# Port of Port Hedland Zone 5 Bypass Channel Project

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29 July 2025

## Sampling and Analysis Plan

## Document Information

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## Acronyms and Abbreviations

| Abbreviation | Definition |
|---|---|
| Ag | Silver |
| Al | Aluminium |
| ANZG | Australian and New Zealand Guidelines for Fresh and Marine Water Quality |
| As | Arsenic |
| Cd | Cadmium |
| CoC | Chain of Custody |
| COPC | Contaminant of Potential Concern |
| Cr | Chromium |
| Cu | Copper |
| DBT | Dibutyltin |
| DCCEEW | Department of Climate Change, Energy, the Environment and Water |
| DQO | Data Quality Objective |
| EQG | Environmental Quality Guideline |
| ESA | Ecotox Services Australasia |
| Fe | Iron |
| GPS | Geographical Positioning System |
| Hg | Mercury |
| IMO | International Maritime Organisation |
| ISQG | Interim Sediment Quality Guidelines |
| JHA | Job Hazard Analysis |
| JSEA | Job Safety and Environmental Analysis |
| MBT | Monobutyltin |
| Mn | Manganese |
| NAGD | National Assessment Guidelines for Dredging |
| NATA | National Association of Testing Authorities |
| Ni | Nickel |
| NORMS | Naturally occurring radioactive materials |
| OC | Organochlorine pesticides |
| OP | Organophosphorus pesticides |
| PAH | Polycyclic Aromatic Hydrocarbons |
| Pb | Lead |
| PCB | Polychlorinated biphenyls |
| PFAS | Per- or Poly-Fluorinated Alkyl Substances |
| PFOA | Perfluorooctanesulphonamidoethanols |
| PFOS | Perfluorooctanesulphonamides |
| Pilbara Ports | Previously Pilbara Ports Authority |
| PPE | Personal Protective Equipment |
| PQL | Practical Quantitation Limit |
| PSD | Particle Size Distribution |
| QA/QC | Quality Assurance/Quality Control |
| SAP | Sampling and Analysis Plan |
| Sb | Antimony |
| SDP | Sea Dumping Permit |
| SG | Spoil Ground |
| SG7 | Spoil Ground 7 |

| Abbreviation | Definition |
|---|---|
| SG7A | Spoil Ground 7A |
| SG7B | Spoil Ground 7B |
| SG7C | Spoil Ground 7C |
| TACC | Technical Advisory and Consultative Committee |
| TBT | Tributyltin |
| TOC | Total Organic Carbon |
| TOF | Total Organic Fluoride |
| TRH | Total Recoverable Hydrocarbons |
| TSHD | Trailer Suction Hopper Dredge |
| UCL | Upper Confidence Limits |
| Zn | Zinc |

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# 1 INTRODUCTION

## 1.1 Background

The Port of Port Hedland is located approximately 1,660 kilometres north of Perth, within the Pilbara Region of Western Australia. The Port of Port Hedland is one of the world's largest bulk export ports, predominantly serving the iron ore mining industry of the Pilbara. Also important to the regional economy are its exports of salt, manganese, copper concentrates and spodumene.

The Port of Port Hedland is one of Western Australia's most important infrastructure assets and continues to make significant and growing contributions to the Australian economy. The total economic contribution of the Port Hedland Port Supply Chain within Australia was approximately $103.73 billion in 2022-23. As a result, economic activity either directly or indirectly supported by the Port of Port Hedland and the trade that is facilitated through the Port equated to approximately 4% of the national economy during this period. The total economic contribution to the WA economy was approximately $90.68 billion, equating to over 20 per cent of all economic activity in the state.

The Port of Port Hedland currently operates shipping via a single-entry/exit channel (the Channel), which is 23 nautical miles (nm) long and tidally constrained. The Channel can be broken down into six distinct zones based on location, bathymetry, channel slopes and sea conditions (**Error! Reference source not found.**). As vessel sizes have increased and traffic volumes grown, the consequences of any disruption to this route have become more pronounced. Although vessel control failures remain relatively infrequent, incidents in recent years have demonstrated that even brief mechanical or navigational issues can escalate quickly within the confined geometry of the channel. In certain sections, such as Zone 5, the physical characteristics of the channel provide limited opportunity for recovery once control is lost.

Pilbara Ports is proposing to conduct capital dredging to create a bypass channel to the east of (what is known as) Zone 5 of the existing Channel (the Project). Once the capital works are completed, this area will become part of the annual channel maintenance dredging campaign. The Project is a strategic marine risk-mitigation project intended to maintain vessel transit at an acceptable reduced capacity, should a grounding incident occur in Zone 5 of the channel.

Disposal of dredge spoil at sea requires approval by the Australian Department of Climate Change, Energy, the Environment and Water (DCCEEW) under the *Environment Protection (Sea Dumping) Act 1981*.

Prior to completing an application for disposal at sea, proponents are required to undertake appropriate investigations to characterise the physical and chemical nature of sediments to be dredged and disposed, as specified in the National Assessment Guidelines for Dredging (hereafter referred to as the 'NAGD') (Commonwealth of Australia 2009). Under the NAGD, a phased series of investigations is required depending on the area's history and the level of contamination found.

This document presents the Sampling and Analysis Plan (SAP) to characterise the properties of the sediments to be dredged and disposed for the Zone 5 Bypass Channel Project at Port Hedland.

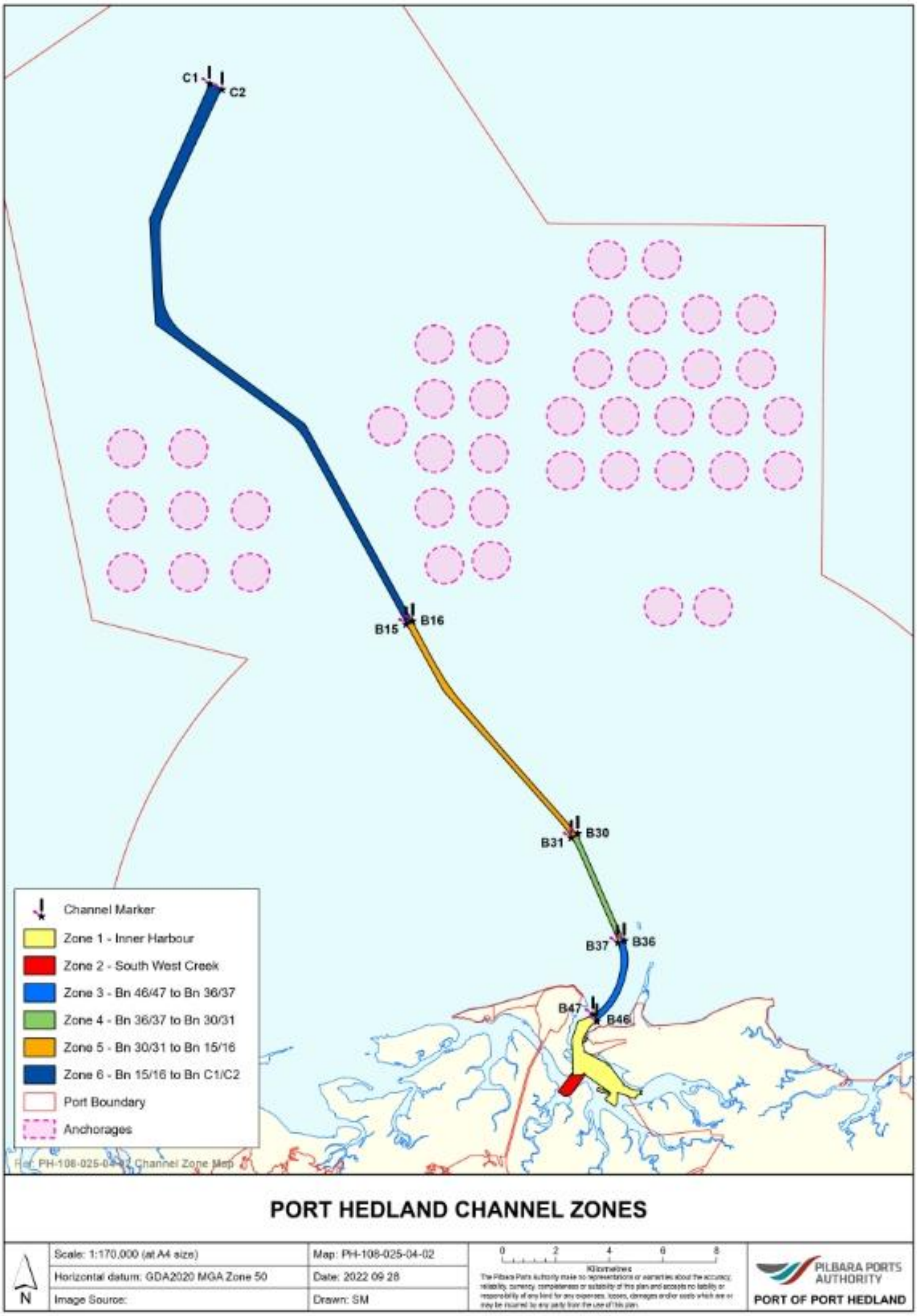



*Figure 1-1. Port of Port Hedland Channel Zones*

## 1.2 Previously Permitted Dredging Activities at the Port

The dredging programs that have occurred at the Port of Port Hedland since 1977 are listed in Table 1-1.

*Table 1-1. Previous permitted dredging activities at the Port of Port Hedland (adapted from GHD (2023))*

| Year | Type of Dredging | Proponent | Volume ($m^3$) |
|---|---|---|---|
| 1977 | Maintenance | Pilbara Ports | 150 000 |
| 1981 | Maintenance | Pilbara Ports | 268,000 |
| 1985 | Capital and Maintenance | Pilbara Ports | 7,000,000 |
| 1986 | Capital | Pilbara Ports | 13,600,000 |
| 1990 | Maintenance | Pilbara Ports | 350,000 |
| 1993 | Maintenance | Pilbara Ports | 200,000 |
| 1994 | Maintenance | Pilbara Ports | 114,000 |
| 1997 | Maintenance | Pilbara Ports | 330,000 |
| 2001 | Maintenance | Pilbara Ports | 580,000 |
| 2002 | Capital | BHP | 460,000 |
| 2004 | Maintenance | Pilbara Ports | 550,000 |
| 2006-07 | Capital | FMG | 5,000,000 |
| 2007 | Maintenance | Pilbara Ports | 730,000 |
| 2008 | Capital | FMG | 3,400,000 |
| 2009 | Capital | BHP | 3,900,000 |
| 2010 | Capital | BHP | 6,000,000 |
| 2010 | Capital | Pilbara Ports | 8,800,000[#] |
| 2010 | Maintenance | Pilbara Ports | 930,000 |
| 2012 | Capital | Pilbara Ports | 5,880,000[#] |
| 2012 | Maintenance | Pilbara Ports | 312,850 |
| 2012 | Capital | BHP | 1,720,000 |
| 2013 | Maintenance | Pilbara Ports | 680,839 |
| 2014 | Maintenance | Pilbara Ports | 344,789 |
| 2015 | Maintenance | Pilbara Ports | 473,395 |
| 2016 | Maintenance | Pilbara Ports | 272,048 |
| 2017 | Capital | Pilbara Ports | 3,361,000[#] |

| Year | Type of Dredging | Proponent | Volume ($m^3$) |
|---|---|---|---|
| 2018 | Capital | Pilbara Ports | 400,000# |
| 2018 | Maintenance | Pilbara Ports | 102,686 |
| 2019 | Maintenance | Pilbara Ports | 381,608 |
| 2021 | Maintenance | Pilbara Ports | 974,512 |
| 2021 | Capital | Pilbara Ports | 190,000# |
| 2022 | Capital | Pilbara Ports | 89,073 |
| 2023 | Capital | Pilbara Ports | 48,455 |
| 2024 | Maintenance | Pilbara Ports | 135,499 |
| 2024 | Maintenance | Pilbara Ports | 239,420 |

# Volumes approved under the sea dumping permit, but not necessarily dredged

Note: Pilbara Ports includes the predecessor organisations Port Hedland Port Authority and Pilbara Ports Authority

## 1.3 Regulation and Guidelines

This SAP has been prepared based on guidance in the NAGD (Commonwealth of Australia 2009) and the updated Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018).

## 1.4 Review of the SAP

This SAP will be submitted for approval by Pilbara Ports to DCCEEW as the Determining Authority. In parallel, Pilbara Ports will also continue to engage with the Port Hedland Technical Advisory and Consultative Committee (TACC) in relation to the Project, including present updates on the development and implementation outcomes of the Project. The TACC comprises a representative stakeholder group that includes port users, state and federal governments and the community.

## 1.5 Objectives and Scope of the SAP

The purpose of this document is to describe the methods and associated quality assurance/quality control (QA/QC) procedures required to assess the sediment quality of proposed dredge material to be removed during capital dredging for the Project within the Port of Port Hedland. Sampling sites and procedures are based on the requirements outlined in the NAGD and available data on the history of sediments in the area to be dredged. This document provides:

- A brief description of the proposed dredging activity;
- A review of existing information on sediment characteristics in the dredge area;
- An outline of the proposed sampling program with information on the number, type and location of samples required to adequately assess the contaminant status of the sediments for all identified contaminants of concern;

- The proposed method for sampling, sample preservation, transportation and storage to ensure the integrity of the sample is maintained; and
- The proposed QA/QC procedures, including data quality objectives (DQOs), to ensure the data collected and statistical analyses are of appropriate quality.

DQOs for the proposed works include:

- Collection and handling of samples in accordance with proposed procedures (Section 3.3);
- Completion of documents and labelling in accordance with proposed procedures (Section 3.6.1);
- Compliance with chain of custody for samples (Section 3.6.4);
- Appropriate sample storage and transport, and meeting sample holding times (Section 3.6.3);
- Meeting laboratory quality assurance outcomes (Section 3.6); and
- Collection of appropriate QA/QC field samples (Section 3.6).

### 1.5.1 SAP Implementation Report

The results of the SAP will be compiled into an implementation report to accompany the Sea Dumping Permit (SDP) application. The report will provide complete results and detailed methodology, including description of any deviation from the approved SAP. The SAP implementation report will also evaluate the quality control data, including whether the DQOs listed above were met, and which, if any, results will be qualified because they failed to meet data quality guidelines. Results in the report will be provided in table form and use the statistical methods described in Appendix A of the NAGD to evaluate whether sediment quality meets the requirements of the NAGD. Original certificates of sediment assays will be attached to the implementation report.

## 1.6 Proposed Dredging Activity

Pilbara Ports is proposing to conduct capital dredging to create a bypass navigation channel. The dredging footprint occurs to the east of Zone 5 of the existing Channel (Figure 1-2). The bathymetry of Zone 5 is predominantly greater than 10 metres depth with scattered shoal patches, one of which lies close to the Channel with water depths of 8 meters at lowest astronomical tide (LAT).

Table 1-2 summarises the design depth of the proposed dredging area.

*Table 1-2. Design and maximum depths of proposed dredge area*

| Location | Design Depth (m CD) | Maximum Depth* (m CD) |
|---|---|---|
| Zone 5 Bypass Navigation Channel | -11.5 | -12.5 |

*This depth includes an allowance of 1.0 m extra depth for over dredging

The design depth of the bypass navigation channel is -11.5 m chart datum (CD) and would be 200 m wide between the designed toelines (the outer horizontal limit of the dredge design profile). A dredging approval to an average depth of -12.5 m CD will be required to allow the dredging equipment to operate safely and productively. This 1.0 m below the design depth will be referred to as the dredging tolerance (also known as over-dredging), which will also create deeper pockets in areas of high sedimentation, increasing the interval between maintenance dredging.

The maximum volume of dredged material to be removed under the largest dredging scenario would be 1,200,000 $m^3$. The dredge material is proposed for offshore disposal.

An established spoil ground (Spoil Ground 7 [SG7]) previously approved for spoil disposal and used in several recent capital and maintenance dredging campaigns will be used for spoil disposal. Recent campaigns have used sub-areas SG7A and SG7B inside the SG7 boundaries (Figure 1-3). These areas are too shallow for the expected draft of the TSHD and disposal for the Project will target sub-area SG7C inside the greater SG7. All the proposed capital dredging works and offshore disposal are within the declared port limits of the Port of Port Hedland.

It is currently anticipated that the dredging will be undertaken by a trailer suction hopper dredge (TSHD). In the event small areas of consolidated material are identified that cannot be removed by the TSHD, an alternative mechanical-based dredging method (e.g. backhoe dredge) may be used to break up or dredge the consolidated material.

The dredging program is expected to take approximately three (3) weeks and is planned to be conducted once all necessary approvals for the Project have been granted. The exact timing and duration of the works will depend on the availability and size/capacity of the dredge offered by the preferred contractor. The capital dredging program is planned to be conducted in conjunction with the annual maintenance dredging of Pilbara Ports port facilities at the Port of Port Hedland.

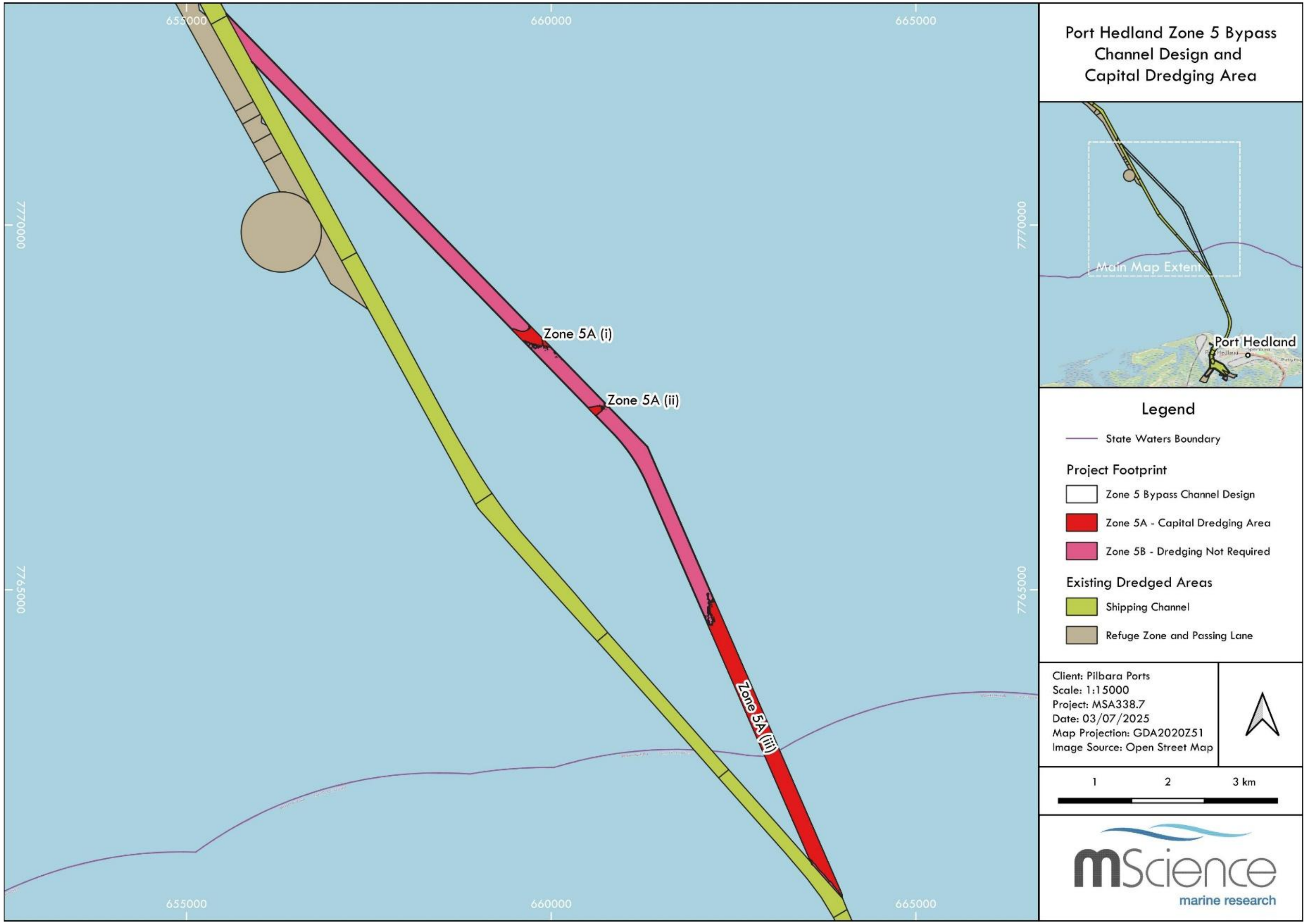



Figure 1-2. Zone 5 bypass channel design and capital dredging area


*Figure 1-3. Proposed spoil ground 7C*

# 2 EVALUATION OF EXISITING INFORMATION (PHASE I)

## 2.1 Catchment and History of the Dredge Area

Port Hedland is located approximately 1660 km north of Perth, within the Pilbara region of Western Australia. The port is situated on the confluence of five shallow ephemeral creek systems. Catchment runoff has the potential to provide small amounts of metal contamination, however there is very little fluvial input other than intermittent and heavy runoff associated with seasonal cyclonic events. During these events, many potential contaminants are rapidly flushed out of the relatively short waterways of Port Hedland Harbour (SKM 2008). Given the small and irregular amounts of runoff this source may be considered unlikely to be significant.

Historically, Port Hedland was established as a service centre for the pearling, pastoral and gold mining industries. Port Hedland began major redevelopment in the 1960's to service the growing iron ore industry in the region at the time. Existing industries in Port Hedland Harbour are generally associated with the trade of bulk minerals (iron ore, manganese, chromite and copper concentrate), petroleum products, ammonium nitrate, bulk liquids and other general cargo.

The dredge area is located approximately seven kilometres offshore (at its nearest point) from entrance to the inner harbour of the Port of Port Hedland. The majority of the area has not been subject to capital dredging or development previously, with the exception of the dredging for the Channel Entry Project (CEP). The dredged footprint for the CEP, overlaps the southern area of the dredging footprint proposed for the Project. Capital dredging for the CEP was completed by Pilbara Ports in 2021.

Shipping activities present the primary risk of contaminant introductions to sediments in the proposed dredge area.

## 2.2 Existing Sediment Chemistry Information

Maintenance dredging has been undertaken at the Port of Port Hedland since 1977, and several capital dredging programs have been conducted in support of various port expansion projects since that time. Testing of sediments for these previous dredging programs has been undertaken on many occasions by a range of proponents. Whilst many of the dredging programs have involved sediment sampling programs within the inner harbour areas, sampling has been undertaken in offshore areas since 1997.

Table 2-1 details the previous sediment testing campaigns conducted in offshore areas, in and around the Channel, and includes any noteworthy contaminants detected in which the upper 95th percent confidence limit (95% UCL) of the mean exceeded screening levels.

A summary of all the sediment sampling that has been implemented within the Port of Port Hedland, including the inner harbour, since 1990 has been provided in Appendix A (Table A - 1).

Past studies, specific to the current project area, including the most recent survey (MScience 2022a), have identified some metal concentrations (e.g. arsenic, chromium and nickel) above the screening guidelines. Arsenic and nickel concentrations have been observed to be consistently above NAGD screening levels across all surveys. It has been shown that these concentrations are widespread, naturally occurring and bound to fine sediments, and thus not considered to be of concern for unconfined ocean disposal (Stoddart et al. 2019).

For studies in which an exceedance was noted for metals (such as arsenic, chromium and nickel), further analysis, including elutriate and ecotoxicity testing, was undertaken. On each occasion it was concluded that the concentration of metals in these sediments did not present a significant risk to the environment and/or found no evidence to link these concentrations with acute or chronic toxicity.

Testing of sediments at Pilbara Ports managed spoil grounds most recently occurred in 2022 for SG7 (MScience 2022a). Results from the survey indicate that the 95%UCL for total metals, with the exception of arsenic, were below the respective NAGD low interim sediment quality guidelines. Previous testing of sediments from SG7 in 2017 (Jacobs 2017) also found the 95%UCL for arsenic to be above NAGD guidelines. At the time of sampling the area had not yet been used as a spoil ground, as such, it is suggested that arsenic concentrations are naturally high in the Port Hedland region.

The results of these previous sediment characterisation campaigns have been used to inform the design for the current SAP.

### 2.2.1 Conclusions from Previous Studies

On the basis of past investigations of sediment chemistry from the inner harbour (Appendix A) and offshore areas of the Port of Port Hedland (Table 2-1), the contaminants of concern depend mainly on the sediment type and presence of naturally occurring metals. This is summarised below:

- The distribution of contaminants has been confined largely to the fine sediments in the upper strata (0.5 m);
- The detection of contaminants has been more likely to occur in the sediments of high vessel traffic areas and previously dredged areas such as channels that accumulate sediments;
- Consolidated sediments underlying upper soft strata have been very unlikely to contain contaminants above screening levels;
- Consolidated sediments and calcarenite have tended to be effectively impermeable to contamination by particulate matter and to migration of dissolved contaminants in pore waters;
- Naturally occurring high levels of arsenic, chromium and nickel are present within the Port of Port Hedland and the Pilbara region;
- Historically, exceedance of TBT has occurred most often around the oldest berths within the inner harbour of the port, at Nelson Point. A single sample collected in 2004 between Channel Beacon 40 and 41 exceeded the NAGD screening level for TBT (at 18.5 µg Sn/kg) (URS 2004a). The authors suggested this single sample represented a flake of paint from a ship using the Channel rather than any wider level of contamination. This risk of high levels of TBT within the proposed dredge area is low, as TBT has been banned on vessels which use the port since 2008 or earlier;
- The presence of petroleum hydrocarbons has usually been low; and
- All surveys conducted have confirmed that the sediment quality meets the applicable guidelines for safe ocean disposal at that time.

*Table 2-1. Previous sediment quality assessments in and around the Channel, and contaminants detected*

| Project (Reference) | Proponent* | Noteworthy Contaminants Detected in which the 95%UCL of the Mean Exceeded Screening Levels (dashes indicate 95%UCL below screening guideline) | | | Safe for Ocean Disposal[#] |
|---|---|---|---|---|---|
| | | TBT** | Metals | Organics | |
| Dredging of Harbour and Channel (CMP&F 1997) | PHPA | - | - | - | Yes |
| Dredging of Harbour and Entrance Channel (ENV 2000) | PHPA | - | - | - | Yes |
| Dredging of Harbour and Entrance Channel (ENV 2001) | PHPA | - | Nickel in the channel | - | Yes |
| Maintenance Dredging (URS 2004b) | PHPA | - | - | - | Yes |
| Maintenance Dredging (URS 2004a) | PHPA | - | Nickel and arsenic in the channel | - | Yes |
| Maintenance Dredging (sampling incl Spoil Gnd 'I') (Koskela Group 2007) | PHPA | - | Nickel and arsenic in the channel | - | Yes |
| Outer Harbour Development | BHPBIO | - | Arsenic in surficial sediments in all areas surveyed. Chromium and nickel at depth in borehole samples. | - | Yes |

| Project<br><br>(Reference) | Proponent* | Noteworthy Contaminants Detected in which the 95%UCL of the Mean Exceeded Screening Levels (dashes indicate 95%UCL below screening guideline) | | | Safe for Ocean Disposal[#] |
|---|---|---|---|---|---|
| | | TBT** | Metals | Organics | |
| (SKM 2011) | | | | | |
| Maintenance Dredging (sampling incl Spoil Gnd 'I')<br><br>(Worley Parsons 2012a) | PHPA | - | - | - | Yes |
| Spoil Ground 'I' Extension<br><br>(Worley Parsons 2015) | PPA | - | - | - | N/A[+] |
| Maintenance Dredging (sampling incl Spoil Gnd 'I')<br><br>(Jacobs 2015) | PPA | - | - | - | Yes |
| Maintenance Dredging<br><br>(GHD 2016) | PPA | - | - | - | Yes |
| Channel Risk and Optimisation Project<br><br>(sampling incl Spoil Gnd 7)<br><br>(Jacobs 2017) | PPA | - | Arsenic in the channel, refuge zone and spoil grounds. Appears to be naturally elevated. | - | Yes |
| Channel Entry Project<br><br>(MScience 2022a) | Pilbara Ports | - | Arsenic in Zone A and B. Appears to be naturally elevated. | - | Yes |

| Project<br><br>(Reference) | Proponent* | Noteworthy Contaminants Detected in which the 95%UCL of the Mean Exceeded Screening Levels (dashes indicate 95%UCL below screening guideline) | | | Safe for Ocean Disposal[#] |
|---|---|---|---|---|---|
| | | TBT** | Metals | Organics | |
| Port Hedland Annual SAP Implementation for Maintenance Dredging<br><br>(sampling incl Spoil Gnd 7)<br><br>(MScience 2022b) | Pilbara Ports | - | - | - | Yes |

*Port Hedland Port Authority (PHPA) transitioned to Pilbara Ports Authority (PPA) in 2014 and is now known as Pilbara Ports.

**TBT screening levels increased from 5 µg/kg to 9 µg/kg when NODGDM was superseded by the NAGD (Commonwealth of Australia 2009) in early 2009

# if contaminants found above their relevant screening levels, subsequent elutriate, bioavailability and/or toxicity testing found if sediments were safe for ocean disposal

+ N/A - not applicable since survey was designed for sediment characterisation only and/or the project did not seek an application for ocean disposal

## 2.3 Contaminants of Potential Concern

Establishing the list of contaminants that the SAP should address involves integration of the following:

- The possible contaminant sources identified in Section 2.1;
- The results from previous surveys of sediment quality summarised in Table 2-1 and Appendix A; and
- The key sediment contaminants known in Australia as shown in Table 1 of the NAGD.

The contaminants of potential concern (COPC) expected from typical sediments proposed for dredging have been listed in Table 2-2.

Certain chemical constituents have been proposed for exemption from testing based on their likely sources. All metal and metalloid contaminants included in Table 1 of the NAGD have been considered, only those with screening levels defined in Table 2 of the NAGD and been listed in Table 2-2.

*Table 2-2. Contaminants of potential concern*

| Class of Constituent | Chemical Constituent | Potential or Likely Sources | Proposed Exemption from Testing |
|---|---|---|---|
| Metals and Metalloids | Arsenic (As)<br>Antimony (Sb)<br>Cadmium (Cd)<br>Chromium (Cr)<br>Copper (Cu)<br>Iron (Fe)<br>Lead (Pb)<br>Manganese (Mn)<br>Mercury (Hg)<br>Nickel (Ni)<br>Silver (Ag)<br>Zinc (Zn) | Trace metal contaminants are likely to be present within the Port of Port Hedland from shipping activities. Metals associated with export industries within the port, such as iron, copper and manganese have been identified in past studies; these metals will be included within the metals suite to be analysed in the current SAP<br><br>Historical surveys of the area have repeatedly identified high background concentrations of arsenic, chromium and nickel in uncontaminated Port Hedland sediments; therefore, these trace metal contaminants are not considered to represent a significant risk, but still warrant assay. | No |
| Petroleum Hydrocarbons | Total Recoverable Hydrocarbons (TRHs)<br>Polycyclic Aromatic Hydrocarbons (PAHs) | Hydrocarbons may accumulate from small releases of fuel or oils from vessels, bunkering and fuel imports. While no significant spills of such compounds have been reported, the industrial nature of the area provide a sufficient risk of their occurrence to warrant assessment in any sampling/assay regime for this area. | No |

| Class of Constituent | Chemical Constituent | Potential or Likely Sources | Proposed Exemption from Testing |
|---|---|---|---|
| Organotins | Monobutyltin (MBT)<br><br>Dibutyltin (DBT)<br><br>Tributyltin (TBT) | Within berth areas abrasion of ship hulls (e.g. against adjacent wharf structures) can cause flaking of paints and anti-foulants such as TBT. In and around departure and approach channels, sediments dispersed from berths and paints flaking during ship movements may provide an ongoing source of organotin. Previous studies have shown TBT to occur above guideline levels in and arounds berths within the inner harbour (GHD 2023). Historical studies have showed the proportion of samples returning TBT concentrations above the screening guidelines has been decreasing over subsequent surveys. Given the phasing out of TBT paints under International Maritime Organisation (IMO) guidelines, TBT may no longer be a significant factor around the Channel but will still warrant assay. | No |
| Pesticides | Organochlorine (OC)<br><br>Organophosphorus (OP) | Full testing of pesticides is normally required under the NAGD. Testing for OC and OP pesticides has been implemented at the Port of Port Hedland on four occasions. Once in 2007, twice in 2010 and once in 2017 (BHPBIO 2010; GHD 2012; MScience 2017a; Worley Parsons 2010). Pesticides were not detected at concentrations above the PQLs outlined in Table 1 of the NAGD.<br><br>The presence of pesticides is normally associated with agricultural run-off. There are no riverine catchment inputs of any size to be of concern. In addition, the area proposed to be dredged is far from shore, as such, there is no feasible pathway for contamination with pesticides. Testing for pesticides is not planned and exemption is requested. | Yes |
| Halogenated Aromatic Hydrocarbons | Dioxins<br><br>Furans | There is no natural or industrial source of dioxins or furans within the vicinity of the Port of Port Hedland. Additionally, within the area of the Port of Port Hedland there is no riverine catchment. Full testing of dioxins and furans would be unnecessary. | Yes |
| Volatile Chlorinated Hydrocarbons | Polychlorinated biphenyls (PCBs) | There is no industrial source of PCBs within the vicinity of the Port of Port Hedland. Testing for PCBs at the Port of Port Hedland occurred in 2007, 2010 and 2017, and were not detected at concentrations above the PQLs outlined in Table | Yes |

| Class of Constituent | Chemical Constituent | Potential or Likely Sources | Proposed Exemption from Testing |
|---|---|---|---|
| | | 1 of the NAGD (GHD 2012; MScience 2017a; Worley Parsons 2010).<br><br>Additionally, within the area of the Port of Port Hedland there is no riverine catchment inputs, and the area proposed to be dredged is far from shore. As such, there is no feasible pathway for contamination with PCBs. Full testing of PCBs would be unnecessary. | |
| Phenol, Phenolics | Phenol,<br><br>Cresol etc. | No likely source.<br><br>Full testing of Phenolic compounds would be unnecessary. | Yes |
| Nutrients | Phosphorus<br><br>Nitrogen | No catchment inputs of any size to be of concern. No likely source. | Yes |
| Radioactive Materials | | Previous SAPs for this port have been granted exemption from sampling radionuclides on the basis of low probability of occurrence. The risk of radionuclides remains unchanged. No transport of bulk radioactive materials (such as mineral sands) occurs at the port.<br><br>Sand blasting with garnet may contain traces of thorium, but its WA Health code of practice forbids use of abrasives above 1 Bq/g (NAGD screening level – 35 Bq/g). Any sand blasting with garnet around the port is currently restricted to land-side operations with no runoff allowed.<br><br>Based on the above, there is no reason to alter the past exemption on assay of radionuclides. | Yes |
| Per- or poly-fluorinated alkyl substances (PFAS) | TOF,<br><br>PFOS,<br><br>PFOA etc. | The presence of PFAS is normally associated with urban areas. The area proposed to be dredged is far from shore, as such, there is no feasible pathway for contamination with PFAS.<br><br>Previous testing of PFAS chemicals in sediment samples collected within the Port of Port Hedland found no significant concentration of PFAS chemicals (MScience 2017b).<br><br>Testing for PFAS is not planned and exemption is requested. | Yes |

### 2.3.1 Environmental Factors

The geology of the offshore areas of the Port of Port Hedland has been well documented in previous sediment sampling and analysis assessments and geotechnical investigations for the proposed Outer Harbour Development Project and Channel Risk and Optimisation Project (Jacobs 2017; SKM 2011). Geotechnical bores have demonstrated that unconsolidated sand and shell is generally restricted to the upper 2 m of sediment. The following describes the generalised geological profile of the area based on cores from those studies, note that Unit 2a is 'alluvial sand and shell; all other categories are rock or heavily consolidated material:

- Unit 2a - Holocene sands and gravels: This unit consists of loose dark brown to grey, fine to coarse (though mainly coarse) quartz sands, with varying amounts of shell and coral debris, fine to medium gravel, clay and silt. This layer is typically calcareous, with a very loose to medium dense consistency. The calcareous component is largely composed of eroded calcarenite and water-worn calcrete nodules.
- Unit 2b - Holocene marine muds: This unit typically comprises black, dark brown, greybrown, silty and sandy clays, which are very soft to firm in consistency and commonly malodorous.
- Unit 4b - Siliceous calcarenite: This unit generally consists of siliceous calcarenite, which is lithified beachrock comprising quartz sand, whole shells, shell fragments and ooliths (sand-size concretions of carbonate material). Preliminary laboratory testing indicates that the siliceous calcarenite contains up to 40% quartz grains. The unit is generally very weak to moderately weak, decreasing in strength with depth.
- Unit 6a - Upper red beds: This unit generally comprises relatively uniform red brown clayey sand, silty sand and sandy clay, ranging from medium dense to very dense and stiff to hard in consistency. In contrast to the underlying, and more cemented, Unit 6b, the consistency of Unit 6a is the consequence of compaction by self-weight, rather than by cementation. Although cemented layers may be encountered within Unit 6a, the majority of this unit is uncemented.
- Unit 6b – Lower red beds: This unit generally comprises very weak to moderately weak clayey sandstone, sandstone, calcareous sandstone and conglomeratic sandstone towards the base of the layer. The sandstone and clayey sandstone can be very weakly cemented in places. The quartz content of the lower red beds has been estimated as being up to 90%, though 30–60% is more common.
- Unit 7 – Sandstone Breccia, Silcrete Breccia and Calcareous Breccia: This unit generally comprises sandstone breccia, silcrete breccia and calcareous breccia, which are distinguishable by the nature of the cementing material (silcrete/ferricrete/ calcrete). Unit 7 tended to be the hardest, most rock-like material encountered.

The potential distribution of contaminants in these areas is most likely to be in the fine sediments in the upper stratum (0 - 1 m). The historic consolidated sediments and calcarenite are effectively impermeable to contamination by particulate matter and also to migration of dissolved contaminants in pore waters. The surficial sediment layer is created and replenished by tidal flushing and terrestrial inputs, although it should be noted that due to the low amounts of rainfall in the region, terrestrial inputs and associated organic content are limited.

The effective concentration of contaminants in sediments depends on their bioavailability. Metals and PAH have a strong affinity to bind to the fine fraction of sediments (De Gregori et al. 1996; Naes and Oug 1998; Rosental et al. 1986), which in effect reduces bioavailability and hence toxicity.

The Port of Port Hedland sediments have very low levels of organic carbon (TOC, around 0.1 – 0.3% from previous sampling), but frequently have a high percentage of fine sediments. TOC levels will be used as a 'scaling' factor for calculating effective organotin concentrations as specified in the NAGD.

In Western Australia, acid sulphate soils (ASS) are commonly associated with freshwater wetlands, tidal flats, flood plains, shallow estuarine marine deposits and saline sulphate rich groundwater (DER 2015). Areas of concern for ASS in the Pilbara include tidal, intertidal and supratidal flats along the coastline. ASS are not expected within the subtidal environments in which the Project is located. Previous ASS investigations which have been undertaken at Port Hedland (BHP 2011 2011; SKM 2008; URS 2008) have found Potential ASS only within surface sediments to a depth of 2 m within the Inner Harbour. The risk of ASS within the subtidal environment of the outer harbour of Port Hedland is considered low.

## 2.4 Classification of Proposed Survey Area

The NAGD classifies maintenance dredging projects with a proposed dredge volume greater than 500,000 $m^3$ as a 'large-sized project' and suggests that the dredge area be divided into distinct sites based on their suspected contaminant status.

Table 2-3 details the sediment risk classifications of the proposed dredge areas based on information gathered from past studies (Section 2.2). As per the NAGD (Appendix D), dredge areas should be classified as 'probably contaminated', 'suspect' or 'probably clean'. The sediment classification, proposed dredge volume and guidance from the NAGD have been used to inform the sampling design.

### 2.4.1 Classification of Contaminant Status

The classification of the dredge area (Table 2-3) as 'probably clean' is based on the historic distribution and nature of contaminants and current knowledge of the background environment of previously dredged areas outlined in this SAP. Review of those sections suggested that areas in and around the Channel are very unlikely to differ from native sediment chemistry and should be categorised as 'probably clean'.

*Table 2-3. Dredge area risk classification*

| Port Areas | Depth (m CD) | Estimated distribution of dredge volume ($m^3$) | Classification |
|---|---|---|---|
| Zone 5 Bypass Navigation Channel | -12.5 | 1,200,000 | Probably Clean |

# 3 SAMPLING AND ANALYSIS PLAN (PHASE II)

## 3.1 Contaminants List

The proposed analytes have been based on the assessment of COPC outlined in Section 2.3.

Analytes likely to be present and/or used to normalise results will be tested in samples collected from ALL sites (General Suite) and those with a lower likelihood of being detected will be assessed in 50% of sites (Additional Suite).

### 3.1.1 General Contaminant Suite

The samples from ALL sampling locations will be analysed for:

- Aluminium;
- Antimony;
- Arsenic;
- Cadmium;
- Chromium;
- Copper;
- Iron;
- Lead;
- Manganese;
- Mercury;
- Nickel;
- Silver;
- Zinc;
- Moisture;
- Total Organic Carbon (TOC); and
- Particle Size Distribution (PSD)

### 3.1.2 Additional Contaminant Suite

The following contaminants have not been recorded at levels above the relevant NAGD screening levels over the past five years:

- Total Recoverable Hydrocarbons (TRH)
- Polycyclic Aromatic Hydrocarbons (PAH)
- Organotins (TBT, DBT and MBT)

As such, it is proposed that these parameters be tested in samples collected from 50% of the sites located within the 'probably clean' dredge area (Zone 5A) and 50% of the sites located within the Zone 5 Bypass Navigation Channel design not proposed to be dredged (Zone 5B, refer to Section 3.2.1 for details). The location of the sites to be tested for the additional contaminant suite has been pre-selected in this SAP (refer to Table 3-2).

## 3.2 Sampling Design

### 3.2.1 Sampling Numbers

The Zone 5 Bypass Navigation Channel design has been divided into two distinct areas, Zone 5A and Zone 5B (**Error! Reference source not found.**), for the purposes of sampling under this SAP.

Zone 5A includes the sediments within the channel design subject to the proposed capital dredging. The sediments located within Zone 5B are not proposed to be dredged as part of the Project but may require material to be removed via maintenance dredging in the future.

The justification for the sampling numbers proposed for Zone 5A and Zone 5B is provided in Sections 3.2.1.1 and 3.2.1.2, respectively.

*Table 3-1. Breakdown of Phase II sampling numbers for each area and contaminant suite*

| Sampling Area | Number of Sampling Sites | Site# for General Suite | Site# for Additional Suite |
|---|---|---|---|
| Zone 5A<br>Capital Dredging Area | 23 | 23 | 12 |
| Zone 5B<br>Sediment Characterisation Area | 10 | 10 | 5 |
| **Total** | **33** | **33** | **17** |

#### 3.2.1.1 ZONE 5A

Zone 5A includes the three distinct areas proposed for capital dredging (5A(i), 5A(ii) and 5A(iii)) (Figure 1-2). The sediment risk classification of the proposed dredge areas has been discussed in Section 2.4 and presented in Table 2-3. Based on the risk classification, the dredge area has been considered as a single continuous region for the purposes of this SAP.

As the proposed dredging is capital in nature, in accordance with the NAGD (NAGD, Appendix D), the number of sample locations within Zone 5A can be based on the layer of recent sediments which could be contaminated. Based on the top 1 m of surficial sediments being potentially contaminated (refer to Section 2.3.1), the relevant volume for sample number determination would be estimated at 950,000 $m^3$ (950,000 $m^2$ x 1 m). However, Pilbara Ports prefers to conduct sediment sampling at a conservative rate to ensure a robust assessment of the material to be dredged. As such, for the purposes of this SAP, sample numbers have been based on the total maximum dredge volume of 1,200,000 $m^3$ as per the methods outlined in the NAGD.

Total number of sample locations is obtained using the below formula provided in the NAGD (Appendix D) or Table 6 from Appendix D of the NAGD (Commonwealth of Australia 2009):

$y = 0.025x + 15.547$

where:

y is the number of sampling stations and

x is the volume of dredge material (x 1000 cubic metres)

Based on Table 6 from the NAGD Appendix D (Commonwealth of Australia 2009), a minimum of 46 sampling locations is required.

The NAGD (Appendix D) suggests that where good quality, current data for the site is already available to support the classification of the dredge area, the number of sample locations in the 'probably clean' category may be halved. Results from a recent survey of the sediments within and adjacent to the proposed dredging area (MScience 2022a) indicate that sediments are likely to be suitable for unconfined ocean disposal (probably clean). Based on the NAGD advice and this recent data, the number of locations recommended using the NAGD formula will be halved to 23, as outlined in **Error! Reference source not found.**.

#### 3.2.1.2 ZONE 5B

This area is not proposed to be dredged for the Project or in the immediate future; however, there may be a need to remove material from this area in the future (i.e. maintenance dredging) should there be an accretion of sediments that may limit safe navigation. If accretion of sediments results in a reduction of the navigable depth to less than the channel design depth of - 12 m CD, then Pilbara Ports would seek to dredge this area as part of the routine maintenance dredging activities in the Port once the area has been included within the approved maintenance dredging area (under Pilbara Ports' 5-Year Sea Dumping Permit for maintenance dredging). As such, the sampling of the sediments within Zone 5B aims to characterise the sediments such that their suitability for offshore disposal at a designated spoil ground can be determined. Pilbara Ports may then seek to add this area to that covered by the existing 5-Year Sea Dumping Permit for maintenance dredging at the Port of Port Hedland.

The target material is considered to be representative of the material which has naturally accreted in this area, and it could be reasonably assumed that any future accretion of material would have similar physiochemical properties to the current in-situ materials which form the seabed. With no volume available upon which to base the number of sampling sites that would be required, the approach has been to acquire sufficient data such that a statistically reliable assessment of the sediment properties can be obtained. As such, for the purposes of this SAP, sediment samples will be collected from 10 sites within Zone 5B.

#### 3.2.1.3 SPOIL GROUNDS

Collection of samples at Spoil Ground 7C is not proposed, due to the current data (within five years) available on the sediment characteristics of representative sites and their adjacent areas collected for Pilbara Ports long term maintenance dredging permit (see Section 2.2).

### 3.2.2 Sampling Locations

Table 3-2 and Figure 3-1 detail the location and sampling requirements for the proposed sediment sampling sites within the Zone 5 Bypass Navigation Channel design.

Samples will be collected via a combination of grab (50% of sites) and diver core (50% of sites) sampling techniques, as detailed in Section 3.3.

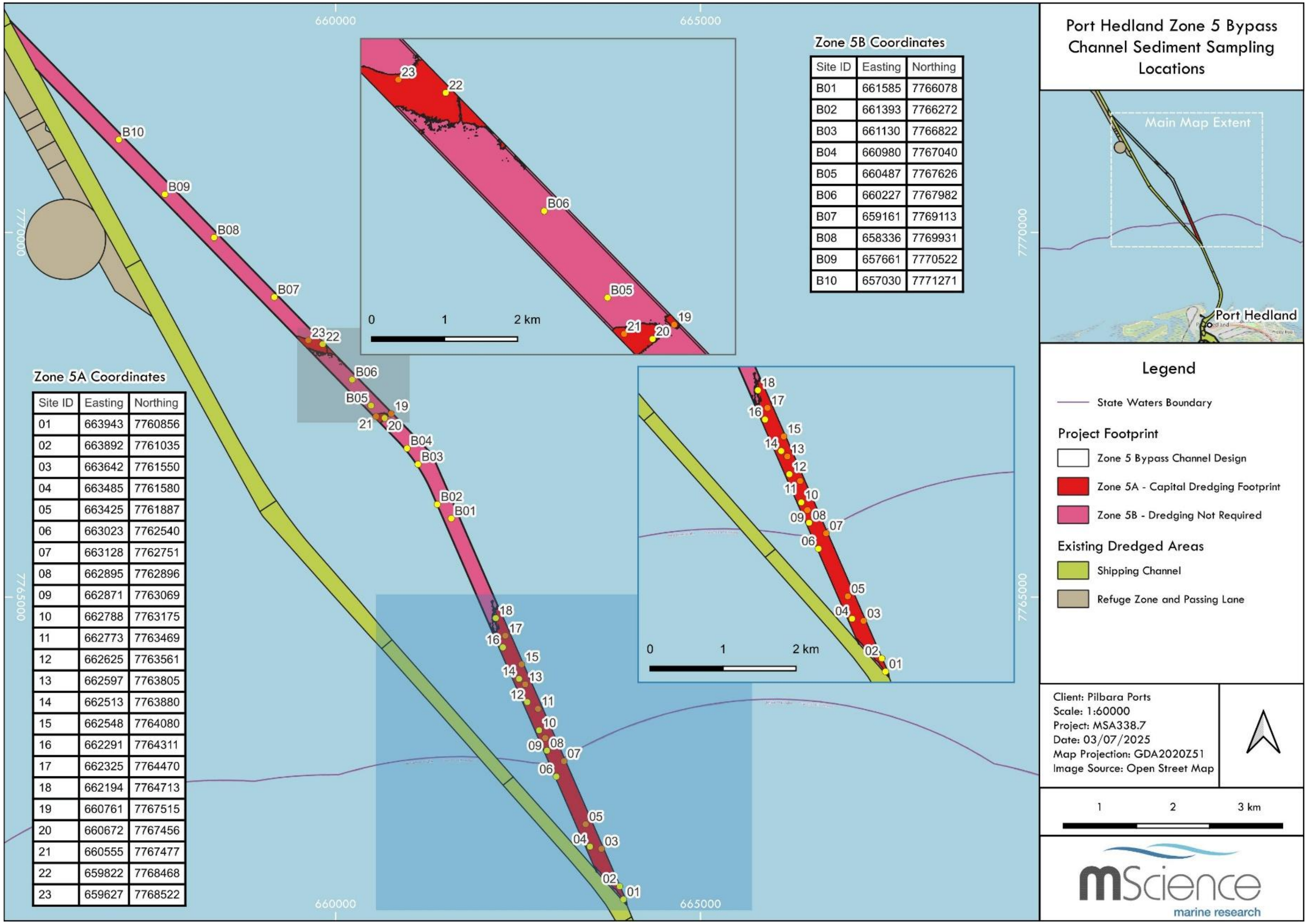
Sediment samples will be collected at random sites within Zone 5A (the 'probably clean' dredging area) and Zone 5B (area proposed for sediment characterisation). Site selection utilised a stratified-random design in accordance with the guidance given by the NAGD (Appendix D). Sampling site locations were selected using a random point allocation extension of the QGIS software package, which randomly assigns a user-nominated number of points to any selected geospatial region or polygon.

*Table 3-2. Details of proposed sampling locations*

| Site ID* | Easting | Northing | Sample Type | | Analysis Suite | |
|---|---|---|---|---|---|---|
| | | | Grab | Diver Core | Basic | Additional |
| Zone 5A – Within areas proposed to be dredged | | | | | | |
| 01 (T) | 663943 | 7760856 | ✓ | | ✓ | ✓ |
| 02 (S) | 663892 | 7761035 | ✓ | | ✓ | ✓ |
| 03 | 663642 | 7761551 | | ✓ | ✓ | |
| 04 | 663485 | 7761580 | ✓ | | ✓ | |
| 05 | 663426 | 7761887 | | ✓ | ✓ | ✓ |
| 06 | 663024 | 7762541 | ✓ | | ✓ | |
| 07 | 663129 | 7762752 | | ✓ | ✓ | |
| 08 | 662896 | 7762897 | ✓ | | ✓ | ✓ |
| 09 | 662872 | 7763070 | | ✓ | ✓ | ✓ |
| 10 | 662788 | 7763176 | ✓ | | ✓ | |
| 11 | 662773 | 7763469 | | ✓ | ✓ | |
| 12 (T) | 662626 | 7763562 | ✓ | | ✓ | ✓ |
| 13 | 662597 | 7763805 | | ✓ | ✓ | ✓ |
| 14 | 662513 | 7763880 | ✓ | | ✓ | |
| 15 | 662549 | 7764080 | | ✓ | ✓ | |
| 16 | 662291 | 7764312 | ✓ | | ✓ | ✓ |
| 17 | 662326 | 7764471 | | ✓ | ✓ | ✓ |
| 18 | 662194 | 7764713 | ✓ | | ✓ | |
| 19 | 660761 | 7767515 | | ✓ | ✓ | ✓ |
| 20 | 660672 | 7767456 | ✓ | | ✓ | ✓ |
| 21 | 660556 | 7767477 | | ✓ | ✓ | |
| 22 | 659823 | 7768468 | ✓ | | ✓ | ✓ |
| 23 | 659628 | 7768522 | | ✓ | ✓ | |
| Zone 5B – Within channel design footprint, outside of areas to be dredged | | | | | | |
| B01 (T) | 661585 | 7766078 | ✓ | | ✓ | ✓ |
| B02 | 661393 | 7766272 | ✓ | | ✓ | |

| Site ID* | Easting | Northing | Sample Type | | Analysis Suite | |
|---|---|---|---|---|---|---|
| | | | Grab | Diver Core | Basic | Additional |
| B03 | 661130 | 7766822 | ✓ | | ✓ | ✓ |
| B04 | 660980 | 7767040 | ✓ | | ✓ | |
| B05 | 660487 | 7767626 | ✓ | | ✓ | ✓ |
| B06 | 660227 | 7767982 | ✓ | | ✓ | |
| B07 | 659161 | 7769113 | ✓ | | ✓ | ✓ |
| B08 | 658336 | 7769931 | ✓ | | ✓ | |
| B09 | 657661 | 7770522 | ✓ | | ✓ | ✓ |
| B10 | 657030 | 7771271 | ✓ | | ✓ | |

*T- Triplicate site, S – Spilt site




Zone 5A Coordinates

| Site ID | Easting | Northing |
|---|---|---|
| 01 | 663943 | 7760856 |
| 02 | 663892 | 7761035 |
| 03 | 663642 | 7761550 |
| 04 | 663485 | 7761580 |
| 05 | 663425 | 7761887 |
| 06 | 663023 | 7762540 |
| 07 | 663128 | 7762751 |
| 08 | 662895 | 7762896 |
| 09 | 662871 | 7763069 |
| 10 | 662788 | 7763175 |
| 11 | 662773 | 7763469 |
| 12 | 662625 | 7763561 |
| 13 | 662597 | 7763805 |
| 14 | 662513 | 7763880 |
| 15 | 662548 | 7764080 |
| 16 | 662291 | 7764311 |
| 17 | 662325 | 7764470 |
| 18 | 662194 | 7764713 |
| 19 | 660761 | 7767515 |
| 20 | 660672 | 7767456 |
| 21 | 660555 | 7767477 |
| 22 | 659822 | 7768468 |
| 23 | 659627 | 7768522 |

Zone 5B Coordinates

| Site ID | Easting | Northing |
|---|---|---|
| B01 | 661585 | 7766078 |
| B02 | 661393 | 7766272 |
| B03 | 661130 | 7766822 |
| B04 | 660980 | 7767040 |
| B05 | 660487 | 7767626 |
| B06 | 660227 | 7767982 |
| B07 | 659161 | 7769113 |
| B08 | 658336 | 7769931 |
| B09 | 657661 | 7770522 |
| B10 | 657030 | 7771271 |

*Figure 3-1. Proposed sampling locations within the capital dredging area*

## 3.3 Field Procedures

### 3.3.1 Sampling Method Rationale

Historically, sediment sampling has been conducted for this area using diver-held polycarbonate cores or pneumatic drivers. This provides a sample able to be separated into depth profiles, although usually only within the upper 1 m of sediment. Multiple cores are aggregated to a single sample to increase the volume of sediment sampled.

Diver-operated cores are time intensive, especially when bottom time for divers is critical in deeper waters and contain a greater safety risk than sampling by mechanical grab. In the present case, the capacity to sample near the Channel is constrained by this area being subject to high frequency movements of large vessels which would overlap with diving operations.

The NAGD preference for core sampling is based on the presumption that due to deposition and infilling, contaminants may occur in sediments to 1 m depth or greater. However, the NAGD guidelines recognise that grab sampling is appropriate in locations where substantial ship traffic thoroughly mixes the sediments, and/or where the unconsolidated sediment layer is thin.

Past studies collecting core samples around these areas have shown that unconsolidated sediment layers overlying hard undisturbed sediment layers are often quite thin (< 1 m). In these circumstances, hand and pneumatic driven cores usually meet refusal at the base of the soft sediment layer (MScience 2022a).

Previous surveys suggest the distribution of contaminants has been confined to the upper 0.5 m of sediments and has not exhibited significant vertical stratification, due to the physical and geochemical characteristics of the sediment in the area (see Section 2.3.1). During previous studies for the BHPBIO Outer Harbour Development (SKM 2011) and Pilbara Ports Channel Risk and Optimisation Project (Jacobs 2017), assays for potential contaminants in drilled core samples to a depth between 11 – 23 m CD found that samples below 0.5 m contained only naturally occurring levels of metals (arsenic, chromium and nickel).

It is assumed any changes in the chemistry of the sediments that have occurred since the most recent sampling (MScience 2022a) will have occurred in the upper few centimetres of unconsolidated sediments. However, in order to confirm the status of the near surface (0.5 – 1.0 m) sediment profile, the current SAP for capital dredging proposes to utilise a combination of grab sampling and diver-operated cores.

Previous assessments conducted on sediments from the nearby Port of Dampier concluded, after comparing the diver core and grab sampler technique, that both methods produced similar results (Brodie-Hall et al. 2009; SKM 2009).

Based on the above and the proposed shallow depth of 'probably clean' sediments, sampling of sediments via a combination of grab sampler (~10 - 15 cm depth) and diver-operated corer (~0.5 – 1 m depth) should provide an unbiased view of the concentration of contaminants in a load of spoil in a dredge hopper.

### 3.3.2 Site Position

A GPS system will be used to position the survey vessel as close to the proposed sample site as possible, within an accuracy of +/- 10 m. The passage of bulk carriers and other vessels in the area will be taken into account during vessel positioning. A handheld GPS will be used to take an 'actual' GPS location of the site at the time the grab/diver is deployed.

### 3.3.3 Sample Collection

#### 3.3.3.1 GRAB SEDIMENT SAMPLES

- Surface sediment samples (~10 - 15 cm depth) will be collected using an appropriate sediment grab sampler (Petite Ponar, Ponar, Van Veen or similar). The grab will have a minimum gape size of 0.02 $m^3$ and be fitted with a rubber cover or similar, to ensure minimal loss of fines.
- Pull speed during recovery will be moderated to retain the sample in the grab.
- Multiple grabs may be required from each site in order to obtain sufficient volume of sediment for analysis.

#### 3.3.3.2 DIVER CORE SEDIMENT SAMPLES

- Surface (0 - 10 cm depth) and near surface sediment samples (~0.5 – 1 m depth) will be collected via diver-operated cores. The corers will consist of a 1 m polycarbonate core barrel, of at least 5 cm diameter.
- Multiple cores may be required from each site in order to obtain sufficient volume of sediment for analysis. If so, each corer will be collected within an area of 1 x 1 m.

### 3.3.4 Sample Handling

- The contents of the corers will be photographed prior to extrusion into a glass, uPVC, Teflon coated or stainless-steel bowl. Samples will be homogenised at two depth profiles; the top 10 cm of sediment and sediment below 50 cm.
- The contents of the grabs will be dispensed into a glass, uPVC, Teflon coated or stainless-steel bowl, taking care to avoid sediment in contact with the sides of the grab and photographed prior to being homogenised.
- Sediment which is to be analysed for volatiles will be collected from midway of the sampling interval prior to mixing.
- The sample will then be homogenised using a Teflon coated, uPVC, stainless steel or wooden spoon until the colour and texture is uniform.
- The mixing of the sample will be limited to avoid introducing excess oxygen into the sample.
- An appropriate volume of sediment will be collected for each analyte (refer to Section 3.6.3, Table 3-4 and Section 4.3, Table 4-1 if Phase III analysis is required), and placed into the appropriate sample containers provided by the nominated laboratories.
- The sediment from the QA/QC split sites will be divided into three samples as described in Section 3.6.6. Sediment from QA/QC triplicate sites will be treated as three independent samples. Where multiple grabs are required to be homogenised to form a single sample, consecutive grabs will be pooled to obtain the three independent samples.

The following data and metadata will be entered into a field log after sediment collection:

- Date and time of sampling.
- Site number.
- Co-ordinates of each location at which samples are taken (information to be recorded on a handheld GPS).
- Water depth of sampling location.
- Identity of sampler.

- Sediment characteristics including colour, odour, grain size, plasticity, presence of organic matter, marine organisms, mineral ore, shell and other relevant features.
- Sample identifier (ID), including image number.

## 3.4 Field Operations

### 3.4.1 Field Equipment and Personnel

The proposed field personnel will be experienced in the correct procedures for collection of marine sediments. The sediment sampling program will require the following equipment to adequately collect sediment samples for chemical and physical screening:

- Vessel GPS/hand-held GPS.
- Grab sampler (e.g. petite ponar, ponar, van veen) (and spare).
- 1.0 x 0.05 m polycarbonate corer (plus spares).
- Clean sample containers provided by the nominated laboratories.
- Coolers and ice blocks.
- Inert gloves.
- Glass or stainless steel bowls.
- Teflon coated, stainless steel or wooded spoons.
- Decontaminant solution (e.g. Decon 90).
- Digital camera.
- Waterproof pens, pencils and paper.
- Field logs and CoC forms.

### 3.4.2 Health and Safety

All operations will be conducted under a suitable occupational health and safety management plan and/or dive management plan prior to the commencement of any field work.

Prior to the initial deployment of the grab sampler or diver, a Job Hazard Analysis (JHA) or Job Safety and Environmental Analysis (JSEA) will be completed to address the workplace health and safety associated with the field survey and diving operations.

If requested, the health and safety management plan and/or dive management plan will be submitted to Pilbara Ports for review and approval prior to commencement of works. The party(s) contracted to implement this SAP will adhere to all Pilbara Ports health, safety and environmental requirements and attend a site induction, if required.

Sediment chemistry is highly unlikely to present a health or safety hazard to the field personnel. Decontaminant solutions such as Decon 90 will be used in the field for decontamination purposes, no other chemicals will be used. Field personnel involved in handling sediments will wear inert gloves at all times and additional PPE, such as safety boots, glasses and coveralls, will also be used.

### 3.4.3 Contingency Planning

The sampling program will cease in the event of unforeseen bad weather or critical equipment (e.g. vessel) failure and resume as soon as possible. In case of extended delays, any samples already collected will be submitted to the laboratory for testing and not held until completion of the entire sampling program.

Where batch sampling and analysis is necessary, a PSD sample and a chemical constituent sample from each batch will be retained for inclusion with the samples from the subsequent batch analysis. These samples shall be referred to as inter-batch samples for quality assurance purposes and will be labelled with both site and batch number. Inter-batch samples shall be collected for each sample collection campaign and held for inclusion in subsequent campaigns up to a period of 6 months, beyond which the sediment holding times allowing for accurate analysis will have elapsed.

If a subsequent sampling campaign is initiated within the 6-month period of inter-batch sample retention, then the elapsed time between campaigns will be recorded. The elapsed time will then be compared to the holding times for chemical analysis of contaminants in sediments. Analysis will proceed for all constituents where the holding time recommended for that constituent exceeds the time elapsed between sample collections. PSD will be done for all inter-batch samples irrespective of elapsed time.

#### 3.4.3.1 INABILITY TO SAMPLE AT A PARTICULAR SAMPLING LOCATION

As the sediment layer to be sampled is thin there is a chance that refusal may be encountered when the grab or core is deployed.

Where refusal by the grab is encountered, best endeavours should be made to collect a sample in close proximity to the sampling location. Continued refusal (up to four attempts) by the grab when attempting to collect a sample after initial refusal at a sampling location should warrant no further sampling at that sampling location. The team implementing the sampling should seek to find an alternative location as close to the original location as possible where a sample can be taken.

Where refusal of a core is encountered, another attempt should be made with the sampling site moved an additional metre from the original sampling site. The movement away from the original sampling site need not be linear but in a series of concentric circles each one metre greater in radius than the previous one. A total of four attempts should be made before formally recording / logging that a sample is unable to be obtained at a particular site. The team implementing the sampling should seek to find an alternative location as close to the original location as possible where a sample can be taken.

An alternative location for sampling may also be required if a sampling location is unavailable for safety reasons, such as the presence of other vessels or other operations of the port that could influence the safety of those undertaking the sediment sampling. If such an event occurs, then an alternative sampling location as close as possible which allows for safe sampling should be substituted for the original sampling location.

## 3.5 Laboratory Analysis

### 3.5.1 Analysis of Samples, Guidelines and Screening Thresholds

The regulations and guidelines that provide assessment frameworks for different aspects of the sediment sampling program have been outlined in Section 1.2.

The values in Table 3-3 have been adapted from the NAGD (Appendix A). They list the Practical Quantitation Limits (PQLs) and Interim Sediment Quality Guidelines (ISQGs) for the contaminants of concern to be measured during the proposed sediment survey. A full list of the PQL's and ISQG's for all analytical parameters stated in the NAGD can be found in Table 1 and Table 2 in Appendix A of the NAGD.

*Table 3-3. Proposed analytes and their respective PQLs and ISQG Trigger Values*

| **Parameter** | | **PQL (mg/kg unless stated)** | **Screening Level (ISQG Trigger Value) (mg/kg unless stated)** |
|---|---|---|---|
| **ALL Samples** to be Tested for the General Contaminants Suite: | | | |
| Moisture Content | | 0.1% | N/A |
| Total Organic Carbon (TOC)* | | 0.1% | N/A |
| Particle Size and Distribution (PSD) | | Size distribution (sieve & hydrometer) | N/A |
| Metals and Metalloids | Aluminium (Al) * | 200 | N/A |
| | Arsenic (As) | 1 | 20 |
| | Antimony (Sb) | 0.5 | 2 |
| | Cadmium (Cd) | 0.1 | 1.5 |
| | Chromium (Cr) | 1 | 80 |
| | Cooper (Cu) | 1 | 65 |
| | Iron (Fe) * | 100 | N/A |
| | Lead (Pb) | 1 | 50 |
| | Manganese (Mn)** | 10 | See footnote |
| | Mercury (Hg) | 0.01 | 0.15 |
| | Nickel (Ni) | 1 | 21 |
| | Silver (Ag) | 0.1 | 1 |
| | Zinc (Zn) | 1 | 200 |
| **50% of Samples** to be Tested for the Additional Contaminants Suite: | | | |
| Organotins (TBT, DBT, MBT) | | 1 µgSn/kg | 9 µgSn/kg |
| Total Recoverable Hydrocarbons (TRH)# | | 100 | 550 |
| Polyaromatic Hydrocarbons (PAH) | | Individual: 5 µg/kg<br>Sum of PAHs: 100 µg/kg | 10,000 µg/kg |

Source: Table 1 and 2 in the NAGD (Appendix A)

*Not a contaminant but included as potential normalising element

**Manganese does not have a fixed screening level under the NAGD. Its screening level is the mean background concentration multiplied by two.

#ensuring Total Petroleum Hydrocarbon fractions $C_6$ – $C_{36}$ are reported for comparison with NAGD screening levels

### 3.5.2 Laboratory Methods

Only laboratories accredited under the National Association of Testing Authorities (NATA) for the parameters to be tested will be used. A primary laboratory will analyse the bulk of sediments and a secondary laboratory will analyse inter-laboratory field duplicates (refer to Section 3.6.6). All of the proposed laboratories will be capable of achieving appropriate limits of reporting (LoRs) to meet the PQLs outlined in Table 3-3.

According to NAGD, for most parameters there are a variety of acceptable methods, and laboratories are free to choose standard methods that demonstrably provide the necessary performance characteristics, which entails validation with standard reference materials (as is current practice in Australia).

## 3.6 Quality Assurance/Quality Control

### 3.6.1 Sample Labelling

All of the sample containers will be clearly labelled in two locations using a waterproof marker with the sample ID, date of collection and the project name/number. Samples for PSD, stored in the appropriate laboratory supplied containers, will contain an additional label on waterproof paper on the inside of the bag. The field log will be kept to ensure that each sample can be identified. A copy of the field log will be made as back-up.

### 3.6.2 Cross-contamination Control

To avoid cross-contamination between sediment sites, all sampling equipment will be stainless steel, uPVC or Teflon coated, where practicable. All equipment will be washed in an appropriate decontaminant solution (e.g. Decon 90) after each site and rinsed in seawater. Field staff handling samples will wear a pair of inert gloves, changing these between each site. When sampling, contact with zinc anodes, surfaces coated with antifouling paint, metal-containing sunscreens and engine exhausts will be rigorously avoided.

### 3.6.3 Sample Storage and Transport

The target sample volumes and sample container types for each analysis suite are outlined in Table 3-4. Once collected, samples will be stored cold and in the dark until they can be transported to a fridge or freezer on completion of the day's sampling and stored in accordance with the preservation method in Table 3-4. The samples will remain in the fridge or freezer until they are transported to the nominated laboratories in coolers with ice blocks to ensure the samples remain chilled (≤4°C).

Collection of sediment samples is proposed to be undertaken during a single, continuous sampling campaign, and where possible, all samples will be sent to the respective laboratories in a single batch. Following receipt of the samples, the laboratories shall be responsible for appropriate sample storage whilst awaiting analysis. All samples will be transported with a chain of custody (CoC) form attached to the batch. Inter-batch samples will be labelled with site and batch number for identification and stored in a freezer (chemical sample) or refrigerator (PSD sample) along with a CoC, ready for inclusion with any future batch. The last sediment survey undertaken within the currently proposed dredging area was conducted in 2022; there are no inter-batch samples from this campaign available for inclusion in the current batch of samples. Further procedures for inclusion of inter-batch samples are provided in Section 3.4.3.

*Table 3-4. Sample sizes, storage methods and holding times for each analyte*

| Parameter | Typical Volume (ml)* | Sample Container | Preservation Technique | Storage Conditions | Holding Time |
|---|---|---|---|---|---|
| Metals | 100 | Polyethylene/Glass jar - unpreserved | Refrigerate<br><br>Freeze for extended storage | ≤4°C | 6 months (Hg 28 days unless frozen) |
| TRH, PAH | 250 | Glass jar - unpreserved | Refrigerate<br><br>Freeze for extended storage | ≤4°C, in the dark | 14 days if refrigerated |
| Organotins | 250 | Glass jar - unpreserved | Refrigerate<br><br>Freeze for extended storage | ≤4°C, in the dark | 14 days if refrigerated<br><br>56 days if frozen within 12 hours of collection |
| Moisture | 10 - 50 | Polyethylene/Glass jar - unpreserved | Refrigerate | ≤4°C | 14 days if refrigerated |
| TOC | 50 | Glass jar - unpreserved | Refrigerate<br><br>Freeze for extended storage | ≤4°C, in the dark | 28 days if refrigerated |
| PSD | 50 - 100 | Whirlpac/Snap lock bag | Refrigerate | ≤4°C | Undetermined |

*The typical volume of sample required is based on Appendix H of the NAGD. Less volume may be required in some cases. The laboratory conducting the analyses should be consulted prior to sampling to determine the actual sample volume required for the analysis.

### 3.6.4 Chain of Custody Forms

A detailed CoC form will be prepared and will accompany the samples to each of the designated laboratories. The CoC forms allow tracking of individual samples and will ensure that the correct analysis and storage is being undertaken, and that the recommended holding times are being adhered to. The CoC forms will be signed by the laboratories on receipt of the samples and returned to the sender. As per the NAGD, CoC forms that accompany the samples will clearly indicate the samples are of marine origin to ensure the laboratory uses methods to overcome interference from high salt levels.

The CoC forms will include the following:

- Place of sampling.
- Sample ID, client name and project name/number.
- Sampling date.
- Requested analysis (including the LoR).
- Sample storage request.
- Sample transport details, including date of dispatch.

### 3.6.5 Laboratory QA/QC

As part of their standard procedures, all laboratories will undertake the required testing of blanks, spikes and standards, and will complete laboratory duplicates to the satisfaction of the NATA. The description of blanks, spikes, standards and laboratory duplicates is outlined in Appendix A of the NAGD. The results of these QA/QC procedures will be required to meet the DQOs for data validation outlined in the NAGD (Appendices A and F). Reports of these results will be provided in the SAP implementation report. Table 3-7 of this SAP outlines the DQOs for laboratory QA/QC samples.

### 3.6.6 Field Sampling QA/QC

Field QA/QC samples will be collected in accordance with Table 3-5 at the numbers provided in Table 3-6 . These samples will be used as part of the data validation process in accordance with the procedures outlined in Appendix A and Appendix F of the NAGD. Table 3-7 of this SAP outlines the DQOs for field QA/QC samples.

*Table 3-5. Field QA/QC sample details*

| QA/QC Sample Type | Description |
|---|---|
| Field Triplicates | At 10% of sites within a sampling area, field triplicates (three separate samples taken at the same location) will be collected to determine the variability of the physical and chemical sediment characteristics at the scale of sampling. |
| Field intra- and inter-laboratory duplicates (Splits) | At 5% of the sites within a sampling area, intra- and inter-laboratory duplicates (split samples) will be collected. That is, one sample will be thoroughly homogenised as normal and then split into three containers to assess within (intra) and between (inter) laboratory variation. Split samples will be labelled consecutively with different ID numbers, so they are not known to the nominated laboratories. |
| Trip Blank | One trip blank will be collected for each day of the field survey. These will provide an indication of cross contamination from volatile substances during field sampling. Trip blanks should be supplied by the analytical laboratory. |
| Inter-batch duplicate | Refer to Section 3.4.3 and 3.6.3 for inter-batch sample description and requirements. |

*Table 3-6. Breakdown of Phase II field QA/QC sample numbers*

| Sampling Area | Number of Sampling Sites | #Triplicate Sites | # Split Sites |
|---|---|---|---|
| Zone 5A<br>Capital Dredging Area | 23 | 2 | 1 |
| Zone 5B<br>Sediment Characterisation Area | 10 | 1 | - |
| **Total** | **33** | **3** | **1** |

*Table 3-7. Data quality objectives for the SAP*

| Sample Type/Objective | Frequency | Data Quality Objective |
|---|---|---|
| **Precision** | | |
| Field Triplicates | 10% of samples in a sampling zone | <5 x LOR = no limit on RSD<br>>5 x LOR = 0-50% RSD* |
| Intra-laboratory Field Duplicates | 5% of samples in a sampling zone | <5 x LOR = no limit on RPD<br>>5 x LOR = 0-35% RPD* |
| Inter-laboratory Field Duplicates | 5% of samples in a sampling zone | <5 x LOR = no limit on RPD<br>>5 x LOR = 0-35% RPD* |
| Trip Blanks | 1 per field day | </= LOR |
| Laboratory Duplicates | 1 per batch | <5 x LOR = no limit on RPD<br>>5 x LOR = 0-35% RPD* |
| **Accuracy** | | |
| Matrix Spikes | 1 per batch or 20 samples | Recovery 70 - 130 % or as per lab requirements# |
| Matrix Spike Duplicates | 1 per batch or 20 samples | RPDs < 35% |
| Surrogate Spikes | All organic analyses | Recovery 70 - 130 % or as per lab requirements# |
| Laboratory method blanks | 1 per batch | </= LOR |
| Control Samples | 1 per batch or 20 samples | Recovery 70 - 130 % or as per lab requirements# |
| Analysis of Certified Reference Materials (CRMs) | All sediment metal analyses, 1 per batch | <35% RPD, Recovery 70 - 130 % or as per lab requirements# |
| **Representativeness** | | |
| Sampling design appropriate for study area & follows sampling procedures | All media (sediment & water) | All samples |
| Sampling, sub-sampling, and sample handling and storage appropriate for analytes | All media, all analytes | All samples |
| Holding time adhered to | All samples | All samples extracted and analysed within HTs |
| **Comparability** | | |
| SOPs for sample collection, sub-sampling and handling | All samples | All samples collected and handled in accordance with the SOPs by experienced professionals |
| Standard analysis methods | All samples | All samples sub-sampled, extracted/digested and analysed at NATA certified labs by standard methods |
| LORs consistent between laboratories and batches | All samples | Inter-lab differences in LORs for same analytes < 50% different |
| LORs met for all analytes**## | All samples | All samples |
| Outliers and inter-laboratory discrepancies resolved | Affected samples | Affected samples re-extracted and analysed in replicate if still within holding times |
| **Completeness** | | |
| All critical locations sampled, all required samples collected and all samples analysed according to SAP | All samples | All required data obtained |

| Sample Type/Objective | Frequency | Data Quality Objective |
|---|---|---|
| COC forms, field logs, sample descriptions and sample location data recorded and retained | All samples | All samples |
| Samples received at laboratory as specified on COC forms | All samples | All bottles, jars and sample bags received and unbroken, seals intact and samples chilled |
| QC samples sufficient and acceptable results | All QA/QC samples | Full compliance with QA/QC sample submission and analysis |
| **Sensitivity** | | |
| Analysis methods and LORs are appropriate for the media, expected background levels of analytes, and adopted site assessment criteria | All media, all analytes | All samples |

* Contaminant concentrations become increasingly uncertain as they approach the method detection limit. Therefore, criteria are:

- Result < 5xLOR - no limit to RPD or RSD
- Result > 5xLOR - RPD/RSD should be </= 50% (or </=35% for lab replicates)

# Lower recoveries may be recorded for some semi-volatile organics. Recoveries may also be lower on some sediments due to matrix interference from high water content, high salinity, plant wax, sterols, lipids etc

** Occasionally matrix effects may prevent this, requiring any such incidents to be documented by the lab

## If the moisture content of a sample exceeds 50%, the LOR may need to be raised to meet the QA protocol

## 3.7 Data Analysis and Assessment

Simple arithmetic means and 95% UCL will be calculated using the United States Environmental Protection Authority developed software ProUCL v4.0 as recommended in the NAGD and analyses will be undertaken in accordance with the guidance in the NAGD. The ProUCL software automatically computes the recommended parametric or non-parametric method best suited to calculating the 95% UCL for each dataset based on the data's distribution. Exploratory data analysis will be undertaken to assess any spatial heterogeneity within each dredge zone.

All concentrations of organics will be normalised to 1% TOC (to a maximum of x5) and the 95% UCL calculated for each sampling area using ProUCL v4.0.

Sample sites used to generate the means and 95% UCL will be grouped according to the regions defined in **Error! Reference source not found.**, i.e. the 'probably clean' Bypass Navigation Channel dredge area.

The results of the sampling program will be presented in the implementation report to be included as part of the SDP application to be submitted to the DCCEEW. The implementation report will compare the levels of sediment contaminants found with NAGD screening and limit values, as well as appropriate background values.

If the 95% UCL of a contaminant exceeds the specified Screening Level, it is a COPC and comparison to ambient baseline levels for sediments of comparable grainsize will be conducted. The recent reference values described by MScience (2022a) from sites within and adjacent to Spoil Ground 7 and Spoil Ground 'I' will be utilised as an estimate of uncontaminated background contamination for the region. The reference locations have been chosen to be distant from any existing or historic potential for contamination, representative of the disposal sites and to be in an area where the seabed will be a similar depth to that around the dredge areas and with a similar particle sizing.

If the 95% UCL of a contaminant exceeds the specified Screening Level, the contaminant ambient baseline concentrations will be used as the assessment value, and the comparison will be done using the mean of dredge sites and the 80th percentiles for the reference site sediments. If the mean of the dredge sediment concentrations for the substances in question are at, or below, the 80th percentile of the ambient baseline levels (MScience 2022a) in the vicinity of the disposal site, the sediment will be considered to be chemically acceptable for ocean disposal even though the relevant Screening Level(s) were exceeded. If above ambient baseline levels, it is a COPC and Phase III testing will then be required.

Where 95% UCL values exceed the screening levels and the mean concentration is above the 80th percentile of ambient background, Phase III investigation in the form of bioavailability and elutriate testing, as described in Section 4, will be required to determine whether dredged sediments are suitable for unconfined ocean disposal.

Refer to Table 3-7 for the specific DQOs (for data quality validation) related to these data.

# 4 SAMPLING AND ANALYSIS PLAN (PHASE III & PHASE IV)

## 4.1 Rationale

If the 95% UCL of the mean for any contaminant from the Phase II investigations return results which exceed the screening and ambient baseline concentration guidelines for any substances, Phase III testing of samples containing the COPC is conducted using bioavailability and elutriate testing in accordance with Appendix A of the NAGD. These investigations are not likely in the current survey. As such, a subsequent field survey would be implemented should the results indicate the need for further testing.

## 4.2 Sampling Design

If required, sediment samples for bioavailability and elutriate testing will be collected during a subsequent field survey. Site selection will be determined by the results of the Phase II investigation i.e. sampling would be conducted from the sites which returned results above screening guidelines. According to the NAGD, for elutriate, bioavailability and toxicity testing, a lesser number of sample locations are required (compared to Phase II); however, an increased frequency of sample replication (20%) is necessary.

Table 7 of the NAGD (from Appendix D of NAGD) indicates that the volume of potentially contaminated sediment to be dredged is to be used as the basis for calculating the minimum number of sampling sites to survey for elutriate analysis. The volume of contaminated soil would be calculated based on the Phase II sampling outcomes and the relevant number of samples derived from Table 7 of the NAGD.

Where Phase II samples return contaminant concentrations above screening and baseline levels, bioavailability and elutriate analysis would be undertaken for those specific contaminants using a Phase III sample. This would be undertaken using sites selected for the greatest concentration of the COPC dependent on the spatial distribution of contamination. These sites will be required to be spatially representative of the potentially contaminated area, where spatial representation forms another selection criterion. If the distribution of sites that exceed the screening levels is unlikely to be representative of the overall dredged material, then sites returning contaminant concentrations as close as possible to the 95% UCL of the mean may also be targeted to provide a more representative assessment.

As part of the QA/QC commitment, field triplicates would be sampled at 20% of sites to ensure that the samples collected are representative of the overall dredged material. Triplicate and split sites will be nominated prior to field mobilisation to ensure appropriate collection of sediment at these sites.

## 4.3 Field Procedures

Phase III sample collection would occur as per the procedures described in Section 3.3, ensuring sufficient volume to undertake Phase III analysis where required. Separate samples will be collected for elutriate and bioavailability testing to ensure sufficient volume for analysis. In addition to the collection of sediment, an appropriate quantity of seawater (Table 4-1) would be collected from the designated spoil ground to facilitate elutriation. Seawater would be sampled using the methods for water sample collection detailed in ANZG (2018), ensuring sufficient volume is collected for complete sample analysis. Due to the holding time for water, elutriation would need to proceed within 14 days of sample collection.

Sediment interstitial water, or pore water, would be extracted from sediment samples at the laboratory undertaking the analysis (see Section 4.5).

Sample storage would follow the methods set out in Table 4-1. If required, extractable organics in elutriate tests will be held for 7 days.

*Table 4-1. Sample sizes, storage methods and holding times for elutriate testing*

| Parameter | Sediment Volume (mL) | Sediment Sample Container | Volume of Sea Water (L) | Sea Water Sample Container | Preservation Technique | Storage Conditions | Holding Time |
|---|---|---|---|---|---|---|---|
| Metals | 250 | Glass jar-unpreserved | 1.5 - 2 | Plastic Carboy** | Completely fill and refrigerate | ≤4°C, in the dark /airtight | 14 days |

* Note sample volumes required for pore water extraction are larger than those listed for elutriate testing

** The plastic carboy for sea water sample collection to be provided by the laboratory to ensure it contains no contamination that could affect ultra-trace metals analysis.

## 4.4 Field Operations

If Phase III testing is required, field operations would be conducted as per the procedures described in Section 3.4.

## 4.5 Sample Analysis

Both bioavailability and elutriate analysis would be conducted by a NATA accredited laboratory using approved methods in accordance with the testing procedures outlined in Appendix A of the NAGD. Laboratory QA/QC procedures would be conducted using procedures detailed in Section 3.6.5.

Bioavailability tests would likely be conducted for metals, based on past studies and existing information (See Section 2). Dilute acid extraction methods would be used to test the bioavailability of metals in the sediment. The 95% UCL for the dilute acid extractions would be compared to the screening levels listed in Table 3-3.

Sediment samples to be collected for elutriate tests would also be analysed for metals. Samples would only be analysed for the contaminant that exceeds the screening guideline.

The concentrations of contaminants reported in elutriate samples would be compared to the 95% species protection trigger values for water quality described in ANZG (2018). The relevant ANZG (2018) marine water quality triggers should not be exceeded after allowing for initial dilution, defined as that mixing which occurs within four hours of dumping.

For the purposes of this SAP, a minimum initial dilution will be approximated as, 'the liquid and suspended particulate phases of the waste that may be assumed to be evenly distributed after four hours over a column of water bounded on the surface by the release zone and extending to the ocean floor, thermocline or halocline, if one exists, or to a depth of 20 m, whichever is shallower' as defined in the NAGD. For the current planned dredging program, the surface area of the release zone and the volume of material dumped will be dependent on the dredging plant selected for use (currently not yet determined). The test data from the elutriate analysis would be corrected for the calculated dilution factor after the four-hour mixing period, taking into account the 1:4 test dilution in the assay, to assess whether or not the water quality guidelines will be exceeded after disposal.

Analytes, detection limits and assay methods for any required elutriate analysis are presented in Table 4-2.

*Table 4-2. Analytes, detection limits and assay methods for elutriate analysis*

| Parameter | Limit of Reporting (mg/kg) (or as indicated) |
|---|---|
| Seawater Elutriate Testing Procedure | - |
| Dilute Acid Extraction | 1.0 |
| Total metals in Saline Water by ORC-ICPMS | 0.1-100 µg/L |

## 4.6 Ecotoxicity Testing – Phase IV

Toxicity testing would be conducted on samples that elutriate testing identifies as exceeding ANZG (2018) water quality guidelines (95% species protection trigger values), after taking into account initial dilution, or where bioavailability test results exceeded the NAGD 2009 criteria. Toxicity testing would be conducted by a NATA accredited laboratory. The tests proposed under Phase IV here can be performed by Ecotox Services Australasia (ESA); noting other accredited laboratories offering these services could also undertake the work.

As part of Phase IV testing, a desk study (literature survey plus calculations) would be carried out to determine which contaminants present, if any, may bioaccumulate (e.g. mercury). If bioaccumulating substances were present above the SQG-High levels, bioaccumulation tests would be required. The requirements for bioaccumulation tests are similar to those for general toxicity testing except that the organisms need not be sensitive to contaminants. In addition, test organisms must provide adequate biomass for analysis, ingest sediments and be inefficient metabolisers of contaminants. At least two bioaccumulation tests should occur on each sample and selection of species for bioaccumulation tests would be decided in accordance with the NAGD, if required.

Species selected for general toxicity (non-bioaccumulating) testing would include:

- 48-hr larval development using Sydney rock oyster *Saccostrea glomerata* or a similar species of Saccostrea, should the rock oyster be out of season.
- 72-hr sea urchin larval development test using *Heliocidaris tuberculata*

While the rock oyster larval development test (Table 4-3) is most appropriate to testing the effects of TBT, this test, which measures the sub-lethal toxicity of receiving water and elutriates over the first 48 hrs of development in a static system, is relevant as similar oysters will be present around Port Hedland and the larval stage may be susceptible to a variety of stresses other than TBT. Oysters are spawned in the laboratory and eggs fertilised under controlled conditions. The fertilised eggs are added to the test solutions and assessed after 40 hrs exposure. After 48 hrs, the proportion of abnormal larvae in each concentration is compared to the proportion of abnormal larvae in the controls.

*Table 4-3. Summary of rock oyster larval development test*

| **Test Condition** | **Detail** |
|---|---|
| Test species | *Saccostrea glomerata* |
| Protocol followed | ASTM (1990); Thain (1990); APHA (1992); SKMEL SOP#2-11 |
| Source of test organism | Selected oyster farms, oyster hatcheries |
| Test type | Static |
| Exposure duration | 48 hours |
| Temperature | 25±1 or 27±1 ˚C |
| Photoperiod | 24 hours of light |
| Test volume | 5 ml (in 9mL test tubes) |
| Number of test organisms | ~500 organisms per replicate (total of 2000 per conc.) |
| Replicates per test treatment | 4 |
| Dilution water | 0.45 µm filter seawater (local receiving water) |
| Test endpoint | Larval development (48-hr EC50, NOEC and LOEC) |
| Test acceptability | Control abnormalities ≤30%, reference toxicant test results within specified limits |

To undertake acute toxicity testing sediment contaminants in elutriate water, the sea urchin larval development test using *Heliocidaris tuberculata* would be used. The details of this test are provided below (Table 4-4).

*Table 4-4. Summary of sea urchin larval development test*

| **Test Condition** | **Detail** |
|---|---|
| Test species | *Heliocidaris tuberculata* |
| Protocol | APHA and ASTM protocols |
| Test Type | Chronic, static |
| Test duration | 72 hours |
| Temperature | 20 ±1 ˚C |
| Photoperiod | 16:8 light:dark |
| Test volume | 5 mL |
| Number of test organisms | Approx. 150 |
| Replicates per test treatment | 4 |

| Test Condition | Detail |
|---|---|
| Age/size of test organism | Freshly fertilised eggs |
| Test endpoint | Percent normally developed larvae (EC50, NOEC and LOEC) |
| Test acceptability criterion | ≥70% normal development in controls, reference toxicity within specified limits |

In addition to ecotoxicity testing of elutriate water, whole sediment toxicity tests would be carried out using the amphipod, *Melita plumulosa*, as the test species (Table 4-5). There are few whole-sediment toxicity tests available, and the 10-day acute amphipod toxicity test is the only NATA accredited whole-sediment test available at ESA. Further details of the test are provided below.

*Table 4-5. Summary of sediment amphipod acute toxicity test*

| Test Condition | Detail |
|---|---|
| Test Species | *Melita plumulosa* |
| Test type | Acute static |
| Test end-point | Survival (EC50) |
| Test duration | 10 days |
| Test temperature | 20 ±1 ˚C |
| Sample quantity required | 2 kg |

#### 4.6.1 Sampling design

Phase IV sample collection would occur as per the procedures described in Section 3.3, ensuring sufficient volume to undertake all toxicity tests required for the Phase IV assessment. However, in this case, each individual sample sent for analysis would be a composite sample mixed from a minimum of three grabs taken from the one location. The laboratory nominated for the analyses would be consulted before collection to ensure collection of sufficient sample volume and appropriate handling. Further sample handling procedures would be followed in accordance with Appendix D of the NAGD (p. 63). Sediment samples would be provided to the nominated laboratory and elutriation of samples would be undertaken where required.

Sample numbers and locations would be selected on the same basis as described in Section 4.2.

Ecotoxicity of elutriate samples would be compared statistically to the toxicity of the receiving water. If there are no significant differences between the toxicity of the elutriate samples and the receiving water, the sediment would be considered safe for ocean disposal. Where a toxicity test shows less than a 20 per cent effect in the endpoint (e.g. survival, growth) relative to the negative control, the difference is not significant and no toxicity is indicated. A 20–50 per cent effect in the endpoint compared to the control indicates a significant degree of toxicity, and a greater than 50 per cent effect indicates a high degree (very significant) of toxicity.

If any test shows toxicity, the cause will be assessed. Toxicity caused by contaminants of natural origin (e.g. ammonia or hydrogen sulphide) would be accounted for before toxicity was attributed to sediment contaminants (e.g. by the laboratory doing a simple TIE test (Toxicity Identification and Evaluation), or by measuring the ammonia levels in the sediment pore water. The pass/fail criteria for the toxicity tests are those specified in the individual test protocols.

For bioaccumulation, if there are no significant differences in the bioaccumulation data relative to controls (treatments or sites), bioaccumulation is not a concern. For any contaminant where bioaccumulating concentrations are statistically greater than that measured in the controls, bioaccumulation is a possible concern. Where bioaccumulating concentrations are three or more times greater than those measured in the controls, bioaccumulation is a significant concern (Simpson et al. 2013). If the bioavailability, bioaccumulation or toxicity assessments indicate that significant effects from the contaminants are likely, they are considered to be Contaminants of Concern.

For any dredge area, where toxicity (or bioaccumulation) is rated as very significant or significant in any of the tests on any of the samples, and toxicity is not considered due to natural causes (e.g. ammonia in sediments), if the proponent still wishes to dispose of this material at sea, the following investigations would be undertaken:

a. checking existing data to see if a coincident hot spot (i.e. a cluster of two or more samples exceeding the relevant criteria) can be defined using the existing chemistry and/or toxicity data, and NAGD.
b. if no hot spot can be identified, doing step-out sampling and testing (chemistry and toxicity) around the sample location where toxicity was found, to determine if a local hot spot is present.

There are three possible outcomes of this assessment:

1. If any hot spots are identified, the sediments within them are considered toxic and unacceptable for unconfined ocean disposal, and therefore would require separate handling and disposal as per the existing hot spot provisions. The sediment outside the hot spots would be acceptable for ocean disposal.
2. If no hot spots can be identified, and toxicity is only found in a single sample, the spoil may be considered acceptable for ocean disposal on the basis that the bulk composition of the dredge area, considering the initial toxicity testing plus step-out testing, indicates that it is non-toxic.
3. If no hot spots can be identified, yet toxicity is found at scattered locations throughout the dredge area, the toxicity of the sediments is still an issue. To resolve this, with the agreement of the Determining Authority the proponent has the option of carrying out a Weight-of-Evidence assessment (Phase V) which may include other lines of evidence, including benthic community assessment. Any Weight-of-Evidence assessment would be carried out following the procedures set out in Simpson et. al., (2013).

A Phase V assessment is considered highly unlikely for the proposed capital dredging campaign.

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# APPENDIX A – HISTORY OF SEDIMENT SAMPLING WITHIN THE PORT

Since 1991, the sediments of the Port and surrounding marine areas have been widely sampled and, as such, there is considerable reliable information with which to characterise their chemical and physical properties. Most, though not all, of the sediment testing has been implemented to meet the requirements of the National Assessment Guidelines for Dredging (NAGD) or its predecessor the National Ocean Disposal Guidelines for Dredged Material. A summary of these studies, sourced from GHD (2023), is provided in Table A - 1.

*Table A - 1. Summary of historic sediment sampling within the inner harbour and channel areas of the Port of Port Hedland*

| Year | Study | Location | Comments |
|---|---|---|---|
| 1990 | PHPA Harbour Survey | Harbour wide | Copper, zinc and chromium at elevated levels in harbour sediments levels at some sites. Lack of detail and small number of sites means that any analysis is unreliable. |
| 1991 | PHPA Pre Dredge Survey. | Inner Harbour | All samples were below NAGD screening levels and below twice background levels. Small samples size (3 samples only) means that statistical analysis is unreliable. |
| 1993 | PHPA Harbour Survey | Harbour wide | Cadmium and arsenic exceeded ANZECC guideline levels at some sites |
| 1994 | PHPA Harbour Survey | Harbour wide | Copper found to exceed guideline levels in some sediments |
| 1995 | CMPS&F Environmental<br>as referenced within URS (2004c) | PH Berth No. 1 | Copper and manganese levels elevated close to No 1 wharf exceeded ANZECC guidelines levels in some samples. |
| 1996, 1997 | CMPS&F Environmental<br>as referenced within URS (2004c) | PH Berth No. 1 | Copper in residual sediments close to PPA Berth 1 exceeded ANZECC guidelines levels in some samples. Copper concentrate was, and is, loaded at the PPA berths and this detection was almost certainly a consequence of that activity. PPA have since put in place measures to stop the unintended release of copper to the environment. |
| 1997 | BHPB Reported in URS (2004c) | Harbour and Channel sites | Potential contaminants within the channel were either below screening guidelines, or within natural background ranges that occur in the Port Hedland region. |
| 1999, 2000, 2002, 2003 | BHPB Reported in URS (2004c) | As above, plus eight subtidal sites, adjacent to the export wharves (including Nelson Point, Finucane Island Wharf and PH 1 and entrance Channel). | Sampling involved the collection of single samples at various locations. Statistical analysis was not therefore possible. |

| Year | Study | Location | Comments |
|---|---|---|---|
| 2001 | PHPA Maintenance Dredging Sea Dumping Application | Harbour and Channel | Arsenic, cadmium, chromium, copper, lead, mercury, zinc and tributyltin were below NAGD (low) screening levels. Nickel was above screening levels at the majority of sample sites, but comparable to background levels.<br>Small study included toxicity testing by Curtin University that concluded that the amphipod and mollusc bioassays that were (the only ones) undertaken showed the sediments to be not more toxic than reference sediment. |
| 2003 | Sampling and Analysis Plan (SAP) for Maintenance Dredging<br>(URS 2004c) | Shipping Channel<br>Inner Harbour<br>Nelson Point<br>PH 3<br>Western Turning Basin<br>PH 1 | All channel sediments had metals below NAGD (low) screening levels. |
| 2004 | PHPA maintenance dredging Sea Dumping Permit Application<br>(URS 2005) | Harbour and Shipping<br>Channel<br>Reference Location | NAGD (low) screening levels were exceeded by the 95% UCL concentrations for:<br>Arsenic in the channel<br>Chromium at Nelson Point and No 3 Wharf<br>Nickel in almost all areas<br>Tributyltin at Nelson Point, No 3 wharf and No 1<br>wharf approach |
| 2007 | PHPA Maintenance Dredging SAP implementation in support of Sea Dumping Permit Application<br>(Koskela Group 2007) | Harbour and Channel and Spoil Ground “I” | Exceedances of NAGD (low) screening levels of arsenic, tributyltin, nickel and copper in sediments from PH wharves with exceedances of arsenic and nickel in channel sediments. Elutriate and bioavailability testing was undertaken, and all sediments were approved as suitable to be disposed of to Spoil Ground “I”. |
| 2011 | BHPB Outer Harbour Development<br>(SKM 2011) | Large areas in the offshore areas around Port Hedland including the spoil grounds. | 95% UCLs for all metals, tributyltin and polycyclic aromatic hydrocarbons were below screening levels. |
| 2012 | Port Hedland Maintenance Dredging<br>(Worley Parsons 2012a) | Harbour and Channel and Spoil Ground “I” | Exceedances of NAGD screening level (low) for arsenic, nickel and chromium in almost all areas sampled. Copper exceeded NAGD (low) screening levels at PH wharves |
| 2012 | Port Hedland Maintenance | PH 1, 2, 3 and 4<br>Nelson Point | Copper and tributyltin above NAGD (low) screening levels at Nelson Point and PH Berth 4. |

| Year | Study | Location | Comments |
|---|---|---|---|
| | Dredging Post Dredging Survey (Worley Parsons 2012b) | Spoil Ground "I" | |
| 2013 | Anderson Point sampling (SKM 2013) | Anderson Point | Exceedances of NAGD screening level (low) for nickel in areas sampled. |
| 2014 | Port Hedland Maintenance Dredging Sampling (Worley Parsons 2014) | PH 1, 2 and 4 | Exceedances of NAGD screening level (low) for arsenic, nickel and chromium in areas sampled. |
| 2015 | Extension of SpoilGround "I" (Worley Parsons 2015) | Spoil Ground "I" | All parameters that were measured were below NAGD (low) screening guidelines at all locations. |
| 2015 | Port Hedland Maintenance Dredging sampling (Jacobs 2015) | Anderson Point, Stanley Point and Spoil Ground "I" | Exceedances of NAGD screening level (low) for arsenic, nickel and chromium. No exceedances of any other parameters. |
| 2016 | Port Hedland Maintenance Dredging sampling (GHD 2016) | Channel Inner Harbour, various berth pockets and Spoil Ground "I" extension | Exceedances of NAGD screening level (low) for arsenic, nickel and chromium. No exceedances of any other parameters. |
| 2017 | CROP Sampling and Analysis Plan Implementation (Jacobs 2017) | Channel Inner Harbour, Spoil Grounds 7 and 9 | No exceedances of any parameters. |
| 2017 | Port Hedland Maintenance Dredging sampling (MScience 2017a) | Nelson Point, Finucane Island and PH 1 and 2 berth pockets | Exceedances of NAGD (low) screening level for nickel at all sites. Exceedances of NAGD (low) screening level for barium, copper, manganese and tributyltin at PH Wharfs 1 & 2, however elutriate and bioavailability testing found the sediments to be suitable for unconfined ocean disposal. |
| 2019 | ASAP Implementation Reports (Year 1) (Advisian 2019a; Advisian 2019b; Advisian 2019c) | Channel, Finucane Island A, Anderson Point, and Hunt Point Tug Pens | Exceedances of NAGD screening level (low) for nickel and chromium. No exceedances of any other parameters. |

| Year | Study | Location | Comments |
|---|---|---|---|
| 2020 | ASAP Implementation Reports (Year 2)<br>(O2 Marine 2020a; O2 Marine 2020b) | PH 1, 2, 3 and 4 berths, Nelson Point, Finucane Island C and D, Anderson Point Tug Pens | Exceedances of NAGD screening level (low) for arsenic, nickel, copper and chromium. No exceedances of any other parameters. |
| 2021 | ASAP Implementation Reports (2021)<br>(MScience 2021a; MScience 2021b) | Channel, Inner Harbour and Swing Basin, Nelson Point, Stanley Point and Spoil Ground "I" | Exceedances of NAGD screening level (low) for arsenic, nickel and chromium. No exceedances of any other parameters. |
| 2022 | ASAP Implementation Report, 2022<br>(MScience 2022b) | PH 1, 2 and 3 berths, Anderson Point, Lumsden Point and Stingray Creek Cyclone Moorings | Exceedances of NAGD screening level (low) for arsenic, nickel and chromium. No exceedances of any other parameters. |
| 2024 | Port Hedland Maintenance Dredging<br>(MScience 2024) | PH 4 berth, Finucane Island A – D, Anderson Point 1,2 3, Hunt Point tug pens, Anderson Point tug pens, Stingray Creek cyclone moorings | Exceedance of screening level derived for manganese (following NAGD methods) at Anderson Point. No exceedances of any other parameters. |