 2013) for more recent sampling events.

Sediment testing was usually undertaken using a grab sampler for the Outer Channel and a piston corer (to 1.2 m depth) for the Inner Port dredge management areas.

Previous sampling and analysis included the Outer Channel, Inner Port (wharf area), HMAS Navy Base, Marlin Marina and Commercial Fishing Bases 1 and 2. The review of historic sediment quality results was restricted to the dredge areas relevant for the Project, i.e. Outer Channel, Inner Port and Navy Base.

Table B4.2.2a provides a summary of sediment quality data measured to date. In recent years as a result of the evaluation of Contaminants of Potential Concern (COPC) completed by Worley Parsons (2010), a reduction in the frequency and intensity of sampling for some elements including nutrients, the herbicide diuron, TPHs and PAHs has included a reduction in sampling to 20 percent of sample locations for each dredge area.

Table B4.2.2a Summary of Historic Sediment Quality Data 1995-2013

Analyte	Measurement Events – Inner Port, Navy Base	Measurement Events – Outer Channel
Physical parameters		
Particle Size Distribution	2008-2013	2008-2013
Inorganics		
Metals & Metalloids	1995-2013	1995-2000, 2002-2013
Nutrients	2007-2013	2007-2013
Cyanide	1998, 1999, 2006, 2007	1998,1999
Organics		
Organotins	1995-2013	1995-2000, 2002-2013
Diuron	2007-2013	2006-2008, 2010-2013
Total Petroleum Hydrocarbons (TPHs)	1995-2009, 2012	1995-2001, 2003, 2004, 2008, 2012
Benzene, Toluene, Ethylbenzene, Xylene (BTEX)	2000, 2003-2007	2000, 2003, 2004
Polycyclic Aromatic Hydrocarbons (PAHs)	1995, 1996, 2000, 2003-2008, 2012	1995, 2000, 2003, 2004, 2008, 2012
Organophosphate and Organochlorine Pesticides (OPPs and OCPs)	2000, 2003-2007	2000, 2003, 2004
Volatile Chlorinated Hydrocarbons	2006	-
Polychlorinated Biphenyls (PCBs)	2000, 2003-2008	2000, 2003, 2004, 2008
Phenols	Not specified	Not specified
Perfluorinated Compounds (PFCs)	2013	2013

B4.2.3 Present Sediment Quality Data

As part of Phase II assessment of sediments, sediment quality data was collected for the proposed dredge material for the Project. Sediment quality testing was undertaken in accordance with an approved Sampling and Analysis Plan (SAP).

As outlined in the approved SAP, the proposed dredge area was subdivided into two separate dredging subareas (Inner Port and Outer Channel dredge areas) based on contaminant status as inferred from a review of existing data. A total of 44 locations (14 Inner Port locations and 30 Outer Channel locations) were sampled using a combination of piston and vibrocoreing in accordance with the SAP and NAGD requirements.

The findings from this Phase II assessment are summarised in this chapter. Further details including sampling methodology, sampling locations, data analysis, results and QA/QC are included in **Appendix D2, Sediment Quality Report**.

B4.2.4 Sediment Quality Guidelines

Table B4.2.4a shows NAGD screening levels (DEWHA, 2009a) adopted in the present assessment. It is noted that a local screening level of 30 mg/kg for arsenic was agreed to by the Determining Authority in 2009 as part of developing the LTSDMP. Given that NAGD does not specify a screening level for the herbicide diuron, a literature derived screening level of 2 µg/kg was adopted in 2008.

Table B4.2.4a NAGD Sediment Quality Screening Levels

Analyte	Screening Level (ISQG Trigger Value)	High Value (ISQG High)
Metals and Metalloids (mg/kg = ppm)		
Antimony	2	25
Arsenic	20 (30 local)	70
Cadmium	1.5	10
Chromium	80	370
Copper	65	270
Lead	50	220
Mercury	0.15	1.0
Nickel	21	52
Silver	1.0	3.7
Zinc	200	410
Organics (µg/kg = ppb)		
Total PCBs	23	-
DDD	2	20
DDE	2.2	27
Total DDT	1.6	46
Dieldrin	280	270 e / 620
Chlordane	0.5	6
Lindane	0.32	1.0
Endrin	10	120 e / 220
Total PAHs	10,000	50,000
Total petroleum hydrocarbons	550 mg/kg	-
Tributyltin (as Sn)	9 µg Sn/kg	70
Herbicide Diuron	2 (literature derived)	-

B4.2.5 Physical Sediment Characteristics

B4.2.5.1 Historic Data

Results of particle size distribution analysis were relatively consistent across all studies undertaken between 1995 and 2009 and can be summarised as follows:

- Particle size distributions across dredge areas and the dredged material placement area (DMPA) were relatively similar on average
- All dredge areas and the DMPA were dominated by silt and clay fractions
- Sands were in slightly higher proportions within Inner Port (wharf area) sediments
- Outer channel and Inner Port sediments varied considerably in sand and gravel fractions between sampling locations. Sands and gravels were most prevalent at sites near the mouth of Trinity Inlet, but are not a dominant fraction of the sediments to be dredged.

Particle size distribution results were very similar between 2010 and 2013 and consistent with the results of earlier sampling events. Sediments in the Outer Channel and Inner Port were dominated by silts and clays. Outer Channel sediments were typically characterised by approximately 90 percent silts and clays and about 10 percent sands, while sediments in the Inner Port were typically characterised by approximately 80 percent silts and clays and about 20 percent sands. Gravel sediments were uncommon. Silt and clay proportions were highest in 2012 ranging between 97 percent and 99 percent across the Outer Channel and Inner Port dredge areas.

B4.2.5.2 Present Data

Table B4.2.5.2a presents the mean Particle Size Distribution (PSD) values from the Phase II assessment for the Inner Port and Outer Channel dredge area. The Inner Port sediments were generally characterised by high proportions of silt (mean 46.8 percent) and clay (mean 36.9 percent). Sandy and gravelly sediments contributed 13.8 percent and 2.5 percent on average, respectively.

The Outer Channel sediments were also characterised by high proportions of silt (mean 54.8 percent) and clay (mean 33.9 percent). Sandy and gravelly sediments contributed 10.1 percent and 1.3 percent on average, respectively. The data indicated that the sand fraction predominantly comprised fine grained sand, with a generally lower proportion of medium and course grained sand.

This data supports findings from historic data which indicated that Outer Channel and Inner Port sediments were typically characterised by a large proportion of silts and clays and a low proportion of sands.

Table B4.2.5.2a Mean Particle Size Distribution for each Dredge Area

Dredge Area	Clay (<2 µm)	Silt (2-60 µm)	Sand (0.06-2.00 mm)	Gravel (>2mm)
Inner Port	36.9	46.8	13.8	2.5
Outer Channel	33.9	54.8	10.1	1.3

B4.2.6 Metals and Metalloids

B4.2.6.1 Historic Data

Historic sediment quality data was available between 1995 and 2013 as part of the Port of Cairns routine monitoring program.

Being part of the annual routine sediment testing, metals and metalloids generally showed the highest degree of variation of all contaminants, largely attributable to local geology, catchment land use, industries and port operations (CPA 2007). However, metal and metalloid contaminants were typically below NAGD screening levels (or screening levels in National Ocean Disposal Guidelines for Dredged Material – NODGDM prior to 2009).

An exception to this was arsenic. It is recognised that arsenic is naturally elevated in the Cairns region due to the presence of natural mineralisation in metamorphic rocks of catchments discharging to Trinity Inlet (NAGD 2009, Preda & Cox 2002, Munksgaard & Parry 2002). Arsenic has consistently exceeded the screening level at the 95 percent Upper Confidence Limit (95 percent UCL) in most dredge areas. Exceedances tended to be marginal over the 20 mg/kg screening level with a maximum 95 percent UCL of 31.8 mg/kg. Additional elutriate and dilute acid extraction (DAE) analyses were undertaken to assess bioavailability of arsenic and potential impacts on water quality during dredging and dredged material disposal.

DAE analyses indicated a low level of bioavailability of arsenic with concentrations consistently below the 20 mg/kg screening level (maximum recorded DAE concentration was 12.9 mg/kg or 44 percent of total arsenic).

Elutriate testing undertaken with a 1:4 ratio of sediment to seawater returned a maximum concentration of 71.9 µg/L, which exceeded the low-reliability ANZECC/ARMCANZ (2000) limits of 2.3 µg/L for As(III) and 4.5 µg/L for As(V). However, with allowable dilution of at least 100 times at the DMPA, arsenic concentrations were found to be acceptable and unconfined disposal was permitted as an outcome of the 2009 review of Sediment Analysis Plan implementations to inform the 2010-2020 LTDSMP. Given that arsenic analysis results demonstrated an overall low risk to water quality and benthic communities, an increase of the local screening level within the Cairns Port dredge management areas to 30 mg/kg was agreed to by the Determining Authority. Whilst the 95 percent UCL for arsenic sometimes exceeded the NAGD screening level (up to 25 mg/kg) in recent years, it remained below the agreed local screening level of 30 mg/kg.

Cadmium and silver concentrations were mostly below detection limits across all dredge areas. However, the 95 percent UCL for silver exceeded the NAGD screening level of 1 mg/kg with a concentration of 3.37 mg/kg in 2011. Nevertheless, elutriate and DAE results for silver were below the laboratory limit of reporting (LOR) in all analysed samples. Cadmium exceeded the screening level in one sample in 2007. Given that the 95 percent UCL remained below screening level, no further testing was required.

For all studies undertaken between 1995 and 2013, concentrations of all metals/metalloids and their 95 percent UCL were below the NAGD or agreed local screening level. Therefore, metals and metalloids were classified as suitable for unconfined sea disposal.

Furthermore, Carter et al. (2002) noted that there is no evidence for pollution in offshore Trinity Bay. Enhanced spot values of some metal pollutants do occur within Trinity Inlet in the vicinity of Smiths Creek and the Port. Unusually, the high metal values do not correlate well with the fine sediment fraction, and it seems likely that the pollutants lie in the silt-sand grain sizes which are regularly flushed out of the Port area, and diluted in the natural background sediment, by ebb-dominated tidal currents.

B4.2.6.2 Present Data

For the Inner Port dredge area, the 95 percent UCL of the mean concentrations for most metals and metalloids were below their respective NAGD or local screening levels. The only exception was mercury with a 95 percent UCL concentration of 0.196 mg/kg which marginally exceeded the NAGD screening level of 0.15 mg/kg. While mercury concentrations were well below the screening level for most locations in the Inner Port, high concentrations of 1.2 mg/kg and 0.62 mg/kg were measured in two samples.

For the Outer Channel, the 95 percent UCL of the mean concentrations for all metals and metalloids were below their respective NAGD or local screening levels. One elevated mercury concentration was measured in the surface sediment at one location (0.29 mg/kg). Nevertheless, the 95 percent UCL concentration of mercury (0.033 mg/kg) remained well below the NAGD screening level of 0.15 mg/kg for the Outer Channel.

Based on the elevated mercury levels in two samples in the Inner Port and one sample in the Outer Channel, additional elutriate and bioavailability testing (using dilute acid extraction) was undertaken to further investigate potential mercury contamination. Furthermore, re-analysis in triplicate of mercury concentrations in the three samples with elevated concentrations was undertaken.

Elutriate test results were below the LOR for all samples and therefore below the ANZECC trigger level of 0.1 µg/L. Dilute acid extraction results were below the LOR for all samples and therefore below the NAGD screening level of 0.15 mg/kg. The results of elutriate and bioavailability analyses demonstrate that no elevated mercury concentrations are expected during dredging and disposal. Bioavailability of mercury appears to be very low and marine organisms are not expected to be impacted after disposal of the sediments at sea. Furthermore, the triplicate re-analysis of the three samples with elevated mercury concentrations could not confirm the initial results. Therefore it appears to be likely that the initial results were erroneous.

Arsenic concentrations were mostly well below the local screening level of 30 mg/kg in the Inner Port and Outer Channel areas. The only exception was one location in the Inner Port where an arsenic concentration of 33.3 mg/kg was recorded. However, the 95 percent UCL concentration for arsenic in the Inner Port was 20.38 mg/kg which remained well below the local screening level.

Three marginal exceedances of the nickel screening level of 21 mg/kg were recorded at two Inner Port locations. Nevertheless, the 95 percent UCL concentrations in the Inner Port and Outer Channel remained below the NAGD screening level with 16.21 mg/kg and 16.29 mg/kg respectively.

Antimony and cadmium were not detected in any of the Inner Port or Outer Channel samples.

As coring could not penetrate the underlying consolidated clay material, clay plugs (obtained from the end of the core) were sampled for the Inner Port (two samples) and the Outer Channel (four samples) and analysed for potential contaminants. Concentrations of all chemical parameters were below their respective screening levels or below the LOR in all clay samples. The results of the clay plug analysis indicated that deeper sediment layers, which could not be sampled due to core refusal, are unlikely to be contaminated.

B4.2.7 Cyanide

B4.2.7.1 Historic Data

Analysis for cyanide was undertaken in 1998 and 1999 (Outer Channel and Inner Port) as well as in 2006 and 2007 (Inner Port and Navy Base). No detections of cyanide were noted in these sampling events.

B4.2.7.2 Present Data

As per the approved SAP, cyanide was not included in the Phase II assessment of sediments given they were not detected in previous sampling events.

B4.2.8 Nutrients

B4.2.8.1 Historic Data

Nutrients were tested between 2007 and 2013 and generally showed consistent trends between years. Total Nitrogen (TN) and Total Kjeldahl Nitrogen (TKN) concentrations generally increased from the offshore DMPA towards the Inner Port area including the Navy Base. Except for the DMPA, TN consisted mainly of TKN, indicating a high proportion of organically bound nitrogen.

Highest ammonia concentrations were recorded in the Navy Base dredge area with concentrations up to four times higher compared to the Inner Port and Outer Channel dredge areas. Oxidised nitrogen concentrations (nitrite and nitrate) were mostly below the LOR or measured at very low concentrations. Total Phosphorus concentrations did not show a clear concentration gradient and concentrations were similar across all dredge areas.

It is noted that NAGD does not specify screening levels for sediment nutrients. **Table B4.2.8.1a** provides a summary of nutrient concentrations measured between 2010 and 2013 at the Outer Channel, Inner Port and Navy Base dredge areas.

Table B4.2.8.1a Ranges of Sediment Nutrient Concentrations Observed Between 2010 and 2013

Nutrient (mg/kg)	Outer Channel	Inner Port	Navy Base
Total Nitrogen / Total Kjeldahl Nitrogen	410 – 1,500	1,100 – 2,230	1,410 – 2,290
Ammonia	2 - 18	6 - 65	16 - 223
Oxidised Nitrogen (NOx)	<0.1 to 0.2	<0.1 to 0.3	<0.1 to 0.1
Total Phosphorus	286 - 548	328 - 478	408 - 784

B4.2.8.2 Present Data

Current data from Phase II assessments indicated that Total Nitrogen concentrations ranged between 140 mg/kg and 1,540 mg/kg in the Inner Port, and between 150 mg/kg and 1,860 mg/kg in the Outer Channel.

Total Phosphorus concentrations ranged between 139 mg/kg and 581 mg/kg for the Inner Port, and between 126 mg/kg and 1,770 mg/kg for the Outer Channel.

Ammonia concentrations were below the LOR in about half of the Inner Port samples. Where detected, ammonia concentrations ranged between 1 mg/kg and 94 mg/kg. For the Outer Channel, ammonia concentrations were either below the LOR or ranged between 18 mg/kg and 124 mg/kg.

Oxidised nitrogen (NO_x) concentrations were mostly below the LOR with a maximum concentration of 0.2 mg/kg in the Inner Port. NO_x concentrations were below the LOR in all Outer Channel samples.

No screening levels exist in NAGD for nutrients in sediments. However, nutrient levels in the Inner Port were consistent with previous testing from the Inner Port and Navy Base area (**Section B4.2.8.1**). For the Outer Channel, whilst the maximum concentrations were higher than previously recorded in the Outer Channel (**Section B4.2.7.1**), it should be noted that previous sediment sampling was undertaken only for surface sediments (using a grab sampler), and the higher nutrient concentrations detected in this investigation were measured in deeper sediment layers that were sampled using coring for Phase II assessments. Nevertheless, the 95 percent UCL concentrations for nutrients in the Outer Channel appear to be consistent with previous test results.

Potential impacts to water quality from disturbance of nutrients in sediment during dredging is discussed in **Chapter B5, Marine Water Quality**.

Table B4.2.8.2a provides a summary of nutrient concentrations measured as part of Phase II assessments.

Table B4.2.8.2a Ranges and 95 percent UCL (in Parentheses) of Sediment Nutrient Concentrations from Phase II Assessments

Nutrient (mg/kg)	Outer Channel	Inner Port
Total Nitrogen	150 – 1,860 (1041)	140 – 1,540 (1169)
Ammonia	18 – 124 (51.67)	1 – 94 (34.96)
Oxidised Nitrogen (NO _x)	<0.1 (-)	<0.1 to 0.2 (0.082)
Total Phosphorus	126 – 1,770 (535)	139 – 581 (393)

B4.2.9 Organotins

B4.2.9.1 Historic Data

Organotin compounds (including TBT) are derivatives of antifouling paints and have been routinely detected in the marina areas, Navy Base, Inner Port and Outer Channel dredge area at or above screening guideline levels for individual samples. It is, however, noted that exceedances of the screening level at the 95 percent UCL for TBT has, in the past, only occurred for some of the Inner Port dredge areas, whereas the 95 percent UCL has been consistently below the screening level for the Outer Channel.

In terms of spatial distribution of TBT detections in the Inner Port area, the Navy Base and wharf areas typically have had the highest concentrations of TBT. Given the exceedances of the TBT screening level within the Inner Port area, further testing was required with elutriate testing undertaken prior to 2008 and porewater analysis since then. Of the more than 70 elutriate samples analysed for TBT since 2005, none have returned levels above 2 ngSn/L, which is below the 6 ngSn/L ANZECC/ARMCANZ trigger level (95 percent species protection level). While the 2008 porewater testing failed to meet the required laboratory limit of reporting (LOR), the 2009 porewater analyses returned no detections above the required LOR even when total TBT concentrations were up to 92 µgSn/kg, i.e. more than 10 times the NAGD screening level.

In 2011, a 95 percent UCL for TBT of 26.5 µgSn/kg was recorded for the Inner Port dredge area, exceeding the NAGD screening level of 9 µgSn/kg. Despite this relatively high exceedance, further elutriate and porewater analysis resulted in TBT concentrations below the LOR.

Organotin concentrations were below the LOR in all samples of the Outer Channel, Inner Port and Navy Base in 2012.

On the basis of elutriate and porewater testing for TBT it has been consistently concluded that annual maintenance material has been suitable for unconfined ocean disposal as per NAGD.

Observation of trends in the data collected for the annual SAP for Cairns identifies a trend of a continual declining trend in the number of detections and actual concentrations in the port, and this is believed to be as a result of the International Maritime Organization (IMO) ban on TBT application to vessels, natural degradation of TBT, as well as significantly improved site management at the slipway facilities along Smiths Creek.

B4.2.9.2 Present Data

Phase II assessment data indicated that the 95 percent UCL concentration for the organotin Tributyltin (TBT) was 0.7 µgSn/kg for the Inner Port and therefore well below the NAGD screening level of 9 µgSn/kg. Organotins were below the LOR in most samples and, where detected, only measured at low concentrations.

For the Outer Channel, the 95 percent UCL concentration for TBT was 0.4 µgSn/kg and therefore well below the NAGD screening level. Similar to the Inner Port, organotin concentrations were mostly below the LOR or measured at low concentrations in the Outer Channel.

The Inner Port and Outer Channel sediments are therefore considered suitable for ocean disposal with respect to organotins in accordance with the NAGD guidelines.

B4.2.10 Herbicide Diuron

B4.2.10.1 Historic Data

Testing for diuron was requested by the Determining Authority from 2007 onwards. Diuron is a broad spectrum herbicide, primarily used in agriculture but also as an active ingredient on some antifouling paints. Although no human health risk for diuron has been identified to date, the herbicide is thought to have potential impact on aquatic plants such as seagrass and mangrove environments. This herbicide has been banned in Europe and the United Kingdom, and has been subject of review in Australia by the Australian Pesticides and Veterinary Medicine Authority.

Diuron has been consistently below the LOR for the Outer Channel area.

In 2008, diuron was found to be above the literature derived screening level in the sediments of the Inner Port. Subsequent elutriate analysis resulted in concentrations less than one-tenth the literature derived guideline level of 1 µg/L without any additional dilution. Porewater testing for diuron did not result in any detections even when tested at ultra-trace levels of 0.005 µg/L.

Between 2009 and 2013, normalised (to 1 percent Total Organic Carbon) diuron results and their 95 percent UCL were below the literature derived screening level of 2 µg/kg for the Inner Port and Navy Base.

On the basis of relatively low diuron concentrations at the Inner Port and Navy Base dredge areas and no detections noted for the Outer Channel, the sediments have been consistently classified as suitable for ocean disposal.

B4.2.10.2 Present Data

During initial core sampling as part of the Phase II assessment, diuron was detected in six of 16 samples within the Inner Port dredge area. Normalised concentrations ranged between 0.58 µg/kg and 3.84 µg/kg.

The detection of diuron triggered the need for further testing in accordance with the approved SAP. The additional testing involved re-sampling of the untested locations in the Inner Port and 20 percent of Outer Channel locations using a grab sampler. Following detection of diuron in two Outer Channel samples (located close to the Inner Port area), further sampling using a corer and grab sampler was undertaken at the remaining Outer Channel locations and some locations in the Inner Port in accordance with an approved Supplementary SAP (refer **Appendix D2, Sediment Quality Report**).

Table B4.2.10.2a shows the summary statistics for all diuron data including the initial sampling, additional grab sampling and Supplementary SAP sampling.

Table B4.2.10.2a Diuron 95 percent UCL for Various Sampling Events

	Inner Port			Outer Channel		
	Initial sampling (µg/kg)	Initial sampling + additional grabs (µg/kg)	Supplementary SAP (µg/kg)	All samples combined (µg/kg)	Supplementary SAP (µg/kg)	All samples combined (µg/kg)
95% UCL	1.33	1.55	0.63	1.24	-	0.52

Whilst diuron was detected at some locations within the Inner Port dredge area, the 95 percent UCL of 1.24 µg/kg for all sampling data combined (initial sampling and additional grabs, plus Supplementary SAP samples) was below the literature derived screening level of 2 µg/kg.

Diuron was detected at normalised concentrations of 0.57 µg/kg to 0.95 µg/kg (below the screening level of 2 µg/kg) at two locations in the Outer Channel as part of additional grab sampling. Diuron was not detected in any of the remaining sampling locations of the Outer Channel for both grab sampling and Supplementary SAP sampling. The 95 percent UCL diuron concentration for all combined Outer Channel samples was 0.52 µg/kg and therefore well below the literature derived screening level of 2 µg/kg.

Diuron concentrations in the additional clay plugs analysed from the Inner Port were below the LOR in all clay samples indicating that the underlying clay layers are unlikely to be contaminated with diuron.

Based on the combined results of all sampling events, in regard to diuron the Inner Port and Outer Channel sediments are therefore considered suitable for ocean disposal in accordance with NAGD procedures.

B4.2.11 Polycyclic Aromatic Hydrocarbons (PAHs)

B4.2.11.1 Historic Data

PAHs were below the limits of detection in the Outer Channel for all measurements undertaken between 2000 and 2012. Detections of PAHs were noted for the Inner Port and Navy Base from 2004 onwards with naphthalene exceeding the screening level in one sample in 2008. In 2012, some individual detections of PAHs at relatively low concentrations were noted for the Inner Port and Navy Base dredge areas. The total PAHs concentration remained well below the NAGD screening level.

Therefore, sediments for the Outer Channel and Inner Port have been characterised as suitable for unconfined ocean disposal with respect to PAHs.

B4.2.11.2 Present Data

The Phase II assessment data confirmed the historic low concentrations of PAHs in the proposed dredge area. The 95 percent UCL concentration for normalised total PAHs was 35.3 µg/kg for the Inner Port and therefore well below the NAGD screening level of 10,000 µg/kg. Given that the maximum total PAHs concentration of 65.2 µg/kg was well below 10 percent of the screening level, no further testing was required as per the approved SAP.

As per the SAP, no testing for PAHs was undertaken for the Outer Channel dredge area.

Therefore, the results of the Phase II testing have characterised the sediments within the proposed channel and inner port dredge areas as suitable for ocean disposal with respect to PAHs in accordance with the NAGD guidelines.

B4.2.12 Total Petroleum Hydrocarbons (TPHs)

B4.2.12.1 Historic Data

TPHs have been consistently detected in the Inner Port and Outer Channel dredge areas. Although concentrations remained below screening level, total TPH concentrations of greater than 1/10th of the screening level were detected for both the Inner Port and Outer Channel dredge areas.

In 2012, TPH concentrations were mostly below the LOR and therefore below the screening level for the Outer Channel and Inner Port dredge areas.

Sediments of all dredge areas have therefore been characterised as suitable for ocean disposal as per NAGD.

B4.2.12.2 Present Data

In accordance with the SAP for sediment sampling for the Project, testing for TPHs was only undertaken for the Inner Port area.

TPHs were detected at low levels within the Inner Port with the maximum normalised concentration measured at one location (54.2 mg/kg). The 95 percent UCL for total TPHs was 32.2 mg/kg and therefore well below the NAGD screening level of 550 mg/kg. Given that the maximum normalised concentration did not exceed 10 percent of the screening level, no further testing was required for TPHs as per the approved SAP.

Based on these results, the sediments within the proposed channel and inner port dredge areas are considered suitable for ocean disposal with respect to TPH in accordance with the NAGD guidelines.

B4.2.13 Benzene, Toluene, Ethylbenzene and Xylene (BTEX)

B4.2.13.1 Historic Data

Concentrations of BTEX were below detection for both the Inner Port, Navy Base and Outer Channel dredge areas between 2000 and 2007, and subsequently have not been required to be tested for since then.

B4.2.13.2 Present Data

In accordance with the SAP for sediment sampling for the Project, testing for BTEX was only undertaken for the Inner Port area. For the Inner Port area, concentrations of BTEX were below the LOR in all samples. Based on these results, the sediments within the proposed channel and inner port dredge areas are considered suitable for ocean disposal with respect to BTEX in accordance with the NAGD guidelines.

B4.2.14 Polychlorinated Biphenyls (PCBs)

B4.2.14.1 Historic Data

Concentrations of PCBs were below detection for both the Inner Port, Navy Base and Outer Channel dredge areas between 1995 and 2008, and subsequently have not been required to be tested for since then.

B4.2.14.2 Present Data

As per the approved SAP, PCBs were not included in the Phase II assessment of sediments given they were not detected between 1995 and 2008.

B4.2.15 Organophosphate and Organochlorine Pesticides

B4.2.15.1 Historic Data

Concentrations of organochlorine pesticides (OCPs) and organophosphate pesticides (OPPs) were below the LOR for the Inner Port, Navy Base and Outer Channel dredge areas between 2000 and 2007, and subsequently have not been required to be tested for since then.

B4.2.15.2 Present Data

Similar to historic data, concentrations of OCPs and OPPs were below the LOR in all samples from the Inner Port. As per the SAP, no testing for OCPs and OPPs was undertaken for the Outer Channel dredge area.

Therefore, the results of the Phase II testing have characterised the sediments within the proposed channel and inner port dredge areas as suitable for ocean disposal with respect to OCPs and OPPs in accordance with the NAGD guidelines.

B4.2.16 Volatile Chlorinated Hydrocarbons and Phenols

B4.2.16.1 Historic Data

As described in Worley Parsons (2010), no detections of phenols or volatile chlorinated hydrocarbons were noted within the Port of Cairns area.

B4.2.16.2 Present Data

As per the approved SAP, volatile chlorinated hydrocarbons and phenols were not included in the Phase II assessment of sediments.

B4.2.17 Perfluorinated Compounds (PFCs)

B4.2.17.1 Historic Data

Perfluorinated compounds (PFCs) are chemical compounds often used as a component of aqueous film-forming foams (AFFFs) used for firefighting. These compounds are characterised as persistent in the environment with the potential to bio-accumulate or biomagnify. A spill of AFFFs (Tridol S3) occurred on 28 January 2013 from the BP Australia Pty Ltd depot on Draper Street in Cairns resulting in diluted foam being potentially discharged to Trinity Inlet.

Monitoring was undertaken by QLD DEHP, and PFCs were detected at the discharge site just after the event. Subsequent modelling and validation sampling in April 2013 recorded PFCs at low levels, although it was noted that some of the PFCs could have originated from other sources (such as the sewage treatment plant). Based on this monitoring, it was concluded that PFCs occurred at levels that represented a low risk to human health and recreational fishing, but had the potential for low level bioaccumulation and biomagnification.

Ports North undertook testing for PFCs on 39 sediment samples collected during the annual SAP implementation in April 2013. PFC residues were only detected in two samples at the shoreline near Wharf 10, potentially caused by historical contamination sources. The initial advice from the Department of Environment and Heritage Protection indicated that the spill presented a low risk to the Ports North maintenance dredging areas, and this sampling confirmed a low probability of a broad scale contamination issue with regards to PFCs and approval of the maintenance dredging for 2013 was granted. As a precautionary measure, analysis for PFCs was proposed to be included in subsequent SAP implementations, at a selection of sampling locations. Sampling for PFC's was also included in the SAP for the Maritime Safety Queensland dredge area at Smiths Creek, with results of sampling in July 2013 not detecting any PFC residues.

B4.2.17.2 Present Data

Concentrations of PFCs were below the LOR in most samples. Individual PFC compounds were detected at very low concentrations close to LOR in two samples. One sample recorded a normalised concentration of 0.0026 mg/kg of the compound 6:2 Fluorotelomer sulfonate (6:2 FtS). The other sample had a normalised concentration of 0.00009 mg/kg of the compound PFNA.

As per the SAP, no testing for PFCs was undertaken for the Outer Channel dredge area. Given that PFCs were either not detected or measured at negligible concentrations in the Inner Port, the sediments within the proposed channel and inner port dredge areas are considered suitable for ocean disposal with regards to PFCs.

B4.2.18 Acid Sulfate Soils (ASS)

B4.2.18.1 Historic Data

Assessments of acid sulfate soils (ASS) were undertaken as part of the some sediment quality assessments for maintenance dredging for the Inner Port and Outer Channel dredging areas in the late 1990's. However, an assessment of acid sulfate potential for sediments around the HMAS Navy Base area (GHD 2000) indicated that the sediments are potential acid sulfate material (PASS) with levels above the Action Criteria set out by the Queensland Acid Sulfate Soil Investigation Team (QASSIT). Another assessment of sediments in Smiths Creek also detected sulfur concentrations exceeding the QASSIT Action Criteria of 0.03 percent (Golder Associates 2012).

Although historical data from the proposed dredging areas (in particular the Outer Channel) is limited, the existing data indicates that sediments in the study area may have significant acid sulfate potential and would require extensive lime treatment to neutralise their net acidity if they were to be disposed on land. The Phase II sediment quality assessment, as well as additional studies by Golder (2012 and 2013), has included a more detailed assessment of acid sulfate potential of sediments in the proposed dredging areas (discussed below) but further testing is still required to fully identify the PASS characteristics of the dredge material and the applicable management measures commensurate with those findings.

B4.2.18.2 Present Data

Preliminary ASS investigations of the proposed dredge material was undertaken by Golder (2012 and 2013), with further ASS testing undertaken as part of Phase II assessments. The combined ASS data was summarised by Golder (2014). Findings from these studies indicated the likely ASS characteristics of the proposed dredged material as follows:

- Actual acidity was below the LOR at all locations indicating that the sediments in the proposed dredge area are not actual acid sulfate soils (AASS).
- Potential acid sulfate soil (PASS) is expected to be present in the very soft to soft clay and silt materials, which represent approximately 3.6 M m³ of the total 4.4 M m³ dredge volume.
- Given that core refusal was often encountered at relatively shallow depths, no definite conclusions can be made regarding the acid sulfate potential of deeper sediment layers that may be dredged as part of the Project. However, the firm, stiff and very stiff materials underlying the soft clay and silt are unlikely to be PASS (refer to Golder 2014). The firm to stiff clay represents approximately 0.8 M m³ of the total 4.4 M m³ dredge volume.

- The majority of samples tested indicated self-neutralizing PASS within the top 1 m along most of the channel (i.e. these samples had shell or other neutralising material). The very soft to soft sediments in the top 1m of the dredging footprint represent approximately 1.6 M m³ of the total 4.4 M m³ dredge volume. It is expected that some acidity would be released from this self-neutralising material if exposed to air for extended periods, and therefore nominal lime treatment would still be required if the material was placed on land (Golder 2014)
- PASS materials that are not self-neutralising were detected in a total of 17 samples results from all investigations to date. These 'positive' samples were typically from depths of more than 1 m below the existing surface. The very soft to soft sediments in lower layers (i.e. below 1 m) represent approximately 2 M m³ of the total 4.4 M m³ dredge volume.

B4.3 Assessment of Potential Impacts

B4.3.1 Overview

Construction works will involve the capital dredging and the placement of the dredged material at an approved offshore DMPA. Ongoing maintenance dredging and dredged material placement will also be required throughout the ongoing operation of the new channel infrastructure arising from this project. Dredging, placement and other disturbances to marine sediments, can alter the physical and/or chemical characteristics of the existing marine sediment environment, potentially resulting in adverse effects to marine ecological values.

A risk-based approach has been used to assess marine sediment quality impacts, and is based on the consideration of the following:

- Significance of Impact – made up of assessment of the intensity, scale (geographic extent), duration of sediment quality impacts and sensitivity of environmental receptors to the impact. **Table B4.3.1a** is a summary of the categories used to define impact significance.
- Likelihood of Impact – which assesses the probability of the impact occurring. **Table B4.3.1b** is a summary of the categories used to define impact likelihood.
- Risk rating – which assesses the level of risk for key impacting processes. The risk table (**Table B4.3.1c**) adopted is generated from the Significance and Likelihood scores, based on the overall matrix presented in **Part A, Overview** of the EIS.

Based on these consequence and likelihood categories, **Section B4.3.6** provides a tabulated summary of the sediment quality issues addressed by the marine sediment quality impact assessment, including the results of the risk assessment for each issue, the relevant mitigation measures and the resultant residual risk.

Table B4.3.1a Guide to the Expected Consequence of Level of Potential Impact

Impact Magnitude	Description of Consequences
Very High	The impact is considered critical to the decision-making process due to its significance/importance at a national or international scale. Impacts tend to be permanent or irreversible or otherwise long term and can occur over large-scale areas.
High	The effects of the impact are likely to be important to decision-making due to its state significance/importance. Impacts tend to be permanent or irreversible or otherwise long term and can occur over large or medium scale areas.
Moderate	While important at a regional or local scale, these impacts are not likely to be key decision making issues. Impacts tend to be medium or short term and/or occur over a medium to small (local) scale.
Minor	Impacts are recognisable/detectable but acceptable. These impacts are unlikely to be of importance in the decision making process. Nevertheless, they are relevant in the consideration of standard mitigation measures. Impacts tend to be short term or temporary and/or occur at local scale.
Negligible	Minimal change to the existing situation. This could include for example impacts which are beneath levels of detection, impacts that are within the normal bounds of variation or impacts that are within the margin of forecasting error.
Beneficial	Any beneficial impacts as a result of the Project such as for example, the improvement of habitat.

Table B4.3.1b Guide to the Anticipated Likelihood of Potential Impacts

Likelihood of Impacts	
Highly Unlikely/Rare	Highly unlikely to occur but theoretically possible
Unlikely	May occur during construction/life of the Project but probability well below 50%; unlikely but not negligible
Possible	Less likely than not but still appreciable; probability of about 50%
Likely	Likely to occur during construction or during a 12 month timeframe; probability greater than 50%
Almost Certain	Very likely to occur as a result of the project construction and/or operations; could occur multiple times during relevant impacting period

Table B4.3.1c Risk Matrix for Sediment Quality

Likelihood	Significance				
	Negligible	Minor	Moderate	High	Very High
Highly Unlikely/ Rare	Negligible	Negligible	Low	Medium	High
Unlikely	Negligible	Low	Low	Medium	High
Possible	Negligible	Low	Medium	Medium	High
Likely	Negligible	Medium	Medium	High	Extreme
Almost Certain	Low	Medium	High	Extreme	Extreme

Table B4.3.1d Risk Rating Legend

Extreme Risk	An issue requiring change in project scope; almost certain to result in a 'significant' impact on a Matter of National or State Environmental Significance
High Risk	An issue requiring further detailed investigation and planning to manage and reduce risk; likely to result in a 'significant' impact on a Matter of National or State Environmental Significance
Medium Risk	An issue requiring project specific controls and procedures to manage
Low Risk	Manageable by standard mitigation and similar operating procedures
Negligible Risk	No additional management required

B4.3.2 Assessment of Impacts

The assessment of potential impacts considered three broad disturbance categories:

- Construction phase dredging (capital dredging) and sediment disturbance in the dredging footprint
- Construction phase dredge material placement in the offshore Dredge Material Placement Area (DMPA)
- Operational phase effects as a result of either maintenance dredging or other operational activities.

For each of these categories, the assessment primarily focused on the trace metals/metalloids as these are the key contaminants of concern in the context of the Project. Other potential contaminants such as nutrients and potential acid sulfate soils were also considered.

B4.3.2.1 Construction Phase Impacts - Dredging and Sediment Disturbance

Capital dredging during the construction phase of the Project will result in the removal of approximately 4.4 million m³ of sediments. A break-down of the estimated dredge volumes (for each sediment type) is provided in **Table B4.3.2.1a**.

Table B4.3.2.1a Estimated capital dredging sediment volumes (m³)

Material Type	Very soft to soft silts and clays	Firm clays	Stiff clays	Total
Dredge Volume (m ³)	3,570,298	459,405	319,913	4,349,616

Marine sediments may be mobilised at the dredge site via the following mechanisms:

- Sediment disturbance at the dredge site by the dredge propellers and maneuvering thrusters
- Sediment directly disturbed at the dredge site by the dredge head
- Overflow dredging (if required) – where excess water from the dredged material is drained from the hopper and released back into the water column releasing suspended sediment
- Spills from the mechanical backhoe dredger – during the process of transferring sediment from the sea floor to the hopper
- Leaking hoppers, for example due to hopper overloading or seal failure.

Minor disturbance and mobilisation of marine sediments may also occur as a result of other construction activities, particularly the pile driving activities associated with the structural upgrade to the existing shipping wharves.

This chapter is principally concerned with the disturbance of sediments during dredging and construction that could release contaminants within sediments. The potential impacts of increased suspended sediments and turbid plumes to water quality and marine ecology values are discussed separately in **Chapter B5, Marine Water Quality** and **Chapter B7, Marine Ecology**.

As discussed in **Section B4.2**, marine sediments in the proposed dredging areas contain potential contaminants at concentrations (95 percent UCL) that are below NAGD screening levels, and therefore do not pose a toxicity threat. As such, impacts from mobilisation of contaminants from the dredging process are expected to be negligible.

Changes in pH due to disturbance and exposure of acid sulfate soils to the atmosphere can lead to water quality impacts. As discussed in **Section B4.2.18**, potential acid sulfate soil is expected to be present in the very soft to soft clay and silt materials, which represent approximately 3.6 M m³ of the total 4.4 M m³ dredge volume. The majority of samples tested as part of the Phase II assessment indicated self-neutralising PASS in the top 1 m along most of the channel. However, it is still expected that some acidity would be released from this material if exposed to air for extended periods (Golder 2014). PASS material (that is not self-neutralising) detected in sediments at depths below 1 m will potentially release acidity if exposed to air for extended periods. As ocean disposal of the dredged material is proposed, oxidation of the dredge material is considered unlikely as the sediments will stay saturated with seawater. Under normal operating conditions of the dredging vessel (PASS exposure timeframe of less than 24 hours) it is considered that the risk of oxidation is negligible. Therefore, material to be placed at sea, will not require any treatment of the dredged material. Refer to **Chapter C2, Dredge Management Plan** that discusses this.

Therefore, the potential impact to water quality from sediment disturbance from dredging is considered to be negligible.

B4.3.2.2 Construction Phase Impacts – Dredge Material Placement

Dredge material proposed to be placed at the marine DMPA includes predominantly very soft to soft silts and clays, as well as a small proportion of firm to stiff clays. This dredge material has very similar, but slightly different physical characteristics (e.g. grain size, compaction and compressibility) to that now present at the DMPA. Therefore, the placement of dredged sediments at the DMPA is expected to result in an initial smothering with finer sediments at placement sites, eventually leading to a mosaic of patches with different disturbance histories.

Phase II assessment as part of the Sampling and Analysis Plan (**Section B4.2** and **Appendix D2, Sediment Quality Report**) has indicated that these sediments are suitable for ocean disposal as per NAGD. As part of the Sea Dumping Application and State Government approvals for the dredging and dredge material disposal, the suitability of dredge material for unconfined ocean disposal will be confirmed as part of the approvals process.

As the sediment is considered suitable for ocean disposal, dredge material placed at the marine DMPA will not lead to toxic effects to resident benthic communities or nearby marine communities. Therefore, the potential risk associated with placement of dredge material at the DMPA is considered to be negligible.

B4.3.2.3 Construction Phase Impacts – Upgrade to Wharf Infrastructure

Upgrade to the wharf infrastructure will involve installation of independent dolphins requiring steel piles. These piles may be driven by piling rig with crane and hammer from a barge. If required, a drilling rig will be used for rock sockets. It is proposed there will be 21 independent dolphins, with each dolphin requiring four piles. Therefore, 84 piles may require installation during construction.

While there may be some disturbance of bottom sediments during these construction works, the contaminant levels contained within the sediment has been found to be within acceptable screening levels as per NAGD. Therefore, disturbance of these sediments is expected to pose relatively negligible impacts.

B4.3.2.4 Operational Phase Impacts – Future Maintenance Dredging and Placement

Maintenance dredging of the Inner Port and Outer Channel areas is usually undertaken at least annually, with volumes varying over time. Future maintenance dredging and dredge material placement during the operational phase of the Project will be undertaken in accordance with NAGD or future versions of these guidelines, and only acceptable maintenance dredge material will be placed at sea. Consequently, neither a build-up nor entrainment of contaminants at the DMPA would be expected to occur as a result of the placement of maintenance dredge material. Therefore, the potential impacts associated with this activity are considered to be negligible.

B4.3.2.5 Operational Phase Impacts – Increased Shipping

Once operational, it is forecast that cruise shipping activity (and associated refueling activity) will increase by approximately 39 percent by 2026 (i.e. 79 ships to 110 ships).

The increase in shipping and refueling activity may increase the potential for shipping related contaminants (e.g. hydrocarbons) to enter the marine environment with an effect on sediment quality. However, fuel handling and storage procedures are currently part of the Port's operational procedures for existing port operational activities (ship fuel bunkering facilities are currently provided for marine diesel fuels). These procedures will likely need to be revised based on the change in shipping and Intermediate Fuel Oil (IFO) refueling activity resulting from the Project. Implementation of these procedures is expected to reduce the risk of significant loads of contaminants entering the marine environment.

Further to this, the Ports North annual sediment quality monitoring program will continue to monitor sediment contamination levels in the port areas to determine if contamination levels change as a result of the Project.

Therefore, based on the implementation of management procedures already in place for existing port operational activities, the potential impacts to sediment quality from increased shipping are considered to be negligible.

B4.3.3 Mitigation Measures and Residual Impacts

As mentioned previously, marine sediments in the proposed dredging areas have been assessed as uncontaminated in accordance with the NAGD (**Section B4.2** and **Appendix D2, Sediment Quality Report**). As such, these sediments are considered to be suitable for ocean disposal as per NAGD.

In this regard, potential impacts to the marine environment from mobilised sediments are considered to be negligible. Nevertheless, it is assumed that the following standard mitigation measures will be employed to ensure the impacts are negligible:

- Dredge material should ideally remain waterlogged and not be left within TSHD hopper or dump barges for periods longer than 24 hours to minimise the risk of PASS oxidation
- Future maintenance dredging during the operational phase of the Project is undertaken consistent with the LTSDMP noted below and in accordance with NAGD or future versions of these guidelines. Also, maintenance dredge material is to be tested in accordance with the frequency intervals outlined in the guidelines to ensure only acceptable, uncontaminated maintenance dredge material will be placed at sea.

Further to the above standard mitigation measures, the following additional mitigation is proposed to reduce the potential impacts further:

- Revise fuel handling and spill response procedures in the Port's operational procedures to minimise the potential future risk to sediment quality from refueling activities associated with the provision of IFO at the port.

B4.3.4 Monitoring

In accordance with the current Ports North Annual Sediment Monitoring Program and sampling for maintenance dredging, regular monitoring of sediment quality in the port areas will continue to occur. No additional ongoing marine sediment quality monitoring is needed or proposed specifically as part of the Project.

B4.3.5 Long Term Dredge Spoil Disposal Management Plan (LTSDMP)

The Cairns Harbour Long Term Dredge Spoil Disposal Management Plan (Environment North, 2005) provides the long term dredge material placement strategy for the Port. This LTSDMP will continue to be regularly reviewed and updated as required. In particular, the plan will be revised in order to incorporate relevant changes to sampling intensity due to the change in dredge areas and respective volumes, conditions and requirements and the approvals obtained for the Project should it become operational.

In summary, the plan currently describes the following:

- Relevant past, current and proposed dredging activities in the port
- Disposal options, considerations and justification
- Environmental values in the port limits and wider Trinity Bay, including sediment quality, water quality, and sensitive habitats and biological receptors
- Procedures for maintenance dredging and dredge material management, particularly with respect to minimising dredging, minimising ocean disposal, associated environmental impacts and other environmental risks
- Legislative, policy and stakeholder considerations.

As a result of the Cairns Shipping Development Project, a revision of the LTSDMP is likely to be required and will be managed by Ports North through the established Technical Advisory Consultative Committee (TACC).

B4.3.6 Assessment Summary

Table B4.3.6a provides a summary of the sediment quality issues identified by the impact assessment, including the results of the risk assessment for each issue, the relevant mitigation measures and the resultant residual risk.

Table B4.3.6a Impact Assessment Summary

Sediment Quality	Initial assessment with standard mitigation (e.g. statutory compliance) in place				Residual Assessment with additional mitigation in place (i.e. those actions recommended as part of the impact assessment)			
	Standard mitigation measures required	Significance of impact	Likelihood of impact	Risk rating	Additional mitigation measures proposed	Significance of impact	Likelihood of impact	Residual Risk rating
Primary impacting processes								
Capital dredging and placement at DMPA mobilises contaminated sediments	Sediment tested in accordance with an approved Sampling and Analysis Plan (SAP) – this has been completed	Negligible	Highly Unlikely	Negligible	Nil	Negligible	Highly Unlikely	Negligible
Acid sulfate soil oxidation if material exposed to air for extended period	Dredge material should remain waterlogged and not left within TSHD hopper or dump barges for periods longer than 24 hours	Negligible	Unlikely	Negligible	Nil	Negligible	Unlikely	Negligible
Potential decline in sediment quality, in or adjacent to project footprint in the future, as a result of increased shipping	Nil	Negligible	Unlikely	Negligible	Revise and implement fuel handling and spill response procedures in the Port's Operational Procedures	Negligible	Highly Unlikely	Negligible
Future maintenance dredging and placement at DMPA mobilises contaminated sediments	Sediment tested in accordance with an approved Sampling and Analysis Plan (SAP) Existing maintenance dredging operations occur in accordance with NAGD and the approved LTSDMP	Negligible	Highly Unlikely	Negligible	Nil	Negligible	Highly Unlikely	Negligible

B4.4 References

Golder (2012). Geotechnical Review – Cairns Cruise Ship Development Strategy. Report prepared for Ports North.

Golder (2013). Preliminary Geotechnical Investigation – Factual Report. Cairns Shipping Development Project. Prepared for Ports North.

Golder (2014). Assessment of DMPA Land Based Options – Cairns Shipping Development Project EIS. Letter report prepared for Ports North.

GHD (2000) HMAS Cairns – Report on Dredge Spoil Disposal Options. Report prepared for the Department of Defence.

Carter et al 2001 Sedimentology of Trinity Bay.

Golder Associates (2012) Preliminary Investigation – Sediment Sampling and Analysis. Common User Barge Facility, Tingira Street Cairns. Report prepared for Ports North.

Worley Parsons (2010) Cairns Port Long Term Management Plan – Dredging and Dredge Spoil Management. Report prepared for Ports North.

Worley Parsons (2010) Cairns Port 2010 Annual Sampling and Analysis Plan – Sediment Characterisation and Introduced Marine Pest Survey Report. Report prepared for Ports North.

Worley Parsons (2011) Port of Cairns Maintenance Dredging: 2011 – Sediment Characterisation Report. Report prepared for Ports North.

Worley Parsons (2012) Port of Cairns Maintenance Dredging: 2012 – Sediment Characterisation Report and Introduced Marine Pest Survey Report. Report prepared for Ports North.

Worley Parsons (2013) Port of Cairns Maintenance Dredging: 2013 – Sediment Characterisation Report and Introduced Marine Pest Survey Report. Report prepared for Ports North.

