Port of Gladstone Maintenance Dredging 2022 SAP Design Document

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Contents

Tables

Figures

1 Introduction

1.1 Background

Gladstone Ports Corporation Ltd (GPC) was formed in 1914 and is a Government Owned Corporation (GOC) that presently manages three Port precincts – the Port of Gladstone, Port of Rockhampton and Port of Bundaberg. The Port of Gladstone is Queensland's largest multi-commodity port.

In addition to other key roles, GPC is responsible for maintaining navigable port depths and pilotage, while port navigation is controlled by Maritime Safety Queensland (MSQ). Navigable port depths require a minimum depth of clearance below the keel of vessels calling at the Port of Gladstone to allow for effective shipping access to the port and ensure ship safety. GPC undertakes regular maintenance dredging programs to ensure minimum depths are maintained. In addition to the primary navigation channels, GPC is responsible for maintaining auxiliary navigable channels and the Gladstone Marina.

Maintenance dredging campaigns generally target areas where material has accumulated beyond the minimum draft designated by the Harbour Master. The Port of Gladstone Main Channel also comprises of swing basins and berths with all dredge material from these areas is currently placed in the East Banks Sea Disposal Site (EBSDS).

Whilst not every navigable channel requires dredging yearly, the following areas outside of the main channel included in this document are Gladstone Marina, Upper Auckland Inlet, and Boyne River entrance channel (See Figure 1.1).

This draft Sediment Sampling Analysis Plan (SAP) design document provides the proposed plan for the sampling and analysis of sediments from each of the areas requiring maintenance dredging. The SAP will be implemented every five (5) years to support the maintenance dredging approval process at the Port of Gladstone.

Figure 1.1 Gladstone dredging locality

1.2 Sediment Sampling and Analysis Plan (SAP) Objectives

The aim of this SAP is to provide a set of procedures that will allow a statistically valid evaluation of the physical and chemical sediment properties of the sediments to be dredged. The results of this assessment will assist in determining the suitability of sediment for land-based re-use or offshore placement.

The assessment of physio-chemical sediment properties for land-based reuse will be undertaken in accordance with the National Environment Protection (Assessment of Site Contamination) Amendment Measure 1999 (NEPM), with sampling intensity and methodology defined in accordance with the National Assessment Guidelines for Dredging (NAGD 2009). The assessment of the risk of acid sulfate generating potential for land-based placement utilises action criteria defined in Queensland Acid Sulfate Soil Technical Manual (QASSTM, Dear *et al.* 2014) and the National Guidelines for the dredging of acid sulfate soil sediments and associated dredge spoil (Simpson *et al*. 2018). The suitability of sediment for offshore placement will be assessed against the NAGD (2009).

This SAP provides a tier 1 preliminary investigation into potential levels of contamination in sediments destined for land-based reclamation. It follows the recommended process for the assessment of site contamination in the NEPM, using a potential contaminant list derived from very large prior datasets covering most of Gladstone Harbour. This SAP provides guidance for a phase II assessment of sediments for offshore placement as per the NAGD (2009).

The specific SAP objectives are to:

- Provide a summary of proposed dredging and disposal operations for the project
- Identify a list of contaminants based on a review of existing data and potential contaminant sources
- Determine the number of samples required to provide an adequate characterisation of the physical and chemical sediment properties in the entire area to be dredged
- Collect sufficient sediment samples to fully characterise the sediment layer to be dredged
- Maintain rigorous sample handling, transport and storage processes to ensure sample integrity and high-quality data
- Establish Data Quality Objectives relating to quality assurance and quality control (QA/QC) standards and requirements (see Section 3.10)
- Outline adequate QA/QC procedures for field sampling and laboratory analysis
- Provide a description of statistical procedures used to determine the contaminant status of the dredged material
- Describe procedures for validating the analytical data to assess whether the sample collection, handling and laboratory analysis was undertaken to a standard allowing assessment of sediment quality against the appropriate NEPM and NAGD screening levels
- Outline the proposed reporting framework for the sediment quality results that will address the requirements of the Determining Authorities.

1.3 Description of the Proposed Dredging

The proposed maintenance dredging project will re-establish navigable depths in existing channels, marinas, and inlets. Table 1.1 shows the estimated volumes of dredged material, the required depth of dredging, and the presence of appropriate quality existing data for determining the required sampling effort and intended placement.

Maintenance across the main shipping channel will remove up to 0.5 m of surface material. Dredging in Auckland Inlet will reduce the bed sediment level to -3.0 m LAT. Maintenance dredging in Gladstone Marina will go to -5 m LAT (-4.5 m with 0.5 m over-dredging) in the channels, and -3 m LAT near the piles, while maintenance of the Boyne River inlet will be to -1.0 m LAT.

Table 1.1 Approximate Dredging Volumes

Component	Anticipated Dredge Volume (m3)	Required Dredge Depth	Past Sediment Quality Data	Intended Placement
Main Channel, Swing, Berth, & EBSDS	340,000 p/a	Variable – to 0.5 m below 'maintained depth' as noted on the Gladstone Harbour Aus charts	BMT (2012, 2014), AMA (2017)	EBSDS and Tide Island DMPA
Upper Auckland Inlet	100,000 (once)	-3.0 m LAT	AMA (2017)	EBSDS and/or Land-based reuse
Gladstone Marina	300,000 over 5 yrs. 40,000 – 60,000 accumulation p/a	-5.0 m LAT	AMA (2015, 2017)	EBSDS and/or Clinton Channel dispersal and/or Land-based reuse
Boyne	40,000 (once)	-1.0 m LAT	BMT (2017)	EBSDS and/or Land-based reuse

1.4 Description of Proposed Disposal

As discussed further below the intended disposal methodology for each area is as follows:

- **Main Channel** – all material dredged from these channels will be placed at the EBSDS, or the Tide Island Dredge Material Placement Area (DMPA).
- **Gladstone Marina and Upper Auckland Inlet** – will be placed at EBSDS, Clinton Channel DMPA, or the nearby reclamation areas where appropriate and suitable.
- **Boyne Entrance Channel** – will be placed on land where possible for an engineering beneficial reuse, otherwise EBSDS.

To reduce the quantity of dredge spoil in Gladstone Port reclamation areas, applications have been prepared are currently being reviewed for two new proposed DMPAs in Gladstone Harbour:

- Clinton Channel DMPA (BMT, 2022a) – which would involve relocation of dredged sediment from onshore areas to nearby channels. The Gladstone Marina dredge slurry is proposed to be discharged on the edge of the Clinton Channel for in-water dispersal.
- Tide Island DMPA (BMT, 2022b) – which would involve relocation of dredged sediment from the inner harbour channels and LNG terminals to the Tide Island DMPA. The area is naturally dispersive with high tidal currents and deep channels below required dredge depths.

Material from the Main Channel and any other material from surrounding footprints that conforms to the sediment quality requirements of the NAGD (2009) will be placed at the EBSDS and or the new Tide Island DMPA. For the Upper Auckland Inlet and Marina, GPC proposes the Clinton Channel DMPA if the sediment meets the NAGD requirements for disposal at sea. Subsequently, sediment from the Marina and Upper Auckland Inlet that cannot be disposed at sea and meet the requirements of the NEPM will be used as beneficially reuse materials in any of the existing onshore reclamations at

Western Basin Reclamation Area (WBRA), Wiggins Island Coal Terminal reclamation areas B & C or the RG Tanna Coal Terminal Reclamation Area.

Boyne River Inlet dredge spoil location has not been specified at this point but with a preference for engineering beneficial reuse. Previous sediment analysis was found to be suitable for land-based re-use based on the most stringent NEPM screening levels. Analysis will retain HIL-A screening levels for the maximum amount of flexibility in placement locations.

The EBSDS will be made available to all suitable dredge material should it be required.

1.5 Sampling and Analysis Plan Rationale

The NAGD (2009) provides a framework for the assessment of suitability of dredged sediments for offshore material placement, but it does not address land-based re-use. However, the methodologies for determining sampling effort and contaminated strata delineation represent best practice for sampling and assessment of marine sediments. Therefore, the procedures for site selection and sampling effort for sediments intended for land-based re-use are based around the NAGD.

The assessment of sediment contamination for land-based re-use will be undertaken in accordance with relevant requirements set out in the NEPM. Material will eventually be used as commercial and industrial land, so screening levels should be based on HILs and ESLs for commercial and industrial land uses (HIL-D and ESL). Although each of the reclamation sites border areas of ecological significance, this SAP assumes that groundwater will be retained within each reclamation site and managed within separate tail-water and acid sulfate management programs. Therefore, screening levels are based on:

- Upper Auckland Inlet, Gladstone Marina:
  - The Health-based Investigation Levels for commercial and industrial areas (HIL-D)
  - Ecological Screening Levels (ESLs) for commercial and industrial areas.
- Boyne River inlet
  - The Health-based Investigation Levels for residential areas with accessible soils (HIL-A)
  - Ecological Screening Levels (ESLs) for areas of ecological significance.

To determine if sediments are suitable for offshore placement at the EBSDS, contaminant concentrations will be assessed against the NAGD (2009) screening levels.

Other guidelines set out by the Queensland government's Model Operating Conditions, ERA 16 – Extractive and Screening Activities (DEHP 2016) are referred to, including the Queensland Acid Sulfate Soil Technical Manual (QASSTM, Dear *et al.* 2014) and National Guidelines for the Dredging of Acid Sulfate Soil Sediments and Associated Dredge Spoil (Simpson *et al.* 2018).

2 Review of Existing Information

2.1 Environmental Factors

Seabed Geology

Hydrodynamic processes (waves, tidal currents, fluvial input) control patterns in sediment deposition, erosion and re-suspension, and therefore, the sediment types found at loading sites. Most mobile sediment is already present, with the majority of new sediment entering the port from the southern entrance. The natural littoral transport system of fine-grained sediment along the Queensland coastline inputs travels in a north-westerly direction. 15-20% of this sediment has a net transport into the Inner Harbour region of the PoG through the South Entrance (Ports & Coastal, 2019). New fluvial sediment enters Port Curtis primarily through the Calliope and Boyne rivers, with some input from the Fitzroy River (via the Narrows). However, an investigation into the Fitzroy River discharge in the aftermath of the April 2017 flooding found insignificant sediment flow through the narrows into the Gladstone Harbour system (Larcombe *et al.*, 2019). Under most flow conditions, the Calliope River is the main contributor, due to the Awoonga Dam on the Boyne River acting as a sediment trap. Under very large flow conditions such as the 2013 floods, the Boyne River can exceed the Calliope River as accumulated sediments are mobilised over the spillway.

The downstream estuaries of the Calliope and Boyne rivers are dominated by large areas of tidal flats and mangrove forest, which act as depositional areas for sediment due to reduced flows around convergent currents and entrapment. The large spring tidal range and tidal storage areas within the estuary create strong tidal velocities in the Main Channels of Port Curtis. Strong tidal currents in the channels re-suspend sediment during peak tidal flows (Figure 2.1) and much of this tidally mobilised sediment is deposited back into the channels during slack tide. The peak flow also creates ripples or migrating sand ridges that could be mistaken as depositionary. Some is resuspended sediment deposited onto the shallow shoals and intertidal flats, resulting in continuous cycles of resuspension and deposition, and an overall pattern of finer sediments along tidal flats and coarser sediments within the main channels Figure 2.2 (Dunn *et al*., 2015)(BMT WBM, 2018).

Using time series analysis of bathymetry data, the highest rates of sedimentation were found to occur in the upstream (Jacobs and Targinnie Channel areas) and outer harbour (Golding, Boyne and Wild Cattle Cuttings) regions of the PoG (Ports & Coastal, 2018a). With the differing conditions at each location, the upstream is predominantly fine-grained silt and clay with the Outer Harbour seeing a variable deposition of sand and silt/clay. A gap analysis (Port & Coastal, 2018b) identified that sufficient evidence was found to inform the sources of sediment to the PoG, however, there is insufficient data to confirm the sources of sediment deposited into maintained channels and berths.

Tidally driven resuspension is generally more influential than wave-driven resuspension inside of the harbour, while wave energy and longshore currents drive resuspension and bed movement outside of the harbour. Longshore drift outside of the harbour moves sediments in a northerly direction, driven by south-easterly winds. The areas with the highest currents and most wave exposure tend to have the coarsest sediments, while more sheltered, low tidal energy environments inside the harbour and in berthing pockets tend to have finer sediments and be depositional (Figure 2.2).

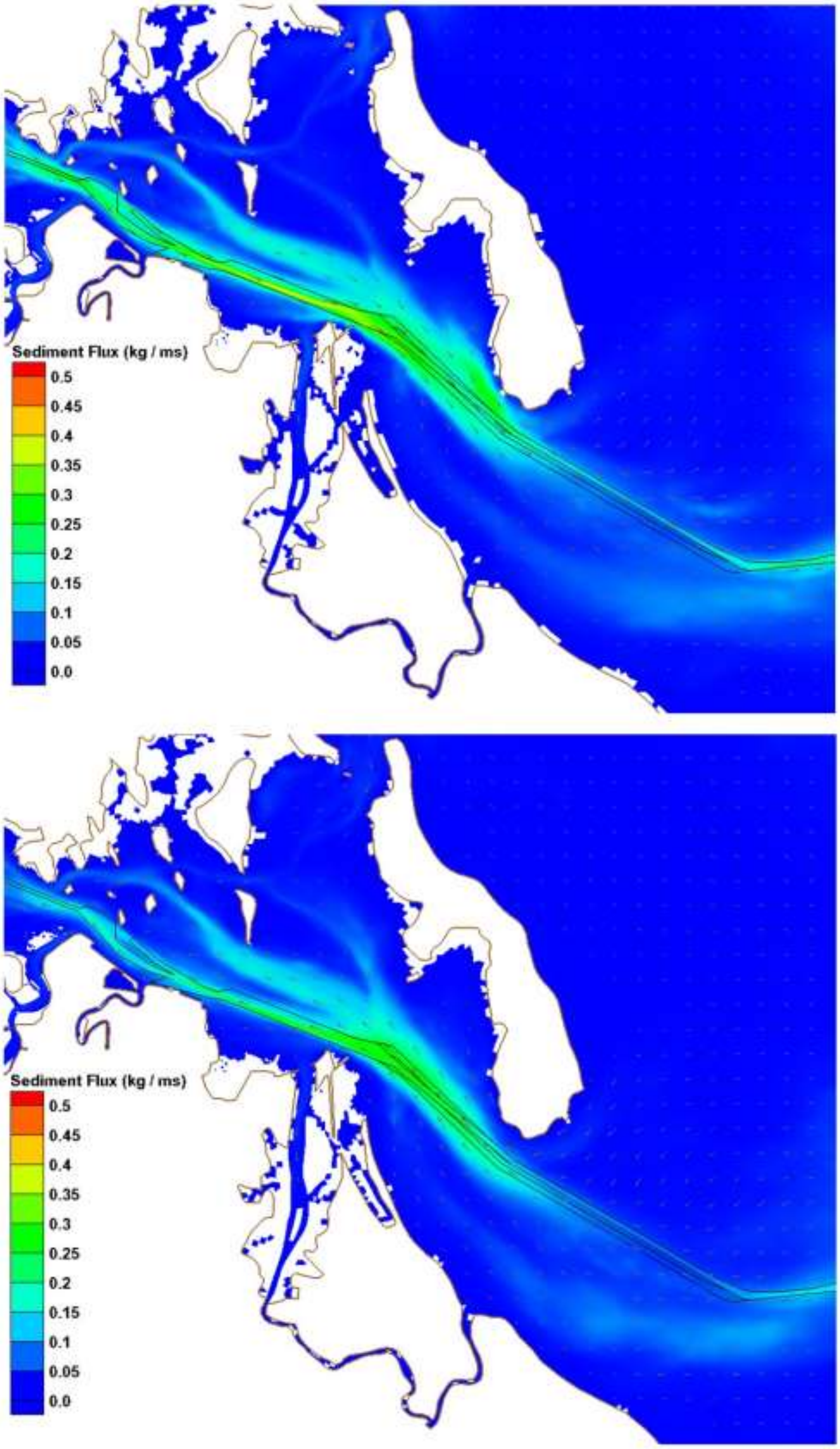

Figure 2.1 Example Total Sediment Fluxes (kg/s per metre) for Ebb Spring Tide (Top) and Flood Spring Tide (Bottom) (BMT WBM, 2018)

Figure 2.2 Interpolated Fine Content within the Main Channel (Data from Aurecon 2012; BMT WBM 2012, 2014; AMA 2018)

The coarse sediments in sections of the Main Channel generally consist of back-stepping channel sands (landward accumulation). In the Golding and Gatcombe sections of the Main Channel these coarse sands become dominated by gravels with increasing depth below the ground level. The coarsest sediments tend to have more marine material (calcium carbonates) while the finer fractions contain more terrigenous material and organics and have more potential to contain anthropogenic contamination.

Factors Influencing Contaminants in Sediments and Potential Pollutant Sources

The catchment of Port Curtis includes the City of Gladstone and a variety of coastal and hinterland townships. Industries in the catchment include pastoral, agricultural, processing and manufacturing. Potential pollutant sources in the Port of Gladstone are highlighted in Table 2-1.

Based on previous studies undertaken in the Port of Gladstone, potential contaminant types include:

- Metals and metalloids
- Polycyclic Aromatic Hydrocarbons (PAHs)
- Organotin compounds including tributyl tin, dibutyl tin, monobutyl tin (TBT, DBT, MBT).

In addition to historical contaminants, emerging contaminants (ECs) will be sampled to inform the contaminant list. Insufficient data exists to determine the status ECs in the Port of Gladstone, and in accordance with NAGD, a pilot study will be used to inform the contaminants list. The pilot study will propose to sample 20% of the locations specified in NAGD. Refer to Section 3.7 for the contaminant list, including ECs.

Contaminant concentrations found in estuarine sediments are controlled by a range of processes. Sediments near contaminant sources, such as those shown in Table 2-1, can have concentrations of metals and organic pollutants that are elevated in comparison to natural background levels. Sediment grain size, which itself is a function of hydrodynamic processes (currents, waves) is also a primary determinant of contaminant concentrations and potential ecotoxicity. Due to their physical and chemical characteristics, fine-grained sediments tend to adsorb contaminants, and areas containing a high proportion of sediments in this size range can have higher contaminant concentrations (particularly metals/metalloids) than areas dominated by coarser grain sediments. Fine sediments such as clay can also chelate contaminants, making them less biologically available.

A wide range of physico-chemical sediment properties and biological processes (e.g. bioturbation by burrowing organisms) also strongly influence contaminant concentrations. The natural geology occasionally has high concentrations of nickel, arsenic, and manganese, which have been found in reference sediments in several studies (Section 2.2).

Table 2.1 Potential Pollutant Sources in the Port of Gladstone

Potential source	Metals/ Metalloids	PAHs	Hydrocarbons (TPHs, BTEX)	Organotins (TBT)	Herbicides Pesticides	Nutrients	Cyanide	Bauxite, coal, clinker, alumina
Natural geology	✓	✓	✓			✓		✓
Shipping and portside operations	✓	✓	✓	✓		✓		✓
Industrial discharges and site runoff	✓	✓	✓			✓	✓	✓
Landfills	✓	✓	✓			✓		
Agriculture and horticulture					✓	✓		

Potential source	Metals/ Metalloids	PAHs	Hydrocarbons (TPHs, BTEX)	Organotins (TBT)	Herbicides Pesticides	Nutrients	Cyanide	Bauxite, coal, clinker, alumina
Urban stormwater runoff	✓	✓	✓		✓	✓		

In the wider Port of Gladstone, maintenance dredging sediments have consistently been found to be uncontaminated except for TBT in lower Auckland Inlet (see Section 2.2). Based the review of existing sediment data (see Section 2.2), and taking into consideration the above factors, it is expected that the proposed loading sites will have a similar contamination status. Therefore, the sampling design adopted in this SAP has been randomised to ensure that a representative sample of all sediments is measured. Additionally, the main channel and associated areas have been weighted prior to randomization to accurately represent the material dredged (see 3.1).

Sampling Considerations

The following environmental factors are relevant in the context of undertaking sampling:

- The area is affected by strong currents and moderate local wind-waves which can affect the ability to deploy a core sampler.
- The depth of unconsolidated material can vary throughout the dredge area. Where there is insufficient unconsolidated material in the sample a second sample may be required.
- Sharks, crocodiles and stingers although present are not considered a major consideration in the context of a sediment sampling program undertaken from a vessel using coring or grab sampling equipment.

The sampling procedures outlined in Section 3, including the Contingency Plan (Section 3.4), take into account these environmental influences.

2.2 Recent Sediment Quality Investigations

Given that the proposed dredged material is expected to comprise of material from the deposition of fine sediments, gravel, and cobble, the review of existing data includes relevant reports on sediment quality from capital and maintenance dredge material in the study area. This will allow an adequate assessment of the likely contaminant status of both native and anthropogenic material to be dredged from the proposed dredge areas.

Existing sediment quality information from the study area includes the following:

- AMA (2017) Implementation Report - Sediment Sampling and Analysis Plan for the Port of Gladstone Maintenance Dredging
- BMT WBM (2017) Sediment Quality Report – Boyne River Mouth Maintenance Dredging
- AMA (2015a) Sediment Sampling and Analysis Plan: Implementation Report, Auckland Inlet
- AMA (2015b) Sediment Sampling and Analysis Plan, Gladstone Marina
- BMT WBM (2014) Maintenance Dredging of the Western Basin Dredging and Disposal Project Footprint – Sediment Quality Report
- Aurecon (2012) Additional Sediment Sampling Implementation Report
- BMT WBM (2012) Port of Gladstone Maintenance Dredging – SAP Implementation Report
- Butler Partners (2012) Environmental and Acid Sulfate Soils Investigation – Tug Base Development Bryan Jordan Drive Gladstone

- GHD (2009b) Report for Western Basin Dredging and Disposal Project – Sediment Quality Assessment
- DEHP (2012) Update on the Quality of Sediment from Port Curtis and Tributaries.

Main Channel, Gatcombe Head Harbour, Gladstone Marina and Lower Auckland Inlet, Upper Auckland Inlet (AMA, 2017)

Twenty-four sites in the Main Channels, six sites in the Gatcombe Head Harbour, 13 sites in the Gladstone Marina and Lower Auckland Inlet, and 18 sites in Upper Auckland Inlet were sampled in 2017 to assess sediment quality for the purposes of maintenance dredging. The analytical results are summarised in the following sections.

Metals and Metalloids

The 95% upper confidence limits (UCL) of the mean concentrations were below their respective NAGD and NEPM screening levels for all investigated metals and metalloids. 95% UCL concentrations of aluminium and iron exceeded the twice the measured background concentration (TMBC) levels, manganese exceeded the Simpson et al. (2005) screening level, and tributyltin exceeded the NAGD screening level of Gladstone Marine and Lower Auckland. Concentrations of iron and manganese exceeded the relevant screening levels at Upper Auckland Inlet. The maximum 95% UCL concentrations of manganese of 1200 mg/kg was far below the 60,000 mg/kg NEPM HIL-D screening level.

Organic Compounds

Concentrations of benzene, toluene, ethylbenzene and xylene (BTEX) were below limits of reporting (LORs) in all samples. Total petroleum hydrocarbons (TPH) and PAH concentrations were either below laboratory detection limits, or well below the NAGD screening levels.

TBT marginally exceeded screening levels which was adjacent to a former slipway in lower Auckland inlet. Elutriate testing indicated that TBT concentrations in the water column would be less than the water quality guideline value assuming a 1:100 dilution factor (using seawater from the EBSDS). On this basis, dredged material was considered suitable for ocean disposal.

Acid Sulfate Potential

The potential for acid generation from potential acid sulfate soils (PASS) was considered to be low in Gatcombe Head Harbour, Gladstone Marina and Lower Auckland Inlet. Most sediments did not contain net acidity (i.e. only one sample had net acidity > 0.02). The natural buffering capacity of the sediments at this location was considered sufficient to neutralise acids generated. However, PASS have been identified in the upper reaches of Upper Auckland Inlet above net acidity of 0.02 and further investigation would be required.

Boyne River Mouth (BMT WBM (2017)

Due to heavy rainfall in the 2010-2011 and 2013 wet seasons, additional sediment deposition in the Boyne River entrance presented a risk to small vessel movements. Of the nine sites chosen for sampling, only three were analysed for contaminants due to the coarse sediment size and lack of fine material. The results are summarised in the below sections.

Metals and Metalloids

The 95% UCL of the mean concentrations of all analysed metals and metalloids were well below their respective NEPM and NAGD screening levels with antimony, cadmium, selenium, mercury, and silver not detected in any sample.

Organics

Concentrations of BTEXN were below their respective LORs in all samples. While petroleum hydrocarbons longer than C15 were detected above LOR, none of these fractions or TPHs were above NEPM and NAGD screening levels.

Individual PAHs and Organotins (including tribulytin, TBT) were not detected above LOR in any of the samples.

No samples were above their respective LORs for organochlorine pesticides, organophosphorus pesticides, or phenoxyacetic acid herbicides.

Cyanide

Concentrations of cyanide were below the LOR for all samples. While the LOR was above the NAGD requirement, it was well below the NEPM screening level of 250 mg/kg.

Acid Sulfate Potential

Potential sulfidic acidity was detected in 16 out of 19 samples indicating that most of the tested sediments have the potential to generate sulfidic acidity and are classified as potential acid sulfate soils (PASS). However, all samples had sufficient capacity for neutralising acids upon oxidation. The coarse nature of the material, low actual acidity and large degree of self-naturalising capacity suggest there is little risk of acid formation during stockpiling or placement on land.

Gladstone Marina and Lower Auckland Inlet Sediment Quality (AMA, 2015a, 2015b)

Twelve sites in the Gladstone Marina, and nine sites in lower Auckland Inlet, were sampled in 2015 to assess sediment quality for the purposes of maintenance dredging. The analytical results are summarised in the following sections.

Metals and Metalloids

The 95% upper confidence limits (UCL) of the mean concentrations were below their respective NAGD and NEPM screening levels for all investigated metals and metalloids. Cadmium was the only metal not detected.

Organic Compounds

Concentrations of benzene, toluene, ethylbenzene and xylene (BTEX) were below limits of reporting (LORs) in all samples. Total petroleum hydrocarbons (TPH) and PAH concentrations were either below laboratory detection limits, or well below the NADG screening levels.

TBT was detected at three sites adjacent to a former slipway in lower Auckland inlet. Elutriate testing indicated that TBT concentrations in the water column would be less than the water quality guideline value assuming a 1:100 dilution factor (using seawater from the EBSDS). On this basis, dredged material was considered suitable for ocean disposal.

Acid Sulfate Potential

The potential for acid generation from potential acid sulfate soils (PASS) was considered to be low. Most of sediments did not contain net acidity (i.e. only one sample had net acidity > 0.02). The natural buffering capacity of the sediments at this location was considered sufficient to neutralise acids generated. Actual acidity was above pH 8.7 in all locations.

Western Basin Maintenance Dredging Sediment Quality (BMT WBM 2014)

Seventeen sites from the Western Basin channel network[1] were sampled in 2014 to characterise sediments. The results are summarised below.

Metals and Metalloids

The 95% UCL of the mean concentrations were below their respective NAGD and NEPM screening levels for all investigated metals and metalloids. Antimony, cadmium and silver were not detected in samples.

Organics

Concentrations of BTEX and TPHs were below their respective LORs in all samples. PAHs detected in very low concentrations (close to the LOR) in seven out of 17 samples. Concentrations of individual PAHs were below the benzo(a)pyrene toxicity equivalency in the NEPM and total PAH concentrations were below the LOR in all samples, below the NEPM (HIL-D) of 4,000 µg/kg, and below the NAGD screening level of 10,000 µg/kg.

Concentrations of all other investigated organic contaminants were below their respective laboratory LORs including organotins (TBT, DBT and MBT).

Cyanide

Cyanide concentrations were below the laboratory LOR in all samples.

Acid Sulfate Potential

The acid sulfate test results for the Western Basin sediments indicated that management would be required at three out of 17 tested locations should the material be placed on land or exposed to air. The locations requiring potential management were located in the Passage Islands Channel and in the channel in front of the Wiggins Island Coal Terminal. Liming rates ranging between 0.77 kg CaCO3/t and 17 kg CaCO3/t were calculated for these samples corresponding to a net acidity ranging between 10 moles H+/t and 230 moles H+/t.

Potential sulfidic acidity was detected in 12 out of 17 samples indicating that most of the tested sediments had the potential to generate sulfidic acidity and were classified as PASS. However, most samples had sufficient capacity for neutralising acids upon oxidation.

Actual acidity was below the LOR in all samples indicating that the samples are not actual acid sulfate soils (AASS).

Additional Sediment Sampling in the Clinton and Bypass Channel (Aurecon 2012; 2016)

Eleven sites in the Clinton Bypass Channel were sampled in 2012, with another different 11 sites sampled in the Clinton Channel widening footprint in 2016. Core samples were taken to the point of refusal with core depths of between 0.3 and 2.2 m below ground being achieved. The analytical results are summarised in the following sections.

Acid sulfate material was not tested for in 2012, and although there were discrete locations where acidity was detected in 2016, the presence of shell material throughout the dredging footprint was sufficient for self-neutralising.

[1] From the Clinton Bypass Channel to the Passage Islands Channel (including Fisherman's Landing and the Tug Base at RG Tanna)

Metals and Metalloids
The 95% UCL of the mean concentrations were below their respective NAGD screening levels and NEPM HIL-D for all investigated metals and metalloids.

Organics
Individual TPH fractions were above laboratory LORs, but all fractions were below Environmental Investigation Levels (EILs) specified by DEHP (formerly DERM) and below the NEPM ESL-D screening levels. Concentrations of all other investigated organic contaminants were below their respective laboratory LORs including:

- BTEX
- TPHs
- Organochlorine and Organophosphate Pesticides (OC/OP pesticides);
- Organotins (including TBT, DBT and MBT)
- Polychlorinated Biphenyls (PCBs).

Port Curtis Maintenance Sediment Quality (BMT WBM 2012)

A total of 41 sites within the Port of Gladstone channel (from the Wild Cattle Cutting to Fisherman's Landing) and six wharf sites (Boyne, South Trees, Barney Point, Auckland Point, Clinton Channel and Fisherman's Landing) were sampled in 2012 to assess maintenance dredge sediment quality. The analytical results are summarised in the following sections.

Acid sulfate potential of the sediments was not assessed in this program given the proposed placement of the dredged material at sea, which is unlikely to result in oxidation of the material under standard operating procedures during dredging and placement.

Metals and Metalloids
The 95% UCL of the mean concentrations were below their respective NAGD screening levels (and NEPM HIL-D) for all investigated metals and metalloids. Arsenic concentrations exceeded the NAGD screening level at four sampling locations within Wild Cattle Cutting. However, the 95% UCL concentration for arsenic (13.7 mg/kg) was below the NAGD screening level of 20 mg/kg. These concentrations were also well below the NEPM HIL-D of 3,000 mg/kg.

Organics
Concentrations of PAHs were generally very low within the channel and highest at the wharf locations; total PAH concentrations were below the LOR in 43 or 47 samples. The four sites where total PAHs were detected included three berthing sites and one channel site. The highest normalised total PAH concentration was measured at Clinton wharf with 607 µg/kg. This concentration and the normalised 95% UCL of the mean concentration across the whole dredge area (96 µg/kg) were well below the NAGD screening level of 10,000 µg/kg and the NEPM HIL-D of 4,000 µg/kg.

Concentrations of individual carcinogenic PAHs were below the benzo(a)pyrene toxicity equivalency in the NEPM HIL-D, although one site at Clinton Wharf was just below (39.6 µg/kg) the limit of 40 µg/kg.

Concentrations of all other investigated organic contaminants were below their respective laboratory LORs including:

- Benzene, Toluene, Ethylbenzene and Xylene (BTEX)
- Total Petroleum Hydrocarbons (TPHs)

- Organochlorine and Organophosphate Pesticides (OC/OP pesticides)
- Organotins (including TBT, DBT and MBT)
- PCBs.

Cyanide
Cyanide concentrations were below the laboratory LOR in all samples.

Western Basin Capital Sediment Quality (GHD 2009b)

GHD (2009b) investigated marine sediment quality for the Western Basin Dredging and Disposal Project. A total of 145 locations were sampled within the Western Basin area. Stage 1A of the project included part of the Main Channel and consisted of up to 396 samples from 76 locations. Stage 1B sampling in the Targinnie reach of the Main Channel also included up to 208 samples from 41 locations. Analytical results are summarised below.

Metals and Metalloids
The 95% UCL of mean concentrations were below their respective NAGD screening levels (and NEPM HIL-D) for all investigated metals. A few individual exceedances of the NAGD screening level for arsenic, and nickel were recorded, most likely due to natural geological conditions. The maximum concentrations of arsenic (32.4 mg/kg [Stage 1B]), nickel (40 mg/kg [Stage 1B]) were much lower than the NEPM HIL-D of 3,000 and, 6,000 mg/kg respectively. Manganese was also detected above Queensland EPA draft EILs on 127 instances in Stage 1A; 39 instance in Stage 1B, with a maximum concentration of 7,680 mg/kg detected, which was far below the 60,000 mg/kg NEPM HIL-D screening level.

Organics
TBT was detected above LOR in one individual sample from each area. The normalised concentrations were below the NAGD screening level.

Low concentrations BTEX and TPH compounds were detected in the Western Basin dredging areas, with no BTEX above LOR detected in the Stage 1A or 1B areas. The 95% UCL of the mean TPH concentration was below the NAGD screening level for all dredge areas.

Low concentrations of individual PAHs compounds were present in a number of samples within the dredge areas. The 95% UCL for Total PAHs was below the NAGD screening level for all dredge areas and below the NEPM HIL-D of 4,000 µg/kg.

Concentrations of PCBs, OC/OP pesticides, herbicides and insecticides and chlorinated hydrocarbons were below their respective laboratory LORs in all samples from Stage 1A. However, 11 of 194 samples from Stage 1B had LORs which were higher than the screening level, and the presence of PCBs could not be deduced.

Radionuclides
Concentrations for gross alpha and beta ranged between 356 mBq/g and 603 mBq/g and therefore, were well below the NAGD screening level of 35,000 mBq/g or less than 2% of the screening level.

Whilst all samples recorded beta radiation at low concentrations above the laboratory LOR, only three samples recorded alpha radiation above the LOR at low concentration.

Acid Sulfate Potential
Between 3% and 30% of samples within the individual dredge areas were classed as PASS containing elevated amounts of Net Acidity (i.e. have the potential to generate excess acidity of ≥18 moles H+/tonne if they become oxidised).

Sufficient acid neutralising capacity was present in most of the samples in the form of calcium carbonate (e.g. shell fragments). Actual acidity of the samples showed that pH was generally above 8 with very few samples falling below pH 6.

Tug Base Capital Sediment Quality (Butler Partners 2012)

A total of five locations were sampled in 2012 from the tug base development adjacent to Clinton Wharf using a grab sampler.

Metals and Metalloids
The concentrations of all tested metals and metalloids were below their respective NAGD screening levels (and NEPM HIL-D).

Organics
Individual PAHs compounds were detected at low concentrations and normalised total PAHs concentrations (maximum of 410 µg/kg) were well below the NAGD screening level of 10,000 µg/kg at all locations.

Concentrations of BTEX compounds were below the laboratory LOR in all samples. Concentrations of total TPH were well below the NAGD screening level of 550 mg/kg with a maximum normalised concentration of 124 mg/kg.

Concentrations of organotins, OC/OP pesticides and PCBs were below the laboratory LOR in all samples.

Acid Sulfate Potential
The sediments at two locations were classified as PASS. However, net acidity was below detection given that sufficient acid neutralising capacity was present in all samples in the form of shell fragments.

Port Curtis Sediment Quality (DEHP 2012)
Sediment sampling was undertaken in 2012 using grab sampling at 31 sites throughout Port Curtis. Results were compared to the Australian Interim Sediment Quality Guidelines (ISQG), historical Gladstone data and national dioxin data. Summaries of the findings are provided in the following sections.

Metals and Metalloids
Most metals and metalloids had concentrations below the ISQG-low values (below the NEPM HIL-D). The only exception was arsenic, which exceeded the ISQG-low value at four of 31 sites. One sample had mercury concentration exceeding the ISQG-low value. Repeated sampling at this location could not confirm elevated mercury levels at this site, suggesting that this sample was atypical and represented an outlier.

Organics
Organotins were detected in only a small number of samples at levels below the ISQG-low value.

Concentrations of TPH were generally low and well below the NAGD screening level.

Dioxins were detected in Port Curtis sediments. However, a comparison to national dioxin data indicated that concentrations were in the typical range for Australian sediments adjacent to urban/industrial environments. Compared to background concentrations given in the National Dioxin Program (Müeller et al. 2004) the Port Curtis sediments are typical of estuaries in Australia.

The concentrations of BTEX, OC/OP pesticides and PCBs were below their respective laboratory LORs in all samples.

2.3 Conceptual Site Model

Existing contamination sources, measured levels of contamination, the natural geology, environmental and physical processes were examined to create a simple conceptual site model shown in Figure 2-3.

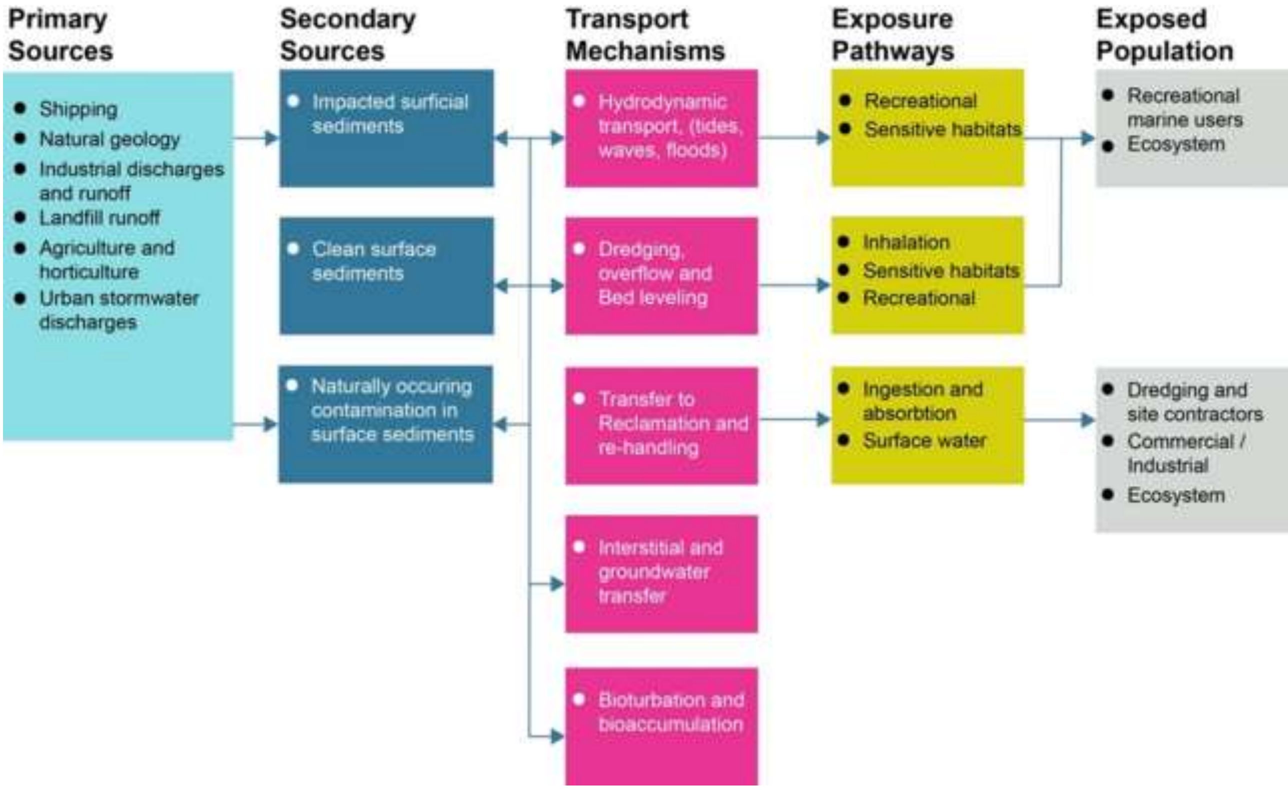

Figure 2.3 Conceptual site model flow diagram for contamination sources in Port Curtis.

3 Sampling and Analysis

3.1 Sampling Rational, Locations and Sample Numbers

NEPM does not provide guidance regarding number of samples to be collected and sampling methods for the assessment of marine sediments. On this basis, the NAGD, which is considered best practice for assessment of marine sediments, was followed. Appendix D of the NAGD sets out the minimum number of sampling locations based on the volume of potentially contaminated material to be dredged. The sampling and analysis approach outlined below aims to characterise the full thickness of potentially contaminated sediment to be dredged, i.e. the entire maintenance material layer.

Number of Sampling Locations

The volumes of potentially contaminated sediment for each dredge area are shown in Table 3-1. If good quality, current data are available within the dredge footprint, the number of required sites can be halved, according to the NAGD. For the main shipping channel, Gladstone Marina, Upper Auckland Inlet and Boyne, good quality data exist, bringing the number of required sites in these areas down from 48, 26, 18 and 11 sites, to 24, 13, 9 and 6 sites, respectively (Table 3.2).

Long-term sites on the EBSDS and surrounding reference sites have also been included and are shown in Figure 3.1. These sites allow potential investigation of the existing levels of contamination on the EBSDS and surrounding area, including Rodd's Bay, particularly in cases where screening levels of parameters are unknown (see Section 3.7). These sites do not form part of the required site numbers for any dredge footprint.

Sampling Design

As per the NAGD requirements, sample locations were selected by laying a square grid over the dredge area with at least five times the number of grid squares as the required number of sampling locations. Sample locations were chosen using a random number generator and applied to cell numbers. Cells that fell outside the footprint were moved into the footprint's nearest point. Maps of the proposed sampling locations are shown in Figure 3-1 to Figure 3-4.

For the Main Channel and associated areas, a weighted system was applied to individual channel areas. Nine areas were identified as distinct locations as per the NAGD (2008) sample location selection guidance. These were given a weighted percentage of the allocated 24 sites according to their 2021 dredged volume (see Table 3.1). This is seen to give the sediment collected a more representative sampling of actual dredged material while still retaining the random site selection in each region.

Table 3.1 Main Channel and Associated Areas Weighted Site Selection

Channel or Area	2021 dredged material (m^3)	% of total dredge volume	Allocation of 24 sites
Wild Cattle Cutting	23,456	9.80%	2
Boyne Cutting	13,372	5.59%	1
Golding Cutting	61,305	25.63%	6
Gatcombe Channel	5,690	2.38%	1
Auckland Channel	16,156	6.75%	2

Channel or Area	2021 dredged material (m^3)	% of total dredge volume	Allocation of 24 sites
Clinton Channel	25,911	10.83%	2
Clinton Bypass Channel	7,247	3.03%	1
Targinnie	17,400	7.27%	2
Jacobs Channel	68,691	28.71%	7
Total Volume	**239,228**	**100%**	**24**

Table 3.2 Sampling Rationale, Locations and Sample Numbers

Parameter	Value/Description
Main Channel, Swing, Berth and EBSDS	
Sediment classification	Probably Clean (BMT WBM 2012a, 2014) (AMA 2018)
Sediment composition	Sand dominant, with areas of fine material, gravel, and cobble
Total Dredge volume	340,000 m^3
Maximum depth of dredging	0.5 m below ground level (BGL)
Number of locations	24 (half of 48)
Number of field triplicates (QA/QC)	Three locations (i.e. three separate grab samples at three randomly selected location)
Number of triplicate split samples (QA/QC)	Two locations (i.e. split the sample at two locations into three sub-samples)
Number of trip blank samples	One each day of sampling
Gladstone Marina	
Sediment classification	Probably Clean (BMT WBM 2012a, 2014) (AMA 2018)
Sediment composition	Silt and clay dominant, with sand
Total Dredge volume	300,000 m^3 (40,000 – 60,000 m^3 p/a
Maximum depth of dredging	-5.0 m LAT within the marina
Number of locations	13 (half of 26)
Number of field triplicates (QA/QC)	Two locations (i.e. three separate core samples at two randomly selected location)
Number of triplicate split samples (QA/QC)	One location (i.e. split the sample at one location into three sub-samples)
Number of trip blank samples	One each day of sampling
Upper Auckland Inlet	
Sediment classification	Probably clean (AMA 2018)
Sediment composition	Silt and clay dominant, with sand

Parameter	Value/Description
Total Dredge volume	100,000 m^3
Maximum depth of dredging	-3.0 LAT
Number of locations	9 (half of 18)
Number of field triplicates (QA/QC)	One location (i.e. three separate core samples at one randomly selected location)
Number of triplicate split samples (QA/QC)	One location (i.e. split the sample at one location into three sub-samples)
Number of trip blank samples	One each day of sampling
Boyne	
Sediment classification	Probably clean (BMT WBM 2017)
Sediment composition	Gravel, cobble and sand dominant
Total Dredge volume	40,000 m^3
Maximum depth of dredging	-1.0 m LAT
Number of locations	6 (half of 11)
Number of field triplicates (QA/QC)	One location (i.e. three separate core samples at one randomly selected location)
Number of triplicate split samples (QA/QC)	One location (i.e. split the sample at one location into three sub-samples)
Number of trip blank samples	One each day of sampling

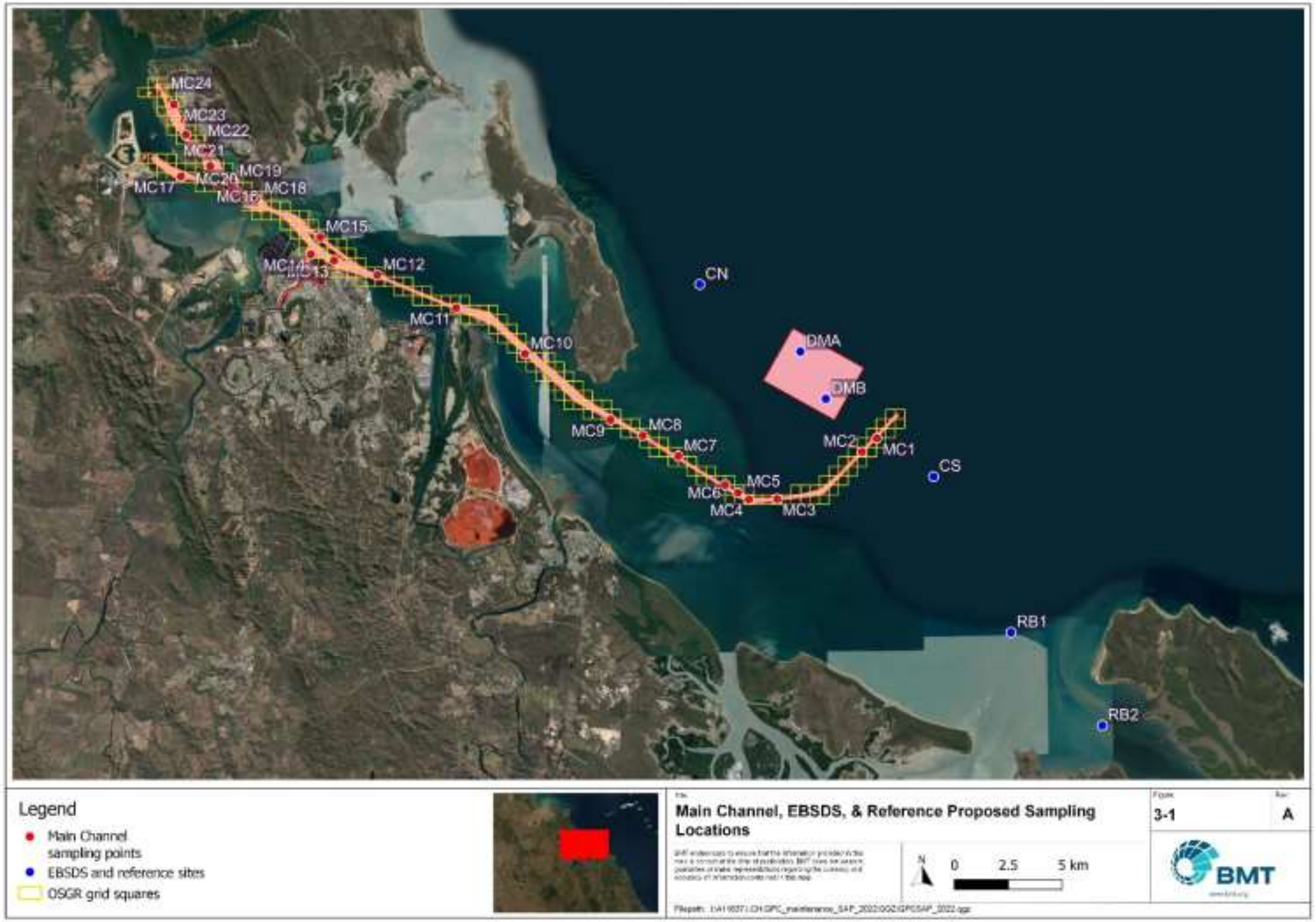

Figure 3.1 Main Channel – Proposed Sampling Locations

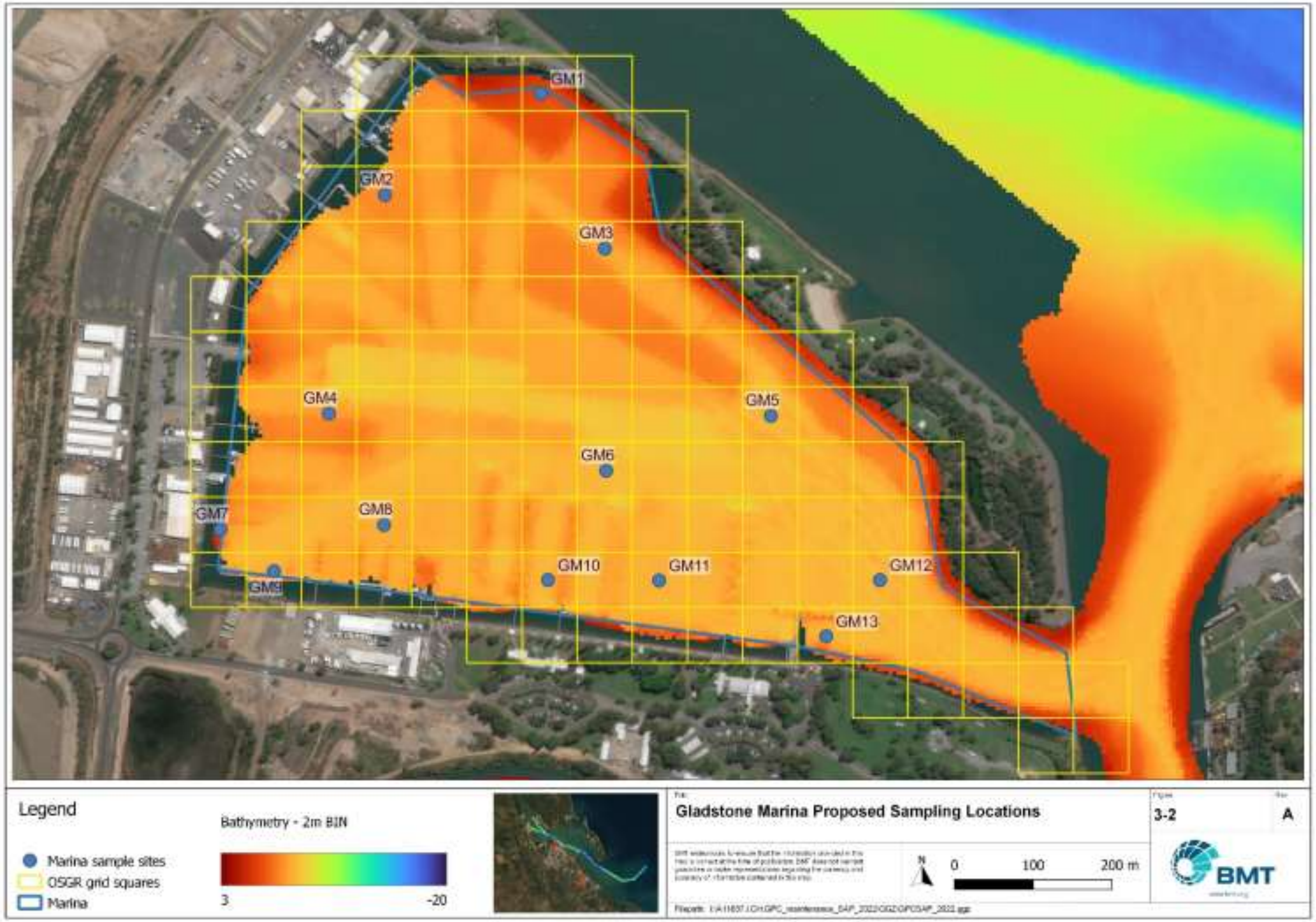

Figure 3.2 Gladstone Marine – Proposed Sampling Locations

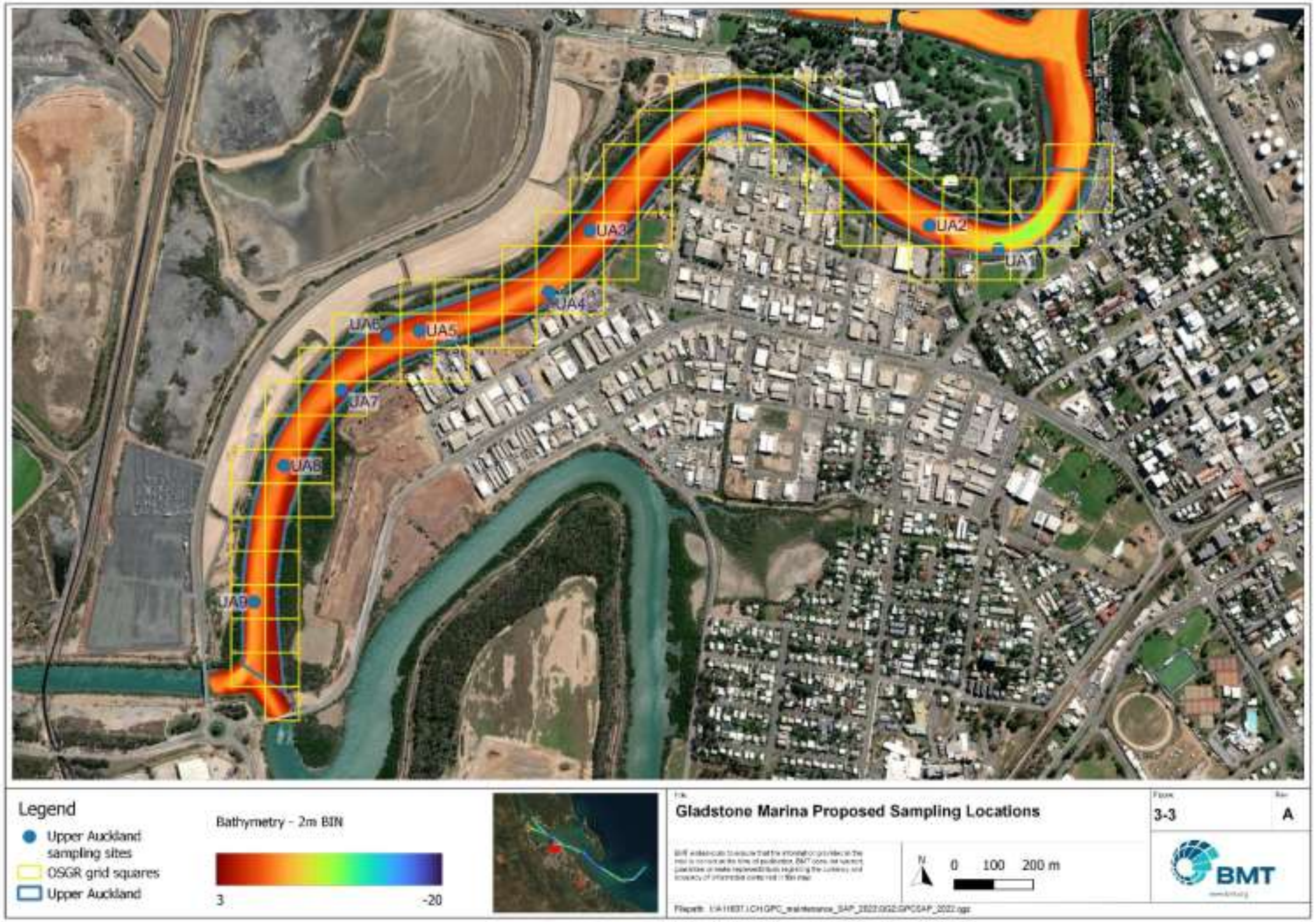

Figure 3.3 Upper Auckland Inlet – Proposed Sampling Locations

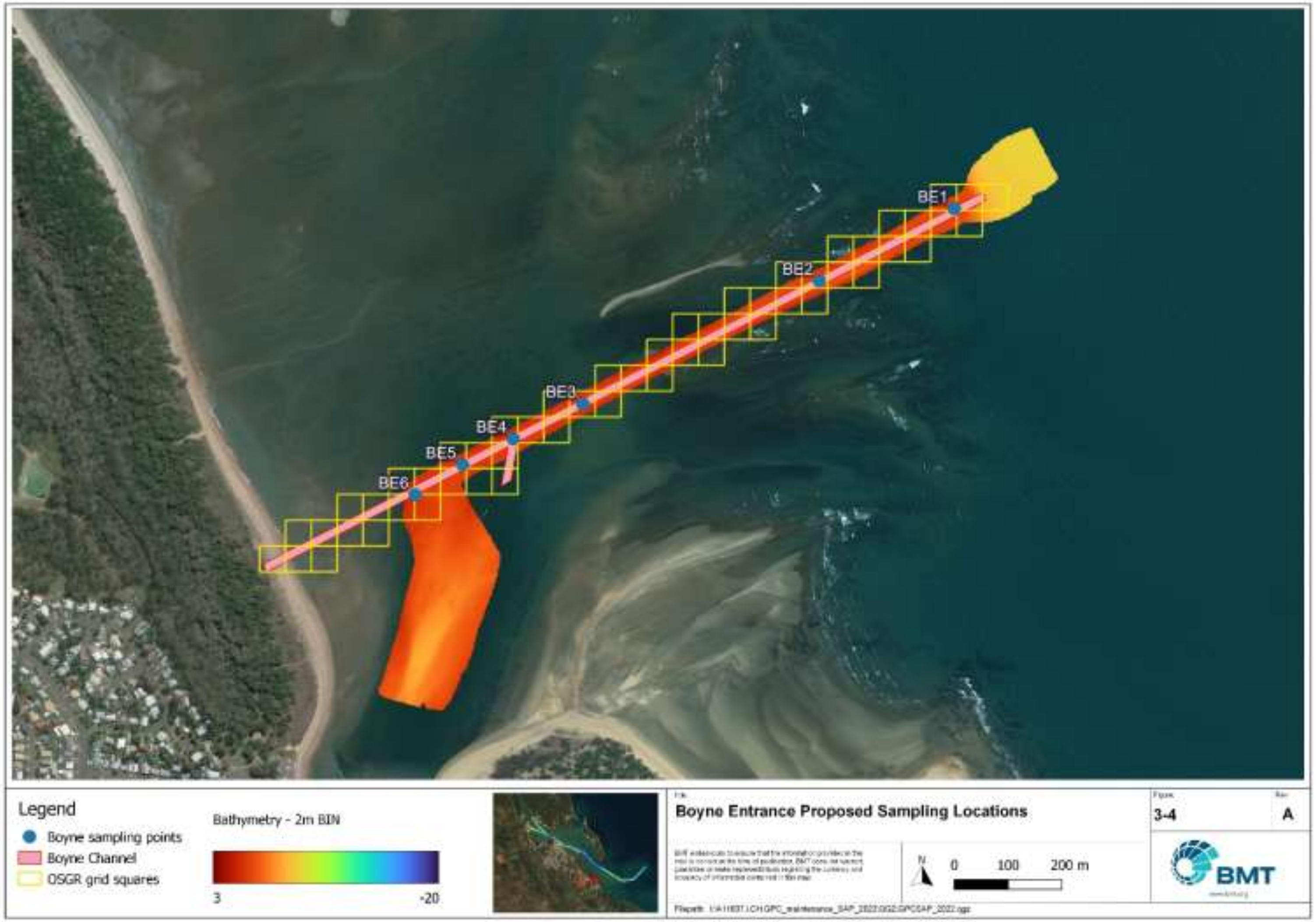

Figure 3.4 Boyne Entrance – Proposed Sampling Locations

Table 3.3 Sampling Sites, Required Core Depth, Subsample Detail (Excluding QA/QC)

Site	Depth (m LAT)	Dredge Depth LAT (m)	Desired Core Length (m)	Contaminant sub-samples	# of ASS Sample	Easting GDA 94 Zone 56	Northing GDA 94 Zone 56
Main Channel							
MC1	-16.4	<0.5m BGL	NA - grab	1	0	347622.9	7355457
MC2	-16.8	<0.5m BGL	NA - grab	1	0	346933.6	7354829
MC3	-16.8	<0.5m BGL	NA - grab	1	0	342983.5	7352641
MC4	-18	<0.5m BGL	NA - grab	1	0	341675.4	7352620
MC5	-16.4	<0.5m BGL	NA - grab	1	0	341162.5	7352930
MC6	-16.1	<0.5m BGL	NA - grab	1	0	340570.3	7353290
MC7	-16.7	<0.5m BGL	NA - grab	1	0	338388.7	7354626
MC8	-16.4	<0.5m BGL	NA - grab	1	0	336735.5	7355589
MC9	-15.2	<0.5m BGL	NA - grab	1	0	335230.8	7356318
MC10	-16.2	<0.5m BGL	NA - grab	1	0	331251.5	7359382
MC11	-16.5	<0.5m BGL	NA - grab	1	0	328054.4	7361518
MC12	-16.2	<0.5m BGL	NA - grab	1	0	324388.3	7363040
MC13	-16.2	<0.5m BGL	NA - grab	1	0	322381.4	7363725
MC14	unknown	<0.5m BGL	NA - grab	1	0	321303.9	7364007
MC15	-14.9	<0.5m BGL	NA - grab	1	0	321741.1	7364806
MC16	-11.3	<0.5m BGL	NA - grab	1	0	317620.6	7366868
MC17	-11.3	<0.5m BGL	NA - grab	1	0	315262.6	7367632
MC18	-13.4	<0.5m BGL	NA - grab	1	0	318722.2	7366598
MC19	-13.5	<0.5m BGL	NA - grab	1	0	317710.1	7367391
MC20	-13.8	<0.5m BGL	NA - grab	1	0	317624.1	7367317
MC21	-13.3	<0.5m BGL	NA - grab	1	0	316618.9	7368104
MC22	-13.4	<0.5m BGL	NA - grab	1	0	316457.1	7368823
MC23	-13.5	<0.5m BGL	NA - grab	1	0	315485.4	7369565
MC24	-12.1	<0.5m BGL	NA - grab	1	0	314935.4	7370970
Gladstone Marina							
GM1	-1	-5.0 m LAT	1.98	3	4	321183.9	7363812
GM2	-3.1	-5.0 m LAT	1.90	3	4	320986.0	7363683
GM3	-4.1	-5.0 m LAT	0.86	2	2	321265.2	7363615
GM4	-3.7	-5.0 m LAT	-0.68	1	1	320914.7	7363406
GM5	-4.1	-5.0 m LAT	0.86	2	2	321475.8	7363403
GM6	-4.7	-5.0 m LAT	0.29	1	1	321266.7	7363334
GM7	-1.9	-5.0 m LAT	2.21	3	4	320777.2	7363259
GM8	-4.3	-5.0 m LAT	0.70	2	2	320984.8	7363265
GM9	-4.2	-5.0 m LAT	-1.17	1	2	320845.2	7363206
GM10	-4.6	-5.0 m LAT	0.45	1	1	321193.0	7363195
GM11	-4.5	-5.0 m LAT	0.53	1	1	321334.1	7363194
GM12	-4.7	-5.0 m LAT	0.34	1	1	321614.6	7363195
GM13	-4.4	-5.0 m LAT	0.61	1	1	321546.3	7363124

Site	Depth (m LAT)	Dredge Depth LAT (m)	Desired Core Length (m)	Contaminant sub-samples	# of ASS Sample	Easting GDA 94 Zone 56	Northing GDA 94 Zone 56
Upper Auckland Inlet							
UA1	-2.7	-3.0 LAT	0.3	1	1	321857.5	7362583
UA2	-3.2	-3.0 LAT	-0.2	1	1	321606.1	7362598
UA3	-1.4	-3.0 LAT	3.6	3	7	320743.6	7362585
UA4	-2.4	-3.0 LAT	2.6	3	5	320639.1	7362429
UA5	-2.9	-3.0 LAT	2.1	3	4	320311.5	7362331
UA6	-0.2	-3.0 LAT	4.8	3	9	320229.3	7362318
UA7	-2.2	-3.0 LAT	2.8	3	6	320113.3	7362181
UA8	-2.6	-3.0 LAT	2.4	3	5	319967	7361988
UA9	-3.8	-3.0 LAT	1.2	2	2	319892.1	7361643
Boyne							
BE1	-0.8	-1.0 LAT	NA - grab	1	1	333739.8	7352835
BE2	-1	-1.0 LAT	NA - grab	1	1	333048.5	7352473
BE3	-0.8	-1.0 LAT	NA - grab	1	1	332919	7352408
BE4	-0.9	-1.0 LAT	NA - grab	1	1	332824.7	7352359
BE5	-0.2	-1.0 LAT	NA - grab	1	1	332736.8	7352304
BE6	-1.4	-1.0 LAT	NA - grab	1	1	333488.8	7352701
East Banks Sea Disposal Site (EBSDS) and Reference Sites							
DMA	-10	NA	NA – grab	1	0	344067	7359493
DMB	-10	NA	NA – grab	1	0	345249	7357295
CN	-12	NA	NA – grab	1	0	339384	7362614
CS	-12	NA	NA – grab	1	0	350261	7353681
RB1	NA	NA	NA – grab	1	0	353862	7346440
RB2	NA	NA	NA - grab	1	0	358107	7342115
		Total					

3.2 Grab Sampling

Grab sampling will be performed at sites in the Main Channel where sediments are well mixed, tidal currents are strong, and shipping movements limit the time available for sample collection.

Grab sampling will also be used for the Boyne River inlet. Previous results indicated that metals and metalloids were either below NEPM/NAGD or not detected, organics had a similar result and cyanide below NEPM screening levels. This is in addition to the average depth of sediment to be sampled is 0.14 m.

3.3 Core Sub-sampling

Core sampling will be undertaken in the Gladstone Marina and Auckland Inlet. As described in Appendix D of the NAGD, samples are required from the full depth of dredging for potential contaminants, with "full depth" representing the entire upper layer (see Section 3.1). Acid sulfate may be present through the dredged material and will be sampled at 0.5 m intervals from surface to dredge depth. Therefore, acid sulfate sampling will occur at 0.5 m increments to the maximum dredge depth (or core refusal, whichever is least) while potential contaminants of concern will be sampled from three horizons:

- 0 - 0.5 m, BGL
- 0.5 – 1 m BGL
- Between 1 m BGL and the end of the core (refusal depth) as a composite sample.

A summary of subsampling required based on the above sampling effort, present bathymetry and required dredge depth is shown in Table 3-2 above.

3.4 Field Quality Control

Quality Control Samples

The following field and laboratory quality control samples will be obtained (Table 3.2).

- Field triplicate samples (additional core samples at randomly selected locations as per Table 3.2) to determine the small-scale variability of the sediment's physical and chemical characteristics. At each field triplicate sample location, three separate cores/grabs will be collected.
- Triplicate split samples (sample numbers as per Table 3-1) where sediments will be thoroughly mixed and split into three sample containers set to assess laboratory variation, with one of the three samples sent to a second (reference) laboratory for analysis.
- One trip blank container per sampling day will be filled with inert material (e.g. chromatographic sand) to be analysed concurrent with the analysis of volatile organic substances.

3.5 Sample Collection Methodology

Survey Vessel and Field Personnel

The vessel to be used as the platform for the sampling will be a registered commercial vessel and will be operated by a suitably qualified skipper, and will include:

- At least 2D for partially smooth or 2C survey for outside of partially smooth waters, with davit arm/winch
- A differentially corrected global positioning system (dGPS) with an accuracy of approximately ±1 m
- On-board depth sounder (reliably accurate to ± 0.25m).

Field works will be undertaken by appropriately qualified sediment quality scientists and field technicians experienced in undertaking marine sediment quality studies.

Sediment Sampling Methodology and Equipment

Sediments in the Main Channel will be collected using a large van Veen grab with a gape of at least 0.1 m^2. The coarse nature of some sediments may prevent the effective closure of the grab. Any instances where the grab does not close fully will require re-sampling.

Sediments in dredge footprints outside of the Main Channel will be sampled with a vibro-core or other appropriate core sampling device. The choice of core barrel diameter and coring methodology (i.e. vibro-coring or drilling) would be dependent on the volume of material required for analyses, the texture of the sediment encountered at each sample location and the required length of core. Generally, vibro-coring would be undertaken in sandy to muddy substrates. Core penetration in muddy and sandy substrates is likely to be good, whereas poor penetration will be possible in cobble or gravel substrates (but such sediments are unlikely to be contaminated).

The acceptability of each sediment core will be determined immediately following collection, and the criteria for acceptance of the core will include:

- No obvious loss of surficial sediment
- The core must have entered the profile vertically
- There must be no gaps in the stratigraphy
- There must be no disturbance of the sediment stratigraphy
- The core must reach the depth of dredging, or core refusal in clay, dense sand or rock.

The sampling device will be thoroughly cleaned with De-con 90 solution prior to use and cleaned and rinsed with seawater between sampling locations to prevent cross contamination between samples. Samples in the pilot study for PFAS will only use mechanical cleaning (no De-con 90), personal care product will be minimised or not used (sunscreen, insect repellent, moisturiser, etc.), nitrile gloves and plastic containers (high-density polyethylene).

An appropriate number of samples will be obtained from each sampling location and composited to collect sufficient volume of sediment for all analyses.

Sample Handling and Chain of Custody

Sample management procedures will include the careful collection of sediment samples from the core tube or grab, following the recovery of the sediment sample from the seabed.

Photographs of the grab samples and cores will be taken and field personnel will log each core profile for its physical characteristics and variations in sediment type and texture. The core length will be measured and the appropriate sample interval sub-sampled and collected in a clean, stainless steel bowl for homogenisation prior to the filling of analytical laboratory-supplied clean sampling jars.

Sub-sampling of cores will be undertaken in accordance with Section 3.2.

Sample identifiers will include the location and depth interval, for example, GM1_0.50-1.00 will indicate that the sediment sample was collected from Gladstone Marina grid cell 1 (Figure 3-2) over the interval from 0.50 m to 1.00 m.

QA/QC samples will be blind-labelled to ensure that the laboratories cannot relate the QA sample back to the primary sample.

All sample handling and processing will be performed to minimise contamination and sample mix-ups. All sample equipment will be cleaned prior to sample collection using a scrub with decontamination solution followed by a rinse with seawater.

The workspace on the vessel will be washed down regularly with ambient seawater to clean all surfaces and minimise the potential for dust contamination of samples. All sample processing will be undertaken away from any potential contamination sources such as engine exhausts, fuels, oils, greases, lead weights, zinc anodes, antifouling paint etc.

Nitrile gloves will be worn by all field personnel handling the sediment, and gloves will be disposed of after processing of each core sample.

Utmost care will be maintained in ensuring that cross-contamination between samples is not possible. Samples collected from each interval will be placed into appropriately cleaned and preserved containers (labelled prior to filling) provided by the analytical laboratories.

Following sample processing and filling of sample containers, all samples will be immediately chilled. The chilled samples will be submitted to the laboratory under appropriate Chain of Custody documentation to ensure that the sample possession and processing can be traced from sample collection to reporting of results.

Core Log

All sediment cores will be geotechnically logged upon collection on a standardised pro-forma. The following information will be recorded:

- Project name and number;
- The name of the sample collector;
- Date and Time of sampling;
- Type of core sampler used (vibro-corer/ piston corer, type of core barrel used or manual excavation);
- Field sample number;
- Northing and Easting of sample location (from onboard dGPS);
- Sediment colour;
- Sediment odour;
- Field texture (fine sand, silt, clay, sand, clayey sand);
- Tidal predictions and water depth at sample location (derived from onboard depth sounder);
- Weather and sea state conditions at the time of sampling; and
- General comments pertaining to the sample (e.g. presence of organic matter or benthic organisms, etc.

3.6 Health and Safety and Contingency Plan

Health and Safety

The vessel skipper will keep in close contact with Harbour Control during sampling. Grab sampling can be completed within 10 minutes while core sampling can be completed at each location between 20 minutes and one hour with logging and processing undertaken in locations out of the path of large vessels (as necessary and dependent upon shipping movements).

A single anchor may be used to anchor the vessel; alternatively stern anchors may also be used if necessary. The main anchor would be placed upstream and upwind of the vessel. A marker buoy may be placed on the anchor if required.

The sampling vessel will display appropriate flags (R over Y, and/or circle diamond circle) for the work being carried out at all times. Interactions with other vessel traffic will be minimised by being mindful of approaching vessels.

Adverse Weather

The planning of field sampling will involve regular checking of available weather forecast services for the study area. There are no unusual hazards in operating the corer in wet weather.

In case of adverse weather conditions that would make sampling unacceptable due to strong winds and high waves, the sampling team and vessel operator would remain on stand-by until weather conditions improve to allow rigorous and safe collection of sediment samples.

Equipment Failure

The grab, corer, and lifting arrangement will be sufficiently robust to afford good operation and no failure of the equipment is expected to occur during the sampling. Prior to sampling, all equipment will be thoroughly checked and repaired if necessary. A secondary GPS, multiple spare core barrels, and tools to fix minor problems with coring equipment will be taken on the vessel in the event of gear failure.

In the unlikely event of equipment failure during sampling, repairs to any equipment would be undertaken as soon as possible to minimise delays as far as practical. The site is located near Gladstone, a major regional centre, where replacement equipment (including an alternate vessel) could be sourced if required.

3.7 Contaminants List

Table 3-3 provides the list of contaminant parameters to be analysed for this project. Based on the review of existing good quality data (Section 2) and in accordance with NAGD and NEPM requirements, the parameter test list includes substances known to occur in Port Curtis at levels greater than one-tenth of the screening levels, or substances which are potentially present based on historical review. Furthermore, supplementary sediment parameters such as particle size distribution, moisture content, total organic carbon, nutrients and acid sulfate potential will be analysed.

Contaminant screening levels are based firstly on the NAGD (2009) and subsequent updates to it (Simpson et al., 2013) as these are supported by recent effects-based data. For contaminants without screening levels in the NAGD, screening levels from the NEPM have been adopted. Contaminants without known screening levels will be assessed against twice the mean background concentration, as per the recommendations of ANZEEC/ARMCANZ 2000.

Several potential ECs are included in the list that have not been detected to date:

- BTEX – noting increases in potential sources in recent times, e.g. commercial and recreational vessels, LNG projects at Curtis Island.
- OC / OP pesticides and herbicides – while these compounds have not been detected in previous investigations in Port Curtis, Auckland Inlet is the receiving environment of urban and some agricultural catchments potentially containing these parameters. For this reason, OC / OP pesticides, and herbicides represent potential contaminants at Auckland Inlet, and are included as a precautionary measure because there is no recent past data for this site. There is a large body of evidence suggesting that OC / OP pesticides and herbicides are absent from the main channel.
- PFAS – limited testing of sediment outside of Port Central groundwater and seafood sampling in Ship Creek.

Dioxins and furans have been detected at low levels elsewhere in Port Curtis (DEHP 2012) at concentrations that fall within the inter-quartile range of other data collected in Australian estuaries (Müeller et al., 2004). In 2017, furans were not detectable in any of the sediments tested. However, dioxins were detected in varying levels, which is not uncommon in estuarine regions. The highest concentration occurred in Jacobs Channel (2680 pg/g) and lower at the EBSDS (114 pg/g) with reference sites returning a mean of 815 pg/g. In 2012, a report from the Queensland Department of Environment and Heritage Protection (DEHP, 2012) concluded the dioxin and furan concentration ranged from 43 to 5270 pg/g.

Due to the lack of elevated Dioxins/Furan in all previous studies and the high analysis costs, dioxins will be analysed from all reference and EBSDS sites, as well as 20% of test locations as a pilot study. Significant contamination (beyond twice mean background) will trigger further testing of 30% of sampling locations (the full 50% of locations specified in Table 6 of NAGD, as required for probably clean sediments).

Perfluoroalkyl substances (PFAS) was widely utilised in firefighting foam that has only recently been phased out (complete ban coming into effect in 2019). While also used in other industrial products, highly contaminated sites are largely due to foam use at airports, fuel storage facilities, refineries and ports. PFAS has been detected at Port Central in ground water and Ship Creek from seafood sampling. PFAS has historically not been tested in previous SAP's (AMA 2017, BMT 2017, BMT 2012). A pilot study will be undertaken to assess whether PFAS should be included on the contaminant list. A total 20% of sample sites will be analysed, and any significant contamination will trigger further testing of 30% of sampling locations (the full 50% of locations specified in Table 6 of NAGD, as required for probably clean sediments).

TBT assessment in the NAGD has been updated with an explanatory note (Commonwealth of Australia, 2021). The new guidance allows for selective dredging of hotspots and normalisation of toxicity with porewater. TBT in PoG has recently only been found in one location, Lower Auckland inlet adjacent to the Auckland Point Wharfs at a historic slipway (AMA 2015a, 2018). This area (Lower Auckland Inlet) is not included in this SAP. TBT will still be tested in all samples due to proximity (Marina and Upper Auckland) as well as its normal distribution in marine sediments from anti-fouling paint.

The latest advice from the Department of Environment and Science (DES) stipulates that Acid Neutralising Capacity (ANC) is not allowed unless verified as 'available for neutralisation'. Considerations for the PoG in this respect are solely for areas targeted for onshore disposal, Marina, Upper Auckland, and Boyne River. These areas are to be considered for a combination of terrestrial and marine disposal (Section 1.4).

Laboratory testing of ASS will also be conducted on samples taken at 0.5m (or where change in lithology is identified) intervals along the full length of the retained core as described in Table 3.3. Extra sample will be retained for possible Slab or Chip Tray Incubation tests in the case of breaching the Practical Quantification Limit of 2 mole H^+/tonne. This will allow for an accurate assessment of ASS risk and confirmation of Acid Neutralising Capacity (ANC)(Simpson *et al*, 2018).

Boyne River Mouth contains mostly sand and gravel with little in the way of fines for testing of contaminants (BMT WBM 2017). The most recent sediment analysis from 2017 found that most contaminants of potential concern were not detected. For the purposes of this SAP, it is proposed that this area is probably clean.

Table 3.4 Contaminant List, Target Practical Quantification Limits (PQLs), Guideline Screening Levels, and Level of Investigation

Parameter	Target PQL	Screening Level	Level of Investigation
Basic Characteristics			
Particle Size Distribution	63 to 0.002 mm	-	All Samples
Moisture Content (%)	0.1	-	
Total Organic Carbon (%)	0.1	-	
Metals and Metalloids (mg/kg)			
Aluminium	200	12,918[1]	All Samples
Antimony	0.5	2[2]	

Parameter	Target PQL	Screening Level	Level of Investigation
Arsenic	1	20[2]	
Cadmium	0.1	1.5[2]	
Chromium	1	80[2]	
Copper	1	65[2]	
Iron	100	33,870[2]	
Lead	1	5[2]	
Mercury	0.01	0.15[2]	
Manganese	10	-	
Nickel	1	21[2]	
Silver	0.1	1[2]	
Zinc	1	200[2]	
Cyanide			
Cyanide	0.25	20[4]	All sites in Upper Auckland Inlet, reference sites and EBSDS
Organotin Compounds (µgSn/kg)			
MBT, DBT, and TBT	1 µg/kg[3]	9 µg/kg[2]	All samples
Organics (mg/kg)			
Total Petroleum Hydrocarbons	100	280[3]	All Samples
TPH Fractions	10-100	-	
Benzene, Toluene, Ethylbenzene, Xylene (BTEX)	0.2	10 (Benzene)[5] 65 (Toluene)[5] 40 (Ethylbenzene)[5] 1.6 (Xylenes)[5]	
Polycyclic Aromatic Hydrocarbons (PAHs)	0.005 (0.1 for sum)	10,000[3]	
Organochlorine Pesticides (DDT DDE DDD, aldrin and dieldrin, chlordane, endosulfan, endrin, heptachlor, HCB, methoxychlor, mirex, toxaphene)	0.5-1	1.2 (DDT)[3] 1.4 (DDE)[3] 3.5 (DDD)[3] 2.8 (Dieldrin)[3] 4.5 (Chlordane)[3] 2.7 (Endrin)[3] TMBC- remainder[1]	
Organophosphorus Pesticides (Chloryrifos)	0.5	TMBC[1]	
Herbicides (2,4,5-T, 2,4-D, MCPA, MCPB, Mecoprop, Picloram)	0.02	TMBC[1]	
Dioxins and Furans	0.02 µg/kg	TMBC[1]	All samples in pilot study (20% sites)
PFAS (mg/kg)			

Parameter	Target PQL	Screening Level	Level of Investigation
PFAS	0.0005	TWBC	All samples in pilot study (20% sites)
Nutrients			
Total Nitrogen as N	20	-	All samples
Total Kjeldahl Nitrogen as N	20	-	
Total Phosphorus as P	1	-	
Nitrate and Nitrite as N	0.1	-	
Ammonia as N	0.1	4[3]	
Acid Sulfate Potential			
Chromium Suite	2 mole H^+/tonne	Liming rate based on Table 4.2 (Dear *et al.*, 2014)	All sites in Upper Auckland Inlet, Gladstone Marina, and Boyne River Mouth
Slab/Chip Tray Incubation test (for ANC)	0.1 pH unit	As per Slab Incubation Method NLM-8.1/ Chip Tray NLM-8.2	Undertaken on samples if initial net acidity results (less ANC) are greater than action criteria (0.03 %S / 8 mol H^+/t)

- No guideline for comparison

[1]TMBC = twice the mean background concentration. For aluminium and iron, 12,918 mg/kg and 33,870 mg/kg, respectively, have been used (URS 2009). Other organics will be compared to TMBC based on data from reference sites sampled in this SAP

[2]National Assessment Guidelines for Dredging NAGD (2009)

[3]Updated screening levels as per Simpson et al., (2013)

[4]Interim Sediment Quality Guideline (ISQG) from ANZECC ARMCANZ (2000)

[5] National Environment Protection (Assessment of Site Contamination) Measure April 2011

Not Included Parameters

It is proposed that the following contaminant groups be excluded from all analyses (except some analytes upper Auckland Inlet) based on the review of existing data (refer to Section 2 for details):

- PCBs – not detected in any previous studies
- Radionuclides – detected at low levels elsewhere in Port Curtis but lower than 1/10th of the screening level (less than 2% of screening level)
- Cyanides – not detected in previous sampling (to be sampled in upper Auckland Inlet only as a precaution given previous reporting (AMA, 2018) concentrations were below the LoR).
- OC and OP pesticides and herbicides – No pesticides or herbicides were detected in any of the previous studies (to be sampled in upper Auckland Inlet only as a precaution given a lack of existing data).
- Selected metals – including cobalt, molybdenum, selenium, vanadium, and uranium. Cobalt and selenium concentrations (Angel et al., 2012) are generally well below 10% of the NEPM HIL-A. There are no guideline concentrations for the remaining metals, but metal concentrations generally are lower in Port Curtis than other Ports within Australia (Angel et al., 2012). There are no sources of uranium within the catchment.

3.8 Laboratory Analysis

Analytical Laboratories

The primary and secondary analysis of sediment samples will be undertaken by analytical laboratories fully accredited by the National Association of Testing Authorities (NATA) for the required analyses.

Both laboratories will follow laboratory QC procedures in accordance with requirements outlined in Appendix F of NAGD. This includes analysis of laboratory blanks, duplicates, certified reference materials and spiked samples.

Analytical Tests and PQLs

All samples must be analysed for parameters outlined in Table 3.4.

Sample Containers

Sample volumes will be specified by the laboratory performing the analysis. Large cobble and gravel fragments should be removed from the sample prior to storage in containers. Based on the proposed analyses, the following sample containers would be required per sample:

- 2 x 250 mL glass jar – organic/inorganic chemical analysis
- 1 x 125 mL glass jar – nutrient analyses
- 1 x 250 mL plastic jar – PFAS analysis
- 1 x medium plastic clipseal bag (50-100 g) – particle size distribution
- 1 x small clipseal bag (200 g) – acid sulfate soil.

3.9 Data Analysis and Assessment

Concentrations of contaminants measured in sediment samples will be compared to screening levels as described in Table 3-3. Those being Table 2 of NAGD in the first instance for all samples, and subsequently, Table 1A(1) and Table 1B(6) of the NEPM Volume 2 Schedule B1, and to determine whether the material is acceptable for placement at sea or on land.

Specifically, mean concentrations of chemical parameters at the upper 95% confidence level (95% UCL) will be compared against screening levels described in Table 3-3. The statistical analysis will follow the approach given in Appendix A of NAGD. This will inform whether the material is appropriate for placement at sea.

An assessment of the material’s suitability for land-based re-use (if required) will follow the statistical analysis and the data evaluation procedures in Section 3.4, Volume 5 Schedule B4 of the NEPM. In the event that 95th percentile upper confidence limits for particular contaminants are exceeded, the next steps would be to follow the decision tree in Volume 1, Schedule A of the NEPM to determine a site remediation plan or collect further data describing the nature of contamination.

Given the lack of contamination history in past and present data elsewhere in Port Curtis, the probability of guideline exceedance is considered low, and will be addressed in a supplementary SAP if required.

3.10 Data Quality Objectives and Data Validation

Data quality aim for this SAP is that the information collected is suitable for undertaking an assessment of dredge material contamination in accordance with the framework provided in the NAGD. To achieve this aim, data quality objectives outlined in Table 3-4 must be met. The data quality objectives encompass:

- Data validation objectives - All laboratory analyses will be validated in accordance with Appendix A of NAGD (which are specific to marine sediments) to confirm suitable data quality for undertaking a rigorous characterisation of the proposed dredge material. This will involve an assessment of the following:
  - Sample holding times and storage conditions
  - Laboratory blanks, duplicates and surrogate/matrix spikes
  - Field triplicates samples, triplicate sample splits and trip blank.
- Completeness objective - At least 95% of all data received should be validated as suitable for use.
- Chain-of-custody form objectives – completed forms shall accompany the samples.
- Laboratory sample receipt objectives – the laboratory shall provide written confirmation on whether: the sample names/numbers received agree with chain-custody forms; samples were received intact; samples were received at specified temperature; and samples were received within appropriate holding times.

Table 3.5 Data Quality Objectives for Data Validation

Parameter	Data Quality Objective
Holding Time	Samples received within specified holding time (NAGD Appendix H)
Field Triplicate Samples	Relative Standard Deviation <50%
Triplicate Split Samples, including inter-laboratory samples	Relative Standard Deviation <50%
Laboratory Blanks	At or near the Limit of Reporting (LOR)
Laboratory Duplicate Samples	Relative Percent Difference (RPD) <35% or as per laboratory requirements
Laboratory Matrix Spikes	Recovery as per laboratory requirements
Surrogate Spikes	Recovery as per laboratory requirements
Chain-of-Custody forms	100% complete and included in SAP implementation report
Sample Receipt from Laboratory	Sample names/numbers received agree with chain-of-custody forms Samples were received intact Samples received at specific temperature Samples received within laboratory holding times
Completeness Objective	At least 95% of all data received should be validated as suitable for use

3.11 Reporting

The reporting of sediment quality results will be undertaken in a SAP Implementation Report that includes the following components:

- Summary of the SAP, or SAP appended to the report

- Outline of potential problems encountered and deviations from the SAP, including justification
- Description of the sampling carried out, along with the actual sampling locations, sample numbers (including replicates and QA samples), completed chain of custody (COC) forms, field logs and description of sediments
- Comparison of the 95% UCL of mean chemical concentrations of sediments in each of the proposed dredge pockets with appropriate screening levels described in Table 3-3
- Assessment of QA/QC procedures for both field and laboratory data
- Data validation including comparison to data quality objectives
- Appendices including all laboratory and field data, photos and statistics
- Conclusions regarding the acceptability of dredge material contaminant concentrations for beneficial re-use based on the NAGD in the first instance, and subsequently from the NEPM screening levels, as well as recommendations as to further work required including any requirements for ASS/PASS management.

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