Appendix B Technical Memorandum – Sediment Characteristics

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Memorandum

Subject	Long-term Maintenance Dredging Management Plan		
Date	1 November 2021	Pages	300
To	Adam Fletcher – Ports North	From	Alex Kochnieff Andrew Keep
CC	Bill Boylson (Advisian)		
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Project	Port of Cairns – Maintenance Dredge Material Characteristics		

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1 Introduction

This technical memorandum has been prepared to support the compilation of a new Long-term Maintenance Dredging Management Plan (LTMDMP) by BMT for Ports North by providing:

- Description of physical and chemical properties of maintenance dredge sediment based on annual sediment characterisation reports prepared for Ports North since 1995 and targeted geotechnical assessment of physical properties.
- Description of maintenance dredging and disposal requirements based on historical maintenance dredging information provided by Ports North.

1.1 Scope

The scope of works agreed between Advisian and Ports North for the development of the memorandum includes:

Task 1.2: Review of existing maintenance sediment data

- Review existing reports to identify sediment material data relevant to the maintenance dredge footprint area (Outer Channel (OC), Inner Port (IP), Marlin Marina (MM), HMAS Cairns Navy base (NB), Commercial Fishing Base (CFB) 1 and 2) and identify gaps in geotechnical data that may be addressed to assist long term management. The review of geotechnical information focused on key reports generated by Golder Associates and the Flanagan Consulting Group Options Study Report (2016).
- Identify and plot the location of relevant sampling locations/boreholes on a map, and identify analytical tests completed at relevant locations.

Task 1.3: Sediment properties analysis

- Review relevant historical contaminant quality and volume trends using data collected by Advisian from 2010 to 2020, BMT EIS data and available historical data (pre-2010) to identify potential opportunities to improve the annual Sampling and Analysis Plan (SAP) program.
- Review available maintenance sediments geotechnical data (such as Particle Size Distribution (PSD), moisture, plasticity, density, strength, permeability subject to availability) and identify attributes that may assist in assessments of beneficial reuse studies.
- Undertake a geotechnical assessment to characterise the physical properties of maintenance dredge materials at the Port based on samples collected by Ports North in December 2020, and to verify conclusions of past assessments completed at the Port.

Task 1.4: Reporting

- Develop a technical memorandum that contains the information described above in a format suitable for direct inclusion into the LTMDMP. The memorandum will include information under the following main areas:
  - History of dredging and disposal supported by a summary of historical dredge volumes
  - Summary of existing available data and on maintenance dredge spoil characteristics (i.e. geochemical and geotechnical) supported by:
    - a summary list of relevant borehole sampling / analyses completed

  - summary of key reports and available data with conclusions of previous beneficial reuse studies..
- Identify opportunities and provide recommendations of where the future 2022 to 2032 SAPs can be optimised.
- Propose an SAP approach for the 2022 to 2032 period.

At the time of writing this memorandum, the annual SAP for 2021 was being undertaken. As a result, data for 2021 will not be included. Management of the 2021 campaign will consistent with the process over the past permit term, and outcomes of it will be evaluated during the preparation for the 2022 and forward year SAP implementation.

1.2 Structure of memorandum

The structure of the memorandum is provided in Table 1-1 below.

Table 1-1: Memorandum structure

Section	Section title
1	**Introduction**
1.1	Scope
1.2	Structure of memorandum
2	**History of dredging and disposal**
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2.2	Maintenance dredging
2.2.1	Current permits
2.2.2	Outer Channel
2.2.3	Inner Port
2.2.4	HMAS Cairns Navy Base
2.2.5	Marlin Marina
2.2.6	Commercial Fishing Bases 1 and 2
2.2.7	Historical dredging volumes
2.3	Dredging requirements 2022-2032
2.4	Other dredge sediment studies
3	**Sampling and analysis**
3.1	Maintenance sediment characterisation and introduced marine pest survey program
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3.1.1.1	Sampling locations
3.1.1.2	Sampling horizons
3.1.2	Laboratory analysis
3.1.3	Introduced marine pest survey
3.2	Physical characteristics
3.2.1	Samples considered in assessment of physical characteristics
3.2.1.1	2010-2020 A-SAP and 2020 geotechnical sampling
3.2.1.2	Golder (2016)
3.2.1.3	Summary of data included in assessment
3.2.2	Particle Size Distribution (PSD)
3.2.3	Organic Content
3.2.4	Moisture content
3.2.5	Atterberg limits and linear shrinkage
3.2.6	Particle density and bulk dry density
3.2.7	Strength and consolidation
3.2.7.1	Consolidated Isotropic Undrained (CIU) Triaxial
3.2.7.2	1D Consolidation (Oedometer)
3.2.7.3	Falling Head Permeability

Section	Section title
3.2.8	Carbonate (CaCO3) content
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3.3	Chemical characteristics
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3.3.2.5	Hydrocarbons
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3.3.2.7	Other contaminants
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3.3.4	Emerging contaminants
4	**Opportunities and recommendations**
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5	**Proposed approach**
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5.3	Sampling design
5.3.1	Sampling locations for sediment characterisation
5.3.2	Sample collection methods and sampling horizons
5.4	Sampling processing
5.5	Data analysis
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5.7	Process for moving from screening levels assessment to elutriates and bioavailability assessment
5.8	Reporting
5.9	Summary of sampling collection program
6	**References**
7	**Attachments**
7.1	Ports North Environmental Relevant Activity 16 Maintenance Dredge Port Area
7.2	Geotechnical memorandum for samples collected in 2020

Section	Section title
7.3	Graphs of historical contaminants of concern
7.4	Mann-Kendall input tables – annual averages
7.5	Mann-Kendall output tables
7.6	Sampling Analysis Plan for 2022 to 2032

2 History of dredging and disposal

2.1 Capital dredging

Following the ports declaration in 1876, the first capital dredging works were undertaken within the access channel and berths by *The Platypus* dredge in 1887. As *The Platypus* was unable to keep-up with the task of maintaining required depths, the *Trinity Bay* dredge took up operations from 1913, deepening the channel and increasing its width to 45m by 1929. By the early 1940s the channel had been widened progressively to 60m. During the 1970s a dredging contractor undertook a further widening of the channel (75m) and deepened the entrance to 8.2m. The *Sir Thomas Hiley* dredge replaced the *Trinity Bay* dredge in 1972 and completed the capital dredging expansion during 1990, widening the channel to 90m and a design depth of 8.3m.

The most recent capital dredging campaign was completed in 2019 as part of the Cairns Shipping Development Project (CSDP) to accommodate larger cruise ships and potential future expansion of the Navy Base. This is the first significant capital dredging activity at the port in 29 years. Dredging was completed by backhoe dredge *Woomera* and the Trailing Suction Hopper Dredge (TSHD) *Balder R* and involved dredging up to 1,000,000m^3 to widen and deepen the shipping channel and Crystal Swing Basin and establish a new shipping swing basin (Smith Creek Swing Basin) upstream of the existing Main Swing Basin. Specifically, the CSDP included:

- Dredging to increase the Channel declared depth from -8.3 m to -9.2m lowest astronomical tide (LAT) with a target design depth of -9.7 to -10.8 mLAT to cater for the annual siltation,
- Widening the Channel width to 90 -100m
- Widening the Channel width generally to 110m and outer bend to 180m to provide safe manoeuvring space for the cruise vessels while passing through the bend
- Deepening of the existing Crystal Swing Basin to -9.2 mLAT for inner portion and -8.5 mLAT for the outer portion. The target depths being -9.5 mLAT and -8.7 mLAT respectively
- Establishing Smiths Creek Swing Basin to a declared depth of -8.6mLAT, target depth of -8.6 mLAT and diameter of 310m to enable future expansion of the NB
- Dredging to increase the declared depth of the Wharves 1-6 to -9.3mLAT, with a target depth of -9.7 mLAT and a width of 50m.

The location and declared depths of the dredging areas is presented on Ports North ERA16 Maintenance Dredging Port Area attached at Section 7.1. A summary of the declared depths in provided in Table 2-1.

2.2 Maintenance dredging

Maintenance dredging operations have been an ongoing annual requirement at Port of Cairns, since it was developed over a hundred years ago. Ports North is required under the *Transport Infrastructure Act 1994* to maintain navigable depths within the port navigation areas to ensure effective and efficient port facilities and services. To meet this obligation, Ports North have an augmented maintenance operation where the channel and swing basins are dredged by *TSHD Brisbane*, and the Inner Port (IP) wharf areas and smaller, access constrained marinas including the NB, MM and CFB 1 and 2, are dredged using the *Willunga,* a clam shell dredger (i.e. bucket grab dredge and two hopper bottom barges). On occasion, when tides permit safe manoeuvring, the *TSHD Brisbane* may be used to dredge adjacent to the Main Wharf areas into which material from the berth pockets is dragged using a bar leveller.

Ports North undertake annual routine maintenance dredging operations generally within three separate campaigns that differ in dredging volumes, frequency and dredging plant. These separate campaigns include:

- Outer and inner shipping channel and associated swing basins
- IP (main wharves 1 to 8 and 10 to 12), MM, CFB1 and CFB2
- NB.

Maintenance dredged material for each campaign is placed at the approved Dredge Material Placement Area (DMPA). The DMPA has been known as the Offshore Disposal Site within past SAP processes; however, for the forward plan, the globally accepted terminology of DMPA is to be adopted.

2.2.1 Current permits

The Commonwealth and State Marine Parks Permit No. G10/33155.1 (administered by the Great Barrier Reef Marine Park Authority (GBRMPA)), and Sea Dumping Permit No.10/03 (administered by the Commonwealth Government Department of the Environment and Energy (DoEE)) were jointly granted on 17 June 2010 and are valid until 1 June 2020. *Due to the timing of the studies and administration process required for the new long-term permit process, the existing Sea Dumping Permit was extended to June 2022, whilst the Marine Park permit continues to have effect whilst the new permit is under assessment*.

Both permits were initially issued to provide for a total quantity of dredging and material placement of 6,600,000m^3 (wet load) over ten years between 17 June 2010 and 1 June 2020. This comprised an annual permitted quantity of dredging and placement of 550,000 (wet load) m^3 (Condition 6) along with a maximum of 1,100,000 (wet load) m^3 of contingency maintenance dredging (Condition 7) over the period of the permits. Condition 6 of the marine parks permit and Condition 19 of the sea dumping permit was varied on 29 August 2014 to change the units of measure in the permits from 'wet load' to 'dry tonnes'. With this amendment the annual permitted quantity of dredging and placement became 350,000 dry tonnes and as such 3,500,000 dry tonnes of annual (non-contingency) maintenance dredging was permitted over the ten-year period.

2.2.2 Outer Channel (OC)

The OC is a total length of 12km and has a declared depth of -9.2 mLAT, and is described as the portion of channel seaward of the MM. The OC is generally 90 m to 100m wide, however, widens at the bend to 180m. An average of 249,119 dry tonnes was dredged annually by the TSHD from 2010 to 2020. This dredging usually takes approximately three weeks to complete. Dredged material is placed at the approved DMPA consistent with approvals by the Determining Authority. A summary of the declared depth and volumes are provided in Table 2-1.

2.2.3 Inner Port (IP)

The Inner Port includes the Inner Channel upstream from the Marina, Wharves 1 – 8, 10 – 12, new inner harbour extension, Main Swing Basin, Crystal Swing Basin, and the new Smiths Creek Swing Basin. Collectively these areas stretch across a length of 3.7 km. The declared depth of the Inner Channel, wharves, new harbour extension is -9.2 mLAT. This is the same declared depth for the inner Main Swing Basin and Crystal Swing Basin, however, the declared depth for the outer areas of these swing basins is -9.1 mLAT and -8.5 mLAT respectively. The New Smith's Creek Swing Basin has a declared depth of -8.3 mLAT.

Historically, dredging of the swing basins and Inner Channel has not been required regularly, as the natural scouring of the currents have not allowed sediment to settle. As a result, only the IP (Wharves 1 – 8, and 10 – 12) have required dredging. This has been undertaken using the '*Willunga*'. The historical annual average dredged volume for the 2010 to 2020 period has been 8,402 dry tonnes from these areas. A summary of the declared depths and volumes are provided in Table 2-1.

2.2.4 HMAS Cairns Navy Base (NB)

NB comprises an inner and outer dredge area. The declared depth of the inner portion ranges from -2.5 to -4.5 mLAT, while the outer portion ranges from -2.5 to -7.0 mLAT. Dredging of both areas occurs on an alternating basis undertaken annually using the '*Willunga*'. The quantity from the inner berth area is around twice that required to be removed each second year from the outer berth areas due to the prevailing consistent siltation patterns. The historical annual average dredged volume for the 2010 to 2020 period has been 14,593 dry tonnes. A summary of the declared depths and volumes are provided in Table 2-1.

2.2.5 Marlin Marina (MM)

MM comprises a northern and southern portion. The declared depth of both portions ranges from -2.5 to -5.0 mLAT. Dredging of both portions occurs on an alternating basis undertaken annually using the '*Willunga*'. The historical annual average dredged volume for the 2010 to 2020 period has been 6,952 dry tonnes. A summary of the declared depths and volumes are provided in Table 2-1.

2.2.6 Commercial Fishing Bases (CFB) 1 and 2

CFB1 and CFB2 have a declared depth of -3.5 mLAT with dredging only required on an infrequent basis completed using the '*Willunga*'. Maritime Safety Queensland (MSQ) has a berth located in CFB2. Both CFB1 and CFB2 do not have significant dredging requirements, however, when it is required, most dredging at is concentrated in the inner portions of both. When dredging was required, the historical average dredged volume for the 2010 to 2020 period was 11,149 dry tonnes for CFB1 and 2,613 dry tonnes for CFB2. A summary of the declared depths and volumes are provided in Table 2-1.

Table 2-1: Ranges of annual routine maintenance dredging volume and quantities for the 2010 to 2020 period and declared depths within Port of Cairns

Dredge Area		Dredging volume Min	Dredging volume Max	Dredging volume Average	Dredging weight Min	Dredging weight Max	Dredging weight Average	Percentage of total (dry tonnes)	Dredge Name	Dredge Type	Design dredge depth (m LAT)
		(*in situ* m^3)			(dry tonnes)						
Outer Channel		136,309	531,953	375,762	136696	336,795	249,120	90 – 95%	TSHD Brisbane	Trailing Arm Suction Hopper Dredge	-9.2
Inner Port	Main Swing Basin	2,094	27,518	10,006	1,759	23,276	8,402	1.5 – 4%	Willunga	Bucket Grab Dredge	-9.2 inner / -9.1 Outer
	Wharves 1 – 8, 10 – 12										-9.2
	Crystal Swing Basin										-9.2 inner / -8.5 outer
	Inner Channel										-9.2
Navy Base	NB inner	14,058	23,330	21,486	13,226	21,949	19,651	5-7%	Willunga	Bucket Grab Dredge	-2.5 to -4.5
	NB outer	10,768	22,134	13,538	8,442	18,964	11,443				-2.5 to -7.0
Marinas	MM	897	18,844	8,861	824	14,774	7,821	0.50%	Willunga	Bucket Grab Dredge	-2.5 to -5.0
	CFB 1	11,366	14,656	12,762	9,929	12,804	11,149	1 – 2%	Willunga	Bucket Grab Dredge	-3.5
	CFB 2	1,496	5,384	2,991	1,307	4,703	2,613				-3.5
	MSQ	5,384	5,384	5,384	5,065	5,065	5,065				

2.2.7 Historical dredging volumes

Table 2-2 outlines actual wet load dredge volumes, dry tonnes and in-situ volumes recorded for the period 2010-2020.

Table 2-2: Dredge volumes and quantities for 2010 to 2020

Year	Dredge	Wet Load (m^3)	Dry Tonnes	In-situ (m^3)
2010	Brisbane	708,923	177,505	317,985
	Willunga	34,505	24,154	30,808
	TOTAL	743,428	201,659	348,793
2011	Brisbane	736,631	205,990	396,943
	Willunga	46,900	32,830	41,875
	TOTAL	783,531	238,820	438,818
2012	Brisbane	719,220	220,043	337,680
	Willunga	57,955	46,049	51,746
	TOTAL	777,175	266,092	389,426
2013	Brisbane	866,894	283,552	366,781
	Willunga	61,305	48,138	54,737
	TOTAL	928,199	331,690	421,518
2014	Brisbane	822,225	336,795	531,953
	Willunga	47,570	39,239	42,473
	TOTAL	869,795	376,034	574,426
2015	Brisbane	946,211	316,910	497,678
	Willunga	41,309	31,692	36,883
	TOTAL	987,520	348,602	534,561
2016	Brisbane	804,726	306,801	416,559
	Willunga	39,865	32,411	35,594
	TOTAL	844,591	339,212	452,153
2017	Brisbane	779,414	258,482	358,095
	Willunga	32,160	24,562	28,714
	TOTAL	811,574	283,044	386,809
2018	Brisbane	834,503	321,497	513,858
	Willunga	4,355	3,407	3,888
	TOTAL	838,858	324,904	517,746
2019	Brisbane	531,647	177,046	259,539
	Willunga	67,670	54,106	60,420
	TOTAL	599,317	231,152	319,959
2020	Brisbane	313,748	135,696	136,309
	Willunga	48,240	39,875	43,071
	TOTAL	361,988	175,571	179,380
Subtotals	Brisbane	8,064142	2,740,317	4,133,380
	Willunga	481,834	376,463	430,209
Total Dredged for 2010 to 2020		**8,545,976**	**3,116,780**	**4,563,589**

2.3 Dredging requirements 2022-2032

The required annual maintenance dredging requirements for the Port of Cairns for the 2022-2032 period are provided Table 2-3. These amounts have been calculated based on average maintenance dredge volumes and quantities from the 2010 to 2020 period and forecast of sediment accumulation for the 2022 to 2032 period, informed by the patterns of observed siltation and dredging effort of past periods, and understanding of future vessel and operations in the respective areas. These are considered to be relatively reliable estimates. However, whilst routine annual maintenance dredging is largely a function of prevailing sediment movement and hydrodynamics, periodic events such as cyclones and floods can significantly alter annual dredge estimates or actual requirements. For this reason, a contingency volume of 730,000 m^3 provision has been included in the operational and maximum forecast estimates provided in Table 2-3.

Table 2-3: Estimated spoil disposal quantities under 10-year LTMDMP (2022-2032)

Operational case	Dry Load (t)	Insitu (m^3)
Annual average of maintenance dredging	365,000	520,000
Annual maximum forecast	500,000	730,000
Contingency (spread across the 10 year period)	500,000	730,000
Total requirement for 10-year permit duration	3,650,000	5,200,000

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2.4 Other dredge sediment studies

The following section provides a summary of the previous studies undertaken at the Port of Cairns and provide relevant chemical and physical data. The relevant sampling locations from these studies and annual SAPs from 2010 to 2020 are presented on Figure 2-1 to Figure 2-7.

2.4.1 1990, Connell Wagner and associated consultants: Cairns Harbour and channel spoil disposal study Phase 1 Site Selection

The purpose of this study was to review the aspects pertaining to the need for dredging (capital and maintenance) at the Port of Cairns and search for suitable spoil disposal sites. It included a summary of a previous study undertaken in 1987 by Winders Barlow and Morrison that included "chemical properties of Cairns Harbour mud". A summary of the data is provided in Table 2-4 and indicate concentrations of targeted chemical properties ranged from below to above the NAGD Screening Levels for arsenic, cadmium and mercury. Samples were also tested for organochlorine pesticides (OCP), polychlorinated biphenyls (PCBs) and radioactivity. The analysis indicated that concentrations of these contaminants were below the respective laboratory limit of reporting (LOR).

Table 2-4: Summary of chemical properties of Cairns Harbour mud (Winders Barlow and Morrison, 1987)

Parameter	Range (mg/kg)	Median (mg/kg)	NAGD Screening Level (mg/kg)
Arsenic	13 – 33	21	20 (30*)
Cadmium	<1 – 2.2	<1	2
Copper	10 – 115	15	65
Lead	30 – 48	39	50
Mercury	<0.1 – 0.2	0.1	0.15
Zinc	40 – 69	58	200
Biochemical Oxygen Demand (5 day)	18 - 1030	300	-
Chemical Oxygen Demand	2000 – 81400	26000	-
Total oil, fat and grease	70 – 280	145	-

This report also provides a summary of chemical concentrations from two hand augered boreholes located along the existing Cairns Harbour shipping channel with samples collected from the surface, 1m and 2m. These boreholes were completed by Hollingsworth Dames and Moore in 1990. It was noted that these locations accurately reflect the chemical nature of the material to be dredged. Borehole 1 was logged as dark grey silty clay with organics and shells, while borehole 2 was logged as a medium coarse silty sand / silty sand to clay/silt.

A summary of the data from Hollingsworth Dames and Moore, 1990 is provided in Table 2-5. Concentrations were below respective NAGD Screening Levels (except for mercury) and notably less than the concentrations ranges in Table 2-4 and data for 2010 to 2020 period (refer to Section 3.3.1). The values in Table 2-5 are lower by at least a magnitude of ten, and generally less than 1mg/kg, particularly for arsenic, copper, lead and zinc. As these values are so low they do not seem to be comparable to maintenance material and therefore not considered for comparison against data for 2010 to 2020 period.

Table 2-5: Summary of chemical properties of samples collected along Cairns Harbour Shipping channel (Macdonald Wagner and Hollingworth Consultants, 1989)

Parameter	Range (mg/kg)	Median (mg/kg)	NAGD Screening Level (mg/kg)
Organic matter	3.1 – 3.4%	-	-
Arsenic	4.1 – 9.8	7	20 (30*)
Cadmium	<0.34 – 0.09	-	2
Copper	0.55 – 0.89	0.65	65
Lead	0.18 – 0.29	0.25	50
Mercury	<0.2 - <0.3	-	0.15
Zinc	0.64 – 0.75	0.71	200
OCP	0.01 – 0.11	0.09	-
Organophosphate Pesticides (OPP)	<0.002 – 0.04	-	-
Total PCBs	0.05 – 0.2	-	0.023
Biochemical Oxygen Demand (5 day)	720 – 3740	1676	-
Chemical Oxygen Demand	3640 – 62570	32235	-
Total oil, fat and grease	580 – 2435	1116	-
Total Nitrogen (TN)	450 – 590	550	-
Total Phosphorus	83 – 5900	3465	-

Hollingsworth Dames and Moore, 1990 also completed an Acid Sulfate Soil (ASS) test on a sample from the surface of the dredge spoil area. The results indicated pH reduced from 8.5 to 3.6 (water, oxygen, 90^{o}F) and from 8.5 to 4 (water, bacteria) both after 21 days generating sulfuric acid. There was also 23000mg/kg of sulfate, >3000mg/kg iron and 287000mg/kg of organic content. The report indicates these results suggest material are ASS.

2.4.2 1992, Connell Wagner and associated consultants: Cairns Harbour and Channel Spoil Disposal Study Phase 2 – Site Selection

Connell Wagner and associated consultants were commissioned to undertake Phase 2 of the channel spoil disposal to address the concerns and reduce uncertainty regarding the conclusions from the Phase 1 study. This Phase 2 study included a summary of chemical data collected from three campaigns between 1987 and 1992. The results are summarized in Table 2-6. Connell Wagner, 1992 indicate that the data exhibited large variations associated with natural variation and inaccuracies in the sampling and testing. The ranges in Table 2-6 are less than the respective NAGD Screening Levels, except for mercury and are generally lower or consistent with concentrations in the 2010 to 2020 period, however, concentrations of cadmium and mercury are higher in this historical dataset.

Table 2-6: Summary of chemical properties analysis of spoil (CW, 1992)

Parameter	Range (mg/kg)	NAGD Screening Level (mg/kg)
Arsenic	17 – 25	20 (30*)
Cadmium	<0.6 – 2	2
Copper	8.4 - 11	65
Lead	1.9 – 11.7	50
Mercury	<0.02 – 0.4	0.15
Zinc	13 – 41	200
TN	440 – 2100	-
TP	300 – 450	-
OCP	Not detected	-
OPP	Not detected	-
PCB	Not detected	0.023
Biochemical Oxygen Demand (5 day)	200 – 424	-
Chemical Oxygen Demand	37000 – 52000	-
Oil and grease	140 – 573	-

2.4.3 2000, GHD: Department of Defense HMAS Cairns – Report of Dredge Spoil Disposal Options

GHD completed an investigation into the options for land disposal of spoil from dredging of the Outer and Inner Basins at HMAS Cairns. It included a review of TBT and copper sources and leaching rates from vessels, TBT and copper behavior, toxicity and environmental fate, sediment processes, assessment of previous sediment contaminant data including ASS, assessment of previous water quality data, and review of disposal options.

Due to the past use of certain hull treatments, including TBT on Defense vessels, both in Cairns and at a range of other facilities around Australia, the work was completed to assist in determining the contaminant status and any implications for future disposal options. The report also suggests that the main contributor of TBT in sediments at the NB is likely to be high inputs at Smiths Creek such as the slipway as TBT adsorb to sediments and is transported downstream. Other conclusions indicate:

- TBT decreases with depth through the sediment profile
- TBT is leachable if disposed on land, but copper is not
- As sediments are regularly dredged and TBT has a low bioavailability the risk to marine organisms is low
- The input of TBT to sediments at the NB will decrease over time due to the introduction of non-TBT antifouling, reduced input from Smith Creek operations and better environmental control

- Vessels moored at the NB are likely to contribute some point source TBT to sediments, but this should decrease in the medium to long-term due to the introduction of non-TBT antifouling
- Copper concentrations are likely to reduce significantly
- PASS are present and would require treatment if brought to land.

2.4.4 2014, BMT WBM: CSDP Draft EIS Sediment Quality Report

In 2014 BMT WBM completed a sediment characterisation study to assess the physical and chemical properties of capital sediments to be dredged as part of the CSDP. This was based on the approach set out in NAGD, 2009 to assess the suitability of dredged material for unconfined ocean disposal. This included an evaluation of existing information (Phase I) and sampling and analysis of proposed sediments to be dredged (Phase II and III). The Phase II and III assessment focused on the sediment profile not previously dredged (i.e. capital sediment material) and was undertaken following the completion of the 2013 maintenance dredging campaign (July-August).

Sampling was completed from 18 to 23 October 2013 with additional grabs collected on 26 November 2013. Sampling was completed at 44 locations (14 IP and 30 OC locations) using a combination of piston and vibrocoring ranging in depth from the sea bed to 0.2 to 2.9m below seabed level. Refusal was encountered at 25 locations on stiff clays, rock or gravelly substrate. Additional grab samples were collected 26 November 2013. Sediments were sampled in 0.5m horizons, i.e. 0.0-0.5, 0.5-1.0, 1.0-1.5, etc to the end of the core.

Phase II analysis indicated sediments were mainly silts and clays and detected concentrations of mercury, arsenic, nickel and Diuron in the IP and mercury and Diuron in the OC above the NAGD and/or local screening criteria. The 95% UCL was below the NAGD Screening Levels for contaminants except for mercury that had a 95% UCL concentration of 0.196 mg/kg. This exceeded the NAGD screening level of 0.15 mg/kg. This triggered Phase III assessment including reanalysis of samples in triplicate to validate elevated results, elutriate and DAE analysis. Additional testing indicated mercury concentrations below the respective Screening Levels, therefore mercury was considered unlikely to impact marine organisms.

The detection of Diuron concentrations ranging from 0.58 to 3.84μg/kg triggered the need for further assessment despite 95% UCL concentrations being below the literature derived Screening Level of 2μg/kg. The additional testing indicated concentrations of Diuron that were below the literature derived Screening Level and therefore suitable for unconfined ocean placement.

Perfluorinated compounds (PFCs) were also tested in sediments from the IP. However, PFCs were only detected in two samples containing very low concentrations of individual PFC compounds: 6:2 Fluorotelomer sulfonate 6:2 FtS) (0.0026mg/kg) and compound PFNA (0.00009 mg/kg). All other remaining samples tested for PFCs had concentrations below the LOR.

All remaining parameters including TPH, PAH, organotins, OCP and OPPs had 95% UCL concentrations below the respective Screening Levels and therefore sediments from the IP and the OC were considered suitable for ocean disposal.

ASS sampling testing was also undertaken at the IP and OC. This included the sampling and analysis of 10 samples collected within the surface 1m of sediment from the IP and 30 samples at the OC. All 10 IP samples tested had concentrations of potential sulfidic acidity and self neutralisaing capacity. However, only two samples indicated that treatment (e.g.. liming) may be required as net acidity ranged between

226 moles H+/t and 2210 moles H+/t. The liming rates required ranged from 17 kg CaCO3/t and 166 kg CaCO3/t. Only four OC samples (all located at the southern end of the channel) require treatment for net acidity ranging from 25 moles H+/t and 1270 moles H+/t requiring 2 kg $CaCO_3$/t to 95 kg $CaCO_3$/t. As the sampling was shallow, the study was augmented with additional ASS data from a letter report prepared for Ports North by Golder Associates, 2014: Assessment of DMPA Land Based Options – Cairns Shipping Development Project EIS. This report was unavailable, but a summary is provided in BMT WBM, 2014. The summary indicates:

- The majority of samples tested within the top 1m of sediment were self-neutralising PASS with sufficient capacity to negate all acidity; however, the report recommended a nominal liming rate of 3-5 kg $CaCO_3$/t should the material be placed on land
- Non self neutralising PASS were located at depths greater than 1m and potentially require liming with rates ranging from 30 kg lime/m^3 to 270 kg lime/m^3 and an average liming rate of 90 kg lime/m^3
- Deeper firm, stiff and very stiff materials are unlikely to be PASS and therefore are unlikely to require lime treatment
- In the absence of more comprehensive sampling, a nominal liming rate of 75 kg lime/m^3 should be applied to the very soft to soft dredged material.

2.4.5 2016, Golder Associates: CSDP Revised Draft EIS Baseline Assessment – Dredged Material

This study was undertaken to provide further assessment of subsurface conditions likely to be encountered during dredging, including geotechnical and ASS properties of dredged material, and to generate a 3D model of ground conditions. The specific locations of the boreholes completed and relevant to this LTMDMP are provided in Section 3.2. Sampling of ASS was undertaken at eight borehole locations and 20 grab locations in the (then) proposed dredge areas of the OC.

Samples were analysed using the Chromium Suite (S_{CR}) with results indicating that soft silt and clay sediment and mud samples were primarily self-neutralizing PASS; however, some samples indicated potential requirement for liming with rates ranging from 30 kg lime/m^3 to 85 kg lime/m^3. The underlying stiff clay was not considered to be PASS.

2.4.6 2017, BMT WBM: CSDP Revised Draft EIS Sediment Quality Report

The 2017 study formed an update to the 2014 study completed by BMT, however, the sediment data from 2014 was augmented with ASS data from Golder Associates, 2017. This indicated that sediment within 1m of the seabed was likely to be self-neutralising PASS; however, despite the self-neutralising component, a nominal liming rate of 3-5kg $CaCO_3$/t was recommended during onshore placement. Sediment located deeper than 1m was identified as PASS that would not self-neutralise, and therefore liming rates ranging from 30 to 270 kg $CaCO_3$/t were identified for this material.

2.4.7 2017, Golder Associates: CSDP Revised EIS – Additional Studies Dredged Materials

Golder undertook an assessment of the materials likely to be encountered during dredging based on revised channel design. This assessment formed a continuation of their work in 2016 and included a revision of the ground model and recalculation of volumes. Further information is provided in Section 3.2.

2.4.8 2020, EnRiskS: Human Health and Ecological Risk Assessment: Investigation of PFAS at HMAS Cairns

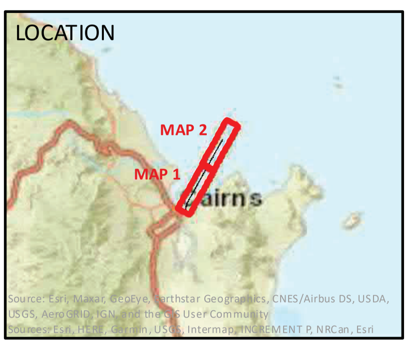
EnRiskS completed a human health and ecological risk assessment (HHERA) using available data considering the presence of per- and polyfluoroalkyl substances (PFAS) at the NB and the adjacent seabed areas. The HHERA included a screening level assessment of potential ecological risks relevant to the environment.

EnRiskS indicate that ecological receptors can be exposed to PFAS via direct contact exposure or following exposure through bioaccumulation through the food chain including:

- Where organisms live in, drink from, or have access to (come into contact with) impacted water and soil/sediment. This is referred to as direct toxicity;
- Where organisms consume sediment, soil or vegetation that has been grown in impacted soil and/or water; and
- Where organisms consume prey that has consumed impacted water/soil/food. This is referred to as secondary poisoning.
- The screening level ecological risk assessment (ERA) noted that there are no Australian screening level guidelines for PFOS and PFOA in sediment relevant to the protection of aquatic ecosystems (i.e. in Trinity Inlet). Therefore, in the absence of specific Australian guidance for PFAS in sediment, the preferred approach for the assessment of PFAS in aquatic ecosystems due to the bioaccumulation in Trinity Inlet is to measure concentrations in water and food sources that may be consumed by bird and mammals (i.e. aquatic biota). The PFAS National Environmental Management Plan (NEMP) provides the biota guideline values presented in Table 2-7.
- The report concluded no specific findings in regard to sediment, however noted low and acceptable risks for Human and Ecological Health off the Base, with the exception of two specific potential groups, in regard to seafood consumption or bioaccumulation in higher order consumers and made a recommendation for development of a PMAP (PFAS Management Area Plan) at the Base and adjacent Trinity Inlet area.

Table 2-7: NEMP, 2020 Biota guideline values used for screening assessment of PFAS in sediments in EnRiskS

Exposure scenario	Sum of PFOS and PFHxS	PFOA	Description	Comments and sources
Ecological direct exposure for wildlife diet	4.6 µg/kg		Mammalian diet consumption of biota as wet weight food	Canadian Federal Environment Quality Guidelines (ECCC 2018). This guideline value is to be used on sampled biota tissue for assessing risk to mammal and avian receptors based on their diet. The avian diet value may not be protective of migratory wading birds that have a high food intake due to the need to gain weight rapidly. These diet values may also not be protective of reptiles and amphibians.
	8.2 µg/kg		Avian diet – consumption of biota as wet weight food	
Ecological exposure protective of birds	0.2 µg/kg		Whole bird egg as wet weight	Adapted from Canadian Federal Environment Quality Guidelines (ECCC 2018) using an additional uncertainty factor. This guideline value is to be used on sampled bird eggs to assess risk to sensitive avian ecological receptors
Notes: Where the guideline values refer to the sum of PFOS and PFHxS, this includes PFOS only, PFHxS only, and the sum of the two. The Canadian guidelines refer to the criterion for PFOS only; in the NEMP the guideline values for ecological direct exposure for wildlife diet refer to the levels of PFOS and PFHxS in food consumed by mammals or birds. This has been adapted to allow for uncertainties and potential similar toxicities of PFHxS with PFOS.				



LEGEND

Historical Sampling Locations

- Golder (2012)
- BMT/WBM (2013)
- Golder (2013)
- Golder (2016)
- Sampling grid
- Dredge area

WorleyParsons/Advisian 2010-2020 *(colour denotes year)* — Sediment and Pest *(unless noted otherwise)* — Pest

2010	2012	2014 (Sediment)	2015 (Sediment)	2016 (Sediment)	2017 (Sediment)	2018	2020 (Sediment)	2020 (Geotech)
2011	2013	2014 (Pest)	2015 (Pest)	2016 (Pest)	2017 (Pest)	2019	2020 (Pest)	

Figure 2-2 – Outer Channel Historical Sampling Locations

Advisian
Worley Group

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LEGEND

Historical Sampling Locations

BMT/WBM (2013) | Golder (2013) | Golder (2016)

WorleyParsons/Advisian 2010-2020 *(colour denotes year)* | Sediment and Pest *(unless noted otherwise)* | Pest

Sampling grid

Dredge Area

2010 | 2013 | 2015 (Sediment) | 2017 (Sediment) | 2020 (Sediment)

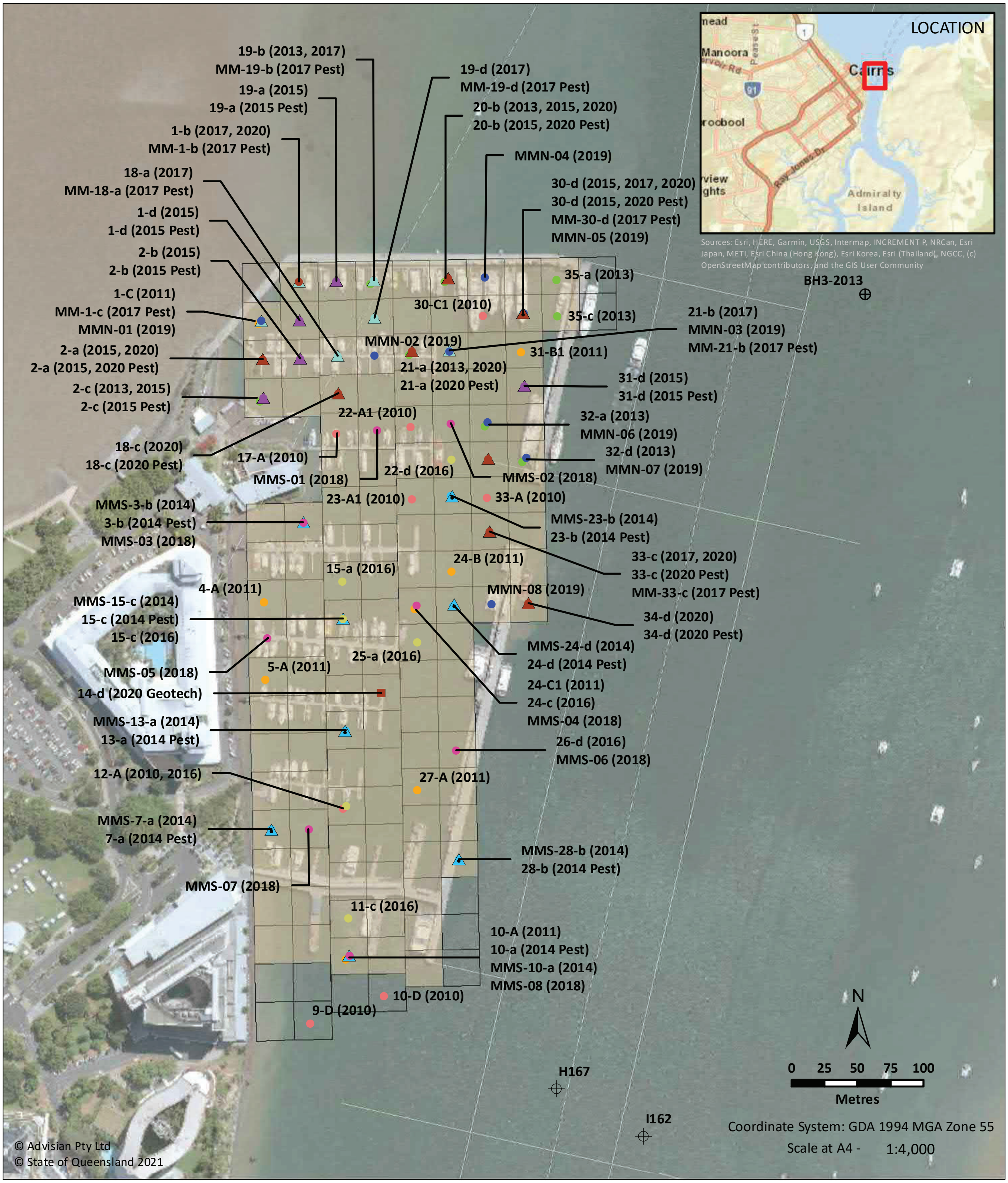
2011 | 2014 (Sediment) | 2015 (Pest) | 2017 (Pest) | 2020 (Pest)

2012 | 2014 (Pest) | 2016 (Sediment) | 2018 | 2020 (Geotech)

2016 (Pest) | 2019

Advisian
Worley Group

Figure 2-3 – Inner Port - Historical Sampling Locations



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Historical Sampling Locations

BMT/WBM (2013) | Golder (2013)

WorleyParsons/Advisian 2010-2020
(colour denotes year)

Sediment and Pest
(unless noted otherwise)

Pest

2010	2013	2015 (Sediment)	2017 (Sediment)	2020 (Sediment)
2011	2014 (Sediment)	2015 (Pest)	2017 (Pest)	2020 (Pest)
	2014 (Pest)	2016	2018	2020 (Geotech)
			2019	

Sampling grid

Dredge area

Figure 2-4 – Marlin Marina - Historical Sampling Locations

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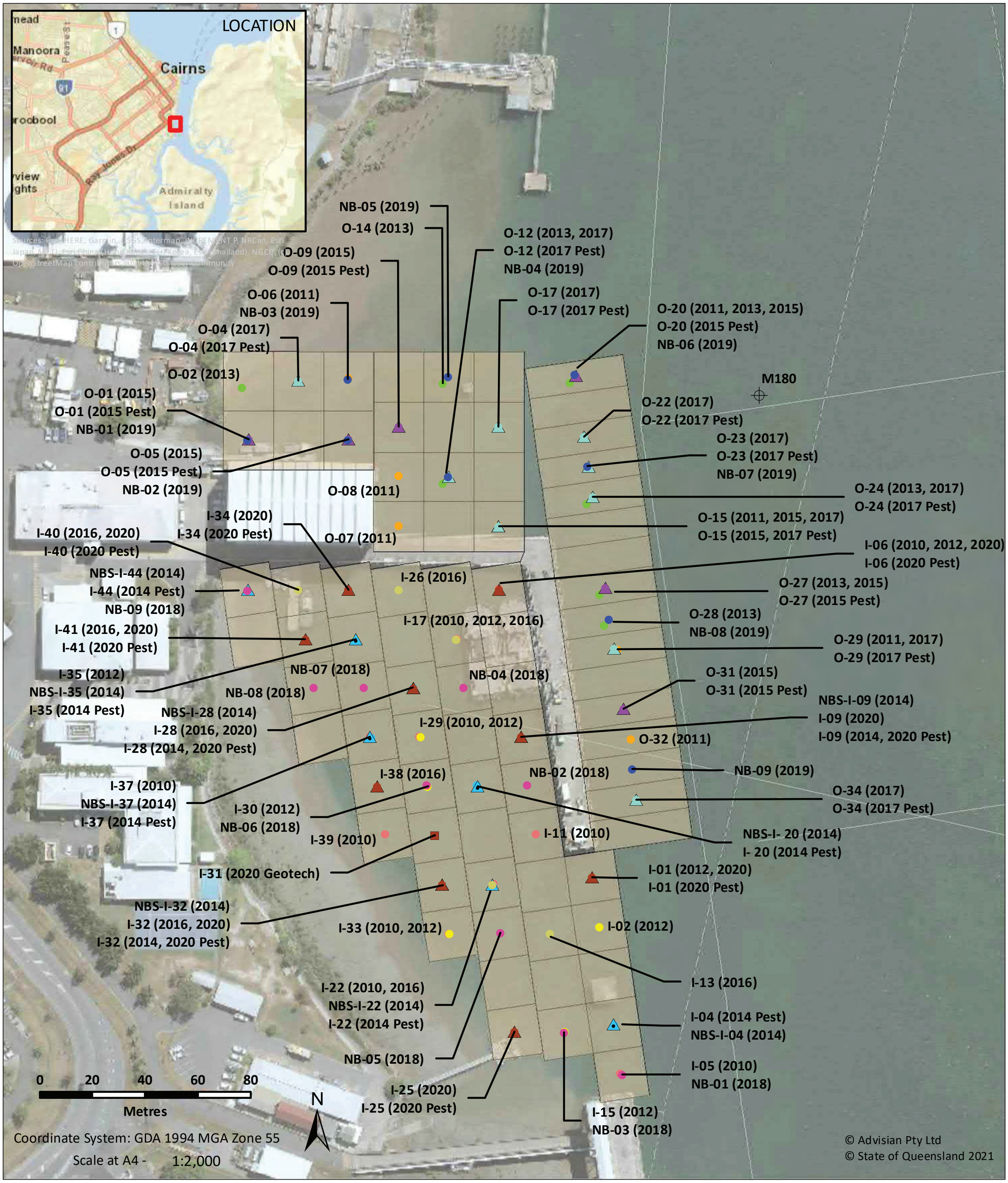

LEGEND

Historical Sampling Locations

BMT/WBM (2013)

WorleyParsons/Advisian 2010-2020 *(colour denotes year)*

Sediment and Pest *(unless noted otherwise)*

Pest

2010, 2011, 2012, 2013, 2014 (Sediment), 2014 (Pest), 2015 (Sediment), 2015 (Pest), 2016, 2017 (Sediment), 2017 (Pest), 2018, 2019, 2020 (Sediment), 2020 (Pest), 2020 (Geotech)

Sampling grid

Dredge area

Figure 2-5 – HMAS Cairns Navy Base - Historical Sampling Locations

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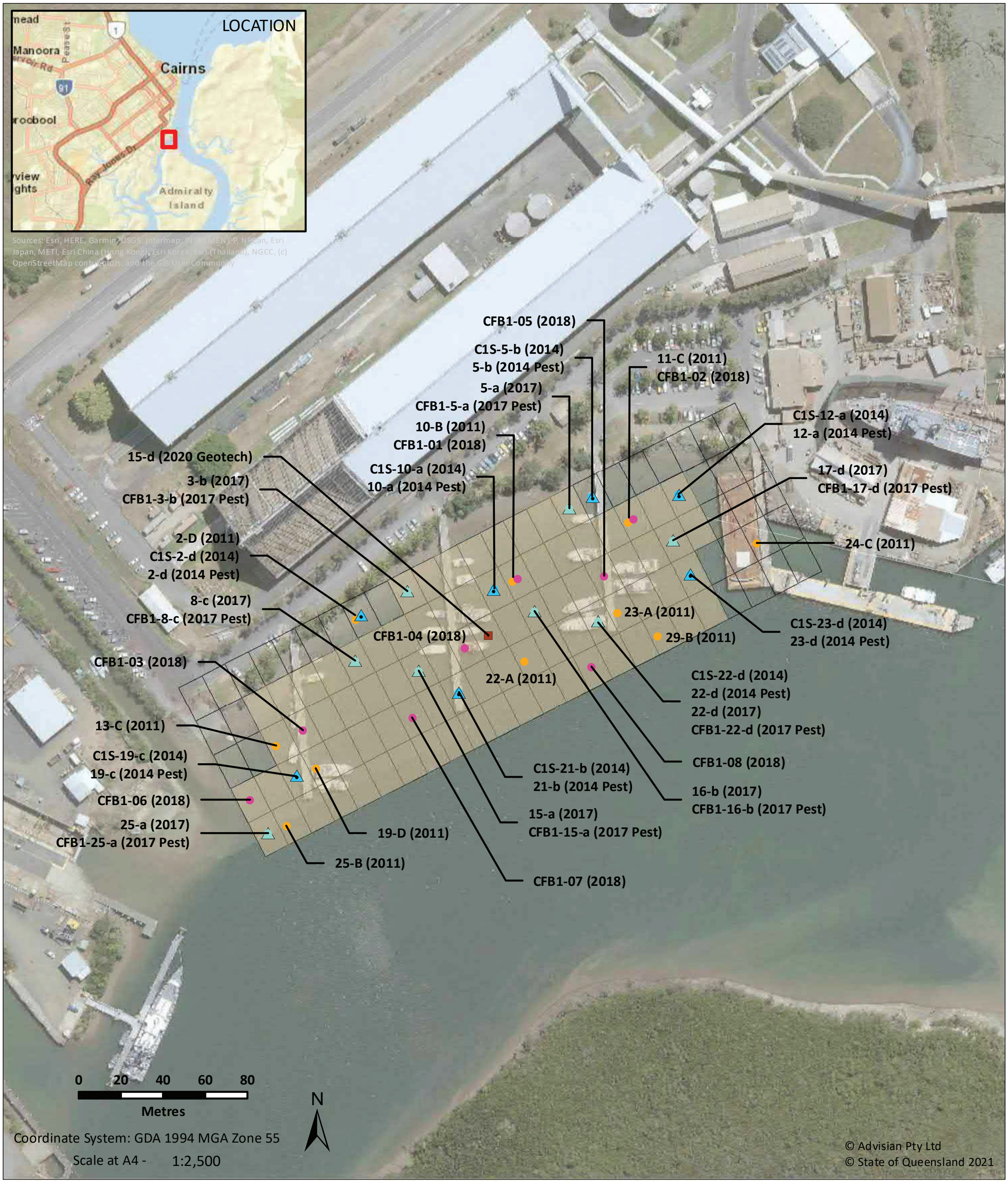

LEGEND

Historical Sampling Locations

WorleyParsons/Advisian 2010-2020
(colour denotes year)

Sediment and Pest
(unless noted otherwise)

Pest

- 2011
- 2014 (Sediment)
- 2014 (Pest)
- 2017 (Sediment)
- 2017 (Pest)
- 2018
- 2020 (Geotech)
- Sampling grid
- Dredge area

Figure 2-6 – Commercial Fishing Base 1 - Historical Sampling Locations

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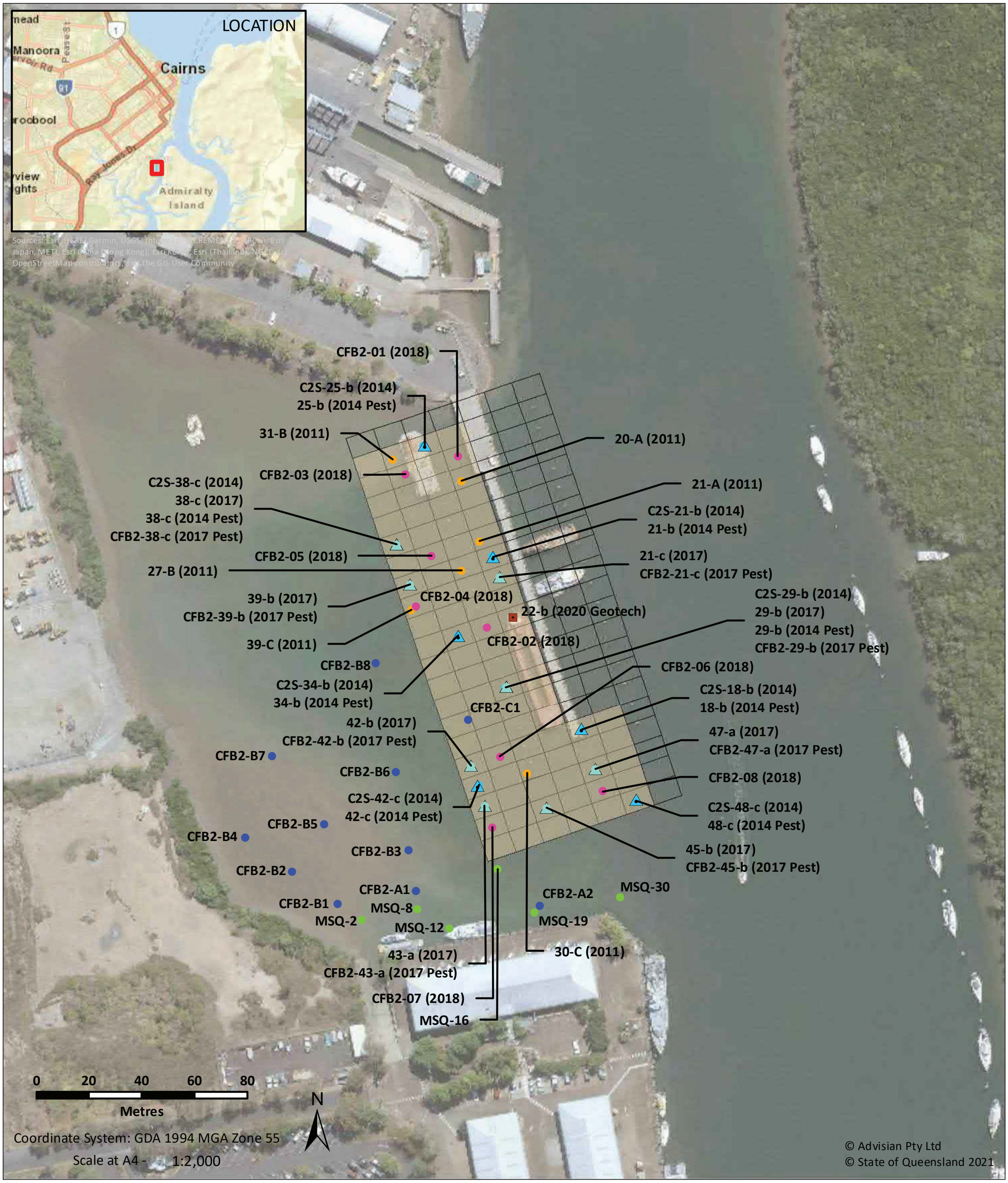

LEGEND

Historical Sampling Locations

WorleyParsons/Advisian 2010-2020

(colour denotes year) *(unless noted otherwise)*

- 2011
- 2014 (Sediment)
- 2014 (Pest)
- 2017 (Sediment)
- 2017 (Pest)
- 2018
- 2020 (Geotech)
- Sampling grid
- Dredge area

Figure 2-7 – Commercial Fishing Base 2 - Historical Sampling Locations

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