SMITH BAY WHARF

DRAFT ENVIRONMENTAL IMPACT STATEMENT

APPENDIX F

PREPARED FOR KANGAROO ISLAND PLANTATION TIMBERS BY ENVIRONMENTAL PROJECTS

JANUARY 2019

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APPENDIX **F**

APPENDIX F – MARINE WATER QUALITY

Appendix F1 – Assessment of Marine Sediments – COOE

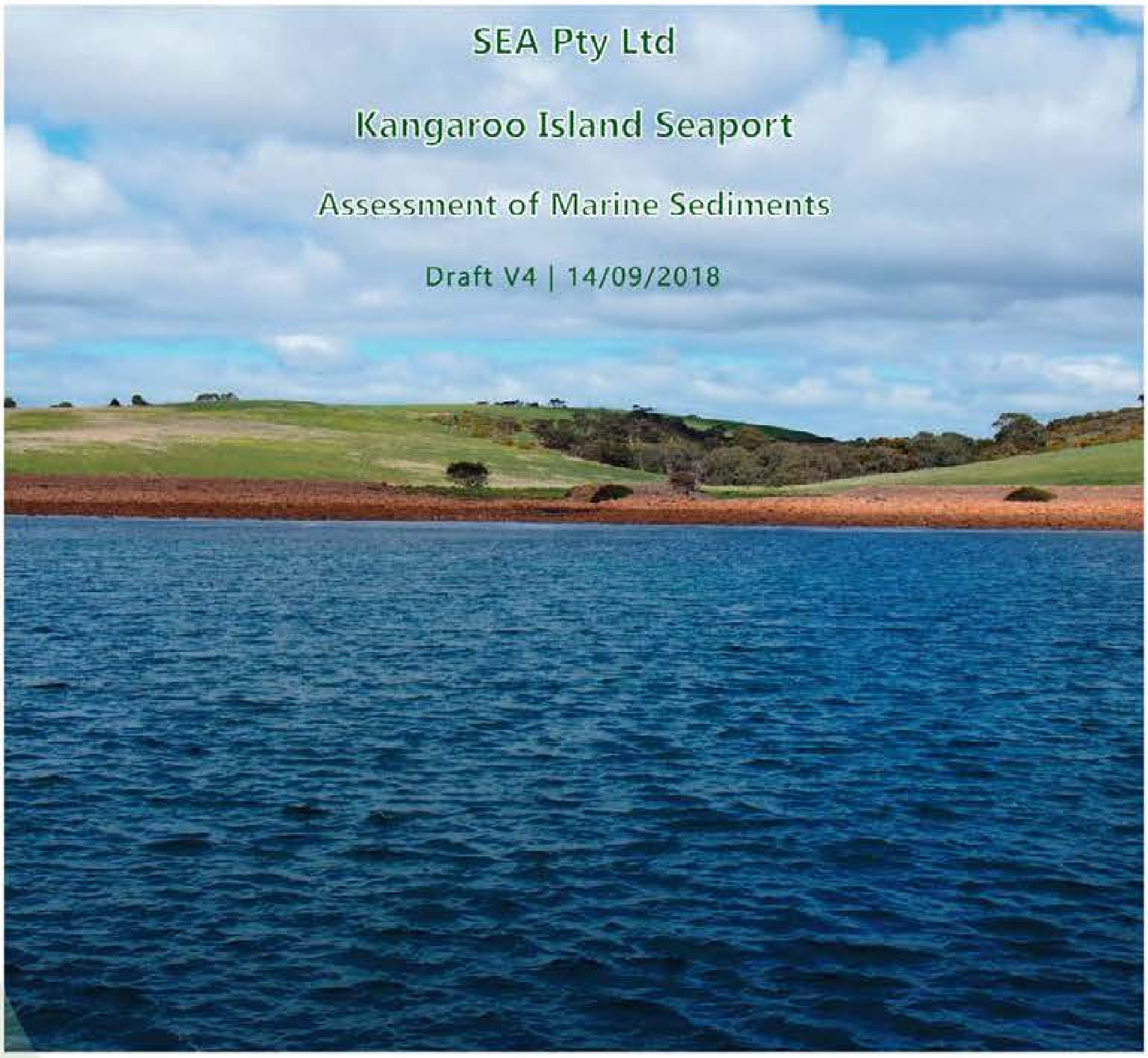
Cooe
Care Of Our Environment

SEA Pty Ltd

Kangaroo Island Seaport

Assessment of Marine Sediments

Draft V4 | 14/09/2018



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Front Cover: Smith Bay Foreshore

Kangaroo Island Seaport

Assessment of Marine Sediments

SEA Pty Ltd

14/09/2018

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EXECUTIVE SUMMARY

This report was commissioned by Social & Ecological Assessment Pty Ltd (SEA) to evaluate marine sediment in Smith Bay Kangaroo Island, for the proposed Kangaroo Island Seaport.

Sediment samples were collected from 12 locations in September 2017 and 6 new locations in August 2018. The second set of samples were collected to evaluate a new proposed dredging footprint further offshore. All samples were analysed for a comprehensive suite of physical and chemical parameters.

The overall findings of this site investigation suggest that sediment in the study area within Smith Bay is relatively pristine with no synthetic or natural pollutants.

Sediment on the hard seafloor ranged from no sediment cover to 140 cm thick in the 2017 survey and thicker than 60 cm in the more offshore sites sampled in 2018. The texture of sediment was mostly coarse white and grey sand with shell grit and organic detritus. The deep sediment layer at site SB7, had more fines and a higher organic matter content below 65 cm, than the other sites. This is supported by particle size distribution curves generated for the Smith Bay sites.

Metals and metalloids were found at low concentrations that were well below the Australian Interim Sediment Quality Guideline low trigger level. The deeper sediment at site SB7 had the maximum concentrations of all metals investigated. Arsenic was higher at site SB9. These sites are no longer within the proposed dredging footprint.

Synthetic chemicals tested, including phenols, petroleum hydrocarbons, organotins, organochlorine and organophosphorus pesticides, polychlorinated biphenyls, and polynuclear hydrocarbons were not detected in any sediment samples at ultra-low levels of detection.

Potential acid sulfate soils were not expected in the coarse sand sediments of Smith Bay. The pH of deep sediment at site SB7 was near neutral (pH 6.5) after 48 hours of exposure to air, showing no acid generation.

Nutrient content in the sediment samples was low, with total nitrogen in a range between 110 and 690 mg/kg, apart from one outlier reporting 2,850 mg/kg in sample SB7.2. Total phosphorus in all sediment samples ranged from below the limit of detection (<0.1) to 2.1 mg/kg.

Organic matter content in sediment samples ranged from 0.17 mg/kg to 0.76 mg/kg, apart from sample SB7.2, which was well outside this range at 4.47 mg/kg.

The sediment samples collected in 2018 from within the new proposed dredging area came from similar and apparently more pristine sediments as those collected in 2017 closer to shore. .sediment sampled within Smith Bay did not have any natural or synthetic pollutants. The concentration of all elements and synthetic compounds tested were found at below the relevant Australian Interim Sediment Guidelines Low trigger levels.

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1. INTRODUCTION

Smith Bay is located on the northern side of Kangaroo Island, approximately 7 km west of Emu Bay and approximately 40 km north-west of American River, Figure 1. The land adjacent to the proposed export wharf is currently owned by Kangaroo Island Plantation Timbers (KIPT).

Figure 1. Location of Smith Bay Kangaroo Island South Australia

1.1 Project Description

KIPT propose to build a Deep-Water Export Facility at Smith Bay, Kangaroo Island by KIPT. On 16 February 2017, the Minister for Planning declared the Smith Bay Port Facility to be a Major Development, pursuant to section 46 of the Development Act 1993.

A Development Application provided by KIPT to the Department of Planning Transport and Infrastructure in March 2017 and was referred to the Development Assessment Commission (DAC) for examination in accordance with the requirements of the Development Assessment Act 1993.

Project details

The proposed deep-water export facility will comprise of the following elements on the KIPT Smith Bay property, parts of the adjacent foreshore (Crown land) and within the adjacent coastal waters and seabed:

- wharf structures, including a causeway, link span bridge, tug mooring facilities, berthing pocket, retaining structures and mooring dolphins
- stockpile and storage facilities
- ship loading systems
- laydown area
- road transport access, including a two-lane road from the laydown area to the ship loading area

- ancillary facilities, including administrative buildings and infrastructure.

Figure 2 presents the footprint of the Kangaroo Island Seaport infrastructure and the proposed dredge area extent.

Figure 2 Kangaroo Island Seaport Proposed Infrastructure and Dredge Area

Scope for this study

COOE was commissioned to investigate seabed sediment chemical and physical properties to support the proponent's assessment of the marine environment.

1.2 Background to marine sediment in Smith Bay

Smith Bay is located on the north shore of Kangaroo Island in a relatively pristine marine environment. The foreshore is generally rocky with very small pockets of sand. Smith Creek, is a small ephemeral creek that feeds into the Bay close to the proposed Seaport. The catchment area for Smith Creek collects runoff from pastures, forest and the North Coast Road, Figure 3.

The Kangaroo Island Abalone farm located near the proposed Seaport draws seawater from Smith Bay and discharges used water back into the bay over the rocky foreshore.

Runoff from the Smith Creek catchment is likely to carry sediment, nutrients and organic matter into the bay. Seawater discharge from the Abalone farm is assumed to be within the South Australian Environment Protection (Water Quality) Policy 2015 and is therefore not expected to carry any significant nutrient or synthetic pollutants.

Barging operations were carried out at Smith Bay between the First and Second World War, however, insufficient information is available on these activities to evaluate their marine impacts. Other human activities that may have contributed to sediment quality in Smith Bay include agricultural, aquaculture (abalone), tourism and the township of Emu Bay, located around 7 kilometres to the east.

Potential contaminants from these activities include hydrocarbons, herbicides, antifouling compounds, and nutrients. A preliminary investigation of the South Australian contaminated site register found no records for Smith Bay.

An investigation of the National Soil Database found no indication of potential for Acid Sulfate Soils in the marine sediment or topsoil on the foreshore, (ASRIS, 2017). Soils in the Smith Bay area are reported by the database as moderately alkaline to alkaline, and the subsoil as moderately alkaline, further reducing the potential for acid sulfate soils.

This foregoing research suggests that Smith Bay is a relatively pristine bay, with minor potential impacts from historic and current human activities. This study is designed to test the hypothesis that Smith Bay has no adverse levels of synthetic or natural pollutants.

Figure 3. Smith Bay proposed dredging area and surrounds

A bathymetric survey was undertaken by KIPT for the engineering design of the proposed dredge area and wharf infrastructure, shown in Figure 4.

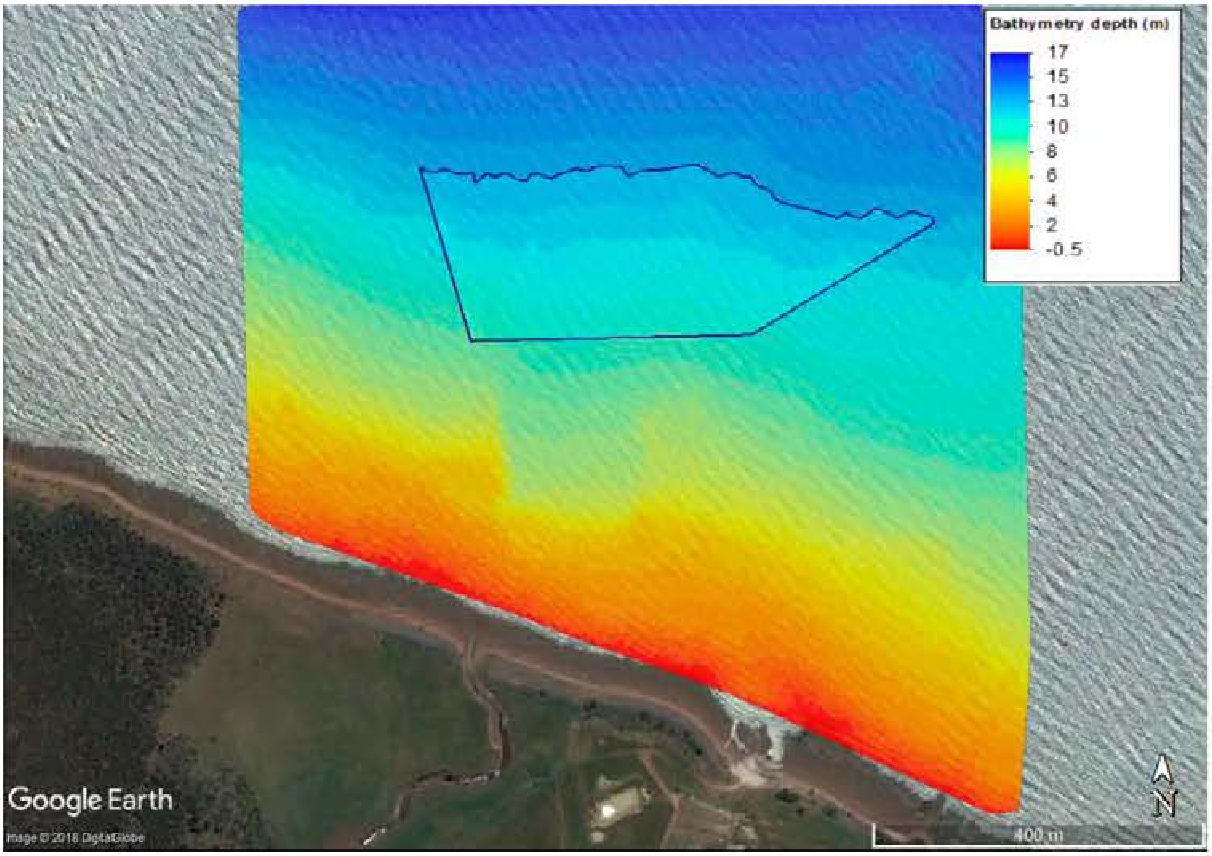

Figure 4. Bathymetric map of the proposed dredge area

1.3 Design of sediment study

The sediment assessment followed the National Assessment Guidelines for Dredging (NAGD), Phase I and Phase II (NAGD, 2009). The focus of this sediment quality assessment was to investigate potential artificial and natural contaminants of potential concern (COPC). A sediment Sampling and Analysis Plan (SAP) was developed prior to undertaking this work, discussed in Section 2, and a comprehensive list of analytes is presented below. The analytical results were compared to the applicable Interim Sediment Quality Guidelines (ISQG) screening levels to see if any exceeded the "Low" or "High" levels.

This is the first known sediment testing in Smith Bay and therefore provides a baseline for background levels, prior to construction of the wharf.

Sediment quality

Sediment samples were analysed for a comprehensive range of physical and chemical parameters to detect and document any background contamination in the Bay. The parameters investigated include:

Physical Properties
- pH (Saturated Paste)
- Moisture Content
- Particle Size Distribution (12 size categories between 75 μm and 75 mm)
- Underflow Density
- Particle Settling Rate
- Soil Particle Density

Total Metals in Sediments by ICP-AES
- Aluminium

- Iron

Total Metals in Sediments by ICPMS

- Antimony
- Arsenic
- Cadmium
- Chromium
- Copper
- Cobalt
- Lead
- Manganese
- Nickel
- Selenium
- Silver
- Vanadium
- Zinc

Total Recoverable Mercury by FIMS

- Mercury

Nutrients

- Total Nitrogen as N (TKN + NOx)
- Reactive Phosphorus as P by discrete analyser

Organic Compound

- Total Organic Carbon

Phenolic Compounds

- Phenol
- 2-Chlorophenol
- 2-Methylphenol
- 3- & 4-Methylphenol
- 2-Nitrophenol
- 2.4-Dimethylphenol
- 2.4-Dichlorophenol
- 2.6-Dichlorophenol
- 4-Chloro-3-methylphenol
- 2.4.6-Trichlorophenol
- 2.4.5-Trichlorophenol
- Pentachlorophenol

Petroleum Hydrocarbons

- C10 - C14 Fraction
- C15 - C28 Fraction
- C29 - C36 Fraction
- C10 - C36 Fraction (sum)

Recoverable Hydrocarbons - NEPM 2013 Fractions

- >C10 - C16 Fraction
- >C16 - C34 Fraction
- >C34 - C40 Fraction
- >C10 - C40 Fraction (sum)

Organo-tin Compounds

- Monobutyltin
- Dibutyltin

- Tributyltin

Organophosphorus Pesticides (Ultra-trace)

- Bromophos-ethyl
- Carbophenothion
- Chlorfenvinphos (E)
- Chlorfenvinphos (Z)
- Chlorpyrifos
- Chlorpyrifos-methyl
- Demeton-S-methyl
- Diazinon
- Dichlorvos
- Dimethoate
- Ethion
- Fenamiphos
- Fenthion
- Malathion
- Azinphos Methyl
- Monocrotophos
- Parathion
- Parathion-methyl
- Pirimphos-ethyl
- Prothiofos

Organochlorine Pesticides

- Aldrin
- alpha-BHC
- beta-BHC
- delta-BHC
- 4.4`-DDD
- 4.4`-DDE
- 4.4`-DDT
- Sum of DDD + DDE + DDT
- Dieldrin
- alpha-Endosulfan
- beta-Endosulfan
- Endosulfan sulfate
- Endosulfan (sum)
- Endrin
- Endrin aldehyde
- Endrin ketone
- Heptachlor
- Heptachlor epoxide
- Hexachlorobenzene (HCB)
- gamma-BHC
- Methoxychlor
- cis-Chlordane
- trans-Chlordane
- Total Chlordane (sum)

Total Polychlorinated biphenyls

- Aroclor 1016
- Aroclor 1221
- Aroclor 1232

- Aroclor 1242
- Aroclor 1248
- Aroclor 1254
- Aroclor 1260

Polynuclear Aromatic Hydrocarbons

- Naphthalene
- 2-Methylnaphthalene
- Acenaphthylene
- Acenaphthene
- Fluorene
- Phenanthrene
- Anthracene
- Fluoranthene
- Pyrene
- Benz(a)anthracene
- Chrysene
- Benzo(b+j)fluoranthene
- Benzo(k)fluoranthene
- Benzo(e)pyrene
- Benzo(a)pyrene
- Perylene
- Benzo(g.h.i)perylene
- Dibenz(a.h)anthracene
- Indeno(1.2.3.cd)pyrene
- Coronene

2. SEDIMENT SAMPLING AND ANALYSIS PLAN

Sampling sites during the 2017 run were located on a grid, designed for the geotechnical investigations, Figure 5. This grid provided a systematic rather than a random array of sample locations, appropriate in an investigation of a greenfield site.

The grid spacing was around 60 m by 100 m. This grid was deemed to be both efficient for anchoring the drill rig between sampling locations and representative of the extent of the proposed dredging area.

Core samples were collected using a drill rig equipped to take enviro core samples, Photo 1 (see Appendix A). This method employs a disposable plastic tube, housed within a metal drill bit, Photo 2. The drill bit is pushed with up to 10 tonnes of hydraulic pressure into the sediment until resistance is met. The sediment sample is recovered cleanly from the plastic tube, which was cut open with a special cutting tool to prevent cross contamination. This method allows for visual inspection, measurements and the collection of clean (uncontaminated) sediment samples, Photo 3.

The second sampling event was done by SCUBA divers equipped with a PVC tube and a rubber mallet to drive the tubes into the sediment, Photo 7. Around 60 cm of sediment were recovered in the hand driven sediment core sampler.

All sediment samples were immediately transferred to clean, glass sampling jars supplied by the NATA certified laboratory that also undertook the analysis. The labelled jars were stored in an ice box and transferred to a refrigerator at less than 4°C until packaged for transport to the laboratory. A chain-of-custody form was completed and sent with the samples. Quality control and assurance included:

- a field rinsate blank (made by rinsing the sampling equipment with laboratory grade water) and

- a blind replicate (made by splitting a core sample) were included to test field contamination and laboratory precision.
- a NATA certificate of analysis from the analytical laboratory, attached.

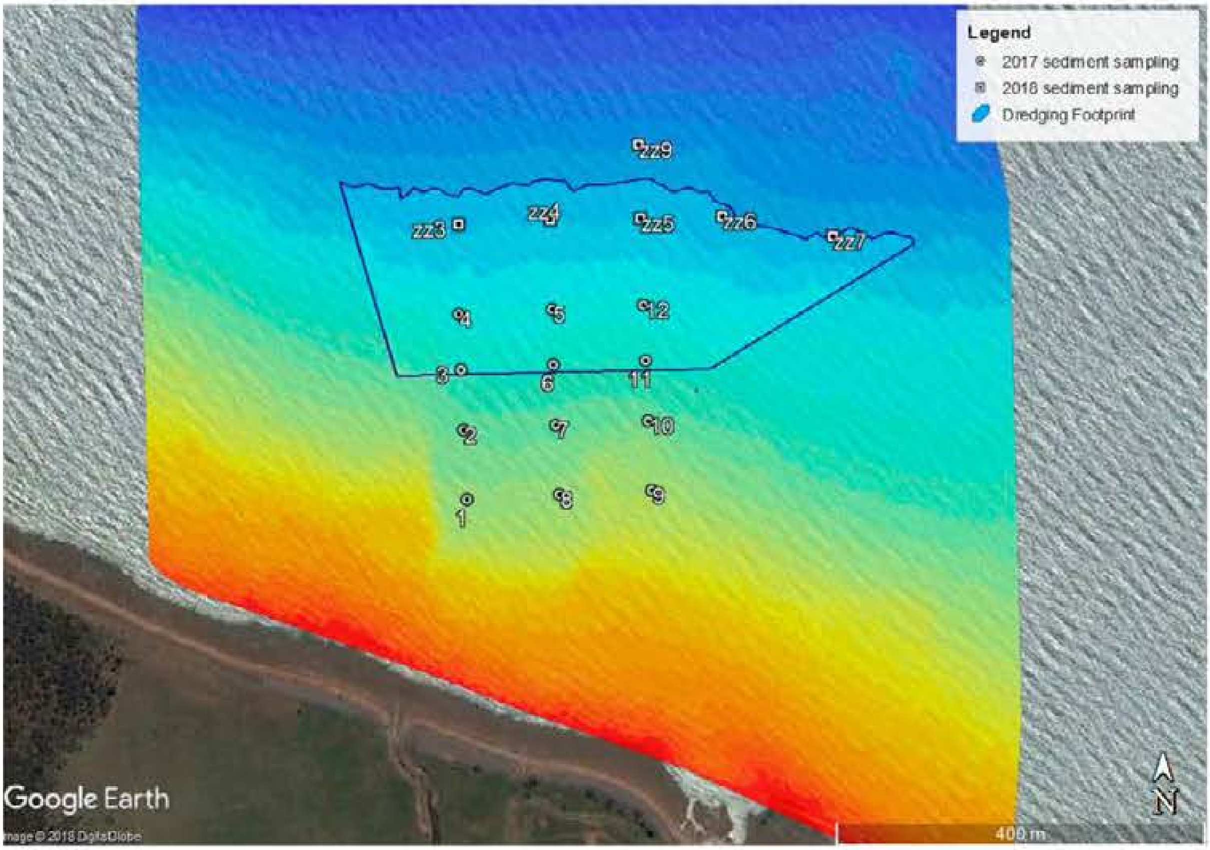

Figure 5. Sediment sampling sites

3. RESULTS

3.1 Sediment distribution

Sediment samples were collected from all sites, with some requiring two and even three attempts to collect any sediment, mainly during the drill rig sampling in 2017. The length of sediment core sample collected from each sampling site during 2017 is presented in Figure 6.

Sediment cover over hard substrate in the sampling area ranged from zero (0 cm) to 140 cm, thickest at Site SB7. This site was the only site with distinct deeper layer of organic mud from around 65 cm to 140 cm, shown in Photo 4. Site SB7 appears to be in a depression of around 200 m long by 100 m across, in which organic materials have built up with silts and clays.

The sediment samples collected during 2018 come from a relatively flat unconsolidated seabed, there is no information regarding the thickness of the sediment over the hard substrate, sampling site but no thickness are show in Figure 6 for the 2018 sampling event.

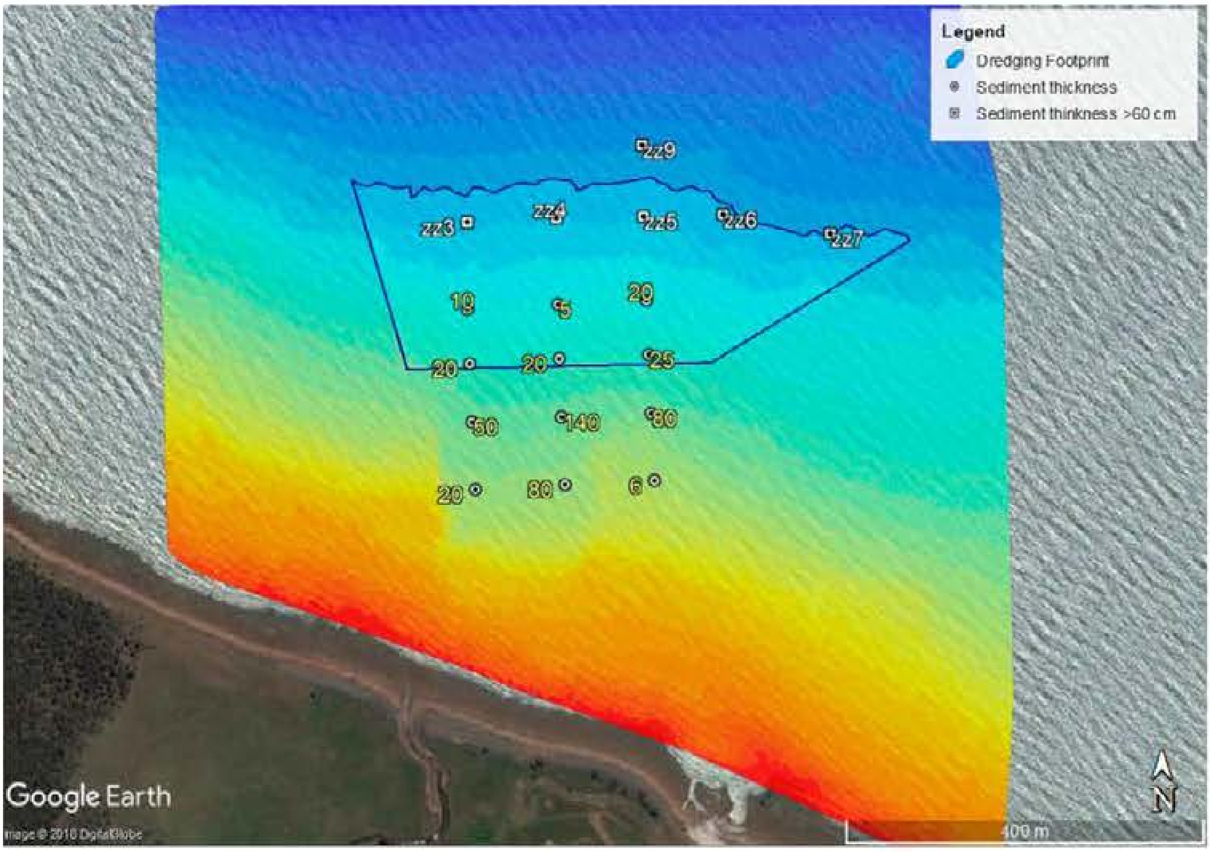

Figure 6. Sediment thickness

Table 1 provides a summary of site details, including site code, sediment core length recovered, sediment texture, number of samples collected for contaminant analysis and particle sizing and the GPS coordinates of each site. Figure 7 provides a sediment classification based on the results of particle size distribution analyses.

Table 1. Information on sampling site locations and field data

Site	Length (cm)	Description	Cont. Samp.	PSD Samp.	Easting (mE)	Northing (mS)
SB1	20	coarse sand + shell grit	1	1	719779.700	6058925.934
SB2	50	coarse sand	1	1	719777.997	6059000.915
SB3	20	coarse sand + silt	2	1	719776.521	6059065.898
SB4	10	coarse sand + organic mat.	1	0	719775.159	6059125.882
SB5	5	coarse sand / calcrete	0	1	719875.133	6059128.153
SB6	20	coarse sand + silt	1	1	719876.496	6059068.168
SB7	140	coarse sand |65| black mud	3	2	719877.972	6059003.185
SB8	80	coarse sand	2	1	719879.674	6058928.204
SB9	6	coarse sand + rock fragments	1	0	719979.649	6058930.475
SB10	80	coarse sand + rock fragments	1	1	719977.946	6059005.456
SB11	25	coarse sand + gravel	1	1	719976.470	6059070.439
SB12	20	coarse sand + rock fragments	1	1	719975.108	6059130.473
ZZ3	~60	X	1	1	719777.16	6059221.91
ZZ4	~60	X	1	1	719876.40	6059224.24
ZZ5	~60	X	1	1	719974.01	6059223.38
ZZ6	~60	X	1	1	720062.78	6059223.48
ZZ7	~60	X	1	1	720181.91	6059199.27

Site	Length (cm)	Description	Cont. Samp.	PSD Samp.	Easting (mE)	Northing (mS)
ZZ9	~60	X	1	1	719974.05	6059302.97

Key: SB = Smith Bay, ZZ = samples collected in 2018, Cont. Samp. = sample for contaminant testing, PSD Samp. = sample for particle sizing or settleability, X no description provided (see PSD), The GPS coordinates are in Zone 53H

3.2 Physical properties of sediment

Sediments from nine sites in 2017 and six in 2018 were screen for particle size distribution (PSD) using a sieve and a hydrometer. Samples from two sediment sites (SB3 and SB11) in 2017 and in all six sites in 2018 were tested for settleability of sediment in saline water. This information will be used by the sediment plume modellers. Insufficient material was available to test particle size at sites SB4 and SB9.

Sediment texture and colour were recorded in the field in 2017 but not in 2018, all sediment samples, apart from the deeper layer of Site SB7 were evaluated as coarse sands with various amounts of shell grit, fines and organic detritus, Photo 5 and Photo 6. Texture appearance was not recorded in 2018 but included in the physical parameters results presented in Appendix B.

The sediment in Smith Bay consisted mainly of sand and gravel with between 10 and 25% of fine particulates (clay and silt), apart from the deeper sediment at Site SB7 (SB-7.2), which had 59% fines (shown as SB-7.2 in the graph). The sediment samples from the 2018 sampling survey were collected from further offshore and as expected had lower fine particulate content.

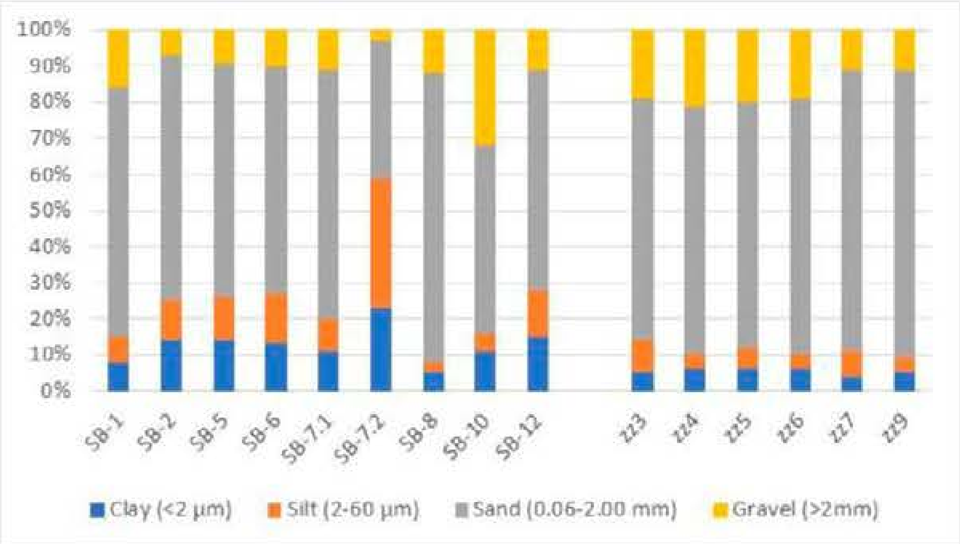

Figure 7. Sediment classification based on particle size

Particle size distribution curves were for the fifteen sediment samples are presented in XX. Note that two samples came from site SB7, upper (7.1) and lower (7.2) layers. The curves show a relatively consistent particle size distribution with site 7.2 having the finest particles and SB-10 the coarsest. The complete laboratory results for PSD is presented in Appendix B

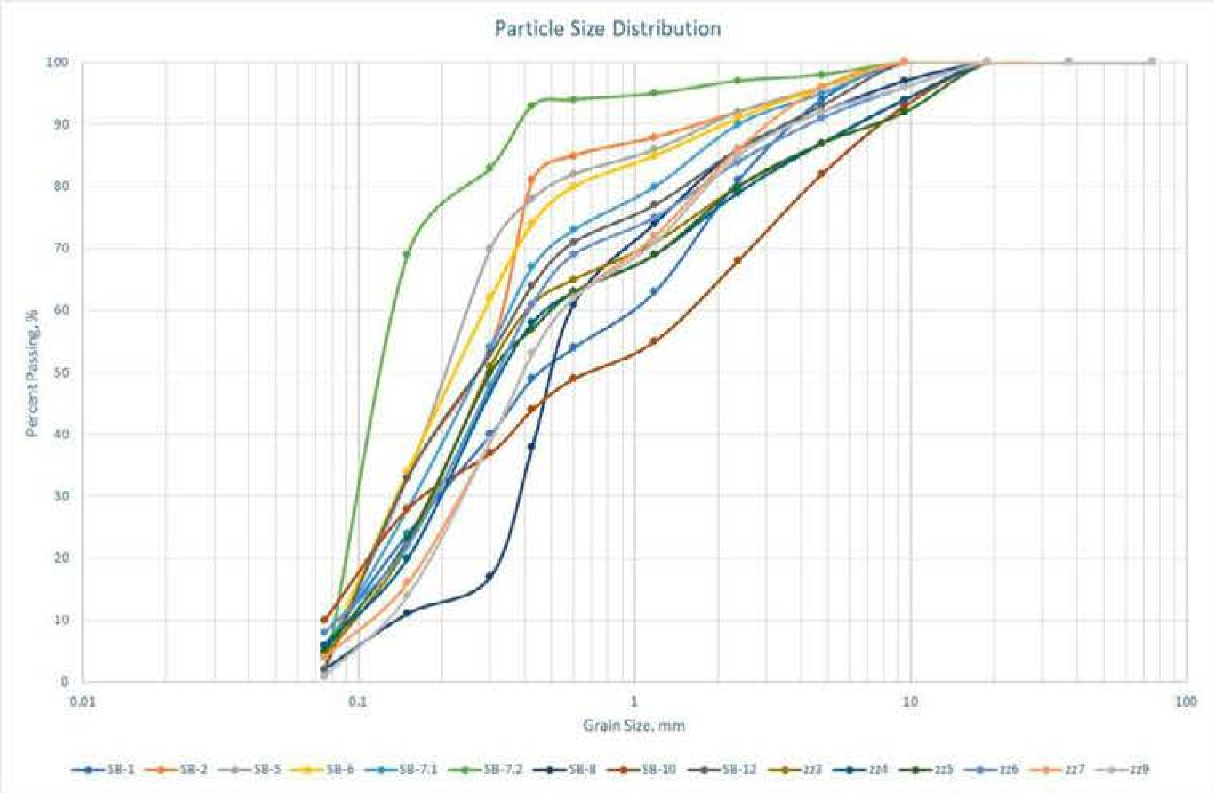

Figure 8. Sediment Particle Size Distribution Curves

The rate suspended sediment will settle is seawater (settleability 10%) was measured to provide sediment plume modellers information on how the sediment particles will settle. This measurement considers how suspended solids, when mixed with seawater will clump together and form floc will settle. The density and shape of the floc will determine the rate of settlement. Table 2 shows that sediments collected during the 2018 campaign were within the range settleability observed in 2017.

Table 2 Settleability

Settleability 10%	Unit	LOR	SB3	SB11	ZZ4	ZZ9
Underflow density	g/cm3	0.01	1.54	1.52	1.43	1.56
Underflow solids	%	0.1	59	55	49.8	49.3
Settling rate @ 50% of settlement	mm/min	0.001	10.2	52.8	18.6	18.2
Settling rate @ 90% of settlement	mm/min	0.001	10.4	52.8	18.6	18.2
Clarity			clear	clear	clear	clear

3.3 Chemical properties of sediment in Smith Bay

Testing of data quality

A field sampling methods blank was made by spraying the metal tube and drill head with mineral water prior to sampling. Test results show that two elements were detected in the rinse blank water. These were boron and lead. Boron was not measured in sediments and the level of lead in the rinse water was below the level of reporting for sediment analysis. This demonstrates that the methodology used has a very low probability of contaminating the sediment samples collected during this sampling event.

A split blank was also sent to the laboratory to test repeatability of analysis. The relative percent difference was calculated on the split sediment samples results, Appendix C. The Australian Standard for Soils (AS 4482.1-2005), gives an acceptance criteria RPD of 30-50%, noting that the variation is higher for organic than inorganic analyses. All RPD quality control results were within the Australian Standard, with iron returning the highest RPD, which was close to the limit of acceptance.

Field quality control samples were not collected on the second sampling event. Cross checking the results from the second sampling trip with the first found that the results were compatible and therefore considered to be at an acceptable standard.

Metals and metalloids in Smith Bay Sediment

Sediment samples collected from 11 sites during the 2017 sampling campaign and 6 sites in the 2018 campaign, were screened for a comprehensive suite of potential metal pollutants. No sample was found to contain any pollutants exceeding the Australian Interim Sediment Quality Guidelines for metals. The maximum sediment metal content was found in the dark mud in sample SB7.2, and arsenic content in sample SB9. All these maximums were below the ISQG (low trigger). Since all the maximums were below any trigger levels, testing of the 95 percent UCL of mean concentrations was unnecessary. All sites sampled further offshore during 2018 had lower than the maximum values for all metals.

The results of the maximum values for each element tested was compared to geological crustal abundance using the Bowden GAI Index, (Bowen, 1997). No elements were found to be significantly higher than natural crustal abundance.

Table 3. Metals in sediment compared to the Australian Interim Sediment Quality Guidelines

Analyte	ISQG (low)	ISQG (High)	Maximum
Antimony	2	25	1.64
Arsenic	20	70	11
Cadmium	1.5	10	<LOR
Chromium	80	370	26.8
Copper	65	270	10.3
Cobalt	NA	NA	5.7
Lead	50	220	5.9
Manganese	NA	NA	104
Nickel	21	52	11
Selenium	NA	NA	1.5
Silver	1	3.7	0.1
Vanadium	NA	NA	29.5
Zinc	200	410	18.4
Mercury	0.15	1	0.02

NA guideline value not available, <LOR less than level of reporting by laboratory

It was concluded that metals and metalloids found within the study area of Smith Bay do not pose any significant environmental risk. Therefore, no further testing of elutriate and dilute acid extraction (DAE) was required.

Nutrients in Sediment collected in Smith Bay

Total Nitrogen (TN) and Total Reactive Phosphorus (TRP) have organic and inorganic sources, (OzCoasts, 2017). TN concentration measured in Smith Bay sediment was the combined organic and inorganic nitrogen, analysed as Kjeldahl nitrogen (organic nitrogen and ammonia) and inorganic nitrogen (nitrates and nitrites). TN was not analysed in the 2018 sampling event.

The statistical dispersion of TN concentration in sediment within the study area is displayed by a box and whisker graph in Figure 9. The outlier (blue dot on graph) is 2,850 mg/kg TN, in sample SB7.2, from between 65 cm and 140 cm below the surface. The average (618 mg/kg) is shown as X on the plot. The median (490 mg/kg) is represented by a solid blue line dissecting the box. The upper and lower edges of the box are the first and third quartile, 290 mg/kg and 640 mg/kg TN, respectively. The whiskers show the local minimum (110 mg/kg) and maximum (690 mg/kg), that is without the outlier. Note that the local maximum is sample SB7.1, the upper layer of sediment at site SB7.

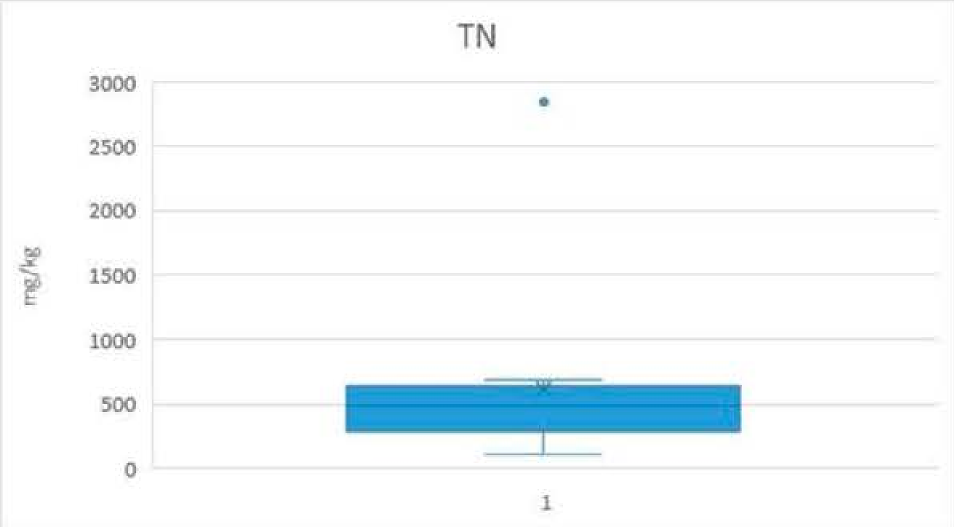

Figure 9. Box and whiskers plot of total nitrogen in Smith Bay

The distribution of nitrogen in the upper sediment layers is relatively consistent, with a coefficient of variation of 44%. The geospatial distribution of nitrogen in the upper layers of sediment in Smith Bay is shown on a site map in Figure 10.

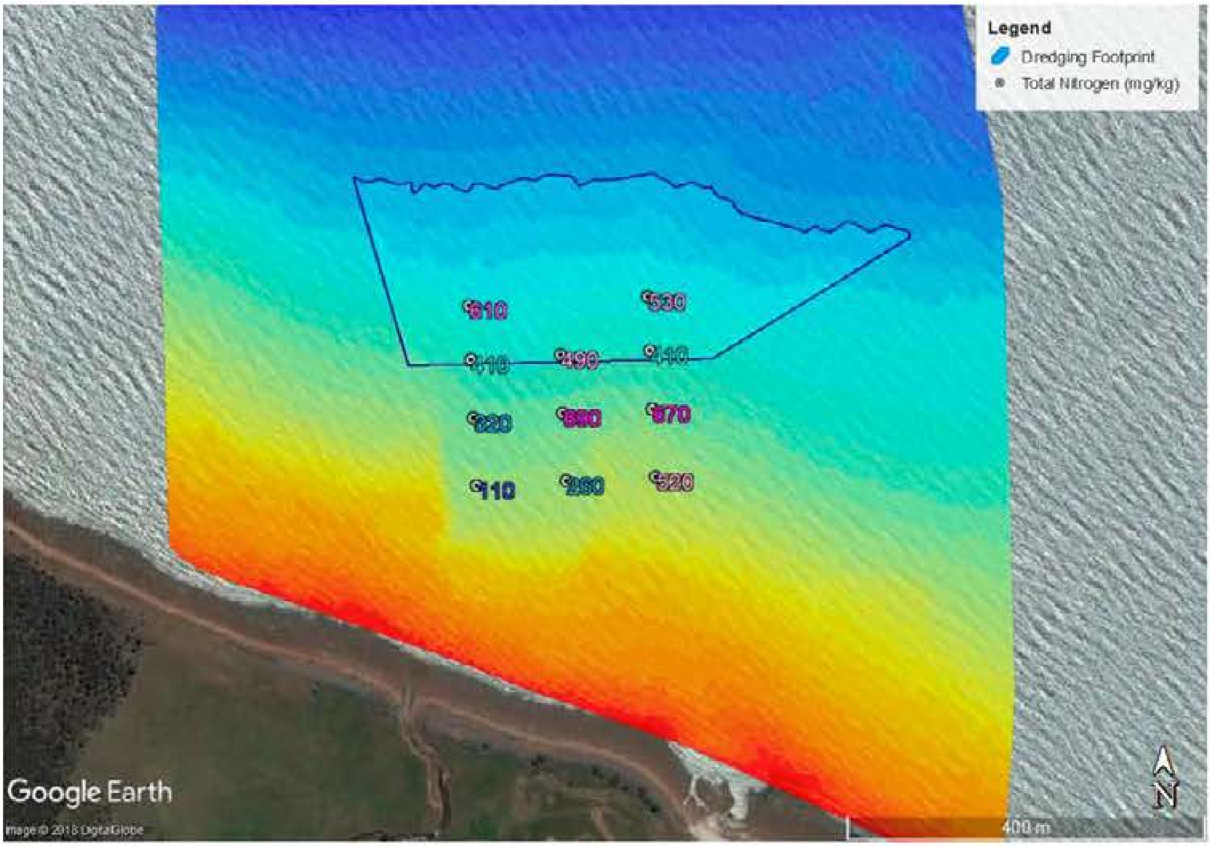

Figure 10. Total nitrogen (mg/kg) in Smith Bay sediment Smith Bay

Total reactive phosphorus ranged from below the level of detection 0.1 mg/kg at several sites to 2.1 mg/kg at Site SB10, Figure 11. The maximum TRP concentration found 2018 sediment samples was 0.3 mg/kg. No South Australian marine sediment data for TP or total reactive phosphorus was available for comparison, but the overall level of phosphorus in the sediment off Smith Bay was very low and assumed to be typical of nutrient poor, seabed environments.

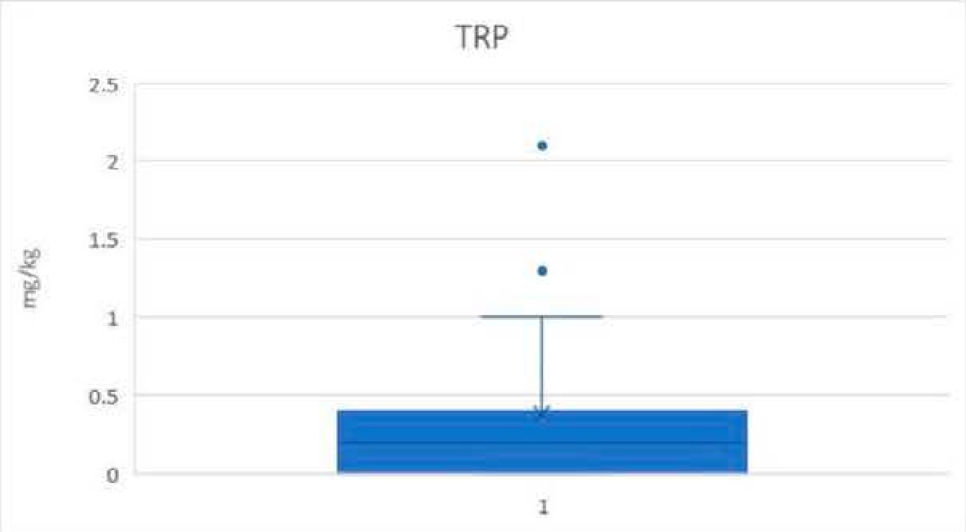

Figure 11. Box and whiskers plot of total reactive phosphorus

Organic Carbon in Smith Bay

The total organic carbon (TOC) concentration in marine sediment refers to the amount of organic matter preserved within the sediment. The amount of organic matter at the time of sampling is a function of organic matter from terrestrial and marine origins settling on the seabed, burial by tidal and wave action, and decomposition by chemical and microbial processes.

The rate of decomposition of organic matter increases as nitrogen and phosphorus content increase. Sediment analysis found relatively low organic matter within the study area, except for the dark mud in sample SB7.2. The box and whisker plot for total organic carbon is presented in Figure 12.

The outlier (blue dot on graph) is sample SB7.2 with a concentration of 4.47 mg/kg TOC. This is statistically different to the other sediment samples, which range between 0.17 and 0.76 mg/kg TOC with a median of 0.6 mg/kg TOC.

This range of TOC is comparable to sediment sampling undertaken by the researcher in Gulf St Vincent, with TOC concentrations between 0.18 and 1.96 mg/kg, and in the Upper Spencer Gulf, with TOC concentrations between 0.45 and 0.67 mg/kg.

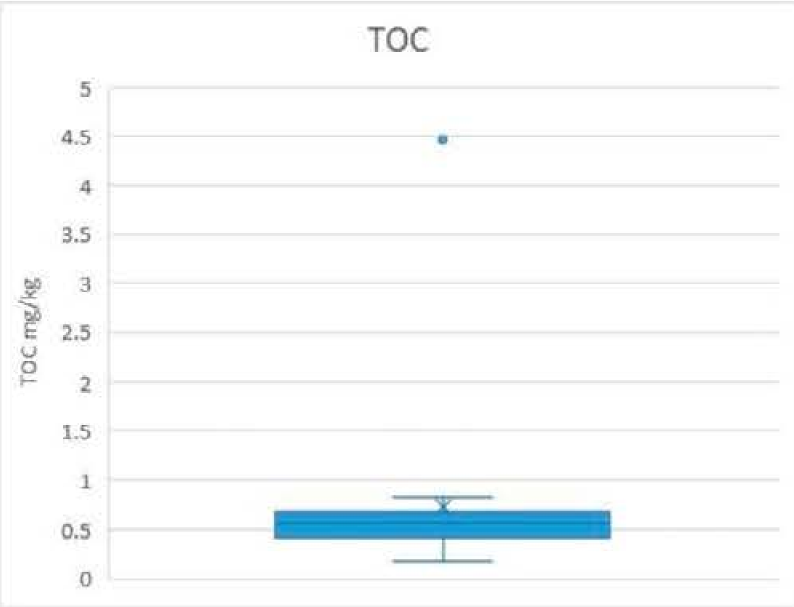

Figure 12. Box and whiskers plot of total organic carbon in Smith Bay

Synthetic Chemicals

A comprehensive suite of potential chemical pollutants was screened as outlined in Section 1.3. These included phenolic compounds, petroleum hydrocarbons and organotin compounds. No sediment samples were found to contain any detectable concentration of these compound. The levels of detection were below the relevant ISQG screening level low trigger values.

Phenols

Phenols can occur naturally in the environment as a product of organic matter decomposition and combustion of wood. Phenols have many uses in society, from general disinfectant, in the manufacture of artificial resins, medical and industrial organic compounds and dyes. It is also used in the manufacture of fertilisers, explosives, paints and paint removers, drugs, pharmaceuticals and textiles.

No detectable concentrations of the 12 phenolic compounds analysed were found in any sediment sample from Smith Bay.

TPH and TRH

Total petroleum and recoverable hydrocarbons (TPH and TRH) analysis of sediment in Smith Bay was used to quantify the concentrations of potential hydrocarbon contamination by petroleum products. TRH is currently being phased in to replace TPH by the Australian National Environment Protection Council (ANEPC) for the assessment of site contamination.

TRH includes many different chemicals found in crude oil and in other petroleum products. Since it is impractical to measure each one separately, TRH is a useful measure for all these compounds. TRH is measured and reported at various levels. These complex mixtures of organic compounds are reported in bands C6-C9, C10-16, C16-C34 and C34-C40. In this study the volatile hydrocarbons C6-C9 range were not measured. The C10-C16 band captures diesel oils and the higher bands capture crude or heavy fuel oils used in shipping.

The screening trigger level for TRH marine sediments is 550 mg/kg. The level of detection by the NATA certified laboratory was between 50 and 100 mg/kg depending on the carbon chain length. No detectable TRH in any fraction tested was found in sediments from Smith Bay.

Traces of TRH within the C16 and C34 fraction were observed during the 2018 sediment survey in two sites, zz3 and zz5 at 3 and 4 mg/kg. These results are at or very near the ultra-trace detection level of 3 mg/kg and can therefore be considered as negligible.

Organotin Compounds

Organotins are powerful fungicides and bactericides. Tributyltins are industrial biocides used in antifouling paints and in wood treatment and preservation. They find use as disinfectants and agents for destroying molluscs.

Tributyltin is an active ingredient in antifouling ship paints, known to be highly toxic to many species of aquatic organisms at parts per million level or even lower. Non-target aquatic organisms such as crustaceans, molluscs, mussels, clams and oysters may suffer structural changes, growth retardation and death.

Three groups of organotin compounds were analysed in sediment samples from Smith Bay. No sample was found to contain any detectable organotin. The ANZECC 2000 Interim Sediment Quality Guideline for Tributyltin (as Sn) is 5 µg Sn/kg, and the limit of detection for this study was 0.5 µg Sn/kg. Therefore, it is concluded that all sediment samples in Smith Bay study area were below the ANZECC ISQG (trigger) for organotin.

Organophosphorus and Organochlorine Pesticides

Twenty (20) organophosphorus pesticides (OP) and twenty-two (22) organochlorine pesticides (OC) were tested in thirteen sediment samples and one duplicate at the ultra-trace level. No samples had any detectable organochlorine or organophosphate pesticides.

Polychlorinated biphenyls and Polyaromatic Hydrocarbons

Seven polychlorinated biphenyls (PCB) and twenty (20) polynuclear aromatic hydrocarbons (PAH) were tested in thirteen sediment samples and one duplicate at the ultra-trace level. None were detected apart from sediment sample 7.2 which reported 0.091 mg/kg of Perylene, which is a fluorescent dye. This result is well below the NEPM soil contamination level for a domestic household of 20.0 mg/kg for all PAH combined. Note that this area is no longer within the current proposed extent of the dredge area, Figure 5.

Acid Sulfate Soils

The sediment was comprised of sandy to coarse grained sand, and no odours were detected in the sediment apart from the deep sediment at site SB7. Preliminary literature review of the CSIRO database indicates that there is no Potential Acid Sulfate Soil (PASS) sediments in Smith Bay, (ASRIS, 2017).

The organic sediment found below 65 cm at site SB7 had a neutral pH of 6.5. No additional testing for PASS properties in marine sediment was undertaken.

4. CONCLUSIONS

Sediment samples collected from the area of the proposed dredging for the proposed Kangaroo Island Seaport in two sampling events were tested for a range of physical and chemical properties. The second sampling event was undertaken to accommodate a relocated dredge footprint and seaport infrastructure.

Sediment in the 2017 study area ranged from zero cover to 140 cm cover over the hard, underlying substrate. Sediment thickness at all sites collected during the 2018 survey were deeper than 60 cm. The sediment colour was mostly light grey with white and dark speckled coarse sand containing some gravels, organic detritus and fine particles. One sample from deeper than 65 cm at site SB7 had a much higher fine fraction with high levels of organic material. It was assumed that this sampling site came from a depression on the seabed in an area of 100 m by 200 m.

The levels of metal and metalloid content tested in all sediment samples were below the Australian ISQG (low trigger) and within natural crustal abundance levels (Bowden GAI). No detectable hydrocarbons, phenols or organotins were found. Ultra-low detection levels for organochlorines pesticides, organophosphorus pesticides, polychlorinated biphenyls and polynuclear aromatic hydrocarbons were also tested and no detectable levels were found, apart from a trace of perylene (a fluorescent dye) in one sample. This area is no longer within the extent of the current proposed dredge area

This supports the assumption that the proposed dredging area is not contaminated by any of the range of pollutants tested.

5. REFERENCES

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APPENDICES

Appendix A. Photographs

Photo 1. Marine sediment drilling rig

Photo 2. Sediment core in PVC tube recovered from metal drill bit

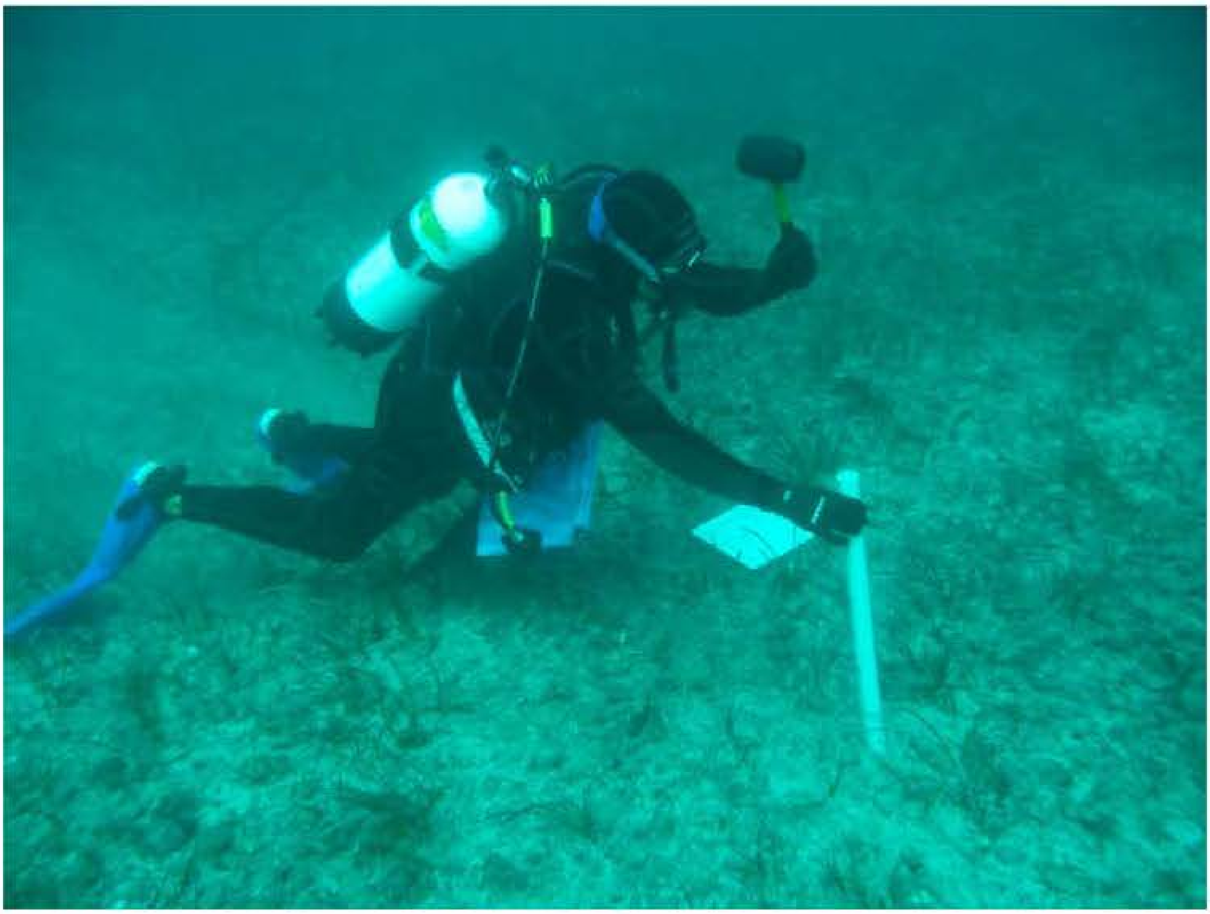
Photo 3. Logging core in open PVC tube

Photo 4. Site 7 layer of organic mud from 65cm to 140 cm

Photo 5. Sediment from the Smith Bay study area

Photo 6. Close-up of sediment showing coarse sand grain

Photo 7. SCUBA diver collecting sediment samples in August 2018



Appendix B. Particle Sizing and Settleability.

Particle Sizing	SB-1	SB-2	SB-5	SB-6	SB-7.1	SB-7.2	SB-8	SB-10	SB-12	zz3	zz4	zz5	zz6	zz7	zz9
+75 µm	82	69	71	70	77	32	91	82	69	82	86	82	86	88	87
+150 µm	66	48	34	42	51	18	85	73	49	53	59	55	60	65	62
+300 µm	57	21	26	30	38	8	64	66	38	43	48	48	47	51	48
+425 µm	52	17	22	24	32	7	41	61	31	39	43	42	39	42	39
+600 µm	43	14	18	19	25	6	28	55	25	33	37	36	33	32	30
+1180 µm	25	10	12	13	15	4	16	42	16	24	27	25	24	18	16
+2.36 mm	12	6	8	8	10	3	10	28	9	17	19	18	17	8	9
+4.75 mm	6	2	4	4	5	1	5	17	2	10	12	13	12	4	5
+9.5 mm	<1	<1	<1	<1	<1	<1	2	10	<1	4	6	5	8	<1	1
+19.0 mm	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
+37.5 mm	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
+75.0 mm	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

Settleability 10%	Unit	LOR	zz4	zz9	SB-3	SB-11
Underflow Density	g/cm^3	0.01	1.43	1.56	1.54	1.52
Underflow Solids	%	0.1	49.8	49.3	59	55
Settling Rate @ 50% of Settlement	mm/min	0.001	18.6	18.2	10.2	52.8
Settling Rate @ 90% of Settlement	mm/min	0.001	18.6	18.2	10.4	52.8
Clarity			transparent	transparent	transparent	transparent

Appendix C. Relative Percent Difference of Sediment Split Sample.

Analyte	RPD (SB7)
Aluminium	-2%
Iron	47%
Antimony	-2%
Arsenic	15%
Cadmium	<
Chromium	-8%
Copper	<
Cobalt	<
Lead	-15%
Manganese	-17%
Nickel	-4%
Selenium	22%
Silver	<
Vanadium	3%
Zinc	-18%
Mercury	0%
Total Nitrogen as N	3%
Reactive Phosphorus as P	-29%
Total Organic Carbon	10%
Phenol	<
2-Chlorophenol	<
2-Methylphenol	<
3- & 4-Methylphenol	<
2-Nitrophenol	<
2.4-Dimethylphenol	<
2.4-Dichlorophenol	<
2.6-Dichlorophenol	<
4-Chloro-3-methylphenol	<
2.4.6-Trichlorophenol	<
2.4.5-Trichlorophenol	<
Pentachlorophenol	<
C10 - C14 Fraction	<
C15 - C28 Fraction	<
C29 - C36 Fraction	<
C10 - C36 Fraction (sum)	<
>C10 - C16 Fraction	<
>C16 - C34 Fraction	<
>C34 - C40 Fraction	<
>C10 - C40 Fraction (sum)	<
Monobutyltin	<
Dibutyltin	<
Tributyltin	<

Key: < means the result was less than the level of reporting (or limit of detection)

Cooe

Appendix D. NATA Certified Laboratory Results

2017 Survey

Primary ID	unit	LOR	SB1	SB2	SB3	SB4	SB6	SB7	SB7	SB8	SB8	SB9	SB10	SB11	SB 12
Level			1	1	1	1	1	1	2	1	2	1	1	1	1
Metals															
Aluminium	mg/kg	50	3370	4210	850	910	670	810	11700	510	550	4160	820	540	770
Iron	mg/kg	50	2900	4290	2020	2440	1890	1560	17900	1260	1440	4560	1600	1320	1770
Antimony	mg/kg	0.5	<0.50	0.54	1.37	0.55	1.64	<0.50	<0.50	1.35	0.71	0.6	<0.50	0.78	0.51
Arsenic	mg/kg	1	3.15	4.43	4.71	3.73	5	2.19	7.36	3.08	2.86	11	1.91	2.68	2.97
Cadmium	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	mg/kg	1	7.4	8.1	6.9	7.4	5.9	6.2	26.8	5.9	7.2	9.6	6.1	5.8	6.7
Copper	mg/kg	1	1.2	1.5	<1.0	1.1	<1.0	<1.0	10.3	<1.0	<1.0	1.1	<1.0	<1.0	<1.0
Cobalt	mg/kg	0.5	0.7	0.9	<0.5	<0.5	<0.5	<0.5	5.7	<0.5	<0.5	3.4	<0.5	<0.5	<0.5
Lead	mg/kg	1	<1.0	1.4	1.2	1.3	<1.0	1.1	5.9	<1.0	<1.0	1.4	1.2	<1.0	1.1
Manganese	mg/kg	10	20	25	20	21	14	20	104	17	19	73	22	14	18
Nickel	mg/kg	1	2.4	2.6	3	2.9	3	2.2	11	2.2	2.2	5.4	2.4	2.4	2.4
Selenium	mg/kg	0.1	0.5	0.4	0.7	0.6	0.8	0.4	1.5	0.6	0.6	1.1	0.5	0.6	0.5
Silver	mg/kg	0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Vanadium	mg/kg	2	7.6	9.8	12.9	8.6	16.7	5.6	29.5	12.8	8	11.6	5.3	13.2	8.4
Zinc	mg/kg	1	5	3.6	3.7	3.9	3.2	3.8	18.4	2.2	2.6	4.6	4.6	2.2	3.3
Mercury	mg/kg	0.01	<0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.02	<0.01	<0.01	0.01
Nutrients															
Total Nitrogen as N	mg/kg	20	110	320	410	610	490	690	2850	260	160	520	670	410	530
Reactive Phosphorus as P	mg/kg	0.1	0.1	0.4	0.4	0.2	<0.1	1	<0.1	<0.1	<0.1	1	2.1	<0.1	1.3
Total Organic Carbon	%	0.02	0.41	0.69	0.65	0.76	0.68	0.6	4.47	0.39	0.17	0.52	0.64	0.45	0.56
Phenolic Compounds															
Phenol	mg/kg	0.5	x	<0.5	x	x	x	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	x	x
2-Chlorophenol	mg/kg	0.5	x	<0.5	x	x	x	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	x	x
2-Methylphenol	mg/kg	0.5	x	<0.5	x	x	x	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	x	x
3- & 4-Methylphenol	mg/kg	1	x	<1	x	x	x	<1	<1	<1	<1	<1	<1	x	x

Primary ID	unit	LOR	SB1	SB2	SB3	SB4	SB6	SB7	SB7	SB8	SB8	SB9	SB10	SB11	SB 12
Level			1	1	1	1	1	1	2	1	2	1	1	1	1
2-Nitrophenol	mg/kg	0.5	x	<0.5	x	x	x	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	x	x
2.4-Dimethylphenol	mg/kg	0.5	x	<0.5	x	x	x	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	x	x
2.4-Dichlorophenol	mg/kg	0.5	x	<0.5	x	x	x	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	x	x
2.6-Dichlorophenol	mg/kg	0.5	x	<0.5	x	x	x	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	x	x
4-Chloro-3-methylphenol	mg/kg	0.5	x	<0.5	x	x	x	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	x	x
2.4.6-Trichlorophenol	mg/kg	0.5	x	<0.5	x	x	x	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	x	x
2.4.5-Trichlorophenol	mg/kg	0.5	x	<0.5	x	x	x	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	x	x
Pentachlorophenol	mg/kg	2	x	<2	x	x	x	<2	<2	<2	<2	<2	<2	x	x
Total Petroleum Hydrocarbons															
C10 - C14 Fraction	mg/kg	50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
C15 - C28 Fraction	mg/kg	100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
C29 - C36 Fraction	mg/kg	100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
C10 - C36 Fraction (sum)	mg/kg	50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Total Recoverable Hydrocarbons															
>C10 - C16 Fraction	mg/kg	50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
>C16 - C34 Fraction	mg/kg	100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
>C34 - C40 Fraction	mg/kg	100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
>C10 - C40 Fraction (sum)	mg/kg	50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Organotin Compounds															
Monobutyltin	µgSn/kg	1	x	<1	x	x	x	<1	<1	<1	<1	<1	<1	x	x
Dibutyltin	µgSn/kg	1	x	<1	x	x	x	<1	<1	<1	<1	<1	<1	x	x
Tributyltin	µgSn/kg	0.5	x	<0.5	x	x	x	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	x	x
Organophosphorus Pesticides (Ultra-trace)															
Bromophos-ethyl	µg/kg	10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Carbophenothion	µg/kg	10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Chlorfenvinphos (E)	µg/kg	10	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
Chlorfenvinphos (Z)	µg/kg	10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Chlorpyrifos	µg/kg	10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Chlorpyrifos-methyl	µg/kg	10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

Primary ID	unit	LOR	SB1	SB2	SB3	SB4	SB6	SB7	SB7	SB8	SB8	SB9	SB10	SB11	SB 12
Level			1	1	1	1	1	1	2	1	2	1	1	1	1
Demeton-S-methyl	µg/kg	10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Diazinon	µg/kg	10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Dichlorvos	µg/kg	10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Dimethoate	µg/kg	10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Ethion	µg/kg	10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Fenamiphos	µg/kg	10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Fenthion	µg/kg	10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Malathion	µg/kg	10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Azinphos Methyl	µg/kg	10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Monocrotophos	µg/kg	10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Parathion	µg/kg	10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Parathion-methyl	µg/kg	10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Pirimphos-ethyl	µg/kg	10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Prothiofos	µg/kg	10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Organochlorine Pesticides															
Aldrin	µg/kg	0.5	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
alpha-BHC	µg/kg	0.5	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
beta-BHC	µg/kg	0.5	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
delta-BHC	µg/kg	0.5	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
4.4`-DDD	µg/kg	0.5	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
4.4`-DDE	µg/kg	0.5	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
4.4`-DDT	µg/kg	0.5	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Sum of DDD + DDE + DDT	µg/kg	0.5	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Dieldrin	µg/kg	0.5	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
alpha-Endosulfan	µg/kg	0.5	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
beta-Endosulfan	µg/kg	0.5	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Endosulfan sulfate	µg/kg	0.5	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Endosulfan (sum)	µg/kg	0.5	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Endrin	µg/kg	0.5	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Endrin aldehyde	µg/kg	0.5	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50

Primary ID	unit	LOR	SB1	SB2	SB3	SB4	SB6	SB7	SB7	SB8	SB8	SB9	SB10	SB11	SB 12
Level			1	1	1	1	1	1	2	1	2	1	1	1	1
Endrin ketone	µg/kg	0.5	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Heptachlor	µg/kg	0.5	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Heptachlor epoxide	µg/kg	0.5	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Hexachlorobenzene (HCB)	µg/kg	0.5	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
gamma-BHC	µg/kg	0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
Methoxychlor	µg/kg	0.5	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
cis-Chlordane	µg/kg	0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
trans-Chlordane	µg/kg	0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
Total Chlordane (sum)	µg/kg	0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
Oxychlordane	µg/kg	0.5	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Total Polychlorinated biphenyls	µg/kg	5	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Aroclor 1016	µg/kg	5	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Aroclor 1221	µg/kg	5	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Aroclor 1232	µg/kg	5	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Aroclor 1242	µg/kg	5	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Aroclor 1248	µg/kg	5	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Aroclor 1254	µg/kg	5	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Aroclor 1260	µg/kg	5	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Polynuclear Aromatic Hydrocarbons															
Naphthalene	µg/kg	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
2-Methylnaphthalene	µg/kg	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Acenaphthylene	µg/kg	4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Acenaphthene	µg/kg	4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Fluorene	µg/kg	4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Phenanthrene	µg/kg	4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Anthracene	µg/kg	4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Fluoranthene	µg/kg	4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Pyrene	µg/kg	4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Benz(a)anthracene	µg/kg	4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4

Primary ID	unit	LOR	SB1	SB2	SB3	SB4	SB6	SB7	SB7	SB8	SB8	SB9	SB10	SB11	SB 12
Level			1	1	1	1	1	1	2	1	2	1	1	1	1
Chrysene	µg/kg	4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Benzo(b+j)fluoranthene	µg/kg	4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Benzo(k)fluoranthene	µg/kg	4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Benzo(e)pyrene	µg/kg	4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Benzo(a)pyrene	µg/kg	4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Perylene	µg/kg	4	<4	<4	<4	<4	<4	<4	91	<4	<4	<4	<4	<4	<4
Benzo(g.h.i)perylene	µg/kg	4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Dibenz(a.h)anthracene	µg/kg	4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Indeno(1.2.3.cd)pyrene	µg/kg	4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Coronene	µg/kg	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Sum of PAHs	µg/kg	4	<4	<4	<4	<4	<4	<4	91	<4	<4	<4	<4	<4	<4

2018 Survey

Site			zz3	zz4	zz5	zz6	zz7	zz9
Analyte grouping/Analyte	**Units**	**LOR**						
Moisture Content	%	1	37.2	35.8	37.4	29.8	32.2	36.7
Total Metals in Sediments by ICP-AES								
Aluminium	mg/kg	50	2670	760	910	760	520	530
Iron	mg/kg	50	1920	1590	1930	1410	1070	1090
Total Metals in Sediments by ICPMS								
Antimony	mg/kg	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Arsenic	mg/kg	1	2.39	3.33	2.92	2.1	1.46	1.18
Cadmium	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	mg/kg	1	6.7	5.9	5.6	4.8	4.6	4.4
Copper	mg/kg	1	1.1	<1	<1	<1	<1	<1
Cobalt	mg/kg	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Lead	mg/kg	1	1.4	1.4	1.3	1	<1	<1
Manganese	mg/kg	10	19	14	16	14	12	11

Site			zz3	zz4	zz5	zz6	zz7	zz9
Analyte grouping/Analyte	**Units**	**LOR**						
Nickel	mg/kg	1	2.7	1.2	2.3	1.8	1.4	1.2
Selenium	mg/kg	0.1	0.4	0.5	0.4	0.3	0.2	0.2
Silver	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Vanadium	mg/kg	2	9.4	14	7.2	5.9	3.8	3.9
Zinc	mg/kg	1	4.5	4.7	3.5	17.4	4.8	2
Total Recoverable Mercury by FIMS								
Mercury	mg/kg	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total Nitrogen as N (TKN + NOx)								
Total Nitrogen as N	mg/kg	20						
Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	mg/kg	0.1	0.3	<0.1	0.2	0.2	<0.1	<0.1
Total Organic Carbon								
Total Organic Carbon	%	0.02	0.63	0.83	0.47	0.41	0.31	0.27
Phenolic Compounds								
Phenol	mg/kg	0.5	<0.5	x	<0.5	x	<0.5	x
2-Chlorophenol	mg/kg	0.5	<0.5		<0.5		<0.5	
2-Methylphenol	mg/kg	0.5	<0.5	x	<0.5	x	<0.5	x
3- & 4-Methylphenol	mg/kg	1	<1	x	<1	x	<1	x
2-Nitrophenol	mg/kg	0.5	<0.5	x	<0.5	x	<0.5	x
2.4-Dimethylphenol	mg/kg	0.5	<0.5	x	<0.5	x	<0.5	x
2.4-Dichlorophenol	mg/kg	0.5	<0.5	x	<0.5	x	<0.5	x
2.6-Dichlorophenol	mg/kg	0.5	<0.5	x	<0.5	x	<0.5	x
4-Chloro-3-methylphenol	mg/kg	0.5						
2.4.6-Trichlorophenol	mg/kg	0.5	<0.5	x	<0.5	x	<0.5	x
2.4.5-Trichlorophenol	mg/kg	0.5	<0.5	x	<0.5	x	<0.5	x
Pentachlorophenol	mg/kg	2	x	x	x	x	x	x
Total Petroleum Hydrocarbons								
C10 - C14 Fraction	mg/kg	50	<3	x	<3	x	<3	x
C15 - C28 Fraction	mg/kg	100	<3	x	<3	x	<3	x

Site			zz3	zz4	zz5	zz6	zz7	zz9
Analyte grouping/Analyte	**Units**	**LOR**						
C29 - C36 Fraction	mg/kg	100	<5	x	<5	x	<5	x
C10 - C36 Fraction (sum)	mg/kg	50	<3	x	<3	x	<3	x
Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
>C10 - C16 Fraction	mg/kg	50	<3	x	<3	x	<3	x
>C16 - C34 Fraction	mg/kg	100	3	x	4	x	<3	x
>C34 - C40 Fraction	mg/kg	100	<5	x	<5	x	<5	x
>C10 - C40 Fraction (sum)	mg/kg	50	3	x	4	x	<3	x
Organotin Compounds								
Monobutyltin	µgSn/kg	1	<1	x	<1	x	<1	x
Dibutyltin	µgSn/kg	1	<1	x	<1	x	<1	x
Tributyltin	µgSn/kg	0.5	<0.5	x	<0.5	x	<0.5	x
Organophosphorus Pesticides								
Bromophos-ethyl	µg/kg	10	<10	----	<10	----	<10	----
Carbophenothion	µg/kg	10	<10	----	<10	----	<10	----
Chlorfenvinphos (E)	µg/kg	10	<10.0	----	<10.0	----	<10.0	----
Chlorfenvinphos (Z)	µg/kg	10	<10	----	<10	----	<10	----
Chlorpyrifos	µg/kg	10	<10	----	<10	----	<10	----
Chlorpyrifos-methyl	µg/kg	10	<10	----	<10	----	<10	----
Demeton-S-methyl	µg/kg	10	<10	----	<10	----	<10	----
Diazinon	µg/kg	10	<10	----	<10	----	<10	----
Dichlorvos	µg/kg	10	<10	----	<10	----	<10	----
Dimethoate	µg/kg	10	<10	----	<10	----	<10	----
Ethion	µg/kg	10	<10	----	<10	----	<10	----
Fenamiphos	µg/kg	10	<10	----	<10	----	<10	----
Fenthion	µg/kg	10	<10	----	<10	----	<10	----
Malathion	µg/kg	10	<10	----	<10	----	<10	----
Azinphos Methyl	µg/kg	10	<10	----	<10	----	<10	----
Monocrotophos	µg/kg	10	<10	----	<10	----	<10	----

Site			zz3	zz4	zz5	zz6	zz7	zz9
Analyte grouping/Analyte	**Units**	**LOR**						
Parathion	µg/kg	10	<10	----	<10	----	<10	----
Parathion-methyl	µg/kg	10	<10	----	<10	----	<10	----
Pirimphos-ethyl	µg/kg	10	<10	----	<10	----	<10	----
Prothiofos	µg/kg	10	<10	----	<10	----	<10	----
Organochlorine Pesticides								
Aldrin	µg/kg	0.5	<0.50	----	<0.50	----	<0.50	----
alpha-BHC	µg/kg	0.5	<0.50	----	<0.50	----	<0.50	----
beta-BHC	µg/kg	0.5	<0.50	----	<0.50	----	<0.50	----
delta-BHC	µg/kg	0.5	<0.50	----	<0.50	----	<0.50	----
4.4`-DDD	µg/kg	0.5	<0.50	----	<0.50	----	<0.50	----
4.4`-DDE	µg/kg	0.5	<0.50	----	<0.50	----	<0.50	----
4.4`-DDT	µg/kg	0.5	<0.50	----	<0.50	----	<0.50	----
Sum of DDD + DDE + DDT	µg/kg	0.5	<0.50	----	<0.50	----	<0.50	----
Dieldrin	µg/kg	0.5	<0.50	----	<0.50	----	<0.50	----
alpha-Endosulfan	µg/kg	0.5	<0.50	----	<0.50	----	<0.50	----
beta-Endosulfan	µg/kg	0.5	<0.50	----	<0.50	----	<0.50	----
Endosulfan sulfate	µg/kg	0.5	<0.50	----	<0.50	----	<0.50	----
Endosulfan (sum)	µg/kg	0.5	<0.50	----	<0.50	----	<0.50	----
Endrin	µg/kg	0.5	<0.50	----	<0.50	----	<0.50	----
Endrin aldehyde	µg/kg	0.5	<0.50	----	<0.50	----	<0.50	----
Endrin ketone	µg/kg	0.5	<0.50	----	<0.50	----	<0.50	----
Heptachlor	µg/kg	0.5	<0.50	----	<0.50	----	<0.50	----
Heptachlor epoxide	µg/kg	0.5	<0.50	----	<0.50	----	<0.50	----
Hexachlorobenzene (HCB)	µg/kg	0.5	<0.50	----	<0.50	----	<0.50	----
gamma-BHC	µg/kg	0.25	<0.25	----	<0.25	----	<0.25	----
Methoxychlor	µg/kg	0.5	<0.50	----	<0.50	----	<0.50	----
cis-Chlordane	µg/kg	0.25	<0.25	----	<0.25	----	<0.25	----
trans-Chlordane	µg/kg	0.25	<0.25	----	<0.25	----	<0.25	----
Total Chlordane (sum)	µg/kg	0.25	<0.25	----	<0.25	----	<0.25	----

Site			zz3	zz4	zz5	zz6	zz7	zz9
Analyte grouping/Analyte	Units	LOR						
Oxychlordane	µg/kg	0.5	<0.50	----	<0.50	----	<0.50	----
Polychlorinated Biphenyls								
Total Polychlorinated biphenyls	µg/kg	5	<5.0	----	<5.0	----	<5.0	----
Aroclor 1016	µg/kg	5	<5.0	----	<5.0	----	<5.0	----
Aroclor 1221	µg/kg	5	<5.0	----	<5.0	----	<5.0	----
Aroclor 1232	µg/kg	5	<5.0	----	<5.0	----	<5.0	----
Aroclor 1242	µg/kg	5	<5.0	----	<5.0	----	<5.0	----
Aroclor 1248	µg/kg	5	<5.0	----	<5.0	----	<5.0	----
Aroclor 1254	µg/kg	5	<5.0	----	<5.0	----	<5.0	----
Aroclor 1260	µg/kg	5	<5.0	----	<5.0	----	<5.0	----
Polynuclear Aromatic Hydrocarbons								
Naphthalene	µg/kg	5	<5	----	<5	----	<5	----
2-Methylnaphthalene	µg/kg	5	<5	----	<5	----	<5	----
Acenaphthylene	µg/kg	4	<4	----	<4	----	<4	----
Acenaphthene	µg/kg	4	<4	----	<4	----	<4	----
Fluorene	µg/kg	4	<4	----	<4	----	<4	----
Phenanthrene	µg/kg	4	<4	----	<4	----	<4	----
Anthracene	µg/kg	4	<4	----	<4	----	<4	----
Fluoranthene	µg/kg	4	<4	----	<4	----	<4	----
Pyrene	µg/kg	4	<4	----	<4	----	<4	----
Benz(a)anthracene	µg/kg	4	<4	----	<4	----	<4	----
Chrysene	µg/kg	4	<4	----	<4	----	<4	----
Benzo(b+j)fluoranthene	µg/kg	4	<4	----	<4	----	<4	----
Benzo(k)fluoranthene	µg/kg	4	<4	----	<4	----	<4	----
Benzo(e)pyrene	µg/kg	4	<4	----	<4	----	<4	----
Benzo(a)pyrene	µg/kg	4	<4	----	<4	----	<4	----
Perylene	µg/kg	4	<4	----	<4	----	<4	----
Benzo(g.h.i)perylene	µg/kg	4	<4	----	<4	----	<4	----

Site Analyte grouping/Analyte	Units	LOR	zz3	zz4	zz5	zz6	zz7	zz9
Dibenz(a.h)anthracene	µg/kg	4	<4	----	<4	----	<4	----
Indeno(1.2.3.cd)pyrene	µg/kg	4	<4	----	<4	----	<4	----
Coronene	µg/kg	5	<5	----	<5	----	<5	----
Sum of PAHs	µg/kg	4	<4	----	<4	----	<4	----

Attachments

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EM1712422**	Page	: 1 of 29
Amendment	: **1**		
Client	: **COOE PTY LTD**	Laboratory	: Environmental Division Melbourne
Contact	: MR JOE MIFSUD	Contact	:
Address	: P.O. BOX 591 LITTLEHAMPTON S.A., AUSTRALIA 5250	Address	: 4 Westall Rd Springvale VIC Australia 3171
Telephone	: +61 08 83624282	Telephone	: +61-3-8549 9600
Project	: SEA.SBD.01	Date Samples Received	: 12-Sep-2017 11:00
Order number	: SEA.SBD.170911	Date Analysis Commenced	: 12-Sep-2017
C-O-C number	: ----	Issue Date	: 13-Nov-2017 11:09
Sampler	: JOE MIFSUD		
Site	: ----		
Quote number	: ADBQ/016/10		
No. of samples received	: 27		
No. of samples analysed	: 27		

NATA

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Amanda Conkie	Organic Chemist	Brisbane Organics, Stafford, QLD
Ben Felgendrejeris		Brisbane Acid Sulphate Soils, Stafford, QLD
Chris Lemaitre	Non-Metals Team Leader	Melbourne Inorganics, Springvale, VIC
Diana Mesa	2IC Organic Chemist	Brisbane Organics, Stafford, QLD
Dianne Blane	Laboratory Coordinator (2IC)	Newcastle - Inorganics, Mayfield West, NSW
Dilani Fernando	Senior Inorganic Chemist	Melbourne Inorganics, Springvale, VIC
Edwandy Fadjar	Organic Coordinator	Sydney Organics, Smithfield, NSW
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Wisam Marassa	Inorganics Coordinator	Sydney Inorganics, Smithfield, NSW
Xing Lin	Senior Organic Chemist	Melbourne Organics, Springvale, VIC

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EA150H: Soil particle density results fell outside the scope of AS1289.3.6.3 (Sample #25, 26). Results should be scrutinised accordingly.
- EA031 (Saturated Paste pH): NATA accreditation does not cover the performance of this service.
- Amendment (30/10/2017): This report has been amended and re-released to allow the reporting of additional analytical data.
- EG020T: EM1712422-009 Total Metal results have been confirmed by re-digestion and re-analysis
- EP090: Sample EM1712422_004 shows poor matrix spike recovery due to matrix interference.
- EA151: ALS does not hold NATA accreditation for Settleability.
- Benzo(a)pyrene Toxicity Equivalent Quotient (TEQ) is the sum total of the concentration of the eight carcinogenic PAHs multiplied by their Toxicity Equivalence Factor (TEF) relative to Benzo(a)pyrene. TEF values are provided in brackets as follows: Benz(a)anthracene (0.1), Chrysene (0.01), Benzo(b+j) & Benzo(k)fluoranthene (0.1), Benzo(a)pyrene (1.0), Indeno(1.2.3.cd)pyrene (0.1), Dibenz(a.h)anthracene (1.0), Benzo(g.h.i)perylene (0.01). Less than LOR results for 'TEQ Zero' are treated as zero, for 'TEQ 1/2LOR' are treated as half the reported LOR, and for 'TEQ LOR' are treated as being equal to the reported LOR. Note: TEQ 1/2LOR and TEQ LOR will calculate as 0.6mg/Kg and 1.2mg/Kg respectively for samples with non-detects for all of the eight TEQ PAHs.

Analytical Results

Sub-Matrix: **SEAWATER** (Matrix: **WATER**)			Client sample ID	DRILL RINSE	----	----	----	----
			Client sampling date / time	09-Sep-2017 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EM1712422-009	--------	--------	--------	--------
				Result	----	----	----	----
EG020T: Total Metals by ICP-MS								
Arsenic	7440-38-2	0.001	mg/L	<0.001	----	----	----	----
Boron	7440-42-8	0.05	mg/L	**0.34**	----	----	----	----
Barium	7440-39-3	0.001	mg/L	<0.001	----	----	----	----
Beryllium	7440-41-7	0.001	mg/L	<0.001	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	----	----	----	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	----	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	----	----	----	----
Copper	7440-50-8	0.001	mg/L	<0.001	----	----	----	----
Manganese	7439-96-5	0.001	mg/L	<0.001	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	<0.001	----	----	----	----
Lead	7439-92-1	0.001	mg/L	**0.002**	----	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	----	----	----	----
Vanadium	7440-62-2	0.01	mg/L	<0.01	----	----	----	----
Zinc	7440-66-6	0.005	mg/L	<0.005	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	----	----	----	----
EP080/071: Total Petroleum Hydrocarbons								
C10 - C14 Fraction	----	50	µg/L	<50	----	----	----	----
C15 - C28 Fraction	----	100	µg/L	<100	----	----	----	----
C29 - C36 Fraction	----	50	µg/L	<50	----	----	----	----
^ C10 - C36 Fraction (sum)	----	50	µg/L	<50	----	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
>C10 - C16 Fraction	----	100	µg/L	<100	----	----	----	----
>C16 - C34 Fraction	----	100	µg/L	<100	----	----	----	----
>C34 - C40 Fraction	----	100	µg/L	<100	----	----	----	----
^ >C10 - C40 Fraction (sum)	----	100	µg/L	<100	----	----	----	----

Analytical Results

Sub-Matrix: SEDIMENT
(Matrix: SOIL)

Compound	CAS Number	LOR	Unit	SB1 PSD	SB1 CONT	SB2 CONT	SB2 SPARE	SB3 CONT
Client sampling date / time				08-Sep-2017 00:00	08-Sep-2017 00:00	08-Sep-2017 00:00	08-Sep-2017 00:00	08-Sep-2017 00:00
				EM1712422-001	EM1712422-002	EM1712422-003	EM1712422-004	EM1712422-005
				Result	Result	Result	Result	Result
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	----	22.6	26.8	27.6	40.3
EA150: Particle Sizing								
+75µm	----	1	%	82	----	----	----	----
+150µm	----	1	%	66	----	----	----	----
+300µm	----	1	%	57	----	----	----	----
+425µm	----	1	%	52	----	----	----	----
+600µm	----	1	%	43	----	----	----	----
+1180µm	----	1	%	25	----	----	----	----
+2.36mm	----	1	%	12	----	----	----	----
+4.75mm	----	1	%	6	----	----	----	----
+9.5mm	----	1	%	<1	----	----	----	----
+19.0mm	----	1	%	<1	----	----	----	----
+37.5mm	----	1	%	<1	----	----	----	----
+75.0mm	----	1	%	<1	----	----	----	----
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	8	----	----	----	----
Silt (2-60 µm)	----	1	%	7	----	----	----	----
Sand (0.06-2.00 mm)	----	1	%	69	----	----	----	----
Gravel (>2mm)	----	1	%	16	----	----	----	----
Cobbles (>6cm)	----	1	%	<1	----	----	----	----
EA152: Soil Particle Density								
ø Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	2.56	----	----	----	----
EG005-SD: Total Metals in Sediments by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	----	3370	4210	4130	850
Iron	7439-89-6	50	mg/kg	----	2900	4290	6910	2020
EG020-SD: Total Metals in Sediments by ICPMS								
Antimony	7440-36-0	0.50	mg/kg	----	<0.50	0.54	0.53	1.37
Arsenic	7440-38-2	1.00	mg/kg	----	3.15	4.43	5.16	4.71
Cadmium	7440-43-9	0.1	mg/kg	----	<0.1	<0.1	<0.1	<0.1
Chromium	7440-47-3	1.0	mg/kg	----	7.4	8.1	7.5	6.9
Copper	7440-50-8	1.0	mg/kg	----	1.2	1.5	1.7	<1.0
Cobalt	7440-48-4	0.5	mg/kg	----	0.7	0.9	0.8	<0.5
Lead	7439-92-1	1.0	mg/kg	----	<1.0	1.4	1.2	1.2
Manganese	7439-96-5	10	mg/kg	----	20	25	21	20

Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)			Client sample ID	SB1 PSD	SB1 CONT	SB2 CONT	SB2 SPARE	SB3 CONT
			Client sampling date / time	08-Sep-2017 00:00	08-Sep-2017 00:00	08-Sep-2017 00:00	08-Sep-2017 00:00	08-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EM1712422-001	EM1712422-002	EM1712422-003	EM1712422-004	EM1712422-005
				Result	Result	Result	Result	Result
EG020-SD: Total Metals in Sediments by ICPMS - Continued								
Nickel	7440-02-0	1.0	mg/kg	----	2.4	2.6	2.5	3.0
Selenium	7782-49-2	0.1	mg/kg	----	0.5	0.4	0.5	0.7
Silver	7440-22-4	0.1	mg/kg	----	0.1	<0.1	<0.1	<0.1
Vanadium	7440-62-2	2.0	mg/kg	----	7.6	9.8	10.1	12.9
Zinc	7440-66-6	1.0	mg/kg	----	5.0	3.6	3.0	3.7
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.01	mg/kg	----	<0.01	0.01	0.01	0.01
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	----	110	320	330	410
EK071G: Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	14265-44-2	0.1	mg/kg	----	0.1	0.4	0.3	0.4
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	----	0.41	0.69	0.76	0.65
EP075(SIM)A: Phenolic Compounds								
Phenol	108-95-2	0.5	mg/kg	----	----	<0.5	<0.5	----
2-Chlorophenol	95-57-8	0.5	mg/kg	----	----	<0.5	<0.5	----
2-Methylphenol	95-48-7	0.5	mg/kg	----	----	<0.5	<0.5	----
3- & 4-Methylphenol	1319-77-3	1	mg/kg	----	----	<1	<1	----
2-Nitrophenol	88-75-5	0.5	mg/kg	----	----	<0.5	<0.5	----
2.4-Dimethylphenol	105-67-9	0.5	mg/kg	----	----	<0.5	<0.5	----
2.4-Dichlorophenol	120-83-2	0.5	mg/kg	----	----	<0.5	<0.5	----
2.6-Dichlorophenol	87-65-0	0.5	mg/kg	----	----	<0.5	<0.5	----
4-Chloro-3-methylphenol	59-50-7	0.5	mg/kg	----	----	<0.5	<0.5	----
2.4.6-Trichlorophenol	88-06-2	0.5	mg/kg	----	----	<0.5	<0.5	----
2.4.5-Trichlorophenol	95-95-4	0.5	mg/kg	----	----	<0.5	<0.5	----
Pentachlorophenol	87-86-5	2	mg/kg	----	----	<2	<2	----
EP080/071: Total Petroleum Hydrocarbons								
C10 - C14 Fraction	----	50	mg/kg	----	<50	<50	<50	<50
C15 - C28 Fraction	----	100	mg/kg	----	<100	<100	<100	<100
^ C29 - C36 Fraction	----	100	mg/kg	----	<100	<100	<100	<100
C10 - C36 Fraction (sum)	----	50	mg/kg	----	<50	<50	<50	<50
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
>C10 - C16 Fraction	----	50	mg/kg	----	<50	<50	<50	<50
>C16 - C34 Fraction	----	100	mg/kg	----	<100	<100	<100	<100

Analytical Results

Sub-Matrix: **SEDIMENT** (Matrix: **SOIL**)			Client sample ID	SB1 PSD	SB1 CONT	SB2 CONT	SB2 SPARE	SB3 CONT
			Client sampling date / time	08-Sep-2017 00:00	08-Sep-2017 00:00	08-Sep-2017 00:00	08-Sep-2017 00:00	08-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EM1712422-001	EM1712422-002	EM1712422-003	EM1712422-004	EM1712422-005
				Result	Result	Result	Result	Result
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions - Continued								
>C34 - C40 Fraction	----	100	mg/kg	----	<100	<100	<100	<100
^ >C10 - C40 Fraction (sum)	----	50	mg/kg	----	<50	<50	<50	<50
EP090: Organotin Compounds								
Monobutyltin	78763-54-9	1	µgSn/kg	----	----	<1	<1	----
Dibutyltin	1002-53-5	1	µgSn/kg	----	----	<1	<1	----
Tributyltin	56573-85-4	0.5	µgSn/kg	----	----	<0.5	<0.5	----
EP130A: Organophosphorus Pesticides (Ultra-trace)								
Bromophos-ethyl	4824-78-6	10	µg/kg	----	<10	<10	<10	<10
Carbophenothion	786-19-6	10	µg/kg	----	<10	<10	<10	<10
Chlorfenvinphos (E)	18708-86-6	10.0	µg/kg	----	<10.0	<10.0	<10.0	<10.0
Chlorfenvinphos (Z)	18708-87-7	10	µg/kg	----	<10	<10	<10	<10
Chlorpyrifos	2921-88-2	10	µg/kg	----	<10	<10	<10	<10
Chlorpyrifos-methyl	5598-13-0	10	µg/kg	----	<10	<10	<10	<10
Demeton-S-methyl	919-86-8	10	µg/kg	----	<10	<10	<10	<10
Diazinon	333-41-5	10	µg/kg	----	<10	<10	<10	<10
Dichlorvos	62-73-7	10	µg/kg	----	<10	<10	<10	<10
Dimethoate	60-51-5	10	µg/kg	----	<10	<10	<10	<10
Ethion	563-12-2	10	µg/kg	----	<10	<10	<10	<10
Fenamiphos	22224-92-6	10	µg/kg	----	<10	<10	<10	<10
Fenthion	55-38-9	10	µg/kg	----	<10	<10	<10	<10
Malathion	121-75-5	10	µg/kg	----	<10	<10	<10	<10
Azinphos Methyl	86-50-0	10	µg/kg	----	<10	<10	<10	<10
Monocrotophos	6923-22-4	10	µg/kg	----	<10	<10	<10	<10
Parathion	56-38-2	10	µg/kg	----	<10	<10	<10	<10
Parathion-methyl	298-00-0	10	µg/kg	----	<10	<10	<10	<10
Pirimphos-ethyl	23505-41-1	10	µg/kg	----	<10	<10	<10	<10
Prothiofos	34643-46-4	10	µg/kg	----	<10	<10	<10	<10
EP131A: Organochlorine Pesticides								
Aldrin	309-00-2	0.50	µg/kg	----	<0.50	<0.50	<0.50	<0.50
alpha-BHC	319-84-6	0.50	µg/kg	----	<0.50	<0.50	<0.50	<0.50
beta-BHC	319-85-7	0.50	µg/kg	----	<0.50	<0.50	<0.50	<0.50
delta-BHC	319-86-8	0.50	µg/kg	----	<0.50	<0.50	<0.50	<0.50
4.4`-DDD	72-54-8	0.50	µg/kg	----	<0.50	<0.50	<0.50	<0.50
4.4`-DDE	72-55-9	0.50	µg/kg	----	<0.50	<0.50	<0.50	<0.50

Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)			Client sample ID	SB1 PSD	SB1 CONT	SB2 CONT	SB2 SPARE	SB3 CONT
			Client sampling date / time	08-Sep-2017 00:00	08-Sep-2017 00:00	08-Sep-2017 00:00	08-Sep-2017 00:00	08-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EM1712422-001	EM1712422-002	EM1712422-003	EM1712422-004	EM1712422-005
				Result	Result	Result	Result	Result
EP131A: Organochlorine Pesticides - Continued								
4.4`-DDT	50-29-3	0.50	µg/kg	----	<0.50	<0.50	<0.50	<0.50
^ Sum of DDD + DDE + DDT	72-54-8/72-55-9/50-2	0.50	µg/kg	----	<0.50	<0.50	<0.50	<0.50
Dieldrin	60-57-1	0.50	µg/kg	----	<0.50	<0.50	<0.50	<0.50
alpha-Endosulfan	959-98-8	0.50	µg/kg	----	<0.50	<0.50	<0.50	<0.50
beta-Endosulfan	33213-65-9	0.50	µg/kg	----	<0.50	<0.50	<0.50	<0.50
Endosulfan sulfate	1031-07-8	0.50	µg/kg	----	<0.50	<0.50	<0.50	<0.50
^ Endosulfan (sum)	115-29-7	0.50	µg/kg	----	<0.50	<0.50	<0.50	<0.50
Endrin	72-20-8	0.50	µg/kg	----	<0.50	<0.50	<0.50	<0.50
Endrin aldehyde	7421-93-4	0.50	µg/kg	----	<0.50	<0.50	<0.50	<0.50
Endrin ketone	53494-70-5	0.50	µg/kg	----	<0.50	<0.50	<0.50	<0.50
Heptachlor	76-44-8	0.50	µg/kg	----	<0.50	<0.50	<0.50	<0.50
Heptachlor epoxide	1024-57-3	0.50	µg/kg	----	<0.50	<0.50	<0.50	<0.50
Hexachlorobenzene (HCB)	118-74-1	0.50	µg/kg	----	<0.50	<0.50	<0.50	<0.50
gamma-BHC	58-89-9	0.25	µg/kg	----	<0.25	<0.25	<0.25	<0.25
Methoxychlor	72-43-5	0.50	µg/kg	----	<0.50	<0.50	<0.50	<0.50
cis-Chlordane	5103-71-9	0.25	µg/kg	----	<0.25	<0.25	<0.25	<0.25
trans-Chlordane	5103-74-2	0.25	µg/kg	----	<0.25	<0.25	<0.25	<0.25
^ Total Chlordane (sum)	----	0.25	µg/kg	----	<0.25	<0.25	<0.25	<0.25
Oxychlordane	27304-13-8	0.50	µg/kg	----	<0.50	<0.50	<0.50	<0.50
EP131B: Polychlorinated Biphenyls (as Aroclors)								
^ Total Polychlorinated biphenyls	----	5.0	µg/kg	----	<5.0	<5.0	<5.0	<5.0
Aroclor 1016	12674-11-2	5.0	µg/kg	----	<5.0	<5.0	<5.0	<5.0
Aroclor 1221	11104-28-2	5.0	µg/kg	----	<5.0	<5.0	<5.0	<5.0
Aroclor 1232	11141-16-5	5.0	µg/kg	----	<5.0	<5.0	<5.0	<5.0
Aroclor 1242	53469-21-9	5.0	µg/kg	----	<5.0	<5.0	<5.0	<5.0
Aroclor 1248	12672-29-6	5.0	µg/kg	----	<5.0	<5.0	<5.0	<5.0
Aroclor 1254	11097-69-1	5.0	µg/kg	----	<5.0	<5.0	<5.0	<5.0
Aroclor 1260	11096-82-5	5.0	µg/kg	----	<5.0	<5.0	<5.0	<5.0
EP132B: Polynuclear Aromatic Hydrocarbons								
Naphthalene	91-20-3	5	µg/kg	----	<5	<5	<5	<5
2-Methylnaphthalene	91-57-6	5	µg/kg	----	<5	<5	<5	<5
Acenaphthylene	208-96-8	4	µg/kg	----	<4	<4	<4	<4
Acenaphthene	83-32-9	4	µg/kg	----	<4	<4	<4	<4
Fluorene	86-73-7	4	µg/kg	----	<4	<4	<4	<4

Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)			Client sample ID	SB1 PSD	SB1 CONT	SB2 CONT	SB2 SPARE	SB3 CONT
			Client sampling date / time	08-Sep-2017 00:00	08-Sep-2017 00:00	08-Sep-2017 00:00	08-Sep-2017 00:00	08-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EM1712422-001	EM1712422-002	EM1712422-003	EM1712422-004	EM1712422-005
				Result	Result	Result	Result	Result
EP132B: Polynuclear Aromatic Hydrocarbons - Continued								
Phenanthrene	85-01-8	4	µg/kg	----	<4	<4	<4	<4
Anthracene	120-12-7	4	µg/kg	----	<4	<4	<4	<4
Fluoranthene	206-44-0	4	µg/kg	----	<4	<4	<4	<4
Pyrene	129-00-0	4	µg/kg	----	<4	<4	<4	<4
Benz(a)anthracene	56-55-3	4	µg/kg	----	<4	<4	<4	<4
Chrysene	218-01-9	4	µg/kg	----	<4	<4	<4	<4
Benzo(b+j)fluoranthene	205-99-2 205-82-3	4	µg/kg	----	<4	<4	<4	<4
Benzo(k)fluoranthene	207-08-9	4	µg/kg	----	<4	<4	<4	<4
Benzo(e)pyrene	192-97-2	4	µg/kg	----	<4	<4	<4	<4
Benzo(a)pyrene	50-32-8	4	µg/kg	----	<4	<4	<4	<4
Perylene	198-55-0	4	µg/kg	----	<4	<4	<4	<4
Benzo(g.h.i)perylene	191-24-2	4	µg/kg	----	<4	<4	<4	<4
Dibenz(a.h)anthracene	53-70-3	4	µg/kg	----	<4	<4	<4	<4
Indeno(1.2.3.cd)pyrene	193-39-5	4	µg/kg	----	<4	<4	<4	<4
Coronene	191-07-1	5	µg/kg	----	<5	<5	<5	<5
^ Sum of PAHs	----	4	µg/kg	----	<4	<4	<4	<4
EP075(SIM)S: Phenolic Compound Surrogates								
Phenol-d6	13127-88-3	0.5	%	----	----	80.1	86.5	----
2-Chlorophenol-D4	93951-73-6	0.5	%	----	----	90.4	96.8	----
2.4.6-Tribromophenol	118-79-6	0.5	%	----	----	42.6	39.9	----
EP075(SIM)T: PAH Surrogates								
2-Fluorobiphenyl	321-60-8	0.5	%	----	----	88.3	95.4	----
Anthracene-d10	1719-06-8	0.5	%	----	----	85.8	91.6	----
4-Terphenyl-d14	1718-51-0	0.5	%	----	----	100	111	----
EP090S: Organotin Surrogate								
Tripropyltin	----	0.5	%	----	----	103	90.2	----
EP130S: Organophosphorus Pesticide Surrogate								
DEF	78-48-8	10	%	----	56.3	67.4	65.5	70.5
EP131S: OC Pesticide Surrogate								
Dibromo-DDE	21655-73-2	0.50	%	----	59.4	64.1	64.4	71.3
EP131T: PCB Surrogate								
Decachlorobiphenyl	2051-24-3	0.5	%	----	97.5	101	74.1	91.5
EP132T: Base/Neutral Extractable Surrogates								
2-Fluorobiphenyl	321-60-8	10	%	----	82.9	80.2	93.5	78.4

Analytical Results

Sub-Matrix: **SEDIMENT** (Matrix: **SOIL**)			Client sample ID	SB1 PSD	SB1 CONT	SB2 CONT	SB2 SPARE	SB3 CONT
			Client sampling date / time	08-Sep-2017 00:00	08-Sep-2017 00:00	08-Sep-2017 00:00	08-Sep-2017 00:00	08-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EM1712422-001	EM1712422-002	EM1712422-003	EM1712422-004	EM1712422-005
				Result	Result	Result	Result	Result
EP132T: Base/Neutral Extractable Surrogates - Continued								
Anthracene-d10	1719-06-8	10	%	----	92.3	94.6	109	96.7
4-Terphenyl-d14	1718-51-0	10	%	----	85.7	87.0	97.9	86.8

Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)			Client sample ID	SB4 CONT	SB11 CONT	SB10 CONT	SB3 PSD	SB2 PSD
			Client sampling date / time	08-Sep-2017 00:00	09-Sep-2017 00:00	09-Sep-2017 00:00	08-Sep-2017 00:00	08-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EM1712422-006	EM1712422-007	EM1712422-008	EM1712422-010	EM1712422-011
				Result	Result	Result	Result	Result
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	35.9	34.3	38.1	----	----
EA150: Particle Sizing								
+75µm	----	1	%	----	----	----	----	69
+150µm	----	1	%	----	----	----	----	48
+300µm	----	1	%	----	----	----	----	21
+425µm	----	1	%	----	----	----	----	17
+600µm	----	1	%	----	----	----	----	14
+1180µm	----	1	%	----	----	----	----	10
+2.36mm	----	1	%	----	----	----	----	6
+4.75mm	----	1	%	----	----	----	----	2
+9.5mm	----	1	%	----	----	----	----	<1
+19.0mm	----	1	%	----	----	----	----	<1
+37.5mm	----	1	%	----	----	----	----	<1
+75.0mm	----	1	%	----	----	----	----	<1
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	----	----	----	----	14
Silt (2-60 µm)	----	1	%	----	----	----	----	11
Sand (0.06-2.00 mm)	----	1	%	----	----	----	----	68
Gravel (>2mm)	----	1	%	----	----	----	----	7
Cobbles (>6cm)	----	1	%	----	----	----	----	<1
EA151: Settleability 10%								
ø Underflow Density	----	0.01	g/cm3	----	----	----	1.54	----
ø Underflow Solids	----	0.1	%	----	----	----	59.0	----
ø Settling Rate @ 50% of Settlement	----	0.001	mm/min	----	----	----	10.2	----
ø Settling Rate @ 90% of Settlement	----	0.001	mm/min	----	----	----	10.4	----
ø Clarity	----	-	-	----	----	----	Transparent	----
EA152: Soil Particle Density								
ø Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	----	----	----	----	2.55
EG005-SD: Total Metals in Sediments by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	910	540	820	----	----
Iron	7439-89-6	50	mg/kg	2440	1320	1600	----	----
EG020-SD: Total Metals in Sediments by ICPMS								
Antimony	7440-36-0	0.50	mg/kg	0.55	0.78	<0.50	----	----
Arsenic	7440-38-2	1.00	mg/kg	3.73	2.68	1.91	----	----

Analytical Results

Sub-Matrix: **SEDIMENT** (Matrix: **SOIL**)			Client sample ID	SB4 CONT	SB11 CONT	SB10 CONT	SB3 PSD	SB2 PSD
			Client sampling date / time	08-Sep-2017 00:00	09-Sep-2017 00:00	09-Sep-2017 00:00	08-Sep-2017 00:00	08-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EM1712422-006	EM1712422-007	EM1712422-008	EM1712422-010	EM1712422-011
				Result	Result	Result	Result	Result
EG020-SD: Total Metals in Sediments by ICPMS - Continued								
Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	<0.1	----	----
Chromium	7440-47-3	1.0	mg/kg	7.4	5.8	6.1	----	----
Copper	7440-50-8	1.0	mg/kg	1.1	<1.0	<1.0	----	----
Cobalt	7440-48-4	0.5	mg/kg	<0.5	<0.5	<0.5	----	----
Lead	7439-92-1	1.0	mg/kg	1.3	<1.0	1.2	----	----
Manganese	7439-96-5	10	mg/kg	21	14	22	----	----
Nickel	7440-02-0	1.0	mg/kg	2.9	2.4	2.4	----	----
Selenium	7782-49-2	0.1	mg/kg	0.6	0.6	0.5	----	----
Silver	7440-22-4	0.1	mg/kg	<0.1	<0.1	<0.1	----	----
Vanadium	7440-62-2	2.0	mg/kg	8.6	13.2	5.3	----	----
Zinc	7440-66-6	1.0	mg/kg	3.9	2.2	4.6	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.01	mg/kg	0.01	<0.01	<0.01	----	----
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	610	410	670	----	----
EK071G: Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	14265-44-2	0.1	mg/kg	0.2	<0.1	2.1	----	----
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	0.76	0.45	0.64	----	----
EP075(SIM)A: Phenolic Compounds								
Phenol	108-95-2	0.5	mg/kg	----	----	<0.5	----	----
2-Chlorophenol	95-57-8	0.5	mg/kg	----	----	<0.5	----	----
2-Methylphenol	95-48-7	0.5	mg/kg	----	----	<0.5	----	----
3- & 4-Methylphenol	1319-77-3	1	mg/kg	----	----	<1	----	----
2-Nitrophenol	88-75-5	0.5	mg/kg	----	----	<0.5	----	----
2.4-Dimethylphenol	105-67-9	0.5	mg/kg	----	----	<0.5	----	----
2.4-Dichlorophenol	120-83-2	0.5	mg/kg	----	----	<0.5	----	----
2.6-Dichlorophenol	87-65-0	0.5	mg/kg	----	----	<0.5	----	----
4-Chloro-3-methylphenol	59-50-7	0.5	mg/kg	----	----	<0.5	----	----
2.4.6-Trichlorophenol	88-06-2	0.5	mg/kg	----	----	<0.5	----	----
2.4.5-Trichlorophenol	95-95-4	0.5	mg/kg	----	----	<0.5	----	----
Pentachlorophenol	87-86-5	2	mg/kg	----	----	<2	----	----
EP080/071: Total Petroleum Hydrocarbons								
C10 - C14 Fraction	----	50	mg/kg	<50	<50	<50	----	----

Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)			Client sample ID	SB4 CONT	SB11 CONT	SB10 CONT	SB3 PSD	SB2 PSD
			Client sampling date / time	08-Sep-2017 00:00	09-Sep-2017 00:00	09-Sep-2017 00:00	08-Sep-2017 00:00	08-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EM1712422-006	EM1712422-007	EM1712422-008	EM1712422-010	EM1712422-011
				Result	Result	Result	Result	Result
EP080/071: Total Petroleum Hydrocarbons - Continued								
C15 - C28 Fraction	----	100	mg/kg	<100	<100	<100	----	----
^ C29 - C36 Fraction	----	100	mg/kg	<100	<100	<100	----	----
C10 - C36 Fraction (sum)	----	50	mg/kg	<50	<50	<50	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
>C10 - C16 Fraction	----	50	mg/kg	<50	<50	<50	----	----
>C16 - C34 Fraction	----	100	mg/kg	<100	<100	<100	----	----
>C34 - C40 Fraction	----	100	mg/kg	<100	<100	<100	----	----
^ >C10 - C40 Fraction (sum)	----	50	mg/kg	<50	<50	<50	----	----
EP090: Organotin Compounds								
Monobutyltin	78763-54-9	1	µgSn/kg	----	----	<1	----	----
Dibutyltin	1002-53-5	1	µgSn/kg	----	----	<1	----	----
Tributyltin	56573-85-4	0.5	µgSn/kg	----	----	<0.5	----	----
EP130A: Organophosphorus Pesticides (Ultra-trace)								
Bromophos-ethyl	4824-78-6	10	µg/kg	<10	<10	<10	----	----
Carbophenothion	786-19-6	10	µg/kg	<10	<10	<10	----	----
Chlorfenvinphos (E)	18708-86-6	10.0	µg/kg	<10.0	<10.0	<10.0	----	----
Chlorfenvinphos (Z)	18708-87-7	10	µg/kg	<10	<10	<10	----	----
Chlorpyrifos	2921-88-2	10	µg/kg	<10	<10	<10	----	----
Chlorpyrifos-methyl	5598-13-0	10	µg/kg	<10	<10	<10	----	----
Demeton-S-methyl	919-86-8	10	µg/kg	<10	<10	<10	----	----
Diazinon	333-41-5	10	µg/kg	<10	<10	<10	----	----
Dichlorvos	62-73-7	10	µg/kg	<10	<10	<10	----	----
Dimethoate	60-51-5	10	µg/kg	<10	<10	<10	----	----
Ethion	563-12-2	10	µg/kg	<10	<10	<10	----	----
Fenamiphos	22224-92-6	10	µg/kg	<10	<10	<10	----	----
Fenthion	55-38-9	10	µg/kg	<10	<10	<10	----	----
Malathion	121-75-5	10	µg/kg	<10	<10	<10	----	----
Azinphos Methyl	86-50-0	10	µg/kg	<10	<10	<10	----	----
Monocrotophos	6923-22-4	10	µg/kg	<10	<10	<10	----	----
Parathion	56-38-2	10	µg/kg	<10	<10	<10	----	----
Parathion-methyl	298-00-0	10	µg/kg	<10	<10	<10	----	----
Pirimphos-ethyl	23505-41-1	10	µg/kg	<10	<10	<10	----	----
Prothiofos	34643-46-4	10	µg/kg	<10	<10	<10	----	----
EP131A: Organochlorine Pesticides								

Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)			Client sample ID	SB4 CONT	SB11 CONT	SB10 CONT	SB3 PSD	SB2 PSD
			Client sampling date / time	08-Sep-2017 00:00	09-Sep-2017 00:00	09-Sep-2017 00:00	08-Sep-2017 00:00	08-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EM1712422-006	EM1712422-007	EM1712422-008	EM1712422-010	EM1712422-011
				Result	Result	Result	Result	Result
EP131A: Organochlorine Pesticides - Continued								
Aldrin	309-00-2	0.50	µg/kg	<0.50	<0.50	<0.50	----	----
alpha-BHC	319-84-6	0.50	µg/kg	<0.50	<0.50	<0.50	----	----
beta-BHC	319-85-7	0.50	µg/kg	<0.50	<0.50	<0.50	----	----
delta-BHC	319-86-8	0.50	µg/kg	<0.50	<0.50	<0.50	----	----
4.4`-DDD	72-54-8	0.50	µg/kg	<0.50	<0.50	<0.50	----	----
4.4`-DDE	72-55-9	0.50	µg/kg	<0.50	<0.50	<0.50	----	----
4.4`-DDT	50-29-3	0.50	µg/kg	<0.50	<0.50	<0.50	----	----
^ Sum of DDD + DDE + DDT	72-54-8/72-55-9/5 0-2	0.50	µg/kg	<0.50	<0.50	<0.50	----	----
Dieldrin	60-57-1	0.50	µg/kg	<0.50	<0.50	<0.50	----	----
alpha-Endosulfan	959-98-8	0.50	µg/kg	<0.50	<0.50	<0.50	----	----
beta-Endosulfan	33213-65-9	0.50	µg/kg	<0.50	<0.50	<0.50	----	----
Endosulfan sulfate	1031-07-8	0.50	µg/kg	<0.50	<0.50	<0.50	----	----
^ Endosulfan (sum)	115-29-7	0.50	µg/kg	<0.50	<0.50	<0.50	----	----
Endrin	72-20-8	0.50	µg/kg	<0.50	<0.50	<0.50	----	----
Endrin aldehyde	7421-93-4	0.50	µg/kg	<0.50	<0.50	<0.50	----	----
Endrin ketone	53494-70-5	0.50	µg/kg	<0.50	<0.50	<0.50	----	----
Heptachlor	76-44-8	0.50	µg/kg	<0.50	<0.50	<0.50	----	----
Heptachlor epoxide	1024-57-3	0.50	µg/kg	<0.50	<0.50	<0.50	----	----
Hexachlorobenzene (HCB)	118-74-1	0.50	µg/kg	<0.50	<0.50	<0.50	----	----
gamma-BHC	58-89-9	0.25	µg/kg	<0.25	<0.25	<0.25	----	----
Methoxychlor	72-43-5	0.50	µg/kg	<0.50	<0.50	<0.50	----	----
cis-Chlordane	5103-71-9	0.25	µg/kg	<0.25	<0.25	<0.25	----	----
trans-Chlordane	5103-74-2	0.25	µg/kg	<0.25	<0.25	<0.25	----	----
^ Total Chlordane (sum)	----	0.25	µg/kg	<0.25	<0.25	<0.25	----	----
Oxychlordane	27304-13-8	0.50	µg/kg	<0.50	<0.50	<0.50	----	----
EP131B: Polychlorinated Biphenyls (as Aroclors)								
^ Total Polychlorinated biphenyls	----	5.0	µg/kg	<5.0	<5.0	<5.0	----	----
Aroclor 1016	12674-11-2	5.0	µg/kg	<5.0	<5.0	<5.0	----	----
Aroclor 1221	11104-28-2	5.0	µg/kg	<5.0	<5.0	<5.0	----	----
Aroclor 1232	11141-16-5	5.0	µg/kg	<5.0	<5.0	<5.0	----	----
Aroclor 1242	53469-21-9	5.0	µg/kg	<5.0	<5.0	<5.0	----	----
Aroclor 1248	12672-29-6	5.0	µg/kg	<5.0	<5.0	<5.0	----	----
Aroclor 1254	11097-69-1	5.0	µg/kg	<5.0	<5.0	<5.0	----	----
Aroclor 1260	11096-82-5	5.0	µg/kg	<5.0	<5.0	<5.0	----	----

Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)			Client sample ID	SB4 CONT	SB11 CONT	SB10 CONT	SB3 PSD	SB2 PSD
			Client sampling date / time	08-Sep-2017 00:00	09-Sep-2017 00:00	09-Sep-2017 00:00	08-Sep-2017 00:00	08-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EM1712422-006	EM1712422-007	EM1712422-008	EM1712422-010	EM1712422-011
				Result	Result	Result	Result	Result
EP132B: Polynuclear Aromatic Hydrocarbons								
Naphthalene	91-20-3	5	µg/kg	<5	<5	<5	----	----
2-Methylnaphthalene	91-57-6	5	µg/kg	<5	<5	<5	----	----
Acenaphthylene	208-96-8	4	µg/kg	<4	<4	<4	----	----
Acenaphthene	83-32-9	4	µg/kg	<4	<4	<4	----	----
Fluorene	86-73-7	4	µg/kg	<4	<4	<4	----	----
Phenanthrene	85-01-8	4	µg/kg	<4	<4	<4	----	----
Anthracene	120-12-7	4	µg/kg	<4	<4	<4	----	----
Fluoranthene	206-44-0	4	µg/kg	<4	<4	<4	----	----
Pyrene	129-00-0	4	µg/kg	<4	<4	<4	----	----
Benz(a)anthracene	56-55-3	4	µg/kg	<4	<4	<4	----	----
Chrysene	218-01-9	4	µg/kg	<4	<4	<4	----	----
Benzo(b+j)fluoranthene	205-99-2 205-82-3	4	µg/kg	<4	<4	<4	----	----
Benzo(k)fluoranthene	207-08-9	4	µg/kg	<4	<4	<4	----	----
Benzo(e)pyrene	192-97-2	4	µg/kg	<4	<4	<4	----	----
Benzo(a)pyrene	50-32-8	4	µg/kg	<4	<4	<4	----	----
Perylene	198-55-0	4	µg/kg	<4	<4	<4	----	----
Benzo(g.h.i)perylene	191-24-2	4	µg/kg	<4	<4	<4	----	----
Dibenz(a.h)anthracene	53-70-3	4	µg/kg	<4	<4	<4	----	----
Indeno(1.2.3.cd)pyrene	193-39-5	4	µg/kg	<4	<4	<4	----	----
Coronene	191-07-1	5	µg/kg	<5	<5	<5	----	----
^ Sum of PAHs	----	4	µg/kg	<4	<4	<4	----	----
EP075(SIM)S: Phenolic Compound Surrogates								
Phenol-d6	13127-88-3	0.5	%	----	----	88.1	----	----
2-Chlorophenol-D4	93951-73-6	0.5	%	----	----	100	----	----
2.4.6-Tribromophenol	118-79-6	0.5	%	----	----	44.2	----	----
EP075(SIM)T: PAH Surrogates								
2-Fluorobiphenyl	321-60-8	0.5	%	----	----	97.8	----	----
Anthracene-d10	1719-06-8	0.5	%	----	----	93.1	----	----
4-Terphenyl-d14	1718-51-0	0.5	%	----	----	110	----	----
EP090S: Organotin Surrogate								
Tripropyltin	----	0.5	%	----	----	119	----	----
EP130S: Organophosphorus Pesticide Surrogate								
DEF	78-48-8	10	%	73.0	61.5	55.4	----	----
EP131S: OC Pesticide Surrogate								

Analytical Results

Sub-Matrix: **SEDIMENT** (Matrix: **SOIL**)			Client sample ID	SB4 CONT	SB11 CONT	SB10 CONT	SB3 PSD	SB2 PSD
			Client sampling date / time	08-Sep-2017 00:00	09-Sep-2017 00:00	09-Sep-2017 00:00	08-Sep-2017 00:00	08-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EM1712422-006	EM1712422-007	EM1712422-008	EM1712422-010	EM1712422-011
				Result	Result	Result	Result	Result
EP131S: OC Pesticide Surrogate - Continued								
Dibromo-DDE	21655-73-2	0.50	%	79.1	89.2	63.1	----	----
EP131T: PCB Surrogate								
Decachlorobiphenyl	2051-24-3	0.5	%	82.4	92.6	73.6	----	----
EP132T: Base/Neutral Extractable Surrogates								
2-Fluorobiphenyl	321-60-8	10	%	91.2	88.0	84.2	----	----
Anthracene-d10	1719-06-8	10	%	110	91.1	103	----	----
4-Terphenyl-d14	1718-51-0	10	%	102	78.9	87.0	----	----

Analytical Results

Sub-Matrix: **SEDIMENT** (Matrix: **SOIL**)			*Client sample ID*	SB11 PSD	SB10 PSD	SB 12 cont	SB 8.1	SB 8.2
			Client sampling date / time	09-Sep-2017 00:00	09-Sep-2017 00:00	09-Sep-2017 00:00	09-Sep-2017 00:00	09-Sep-2017 00:00
Compound	*CAS Number*	*LOR*	*Unit*	EM1712422-012	EM1712422-013	EM1712422-014	EM1712422-015	EM1712422-016
				Result	Result	Result	Result	Result
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	----	----	40.0	34.6	26.5
EA150: Particle Sizing								
+75µm	----	1	%	----	82	----	----	----
+150µm	----	1	%	----	73	----	----	----
+300µm	----	1	%	----	66	----	----	----
+425µm	----	1	%	----	61	----	----	----
+600µm	----	1	%	----	55	----	----	----
+1180µm	----	1	%	----	42	----	----	----
+2.36mm	----	1	%	----	28	----	----	----
+4.75mm	----	1	%	----	17	----	----	----
+9.5mm	----	1	%	----	10	----	----	----
+19.0mm	----	1	%	----	<1	----	----	----
+37.5mm	----	1	%	----	<1	----	----	----
+75.0mm	----	1	%	----	<1	----	----	----
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	----	11	----	----	----
Silt (2-60 µm)	----	1	%	----	5	----	----	----
Sand (0.06-2.00 mm)	----	1	%	----	52	----	----	----
Gravel (>2mm)	----	1	%	----	32	----	----	----
Cobbles (>6cm)	----	1	%	----	<1	----	----	----
EA151: Settleability 10%								
ø Underflow Density	----	0.01	g/cm3	1.52	----	----	----	----
ø Underflow Solids	----	0.1	%	55.0	----	----	----	----
ø Settling Rate @ 50% of Settlement	----	0.001	mm/min	52.8	----	----	----	----
ø Settling Rate @ 90% of Settlement	----	0.001	mm/min	52.8	----	----	----	----
ø Clarity	----	-	-	Transparent	----	----	----	----
EA152: Soil Particle Density								
ø Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	----	2.50	----	----	----
EG005-SD: Total Metals in Sediments by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	----	----	770	510	550
Iron	7439-89-6	50	mg/kg	----	----	1770	1260	1440
EG020-SD: Total Metals in Sediments by ICPMS								
Antimony	7440-36-0	0.50	mg/kg	----	----	0.51	1.35	0.71
Arsenic	7440-38-2	1.00	mg/kg	----	----	2.97	3.08	2.86

Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)			Client sample ID	SB11 PSD	SB10 PSD	SB 12 cont	SB 8.1	SB 8.2
			Client sampling date / time	09-Sep-2017 00:00	09-Sep-2017 00:00	09-Sep-2017 00:00	09-Sep-2017 00:00	09-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EM1712422-012	EM1712422-013	EM1712422-014	EM1712422-015	EM1712422-016
				Result	Result	Result	Result	Result
EG020-SD: Total Metals in Sediments by ICPMS - Continued								
Cadmium	7440-43-9	0.1	mg/kg	----	----	<0.1	<0.1	<0.1
Chromium	7440-47-3	1.0	mg/kg	----	----	6.7	5.9	7.2
Copper	7440-50-8	1.0	mg/kg	----	----	<1.0	<1.0	<1.0
Cobalt	7440-48-4	0.5	mg/kg	----	----	<0.5	<0.5	<0.5
Lead	7439-92-1	1.0	mg/kg	----	----	1.1	<1.0	<1.0
Manganese	7439-96-5	10	mg/kg	----	----	18	17	19
Nickel	7440-02-0	1.0	mg/kg	----	----	2.4	2.2	2.2
Selenium	7782-49-2	0.1	mg/kg	----	----	0.5	0.6	0.6
Silver	7440-22-4	0.1	mg/kg	----	----	<0.1	<0.1	<0.1
Vanadium	7440-62-2	2.0	mg/kg	----	----	8.4	12.8	8.0
Zinc	7440-66-6	1.0	mg/kg	----	----	3.3	2.2	2.6
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.01	mg/kg	----	----	0.01	0.01	0.01
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	----	----	530	260	160
EK071G: Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	14265-44-2	0.1	mg/kg	----	----	1.3	<0.1	<0.1
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	----	----	0.56	0.39	0.17
EP075(SIM)A: Phenolic Compounds								
Phenol	108-95-2	0.5	mg/kg	----	----	----	<0.5	<0.5
2-Chlorophenol	95-57-8	0.5	mg/kg	----	----	----	<0.5	<0.5
2-Methylphenol	95-48-7	0.5	mg/kg	----	----	----	<0.5	<0.5
3- & 4-Methylphenol	1319-77-3	1	mg/kg	----	----	----	<1	<1
2-Nitrophenol	88-75-5	0.5	mg/kg	----	----	----	<0.5	<0.5
2.4-Dimethylphenol	105-67-9	0.5	mg/kg	----	----	----	<0.5	<0.5
2.4-Dichlorophenol	120-83-2	0.5	mg/kg	----	----	----	<0.5	<0.5
2.6-Dichlorophenol	87-65-0	0.5	mg/kg	----	----	----	<0.5	<0.5
4-Chloro-3-methylphenol	59-50-7	0.5	mg/kg	----	----	----	<0.5	<0.5
2.4.6-Trichlorophenol	88-06-2	0.5	mg/kg	----	----	----	<0.5	<0.5
2.4.5-Trichlorophenol	95-95-4	0.5	mg/kg	----	----	----	<0.5	<0.5
Pentachlorophenol	87-86-5	2	mg/kg	----	----	----	<2	<2
EP080/071: Total Petroleum Hydrocarbons								
C10 - C14 Fraction	----	50	mg/kg	----	----	<50	<50	<50

Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)			Client sample ID	SB11 PSD	SB10 PSD	SB 12 cont	SB 8.1	SB 8.2
			Client sampling date / time	09-Sep-2017 00:00	09-Sep-2017 00:00	09-Sep-2017 00:00	09-Sep-2017 00:00	09-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EM1712422-012	EM1712422-013	EM1712422-014	EM1712422-015	EM1712422-016
				Result	Result	Result	Result	Result
EP080/071: Total Petroleum Hydrocarbons - Continued								
C15 - C28 Fraction	----	100	mg/kg	----	----	<100	<100	<100
^ C29 - C36 Fraction	----	100	mg/kg	----	----	<100	<100	<100
C10 - C36 Fraction (sum)	----	50	mg/kg	----	----	<50	<50	<50
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
>C10 - C16 Fraction	----	50	mg/kg	----	----	<50	<50	<50
>C16 - C34 Fraction	----	100	mg/kg	----	----	<100	<100	<100
>C34 - C40 Fraction	----	100	mg/kg	----	----	<100	<100	<100
^ >C10 - C40 Fraction (sum)	----	50	mg/kg	----	----	<50	<50	<50
EP090: Organotin Compounds								
Monobutyltin	78763-54-9	1	µgSn/kg	----	----	----	<1	<1
Dibutyltin	1002-53-5	1	µgSn/kg	----	----	----	<1	<1
Tributyltin	56573-85-4	0.5	µgSn/kg	----	----	----	<0.5	<0.5
EP130A: Organophosphorus Pesticides (Ultra-trace)								
Bromophos-ethyl	4824-78-6	10	µg/kg	----	----	<10	<10	<10
Carbophenothion	786-19-6	10	µg/kg	----	----	<10	<10	<10
Chlorfenvinphos (E)	18708-86-6	10.0	µg/kg	----	----	<10.0	<10.0	<10.0
Chlorfenvinphos (Z)	18708-87-7	10	µg/kg	----	----	<10	<10	<10
Chlorpyrifos	2921-88-2	10	µg/kg	----	----	<10	<10	<10
Chlorpyrifos-methyl	5598-13-0	10	µg/kg	----	----	<10	<10	<10
Demeton-S-methyl	919-86-8	10	µg/kg	----	----	<10	<10	<10
Diazinon	333-41-5	10	µg/kg	----	----	<10	<10	<10
Dichlorvos	62-73-7	10	µg/kg	----	----	<10	<10	<10
Dimethoate	60-51-5	10	µg/kg	----	----	<10	<10	<10
Ethion	563-12-2	10	µg/kg	----	----	<10	<10	<10
Fenamiphos	22224-92-6	10	µg/kg	----	----	<10	<10	<10
Fenthion	55-38-9	10	µg/kg	----	----	<10	<10	<10
Malathion	121-75-5	10	µg/kg	----	----	<10	<10	<10
Azinphos Methyl	86-50-0	10	µg/kg	----	----	<10	<10	<10
Monocrotophos	6923-22-4	10	µg/kg	----	----	<10	<10	<10
Parathion	56-38-2	10	µg/kg	----	----	<10	<10	<10
Parathion-methyl	298-00-0	10	µg/kg	----	----	<10	<10	<10
Pirimphos-ethyl	23505-41-1	10	µg/kg	----	----	<10	<10	<10
Prothiofos	34643-46-4	10	µg/kg	----	----	<10	<10	<10
EP131A: Organochlorine Pesticides								

Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)			Client sample ID	SB11 PSD	SB10 PSD	SB 12 cont	SB 8.1	SB 8.2
			Client sampling date / time	09-Sep-2017 00:00	09-Sep-2017 00:00	09-Sep-2017 00:00	09-Sep-2017 00:00	09-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EM1712422-012	EM1712422-013	EM1712422-014	EM1712422-015	EM1712422-016
				Result	Result	Result	Result	Result
EP131A: Organochlorine Pesticides - Continued								
Aldrin	309-00-2	0.50	µg/kg	----	----	<0.50	<0.50	<0.50
alpha-BHC	319-84-6	0.50	µg/kg	----	----	<0.50	<0.50	<0.50
beta-BHC	319-85-7	0.50	µg/kg	----	----	<0.50	<0.50	<0.50
delta-BHC	319-86-8	0.50	µg/kg	----	----	<0.50	<0.50	<0.50
4.4`-DDD	72-54-8	0.50	µg/kg	----	----	<0.50	<0.50	<0.50
4.4`-DDE	72-55-9	0.50	µg/kg	----	----	<0.50	<0.50	<0.50
4.4`-DDT	50-29-3	0.50	µg/kg	----	----	<0.50	<0.50	<0.50
^ Sum of DDD + DDE + DDT	72-54-8/72-55-9/50-2	0.50	µg/kg	----	----	<0.50	<0.50	<0.50
Dieldrin	60-57-1	0.50	µg/kg	----	----	<0.50	<0.50	<0.50
alpha-Endosulfan	959-98-8	0.50	µg/kg	----	----	<0.50	<0.50	<0.50
beta-Endosulfan	33213-65-9	0.50	µg/kg	----	----	<0.50	<0.50	<0.50
Endosulfan sulfate	1031-07-8	0.50	µg/kg	----	----	<0.50	<0.50	<0.50
^ Endosulfan (sum)	115-29-7	0.50	µg/kg	----	----	<0.50	<0.50	<0.50
Endrin	72-20-8	0.50	µg/kg	----	----	<0.50	<0.50	<0.50
Endrin aldehyde	7421-93-4	0.50	µg/kg	----	----	<0.50	<0.50	<0.50
Endrin ketone	53494-70-5	0.50	µg/kg	----	----	<0.50	<0.50	<0.50
Heptachlor	76-44-8	0.50	µg/kg	----	----	<0.50	<0.50	<0.50
Heptachlor epoxide	1024-57-3	0.50	µg/kg	----	----	<0.50	<0.50	<0.50
Hexachlorobenzene (HCB)	118-74-1	0.50	µg/kg	----	----	<0.50	<0.50	<0.50
gamma-BHC	58-89-9	0.25	µg/kg	----	----	<0.25	<0.25	<0.25
Methoxychlor	72-43-5	0.50	µg/kg	----	----	<0.50	<0.50	<0.50
cis-Chlordane	5103-71-9	0.25	µg/kg	----	----	<0.25	<0.25	<0.25
trans-Chlordane	5103-74-2	0.25	µg/kg	----	----	<0.25	<0.25	<0.25
^ Total Chlordane (sum)	----	0.25	µg/kg	----	----	<0.25	<0.25	<0.25
Oxychlordane	27304-13-8	0.50	µg/kg	----	----	<0.50	<0.50	<0.50
EP131B: Polychlorinated Biphenyls (as Aroclors)								
^ Total Polychlorinated biphenyls	----	5.0	µg/kg	----	----	<5.0	<5.0	<5.0
Aroclor 1016	12674-11-2	5.0	µg/kg	----	----	<5.0	<5.0	<5.0
Aroclor 1221	11104-28-2	5.0	µg/kg	----	----	<5.0	<5.0	<5.0
Aroclor 1232	11141-16-5	5.0	µg/kg	----	----	<5.0	<5.0	<5.0
Aroclor 1242	53469-21-9	5.0	µg/kg	----	----	<5.0	<5.0	<5.0
Aroclor 1248	12672-29-6	5.0	µg/kg	----	----	<5.0	<5.0	<5.0
Aroclor 1254	11097-69-1	5.0	µg/kg	----	----	<5.0	<5.0	<5.0
Aroclor 1260	11096-82-5	5.0	µg/kg	----	----	<5.0	<5.0	<5.0

Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)			Client sample ID	SB11 PSD	SB10 PSD	SB 12 cont	SB 8.1	SB 8.2
			Client sampling date / time	09-Sep-2017 00:00	09-Sep-2017 00:00	09-Sep-2017 00:00	09-Sep-2017 00:00	09-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EM1712422-012	EM1712422-013	EM1712422-014	EM1712422-015	EM1712422-016
				Result	Result	Result	Result	Result
EP132B: Polynuclear Aromatic Hydrocarbons								
Naphthalene	91-20-3	5	µg/kg	----	----	<5	<5	<5
2-Methylnaphthalene	91-57-6	5	µg/kg	----	----	<5	<5	<5
Acenaphthylene	208-96-8	4	µg/kg	----	----	<4	<4	<4
Acenaphthene	83-32-9	4	µg/kg	----	----	<4	<4	<4
Fluorene	86-73-7	4	µg/kg	----	----	<4	<4	<4
Phenanthrene	85-01-8	4	µg/kg	----	----	<4	<4	<4
Anthracene	120-12-7	4	µg/kg	----	----	<4	<4	<4
Fluoranthene	206-44-0	4	µg/kg	----	----	<4	<4	<4
Pyrene	129-00-0	4	µg/kg	----	----	<4	<4	<4
Benz(a)anthracene	56-55-3	4	µg/kg	----	----	<4	<4	<4
Chrysene	218-01-9	4	µg/kg	----	----	<4	<4	<4
Benzo(b+j)fluoranthene	205-99-2 205-82-3	4	µg/kg	----	----	<4	<4	<4
Benzo(k)fluoranthene	207-08-9	4	µg/kg	----	----	<4	<4	<4
Benzo(e)pyrene	192-97-2	4	µg/kg	----	----	<4	<4	<4
Benzo(a)pyrene	50-32-8	4	µg/kg	----	----	<4	<4	<4
Perylene	198-55-0	4	µg/kg	----	----	<4	<4	<4
Benzo(g.h.i)perylene	191-24-2	4	µg/kg	----	----	<4	<4	<4
Dibenz(a.h)anthracene	53-70-3	4	µg/kg	----	----	<4	<4	<4
Indeno(1.2.3.cd)pyrene	193-39-5	4	µg/kg	----	----	<4	<4	<4
Coronene	191-07-1	5	µg/kg	----	----	<5	<5	<5
^ Sum of PAHs	----	4	µg/kg	----	----	<4	<4	<4
EP075(SIM)S: Phenolic Compound Surrogates								
Phenol-d6	13127-88-3	0.5	%	----	----	----	82.0	80.6
2-Chlorophenol-D4	93951-73-6	0.5	%	----	----	----	92.2	91.4
2.4.6-Tribromophenol	118-79-6	0.5	%	----	----	----	40.4	41.4
EP075(SIM)T: PAH Surrogates								
2-Fluorobiphenyl	321-60-8	0.5	%	----	----	----	90.5	91.7
Anthracene-d10	1719-06-8	0.5	%	----	----	----	88.9	87.8
4-Terphenyl-d14	1718-51-0	0.5	%	----	----	----	105	106
EP090S: Organotin Surrogate								
Tripropyltin	----	0.5	%	----	----	----	76.9	106
EP130S: Organophosphorus Pesticide Surrogate								
DEF	78-48-8	10	%	----	----	73.3	62.6	62.5
EP131S: OC Pesticide Surrogate								

Analytical Results

Sub-Matrix: **SEDIMENT** (Matrix: **SOIL**)			Client sample ID	SB11 PSD	SB10 PSD	SB 12 cont	SB 8.1	SB 8.2
			Client sampling date / time	09-Sep-2017 00:00	09-Sep-2017 00:00	09-Sep-2017 00:00	09-Sep-2017 00:00	09-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EM1712422-012	EM1712422-013	EM1712422-014	EM1712422-015	EM1712422-016
				Result	Result	Result	Result	Result
EP131S: OC Pesticide Surrogate - Continued								
Dibromo-DDE	21655-73-2	0.50	%	----	----	79.7	60.1	68.1
EP131T: PCB Surrogate								
Decachlorobiphenyl	2051-24-3	0.5	%	----	----	79.6	62.0	64.9
EP132T: Base/Neutral Extractable Surrogates								
2-Fluorobiphenyl	321-60-8	10	%	----	----	84.3	81.9	77.0
Anthracene-d10	1719-06-8	10	%	----	----	122	119	88.9
4-Terphenyl-d14	1718-51-0	10	%	----	----	120	125	115

Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)			Client sample ID	SB 7.1	SB 7.2	SB 7.3	SB 6	SB 9
			Client sampling date / time	09-Sep-2017 00:00	09-Sep-2017 00:00	09-Sep-2017 00:00	09-Sep-2017 00:00	09-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EM1712422-017	EM1712422-018	EM1712422-019	EM1712422-020	EM1712422-021
				Result	Result	Result	Result	Result
EA031: pH (saturated paste)								
ø pH (Saturated Paste)	----	0.1	pH Unit	----	----	6.5	----	----
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	37.4	48.3	----	37.8	28.2
EG005-SD: Total Metals in Sediments by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	810	11700	----	670	4160
Iron	7439-89-6	50	mg/kg	1560	17900	----	1890	4560
EG020-SD: Total Metals in Sediments by ICPMS								
Antimony	7440-36-0	0.50	mg/kg	<0.50	<0.50	----	1.64	0.60
Arsenic	7440-38-2	1.00	mg/kg	2.19	7.36	----	5.00	11.0
Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	----	<0.1	<0.1
Chromium	7440-47-3	1.0	mg/kg	6.2	26.8	----	5.9	9.6
Copper	7440-50-8	1.0	mg/kg	<1.0	10.3	----	<1.0	1.1
Cobalt	7440-48-4	0.5	mg/kg	<0.5	5.7	----	<0.5	3.4
Lead	7439-92-1	1.0	mg/kg	1.1	5.9	----	<1.0	1.4
Manganese	7439-96-5	10	mg/kg	20	104	----	14	73
Nickel	7440-02-0	1.0	mg/kg	2.2	11.0	----	3.0	5.4
Selenium	7782-49-2	0.1	mg/kg	0.4	1.5	----	0.8	1.1
Silver	7440-22-4	0.1	mg/kg	<0.1	<0.1	----	<0.1	<0.1
Vanadium	7440-62-2	2.0	mg/kg	5.6	29.5	----	16.7	11.6
Zinc	7440-66-6	1.0	mg/kg	3.8	18.4	----	3.2	4.6
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.01	mg/kg	0.01	0.02	----	0.01	0.02
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	690	2850	----	490	520
EK071G: Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	14265-44-2	0.1	mg/kg	1.0	<0.1	----	<0.1	1.0
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	0.60	4.47	----	0.68	0.52
EP075(SIM)A: Phenolic Compounds								
Phenol	108-95-2	0.5	mg/kg	<0.5	<0.5	----	----	<0.5
2-Chlorophenol	95-57-8	0.5	mg/kg	<0.5	<0.5	----	----	<0.5
2-Methylphenol	95-48-7	0.5	mg/kg	<0.5	<0.5	----	----	<0.5
3- & 4-Methylphenol	1319-77-3	1	mg/kg	<1	<1	----	----	<1
2-Nitrophenol	88-75-5	0.5	mg/kg	<0.5	<0.5	----	----	<0.5

Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)			Client sample ID	SB 7.1	SB 7.2	SB 7.3	SB 6	SB 9
			Client sampling date / time	09-Sep-2017 00:00	09-Sep-2017 00:00	09-Sep-2017 00:00	09-Sep-2017 00:00	09-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EM1712422-017	EM1712422-018	EM1712422-019	EM1712422-020	EM1712422-021
				Result	Result	Result	Result	Result
EP075(SIM)A: Phenolic Compounds - Continued								
2.4-Dimethylphenol	105-67-9	0.5	mg/kg	<0.5	<0.5	----	----	<0.5
2.4-Dichlorophenol	120-83-2	0.5	mg/kg	<0.5	<0.5	----	----	<0.5
2.6-Dichlorophenol	87-65-0	0.5	mg/kg	<0.5	<0.5	----	----	<0.5
4-Chloro-3-methylphenol	59-50-7	0.5	mg/kg	<0.5	<0.5	----	----	<0.5
2.4.6-Trichlorophenol	88-06-2	0.5	mg/kg	<0.5	<0.5	----	----	<0.5
2.4.5-Trichlorophenol	95-95-4	0.5	mg/kg	<0.5	<0.5	----	----	<0.5
Pentachlorophenol	87-86-5	2	mg/kg	<2	<2	----	----	<2
EP080/071: Total Petroleum Hydrocarbons								
C10 - C14 Fraction	----	50	mg/kg	<50	<50	----	<50	<50
C15 - C28 Fraction	----	100	mg/kg	<100	<100	----	<100	<100
^ C29 - C36 Fraction	----	100	mg/kg	<100	<100	----	<100	<100
C10 - C36 Fraction (sum)	----	50	mg/kg	<50	<50	----	<50	<50
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
>C10 - C16 Fraction	----	50	mg/kg	<50	<50	----	<50	<50
>C16 - C34 Fraction	----	100	mg/kg	<100	<100	----	<100	<100
>C34 - C40 Fraction	----	100	mg/kg	<100	<100	----	<100	<100
^ >C10 - C40 Fraction (sum)	----	50	mg/kg	<50	<50	----	<50	<50
EP090: Organotin Compounds								
Monobutyltin	78763-54-9	1	µgSn/kg	<1	<1	----	----	<1
Dibutyltin	1002-53-5	1	µgSn/kg	<1	<1	----	----	<1
Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	<0.5	----	----	<0.5
EP130A: Organophosphorus Pesticides (Ultra-trace)								
Bromophos-ethyl	4824-78-6	10	µg/kg	<10	<10	----	<10	<10
Carbophenothion	786-19-6	10	µg/kg	<10	<10	----	<10	<10
Chlorfenvinphos (E)	18708-86-6	10.0	µg/kg	<10.0	<10.0	----	<10.0	<10.0
Chlorfenvinphos (Z)	18708-87-7	10	µg/kg	<10	<10	----	<10	<10
Chlorpyrifos	2921-88-2	10	µg/kg	<10	<10	----	<10	<10
Chlorpyrifos-methyl	5598-13-0	10	µg/kg	<10	<10	----	<10	<10
Demeton-S-methyl	919-86-8	10	µg/kg	<10	<10	----	<10	<10
Diazinon	333-41-5	10	µg/kg	<10	<10	----	<10	<10
Dichlorvos	62-73-7	10	µg/kg	<10	<10	----	<10	<10
Dimethoate	60-51-5	10	µg/kg	<10	<10	----	<10	<10
Ethion	563-12-2	10	µg/kg	<10	<10	----	<10	<10
Fenamiphos	22224-92-6	10	µg/kg	<10	<10	----	<10	<10

Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)			Client sample ID	SB 7.1	SB 7.2	SB 7.3	SB 6	SB 9
			Client sampling date / time	09-Sep-2017 00:00	09-Sep-2017 00:00	09-Sep-2017 00:00	09-Sep-2017 00:00	09-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EM1712422-017	EM1712422-018	EM1712422-019	EM1712422-020	EM1712422-021
				Result	Result	Result	Result	Result
EP130A: Organophosphorus Pesticides (Ultra-trace) - Continued								
Fenthion	55-38-9	10	µg/kg	<10	<10	----	<10	<10
Malathion	121-75-5	10	µg/kg	<10	<10	----	<10	<10
Azinphos Methyl	86-50-0	10	µg/kg	<10	<10	----	<10	<10
Monocrotophos	6923-22-4	10	µg/kg	<10	<10	----	<10	<10
Parathion	56-38-2	10	µg/kg	<10	<10	----	<10	<10
Parathion-methyl	298-00-0	10	µg/kg	<10	<10	----	<10	<10
Pirimphos-ethyl	23505-41-1	10	µg/kg	<10	<10	----	<10	<10
Prothiofos	34643-46-4	10	µg/kg	<10	<10	----	<10	<10
EP131A: Organochlorine Pesticides								
Aldrin	309-00-2	0.50	µg/kg	<0.50	<0.50	----	<0.50	<0.50
alpha-BHC	319-84-6	0.50	µg/kg	<0.50	<0.50	----	<0.50	<0.50
beta-BHC	319-85-7	0.50	µg/kg	<0.50	<0.50	----	<0.50	<0.50
delta-BHC	319-86-8	0.50	µg/kg	<0.50	<0.50	----	<0.50	<0.50
4.4`-DDD	72-54-8	0.50	µg/kg	<0.50	<0.50	----	<0.50	<0.50
4.4`-DDE	72-55-9	0.50	µg/kg	<0.50	<0.50	----	<0.50	<0.50
4.4`-DDT	50-29-3	0.50	µg/kg	<0.50	<0.50	----	<0.50	<0.50
^ Sum of DDD + DDE + DDT	72-54-8/72-55-9/50-2	0.50	µg/kg	<0.50	<0.50	----	<0.50	<0.50
Dieldrin	60-57-1	0.50	µg/kg	<0.50	<0.50	----	<0.50	<0.50
alpha-Endosulfan	959-98-8	0.50	µg/kg	<0.50	<0.50	----	<0.50	<0.50
beta-Endosulfan	33213-65-9	0.50	µg/kg	<0.50	<0.50	----	<0.50	<0.50
Endosulfan sulfate	1031-07-8	0.50	µg/kg	<0.50	<0.50	----	<0.50	<0.50
^ Endosulfan (sum)	115-29-7	0.50	µg/kg	<0.50	<0.50	----	<0.50	<0.50
Endrin	72-20-8	0.50	µg/kg	<0.50	<0.50	----	<0.50	<0.50
Endrin aldehyde	7421-93-4	0.50	µg/kg	<0.50	<0.50	----	<0.50	<0.50
Endrin ketone	53494-70-5	0.50	µg/kg	<0.50	<0.50	----	<0.50	<0.50
Heptachlor	76-44-8	0.50	µg/kg	<0.50	<0.50	----	<0.50	<0.50
Heptachlor epoxide	1024-57-3	0.50	µg/kg	<0.50	<0.50	----	<0.50	<0.50
Hexachlorobenzene (HCB)	118-74-1	0.50	µg/kg	<0.50	<0.50	----	<0.50	<0.50
gamma-BHC	58-89-9	0.25	µg/kg	<0.25	<0.25	----	<0.25	<0.25
Methoxychlor	72-43-5	0.50	µg/kg	<0.50	<0.50	----	<0.50	<0.50
cis-Chlordane	5103-71-9	0.25	µg/kg	<0.25	<0.25	----	<0.25	<0.25
trans-Chlordane	5103-74-2	0.25	µg/kg	<0.25	<0.25	----	<0.25	<0.25
^ Total Chlordane (sum)	----	0.25	µg/kg	<0.25	<0.25	----	<0.25	<0.25
Oxychlordane	27304-13-8	0.50	µg/kg	<0.50	<0.50	----	<0.50	<0.50

Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)			Client sample ID	SB 7.1	SB 7.2	SB 7.3	SB 6	SB 9
			Client sampling date / time	09-Sep-2017 00:00	09-Sep-2017 00:00	09-Sep-2017 00:00	09-Sep-2017 00:00	09-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EM1712422-017	EM1712422-018	EM1712422-019	EM1712422-020	EM1712422-021
				Result	Result	Result	Result	Result
EP131B: Polychlorinated Biphenyls (as Aroclors)								
^ Total Polychlorinated biphenyls	----	5.0	µg/kg	<5.0	<5.0	----	<5.0	<5.0
Aroclor 1016	12674-11-2	5.0	µg/kg	<5.0	<5.0	----	<5.0	<5.0
Aroclor 1221	11104-28-2	5.0	µg/kg	<5.0	<5.0	----	<5.0	<5.0
Aroclor 1232	11141-16-5	5.0	µg/kg	<5.0	<5.0	----	<5.0	<5.0
Aroclor 1242	53469-21-9	5.0	µg/kg	<5.0	<5.0	----	<5.0	<5.0
Aroclor 1248	12672-29-6	5.0	µg/kg	<5.0	<5.0	----	<5.0	<5.0
Aroclor 1254	11097-69-1	5.0	µg/kg	<5.0	<5.0	----	<5.0	<5.0
Aroclor 1260	11096-82-5	5.0	µg/kg	<5.0	<5.0	----	<5.0	<5.0
EP132B: Polynuclear Aromatic Hydrocarbons								
Naphthalene	91-20-3	5	µg/kg	<5	<5	----	<5	<5
2-Methylnaphthalene	91-57-6	5	µg/kg	<5	<5	----	<5	<5
Acenaphthylene	208-96-8	4	µg/kg	<4	<4	----	<4	<4
Acenaphthene	83-32-9	4	µg/kg	<4	<4	----	<4	<4
Fluorene	86-73-7	4	µg/kg	<4	<4	----	<4	<4
Phenanthrene	85-01-8	4	µg/kg	<4	<4	----	<4	<4
Anthracene	120-12-7	4	µg/kg	<4	<4	----	<4	<4
Fluoranthene	206-44-0	4	µg/kg	<4	<4	----	<4	<4
Pyrene	129-00-0	4	µg/kg	<4	<4	----	<4	<4
Benz(a)anthracene	56-55-3	4	µg/kg	<4	<4	----	<4	<4
Chrysene	218-01-9	4	µg/kg	<4	<4	----	<4	<4
Benzo(b+j)fluoranthene	205-99-2 205-82-3	4	µg/kg	<4	<4	----	<4	<4
Benzo(k)fluoranthene	207-08-9	4	µg/kg	<4	<4	----	<4	<4
Benzo(e)pyrene	192-97-2	4	µg/kg	<4	<4	----	<4	<4
Benzo(a)pyrene	50-32-8	4	µg/kg	<4	<4	----	<4	<4
Perylene	198-55-0	4	µg/kg	<4	**91**	----	<4	<4
Benzo(g.h.i)perylene	191-24-2	4	µg/kg	<4	<4	----	<4	<4
Dibenz(a.h)anthracene	53-70-3	4	µg/kg	<4	<4	----	<4	<4
Indeno(1.2.3.cd)pyrene	193-39-5	4	µg/kg	<4	<4	----	<4	<4
Coronene	191-07-1	5	µg/kg	<5	<5	----	<5	<5
^ Sum of PAHs	----	4	µg/kg	<4	**91**	----	<4	<4
EP075(SIM)S: Phenolic Compound Surrogates								
Phenol-d6	13127-88-3	0.5	%	82.8	89.5	----	----	95.2
2-Chlorophenol-D4	93951-73-6	0.5	%	94.0	101	----	----	109
2.4.6-Tribromophenol	118-79-6	0.5	%	42.9	44.3	----	----	39.4

Analytical Results

Sub-Matrix: **SEDIMENT** (Matrix: **SOIL**)			Client sample ID	SB 7.1	SB 7.2	SB 7.3	SB 6	SB 9
			Client sampling date / time	09-Sep-2017 00:00	09-Sep-2017 00:00	09-Sep-2017 00:00	09-Sep-2017 00:00	09-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EM1712422-017	EM1712422-018	EM1712422-019	EM1712422-020	EM1712422-021
				Result	Result	Result	Result	Result
EP075(SIM)T: PAH Surrogates								
2-Fluorobiphenyl	321-60-8	0.5	%	91.5	96.5	----	----	106
Anthracene-d10	1719-06-8	0.5	%	92.7	93.5	----	----	103
4-Terphenyl-d14	1718-51-0	0.5	%	108	109	----	----	120
EP090S: Organotin Surrogate								
Tripropyltin	----	0.5	%	66.0	67.0	----	----	86.2
EP130S: Organophosphorus Pesticide Surrogate								
DEF	78-48-8	10	%	61.1	51.1	----	58.1	53.4
EP131S: OC Pesticide Surrogate								
Dibromo-DDE	21655-73-2	0.50	%	78.7	42.1	----	72.1	76.3
EP131T: PCB Surrogate								
Decachlorobiphenyl	2051-24-3	0.5	%	70.2	65.9	----	62.6	64.6
EP132T: Base/Neutral Extractable Surrogates								
2-Fluorobiphenyl	321-60-8	10	%	82.8	87.6	----	81.4	85.9
Anthracene-d10	1719-06-8	10	%	105	112	----	106	106
4-Terphenyl-d14	1718-51-0	10	%	91.9	107	----	119	105

Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)			Client sample ID	SB 12 PSD	SB 6 PSD	SB 8 PSD	SB 5 PSD	SB 7.1 GREY
			Client sampling date / time	09-Sep-2017 00:00	09-Sep-2017 00:00	09-Sep-2017 00:00	09-Sep-2017 00:00	09-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EM1712422-022	EM1712422-023	EM1712422-024	EM1712422-025	EM1712422-026
				Result	Result	Result	Result	Result
EA150: Particle Sizing								
+75µm	----	1	%	69	70	91	71	77
+150µm	----	1	%	49	42	85	34	51
+300µm	----	1	%	38	30	64	26	38
+425µm	----	1	%	31	24	41	22	32
+600µm	----	1	%	25	19	28	18	25
+1180µm	----	1	%	16	13	16	12	15
+2.36mm	----	1	%	9	8	10	8	10
+4.75mm	----	1	%	2	4	5	4	5
+9.5mm	----	1	%	<1	<1	2	<1	<1
+19.0mm	----	1	%	<1	<1	<1	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	15	13	5	14	11
Silt (2-60 µm)	----	1	%	13	14	3	12	9
Sand (0.06-2.00 mm)	----	1	%	61	63	80	65	69
Gravel (>2mm)	----	1	%	11	10	12	9	11
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA152: Soil Particle Density								
ø Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	2.46	2.47	2.48	2.42	2.41

Analytical Results

Sub-Matrix: **SEDIMENT** (Matrix: **SOIL**)			*Client sample ID*	**SB 7.2 BLACK**	----	----	----	----
			Client sampling date / time	09-Sep-2017 00:00	----	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EM1712422-027**	--------	--------	--------	--------
				Result	----	----	----	----
EA150: Particle Sizing								
+75µm	----	1	%	32	----	----	----	----
+150µm	----	1	%	18	----	----	----	----
+300µm	----	1	%	8	----	----	----	----
+425µm	----	1	%	7	----	----	----	----
+600µm	----	1	%	6	----	----	----	----
+1180µm	----	1	%	4	----	----	----	----
+2.36mm	----	1	%	3	----	----	----	----
+4.75mm	----	1	%	1	----	----	----	----
+9.5mm	----	1	%	<1	----	----	----	----
+19.0mm	----	1	%	<1	----	----	----	----
+37.5mm	----	1	%	<1	----	----	----	----
+75.0mm	----	1	%	<1	----	----	----	----
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	23	----	----	----	----
Silt (2-60 µm)	----	1	%	36	----	----	----	----
Sand (0.06-2.00 mm)	----	1	%	38	----	----	----	----
Gravel (>2mm)	----	1	%	3	----	----	----	----
Cobbles (>6cm)	----	1	%	<1	----	----	----	----
EA152: Soil Particle Density								
ø Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	2.48	----	----	----	----

Surrogate Control Limits

Sub-Matrix: **SEDIMENT**

Compound	CAS Number	Recovery Limits (%) Low	High
EP075(SIM)S: Phenolic Compound Surrogates			
Phenol-d6	13127-88-3	54	125
2-Chlorophenol-D4	93951-73-6	65	123
2.4.6-Tribromophenol	118-79-6	34	122
EP075(SIM)T: PAH Surrogates			
2-Fluorobiphenyl	321-60-8	61	125
Anthracene-d10	1719-06-8	62	130
4-Terphenyl-d14	1718-51-0	67	133
EP090S: Organotin Surrogate			
Tripropyltin	----	35	130
EP130S: Organophosphorus Pesticide Surrogate			
DEF	78-48-8	14	102
EP131S: OC Pesticide Surrogate			
Dibromo-DDE	21655-73-2	10	119
EP131T: PCB Surrogate			
Decachlorobiphenyl	2051-24-3	10	106
EP132T: Base/Neutral Extractable Surrogates			
2-Fluorobiphenyl	321-60-8	55	135
Anthracene-d10	1719-06-8	70	136
4-Terphenyl-d14	1718-51-0	57	127

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: ES1825398	Page	: 1 of 11
Client	: ENVIRONMENTAL PROJECTS	Laboratory	: Environmental Division Sydney
Contact	: Lab Results	Contact	: Customer Services ES
Address	: LEVEL 3 117 KING WILLIAM ST ADELAIDE SA 5001	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: ----	Telephone	: +61-2-8784 8555
Project	: 17004.01 KIPT EIS	Date Samples Received	: 28-Aug-2018 13:00
Order number	:	Date Analysis Commenced	: 29-Aug-2018
C-O-C number	: ----	Issue Date	: 05-Sep-2018 22:12
Sampler	: ----		
Site	: ----		
Quote number	: EN/333		
No. of samples received	: 6		
No. of samples analysed	: 6		

NATA

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Diana Mesa	2IC Organic Chemist	Brisbane Organics, Stafford, QLD
Dianne Blane	Laboratory Coordinator (2IC)	Newcastle - Inorganics, Mayfield West, NSW
Edwandy Fadjar	Organic Coordinator	Sydney Inorganics, Smithfield, NSW
Edwandy Fadjar	Organic Coordinator	Sydney Organics, Smithfield, NSW
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EA150H: Soil Particle Density required for Hydrometer analysis according to AS 1289.3.5.1 2006 was not requested by the client. Typical sediment SPD values used for calculations and consequently NATA endorsement does not apply to hydrometer results.
- EG005: It has been confirmed by re-extraction and reanalysis that poor precision was obtained for Iron on sample ES1825398 #002.
- EP090 Organotin: High LCS recovery deemed acceptable as all associated analyte results are less than LOR
- EA151: ALS does not hold NATA accreditation for Settleability.
- Benzo(a)pyrene Toxicity Equivalent Quotient (TEQ) is the sum total of the concentration of the eight carcinogenic PAHs multiplied by their Toxicity Equivalence Factor (TEF) relative to Benzo(a)pyrene. TEF values are provided in brackets as follows: Benz(a)anthracene (0.1), Chrysene (0.01), Benzo(b+j) & Benzo(k)fluoranthene (0.1), Benzo(a)pyrene (1.0), Indeno(1.2.3.cd)pyrene (0.1), Dibenz(a.h)anthracene (1.0), Benzo(g.h.i)perylene (0.01). Less than LOR results for 'TEQ Zero' are treated as zero, for 'TEQ 1/2LOR' are treated as half the reported LOR, and for 'TEQ LOR' are treated as being equal to the reported LOR. Note: TEQ 1/2LOR and TEQ LOR will calculate as 0.6mg/Kg and 1.2mg/Kg respectively for samples with non-detects for all of the eight TEQ PAHs.

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	ZZ3 13m	ZZ4 13m	ZZ5 13m	ZZ6 13m	ZZ7 13m
			Client sampling date / time	26-Aug-2018 00:00	26-Aug-2018 00:00	26-Aug-2018 00:00	26-Aug-2018 00:00	26-Aug-2018 00:00
Compound	CAS Number	LOR	Unit	ES1825398-001	ES1825398-002	ES1825398-003	ES1825398-004	ES1825398-005
				Result	Result	Result	Result	Result
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	37.2	35.8	37.4	29.8	32.2
EA150: Particle Sizing								
+75µm	----	1	%	82	86	82	86	88
+150µm	----	1	%	53	59	55	60	65
+300µm	----	1	%	43	48	48	47	51
+425µm	----	1	%	39	43	42	39	42
+600µm	----	1	%	33	37	36	33	32
+1180µm	----	1	%	24	27	25	24	18
+2.36mm	----	1	%	17	19	18	17	8
+4.75mm	----	1	%	10	12	13	12	4
+9.5mm	----	1	%	4	6	5	8	<1
+19.0mm	----	1	%	<1	<1	<1	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	5	6	6	6	4
Silt (2-60 µm)	----	1	%	9	4	6	4	7
Sand (0.06-2.00 mm)	----	1	%	67	69	68	71	78
Gravel (>2mm)	----	1	%	19	21	20	19	11
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA151: Settleability 20%								
ø Underflow Density	----	0.01	g/cm3	1.43	----	1.56	----	1.56
ø Underflow Solids	----	0.1	%	49.8	----	49.3	----	53.3
ø Settling Rate @ 50% of Settlement	----	0.001	mm/min	18.6	----	18.2	----	20.2
ø Settling Rate @ 90% of Settlement	----	0.001	mm/min	18.6	----	18.2	----	20.2
ø Clarity	----	-	-	Clear	----	Clear	----	Clear
EG005-SD: Total Metals in Sediments by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	2670	760	910	760	520
Iron	7439-89-6	50	mg/kg	1920	1590	1930	1410	1070
EG020-SD: Total Metals in Sediments by ICPMS								
Antimony	7440-36-0	0.50	mg/kg	<0.50	<0.50	<0.50	<0.50	<0.50
Arsenic	7440-38-2	1.00	mg/kg	2.39	3.33	2.92	2.10	1.46
Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	7440-47-3	1.0	mg/kg	6.7	5.9	5.6	4.8	4.6

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	ZZ3 13m	ZZ4 13m	ZZ5 13m	ZZ6 13m	ZZ7 13m
			Client sampling date / time	26-Aug-2018 00:00	26-Aug-2018 00:00	26-Aug-2018 00:00	26-Aug-2018 00:00	26-Aug-2018 00:00
Compound	CAS Number	LOR	Unit	ES1825398-001	ES1825398-002	ES1825398-003	ES1825398-004	ES1825398-005
				Result	Result	Result	Result	Result
EG020-SD: Total Metals in Sediments by ICPMS - Continued								
Copper	7440-50-8	1.0	mg/kg	1.1	<1.0	<1.0	<1.0	<1.0
Cobalt	7440-48-4	0.5	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Lead	7439-92-1	1.0	mg/kg	1.4	1.4	1.3	1.0	<1.0
Manganese	7439-96-5	10	mg/kg	19	14	16	14	12
Nickel	7440-02-0	1.0	mg/kg	2.7	1.2	2.3	1.8	1.4
Selenium	7782-49-2	0.1	mg/kg	0.4	0.5	0.4	0.3	0.2
Silver	7440-22-4	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Vanadium	7440-62-2	2.0	mg/kg	9.4	14.0	7.2	5.9	3.8
Zinc	7440-66-6	1.0	mg/kg	4.5	4.7	3.5	17.4	4.8
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01
EK026SF: Total CN by Segmented Flow Analyser								
Total Cyanide	57-12-5	1	mg/kg	<1	<1	<1	<1	<1
EK071G: Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	14265-44-2	0.1	mg/kg	0.3	<0.1	0.2	0.2	<0.1
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	0.63	0.83	0.47	0.41	0.31
EP075(SIM)A: Phenolic Compounds								
Phenol	108-95-2	0.5	mg/kg	<0.5	----	<0.5	----	<0.5
2-Chlorophenol	95-57-8	0.5	mg/kg	<0.5	----	<0.5	----	<0.5
2-Methylphenol	95-48-7	0.5	mg/kg	<0.5	----	<0.5	----	<0.5
3- & 4-Methylphenol	1319-77-3	1	mg/kg	<1	----	<1	----	<1
2-Nitrophenol	88-75-5	0.5	mg/kg	<0.5	----	<0.5	----	<0.5
2.4-Dimethylphenol	105-67-9	0.5	mg/kg	<0.5	----	<0.5	----	<0.5
2.4-Dichlorophenol	120-83-2	0.5	mg/kg	<0.5	----	<0.5	----	<0.5
2.6-Dichlorophenol	87-65-0	0.5	mg/kg	<0.5	----	<0.5	----	<0.5
4-Chloro-3-methylphenol	59-50-7	0.5	mg/kg	<0.5	----	<0.5	----	<0.5
2.4.6-Trichlorophenol	88-06-2	0.5	mg/kg	<0.5	----	<0.5	----	<0.5
2.4.5-Trichlorophenol	95-95-4	0.5	mg/kg	<0.5	----	<0.5	----	<0.5
Pentachlorophenol	87-86-5	2	mg/kg	<2	----	<2	----	<2
EP080-SD / EP071-SD: Total Petroleum Hydrocarbons								
C10 - C14 Fraction	----	3	mg/kg	<3	----	<3	----	<3
C15 - C28 Fraction	----	3	mg/kg	<3	----	<3	----	<3
C29 - C36 Fraction	----	5	mg/kg	<5	----	<5	----	<5

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	ZZ3 13m	ZZ4 13m	ZZ5 13m	ZZ6 13m	ZZ7 13m
			Client sampling date / time	26-Aug-2018 00:00	26-Aug-2018 00:00	26-Aug-2018 00:00	26-Aug-2018 00:00	26-Aug-2018 00:00
Compound	CAS Number	LOR	Unit	ES1825398-001	ES1825398-002	ES1825398-003	ES1825398-004	ES1825398-005
				Result	Result	Result	Result	Result
EP080-SD / EP071-SD: Total Petroleum Hydrocarbons - Continued								
^ C10 - C36 Fraction (sum)	----	3	mg/kg	<3	----	<3	----	<3
EP080-SD / EP071-SD: Total Recoverable Hydrocarbons								
>C10 - C16 Fraction	----	3	mg/kg	<3	----	<3	----	<3
>C16 - C34 Fraction	----	3	mg/kg	**3**	----	**4**	----	<3
>C34 - C40 Fraction	----	5	mg/kg	<5	----	<5	----	<5
^ >C10 - C40 Fraction (sum)	----	3	mg/kg	**3**	----	**4**	----	<3
EP090: Organotin Compounds								
Monobutyltin	78763-54-9	1	µgSn/kg	<1	----	<1	----	<1
Dibutyltin	1002-53-5	1	µgSn/kg	<1	----	<1	----	<1
Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	----	<0.5	----	<0.5
EP130A: Organophosphorus Pesticides (Ultra-trace)								
Bromophos-ethyl	4824-78-6	10	µg/kg	<10	----	<10	----	<10
Carbophenothion	786-19-6	10	µg/kg	<10	----	<10	----	<10
Chlorfenvinphos (E)	18708-86-6	10.0	µg/kg	<10.0	----	<10.0	----	<10.0
Chlorfenvinphos (Z)	18708-87-7	10	µg/kg	<10	----	<10	----	<10
Chlorpyrifos	2921-88-2	10	µg/kg	<10	----	<10	----	<10
Chlorpyrifos-methyl	5598-13-0	10	µg/kg	<10	----	<10	----	<10
Demeton-S-methyl	919-86-8	10	µg/kg	<10	----	<10	----	<10
Diazinon	333-41-5	10	µg/kg	<10	----	<10	----	<10
Dichlorvos	62-73-7	10	µg/kg	<10	----	<10	----	<10
Dimethoate	60-51-5	10	µg/kg	<10	----	<10	----	<10
Ethion	563-12-2	10	µg/kg	<10	----	<10	----	<10
Fenamiphos	22224-92-6	10	µg/kg	<10	----	<10	----	<10
Fenthion	55-38-9	10	µg/kg	<10	----	<10	----	<10
Malathion	121-75-5	10	µg/kg	<10	----	<10	----	<10
Azinphos Methyl	86-50-0	10	µg/kg	<10	----	<10	----	<10
Monocrotophos	6923-22-4	10	µg/kg	<10	----	<10	----	<10
Parathion	56-38-2	10	µg/kg	<10	----	<10	----	<10
Parathion-methyl	298-00-0	10	µg/kg	<10	----	<10	----	<10
Pirimphos-ethyl	23505-41-1	10	µg/kg	<10	----	<10	----	<10
Prothiofos	34643-46-4	10	µg/kg	<10	----	<10	----	<10
EP131A: Organochlorine Pesticides								
Aldrin	309-00-2	0.50	µg/kg	<0.50	----	<0.50	----	<0.50
alpha-BHC	319-84-6	0.50	µg/kg	<0.50	----	<0.50	----	<0.50

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	ZZ3 13m	ZZ4 13m	ZZ5 13m	ZZ6 13m	ZZ7 13m
			Client sampling date / time	26-Aug-2018 00:00	26-Aug-2018 00:00	26-Aug-2018 00:00	26-Aug-2018 00:00	26-Aug-2018 00:00
Compound	CAS Number	LOR	Unit	ES1825398-001	ES1825398-002	ES1825398-003	ES1825398-004	ES1825398-005
				Result	Result	Result	Result	Result
EP131A: Organochlorine Pesticides - Continued								
beta-BHC	319-85-7	0.50	µg/kg	<0.50	----	<0.50	----	<0.50
delta-BHC	319-86-8	0.50	µg/kg	<0.50	----	<0.50	----	<0.50
4.4`-DDD	72-54-8	0.50	µg/kg	<0.50	----	<0.50	----	<0.50
4.4`-DDE	72-55-9	0.50	µg/kg	<0.50	----	<0.50	----	<0.50
4.4`-DDT	50-29-3	0.50	µg/kg	<0.50	----	<0.50	----	<0.50
^ Sum of DDD + DDE + DDT	72-54-8/72-55-9/50-2	0.50	µg/kg	<0.50	----	<0.50	----	<0.50
Dieldrin	60-57-1	0.50	µg/kg	<0.50	----	<0.50	----	<0.50
alpha-Endosulfan	959-98-8	0.50	µg/kg	<0.50	----	<0.50	----	<0.50
beta-Endosulfan	33213-65-9	0.50	µg/kg	<0.50	----	<0.50	----	<0.50
Endosulfan sulfate	1031-07-8	0.50	µg/kg	<0.50	----	<0.50	----	<0.50
^ Endosulfan (sum)	115-29-7	0.50	µg/kg	<0.50	----	<0.50	----	<0.50
Endrin	72-20-8	0.50	µg/kg	<0.50	----	<0.50	----	<0.50
Endrin aldehyde	7421-93-4	0.50	µg/kg	<0.50	----	<0.50	----	<0.50
Endrin ketone	53494-70-5	0.50	µg/kg	<0.50	----	<0.50	----	<0.50
Heptachlor	76-44-8	0.50	µg/kg	<0.50	----	<0.50	----	<0.50
Heptachlor epoxide	1024-57-3	0.50	µg/kg	<0.50	----	<0.50	----	<0.50
Hexachlorobenzene (HCB)	118-74-1	0.50	µg/kg	<0.50	----	<0.50	----	<0.50
gamma-BHC	58-89-9	0.25	µg/kg	<0.25	----	<0.25	----	<0.25
Methoxychlor	72-43-5	0.50	µg/kg	<0.50	----	<0.50	----	<0.50
cis-Chlordane	5103-71-9	0.25	µg/kg	<0.25	----	<0.25	----	<0.25
trans-Chlordane	5103-74-2	0.25	µg/kg	<0.25	----	<0.25	----	<0.25
^ Total Chlordane (sum)	----	0.25	µg/kg	<0.25	----	<0.25	----	<0.25
Oxychlordane	27304-13-8	0.50	µg/kg	<0.50	----	<0.50	----	<0.50
EP131B: Polychlorinated Biphenyls (as Aroclors)								
^ Total Polychlorinated biphenyls	----	5.0	µg/kg	<5.0	----	<5.0	----	<5.0
Aroclor 1016	12674-11-2	5.0	µg/kg	<5.0	----	<5.0	----	<5.0
Aroclor 1221	11104-28-2	5.0	µg/kg	<5.0	----	<5.0	----	<5.0
Aroclor 1232	11141-16-5	5.0	µg/kg	<5.0	----	<5.0	----	<5.0
Aroclor 1242	53469-21-9	5.0	µg/kg	<5.0	----	<5.0	----	<5.0
Aroclor 1248	12672-29-6	5.0	µg/kg	<5.0	----	<5.0	----	<5.0
Aroclor 1254	11097-69-1	5.0	µg/kg	<5.0	----	<5.0	----	<5.0
Aroclor 1260	11096-82-5	5.0	µg/kg	<5.0	----	<5.0	----	<5.0
EP132B: Polynuclear Aromatic Hydrocarbons								

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	ZZ3 13m	ZZ4 13m	ZZ5 13m	ZZ6 13m	ZZ7 13m
			Client sampling date / time	26-Aug-2018 00:00	26-Aug-2018 00:00	26-Aug-2018 00:00	26-Aug-2018 00:00	26-Aug-2018 00:00
Compound	CAS Number	LOR	Unit	ES1825398-001	ES1825398-002	ES1825398-003	ES1825398-004	ES1825398-005
				Result	Result	Result	Result	Result
EP132B: Polynuclear Aromatic Hydrocarbons - Continued								
Naphthalene	91-20-3	5	µg/kg	<5	----	<5	----	<5
2-Methylnaphthalene	91-57-6	5	µg/kg	<5	----	<5	----	<5
Acenaphthylene	208-96-8	4	µg/kg	<4	----	<4	----	<4
Acenaphthene	83-32-9	4	µg/kg	<4	----	<4	----	<4
Fluorene	86-73-7	4	µg/kg	<4	----	<4	----	<4
Phenanthrene	85-01-8	4	µg/kg	<4	----	<4	----	<4
Anthracene	120-12-7	4	µg/kg	<4	----	<4	----	<4
Fluoranthene	206-44-0	4	µg/kg	<4	----	<4	----	<4
Pyrene	129-00-0	4	µg/kg	<4	----	<4	----	<4
Benz(a)anthracene	56-55-3	4	µg/kg	<4	----	<4	----	<4
Chrysene	218-01-9	4	µg/kg	<4	----	<4	----	<4
Benzo(b+j)fluoranthene	205-99-2 205-82-3	4	µg/kg	<4	----	<4	----	<4
Benzo(k)fluoranthene	207-08-9	4	µg/kg	<4	----	<4	----	<4
Benzo(e)pyrene	192-97-2	4	µg/kg	<4	----	<4	----	<4
Benzo(a)pyrene	50-32-8	4	µg/kg	<4	----	<4	----	<4
Perylene	198-55-0	4	µg/kg	<4	----	<4	----	<4
Benzo(g.h.i)perylene	191-24-2	4	µg/kg	<4	----	<4	----	<4
Dibenz(a.h)anthracene	53-70-3	4	µg/kg	<4	----	<4	----	<4
Indeno(1.2.3.cd)pyrene	193-39-5	4	µg/kg	<4	----	<4	----	<4
Coronene	191-07-1	5	µg/kg	<5	----	<5	----	<5
^ Sum of PAHs	----	4	µg/kg	<4	----	<4	----	<4
EP075(SIM)S: Phenolic Compound Surrogates								
Phenol-d6	13127-88-3	0.5	%	77.1	----	76.6	----	81.0
2-Chlorophenol-D4	93951-73-6	0.5	%	80.1	----	80.3	----	84.9
2.4.6-Tribromophenol	118-79-6	0.5	%	77.6	----	74.8	----	77.3
EP075(SIM)T: PAH Surrogates								
2-Fluorobiphenyl	321-60-8	0.5	%	91.8	----	90.9	----	96.8
Anthracene-d10	1719-06-8	0.5	%	88.7	----	88.0	----	92.1
4-Terphenyl-d14	1718-51-0	0.5	%	76.4	----	75.2	----	78.6
EP090S: Organotin Surrogate								
Tripropyltin	----	0.5	%	99.4	----	108	----	114
EP130S: Organophosphorus Pesticide Surrogate								
DEF	78-48-8	10	%	48.5	----	43.0	----	71.2
EP131S: OC Pesticide Surrogate								

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	ZZ3 13m	ZZ4 13m	ZZ5 13m	ZZ6 13m	ZZ7 13m
			Client sampling date / time	26-Aug-2018 00:00	26-Aug-2018 00:00	26-Aug-2018 00:00	26-Aug-2018 00:00	26-Aug-2018 00:00
Compound	CAS Number	LOR	Unit	ES1825398-001	ES1825398-002	ES1825398-003	ES1825398-004	ES1825398-005
				Result	Result	Result	Result	Result
EP131S: OC Pesticide Surrogate - Continued								
Dibromo-DDE	21655-73-2	0.50	%	40.6	----	53.0	----	58.6
EP131T: PCB Surrogate								
Decachlorobiphenyl	2051-24-3	0.5	%	66.5	----	61.4	----	61.8
EP132T: Base/Neutral Extractable Surrogates								
2-Fluorobiphenyl	321-60-8	10	%	109	----	80.2	----	92.8
Anthracene-d10	1719-06-8	10	%	118	----	92.3	----	101
4-Terphenyl-d14	1718-51-0	10	%	115	----	110	----	96.2

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	ZZ9 14m	----	----	----	----
			Client sampling date / time	26-Aug-2018 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	ES1825398-006	--------	--------	--------	--------
				Result	----	----	----	----
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	36.7	----	----	----	----
EA150: Particle Sizing								
+75µm	----	1	%	87	----	----	----	----
+150µm	----	1	%	62	----	----	----	----
+300µm	----	1	%	48	----	----	----	----
+425µm	----	1	%	39	----	----	----	----
+600µm	----	1	%	30	----	----	----	----
+1180µm	----	1	%	16	----	----	----	----
+2.36mm	----	1	%	9	----	----	----	----
+4.75mm	----	1	%	5	----	----	----	----
+9.5mm	----	1	%	1	----	----	----	----
+19.0mm	----	1	%	<1	----	----	----	----
+37.5mm	----	1	%	<1	----	----	----	----
+75.0mm	----	1	%	<1	----	----	----	----
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	5	----	----	----	----
Silt (2-60 µm)	----	1	%	4	----	----	----	----
Sand (0.06-2.00 mm)	----	1	%	80	----	----	----	----
Gravel (>2mm)	----	1	%	11	----	----	----	----
Cobbles (>6cm)	----	1	%	<1	----	----	----	----
EG005-SD: Total Metals in Sediments by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	530	----	----	----	----
Iron	7439-89-6	50	mg/kg	1090	----	----	----	----
EG020-SD: Total Metals in Sediments by ICPMS								
Antimony	7440-36-0	0.50	mg/kg	<0.50	----	----	----	----
Arsenic	7440-38-2	1.00	mg/kg	1.18	----	----	----	----
Cadmium	7440-43-9	0.1	mg/kg	<0.1	----	----	----	----
Chromium	7440-47-3	1.0	mg/kg	4.4	----	----	----	----
Copper	7440-50-8	1.0	mg/kg	<1.0	----	----	----	----
Cobalt	7440-48-4	0.5	mg/kg	<0.5	----	----	----	----
Lead	7439-92-1	1.0	mg/kg	<1.0	----	----	----	----
Manganese	7439-96-5	10	mg/kg	11	----	----	----	----
Nickel	7440-02-0	1.0	mg/kg	1.2	----	----	----	----
Selenium	7782-49-2	0.1	mg/kg	0.2	----	----	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	ZZ9 14m	----	----	----	----
			Client sampling date / time	26-Aug-2018 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	ES1825398-006	--------	--------	--------	--------
				Result	----	----	----	----
EG020-SD: Total Metals in Sediments by ICPMS - Continued								
Silver	7440-22-4	0.1	mg/kg	<0.1	----	----	----	----
Vanadium	7440-62-2	2.0	mg/kg	**3.9**	----	----	----	----
Zinc	7440-66-6	1.0	mg/kg	**2.0**	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.01	mg/kg	<0.01	----	----	----	----
EK026SF: Total CN by Segmented Flow Analyser								
Total Cyanide	57-12-5	1	mg/kg	<1	----	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	14265-44-2	0.1	mg/kg	<0.1	----	----	----	----
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	**0.27**	----	----	----	----

Surrogate Control Limits

Sub-Matrix: **SOIL**		Recovery Limits (%)	
Compound	CAS Number	Low	High
EP075(SIM)S: Phenolic Compound Surrogates			
Phenol-d6	13127-88-3	63	123
2-Chlorophenol-D4	93951-73-6	66	122
2.4.6-Tribromophenol	118-79-6	40	138
EP075(SIM)T: PAH Surrogates			
2-Fluorobiphenyl	321-60-8	70	122
Anthracene-d10	1719-06-8	66	128
4-Terphenyl-d14	1718-51-0	65	129
EP090S: Organotin Surrogate			
Tripropyltin	----	35	130
EP130S: Organophosphorus Pesticide Surrogate			
DEF	78-48-8	14	102
EP131S: OC Pesticide Surrogate			
Dibromo-DDE	21655-73-2	10	119
EP131T: PCB Surrogate			
Decachlorobiphenyl	2051-24-3	10	106
EP132T: Base/Neutral Extractable Surrogates			
2-Fluorobiphenyl	321-60-8	55	135
Anthracene-d10	1719-06-8	70	136
4-Terphenyl-d14	1718-51-0	57	127

Certificate of Analysis

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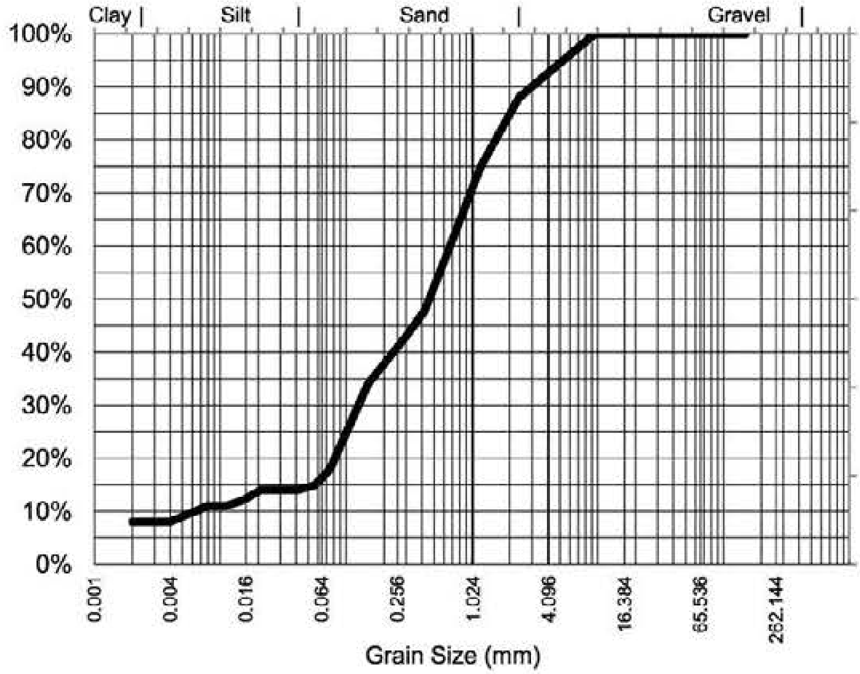
ALS Environmental

Newcastle, NSW

CLIENT:	Joe Mifsud	**DATE REPORTED:**	19-Sep-2017
COMPANY:	COOE PTY LTD	**DATE RECEIVED:**	12-Sep-2017
ADDRESS:	P.O. Box 591 Littlehampton SA, Australia	**REPORT NO:**	EM1712422-001 / PSD
PROJECT:	SEA.SBD.01	**SAMPLE ID:**	SB1 PSD

Particle Size Distribution



Particle Size (mm)	Percent Passing
9.50	100%
4.75	94%
2.36	88%
1.18	75%
0.600	57%
0.425	48%
0.300	43%
0.150	34%
0.075	18%
Particle Size (microns)	
75	18%
57	15%
42	14%
21	14%
11	11%
5	9%
2	8%

Median Particle Size (mm)*	0.464

Samples analysed as received.

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 15-Sep-17

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: SAND, SHELL, FINES, VEG

Dispersion Method Shaker

Test Method: AS1289.3.6.3 2003

Hydrometer Type ASTM E100

Soil Particle Density (<2.36mm) 2.56 g/cm3

Dianne Blane
Laboratory Coordinator
Authorised Signatory

Certificate of Analysis

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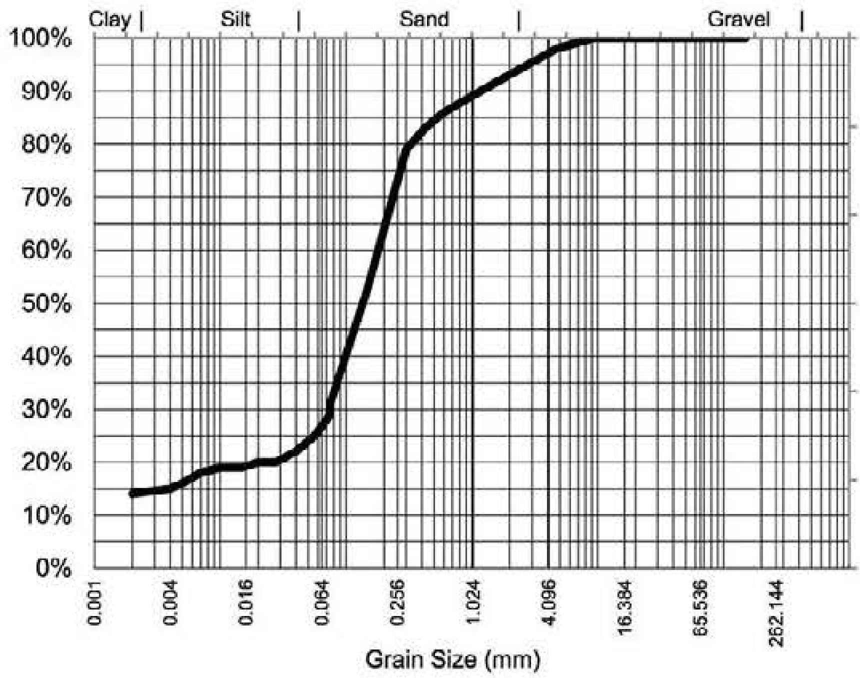
ALS Environmental

Newcastle, NSW

CLIENT:	Joe Mifsud	**DATE REPORTED:**	19-Sep-2017
COMPANY:	COOE PTY LTD	**DATE RECEIVED:**	12-Sep-2017
ADDRESS:	P.O. Box 591 Littlehampton SA, Australia	**REPORT NO:**	EM1712422-011 / PSD
PROJECT:	SEA.SBD.01	**SAMPLE ID:**	SB2 PSD

Particle Size Distribution



Particle Size (mm)	Percent Passing
9.50	100%
4.75	98%
2.36	94%
1.18	90%
0.600	86%
0.425	83%
0.300	79%
0.150	53%
0.075	31%
Particle Size (microns)	
75	29%
57	25%
40	22%
20	20%
10	19%
5	16%
2	14%

Median Particle Size (mm)*	0.140

Samples analysed as received.

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 15-Sep-17

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: SAND, FINES, STONE, VEG

Dispersion Method Shaker

Test Method: AS1289.3.6.3 2003

Hydrometer Type ASTM E100

Soil Particle Density (<2.36mm) 2.55 g/cm3

NATA Accreditation: 825 Site: Newcastle
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Dianne Blane
Laboratory Coordinator
Authorised Signatory

Certificate of Analysis

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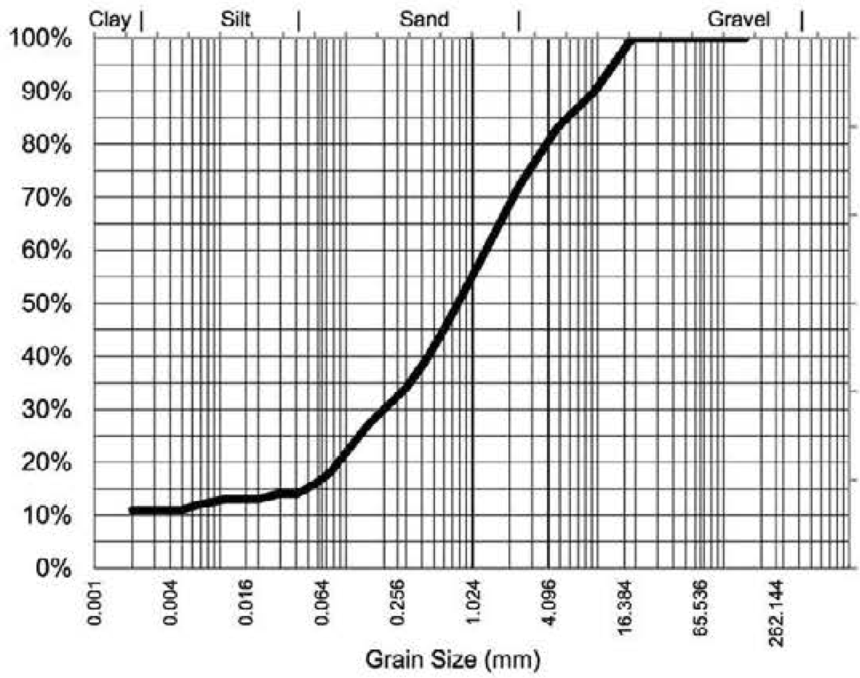
ALS Environmental

Newcastle, NSW

CLIENT:	Joe Mifsud	**DATE REPORTED:**	19-Sep-2017
COMPANY:	COOE PTY LTD	**DATE RECEIVED:**	12-Sep-2017
ADDRESS:	P.O. Box 591 Littlehampton SA, Australia	**REPORT NO:**	EM1712422-013 / PSD
PROJECT:	SEA.SBD.01	**SAMPLE ID:**	SB10 PSD

Particle Size Distribution



Particle Size (mm)	Percent Passing
19.0	100%
9.50	90%
4.75	83%
2.36	72%
1.18	58%
0.600	45%
0.425	39%
0.300	34%
0.150	27%
0.075	18%
Particle Size (microns)	
75	18%
58	16%
41	14%
20	13%
11	13%
5	11%
2	11%

Median Particle Size (mm)*	0.823

Samples analysed as received.

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 15-Sep-17

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: SAND, FINES, STONE, VEG

Dispersion Method Shaker

Test Method: AS1289.3.6.3 2003

Hydrometer Type ASTM E100

Soil Particle Density (<2.36mm) 2.5 g/cm3

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Laboratory Coordinator
Authorised Signatory

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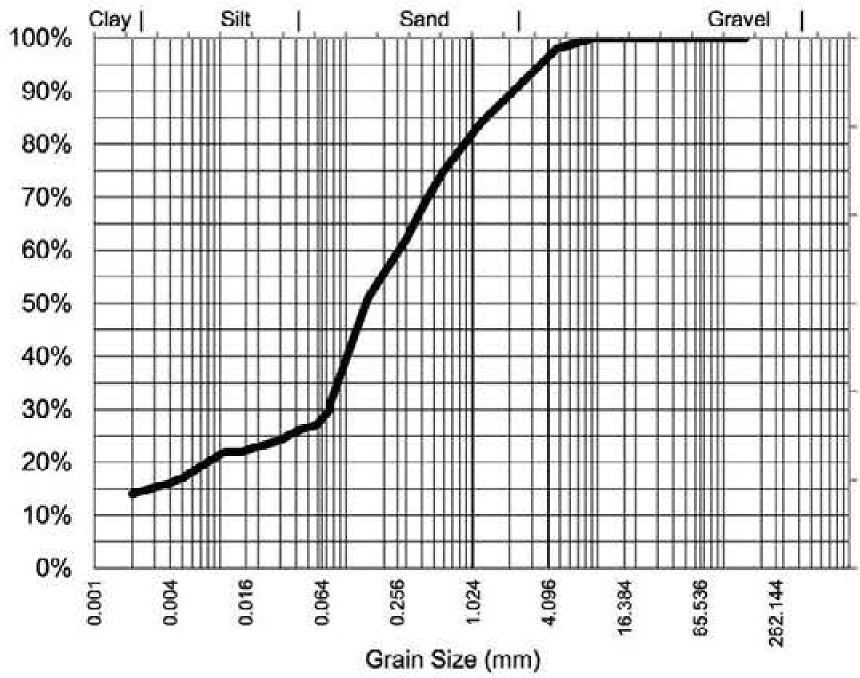
ALS Environmental

Newcastle, NSW

CLIENT:	Joe Mifsud	**DATE REPORTED:**	19-Sep-2017
COMPANY:	COOE PTY LTD	**DATE RECEIVED:**	12-Sep-2017
ADDRESS:	P.O. Box 591 Littlehampton SA, Australia	**REPORT NO:**	EM1712422-022 / PSD
PROJECT:	SEA.SBD.01	**SAMPLE ID:**	SB 12 PSD

Particle Size Distribution



Particle Size (mm)	Percent Passing
9.50	100%
4.75	98%
2.36	91%
1.18	84%
0.600	75%
0.425	69%
0.300	62%
0.150	51%
0.075	31%
Particle Size (microns)	
75	30%
59	27%
42	26%
21	23%
11	22%
5	17%
2	14%

Median Particle Size (mm)*	0.146

Samples analysed as received.

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:		**Analysed:**	15-Sep-17
Loss on Pretreatment	NA	**Limit of Reporting:**	1%
Sample Description:	SAND, FINES, STONE, VEG	**Dispersion Method**	Shaker
Test Method:	AS1289.3.6.3 2003	**Hydrometer Type**	ASTM E100

Soil Particle Density (<2.36mm) 2.46 g/cm3

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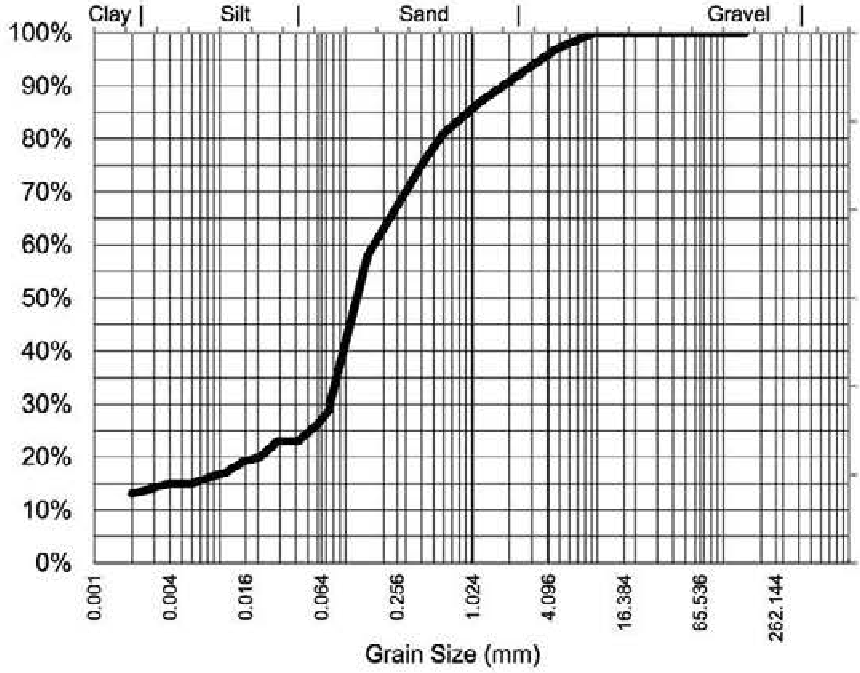
CLIENT:	Joe Mifsud	**DATE REPORTED:**	19-Sep-2017
COMPANY:	COOE PTY LTD	**DATE RECEIVED:**	12-Sep-2017
ADDRESS:	P.O. Box 591 Littlehampton SA, Australia	**REPORT NO:**	EM1712422-023 / PSD
PROJECT:	SEA.SBD.01	**SAMPLE ID:**	SB 6 PSD

Particle Size Distribution



Particle Size (mm)	Percent Passing
9.50	100%
4.75	97%
2.36	92%
1.18	87%
0.600	81%
0.425	76%
0.300	70%
0.150	58%
0.075	30%
Particle Size (microns)	
75	29%
59	26%
42	23%
21	20%
11	17%
6	15%
2	13%

Samples analysed as received.

Median Particle Size (mm)*	0.129

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 15-Sep-17

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: SAND, FINES, STONE, VEG

Dispersion Method Shaker

Test Method: AS1289.3.6.3 2003

Hydrometer Type ASTM E100

Soil Particle Density (<2.36mm) 2.47 g/cm3

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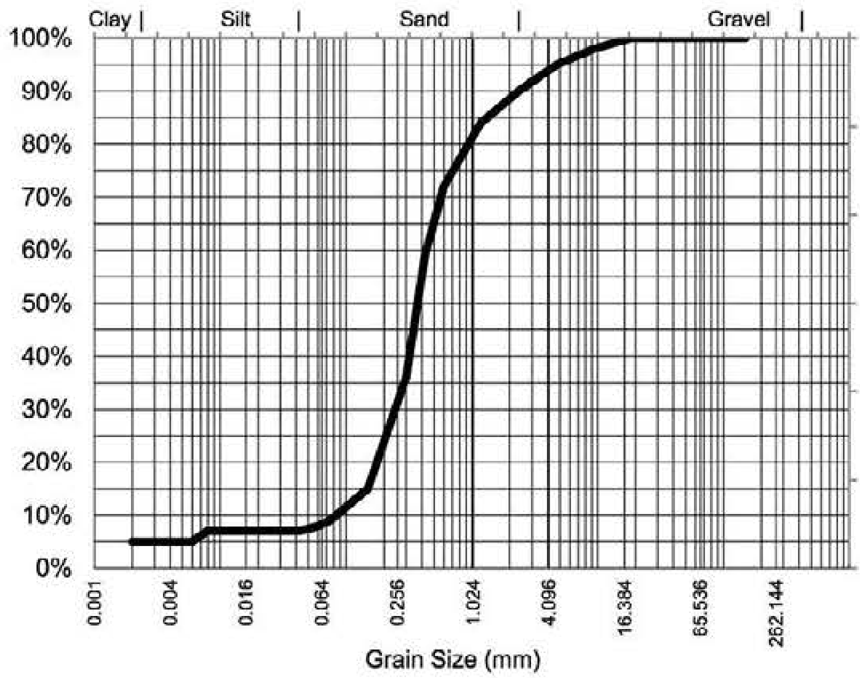
CLIENT:	Joe Mifsud	**DATE REPORTED:**	19-Sep-2017
COMPANY:	COOE PTY LTD	**DATE RECEIVED:**	12-Sep-2017
ADDRESS:	P.O. Box 591 Littlehampton SA, Australia	**REPORT NO:**	EM1712422-024 / PSD
PROJECT:	SEA.SBD.01	**SAMPLE ID:**	SB 8 PSD

Particle Size Distribution



Particle Size (mm)	Percent Passing
19.0	100%
9.50	98%
4.75	95%
2.36	90%
1.18	84%
0.600	72%
0.425	59%
0.300	36%
0.150	15%
0.075	9%
Particle Size (microns)	
75	9%
61	8%
43	7%
22	7%
11	7%
6	5%
2	5%

Samples analysed as received.

Median Particle Size (mm)*	0.376

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:	AS1289.3.6.3 states that this method is not applicable for samples containing <10% fines (<75um). Results should be assessed accordingly	**Analysed:**	15-Sep-17
Loss on Pretreatment	NA	**Limit of Reporting:**	1%
Sample Description:	SAND, SHELL, FINES, VEG	**Dispersion Method**	Shaker
Test Method:	AS1289.3.6.3 2003	**Hydrometer Type**	ASTM E100

Soil Particle Density (<2.36mm) 2.48 g/cm3

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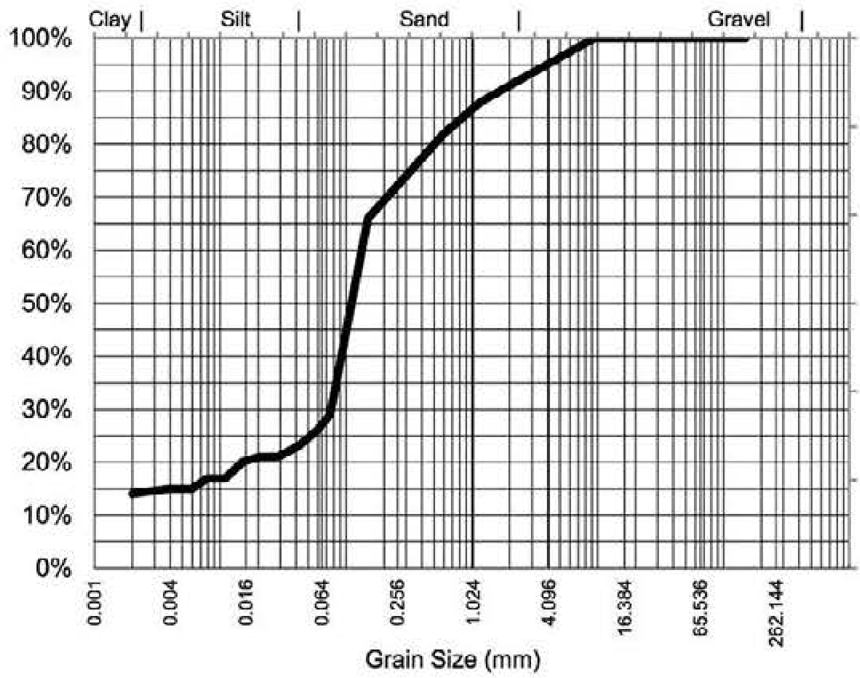
CLIENT:	Joe Mifsud	**DATE REPORTED:**	19-Sep-2017
COMPANY:	COOE PTY LTD	**DATE RECEIVED:**	12-Sep-2017
ADDRESS:	P.O. Box 591 Littlehampton SA, Australia	**REPORT NO:**	EM1712422-025 / PSD
PROJECT:	SEA.SBD.01	**SAMPLE ID:**	SB 5 PSD

Particle Size Distribution



Particle Size (mm)	Percent Passing
9.50	100%
4.75	96%
2.36	92%
1.18	88%
0.600	82%
0.425	78%
0.300	74%
0.150	66%
0.075	29%
Particle Size (microns)	
75	29%
59	26%
42	23%
21	21%
11	17%
6	15%
2	14%

Median Particle Size (mm)*	0.118

Samples analysed as received.

** Soil Particle Density results fell outside the scope of AS 1289.3.6.3. Typical sediment SPD values used for calculations and consequently, NATA endorsement does not apply to hydrometer results*

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 15-Sep-17

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: SAND, FINES, STONE, VEG

Dispersion Method Shaker

Test Method: AS1289.3.6.3 2003

Hydrometer Type ASTM E100

Soil Particle Density (<2.36mm) 2.42 (2.45)* g/cm3

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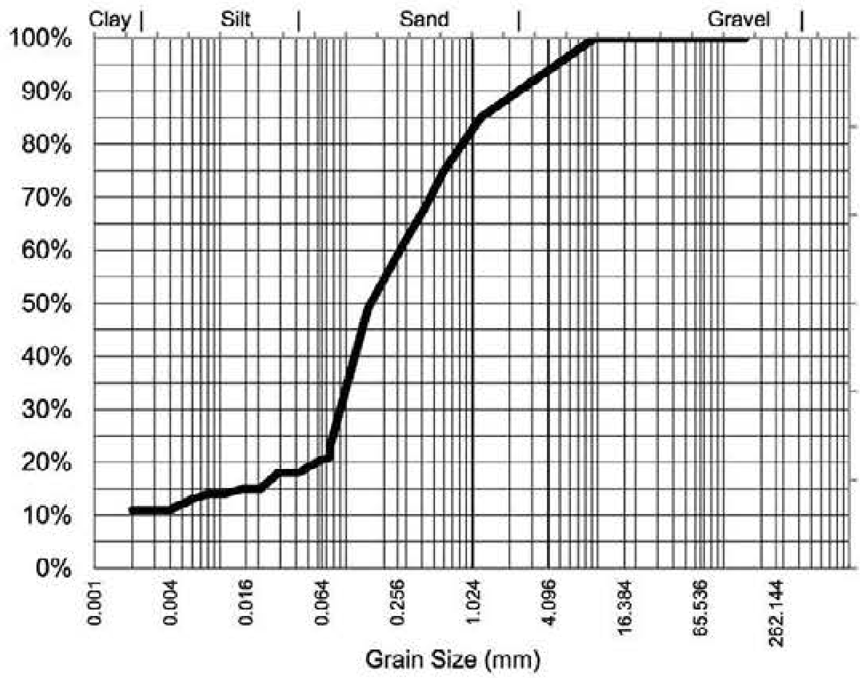
CLIENT:	Joe Mifsud	**DATE REPORTED:**	19-Sep-2017
COMPANY:	COOE PTY LTD	**DATE RECEIVED:**	12-Sep-2017
ADDRESS:	P.O. Box 591 Littlehampton SA, Australia	**REPORT NO:**	EM1712422-026 / PSD
PROJECT:	SEA.SBD.01	**SAMPLE ID:**	SB 7.1 GREY

Particle Size Distribution



Particle Size (mm)	Percent Passing
9.50	100%
4.75	95%
2.36	90%
1.18	85%
0.600	75%
0.425	68%
0.300	62%
0.150	49%
0.075	23%
Particle Size (microns)	
75	21%
59	20%
42	18%
21	15%
11	14%
6	13%
2	11%

Median Particle Size (mm)*	0.162

Samples analysed as received.

** Soil Particle Density results fell outside the scope of AS 1289.3.6.3. Typical sediment SPD values used for calculations and consequently, NATA endorsement does not apply to hydrometer results*

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 15-Sep-17

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: SAND, FINES, STONE, VEG

Dispersion Method Shaker

Test Method: AS1289.3.6.3 2003

Hydrometer Type ASTM E100

Soil Particle Density (<2.36mm) 2.41 (2.45)* g/cm3

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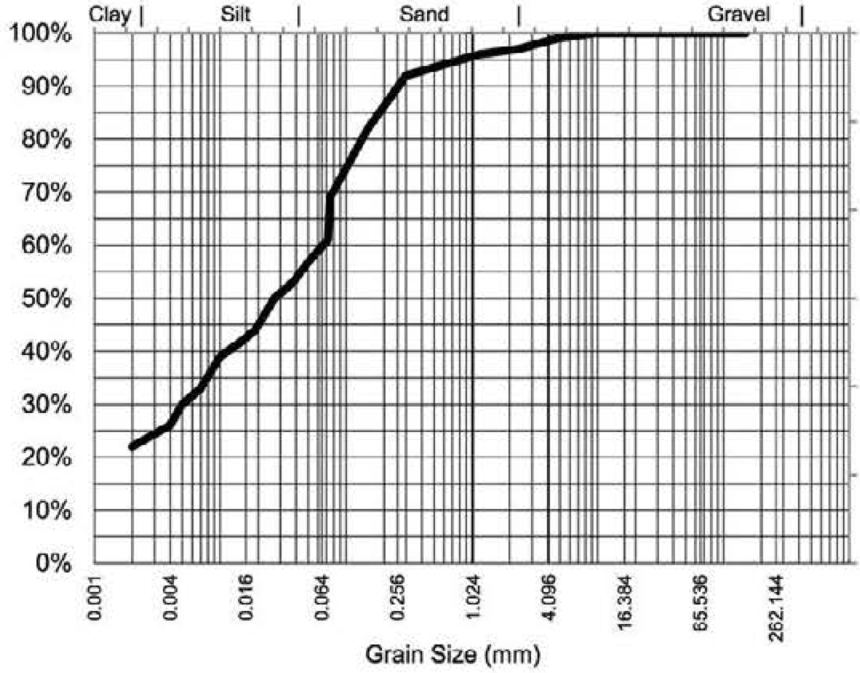
CLIENT:	Joe Mifsud	**DATE REPORTED:**	19-Sep-2017
COMPANY:	COOE PTY LTD	**DATE RECEIVED:**	12-Sep-2017
ADDRESS:	P.O. Box 591 Littlehampton SA, Australia	**REPORT NO:**	EM1712422-027 / PSD
PROJECT:	SEA.SBD.01	**SAMPLE ID:**	SB 7.2 BLACK

Particle Size Distribution



Particle Size (mm)	Percent Passing
9.50	100%
4.75	99%
2.36	97%
1.18	96%
0.600	94%
0.425	93%
0.300	92%
0.150	82%
0.075	69%
Particle Size (microns)	
72	61%
51	57%
38	53%
19	44%
10	39%
5	30%
2	22%

Samples analysed as received.

Median Particle Size (mm)*	0.027

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 15-Sep-17

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: SAND, FINES, SHELL, VEG

Dispersion Method Shaker

Test Method: AS1289.3.6.3 2003

Hydrometer Type ASTM E100

Soil Particle Density (<2.36mm) 2.48 g/cm3

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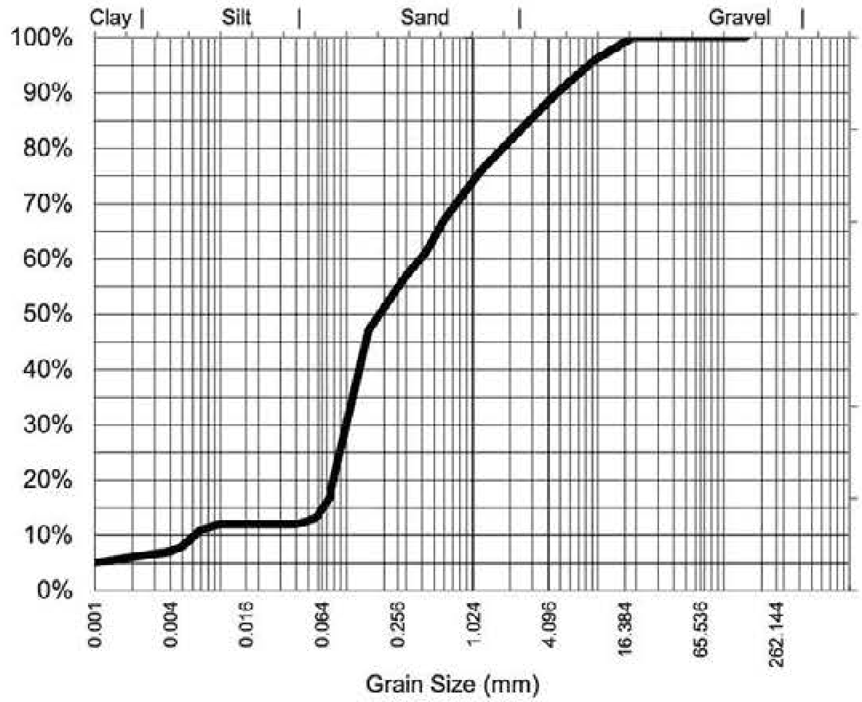
CLIENT:	Lab Results	**DATE REPORTED:**	5-Sep-2018
COMPANY:	ENVIRONMENTAL PROJECTS	**DATE RECEIVED:**	28-Aug-2018
ADDRESS:	LEVEL 3 117 KING WILLIAM ST ADELAIDE	**REPORT NO:**	ES1825398-001 / PSD
PROJECT:	17004.01 KIPT EIS	**SAMPLE ID:**	ZZ3

Particle Size Distribution



Particle Size (mm)	% Passing
19.0	100%
9.50	96%
4.75	90%
2.36	83%
1.18	76%
0.600	67%
0.425	61%
0.300	57%
0.150	47%
0.075	18%
Particle Size (microns)	
57	13%
40	12%
28	12%
20	12%
15	12%
10	12%
7	11%
5	8%
1	5%

Analysis Notes

Samples analysed as received.

** Soil Particle Density required for Hydrometer analysis according to AS 1289.3.5.1—2006 was not requested by the client . Typical sediment SPD values used for calculations and consequently, NATA endorsement does not apply to hydrometer results*

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Median Particle Size (mm)*	0.195

Sample Comments:		**Analysed:**	3-Sep-18
Loss on Pretreatment	NA	**Limit of Reporting:**	1%
Sample Description:	FINES, SAND, STONE	**Dispersion Method**	Shaker
Test Method:	AS1289.3.6.2/AS1289.3.6.3	**Hydrometer Type**	ASTM E100

Soil Particle Density (<2.36mm) #N/A g/cm³

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Newcastle, NSW

CLIENT:	Lab Results	**DATE REPORTED:**	5-Sep-2018
COMPANY:	ENVIRONMENTAL PROJECTS	**DATE RECEIVED:**	28-Aug-2018
ADDRESS:	LEVEL 3 117 KING WILLIAM ST ADELAIDE	**REPORT NO:**	ES1825398-002 / PSD
PROJECT:	17004.01 KIPT EIS	**SAMPLE ID:**	ZZ4

Particle Size Distribution

Particle Size (mm)	% Passing
19.0	100%
9.50	94%
4.75	87%
2.36	81%
1.18	73%
0.600	63%
0.425	57%
0.300	51%
0.150	41%
0.075	15%
Particle Size (microns)	
57	10%
40	10%
28	10%
20	10%
15	10%
10	9%
7	9%
5	7%
1	5%

Analysis Notes

Samples analysed as received.

** Soil Particle Density required for Hydrometer analysis according to AS 1289.3.5.1—2006 was not requested by the client . Typical sediment SPD values used for calculations and consequently, NATA endorsement does not apply to hydrometer results*

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Median Particle Size (mm)*	0.285

Sample Comments:

Analysed: 3-Sep-18

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINES, SAND, STONE

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Hydrometer Type ASTM E100

Soil Particle Density (<2.36mm) #N/A g/cm³

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CLIENT:	Lab Results	**DATE REPORTED:**	5-Sep-2018
COMPANY:	ENVIRONMENTAL PROJECTS	**DATE RECEIVED:**	28-Aug-2018
ADDRESS:	LEVEL 3 117 KING WILLIAM ST ADELAIDE	**REPORT NO:**	ES1825398-003 / PSD
PROJECT:	17004.01 KIPT EIS	**SAMPLE ID:**	ZZ5

Particle Size Distribution

Particle Size (mm)	% Passing
19.0	100%
9.50	95%
4.75	87%
2.36	82%
1.18	75%
0.600	64%
0.425	58%
0.300	52%
0.150	45%
0.075	18%
Particle Size (microns)	
57	11%
40	10%
28	10%
20	10%
15	10%
10	10%
7	7%
5	7%
1	6%

Analysis Notes

Samples analysed as received.

** Soil Particle Density required for Hydrometer analysis according to AS 1289.3.5.1—2006 was not requested by the client . Typical sediment SPD values used for calculations and consequently, NATA endorsement does not apply to hydrometer results*

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Median Particle Size (mm)*	0.257

Sample Comments:

Analysed: 3-Sep-18

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINES, SAND, STONE

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Hydrometer Type ASTM E100

Soil Particle Density (<2.36mm) #N/A g/cm³

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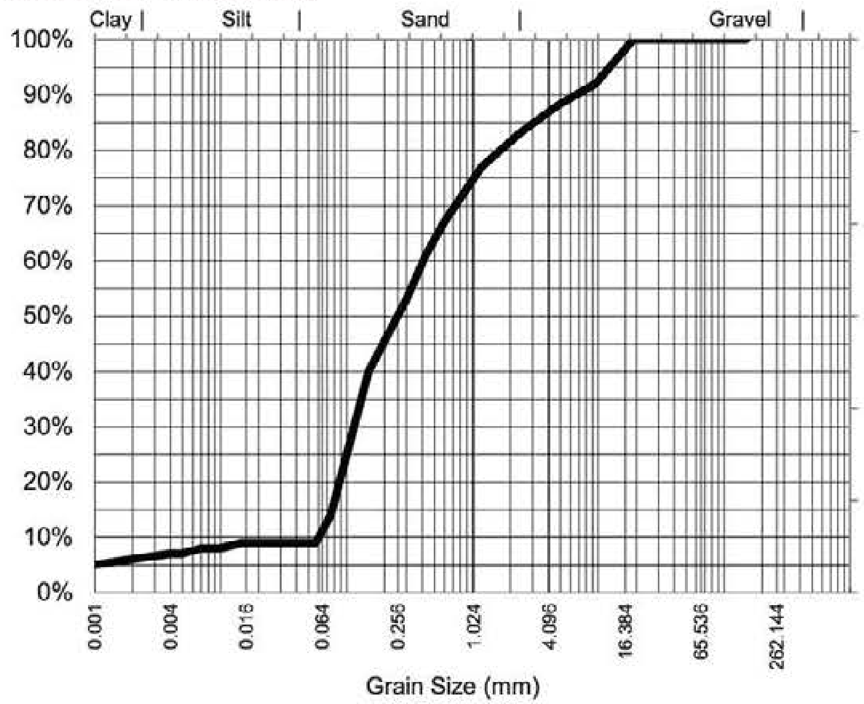
CLIENT:	Lab Results	**DATE REPORTED:**	5-Sep-2018
COMPANY:	ENVIRONMENTAL PROJECTS	**DATE RECEIVED:**	28-Aug-2018
ADDRESS:	LEVEL 3 117 KING WILLIAM ST ADELAIDE	**REPORT NO:**	ES1825398-004 / PSD
PROJECT:	17004.01 KIPT EIS	**SAMPLE ID:**	ZZ6

Particle Size Distribution



Particle Size (mm)	% Passing
19.0	100%
9.50	92%
4.75	88%
2.36	83%
1.18	77%
0.600	67%
0.425	61%
0.300	53%
0.150	40%
0.075	14%
Particle Size (microns)	
57	9%
40	9%
28	9%
20	9%
15	9%
10	8%
7	8%
5	7%
1	5%

Analysis Notes

Samples analysed as received.

** Soil Particle Density required for Hydrometer analysis according to AS 1289.3.5.1—2006 was not requested by the client . Typical sediment SPD values used for calculations and consequently, NATA endorsement does not apply to hydrometer results*

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Median Particle Size (mm)*	0.265

Sample Comments:		**Analysed:**	3-Sep-18
Loss on Pretreatment	NA	**Limit of Reporting:**	1%
Sample Description:	FINES, SAND, STONE	**Dispersion Method**	Shaker
Test Method:	AS1289.3.6.2/AS1289.3.6.3	**Hydrometer Type**	ASTM E100

Soil Particle Density (<2.36mm) #N/A g/cm³

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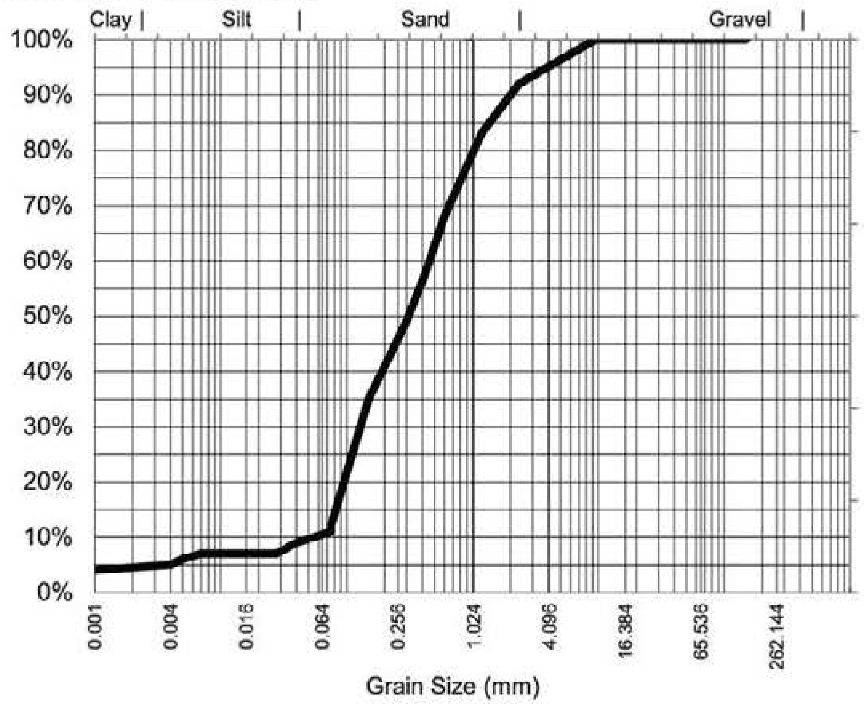
CLIENT:	Lab Results	**DATE REPORTED:**	5-Sep-2018
COMPANY:	ENVIRONMENTAL PROJECTS	**DATE RECEIVED:**	28-Aug-2018
ADDRESS:	LEVEL 3 117 KING WILLIAM ST ADELAIDE	**REPORT NO:**	ES1825398-005 / PSD
PROJECT:	17004.01 KIPT EIS	**SAMPLE ID:**	ZZ7

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	96%
2.36	92%
1.18	83%
0.600	68%
0.425	58%
0.300	49%
0.150	35%
0.075	12%
Particle Size (microns)	
56	10%
40	9%
28	7%
20	7%
15	7%
10	7%
7	7%
5	6%
1	4%

Analysis Notes

Samples analysed as received.

** Soil Particle Density required for Hydrometer analysis according to AS 1289.3.5.1—2006 was not requested by the client . Typical sediment SPD values used for calculations and consequently, NATA endorsement does not apply to hydrometer results*

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Median Particle Size (mm)*	0.314

Sample Comments:

Analysed: 3-Sep-18

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINES, SAND, STONE

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Hydrometer Type ASTM E100

Soil Particle Density (<2.36mm) #N/A g/cm³

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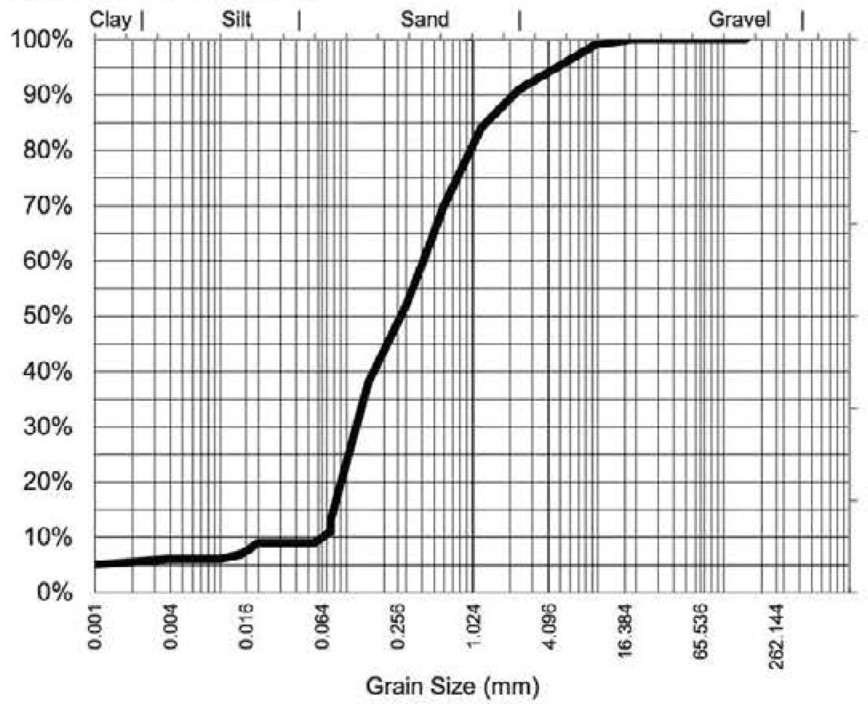
CLIENT:	Lab Results	**DATE REPORTED:**	5-Sep-2018
COMPANY:	ENVIRONMENTAL PROJECTS	**DATE RECEIVED:**	28-Aug-2018
ADDRESS:	LEVEL 3 117 KING WILLIAM ST ADELAIDE	**REPORT NO:**	ES1825398-006 / PSD
PROJECT:	17004.01 KIPT EIS	**SAMPLE ID:**	ZZ9

Particle Size Distribution



Particle Size (mm)	% Passing
19.0	100%
9.50	99%
4.75	95%
2.36	91%
1.18	84%
0.600	70%
0.425	61%
0.300	52%
0.150	38%
0.075	13%
Particle Size (microns)	
56	9%
40	9%
28	9%
20	9%
15	7%
10	6%
7	6%
5	6%
1	5%

Analysis Notes

Samples analysed as received.

** Soil Particle Density required for Hydrometer analysis according to AS 1289.3.5.1—2006 was not requested by the client . Typical sediment SPD values used for calculations and consequently, NATA endorsement does not apply to hydrometer results*

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Median Particle Size (mm)*	0.279

Sample Comments:		**Analysed:**	3-Sep-18
Loss on Pretreatment	NA	**Limit of Reporting:**	1%
Sample Description:	FINES, SAND, STONE	**Dispersion Method**	Shaker
Test Method:	AS1289.3.6.2/AS1289.3.6.3	**Hydrometer Type**	ASTM E100

Soil Particle Density (<2.36mm) #N/A g/cm³

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Dianne Blane
Laboratory Coordinator
Authorised Signatory

Appendix F2 – Hydrodynamic Modelling Report – BMT

Smith Bay EIS - Hydrodynamic Modelling Report

Reference: R.B22454.002.04.Modelling_Report.docx
Date: January 2019

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Document:	R.B22454.002.04.Modelling_Report.docx
Title:	Smith Bay EIS - Hydrodynamic Modelling Report
Project Manager:	Ian Teakle
Author:	Toby Devlin, Ian Teakle
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Client Reference:	

Synopsis: Summary of the hydrodynamic and water quality modelling for the Smith Bay EIS

Executive Summary

The Smith Bay Wharf project involves developing a deep-water wharf facility to provide predominantly for international timber vessels, but also allowing for passenger or general cargo ships. This requires:

- A rock-armoured causeway extending partway offshore, with a piled causeway extending from this out to a floating wharf; and
- Dredging to create berth pockets adjacent to the wharf and additional dredging of approach regions.

In order to achieve this, capital dredging of approximately 100,000 m^3 in-situ will be required in the berth and approach area. This material will be placed onshore and dewatered before being used to build the core of the causeway.

A suite of numerical modelling tools has been developed to support the assessment of potential environmental impacts associated with this project, consisting of:

- Digital Elevation Model covering all of Gulf St. Vincent and the surrounds of Kangaroo Island.
- TUFLOWFV FV 3D hydrodynamic model covering Gulf St. Vincent out to the end of Investigator Strait and Backstairs Passage.
- SWAN nested wave modelling system for coupling with the hydrodynamic and sediment transport model.
- TUFLOW FV sediment transport model (coupled with hydrodynamic and wave models).
- WBNM hydrology model for deriving flood discharges from Smith Creek.

The modelled hydrodynamics, waves and sediment transport are influenced by various boundary condition inputs derived from data recordings, regional models and global models, which include the following:

- Wind;
- Tides;
- Ocean salinity and temperature, and
- Meteorological Conditions.

This technical report describes the development of these modelling tools, the data inputs used, the calibration/validation process, as well as the methodology and key outcomes of the impact assessments.

Model Calibration and Validation

Calibration of the various modelling tools was conducted for the period July 2016 to November 2017, primarily using in-situ wave and current measurements undertaken for the project. An additional model validation was undertaken for the period from January to March 2018 using data from a targeted measurement campaign at multiple sites within Smith Bay.

Model calibration focussed on the ability of the model to reproduce water levels, currents and wave conditions over multiple tidal cycles and a range of wind conditions. Emphasis was also placed on the model's ability to predict the seasonal residual currents. The following conclusions were made about the hydrodynamic and wave model performance:

- Water level predictions validated well against Smith Bay measurements.
- Tidal current speeds and directions were generally well represented.
- The reproduction of residual (non-tidal) currents was generally good.
- The wave height, period and direction predictions were in reasonable agreement with Smith Bay measurements.

Water Quality Impact Assessments

The validated modelling tools were applied to the assessment of a range of potential project-related impacts. The impact assessment undertaken for the Smith Bay EIS has considered the following:

- Sediment plumes generated by dredging activities;
- Sediment plumes generated by causeway construction; and
- Sediment plumes generated by operational shipping activity.

The outputs from these modelling scenarios have been used to inform water quality risk assessments for the EIS and also to inform potential impact mitigation strategies that can be considered as part of the Project Dredge Management Plan.

Coastal Process Impact Assessments

Modelling assessments were also undertaken to understand the changes to coastal processes related to the Project littoral zone infrastructure components, including the following:

- Changes to currents and waves due to the causeway and wharf;
- Impacts to water temperature as a result of changed circulation patterns;
- Impacts to littoral sediment transport; and
- Changes to Smith Bay creek flood plumes.

These modelling have been used to inform coastal process risk assessments for the EIS.

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1 Introduction

1.1 Background

Kangaroo Island Plantation Timbers (KIPT) propose to develop a deep-water wharf at Smith Bay on the north coast of Kangaroo Island (Figure 1). The wharf will be capable of accommodating 30,000 DWT bulk carrier ships. Although the primary purpose of the wharf will be to export timber from plantations on the island, KIPT proposes to make it available for other shipping uses.

The main features of the development at Smith Bay will be:

- A rock-armoured causeway extending approximately 250m offshore;
- A piled jetty extending further out to a floating wharf, approximately 340m offshore;
- Capital dredging of approximately 100,000 m^3 to create berth pockets adjacent to the wharf and additional dredging of approach regions; and
- The dredged material will be placed onshore and dewatered before being used to construct the core of the causeway.

The onshore component of the development at Smith Bay will entail constructing several level tiers over an area of approximately 8 ha to store logs, access roads and associated amenities.

In February 2017 the South Australian Minister for Planning declared Kangaroo Island Plantation Timbers' proposal a major development under s.46 of the Development Act 1993 (SA). Section 46 ensures that matters affecting the environment, the community or the economy to a significant extent are fully examined and taken into account in the assessment of the proposal. As part of the development application an Environmental Impact Statement (EIS) is being submitted to State and Commonwealth regulators.

1.2 Objectives and Purpose

BMT was commissioned to undertake an assessment of baseline conditions and potential environmental impacts for the project related to marine water quality and coastal processes. As part of these baseline and impact assessments, numerical models were developed for predicting potential changes to coastal processes and the dispersion of sediment plumes generated by project activities. This report details the development and validation of these numerical models, as well as the numerical modelling methodology adopted for impact assessment purposes. EIS technical risk assessments related to coastal processes (BMT 2018b) and marine water quality (BMT 2018c) have been informed by the numerical modelling described in this report.

Figure 1-1 Proposed export facility at Smith Bay – site plan

1.3 Site Description and Key Processes

Smith Bay is located on the northern coastline of Kangaroo Island, facing onto Investigator Strait. The Yorke Peninsula coastline is approximately 50 km north of the Smith Bay coastline. Greater fetch distances (~150 km) extend to the northwest and northeast into Spencer Gulf and Gulf St Vincent. Southern Ocean fetches extend to the south and west of Kangaroo Island, and while it is not directly exposed to these fetches the Smith Bay site is also influenced by heavily refracted Southern Ocean swells.

Tidal planes at nearby Emu Bay are summarised in Table 1-1. Spring tidal range at Smith Bay is typically around 1 m, while very low amplitude 'dodge' tides occur mid-way between spring tide periods. Under summer conditions where prevailing wind speeds are relatively low, currents at Smith Bay are predominantly driven by tidal oscillations. Flood tide currents flow to the east at Smith Bay, while ebb tide currents flow to the west. During the winter months, Southern Ocean frontal systems frequently drive significant storm surges into Investigator Strait. Under the stronger winter westerly wind conditions easterly current flows are more likely to prevail.

Table 1-1 Tidal planes at Emu Bay / Smith Bay (Austides 2018)

Tidal Plane	Level (m LAT)	Level (m AHD)
HAT	1.8	1.0
MHHW	1.5	0.7
MLHW	1.0	0.2
MSL	0.8	0.0
MHLW	0.7	-0.1
MLLW	0.2	-0.6
LAT	0.0	-0.8

Smith Bay is a relatively shallow (i.e. straight) embayment, flanked by headlands to the east and west. The beach and dune system are composed of cobble-sized sediment (Figure 1-3). Immediately offshore the seabed is comprised of mixed sandy and coarser sediments, with dense macroalgae and seagrass communities, which become sparse in deeper water further offshore (Figure 1-4).

1.4 Impact Assessment Scope

The impact assessment undertaken for the Smith Bay EIS has considered the following:

- Sediment plumes generated by dredging activities;
- Sediment plumes generated by causeway construction;
- Sediment plumes generated by operational shipping activity;
- Changes to currents and waves due to the causeway and wharf;
- Impacts to water temperature as a result of changed circulation patterns;
- Impacts to littoral sediment transport; and
- Changes to Smith Bay creek flood plumes.

Title:
Study Location

Figure: 1-2

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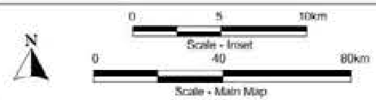

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Figure 1-3 The beach at Smith Bay is formed from cobble sized sediment

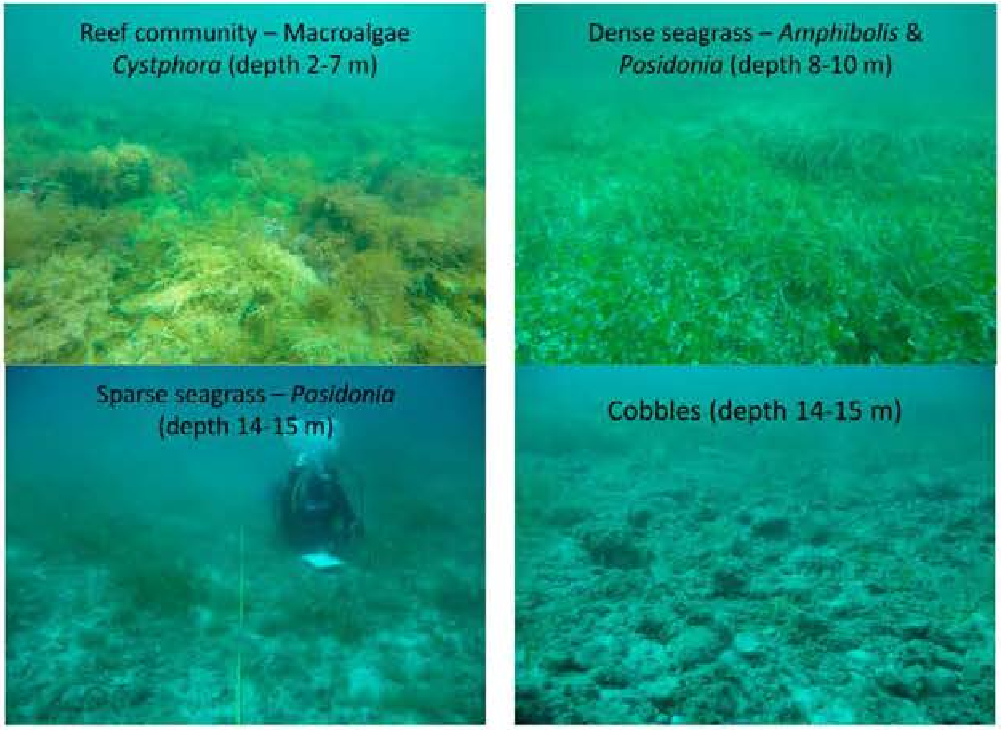


Figure 1-4 Smith Bay seabed characteristics

2 Numerical Model Description

2.1 Hydrodynamics (TUFLOW FV)

The hydrodynamic modelling component of these assessments has been undertaken using the TUFLOW FV software, which is developed and distributed by BMT (http://www.tuflow.com/Tuflow%20FV.aspx). TUFLOW FV is a numerical hydrodynamic model for the two-dimensional (2D) and three-dimensional (3D) Non-Linear Shallow Water Equations (NLSWE). The model is suitable for solving a wide range of hydrodynamic systems ranging in scale from open channels and floodplains, through estuaries to coasts and oceans.

The Finite-Volume (FV) numerical scheme employed by TUFLOW FV can solve the NLSWE on both structured rectilinear grids and unstructured meshes comprised of triangular and quadrilateral elements. The flexible mesh allows for seamless boundary fitting along complex coastlines or open channels as well as accurately and efficiently representing complex bathymetries with a minimum number of computational elements. The flexible mesh capability is efficient at resolving a range of scales in a single model without requiring multiple domain nesting.

2.1.1 Numerical Scheme

The TUFLOW FV model was configured as a 3D model with baroclinic coupling from both salinity and temperature variations. While baroclinic pressure gradients are not expected to be a significant driver of currents locally at Smith Bay they are known to be regionally significant within both Spencer Gulf and Gulf St Vincent.

Horizontal and vertical advective fluxes were calculated using a TVD second-order spatial reconstruction. Bottom friction was modelled using a quadratic drag law with a roughness length-scale parameterisation. Horizontal turbulent mixing was calculated using the Smagorinsky (1963) model for horizontal eddy-viscosity and scalar-diffusivity. Vertical turbulent mixing was calculated through coupling TUFLOW FV with the General Ocean Turbulence Model (Burchard and Bolding, 2000) using a second-order k-omega turbulence scheme. A mode-split scheme was used to advance the solution in time, with barotropic and baroclinic timesteps dynamically calculated based on CFL stability criteria (e.g. Shchepetkin & McWilliams, 2005).

Further details regarding the numerical scheme employed by TUFLOW FV are provided in the TUFLOW FV Science Manual (BMT WBM, 2013).

2.1.2 Wetting and Drying

TUFLOW FV simulates the wetting and drying of intertidal areas. The minimum wetting and drying depths were set to 0.01 m and 0.1 m respectively. Numerically, the drying value corresponds to a minimum depth below which the mesh cell is dropped from computations (subject to the status of surrounding cells). The wet value corresponds to a minimum depth below which cell momentum is set to zero, to avoid unphysical velocities at very low depths.

2.1.3 Advection Dispersion Modelling

A system for modelling the natural re-suspension of sediment and the advection and dispersion of a sediment plume produced during dredging has been developed as part of this study using the Sediment Transport (ST) module of TUFLOW FV (refer Section 2.3), coupled with the 3D hydrodynamic and spectral wave models (refer Section 2.2).

To accurately capture advection and dispersion, the model requires input of dispersion coefficients and sediment characteristics. These inputs determine the resultant spread of fluid and suspended matter throughout the model domain. The choice of dispersion coefficients is discussed in Section 2.3.1. The General Ocean Turbulence Model (GOTM) was coupled with the 3D TUFLOW FV hydrodynamic model to simulate the vertical mixing processes in the presence of density stratification.

2.1.4 Digital Elevation Model

A Digital Elevation Model (DEM) was compiled from the following sources, listed in decreasing order of priority:

- High-resolution bathymetric survey of proposed site, undertaken by Flinders Ports (drawing reference KI18.002, soundings taken 02 January 2018);
- Single-beam survey lines conducted during field deployment in January 2018 (soundings taken by BMT 20 February 2018); and
- Navigation chart data sourced from Australian Electronic Navigation Chart (AusENC) data.

All bathymetric datasets were converted to a common vertical coordinate system, referenced to a Mean Sea Level (MSL) Datum. The vertical offset from Chart Datum (nominally Lowest Astronomic Tide) to MSL Datum at Smith Bay was 0.8 m.

The Smith Bay bathymetry is shown in Figure 2-1 along with the causeway and dredging footprints for reference.

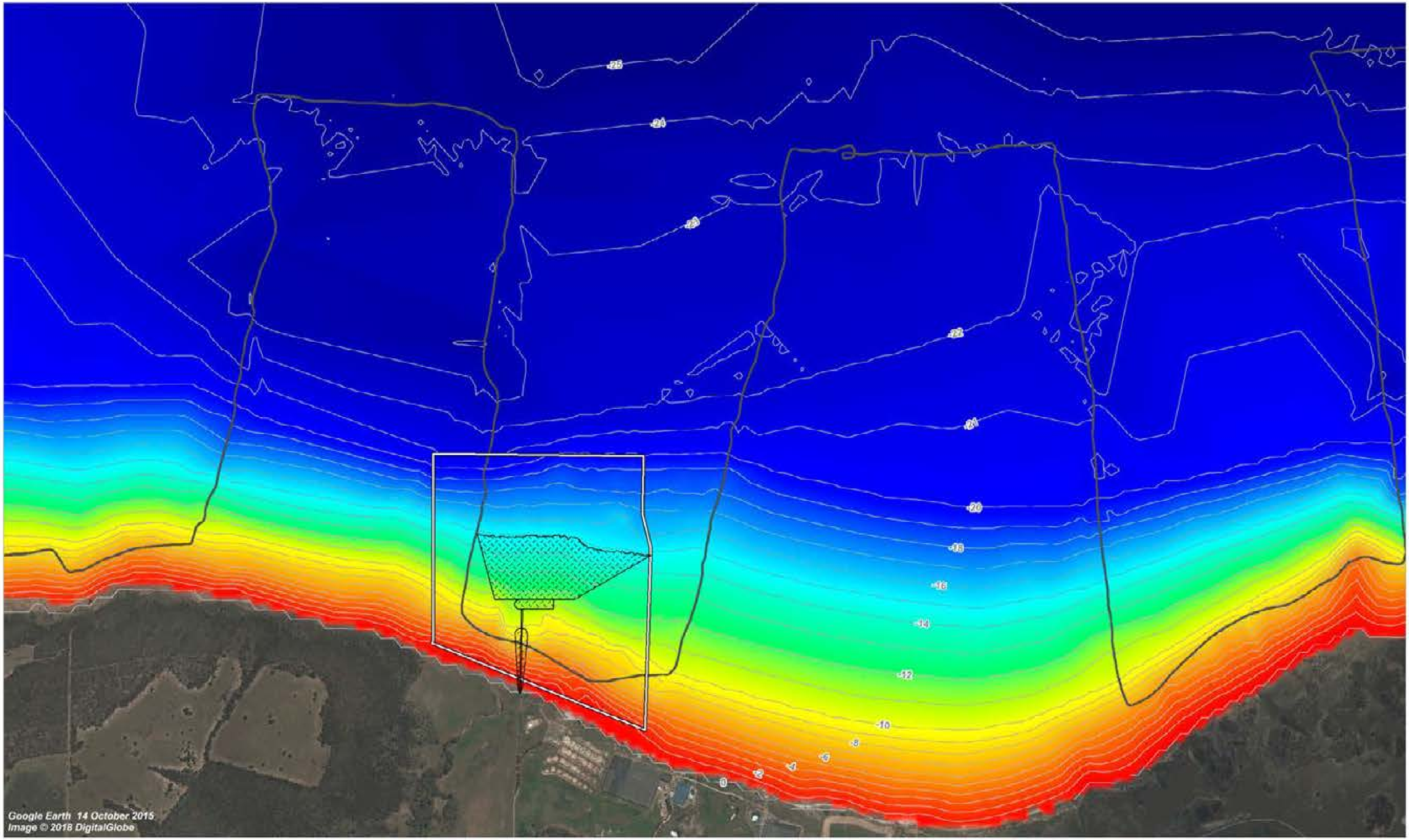
2.1.5 Model Domain and Mesh

The hydrodynamic model domain is shown in Figure 2-2 and extends from Investigator Strait up to the Northern tip of Gulf St. Vincent, including a boundary offshore of Backstairs Passage.

The model consists of approximately 13,500 surface mesh cells with resolution varying from 3 km (mesh cell side length) at the offshore boundary, increasing to ~25 m within Smith Bay. Figure 2-3 shows detail of the model mesh in Smith Bay.

A hybrid z-coordinate vertical grid configuration with three (3) "sigma" layers at the surface was adopted for the KIPT EIS hydrodynamic model. The z-coordinate scheme, with variable bottom layer thickness, is generally better at simulating the stratified ocean environment than a terrain following sigma-coordinate scheme. While the water column is generally only weakly stratified within Smith Bay, where depths are generally less than 15m, it is an important feature to capture at the regional scale.

The multiple surface "sigma" layers allow for a higher resolution of the water surface boundary layer while tracking tidal water surface variations. The vertical grid had 7 layers representing the top 10 m of the water column and 17 layers representing the top 50 m. The deepest sections of the coastal model domain (>70 m deep) were represented with 18 layers.



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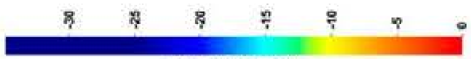
- Contours (1m interval)
- BMT Depth Soundings
- Dredge Area and Causeway Footprint
- Detailed Bathymetry Extent



Title:

Smith Bay Bathymetry

Figure: 2-1

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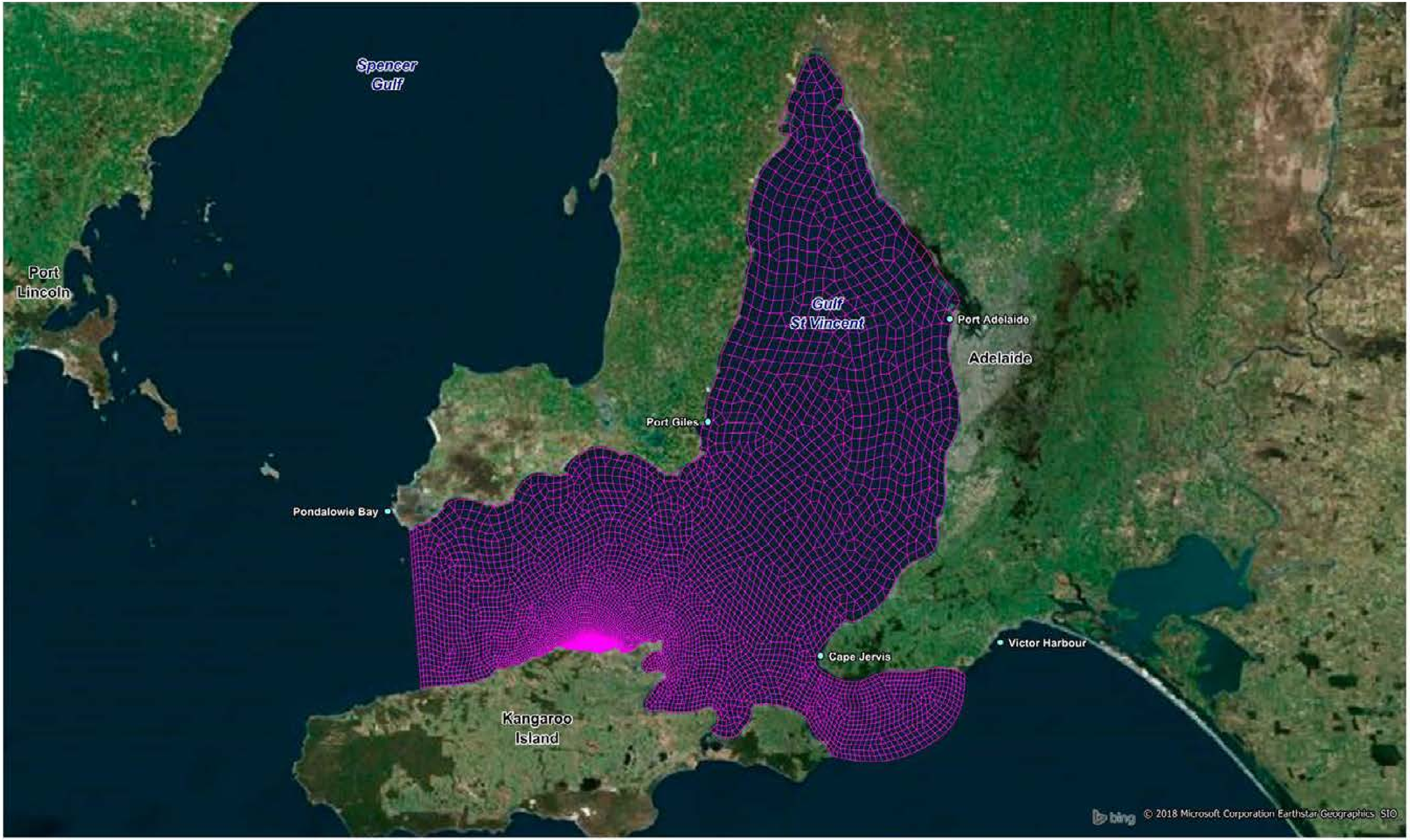

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TUFLOW FV Mesh

Tide Gauge Location

Title:
TUFLOW FV Mesh

Figure: 2-2

Rev: A

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N

0 30 60km

Approx. Scale

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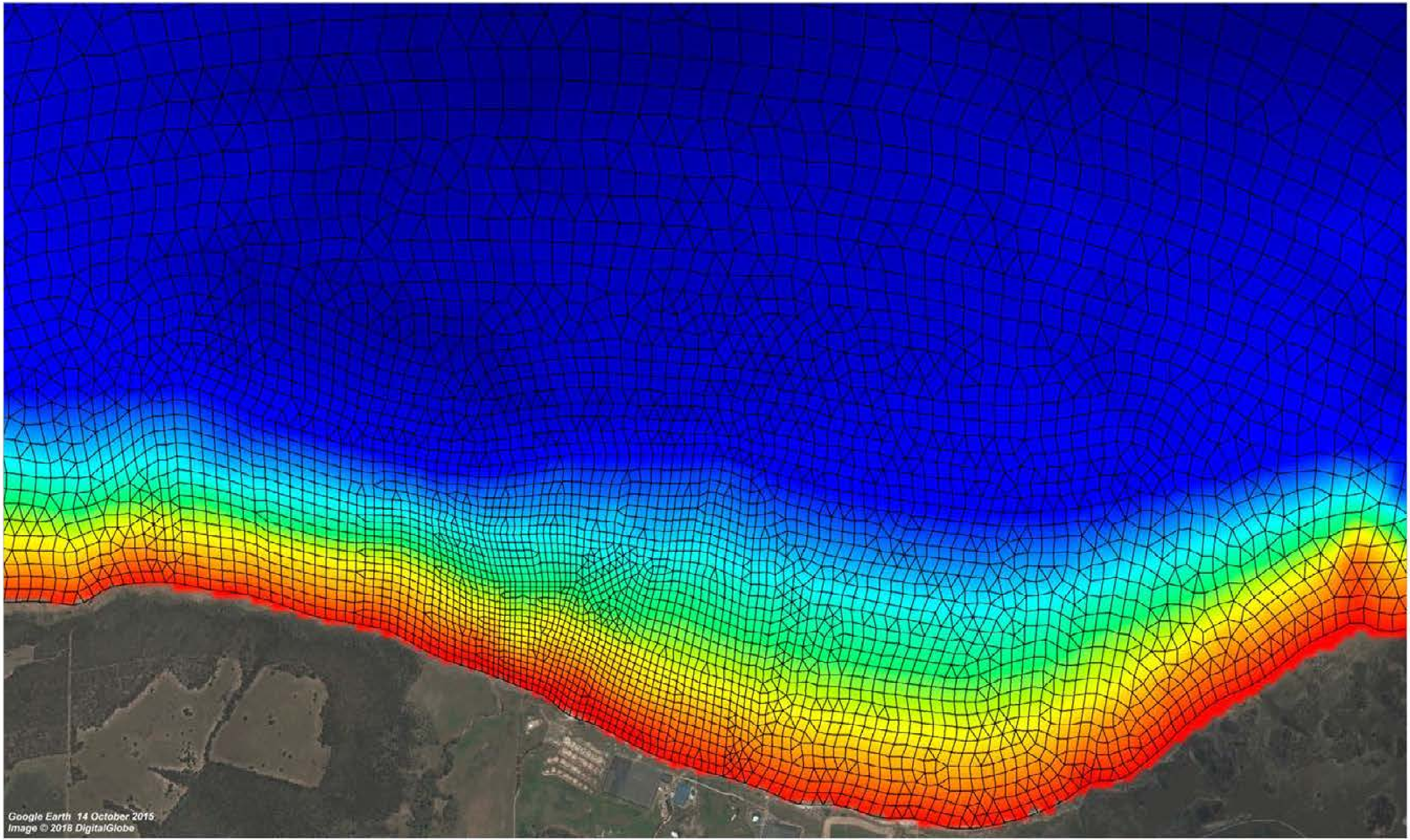

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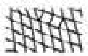

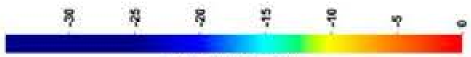

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TUFLOW FV Hydrodynamic Model Mesh Detail

Figure: **2-3**

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N

0 400 800m
Approx. Scale

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2.1.6 Boundary Conditions

The hydrodynamic model predictions require specification of local hydrodynamics estimated by TUFLOW FV are influenced by boundary condition inputs. Information regarding appropriate boundary condition forcing for the study area was obtained from the following sources:

- Local data recordings; and
- Output from models developed by third-parties.

Details of the specific information sources used to develop boundary conditions applied to the hydrodynamic model is provided below.

2.1.6.1 Air Temperature, Radiation, Precipitation and Humidity

Atmospheric heat fluxes and water column heat dynamics were simulated internally within TUFLOW FV. Boundary condition data including air temperature, long- and short-wave radiation, precipitation and relative humidity were derived from global NCEP CFSv2 (http://cfs.ncep.noaa.gov/). These model input fields varied in both space and time to represent both seasonal and higher-frequency variations. The CFSv2 spatial grid resolution at Smith Bay is approximately 20 km and the hindcast timestep is 1 hours.

2.1.6.2 Wind

The wind boundary condition applied to both the hydrodynamic and wave model (refer Section 2.2) was also derived from the CFSv2 global model. Upon reviewing the global model against BoM observations, it was shown that this data set was suitable for predicting the wind in this region. Figure 2-4 shows the comparison of this data with the Cape Borda BoM weather station observations during September 2016.

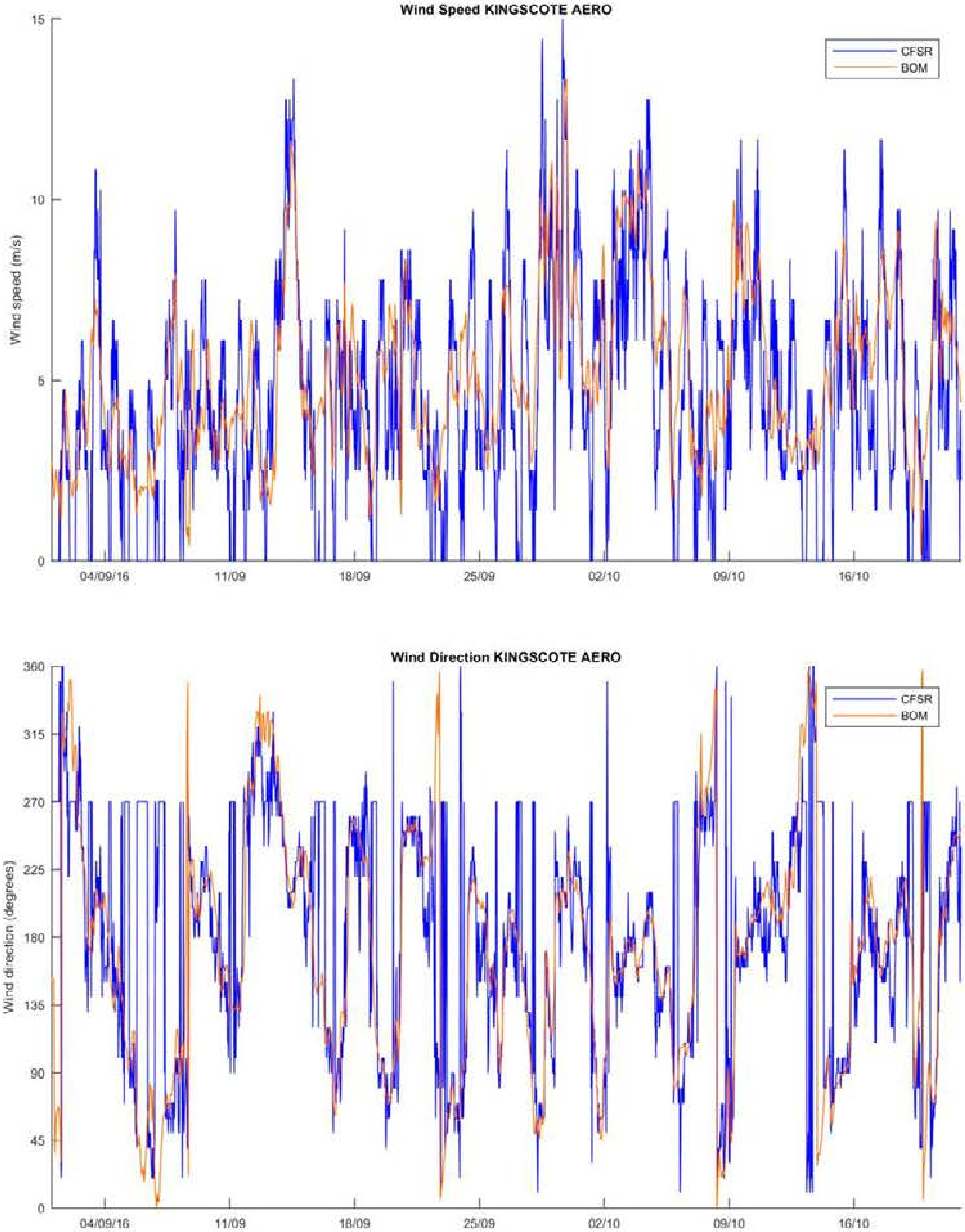

Figure 2-4 Kingscote aero wind calibration

2.1.6.3 Tide

The developed model extent included two open boundaries that required temporal definition of water surface elevations. The eastern boundary (outside Backstairs Passage) has been forced with observed Victor Harbour water levels (sourced from Flinders Ports).

The western open boundary is not adjacent to any regular tide observation location and therefore has been forced with a synthesised water level based on superposition of tide predictions and water level residuals. The predictions are based on astronomic tide harmonic constituents from Pondalowie Bay, sourced from Australian Hydrographic Service AusTides software.

In order to predict the non-astronomic components of tidal water level, the tide residual as measured at Port Giles (in Gulf St. Vincent) has been applied, along with the daily-average difference in sea surface height between the east and west boundaries observed in the global ocean general circulation model HYCOM.

Lastly, as initial calibration efforts found a bias in the residual currents to overpredict the east-heading currents, a mean-water-level offset of +2 cm was applied to the eastern tidal boundary. This change had little effect on the water level calibration but improved the current residual calibration markedly.

2.1.6.4 Ocean water level, salinity and temperature

The TUFLOW FV hydrodynamic model domain has been nested within the global ocean circulation model HYCOM (http://hycom.org/) in order to supply non-tidal water level gradients, salinity and temperature to the open boundary conditions.

The model was initialised using HYCOM predictions and was subsequently warmed up for a minimum period of 6 weeks in order to develop stable internal salinity and temperature distributions.

2.1.6.5 Smith Bay Creek discharge

Catchment runoff or regional river flows were generally not included in the hydrodynamic model simulations as under prevailing condition these are not expected to be of significance to Smith Bay coastal processes. However, under heavy rainfall conditions the creek discharging immediately west of the project location would discharge turbid, freshwater plumes into Smith Bay. An assessment of project impacts to these plumes was undertaken and required the specification of discharge timeseries for Smith Bay Creek. Hydrological modelling was undertaken in order to derive this hydrodynamic model boundary condition (refer Section 2.6 for further details).

2.2 Waves (SWAN)

The wave modelling component of these assessments has been undertaken using the spectral wave model SWAN.

SWAN (Delft University of Technology, 2006) is a third-generation spectral wave model, which can simulate the generation of waves by wind, dissipation by whitecapping, depth-induced wave breaking, bottom friction and wave-wave interactions in both deep and shallow water. SWAN simulates wave/swell propagation in two-dimensions, including shoaling and refraction due to spatial variations in bathymetry and currents. This is a global industry standard modelling package that has been applied with reliable results to many investigations worldwide.

For sediment re-suspension and dispersion modelling the SWAN wave model was coupled with the 3D TUFLOW FV hydrodynamic and advection-dispersion models. This required the wave simulations to be completed separately, with the model output stored at hourly intervals on regular grids. During the subsequent sediment re-suspension and dispersion simulations, the wave conditions were linearly interpolated spatially from the grids to the TUFLOW FV mesh.

2.2.1 Model Domains

A large regional SWAN domain was supplemented with three higher-resolution nested SWAN domains. The regional domain extends from off the continental shelf 110 km west-south-west of Cape du-Couedic in the South-West extent, to the end of Gulf St. Vincent in the North-East extent. The resolution of this SWAN domain is 1000m. Subsequent nests resolve from Investigator Strait in to Smith Bay with 400m, 100m and 50m resolutions. A map of the domain extents of the various SWAN nests is shown in Figure 2-6.

The bathymetry for the numerical wave models has been derived from the same sources as the hydrodynamics as described in Section 2.1.

2.2.2 Model Parameters

The SWAN model:

- 3rd generation source terms, whitecapping and depth-limited breaking (default parameters).
- Collins friction formula, with Cd=0.035.
- Directional spectra resolution, 10°.
- Frequency spectra resolution, 31 grid points 0.04 < f < 1.00Hz.

2.2.3 Boundary Conditions

An offshore swell boundary condition was derived from the NOAA WaveWatch III global hindcast dataset (Chawla et al, 2011). This provides bulk spectral parameters from which SWAN interprets a JONSWAP spectrum at the boundary. A single bulk significant wave height and associated peak-period and direction was used to characterise the offshore swell boundary condition. The NOAA WW3 data was extracted at two locations:

- The southern boundary: (137.5 E, 36.5 S), in ~75 m depth; and
- The western boundary: (135.6 E, 36.5 S), off the continental shelf in ~ 4 km depth.

The southern boundary was applied uniformly across the southern edge of the largest domain. It is unlikely to contribute to much of the swell energy at the location, however may increase wave energy penetrating Backstairs Passage. The western boundary was applied at the South-West corner and linearly reduced to a zero-energy condition at the north-west corner of the SWAN domain. This was to reduce the influence of spurious swell energy entering Investigator Strait from the North-West, where the wind acting on the fetch of the model domain should be sufficient to generate the wave energy. When investigating options at this western boundary, the NOAA WW3 data in the shallower areas along the western edge were providing too much energy when compared to observations and less-accurate directions. The swell boundaries were validated by comparing to the wave buoy at

Cape du Couedic (off the South-West corner of Kangaroo Island), this comparison is shown in Figure 2-5.

The wind boundary condition was derived from the NOAA CFSR and CFSv2 global model datasets (Saha et al, 2011; 2014). The data applied to the model was a 10-m elevation, 10-minute average wind vector.

A static water level set at Mean Sea Level has been assumed in the wave calibration simulations. Inspection of the Metocean buoy dataset indicates that there is minimal tidal modulation of the wave height (~12 m depth). However, inner-most nest wave simulations for coupling with the ST model have been forced with water levels as predicted by the hydrodynamic model. This is to allow for realistic wave conditions in shallow regions where the waves may become depth-limited.

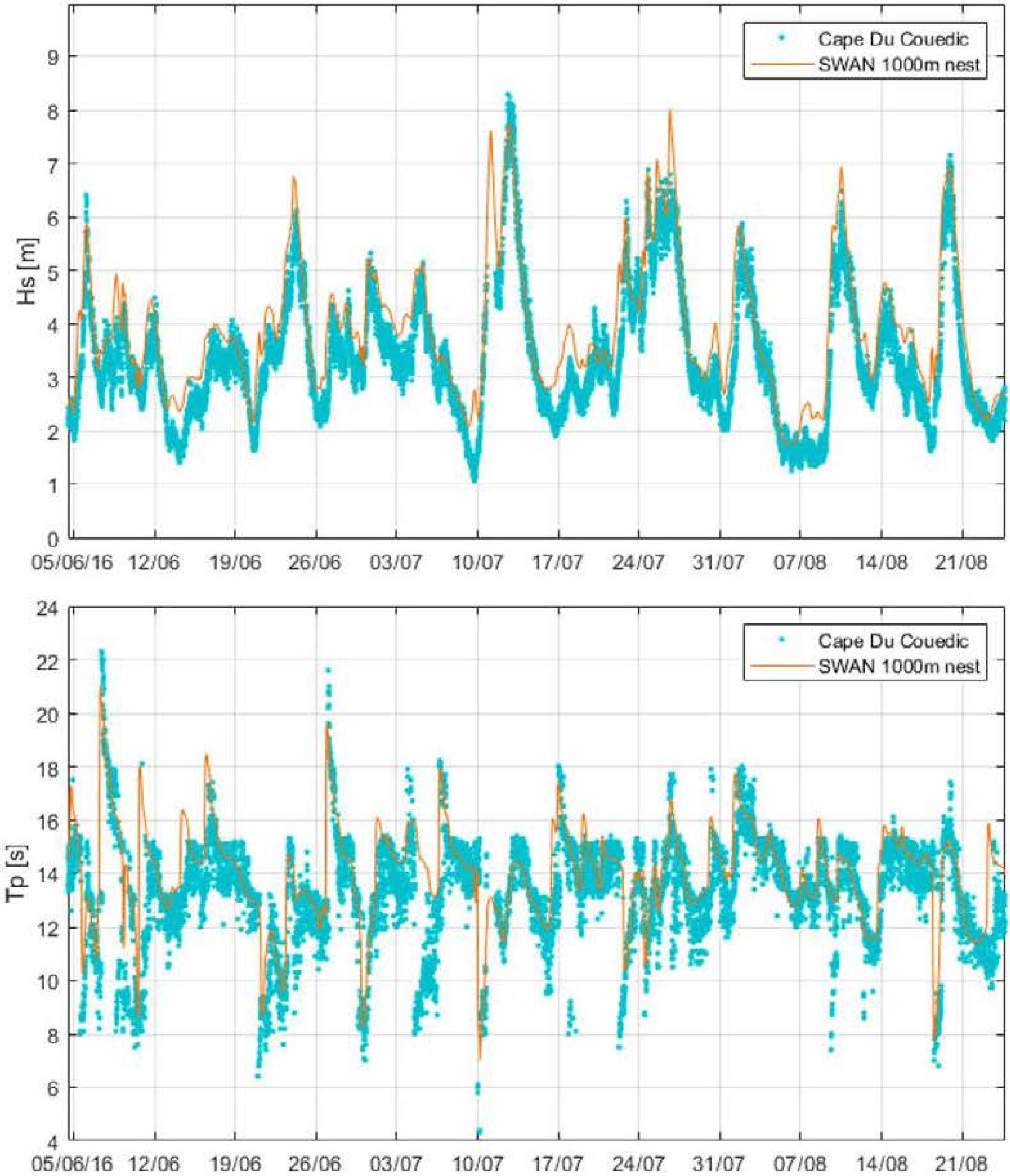

Figure 2-5 Cape du Couedic wave validation

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SWAN Model Domains

- 1000m
- 400m
- 100m
- 50m
- 20m

Title:

Model Domains

Figure: 2-6

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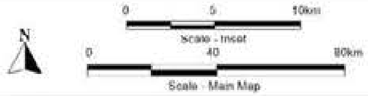

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2.3 Sediment Transport (ST)

The resuspension, dispersion and settling of the natural (ambient) bed sediments throughout the study area has not been estimated within the model. Various assessments simulated the additional resuspension, dispersion and settling of sediment released into the water column and placed on the bed by proposed dredging activities using the TUFLOW FV ST module coupled with the calibrated wave and hydrodynamic models.

The ST module allows for the simulation of multiple sediment fractions in suspension and within the bed. Sediments have been represented by three (3) fractions ranging from cohesive clays and silts to non-cohesive sand fractions.

Bed shear stress is calculated in the ST model from the non-linear interaction of currents and waves using the procedure of Soulsby (1997). A Root-Mean-Square combined wave-current bed shear stress is used as the representative value in the sediment erosion and deposition calculations.

The modelled rate of sediment deposition, Q_d (g/m²/s), is a function of the near-bed sediment concentration (TSS), the still-water fall velocity (w_s) and the bed shear stress (τ_b), according to Equation 2-1. As such, sediment settling may be reduced below its still water value by the action of bed shear stress and associated mixing in the water column. Non-cohesive sediment fractions were modelled without a critical shear stress for deposition, meaning that they have the potential to settle at all times independent of the bed shear stress.

$$Q_d = w_s.TSS.\max\left(0,\ 1-\frac{\tau_b}{\tau_{cd}}\right)$$

Equation 2-1

The rate of erosion, Q_e (g/m²/s), is calculated according to Equation 2-2. Erosion will occur in response to the combined wave-current driven bed shear stress (τ_b) when this exceeds a critical threshold (τ_{ce}). It is scaled by a constant erosion rate parameters (E).

$$Q_e = E.\max\left(0,\ \frac{\tau_b}{\tau_{ce}}-1\right)$$

Equation 2-2

It is commonly considered that the behaviour of sand-mud mixtures with sand content >90% will be dominated by the sand processes, with the fines being released from or trapped within the sand interstices (e.g. Whitehouse et al., 2000). Sediments with >5-15% fines content will tend to become cohesive with behaviour dominated by the finer fraction (e.g. Mitchener & Torfs, 1996). Most surficial bed sediments within the study area comprise silty-sand mixtures (5-25% fines content). A common critical erosion threshold and rate-coefficient was applied across both cohesive and non-cohesive sediment fractions.

The General Ocean Turbulence Model (previously described in Section 2.1.6.4) was used to control the vertical mixing of sediment. A Smagorinsky model was used for the estimation of the horizontal sediment diffusivity.

2.3.1 Modelled Sediment Fractions

Three (3) sediment fractions have been simulated within the model representing fine cohesive materials (clays and silts) and relatively-fine non-cohesive materials (fine sands). It is assumed that coarser sediments (coarse sands to gravel) will not form sediment plumes as is relevant to the water quality assessments. Table 2-1 presents the parameterisation of the three modelled sediment fractions. The critical shear stress for erosion and erosion rate constant are based on values derived for the Adelaide Coastal Waters Seagrass Habitat Modelling study (Deltares, 2017). The adopted critical shear stress for deposition is based on literature parameter values (Mehta, 2014) and is consistent with calibrated parameter sets from similar dredge plume impact assessments where ambient sediment modelling has been undertaken and compared with in-situ suspended sediment measurements (BMT WBM, 2016; BMT, 2018).

Table 2-1 Sediment transport properties

Material Fraction	Settling Velocity (m/s)	Critical Shear Stress for Erosion (N/m^2)	Critical Shear Stress for Deposition (N/m^2)	Erosion Rate Constant ($g/m^2/s$)
Clay	1.0×10^{-4}	1.0	0.18	0.005
Silt	1.0×10^{-3}	1.0	0.18	0.005
Sand	3.0×10^{-2}	1.0	-	0.005

2.4 TSS-Turbidity Relationship

Continuous measurement of water column total suspended solids (TSS) has typically been problematic to perform in the field. Instruments that measure light-scattering in the water column have traditionally been used as a practical means of continuously measuring turbidity in nephelometric turbidity units (NTU) as a proxy for TSS. To facilitate the conversion of modelled TSS concentrations in mg/L into turbidity in NTU (and vice-versa) a linear relationship was derived as shown in Figure 2-7. The derivation of this relationship is discussed in further detail in the baseline water quality technical report (BMT, 2018a). On the basis of this derivation a 1:1 correspondence between sediment plume TSS and turbidity was adopted for this assessment.

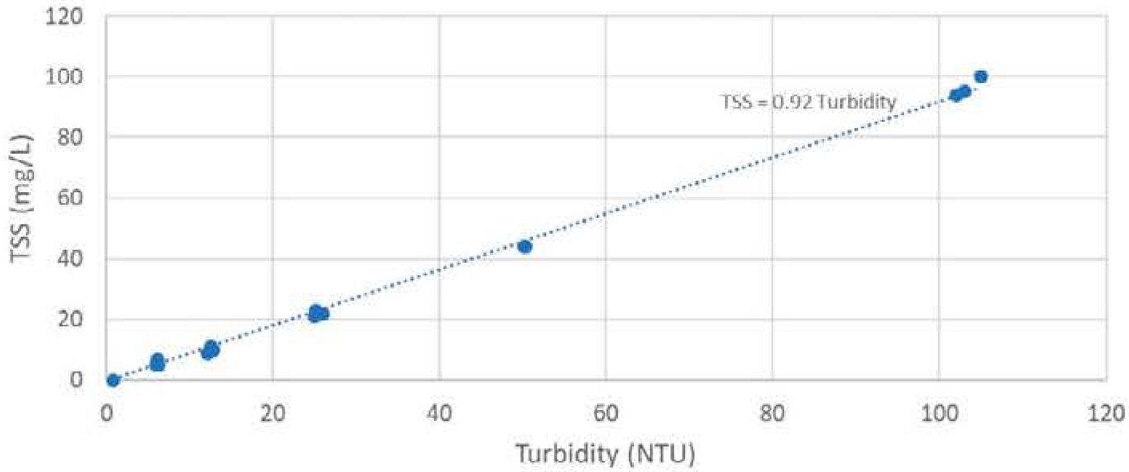


Figure 2-7 TSS-Turbidity correlation

2.5 Photosynthetically Active Radiation (PAR) Attenuation

Benthic PAR is a measure of the amount of light available for photosynthetic processes of the benthic marine community (e.g. seagrasses). Downward transmitted PAR is reduced between the water surface and the seabed by attenuation, which is typically described using an exponential decay relationship parameterised with a decay length-scale, K_d (m^{-1}), i.e.

$$E(z) = E(z_0)\exp[-K_d\ (z - z_0)]$$

Equation 2-3

The decay length-scale, Kd is understood to be dependent on water column properties, including dissolved organic carbon (DOC), Total Suspended Solids (TSS) and phytoplankton chlorophyll (Chl) quantities.

Sediment plumes generated during dredging and construction have the potential to increase TSS and hence reduce benthic PAR levels. Benthic PAR modelling has therefore been undertaken for Smith Bay using data collected during the January/February 2018 field deployment to help parameterise the light attenuation dependence on water column TSS (refer Figure 2-8, BMT, 2018 for details). The derived relationship for K_d as a function of TSS is given below.

$$K_d = 0.19 + 0.06\,TSS$$

Equation 2-4

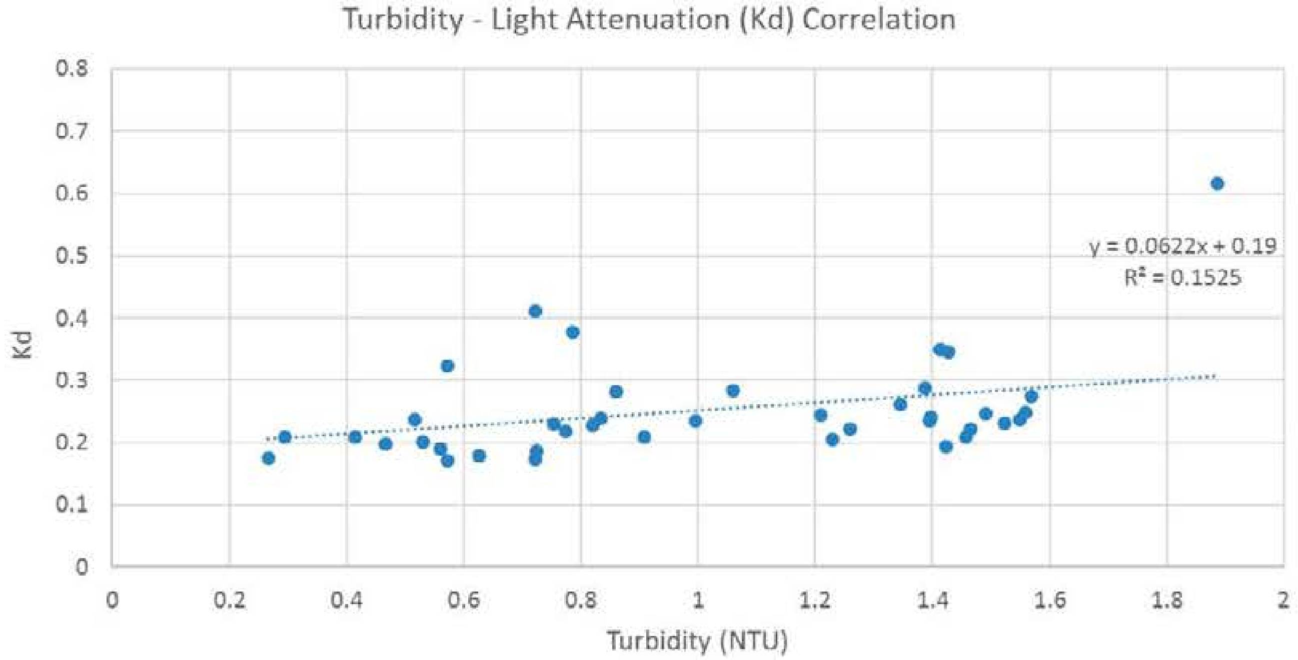


Figure 2-8 Turbidity – Kd correlation

2.6 Ambient Suspended Sediment

A regression model for ambient suspended sediment was developed in order to estimate the Total Suspended Solids (ambient plus plume) as part of the water quality risk assessment. The regression model was based on the 12-month measured turbidity timeseries dataset along with modelled parameters representing the primary environmental drivers of suspended sediment (turbidity). The modelled parameters were current speed, wave height, period and bed shear stress.

The turbidity timeseries data was seen to have wave driven peaks in turbidity followed by calm periods of exponential turbidity decay. The following form of regression relationship was selected based on its ability to match the temporal characteristics of the data.

$$Turb^n = \max\begin{cases} A\,H_s{}^B + C \\ Turb^{n-1}e^{-\left(\frac{\Delta t}{D}\right)} \end{cases}$$

Equation 2-5

where:

- $Turb^n$ [NTU] is the modelled turbidity at the current timestep;
- $Turb^{n-1}$ is the modelled turbidity at the previous timestep;
- Δt [hours] is the timestep; and
- H_s [m] is the significant wave height.

The regression constants were fitted in order to achieve firstly an unbiased Quantile-Quantile prediction (Figure 2-9) and secondly to minimise the root mean square error. The following parameter values were derived from the fitting procedure:

- A = 0.7; B = 2; C = 0.2; D = 9 (hrs)

The fitted regression model between turbidity and H_s had a correlation coefficient (r) of 0.56 and a rmse of 0.58 [NTU].

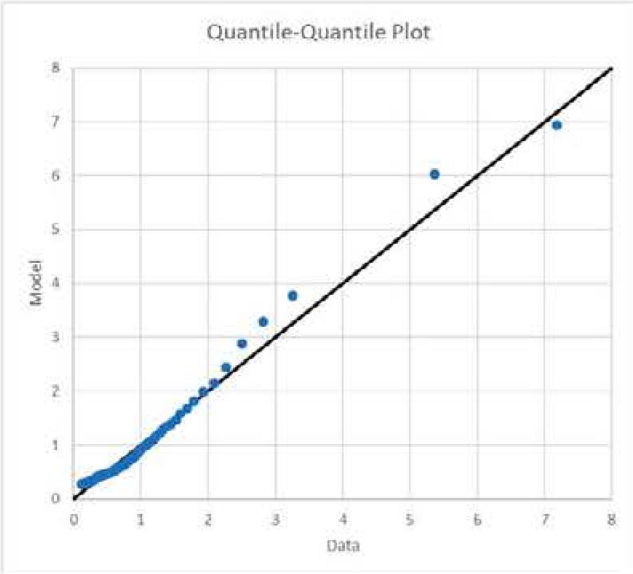


Figure 2-9 Quantile-Quantile plot for ambient turbidity (model vs data)

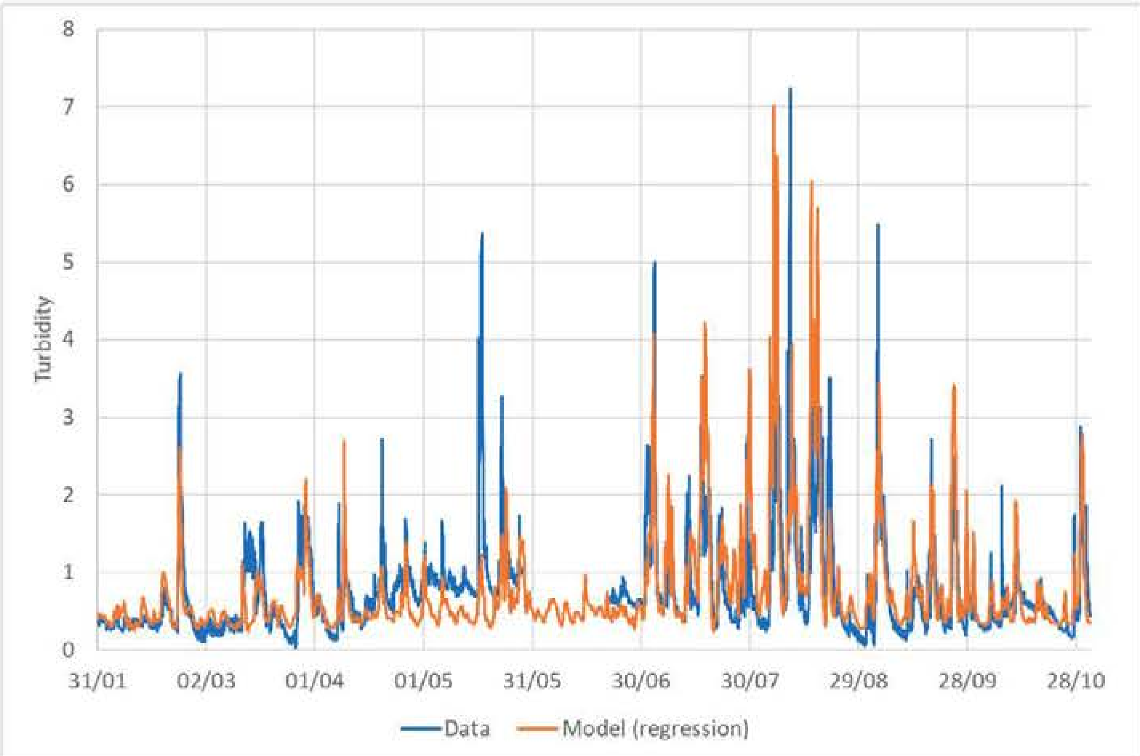


Figure 2-10 Modelled and measured ambient turbidity

The ambient suspended sediment model was used to predict timeseries of TSS at sensitive receptor locations. A 1 : 1 (TSS : turbidity) relationship was used in conjunction with Equation 2-5 to predict an upper-bound estimate of the TSS_{fines}. A further factor-2.0 was applied to predictions of near-bed ambient TSS.

2.7 Hydrology (WBNM)

Hydrologic modelling of the Smith Creek Catchment (3421 ha) was undertaken in order to derive a representative 1-in-10 Annual Exceedance Probability (10% AEP) flood hydrograph for use as a volumetric flux boundary condition in the TUFLOW FV model. The instantaneous flow rates will be used for impact assessments on Smith Bay under flood conditions from Smith Creek.

The non-linear numerical Watershed Bound Network Model (WBNM) (Boyd 2012) has been used for hydrologic modelling of the Smith Creek Catchment. Where for a design storm event derived in accordance with Pilgrim (1987), appropriate losses are applied and resultant excess-rainfall is routed through the effective pervious/impervious area of each sub-catchment. The rainfall-runoff hydrographs from each sub-catchment are then subsequently routed through the stream network completing the hydrologic model.

The contributing catchment has been divided into 35 sub-catchments to provide an accurate representation of the flow regime and lag times within the Smith Creek Catchment, refer to Figure 2-11 for the sub-catchment delineation and stream network used to model the catchment. The land use within the catchment is primarily rural with several roadways, with mostly grass coverage and with smaller portions of uncleared vegetation. An effective fraction impervious of 5% has been assigned to this land use.

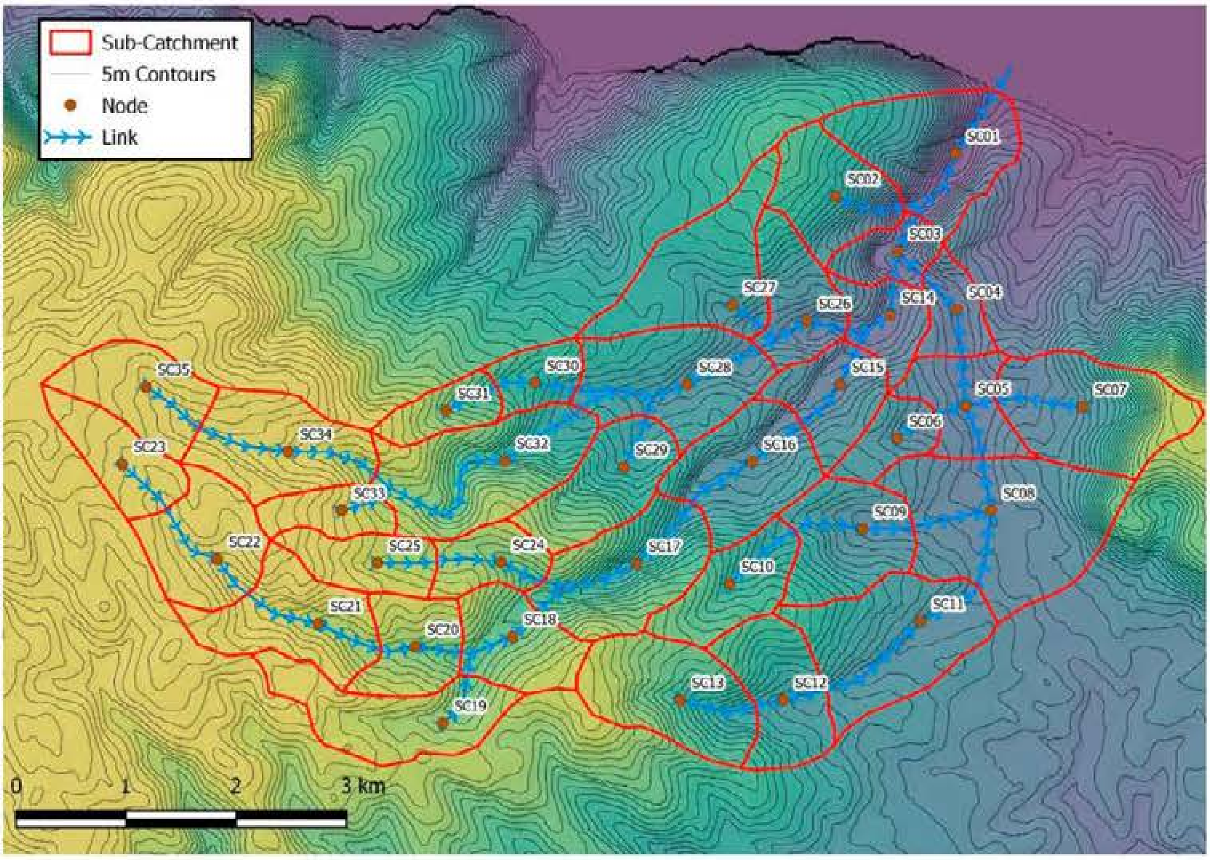


Figure 2-11 Smith Creek sub-catchment delineation and stream network

In order to parameterise the WBNM model, each sub-catchment is defined by an area, an effective fraction impervious, a lag parameter and an impervious lag factor and each stream within a sub-area is defined by a stream lag factor.

The default WBNM parameters have been adopted for all sub-catchments and are as follows:

- Lag Parameter, 1.6;
- Impervious Lag Factor, 0.1; and
- Stream lag factor, 1;

Using the methods prescribed in Pilgrim (1987), dimensionless 1-in-10 AEP Zone 6 temporal patterns have been factored by design rainfall depths (BOM n.d) to derive a set of standard duration design storm events. The nominal method for obtaining the rainfall-excess from hyetographs has been the initial and continuing loss rainfall abstraction method. Initial losses have been assumed to be 0mm based on saturated antecedent catchment conditions. The Continuing loss (CL) value for the pervious portions of the catchment has been adopted as 2mm/hr. These factors serve to derive a faster catchment response to the design rainfall event.

Results from the hydrologic model are presented in Figure 2-12. The 540-minute design storm event has been determined as the critical event and the resultant hydrograph has subsequently been used as the representative 1-in-10 AEP flood hydrographs for the study.

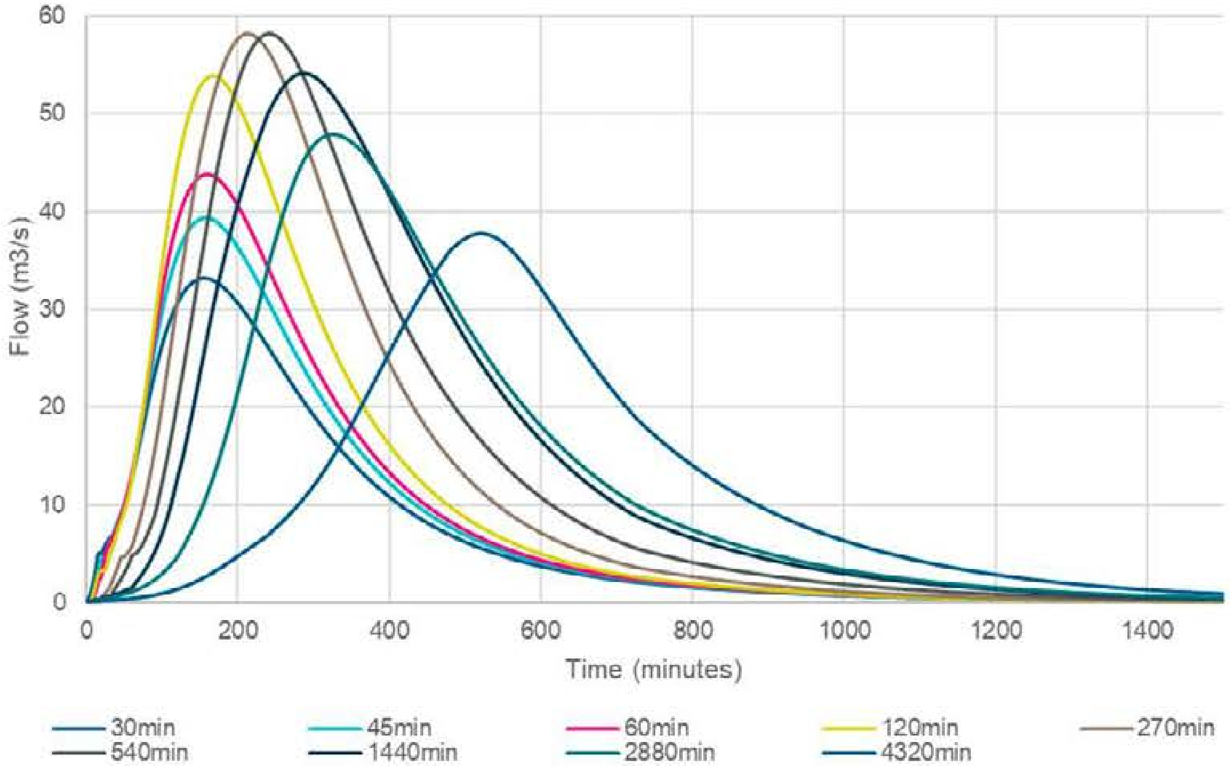


Figure 2-12 Hydrographs for 1 in 10 AEP design storm events

3 Model Calibration

3.1 Baseline Calibration Data

The modelling system was primarily calibrated against measurements conducted on behalf of KIPT by Metocean Services International Pty Ltd (MSI) between June 2016 and November 2017. The measurement buoy was deployed at Smith Bay in around 12 m depth of water (refer Figure 3-2 for location plan). The buoy was equipped with directional wave measurement capability, downward facing Acoustic Doppler Current Profiler (ADCP) and water temperature sonde. Measured tide data was available for the calibration period at Port Giles, Cape Jervis and the Port Adelaide Outer Harbour gauges (refer Figure 2-2).

3.2 Calibration Period Characteristics

The calibration simulation period (June 2016 to November 2017) began during one of the most severe winter (wet-season) periods in several decades for this region (BOM records indicate the wettest winter for South Australia since 2001). Several intense storm events occurred in the early months of calibration. The 2016-2017 Summer was South Australia's sixth wettest summer on record, with some significant rainfall storm events in the early-Summer.

As such, the calibration period included a greater proportion of strong northerly, and westerly wind conditions at Smith Bay. Windroses (from CFSR) are presented in Figure 3-1 for a location offshore from Smith Bay for both the calibration period and for the most recent CFSR period (2011-2017).

The 2017 Winter period conversely, was a period of below-average storminess throughout the state. This range of conditions provides a good starting point for model calibration.

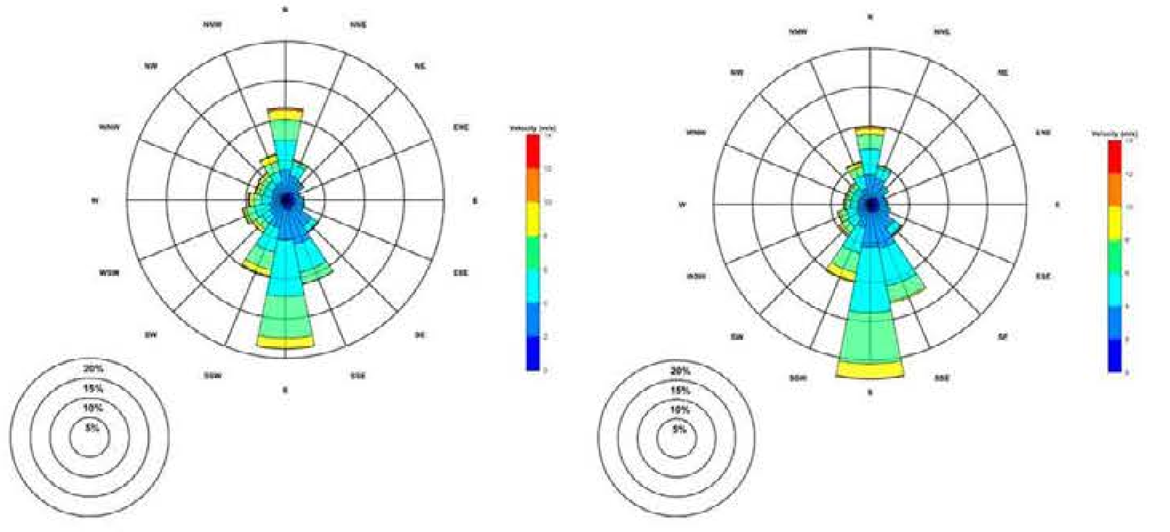
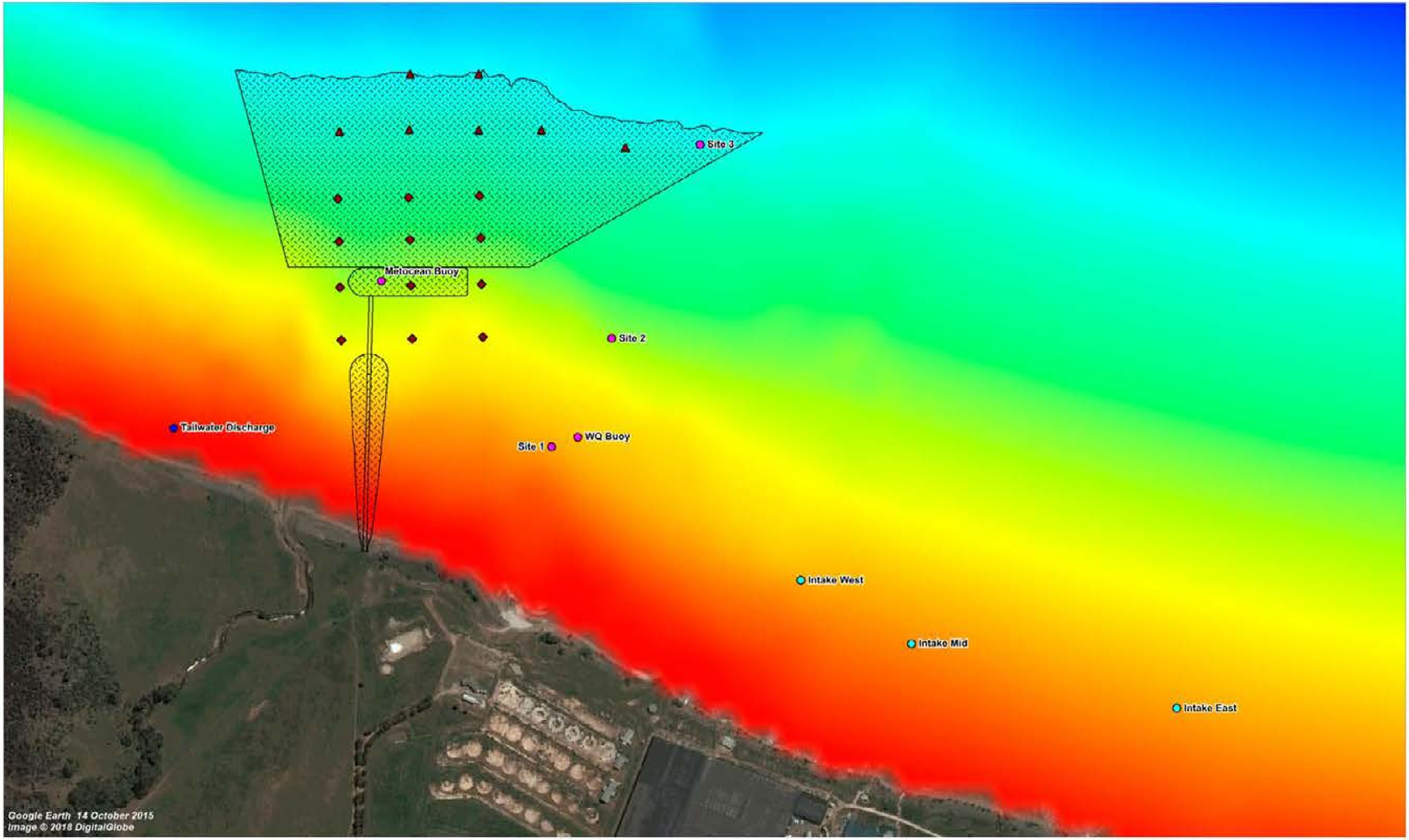
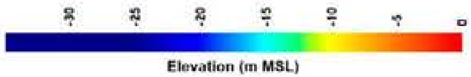


Figure 3-1 CFSR windrose offshore of Smith Bay for calibration period (left) and 2011-2017 (right)



LEGEND

- Instrument Locations
- Water Intake Locations
- Tailwater Discharge Location
- Sediment Sampling Locations
- Dredge Area and Causeway Footprint



Title:

Smith Bay Instrument and Sediment Sampling Locations

Figure: 3-2

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0 100 200m
Approx. Scale

www.bmt.org

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3.3 Statistical Metrics

In order to quantify the 'goodness-of-fit' of the model to the observed data, several statistical metrics have been used and presented. These metrics are based on widely used metrics for assessing comparisons between model predictions, and observations (Stow et al. 2009).

Correlation coefficient (r): The correlation coefficient measures whether two datasets vary together. A value of -1 occurs when predicted and observed values vary inversely. A value of +1 occurs when the two vary together. A correlation coefficient of 1 does not mean a perfect data match, as the data could be offset by a fixed amount. This metric can also be skewed by extreme values that may or may not be representative of the total dataset/s.

Root mean squared error (rmse): This measures the root-mean average magnitude of the error (irrespective of whether positive or negative). Values near zero are ideal.

Average Error (ae): Measures the average bias or offset between predicted and observed values with a directions. A positive value suggests that the predicted values are higher on average than the observed, with a negative value showing that predictions are on average lower.

Average Absolute Error (aae): Also measures the mean error, though ignoring weightings due to direction (positive or negative). Like the rmse, values near zero area ideal, though the absolute error also represents the average amount that the predicted values differ from the observed.

Modelling efficiency factor (mef): measures how a model compares to the mean of the observed dataset. A value of zero shows that the model is no better than the mean of the data set, with values less than zero suggesting that the mean of the observed would be a better predictor. Values near one suggests a close match between the predicted an observed.

3.4 Waves

The modelling system was calibrated against wave measurements obtained as part of the 2016-2017 metocean monitoring (MSI, 2017). The SWAN model used a third-generation wave model setup, in non-stationary two-dimensional mode. Default parameters were otherwise used in the SWAN model as described in the SWAN manual (Delft University of Technology, 2006).

A timeseries comparison shown in Figure 3-3 and a Q-Q plot of the significant wave height is shown in Figure 3-4. A slight over-prediction bias exists at very low wave heights, which appears to be related to refracted Southern Ocean swell. The model also appears to slightly over-predict wave heights during extreme storm events. However, the overall scale of the wave model predictive bias and is modest and would not be expected to invalidate the sediment plume model predictions.

Figure 3-6 suggest a bias towards higher wave periods for much of the more frequent wave conditions (see lack of model values <5s compared to observed). This bias is unlikely to have a large influence on the bed shear stress as the wave heights are relatively small when this bias of the short-period waves is seen. A Hs-Tp scatter plot is shown in Figure 3-7 and confirms that the model has a tendency to predict a dominant period in the swell band when the total wave energy is low.

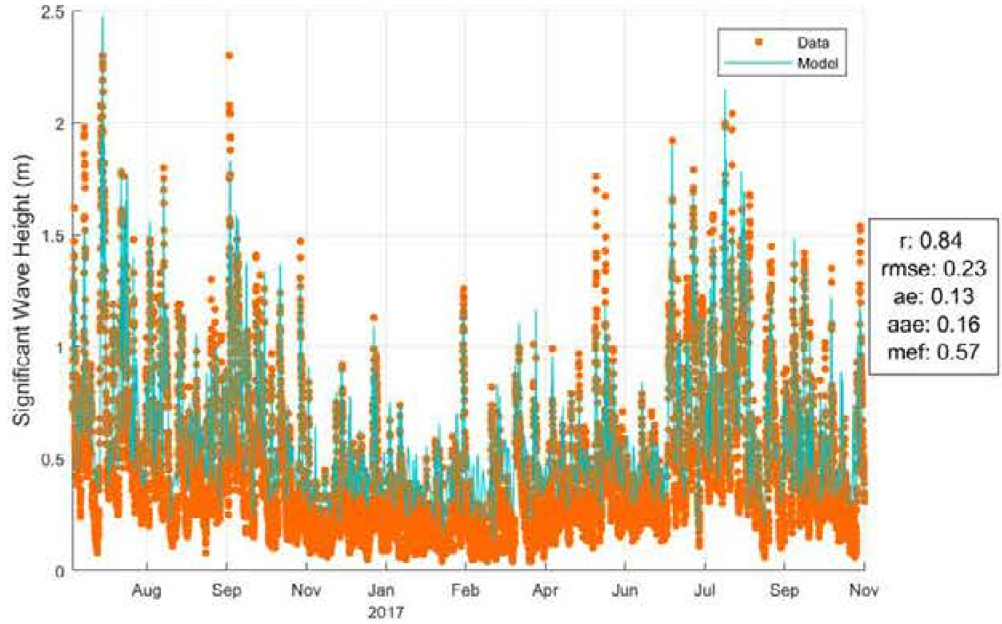


Figure 3-3 Comparison of significant wave height at Metocean buoy

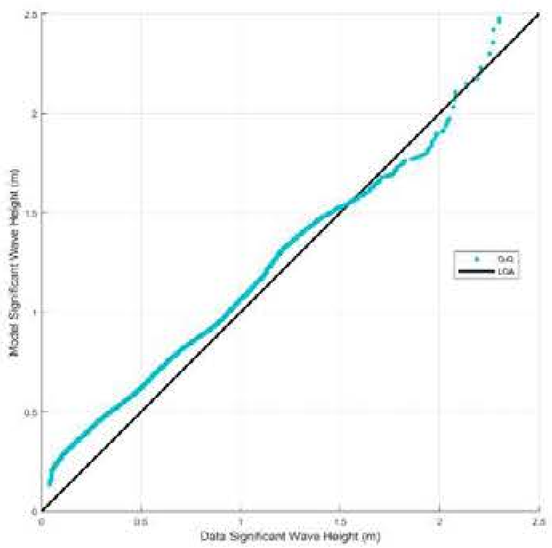


Figure 3-4 Model-Data Q-Q plot of significant Wave height at Metocean buoy

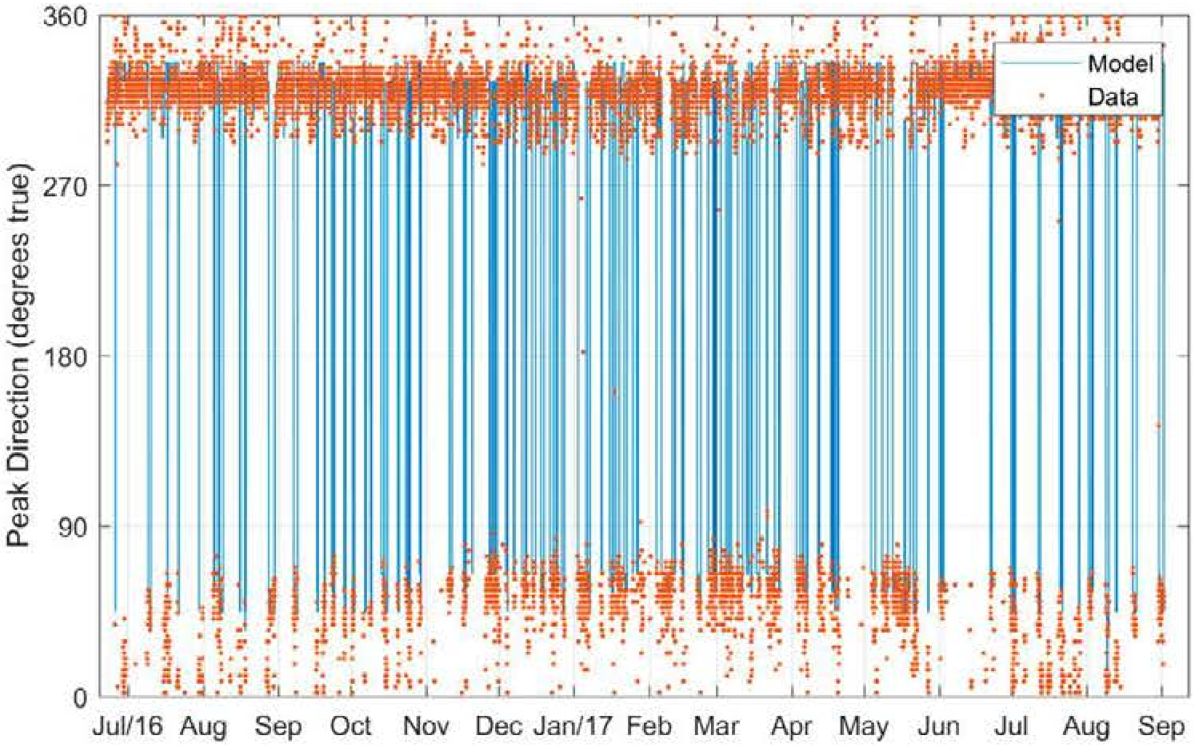


Figure 3-5 Comparison of peak wave direction at Metocean Buoy

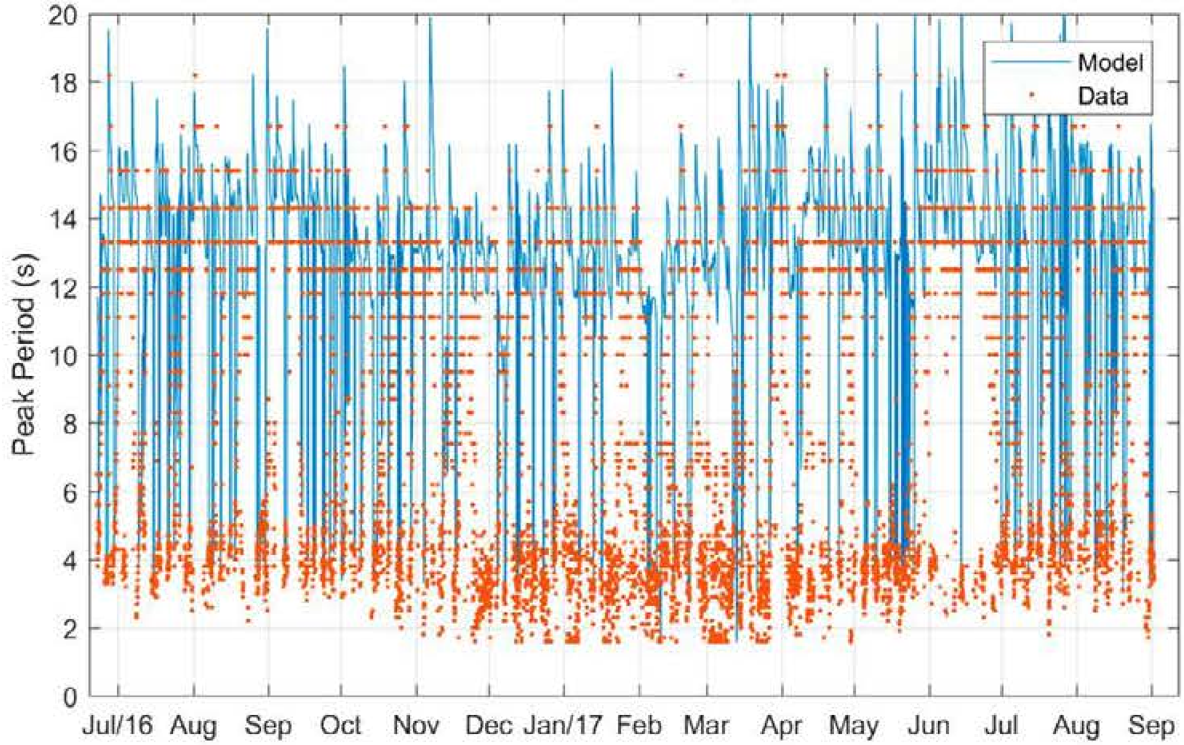


Figure 3-6 Comparison of peak wave period at Metocean Buoy

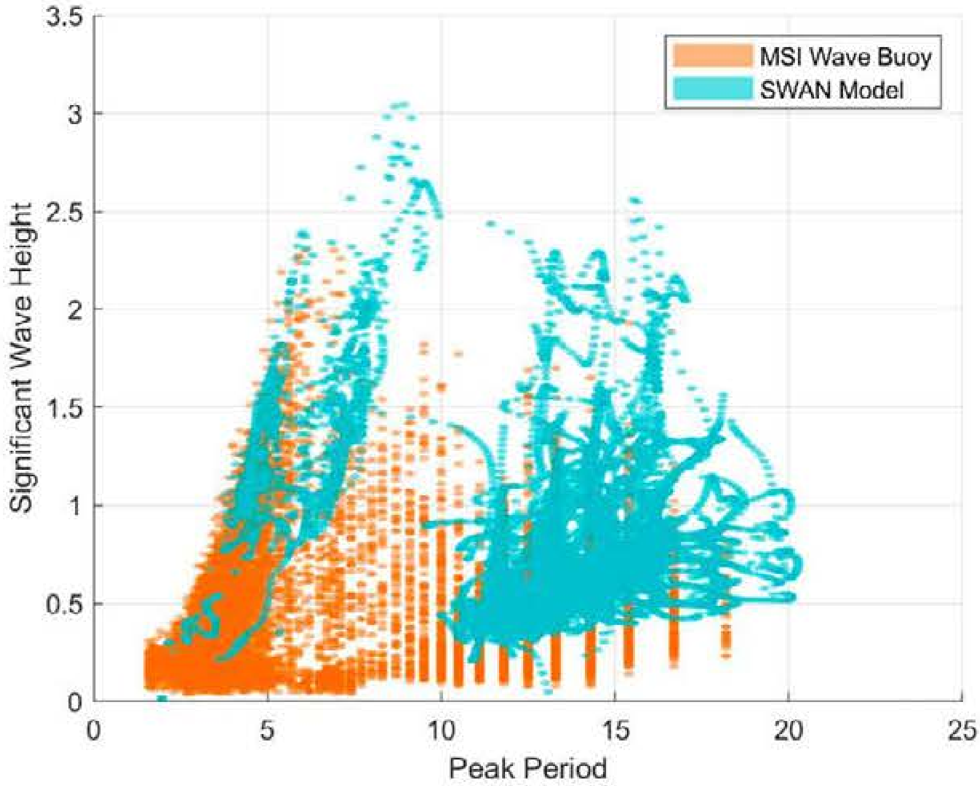


Figure 3-7 Hs-Tp Scatter Comparison

3.5 Hydrodynamics

Hydrodynamic calibration involved adjusting model configuration, parameters and boundary conditions in order to replicate the following:

- Water levels throughout the model domain;
- Current magnitude and direction at Smith Bay;
- Residual (25-hour moving average) current magnitude and direction; and
- Sea-surface temperature at Smith Bay.

3.5.1 Water Levels

Water level variations at Smith Bay are driven a combination of tides, local wind stresses and storm surges propagating into Investigator Strait from the Southern Ocean. The tidal regime has a mixed semi-diurnal classification and exhibits significant diurnal inequality (height difference between successive high/low tides). Spring tidal range at Smith Bay is typically around 1 m, while very low amplitude 'dodge' tides occur mid-way between spring tide periods.

Non-tidal water level variations are generally driven by frontal storm systems, which are most active during autumn and winter. Storm surges exceeding 0.7 m above the predicted (astronomic) tide level are a relatively common occurrence during winter storms.

Reproducing both tidal and non-tidal environmental drivers is important for reproducing water level dynamics within the study area. As discussed in Section 2.1.6, synthesised water levels were derived for the open boundaries to ensure that both tidal and non-tidal variations were applied as boundary conditions. Capturing the non-tidal water level variations was of particular importance for reproducing non-tidal currents (refer following section).

Water level measurements for the calibration period were not undertaken at Smith Bay, however Figure 3-8 shows a comparison of modelled water level and measurements at Port Adelaide Outer Harbour tide gauge. Two representative two-week duration periods are shown in Figure 3-8. The first period in July 2016 shows that while the model is slightly under-predicting tidal amplitude it does a good job at reproducing a storm surge event around the 10th July. During the second period in March 2017 the modelled tidal amplitudes are closer to the Port Adelaide tide gauge measurements. These variations in predictive skill with respect to tidal amplitude are most likely attributable to the western Investigator Strait boundary condition, which relies on a set of tidal constituents for Pondalowie Bay (Section 2.1.6.3).

Overall, the water level calibration results show that the model is capable of reproducing water level dynamics within the broader Gulf St Vincent system. Further site-specific validation of water level predictions at Smith Bay is discussed in Section 4.3.1.

3.5.2 Currents

Similar to water level variations, currents at Smith Bay are driven by a combination of tides, local wind stresses and storm surges. In addition, the direction of the currents in Smith Bay is sensitive to the bathymetric contours within the bay. In order to reproduce the observed directionality careful interpolation of the hydrographic survey data was required, in particular for areas beyond the high-resolution hydrographic survey and where the ENC data was limited.

The modelled depth-averaged current speed and direction is compared with measurements from the MSI buoy in Figure 3-9. The presented comparisons are for the same two-week periods as the water level calibration (Section 3.5.1). A scatter plot comparison of modelled and measured currents is shown in Figure 3-10. These comparisons indicate that the model generally does a good job at predicting current speeds, phases and directions. Some under-prediction of peak tidal currents speeds is observed during the July 2016 period, which is attributable to the under-predicted tidal amplitude during this same period. The prediction of peak tidal current speeds is improved during the March 2017 period, during which tidal amplitudes were well predicted. The model shows good predictive skill during periods of strong westerly winds, such as occurred during 10-12 July, 2017.

Model skill in predicting non-tidal (residual) currents is an important consideration for predicting the advection and dispersion of sediment plumes. A 25-hour moving average filter was applied to both measured and modelled currents, which are compared in Figure 3-11. This comparison shows that the model is capable of predicting the prevailing trend observed in the data of weak westerly residual currents superimposed with relatively strong but short-term easterly residual current events. The easterly residual current events are driven by frontal weather systems and associated winds from the west.

These calibration results indicate that the model can reproduce the timing, direction and speed of currents at the proposed seaport location with a reasonable level of accuracy. Further site-specific validation of current predictions is discussed in Section 4.3.2.

3.5.3 Temperature

Water temperature at Smith Bay is driven by exchange of Southern Ocean water as well as solar heating of the relatively shallow waters within Investigator Strait and Gulf St Vincent. A comparison of modelled water surface temperature and 16 months of measurements from the Smith Bay Metocean buoy are shown in Figure 3-12. The model shows good agreement with the spring through summer warming trend and reasonable agreement with the autumn through winter cooling trend.

The measured temperature data includes short-term spikes during the summer period that are not reproduced by the model. These measured spikes are probably attributable to solar heating of the instrument housing and therefore are unlikely to properly represent the surface water temperature.

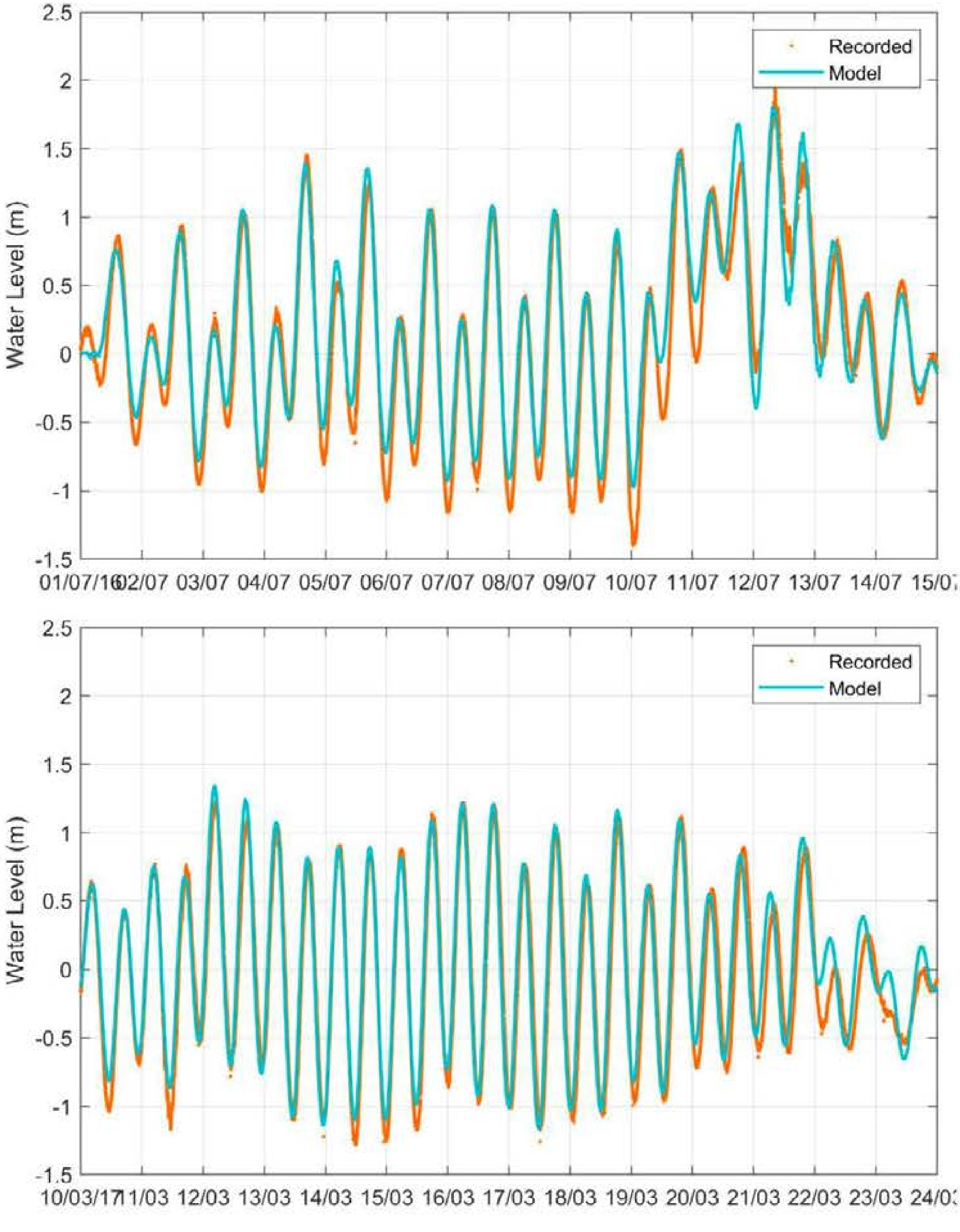


Figure 3-8 Water level timeseries at Port Adelaide Outer Harbour Gauge

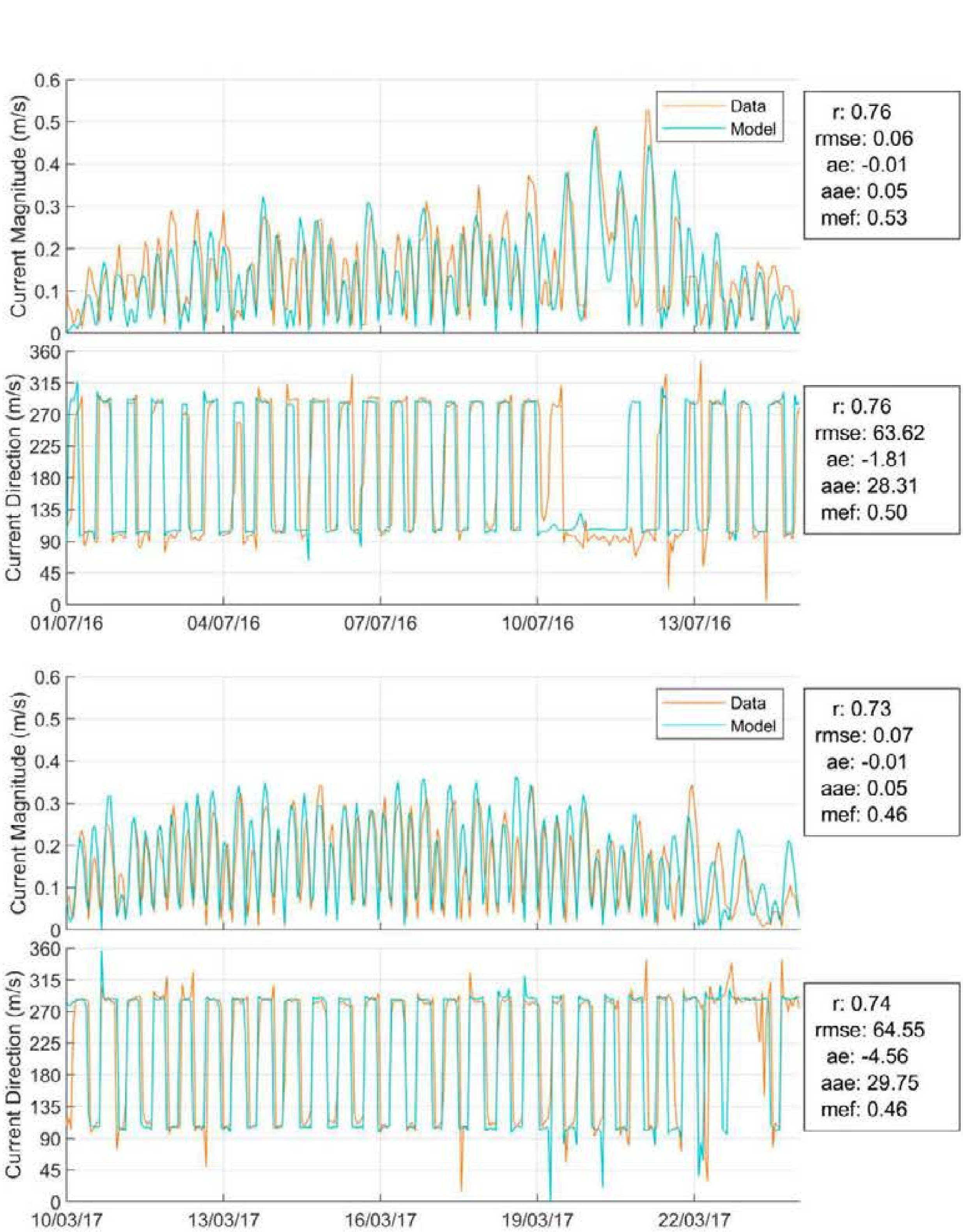


Figure 3-9 Depth-averaged current magnitude and direction timeseries at MSI Buoy

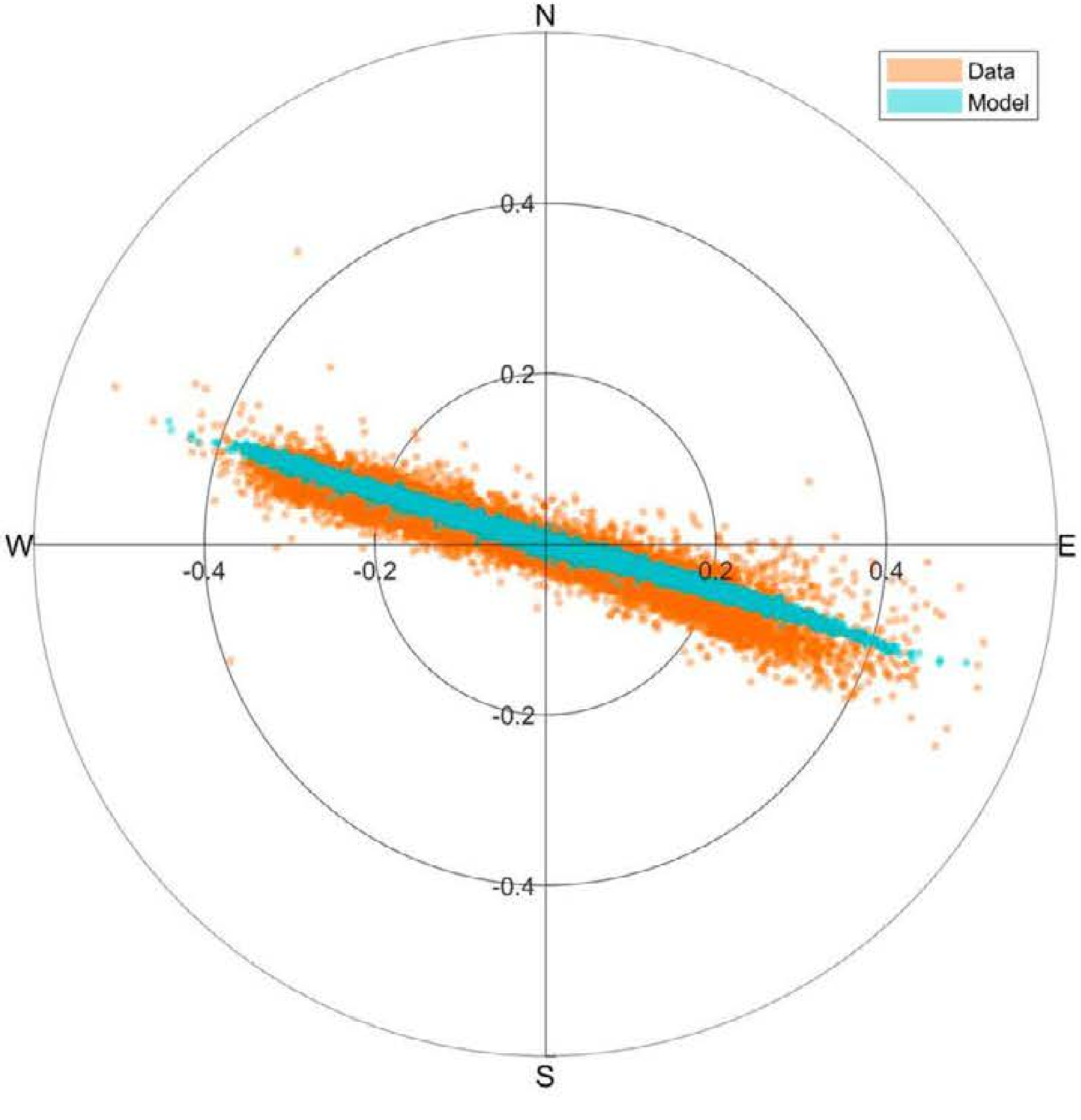


Figure 3-10 Depth-averaged current Scatterplot at MSI Buoy for entire calibration period (July 2016 to November 2017)

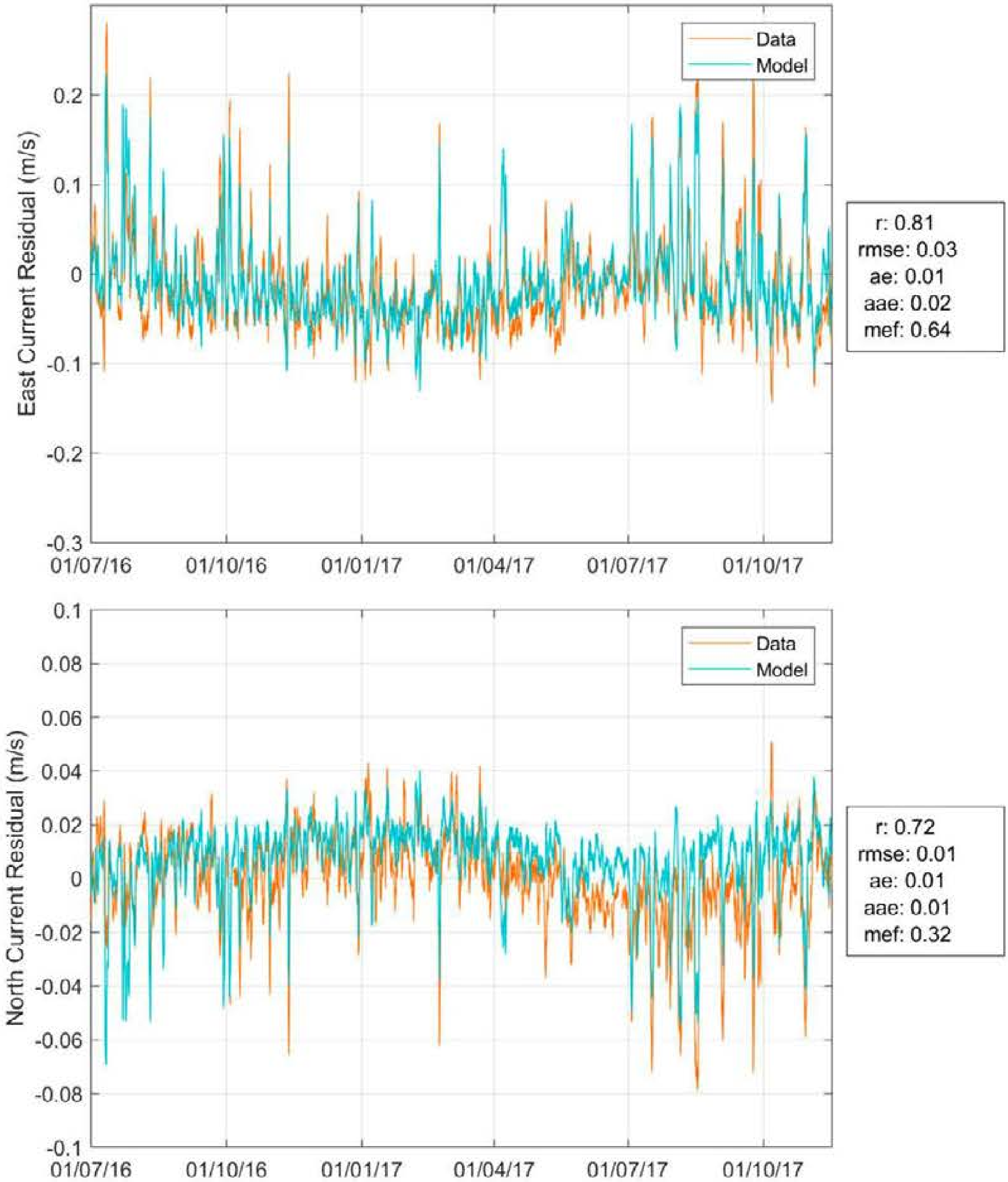


Figure 3-11 Current residual (25-hour moving average) at MSI Buoy. Easterly component (top), Northerly component (bottom)

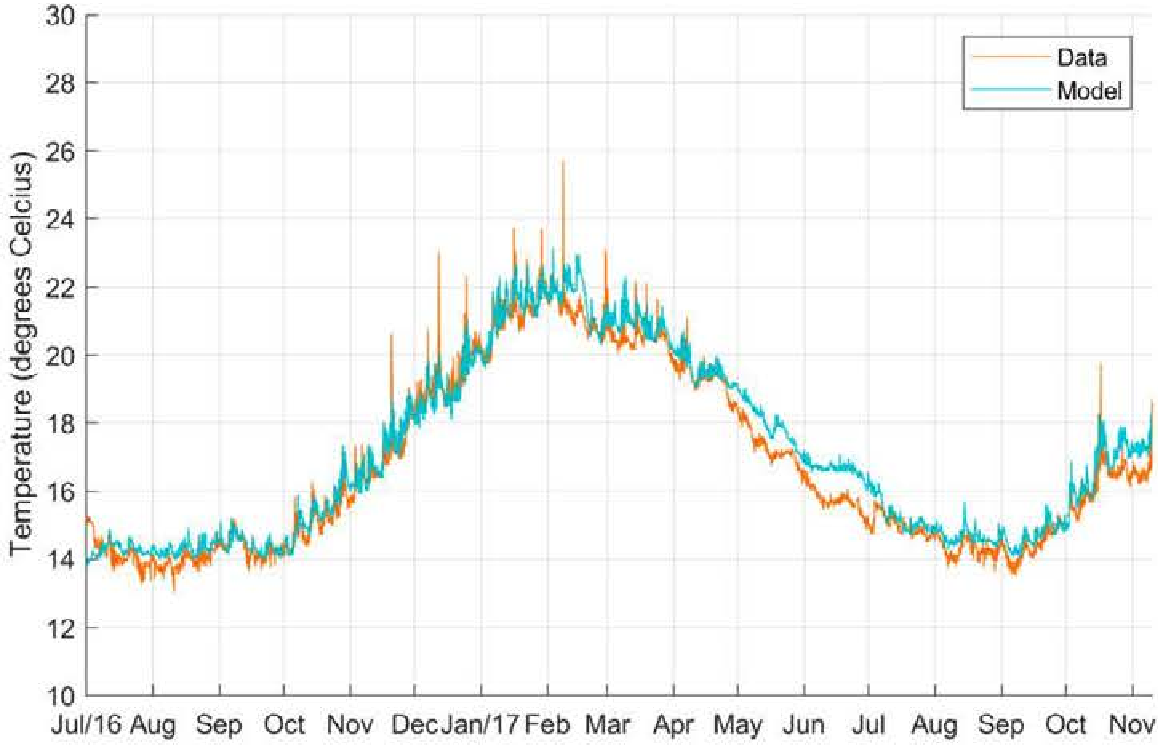


Figure 3-12 Surface temperature at MSI Buoy

4 Model Validation

4.1 Validation Data

A 6-week data collection campaign was undertaken in Smith Bay between 11 January and 24 February 2018. The objective of the data collection was to facilitate validation of the hydrodynamic and wave numerical models, in particular with respect to:

- Spatial variations in currents and waves;
- Near bed temperature, salinity and turbidity;
- Benthic Photosynthetically Active Radiation (PAR); and
- Relationship between Total Suspended Solids and Turbidity.

A cross-shore array of instruments mounted on frames was deployed on the Smith Bay seabed as shown in Figure 3-2. Each frame housed an upward-facing ADCP measuring currents and waves, a YSI measuring depth, salinity, temperature and turbidity and PAR sensors. A failure of the YSI turbidity sonde at the deepest Site 3 location meant that turbidity measurements were not available for this site.

4.2 Validation Period Characteristics

Typically, the summer months in South Australia experience dry conditions with limited storm activity. January and February 2018 experienced below-average wind and rain events. During this period, conditions in Smith Bay were dominated by tidal variation, excluding a wind-driven event on the 13th January. The tidal regime results in a west-heading residual current trend.

4.3 Hydrodynamics

4.3.1 Water level

A comparison of modelled water levels and measurements at BMT Site 3 are shown in Figure 4-1 and indicates a good validation of the model's skill at predicting semi-diurnal tidal variations at the study site. Comparisons at the other measurement sites showed identical levels of correspondence.

Tidal residual water levels were derived by processing the modelled and measured data results with a 25-hour moving average filter. The residual water levels are compared in Figure 4-2 and show that the adopted model boundary condition configuration is capable of reproducing meteorologically driven water level variations at the study site.

4.3.2 Currents

Modelled current speed and direction timeseries are compared with measurements at the three measurement sites in Figure 4-3. These comparisons indicate a good validation of the model's skill at predicting tidal current variations, including:

- Current speed and direction during peak ebb and flood tide flows;
- Semi-diurnal current phasing; and

- Diurnal inequalities and spring-neap variations.

Following a review of the raw data current directions at site 2 were adjusted anti-clockwise by 8 degrees (raw and adjusted data shown in Figure 4-4). Without this adjustment the measured current at site 2 appeared to be directionally inconsistent with the measurements at both the further inshore and offshore locations. Possible reasons for a measurement directional bias could include compass calibration error or magnetic interference for example from an adjacent steel instrument frame. In any case, the magnitude of the adjustment is only relatively small and the good directional comparison with raw measurements at three other instrument sites support the models predictive skill with respect to current directionality. Timeseries and residual comparisons for site 2 are based on the directionally-adjusted data.

The depth-averaged current validation is shown as polar scatterplots in Figure 4-4. These comparisons further confirm that the model is broadly reproducing the current speed and direction at various depths within Smith Bay.

Depth-averaged residual currents obtained by processing results with a 25-hour moving average filter are compared in Figure 4-5. These results show reasonable temporal agreement between the model predictions and measurements. However, the model predicts a slight easterly bias for the residual currents during this relatively calm period.

The response to the 13 January wind event is under-predicted by the model. While the CFSR wind boundary were found to provide a reasonable estimate of observed wind under most conditions, during this event they were underpredicted by around 40% based on comparison with observations at Kingscote Airport.

4.3.3 Temperature

Surface temperature measured at the WQ buoy and near-bed temperature at Site 3 in approximately 15 m water depth are compared with model predictions in Figure 4-6. These results indicate that the model has reasonably good skill at predicting multi-day variations in water temperature. A slight (<2 degrees Celsius) overprediction bias is seen in the model predictions, particularly at the near-bed location. The WQ buoy measurements indicate a greater variability in temperature at the surface of the water column, however it is thought that this measurement may have been influenced by heat conducted from the buoy housing by the metal sonde guard.

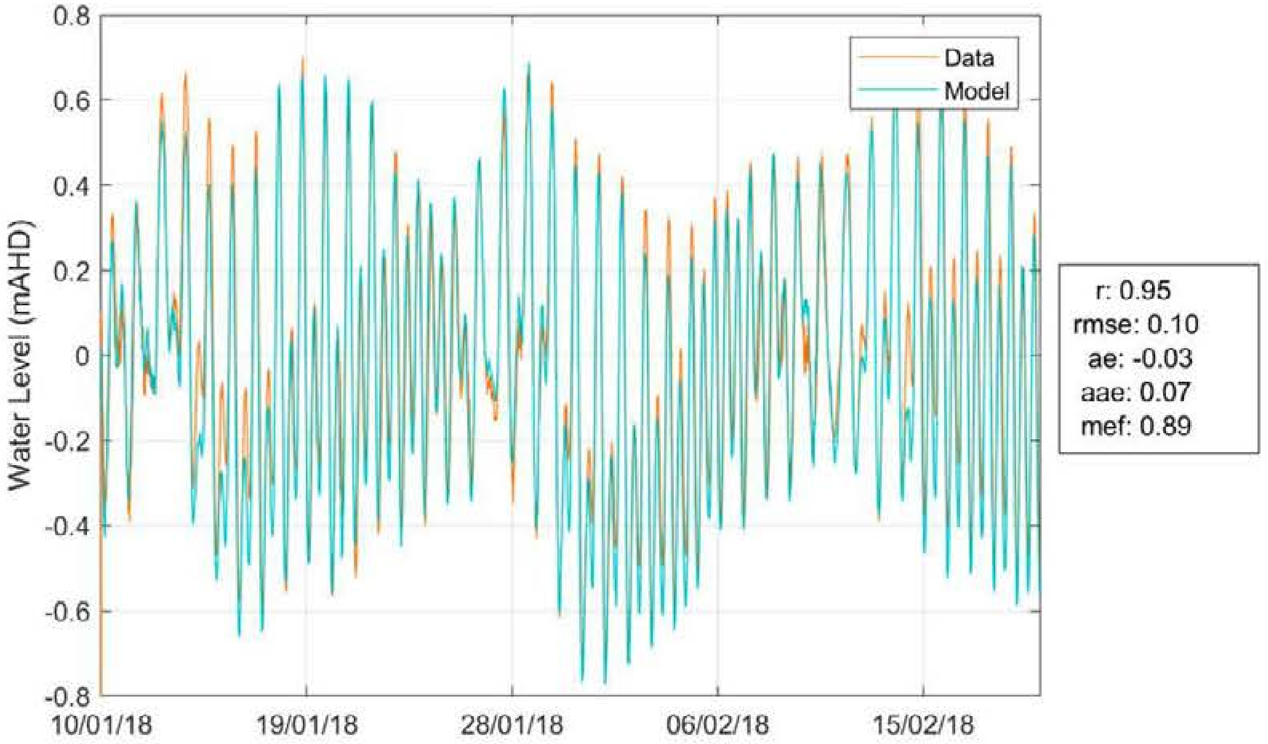


Figure 4-1 Water level comparison at BMT Site 3

Figure 4-2 Residual water level (25-hour moving average filter) comparison at BMT Site 3

Model Validation

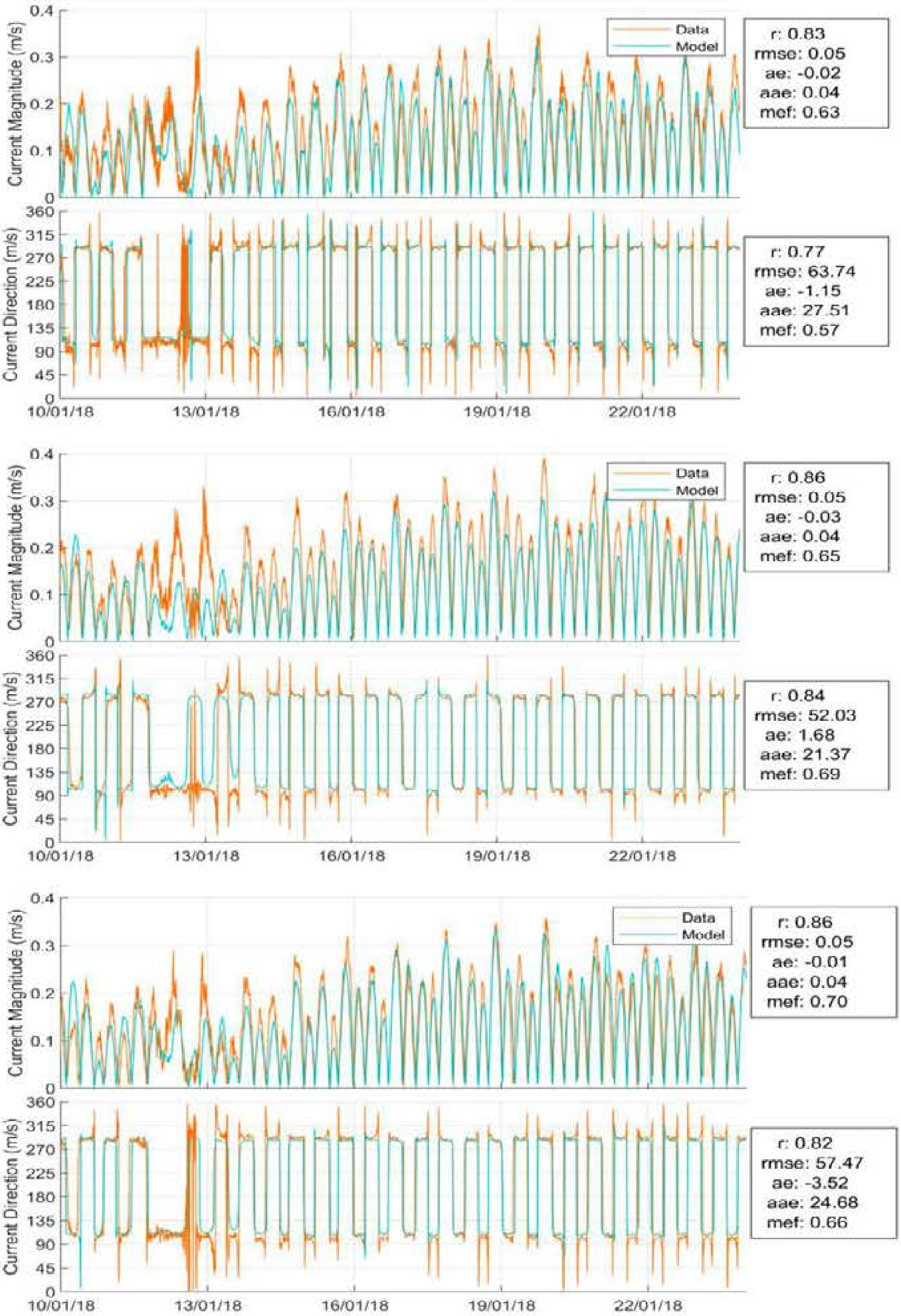


Figure 4-3 Depth-averaged current speed and direction comparisons. Site3-top, site 2-mid, site 1-bottom.

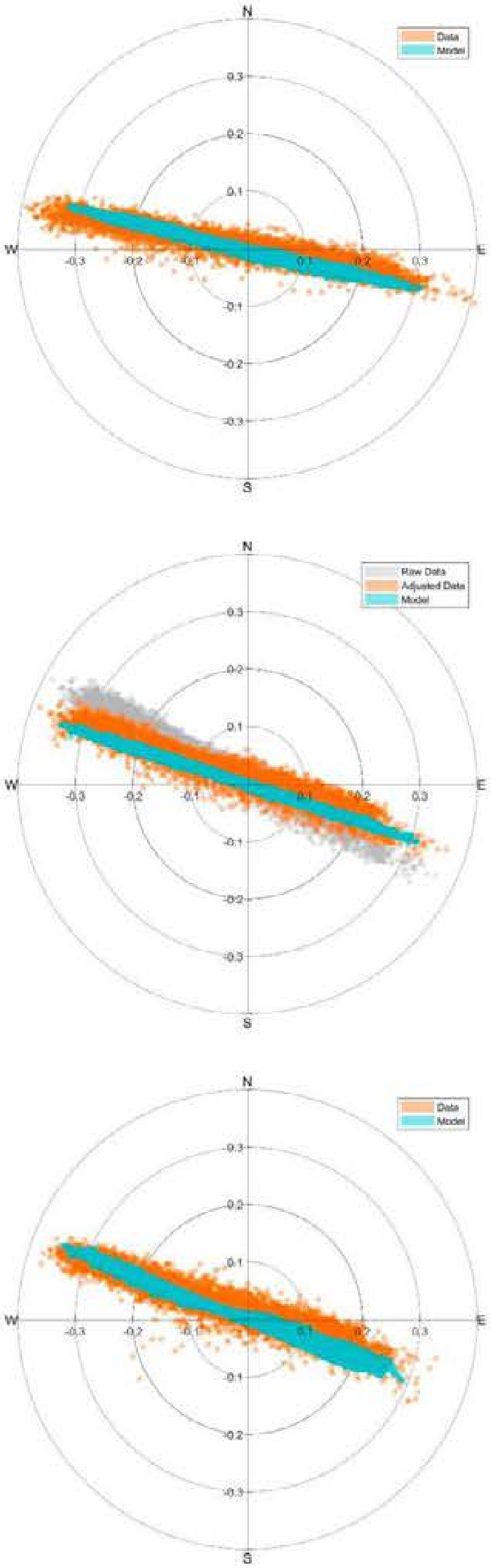


Figure 4-4 Depth-averaged current scatterplots. Site 3-top, Site 2-mid, Site 1-bottom

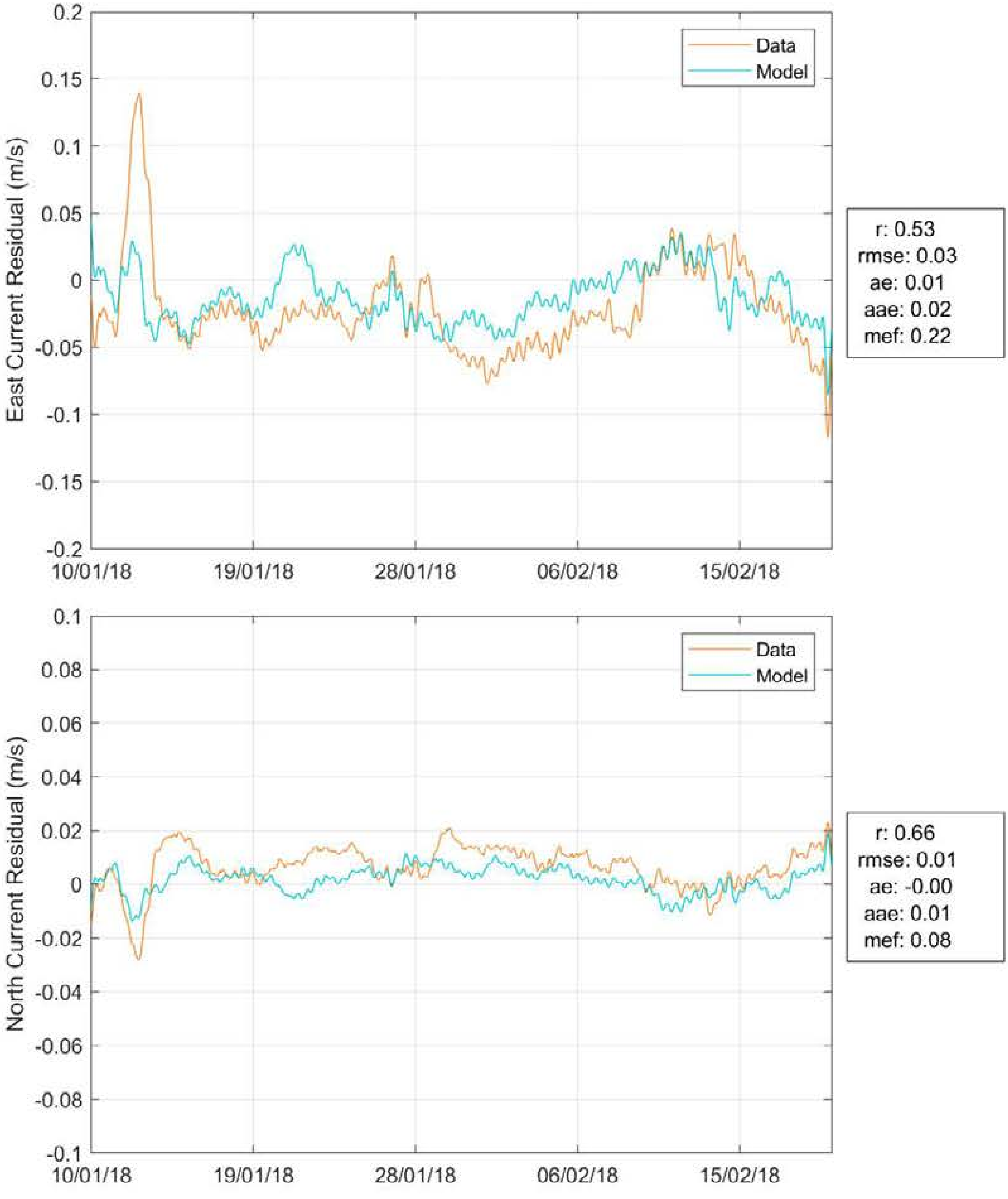


Figure 4-5 Depth-averaged current residuals (25-hour moving average) at BMT Site 3. Water level – top, Easterly current – mid, Northerly current – bottom

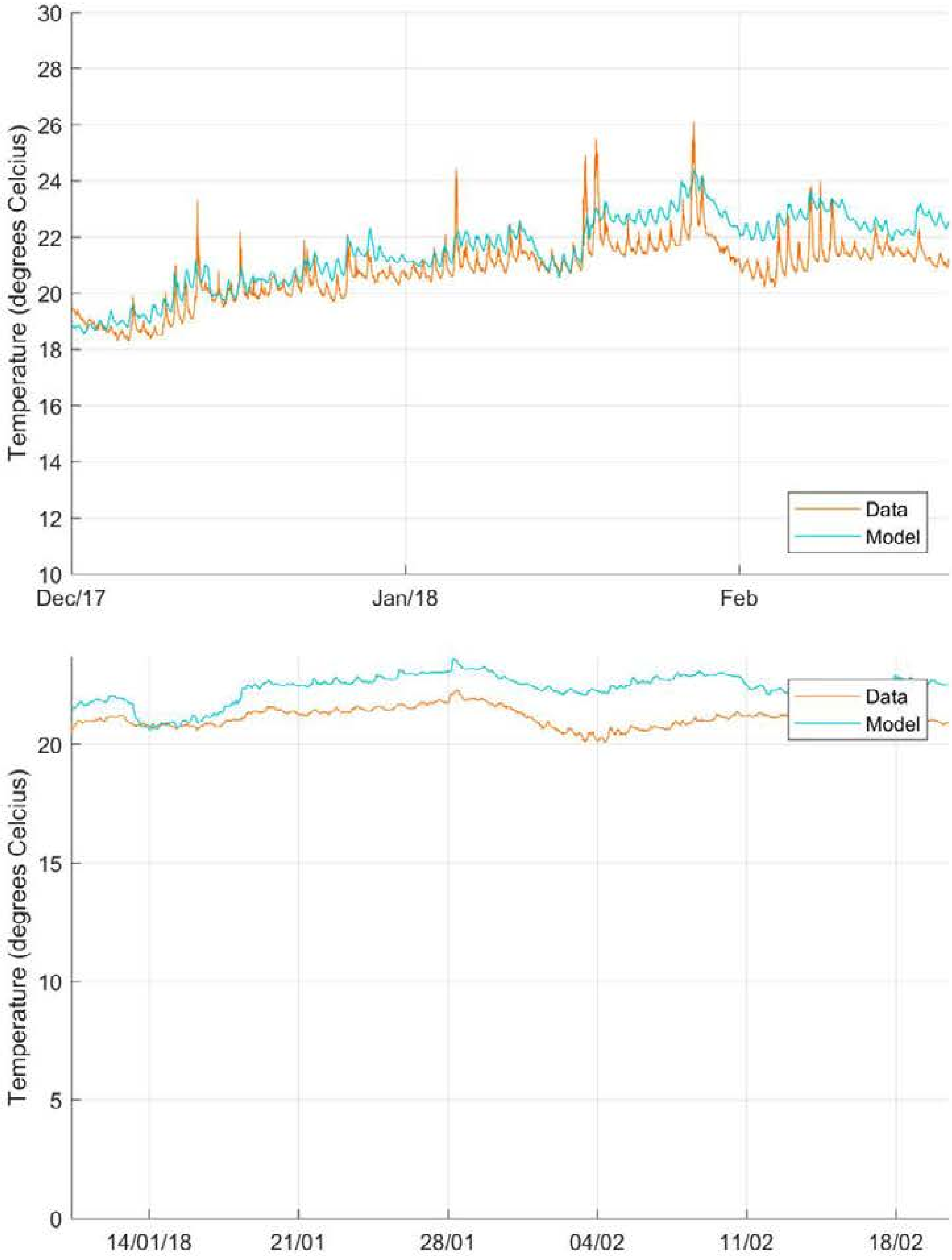


Figure 4-6 Temperature comparisons.
BMT Buoy (surface) - top. BMT Site 3 (near-bed) – bottom

4.4 Photosynthetically Active Radiation (PAR)

A comparison of modelled and measured benthic PAR at BMT Site 2 is shown in Figure 4-7. In these comparisons, measured turbidity has been used to calculate the instantaneous K_d-coefficient.

These comparisons show that the model predictions, based on the parameterisation described in Section 2.5 exhibits reasonable skill in predicting peak benthic PAR levels during clear and calm conditions and is also capable of predicting reduced benthic PAR levels during cloudy periods and/or periods of elevated turbidity due to wave-driven resuspension.

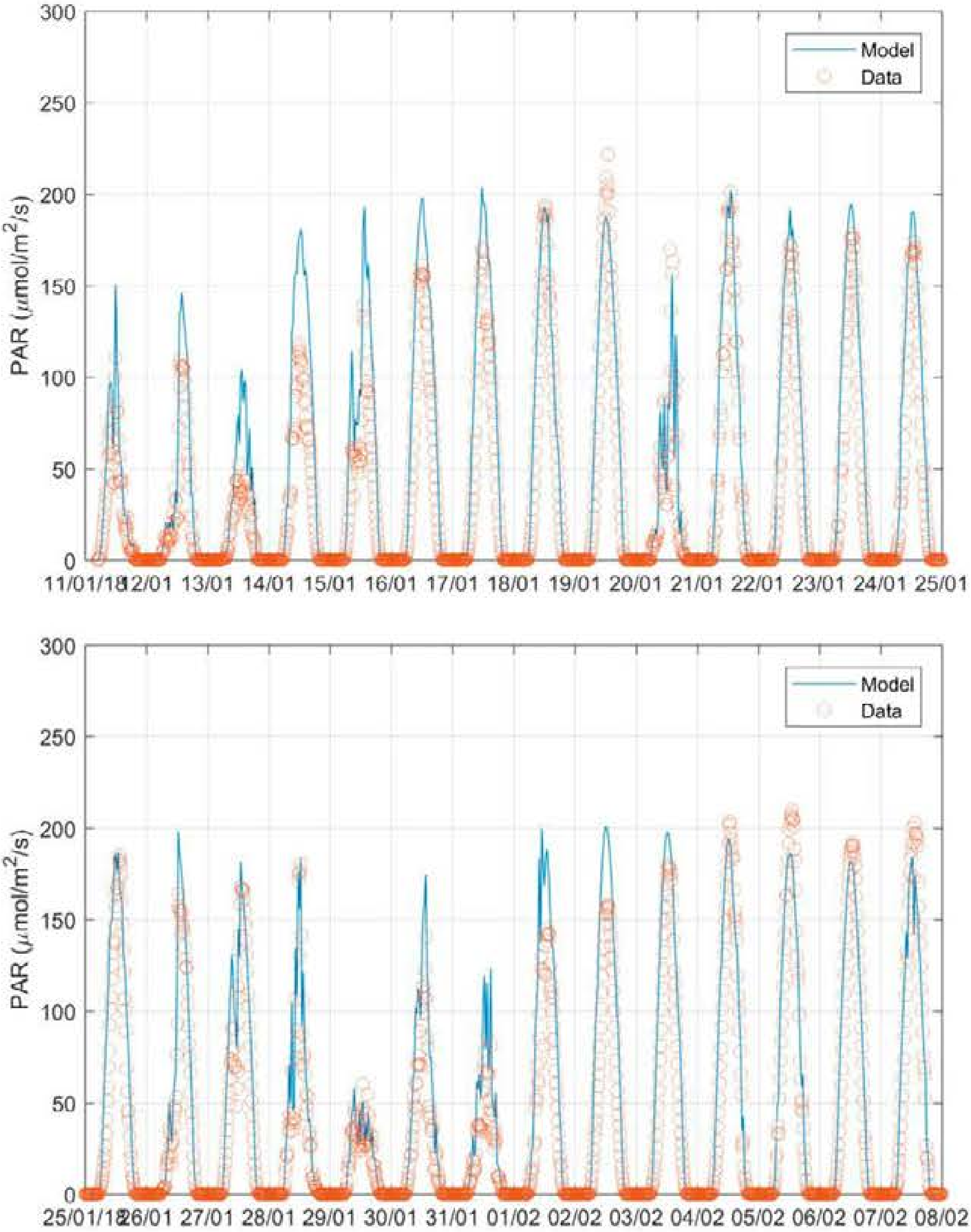


Figure 4-7 Benthic PAR comparison at BMT Site 2

4.5 Validation Summary

The calibration and validation sections of this report have presented the comparisons of model predictions with various measurements both within the Smith Bay study area and also further afield.

These comparisons demonstrate that the modelling platform developed for the Smith Bay environmental impact assessments are capable of predicting with a reasonable level of accuracy the following environmental conditions at Smith Bay:

- Wave heights, periods and directions;
- Tidal water levels and currents;
- Non-tidal (residual) water levels and currents;
- Water column temperatures; and
- Benthic PAR response to water column TSS.

While there are inevitably discrepancies between model predictions and observed conditions, the level of agreement demonstrated by the model validation is considered sufficient for the purpose of robustly assessing the Project impacts. It should be noted that the application of the model for impact assessment purposes involves simulating both base and developed case scenarios and the derivation of incremental impacts as the difference between these cases. The approach of assessing incremental impacts using the model is generally robust even where slight model predictive biases exist.

5 Sediment Plume Impact Assessments

5.1 Introduction

The following section describes the methodology and results of numerical modelling assessments of water quality impacts due to sediment plumes generated during construction or operation of the proposed export facility in Smith Bay. The sediment plume modelling methodology is described in detail followed by the presentation of the model results for the following impact assessments:

- Capital dredging;
- Causeway construction; and
- Operational propeller wash.

5.2 Capital dredging

Capital dredging works would be undertaken in order to construct the berth and approach apron to the Smith Bay wharf facility (refer Figure 3-2). A total dredging volume of 100,000 m^3 is expected in order to provide vessel under keel clearance and also to supply suitable core material for the wharf causeway. In order to ensure a conservative approach to assessing the dredging campaign two separate scenarios have been assessed:

- **Design Scenario A**: This is based on a wharf located ~450 m offshore and dredged to a depth of 14 mLAT with 0.2 m of over-dredge. This represents a total dredging volume of 100,000 m^3.
- **Design Scenario B**: This is based on a wharf located ~370 m offshore and dredged to a depth of 14 mLAT. This represents an upper-bound capital dredging volume of 200,000 m^3.

The two modelled design scenarios have been selected in order to span the range of potential design options. It is understood that final design optimisation may lead towards a slightly shallower design dredge depth (13.5 mLAT) located approximately 370 m offshore. The dredging volume associated with such a design option would be approximately 100,000 m^3.

The proposed dredging would be undertaken using a Cutter Suction Dredge (CSD) pumping material into a confined Dredge Material Placement Area (DMPA) situated on adjacent Smith Bay land. Dredged material would be dewatered within the DMPA and suitable material recycled as causeway core construction material. Treated tailwater from the DMPA would be returned to Smith Bay nearshore waters via a controlled discharge point.

5.2.1 Geotechnical Assumptions

Geotechnical information was reviewed in order to derive properties for the material to be dredged. The COOE (2017), Assessment of Marine Sediments report described the collection of shallow samples of near-surface sediments at 12 locations within the proposed dredging footprint and analysed for a suite of physical and chemical parameters. The sediment sampling locations are shown in Figure 3-2.

The 12 samples were collected across a grid using a drill rig equipped to take enviro core samples. The retrieved sample thickness ranged from 0 cm to 140 cm before hard substrate was encountered.

In general, the sediment in Smith Bay consisted mainly of coarse sand and gravel with between 10 and 25% of fine particulates (clay and silt). The deeper sample from Site SB7 was an outlier in terms of physio-chemical characteristics and was visually described as a black mud The PSD analysis for SB7.2 showed a much higher fines content of around 57%.

Figure 5-1 Sediment cores from COOE (2017) sampling.
Left – prevailing silty sand material, showing relatively coarse grain size.
Right – sandy silt material with high organics content from SB7.2

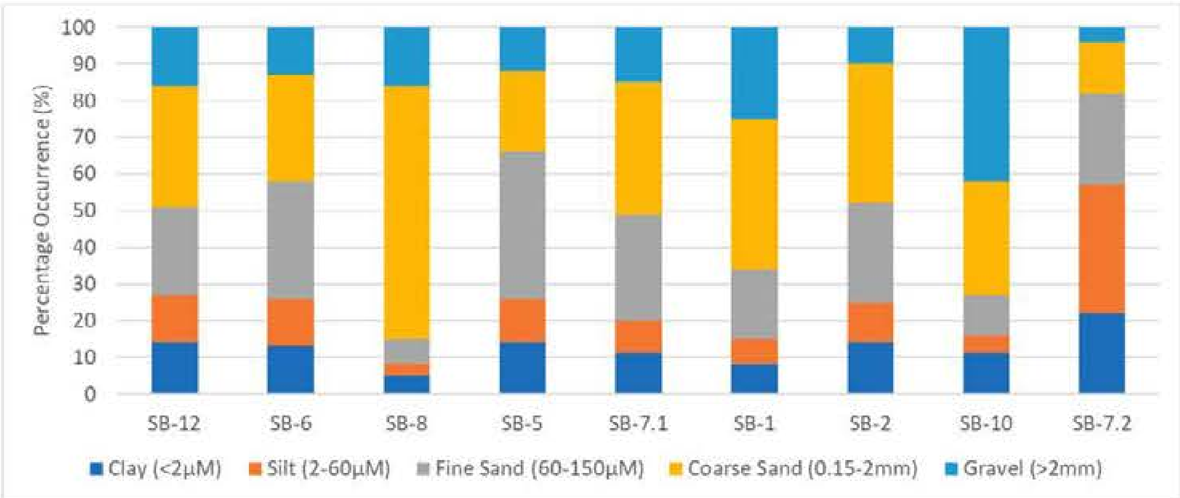


Figure 5-2 Particle Size Distribution summary from COOE (2017)

The CMW Geosciences (30/11/2017) Geotechnical Investigation Report and WGA Borehole Investigation Summary (23/01/2018) were reviewed in order to understand the characteristics of deeper sediment strata. Review of the borehole logs indicated that there was generally 1 to 3 m of marine sediments and sands overlying deeper strata, consisting of cobbles, conglomerates, mudstones and silt/clay/sands. Generally, the deeper strata were below the design dredging depth (-12.0 to -13.0 CD), which indicates that the majority of sediment to be removed will be surface marine sediments. Very little of the surface sediments were retained in the borehole samples and therefore no further characterisation of these sediments was possible beyond the COOE (2017) assessment.

The total volume of in-situ material to be dredged by the CSD has been split into two (2) material classes. The first material class represents the prevailing surface marine sediments (Silty Sand). The second material class was specified to represent a higher fines content material (Sandy Silt) representative of the sediment sampled at SB7.2 (COOE, 2017).

Table 5-1 shows the particle size distributions (PSDs) as well as the assumed dry densities for the material classes, which have been inferred from the COOE (2017) report. Both classes were distributed throughout the whole dredging footprint/s with the sandy-silt representing 25% of the total in-situ volume, while the silty sand represents the other 75% of the total volume to be dredged.

Table 5-1 Material classes (derived by BMT from COOE, 2017)

Material Class	Description	Fraction of total	Insitu Dry Density (kg/m^3)	Particle Size Distribution				
				Clay	Silt	Fine Sand	Coarse Sand	Gravel / Cobbles
Class 1	Silty Sand	75%	1,600	13%	12%	25%	30%	20%
Class 2	Sandy Silt	25%	1,300	22%	35%	25%	14%	4%

5.2.2 Dredging Methodology Assumptions

The assessment of potential impacts associated with the proposed Smith Bay capital dredging works required the development of representative dredging methodology scenarios. These scenarios were developed to span the entire duration of the dredging campaign.

It was assumed that the Smith Bay dredging would be undertaken predominantly with a small CSD with hydraulic placement into an onshore DMPA. The scenario development involved schematisation of a CSD which moved systematically throughout the dredging footprint. Table 5-2 provides assumed quantities and productivities for the CSD operating on Smith Bay sediment classes. It was assumed that the dredge operated with an efficiency of 60%, corresponding to spending 40% of the time in both planned and unplanned shutdowns. This efficiency was simulated as random stoppages with a minimum stoppage time of one-hour.

Additionally, stoppages also occurred when the significant wave height in the area exceeded the 2-week average recurrence wave condition (approximately 1.4 m). This was in addition to of the 40% downtime as it was assumed that these shutdowns would be unplanned and short in duration. This condition occurred more-frequently during the Winter periods than in the Summer periods.

Table 5-2 CSD productivity assumptions

Material Class	Design Scenario A Insitu Material Volume (m^3)	Design Scenario B Insitu Material Volume (m^3)	Production Rate (insitu m^3/hour)	Efficiency (i.e. % of time working)
Class 1	75,000	150,000	250	60%
Class 2	25,000	50,000	200	60%
TOTAL	100,000	200,000	–	–

5.2.3 Plume Generation Assumptions

Numerical simulation of dredge plumes requires specification of sediment plume boundary conditions, i.e. source terms describing temporal and spatial release of sediment suspended sediment size-fractions into the water column.

Plume release rates are typically expressed as a fraction of the in-situ production rate, which have been derived empirically based on field-monitoring of dredge plumes. The release rates used in the plume modelling relate to the far-field (passive) plumes, which have the potential to be transported by currents beyond the immediate dredging footprint. Near-field dynamic plumes are not included in the dredge plume modelling as they do not extend beyond the immediate dredge footprint.

For the CSD operating in Smith Bay sediments a plume-release rate of 5% of the in-situ production rate was adopted (Kemps & Masini, 2017). This plume-release rate represents the passive plume quantity released at the cutterhead. It was assumed that the cutterhead plume release would be evenly mixed over the entire water column by turbulence generated by the dredging equipment. The in-situ dry densities in Table 5-1 and production rates in Table 5-2 were used in calculating the instantaneous release rates.

The dredge plume source PSD has been based on the in-situ material characteristics (Table 5-1). Only the clay, silt and fine-sand fractions were included in the dredge plume modelling, as the coarse-sand and gravel material will settle immediately to the seabed. The derived plume source rates for the CSD operations are summarised in Table 5-3. Only the source terms related to fine sediment fractions (clay and silt) are included in the summary table as these will represent the majority of plume material to disperse outside the dredge footprint.

A tailwater discharge term representing controlled water release from the DMPA was also represented in the plume model. An average tailwater flow rate was derived based on a pumped water volume of approximately six times in-situ dredge volume and a continuous release over the duration of the dredging project. Following settling and dewatering within the DMPA the TSS concentration of the tailwater discharge was assumed to be 50 mg/L comprised of 100% clay-size particles. The assumed location of the tailwater discharge into nearshore waters is shown in Figure 3-2.

The contribution of individual source terms to the total quantity of fine sediment released into passive sediment plumes is summarised in the final column of Table 5-3. The DMPA tailwater source quantity represents less than 2% of the plumes generated by the CSD cutterhead.

Table 5-3 Summary of plume source rates (clay and silt fractions only)

Source Description	Cutterhead Source (kg/s)	Tailwater Discharge (m^3/s)	Tailwater TSS (mg/L)	Tailwater Source (kg/s)	Design Scenario A Total (tonnes)	Design Scenario B Total (tonnes)
CSD – Class 1	1.4	–	–	–	1,500	3,000
CSD – Class 2	2.1	–	–	–	930	1,860
DMPA tailwater	–	0.25	50	0.013	32	64
Total	–	–	–	–	2,500	5,000

5.2.4 Simulation Period Ensemble

Based on the assumed dredge volume and dredging equipment and methodology the shorter campaign is expected to take at least 30 days to complete, with the longer campaign taking 60 days. In order to assess the influence of differing weather conditions on the dredge plume behaviour an ensemble of simulation periods was assessed. The ensemble of 4 different periods were selected to span a typical range of seasonal and wind-strength conditions. Wind conditions were considered as they are the primary driver of non-tidal hydrodynamic variability and also wave conditions at the site. The periods were selected based on inspection of CFSR wind roses for Smith Bay, as shown in Figure 5-3 and described below:

- Relatively calm summer (December 2014 – February 2015);
- Relatively energetic summer (December 2015 – February 2016);
- Relatively calm winter (June – August 2015); and
- Relatively energetic winter (June – August 2016).

As can be seen in Figure 5-3, seasonality is the strongest influence on wind conditions. The summer periods (December-February) experience relatively calm conditions, with wind predominantly from the south and therefore offshore at Smith Bay. The winter periods (June-August) experience more variability in wind direction, including relatively strong onshore winds from the north during the passage of storm fronts.

5.2.5 Results

The numerical dredge plume model has been configured to predict the dredging related Total Suspended Solids (TSS) concentrations above the ambient conditions. That is, ambient TSS is not simulated by the model. This is a reasonable and commonly adopted assumption for dredge plume modelling assessments. Above ambient plume TSS concentrations have been presented in mg/L. Unless otherwise stated depth-averaged TSS values have been derived and presented from the 3D model output since they are most relevant to assessing ecological impacts due to the reduction in seabed Photosynthetically Active Radiation (PAR).

Dredging related (above ambient) sediment deposition has also been assessed as has the reduction in benthic PAR due to dredging-related TSS in the water column.

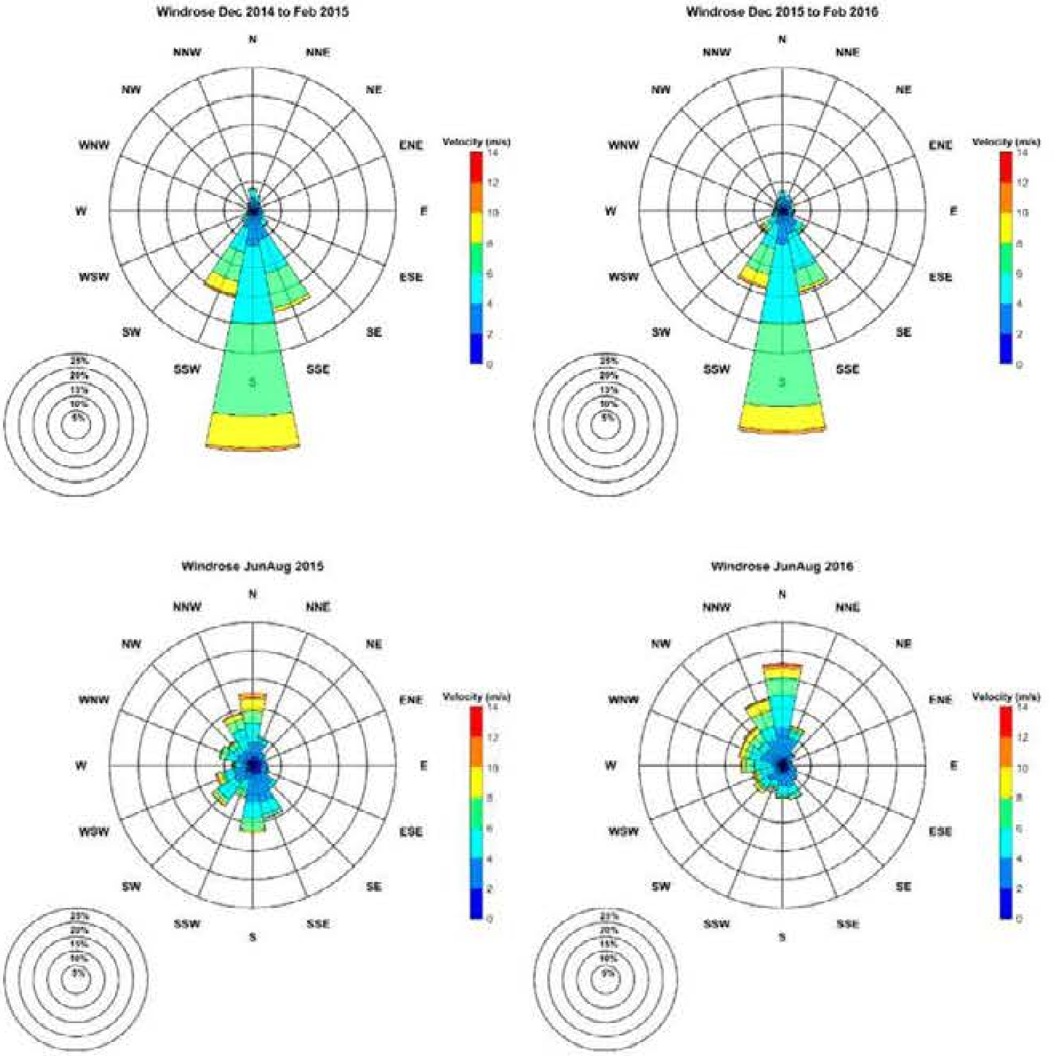


Figure 5-3 Windroses during dredge plume modelling periods

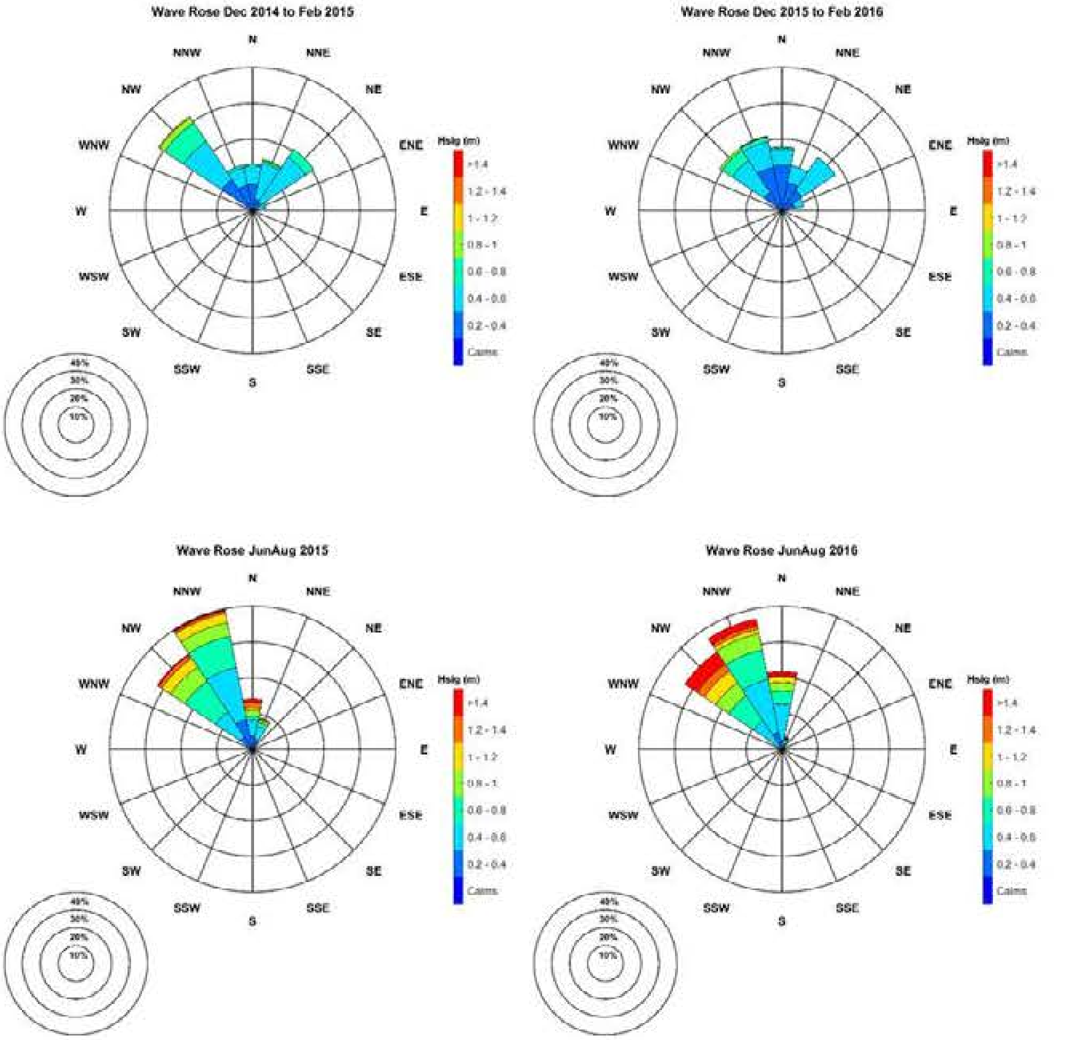


Figure 5-4 (modelled) Wave Roses during dredge plume modelling periods (at MSI Buoy Location)

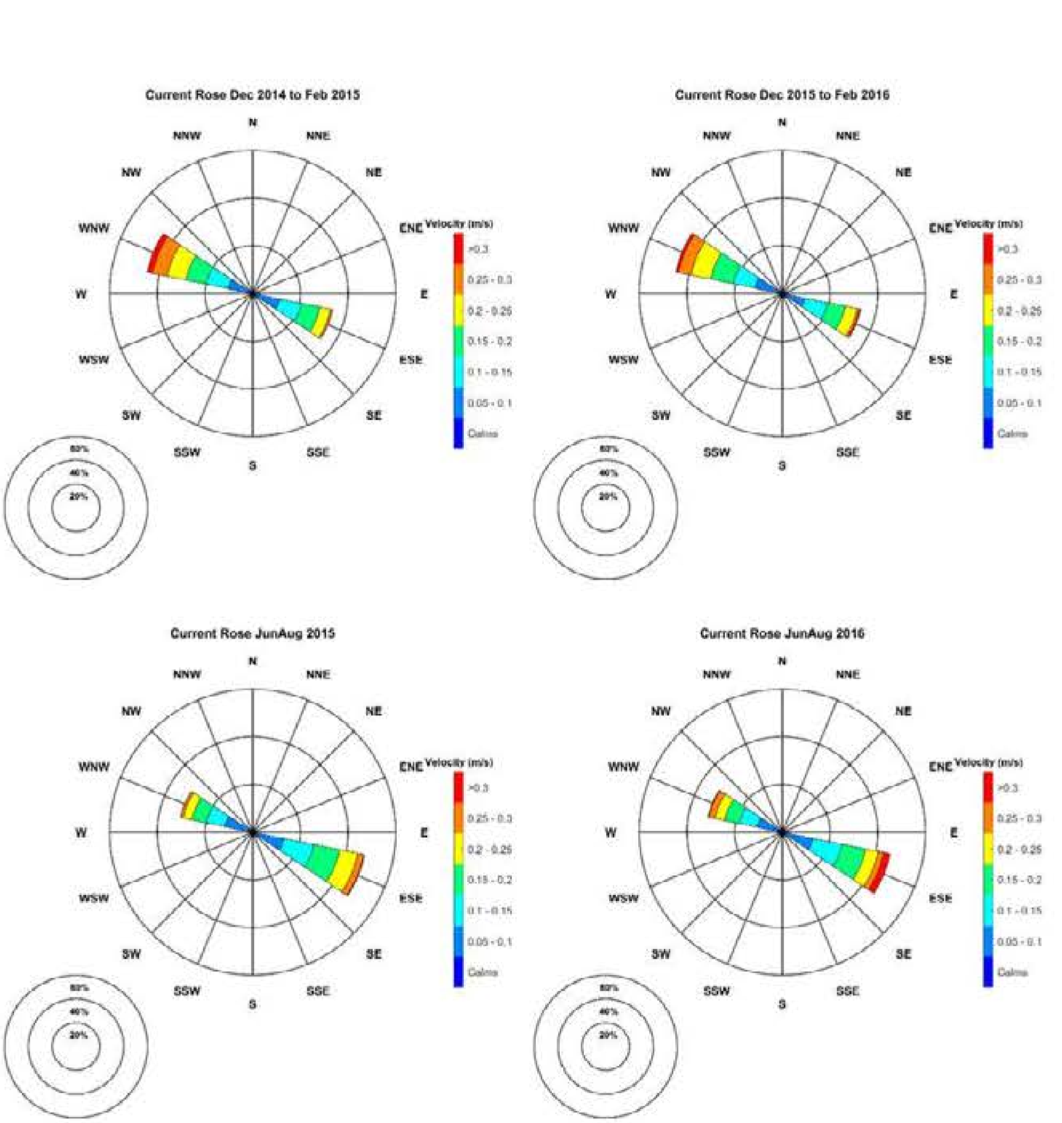


Figure 5-5 (Modelled) Current Rose during dredge plume modelling periods (at MSI Buoy Location)

5.2.6 Plume TSS

5.2.6.1 Plume TSS snapshots

A number of snapshots of depth-averaged dredge plume TSS are shown below in order to provide examples of predicted plume extents at particular instants in time. These plots differ from the spatial plume percentile maps which present statistical measures of plume exposure over the entire simulated dredging campaign. Snapshot times have been selected in order to illustrate different plume tracks and extents as a result of differing hydrodynamic conditions (e.g. timing of tides).

Two representative plume snapshot figures are presented and described below:

(1) Figure 5-6 is a snapshot of depth-averaged dredge plume TSS during an ebbing (westerly) tidal current.

(2) Figure 5-7 is a snapshot of depth-averaged dredge plume TSS during a flooding (easterly) tidal current. Under such conditions there can be a high degree of connectivity between the dredging location and the Yumbah seawater intake locations.

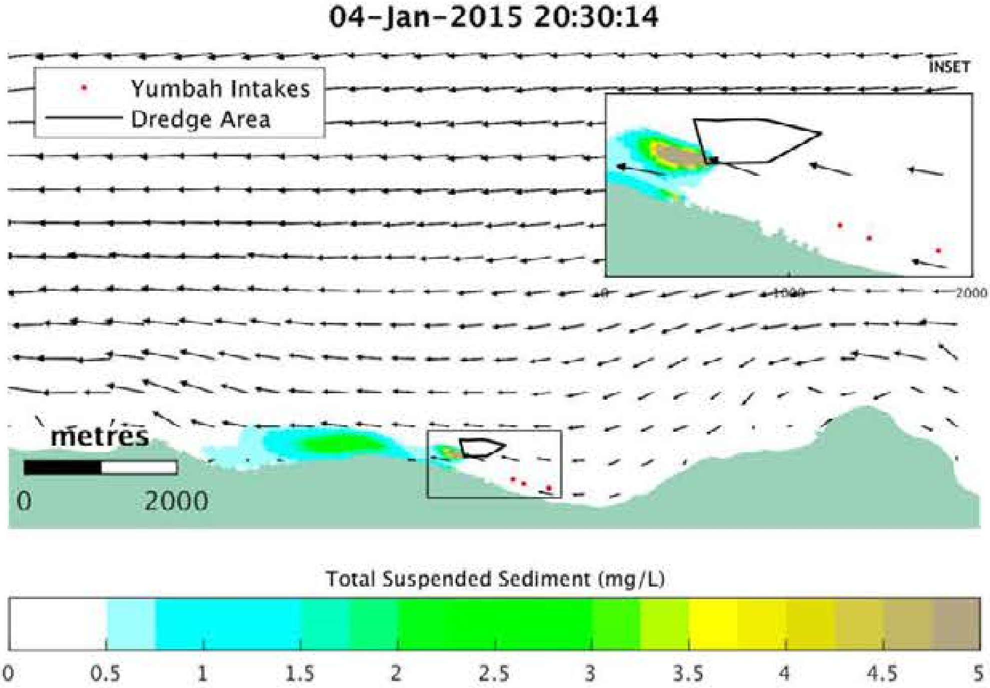


Figure 5-6 Typical dredge plume TSS snapshot during an ebbing (westerly) tidal current. TSS has been depth-averaged through the water column

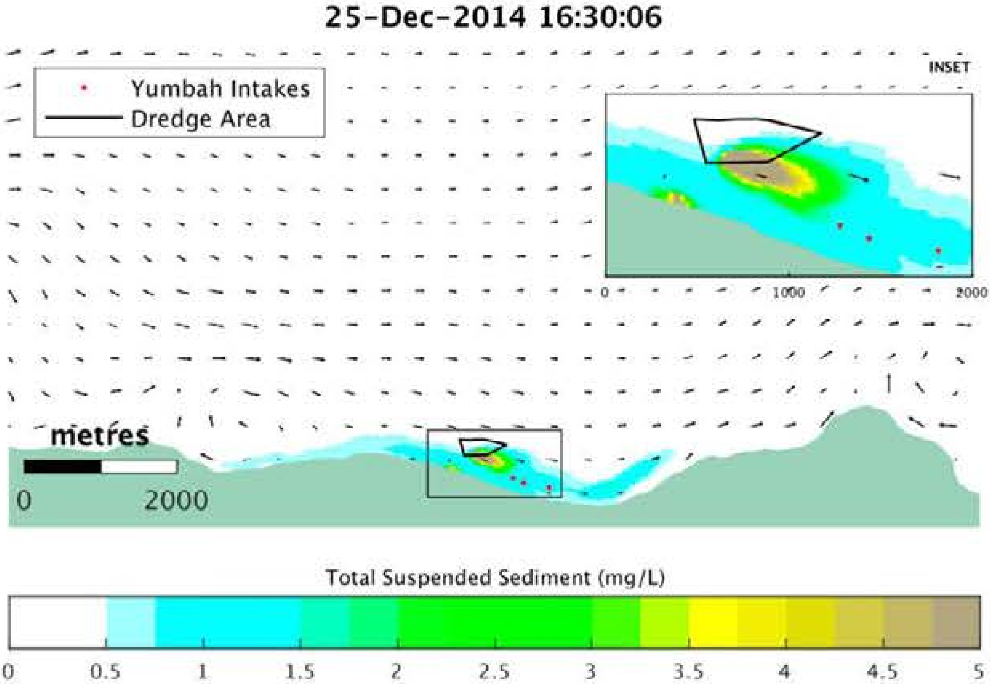


Figure 5-7 Typical dredge plume TSS snapshot during a flooding (easterly) tidal current. TSS has been depth-averaged through the water column

5.2.6.2 Percentile Analysis

The dredge plume simulations have represented the entire Smith Bay dredging campaign, which is expected to take at least 30 days to complete but may take longer depending on operational methodologies and weather conditions. In order to represent the spatially varying exposure to dredge plume effects a statistical percentile analysis was applied to the model predictions of both dredging related TSS and sediment deposition. The percentile maps were used as a primary input to the marine water quality risk assessment (BMT, 2018b).

The percentile analysis involved applying a moving 30-day analysis window over the entire simulation period. Impacts at each percentile level were calculated for every 30-day window during the simulation, and the maximum window at each location in the model domain is presented. Different locations within the model will have experienced their worst period at different times during the simulation and the different percentile statistics may also have occurred during different 30-day windows. It is important to note that the derived turbidity percentile plots do not represent the plume extent at any one particular instance in time.

The 30-day window period is somewhat arbitrary but in a physical hydrodynamic context represents the approximate duration of two (2) consecutive spring-neap tidal cycles, while in an ecological context it is a meaningful timescale for assessing impacts to some key sensitive receptors in the area (e.g. dominant seagrass species *Posidonia*). The moving window analysis was undertaken by moving the 30-day window by 10-day increments over the entire simulation period.

The percentile impact plots correspond to the predicted increase in TSS/sedimentation over ambient conditions that are attributable to the dredging. Percentile values considered in this report are 99th, 80th, 50th and 20th which correspond to exceedance durations of 7hrs (1%), 6 days (20%), 15 days (50%) and 24 days (80%) respectively for the 30-day window. The highest percentiles correspond to relatively acute and short-lived increases in TSS/sedimentation while the lower percentiles correspond to chronic longer-term increases. For conciseness only the 99th percentile (representing acute increases) and 50th percentile (representing chronic increases) are presented in this section of the report. The other percentiles mentioned above have been analysed and used in derivation of the spatial impact zones (BMT, 2018).

In summary, some key features of the moving window percentile analysis include:

- Consideration of a range of impact durations from acute to chronic;
- Can be applied to a long-term programme and capture periods of high intensity versus low intensity impacts; and
- Can be used to robustly compare scenarios with different program durations.

Percentile plot contour limits have been selected with reference to expected impact threshold levels. It is important to note that these are significantly higher for the acute exceedance durations represented by the 99th percentile plots than for the chronic exceedance represented by the 50th percentile plots. The percentile contour limits for depth-averaged TSS are presented in Table 5-4.

Table 5-4 TSS percentile plot contour limits

Percentile	Lower Limit (mg/L)	Upper Limit (mg/L)
99th	1	10
50th	0.2	2

5.2.6.3 Impact Assessment Framework

The Western Australian EPA has developed a technical guidance note outlining a framework for impact prediction and assessment related to dredging projects. The EPA guidelines (WA EPA, 2016) acknowledge that significant uncertainty can exist around the prediction of dredge plume impacts and therefore a **likely range** of Project effects should be derived rather than a singular assessment. A spatially-based zonation of impacts is recommended as a clear and consistent way of describing the extent, severity and duration of predicted impacts. Such a scheme would typically represent at least three different levels of impact:

- Zone of High Impact;
- Zone of Low to Moderate Impact; and
- Zone of Influence (where plumes are detectable but impacts to biota are expected to be negligible).

In order to take account of the uncertainty in the EIA process, the set of predictions may describe the upper and lower limits of the likely range of impacts associated with the proposal. The variability in impact predictions may include consideration of:

(1) Different physical environmental conditions (e.g. tides, winds etc.);

(2) Different dredging scenarios (e.g. footprint and volume);

(3) Uncertainty in model predictive skill, including model inputs; and

(4) Uncertainty in biota response to a given level of dredging-related perturbation.

The dredge plume modelling assessment undertaken for the Smith Bay EIS has assessed impact prediction variability by considering an ensemble of scenario simulations that address (1) and (2) above. From the ensemble of scenario simulations the **Expected** (i.e. average) and **Worst** (i.e. upper-bound) levels of dredge plume effect have been summarised from the full set of ensemble results:

- **Expected**: For a given percentile, the mean level across all simulations was assessed as the 'expected case. Given the distinct seasonality of the model predictions summer and winter averages were assessed separately and the maximum level across both seasons was derived as the 'expected' case.
- **Worst:** For a given percentile, the maximum concentration of all ensemble simulations was taken as the 'worst' level at a given location.

With respect to (3), the dredge plume assessment has endeavoured to apply a thoroughly validated hydrodynamic and sediment transport modelling system using model inputs that are considered to be conservative with respect to the rate of plume generation.

The scope of the modelling assessment does not extend to prediction of impacts to biota but instead provides the necessary physical inputs to the assessment of impacts to Marine Water Quality (BMT 2018b).

5.2.6.4 Percentile Maps

Above-ambient TSS percentile maps for the expected and worst case of base dredging scenario simulations are presented in Figure 5-8 and Figure 5-9. The spatial scale of these figures extends beyond the dredge plume zone of influence (the region within which dredging-related plumes may be detectable).

The acute exceedance level 99th percentiles are shown in Figure 5-8. Similar maps for individual events from the Scenario B ensemble are shown in Figure 5-12.

Understanding the major drivers of variation that can be seen between the Expected and Worst case predictions provides a basis for proposing mitigation and management measures that could be applied to the Project in order to improve environmental outcomes. The following conclusions can be drawn from the 99th percentile depth-averaged TSS percentile maps:

- Acute worst-case TSS levels exceeding 10 mg/L above ambient are restricted to within 400 m of the dredging footprint and immediately adjacent to the tailwater discharge.
- Acute worst-case TSS levels exceeding 5 mg/L above ambient are restricted to within 2100 m of the dredging footprint.
- The winter periods have a larger zone of influence than the summer periods, which is attributable to the higher energy wave and current conditions during the winter season.
- The winter periods have more influence on locations to the east of the dredging footprint, as a result of the more prevalent wind-driven easterly residual currents (refer Section 3.5.2).
- Acute TSS levels during are expected to be in part driven by wave event resuspension of previously deposited dredge plume material.

The chronic exceedance level 50th percentiles are shown in Figure 5-9. In terms of sensitive receptors such as seagrass, chronic (i.e. sustained) plume concentrations are typically of more importance to determining ecological impacts than acute (i.e. short term) levels. The following conclusions can be drawn from the 50th percentile depth-averaged TSS percentile maps:

- Chronic worst-case TSS levels exceeding 2 mg/L above ambient are restricted to within 220 m of the dredging footprint.
- Chronic worst-case TSS levels exceeding 1 mg/L above ambient are restricted to within 2400 m of the dredging footprint.
- The winter periods have significantly more influence to the east of the dredging footprint than the summer periods, as a results of the more prevalent wind-driven easterly residual currents.

5.2.6.5 Yumbah seawater intake sensitive receptors

The Yumbah seawater intakes represent a set of sensitive receptors located approximately between 500 and 1200 m to the east of the dredging footprint. More detailed presentation of predicted above-ambient dredge plume TSS was focussed on the Yumbah seawater intake locations. As the Yumbah seawater intakes are located 1–2 m above the seabed the dredge plume TSS concentrations were conservatively derived for the bottom 1 m of the water column.

The ambient near-bed TSS was modelled using the methodology described in Section 2.6 and the sum of ambient plus plume-generated TSS was derived in order to inform the risk assessments related to the Yumbah intakes. Timeseries of dredge plume plus ambient TSS are shown for the ensemble of dredging scenario simulations in Appendix A, with examples demonstrated in the sensitivity comparison in Figure 5-17. Two reference TSS levels are shown on the timeseries plots; 10 mg/L which relates to the ANZECC guidelines and 25 mg/L which relates to Project-derived thresholds for greenlip Abalone.

The maximum modelled above ambient TSS was derived from the ensemble of base dredging scenario simulations. Maps of the maximum near-bed above-ambient TSS are shown in Figure 5-10 with an inset zoomed to the intake locations.

5.2.6.6 Sediment Resuspension Sensitivity Assessment

A sensitivity test was undertaken for the critical shear stress for erosion parameter (τ_{ce}) as there is some uncertainty about this parameter value given the dense seagrass coverage in the study area. A lower-bound τ_{ce} value of 0.2 N/m^2 was assessed during the sensitivity test, which corresponds to a typical critical shear stress for unconsolidated fine sediment from an un-vegetated seabed. Timeseries of this sensitivity test at the westmost Yumbah intake are shown in Figure 5-17 and Figure 5-18. The results show that there is an overall increase in above-ambient TSS plume concentrations at the intake for both seasons. During Summer, acute concentrations are typically 30% higher with the lower critical shear stress, whereas winter (with far more wave activity) shows 50% higher plume concentrations. Chronic plume concentrations are less sensitive to this parameter, with the summer median concentration 10% higher and the winter concentrations 30% higher.

5.2.7 Sediment Deposition

Increased sediment deposition due to dredging has the potential to impact on benthic ecosystems. Dredging related (above ambient) sediment deposition results are presented as dry sediment mass per unit area i.e. mg/cm^2. As an approximate rule of thumb 500 mg/cm^2 can be converted to an equivalent deposition depth of 1 cm. This conversion assumes a freshly deposited dry sediment density of 500 kg/m^3.

The final distribution of net sediment deposition for the ensemble of base dredging scenario simulations are shown in Figure 5-14. Wave events where wave height exceeds 1 m for at least 2 hours within the dredging footprint are also shown. The following conclusions can be drawn from the final deposition figures:

- The peak final sediment deposition observed was within the dredging footprint and was 126.5 mm (6325 mg/cm^2).

- Final sediment deposition exceeding 50 mm (2500 mg/cm^2) is restricted to within 140 m of the dredging footprint.
- Final sediment deposition exceeding 10 mm (500 mg/cm^2) is restricted to within 240 m of the dredging footprint.
- Final sediment deposition exceeding 1 mm (50 mg/cm^2) is restricted to within 4700 m of the dredging footprint.
- There is less sediment remaining deposited within Smith Bay during following the winter simulation scenarios due to the higher energy wave and current conditions during the winter season.

Additionally, several locations at varying distances from the dredge footprint were selected for presentation of dredge plume sediment deposition timeseries (refer to Figure 5-14 for locations). The timeseries are shown in Figure 5-15 and show that even within 200 m of the dredge footprint the maximum rate of sediment deposition does not exceed 8 mg/cm^2/day.

5.2.8 Benthic PAR

The dredge plume impacts on benthic PAR levels were simulated for the summer period ensemble of base dredging scenario simulations. The winter period simulations were not assessed for PAR impacts as summer is the critical period for seagrass photosynthesis.

In this assessment benthic PAR has been expressed in units of % of surface irradiance (% SI). The benthic PAR impacts are presented in Figure 5-16 as the maximum change to a 30-day average benthic PAR.

The predicted PAR impacts are also presented spatially in Figure 5-16 as the seabed zone that is predicted to drop through a benthic PAR threshold of 10 % SI averaged over a 30-day period as a result of the Project. This presentation shows that there is only a small region of seagrass within Smith Bay that is likely to experience temporarily reduced habitat suitability in terms of PAR exposure. The duration of reduced benthic PAR would be limited to the duration of the dredging construction program.

5.2.9 Summary

Section 5.2 of this report has assessed the potential sediment plumes generated by a base case dredging scenario construction of the Smith Bay seaport. The base case scenario assumes that the dredging is undertaken using a small CSD operating in a "business as usual" setting, without adopting specific mitigation measures.

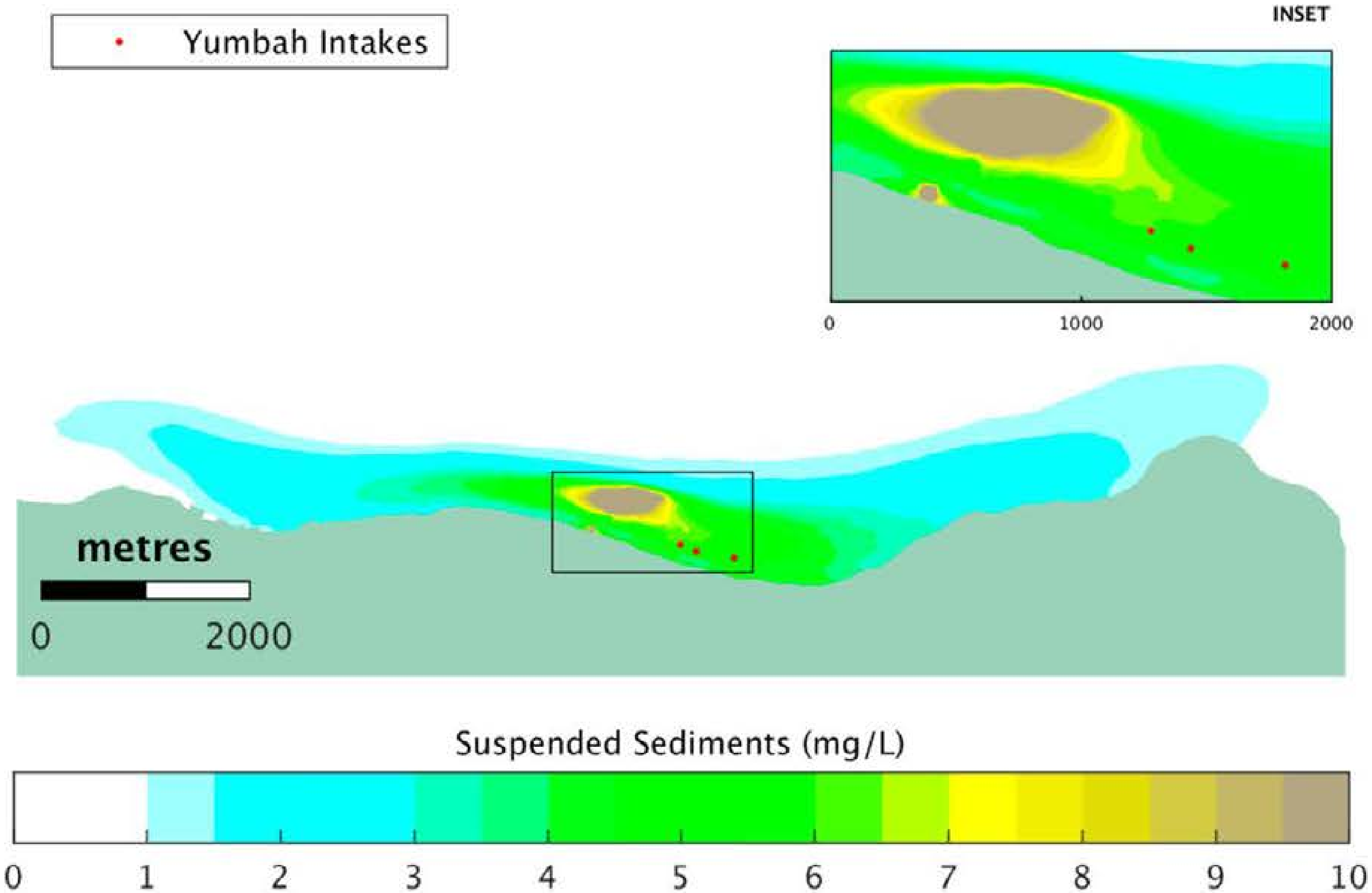
This assessment has derived and presented metrics related to the following impact lines of effect due to the dredging:

- Broad-scale above-ambient TSS concentrations, both for acute (short-term) and chronic (sustained) exceedance durations;
- Nearbed TSS concentrations at the Yumbah seawater intakes;
- Above ambient sediment deposition; and

- Benthic PAR reductions.

Water quality and marine ecology risk assessments are reported elsewhere (BMT 2018b). The environmental risk assessments make use of these modelling assessments as well as other sources of information relating to baseline conditions and tolerance thresholds. With the exception of the Yumbah seawater intakes the risk of impacts to the Smith Bay marine environment as a result of the proposed dredging are assessed as low risk.

Mitigation measures related to specifically reducing the exposure of the Yumbah seawater intakes to dredging related TSS have been considered in Section 5.3.


Yumbah Intakes
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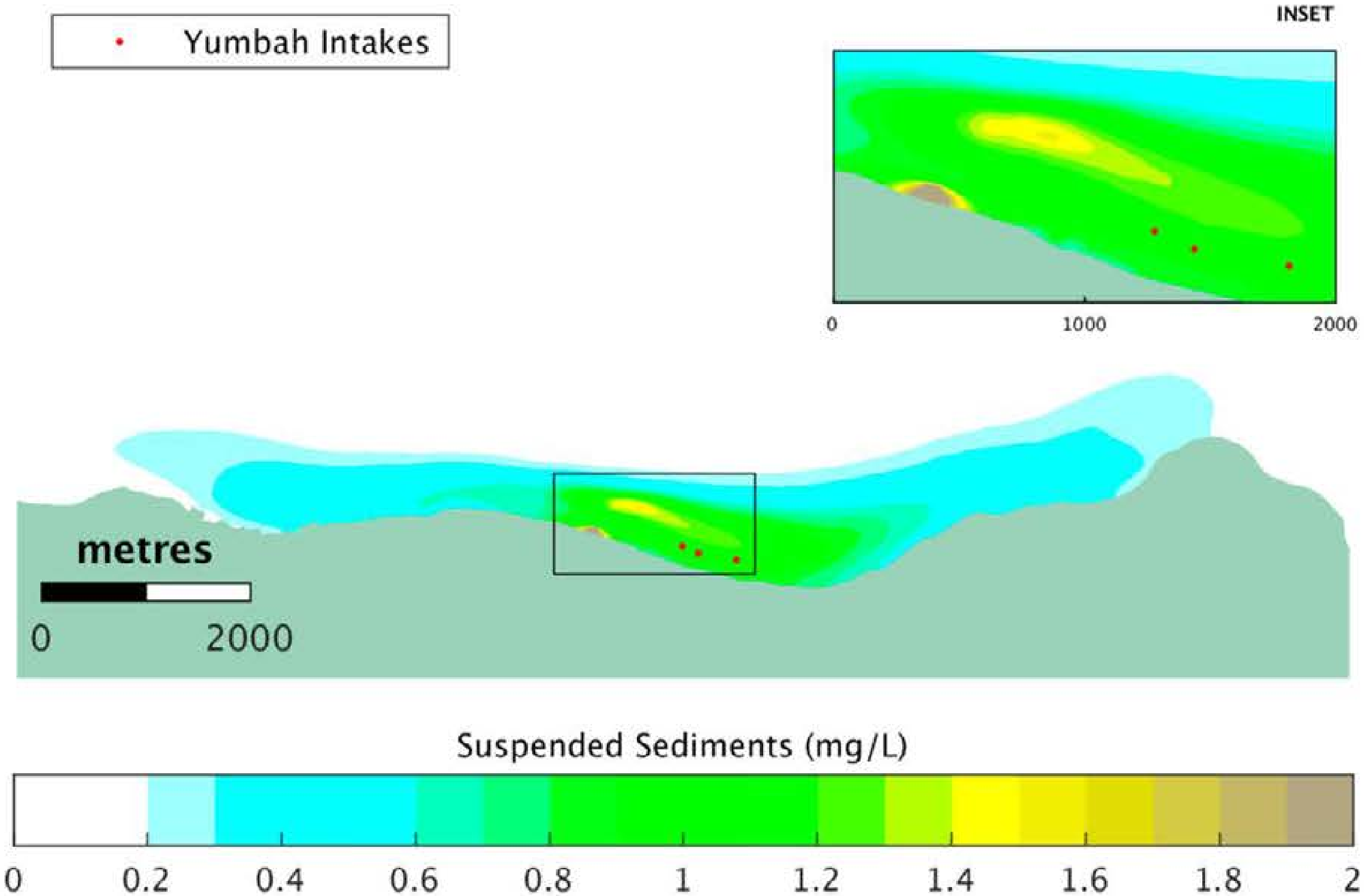
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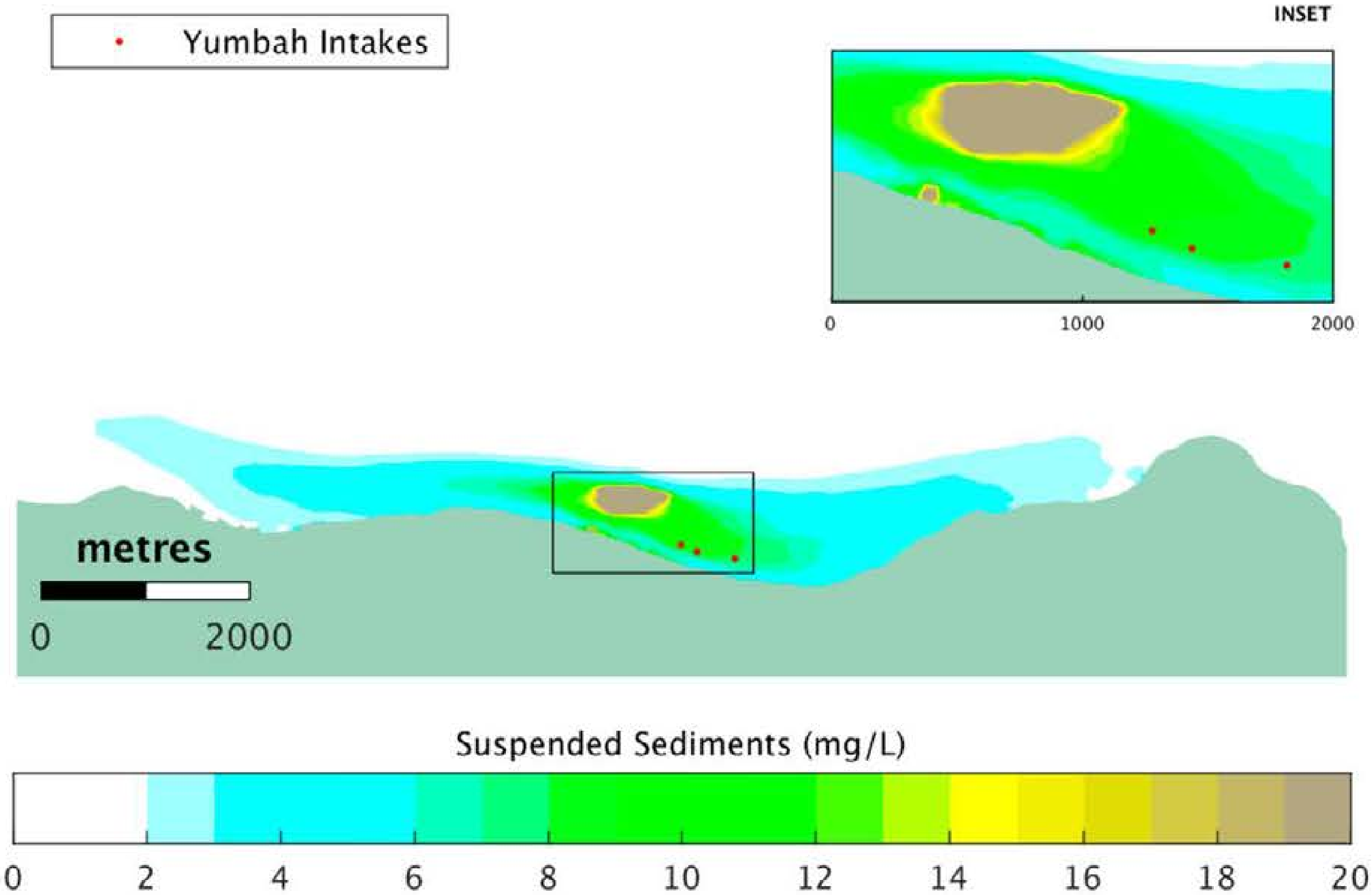
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18
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INSET

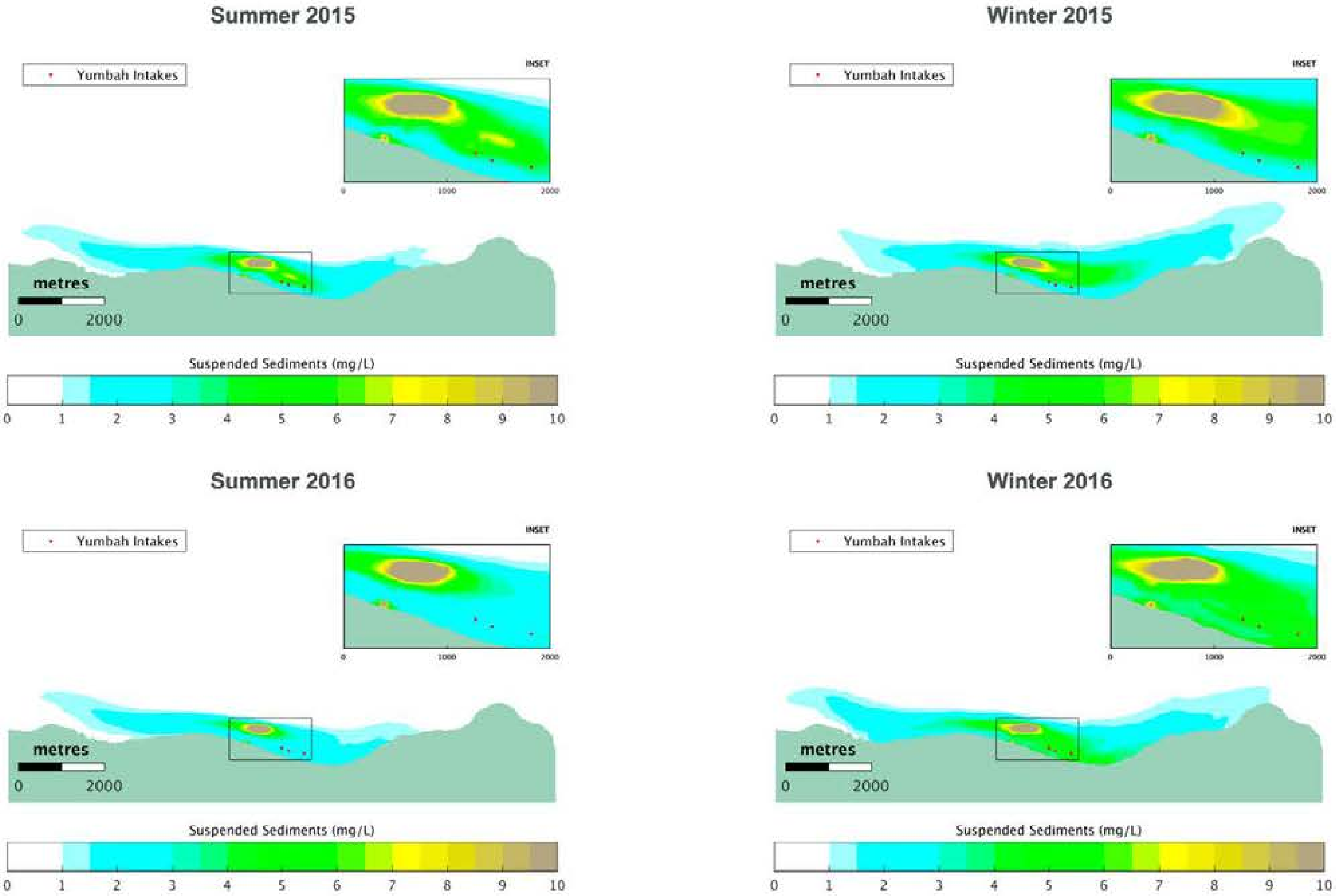


Figure 5-11 Acute (99th Percentile) above ambient depth-averaged dredge plume TSS, design scenario A, individual seasons

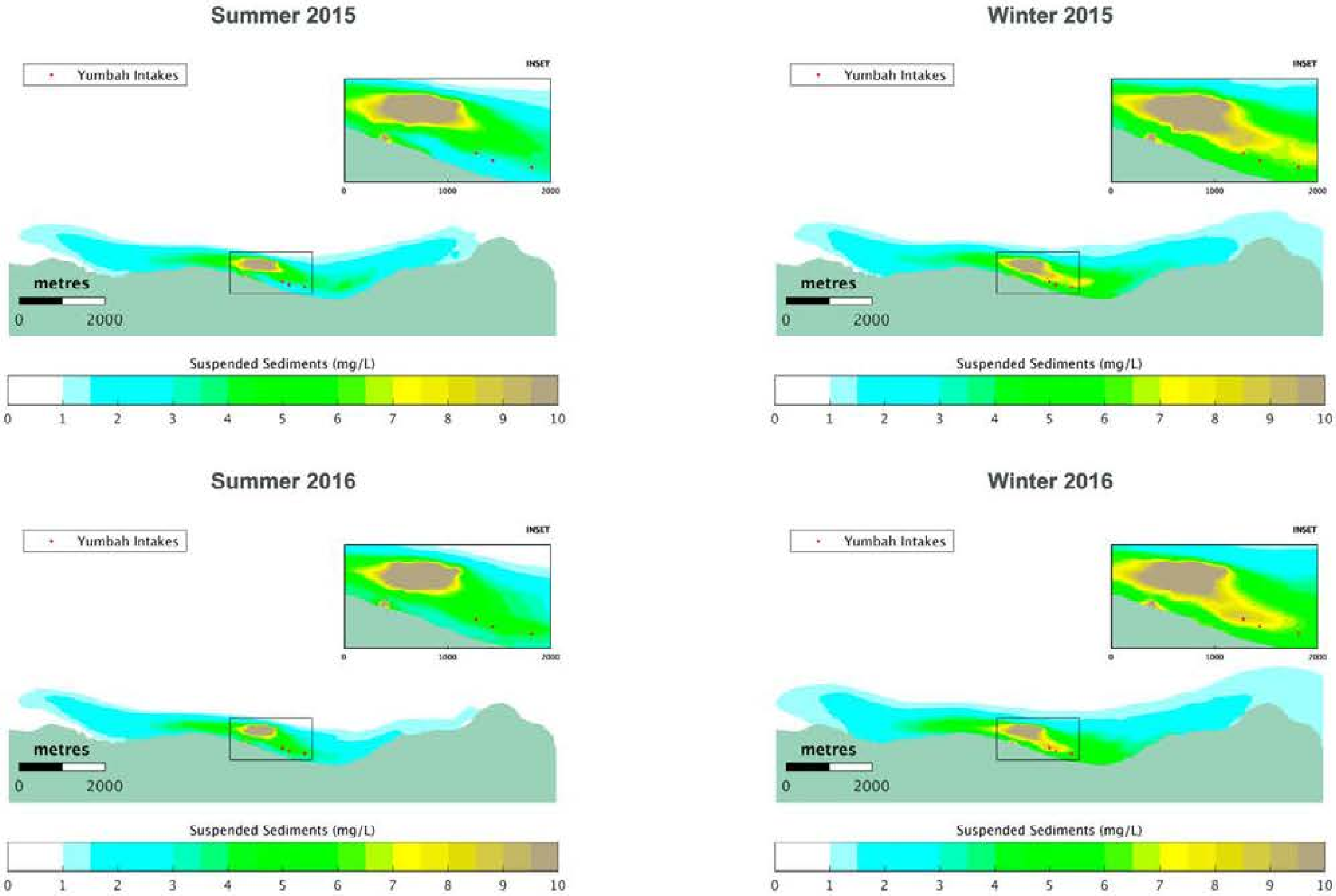


Figure 5-12 Acute (99th Percentile) above ambient depth-averaged dredge plume TSS, design scenario B, individual seasons

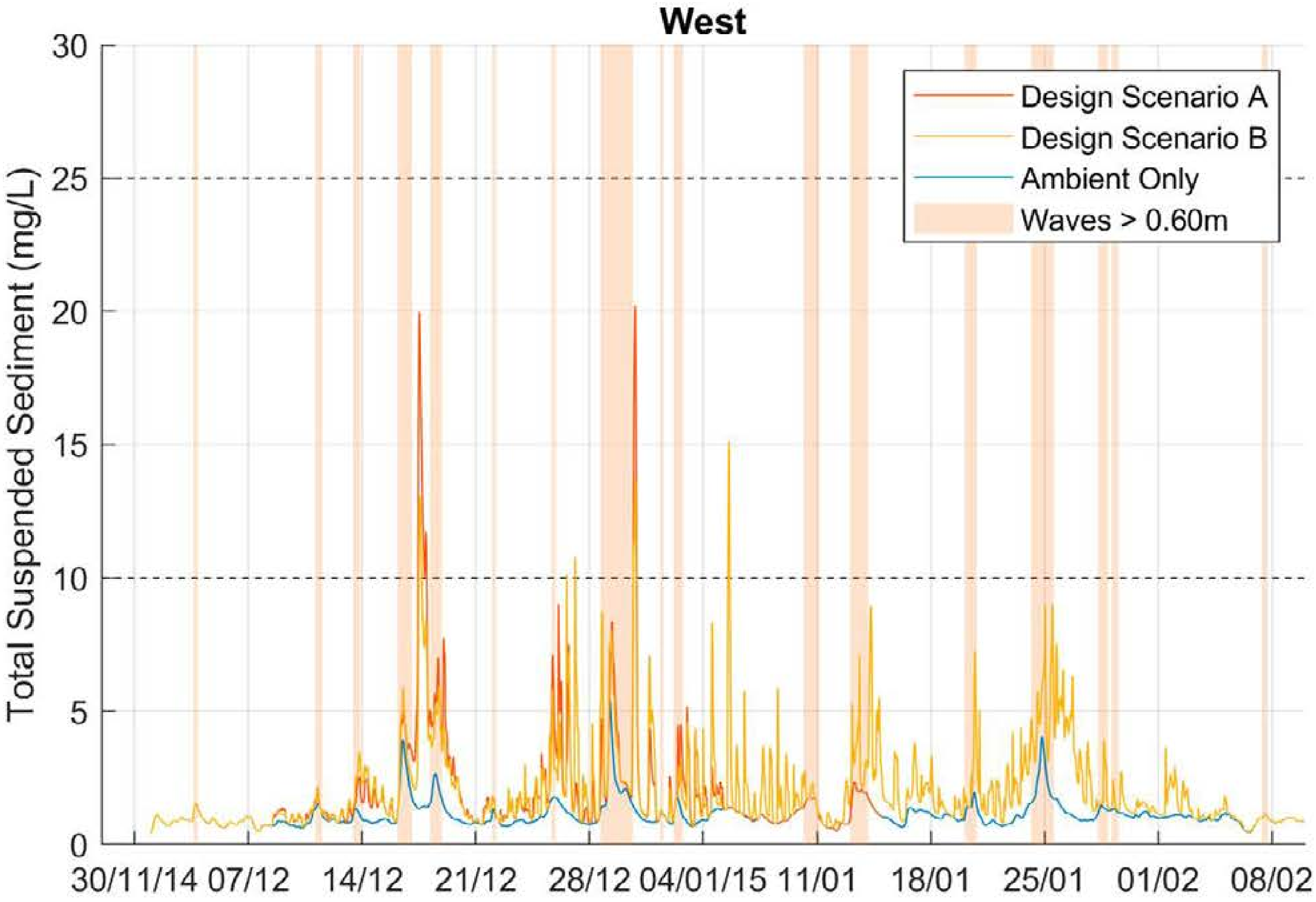


Figure 5-13 Bottom 1 m TSS timeseries (ambient plus dredge plume) at intake West location for Summer 2015 conditions. Refer to Appendix A for all TSS timeseries plots

Table 5-5 Design scenario A TSS (ambient plus dredge plume) summary statistics

Location	Period	50th Percentile TSS (mg/L)			90th Percentile TSS (mg/L)			99th Percentile TSS (mg/L)			Maximum TSS (mg/L)		
		Bottom	Top	Depth-Average	Bottom	Top	Depth-Average	Bottom	Top	Depth-Average	Bottom	Top	Depth-Average
Inactive Intake	Summer 2015	1.60	0.85	1.13	4.61	2.13	3.21	14.34	3.43	7.03	18.92	4.15	8.93
	Summer 2016	1.32	0.71	0.95	2.67	1.34	1.81	5.08	2.44	3.46	10.23	4.97	7.34
	Winter 2015	2.72	1.45	1.95	5.42	2.29	3.65	9.63	3.11	5.23	11.70	5.17	6.03
	Winter 2016	2.98	1.58	2.14	6.10	3.01	4.20	15.78	7.91	10.70	19.10	9.47	12.75
Intake West	Summer 2015	1.55	0.83	1.09	4.71	2.17	3.22	16.19	3.44	6.46	20.22	4.08	7.82
	Summer 2016	1.30	0.70	0.91	2.70	1.31	1.77	6.05	2.47	3.62	10.00	5.08	7.27
	Winter 2015	2.77	1.47	1.94	5.40	2.31	3.44	11.47	3.03	4.90	14.26	4.82	5.79
	Winter 2016	3.05	1.57	2.09	6.66	3.04	4.23	16.23	7.91	10.59	19.36	9.43	12.50
Intake Mid	Summer 2015	1.42	0.79	1.01	4.26	2.31	3.08	7.88	3.47	4.77	9.42	3.88	5.22
	Summer 2016	1.21	0.68	0.86	2.49	1.29	1.66	5.25	2.61	3.66	8.87	5.33	6.77
	Winter 2015	2.61	1.53	1.93	4.57	2.41	3.16	6.82	2.99	4.08	7.71	4.56	5.42
	Winter 2016	2.83	1.60	2.01	6.20	3.09	4.16	15.20	7.88	10.46	18.17	9.38	12.32
Intake East	Summer 2015	1.35	0.73	0.97	3.86	2.16	2.83	7.51	3.46	5.06	8.98	3.91	5.51
	Summer 2016	1.19	0.63	0.85	2.52	1.26	1.68	5.46	2.70	3.83	8.19	5.35	6.51
	Winter 2015	2.69	1.54	2.05	4.54	2.45	3.33	6.09	3.01	4.05	8.14	4.71	5.62
	Winter 2016	2.86	1.64	2.10	6.03	3.13	4.17	15.01	7.98	10.42	18.22	9.50	12.45

Note: Maximum summer and winter percentile values highlighted.

Table 5-6 Design scenario B Plume TSS (ambient plus dredge plume) summary statistics

Location	Period	50th Percentile TSS (mg/L)			90th Percentile TSS (mg/L)			99th Percentile TSS (mg/L)			Maximum TSS (mg/L)		
		Bottom	Top	Depth-Average	Bottom	Top	Depth-Average	Bottom	Top	Depth-Average	Bottom	Top	Depth-Average
Inactive Intake	Summer 2015	1.66	0.89	1.21	4.27	1.95	2.96	8.70	3.18	5.19	12.55	4.45	6.91
	Summer 2016	1.39	0.75	1.02	3.27	1.57	2.27	7.39	3.04	4.97	16.37	5.58	8.21
	Winter 2015	3.40	1.81	2.47	7.12	3.04	4.62	13.63	4.71	7.99	22.74	7.84	13.63
	Winter 2016	3.61	1.86	2.54	8.06	3.75	5.51	17.49	6.92	10.42	23.33	9.54	13.03
Intake West	Summer 2015	1.61	0.87	1.15	4.46	1.93	2.82	9.29	3.19	4.89	15.10	4.43	6.24
	Summer 2016	1.34	0.73	0.97	3.27	1.54	2.12	7.48	3.15	4.86	22.42	5.14	8.22
	Winter 2015	3.52	1.82	2.44	7.60	3.06	4.52	15.41	4.80	7.59	23.01	7.58	12.87
	Winter 2016	3.67	1.84	2.48	8.56	3.81	5.47	19.26	6.90	10.36	36.43	9.57	13.57
Intake Mid	Summer 2015	1.50	0.82	1.07	3.84	1.98	2.62	6.49	3.25	4.32	9.41	4.37	5.78
	Summer 2016	1.25	0.69	0.88	2.84	1.50	1.93	6.21	3.21	4.42	14.38	4.62	7.82
	Winter 2015	3.30	1.87	2.39	6.38	3.13	4.18	10.52	4.89	6.56	16.76	7.97	11.44
	Winter 2016	3.29	1.84	2.33	7.98	3.83	5.22	16.13	6.89	9.63	28.55	9.55	12.57
Intake East	Summer 2015	1.40	0.73	0.98	3.49	1.92	2.52	6.37	3.44	4.59	8.00	4.79	6.22
	Summer 2016	1.20	0.63	0.84	2.70	1.40	1.94	5.69	3.03	4.06	13.64	4.18	7.84
	Winter 2015	3.29	1.89	2.48	6.25	3.20	4.39	9.44	4.81	6.58	14.62	8.64	11.57
	Winter 2016	3.24	1.82	2.39	7.35	3.87	5.20	14.00	6.90	9.17	18.52	9.69	12.69

Note: Maximum summer and winter percentile values highlighted.

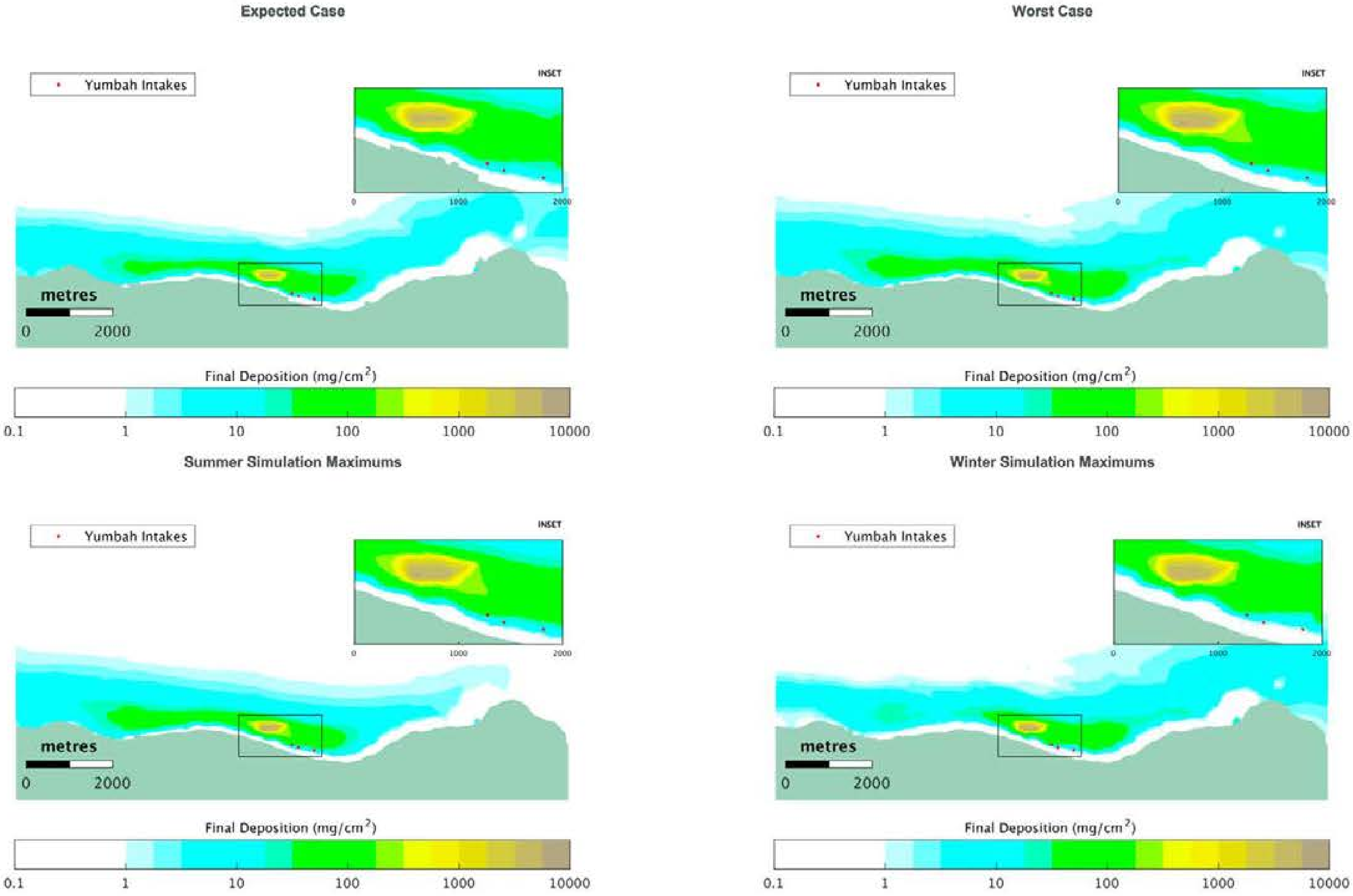


Figure 5-14 Dredge plume sediment deposition (mg/cm²) at end of simulation. Maximum seasonal final deposition also shown

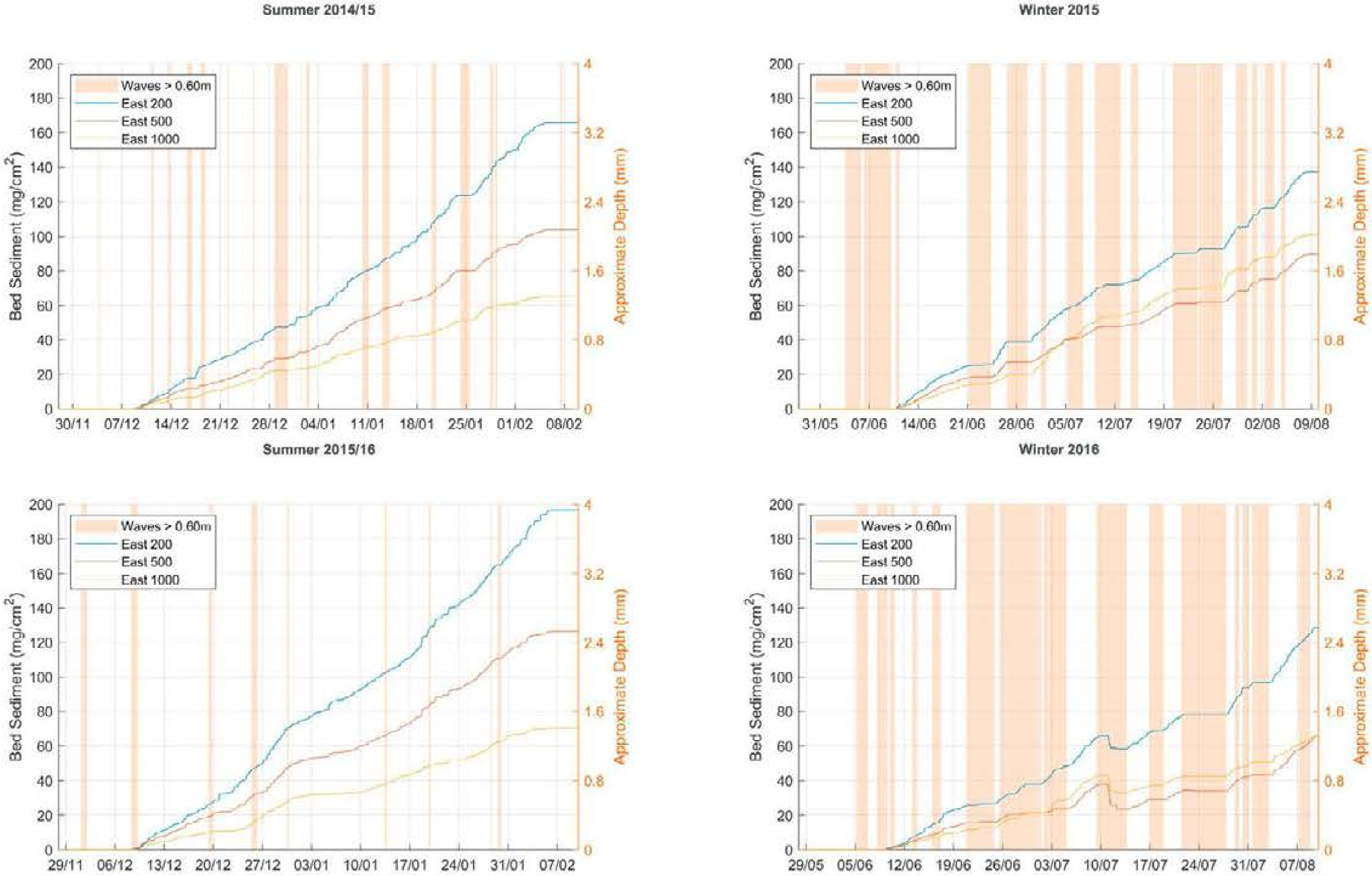


Figure 5-15 Timeseries of dredge plume sediment deposition (mg/cm^2)

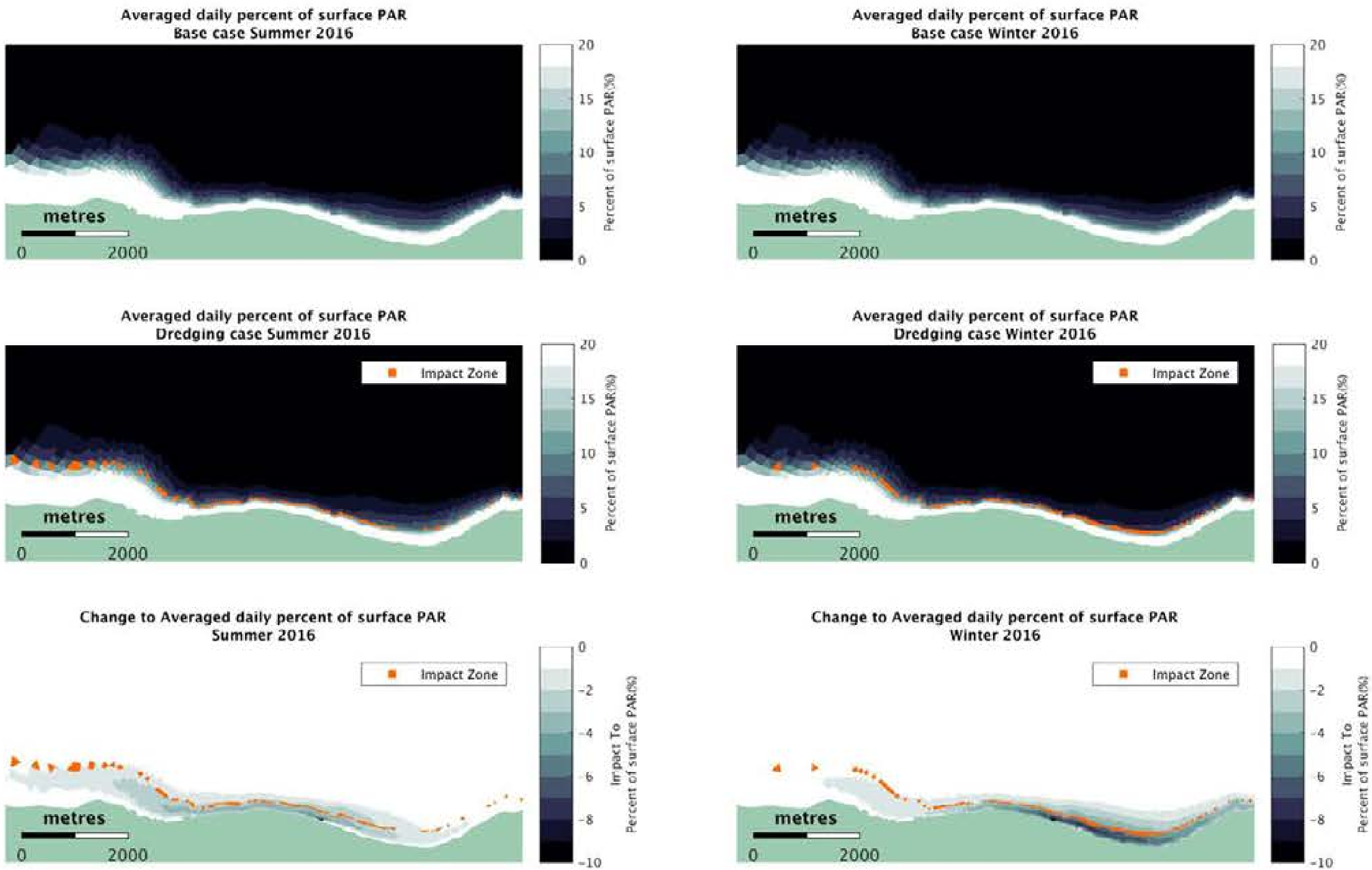
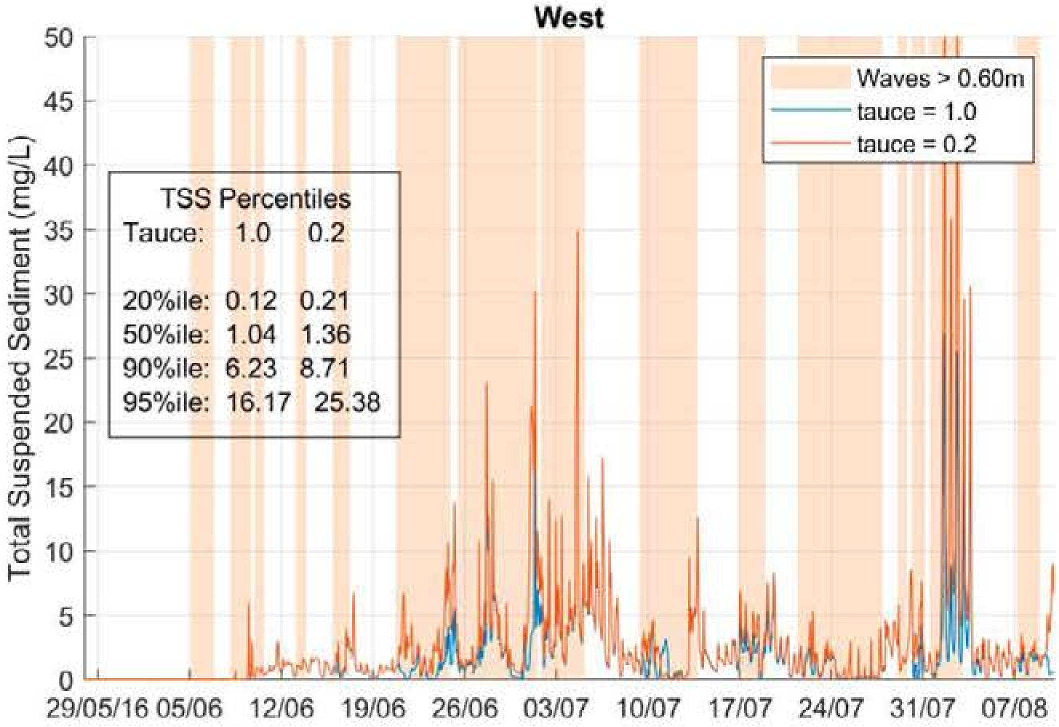


Figure 5-16 Modelled PAR impacts due to dredge plumes. The "impact zone" was derived for locations where PAR was greater than 10% SI under ambient conditions but becomes less than that during dredge conditions



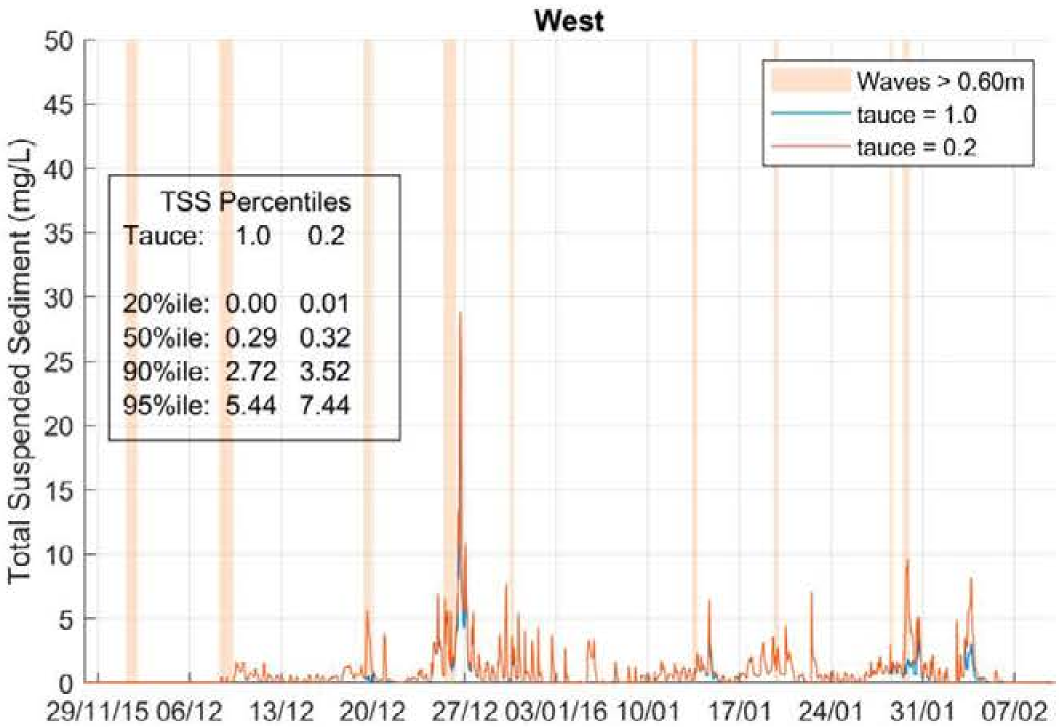


Figure 5-17 Bottom 1m Dredge-Related TSS at Westmost Intake for critical shear stress for erosion sensitivity test; during Winter 2016 (Top) and Summer 2016 (Bottom)

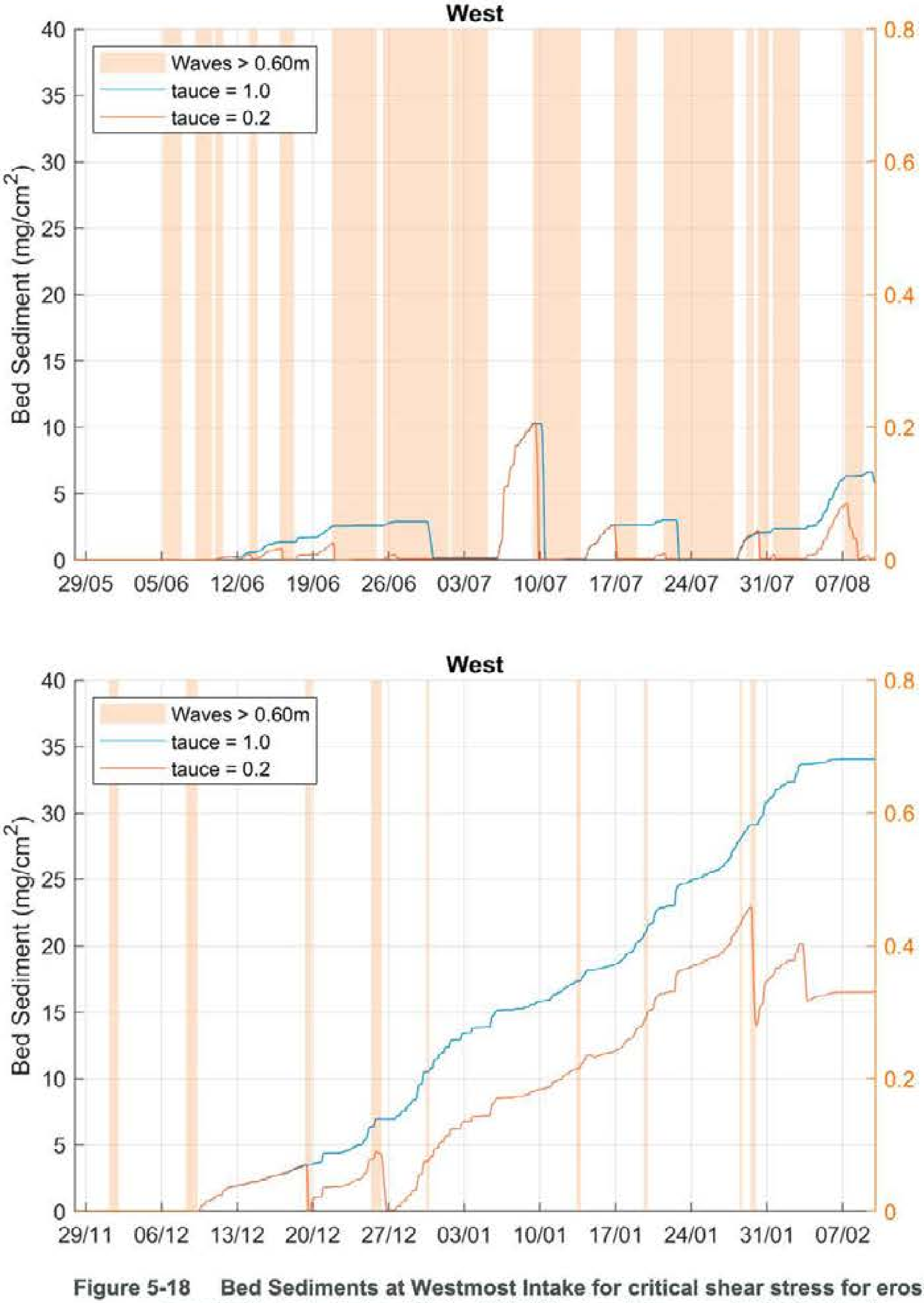


Figure 5-18 Bed Sediments at Westmost Intake for critical shear stress for erosion sensitivity test; during Winter 2016 (Top) and Summer 2016 (Bottom)

5.3 Capital Dredging Impact Mitigation

Based on a review of the capital dredging model simulations the following comments are made regarding potential design or management measures to mitigate dredge plume impacts.

5.3.1 Dredge footprint location and volume

Comparing the dredge plume impact results for the bounding footprint locations and dredge volumes (i.e. Design Scenario A and B) it is evident that the inshore wharf location represents only a marginally higher dredge plume risk. The substantially higher volume of dredging associated with this scenario does not contribute much to the increased dredge plume risk, as this is mainly limited by the dredge productivity. That is, the intensity of plume generation is mainly linked to the dredge size not the total volume to be dredged. Within the bounds assessed there is no reason to suggest that the dredge plume impacts should be mitigated by restricting the volume or location of the footprint.

5.3.2 Dredging window (season)

Comparing the dredge plume impact results for the summer and winter seasons clearly indicates that seasonality has a strong influence on hydrodynamics within Smith Bay. The preferred season for minimising plume impacts to the east of the dredge footprint is summer. Given that this is also likely to be the preferred season for dredging operational efficiency reasons, it is suggested that the EIS assess a limited window of dredging during the period from October to April.

5.3.3 Avoid 'high connectivity' environmental conditions

For short periods under certain tide and wind combinations, a high degree of connectivity can occur by way of currents travelling between the dredge footprint and the Yumbah intakes. Under these high connectivity conditions plumes may travel directly from the footprint to the intakes and short periods of relatively high dredge plume TSS may occur.

A review of the environmental conditions corresponding to the highest peak TSS levels at the Yumbah intakes during the summer period indicates that these occur during Dodge tides accompanied with light to moderate westerly winds. Under these conditions, a relatively steady eastward flow from the dredge footprint towards the Yumbah intakes can occur.

It is therefore recommended that the Dredge Management Plan consider measures to firstly predict and secondly cease dredging during potential high connectivity conditions. If predicted sufficiently in advance these periods may be scheduled for routine dredge maintenance operations with minimal loss of overall productivity.

5.3.4 Tidal dredging

Dredging only during westerly current periods would be the most effective means of mitigating plume impacts to the east of the dredge footprint, including the Yumbah seawater intake locations. However, this would come at the expense of correspondingly increasing dredge plume impacts to the west of the footprint. This would also increase the overall duration of the dredging project by roughly a factor-2, which would have substantial cost implications. It seems reasonable that tidal dredging could be considered as a final management option in a tiered plan.

5.3.5 Realtime Monitoring and Reactive Management

Realtime monitoring of turbidity at a location between the dredge footprint and sensitive receptor locations (e.g. Yumbah intakes) would provide an additional mechanism for reactively managing dredge plume impacts. Due to the relatively close proximity of key receptors and the dredge plume source, turbidity trigger exceedances would need to be closely monitored and the timescale of management response actions would need to be short (~30 minutes) in order to be of benefit in mitigating acute plume impacts at the Yumbah intakes.

5.3.6 Suggested Management Measures

The above considerations suggest that a Dredge Management Plan for the KIPT wharf construction project should include the following components:

- Forecast plume predictions to identify and avoid dredging during 'high connectivity' environmental conditions;
- Realtime monitoring and reactive management to further protect against acute plume impacts at key sensitive receptors; and
- Tiered Dredge Management Plan actions with resort to tidal dredging if required to maximise plume effect mitigation at one set of sensitive receptor locations.

5.4 Causeway Construction

5.4.1 Methodology

The core of the proposed causeway is to be constructed from the de-watered and settled dredged material. For the purpose of undertaking an upper-bound impact assessment it has been assumed that the causeway will be constructed over a relatively short duration 30 day period. There are two key risks during causeway construction: (1) the fines released during the initial placement of the core material; and (2) the potential for fines to be released from the exposed core during a large wave event.

For the purpose of modelling these risks, the fines content of placed material was assumed to be 5% (split evenly between clay and silt). It was assumed that 10% of the placed fines are immediately released into suspension during construction (i.e. 1% of the total placed material). The total load was 181 tonnes of fines dispersed. For comparison this quantity represents around 7% of the total fines released by the capital dredging component of the project.

Additionally, during a large wave event it was assumed that the remainder of the available fines in the outer 300 mm of the exposed core (core to be built in 10 m sections at a time before being capped with geotextile and rock armouring) would be released over a 12-hour period. The upper-bound of this event-driven release is when the furthest offshore 10-meter section of core material is completely exposed, resulting in a total fines release of 8.6 tonnes.

Two simulations were run, covering the relatively energetic summer (with the event released triggered during the event on 29/01/2016) and the relatively energetic winter (event release triggered on 29/01/2016 – the largest wave event modelled).

5.4.2 Results

Figure 5-19 presents aggregated 99th and 50th percentiles of depth-averaged TSS during the construction simulation/s. These percentiles are taken as the spatial maximum of the percentiles for the two individual scenarios.

During causeway construction (including the wave event) the median TSS concentrations did not exceed 0.5 mg/L at the Yumbah intakes. The 99th percentile TSS concentration did not exceed 1 mg/L at the Intakes.

Timeseries predictions of ambient plus plume TSS are shown in Figure 5-21 and indicate that the above-ambient component is relatively minor for the causeway construction activities compared with the capital dredging scenarios (Section 5.2). The corresponding ambient plus plume TSS percentiles for the causeway construction scenarios are summarised in Table 5-7.

Deposition due to causeway construction plumes is an order-of-magnitude lower than the dredge plume scenarios and therefore cumulative impacts would not be increased by any significant margin above the dredge plume scenario results (Section 5.2).

5.4.3 Mitigation

These results indicate that causeway construction plumes are likely to pose a lower level of risk to Smith Bay water quality than the capital dredging activities. Never the less, mitigation of plume impacts due to causeway construction should be achieved by

- Minimising the fines content of material used in the causeway core construction; and
- Minimising the length of exposed causeway core before geotextile and armour placement.

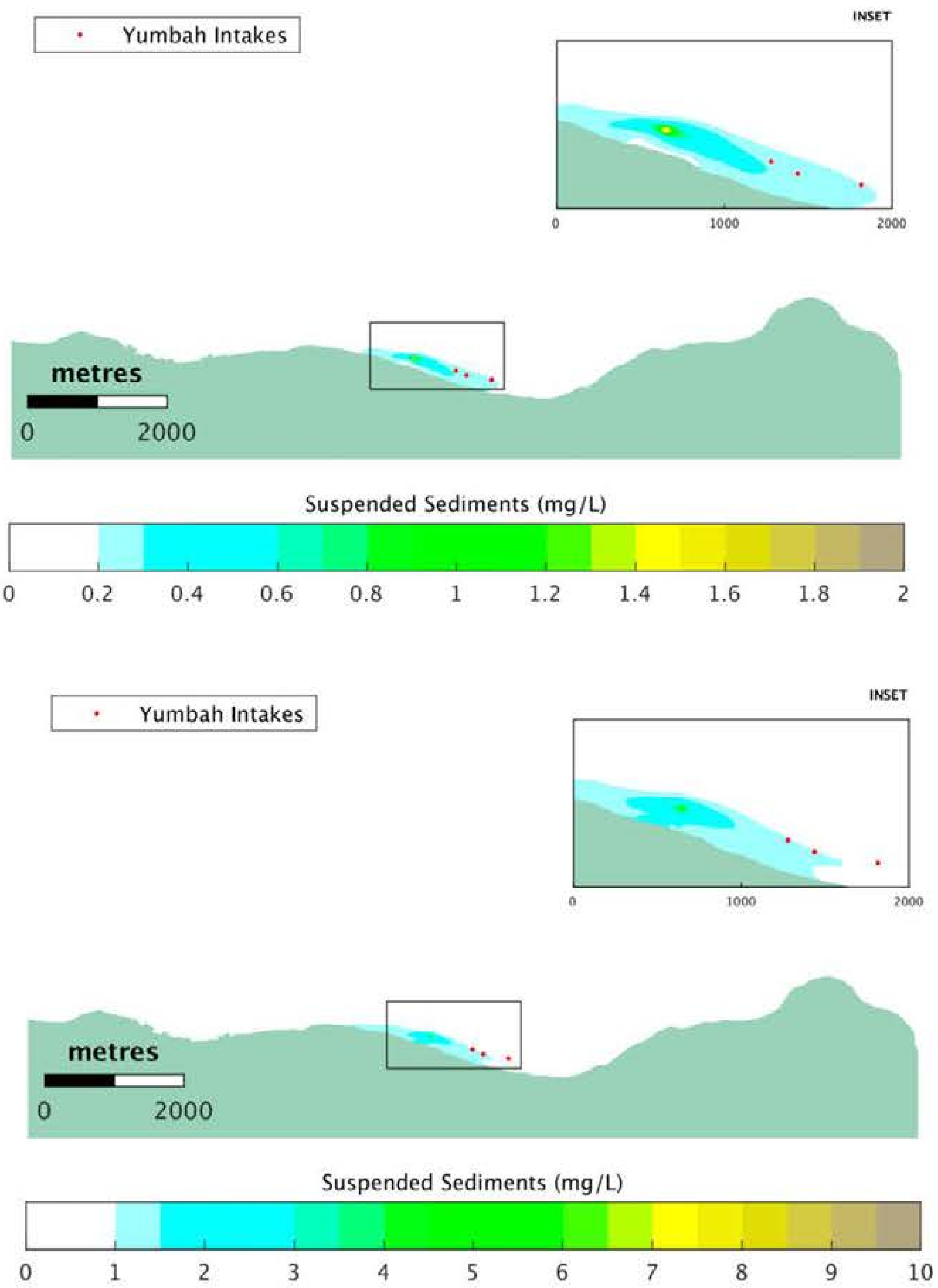


Figure 5-19 Depth-averaged causeway construction plume TSS. Chronic - 50th percentile (Top) and Acute - 99th percentile (Bottom)

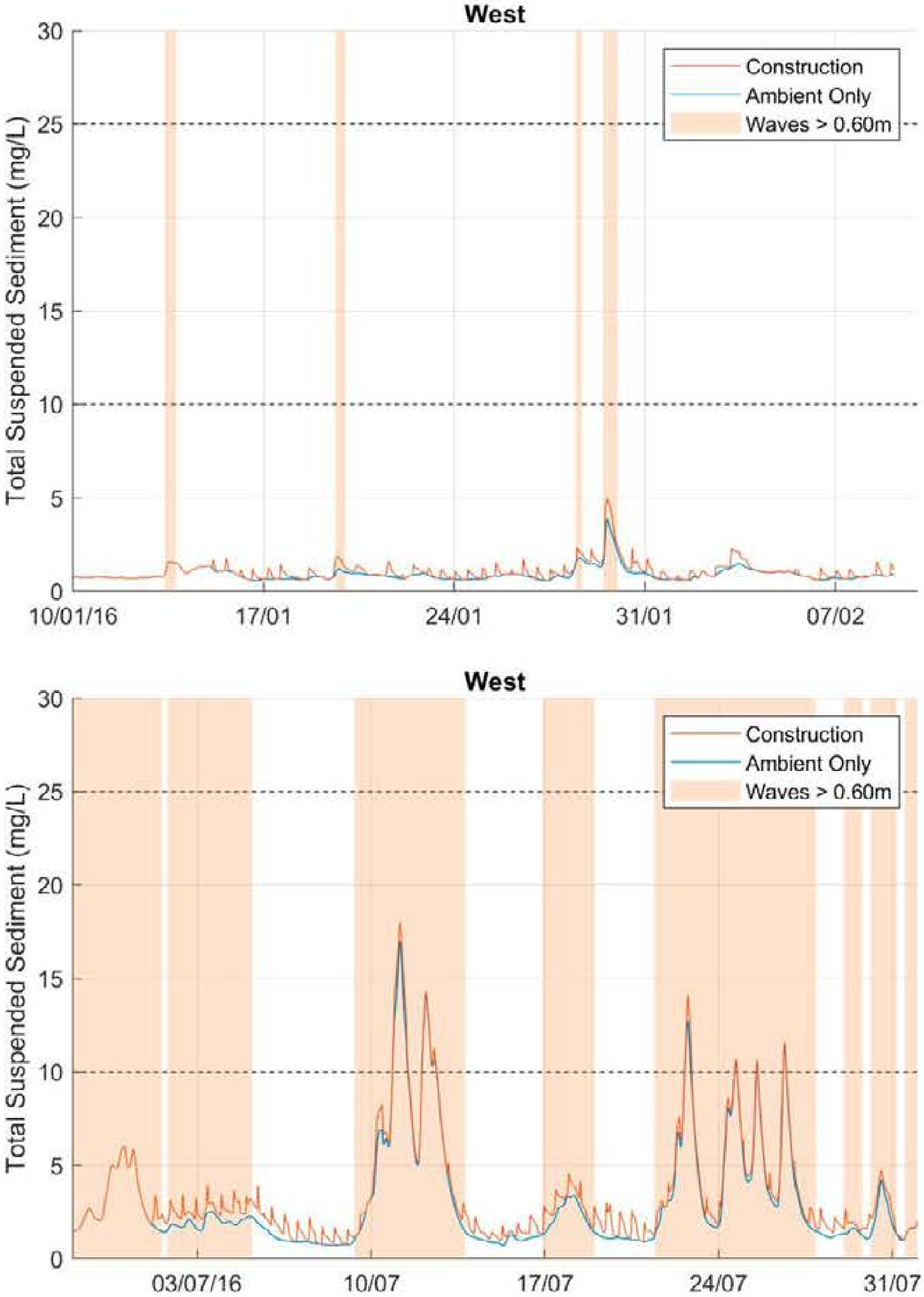


Figure 5-20 Bottom 1 m TSS timeseries (ambient plus causeway construction plume) at intake West location. Summer 2016 (top) and winter 2016 (bottom).

Table 5-7 Causeway construction scenario dredge plume TSS (ambient plus dredge plume) summary statistics

Location	Period	50th Percentile TSS (mg/L)			90th Percentile TSS (mg/L)			99th Percentile TSS (mg/L)			Maximum TSS (mg/L)		
		Bottom	Top	Depth-Average	Bottom	Top	Depth-Average	Bottom	Top	Depth-Average	Bottom	Top	Depth-Average
Inactive Intake	Summer	0.95	0.50	0.67	1.57	0.86	1.12	3.88	2.19	2.79	4.76	2.81	3.47
	Winter	2.37	1.22	1.64	8.11	4.07	5.45	14.83	7.59	10.06	17.82	9.13	12.07
Intake West	Summer	0.95	0.50	0.66	1.61	0.86	1.12	4.06	2.27	2.89	4.95	2.85	3.56
	Winter	2.45	1.24	1.65	8.04	4.09	5.42	14.97	7.69	10.15	17.96	9.20	12.15
Intake Mid	Summer	0.93	0.49	0.64	1.58	0.84	1.10	3.97	2.25	2.82	5.04	2.83	3.60
	Winter	2.40	1.24	1.65	7.99	4.07	5.40	14.94	7.71	10.15	17.90	9.18	12.10
Intake East	Summer	0.87	0.45	0.59	1.47	0.78	1.01	3.49	1.94	2.48	4.80	2.72	3.45
	Winter	2.24	1.17	1.56	7.90	4.00	5.31	14.68	7.54	9.97	17.67	8.99	11.92

Note: Maximum summer and winter percentile values highlighted.

5.5 Operational Propwash Assessment

5.5.1 Methodology

Sediment plumes can be generated by propwash caused by inbound and outbound ships at the proposed wharf. Vessel propulsion leads to localised velocity fields which may be capable of generating sufficient bed shear stress to suspend sediment. The propeller generated velocity fields are a function of the position, orientation, and propeller activation of the vessel over time.

The approach and departure patterns of the vessel are operator influenced and subject to high variability. This study considered simplified but representative vessel approach and departure kinematics, in conjunction with a conservative set of propwash parameters. This is expected to provide an upper bound on the concentration and extent of suspended sediment plumes.

Adopted vessel input parameters are as follows:

- Vessel Description – Panamax Class, DWT = 63,000t, LOA = 200m, Breadth = 32.3m, Draught = 11.6m.
- Vessel Propulsion – Single propeller, SMCR Power = 8990kW, propeller diameter = 6.5m, keel-propellor offset = 3.25m.
- Approach and Departure – angle (to quay line) = 30 degrees, deceleration distance = 4000m (uniform deceleration), acceleration distance = 4000m (uniform acceleration), orientation correction period during berthing and departure = 300s.
- Combined vessel squat and trim at propeller = 1.0m at max velocity, and linearly scaled at lower velocities.
- Propellor operation – propeller is assumed to be operating at full power over the full acceleration and deceleration distance.
- Time in port = 8hrs (during which no plume is generated).

These parameters are sufficient to produce time series of vessel position, orientation, and propeller activation, which provided input to the velocity field calculation approach detailed in BAW (2010) – *Principles for the Design of Bank and Bottom Protection for Inland Waterways*.

The calculated velocity fields were converted to bed shear stress using the bed friction relations proposed in Maynord (2000). A median grain size D_{50} = 0.5mm was applied, corresponding to the maximum value from the geotechnical assessment (COOE, 2017) which maximises the friction coefficient. Sediment suspension source terms were calculated from bed shear stress fields using the parameters of Section 2.3.1.

The total load of fines released by propellor wash was 9 tonnes (split evenly between clay and silt).

The resulting time series of propeller position and sediment source terms were applied to the TUFLOWFV hydrodynamics model used for the sediment plume assessments, during the same time periods used for the causeway construction assessment.

5.5.2 Results

Similar to the approach for the construction plumes, Figure 5-22 presents aggregated 99th and 50th percentiles of depth-averaged TSS during the operational plume simulation/s. These percentiles are taken as the spatial maximum of the percentiles for the two individual scenarios. These percentiles have been calculated over the modelled period of 7-days, rather than the 30-day windowed approach adopted above. During this 7-day period there was a single incoming and outgoing ship movement simulated.

Neither the median or 99th percentile maps show any plume that is above the minimum scale limit shown (0.2 and 1.0 mg/L respectively). This is because the sediment plume occurs over such a short duration that it is not observable for these percentiles. Figure 5-21 presents the maximum concentration observed by either scenario, and shows that local plumes in the berth area are ~10 mg/L and no plumes extend to the Yumbah Intakes.

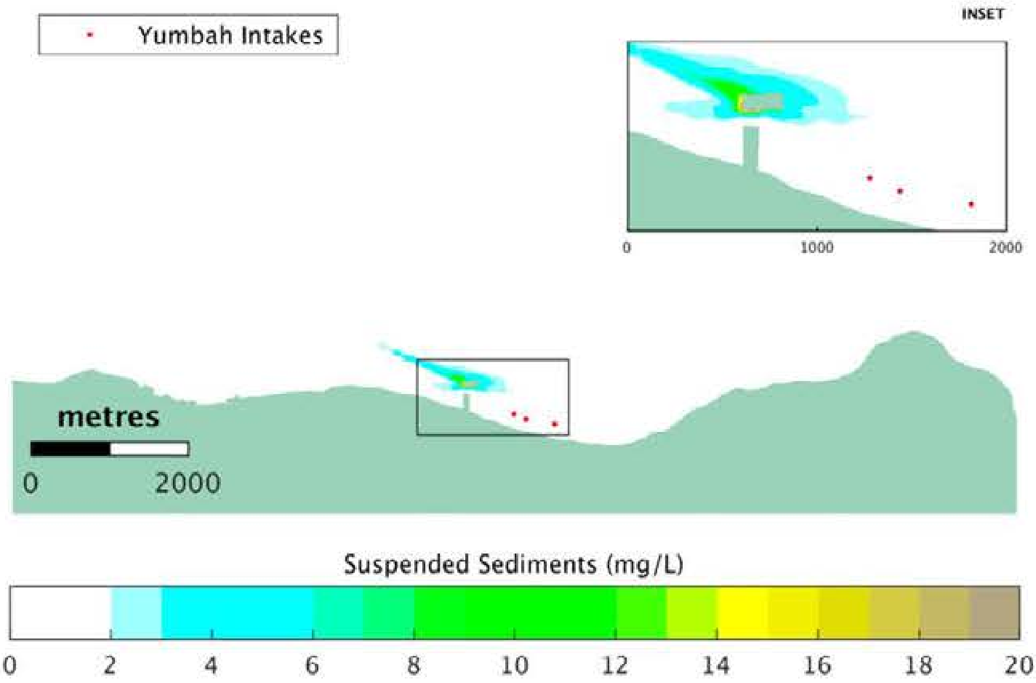


Figure 5-21 Maximum depth-averaged operational propwash TSS

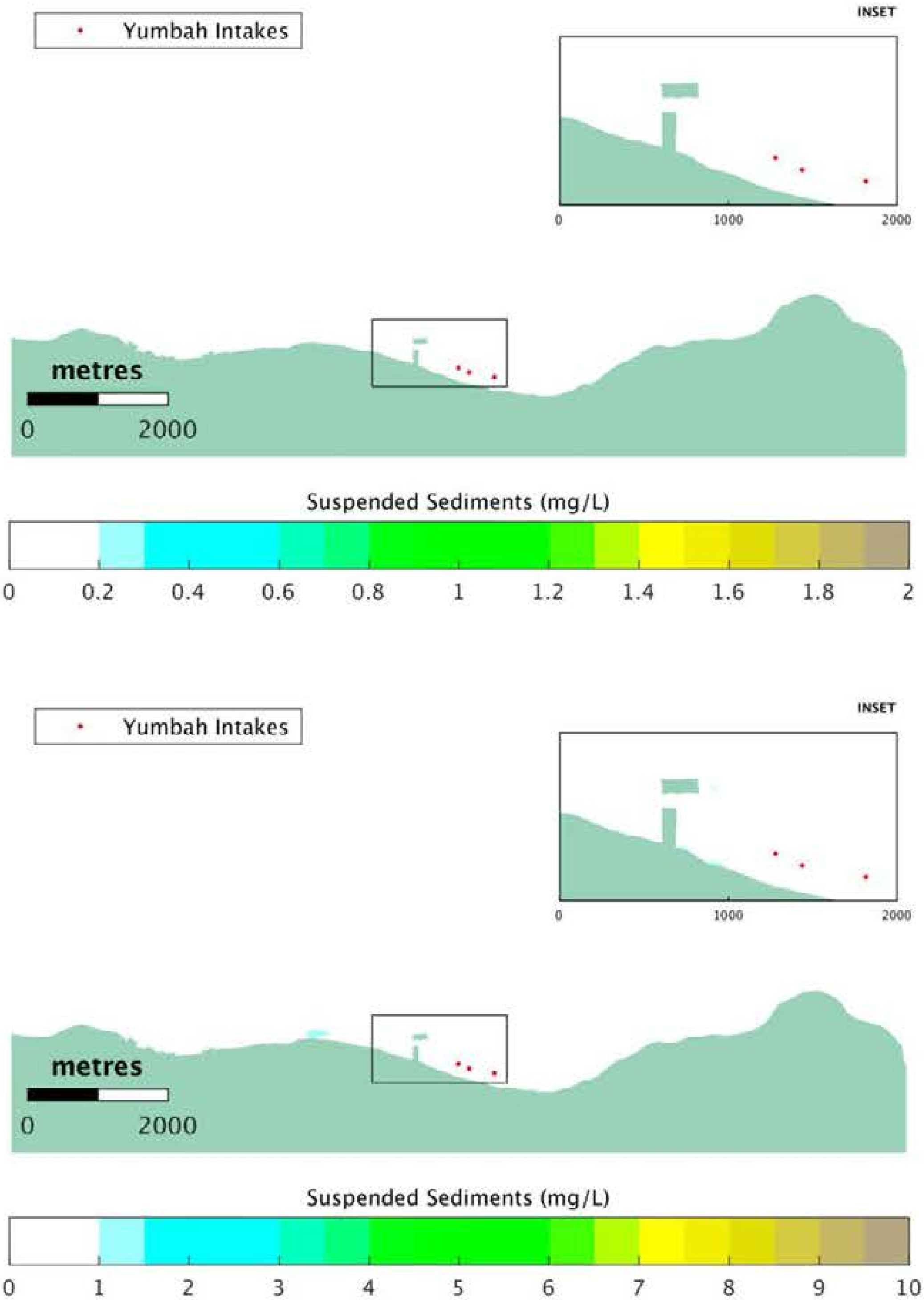


Figure 5-22 Depth-averaged operational propwash plume TSS. Chronic - 50th percentile (Top) and Acute - 99th percentile (Bottom)

6 Coastal Process Impact Assessments

6.1 Introduction

The proposed development has the potential to alter coastal processes, including waves, current circulations and sediment transport pathways due to the construction and operation of infrastructure in the coastal zone. This infrastructure includes a solid causeway extending up to 220 m from the existing shoreline, the dredging of a berth and approach area of approximately 10 ha to a design depth of 13.5 to 14 mLAT. For the purpose of the coastal process impact assessment, the floating barge wharf component has been assumed to be a solid structure extending the full depth of the water column and impervious to both waves and currents. In reality the floating barge would extend over approximately 80% of the water column and may not completely block currents or swell waves. The simplifying assumption employed is consistent with an upper-bound approach and is considered appropriate for the purpose of undertaking the coastal process impact assessment.

The difference in bed elevation between the 'existing case' and 'developed case' scenarios is shown in Figure 6-1. These two scenarios form the basis of the coastal processes impact assessments, with all scenarios (both 3D hydrodynamic and wave impacts) being run for both configurations and the impacts derived as the difference between the developed and base case results.

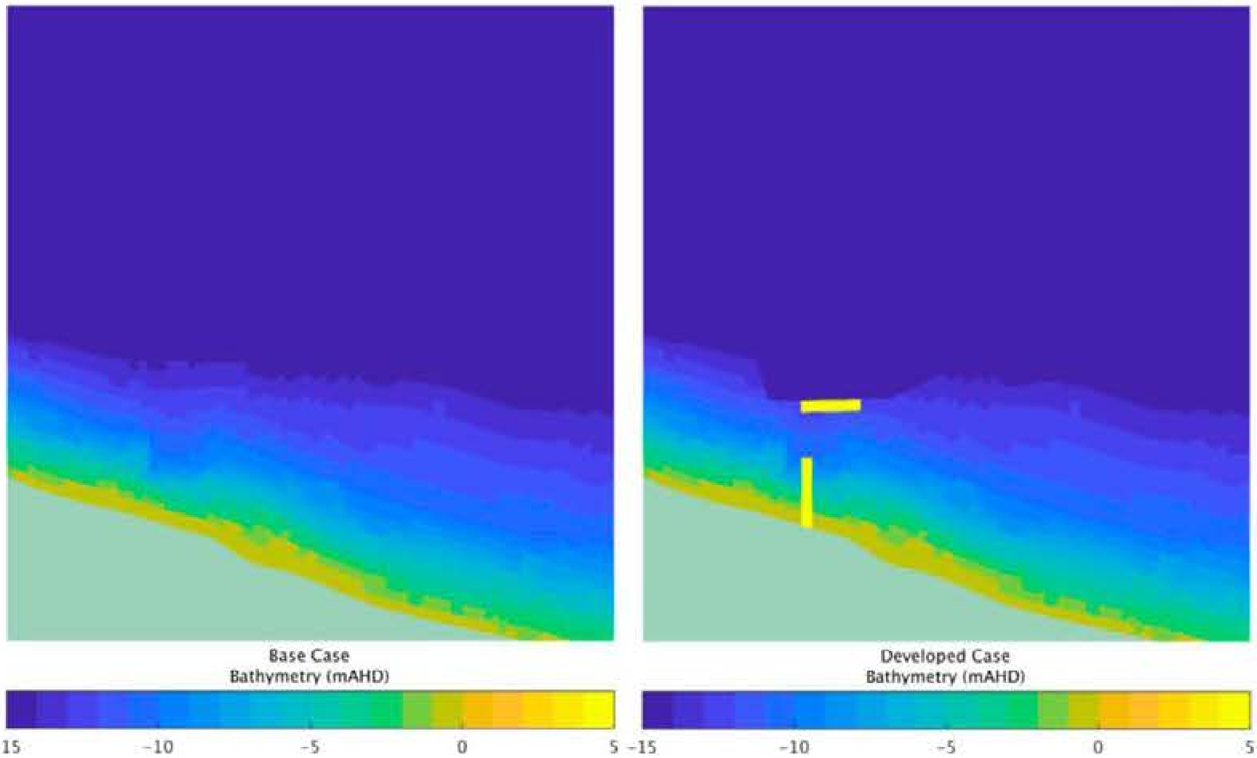


Figure 6-1 Base case (Left) and developed case (Right) bathymetry

Coastal process impacts were assessed by simulating both base case and developed case hydrodynamics and waves for the 4x 3-month simulation periods selected for the construction plume modelling assessments. Based on the selection process this ensemble of results should reasonably span the prevailing seasonal conditions experienced at Smith Bay.

The coastal process impact assessment has modelled potential impacts to waves, flow circulation and water temperature, creek plumes and littoral zone sediment transport.

6.2 Wave Impacts

The causeway and floating wharf structures will generate a localised zone of reduced wave height near the shoreline due to blockage of incoming wave energy.

The impact to the significant wave height during an event in June 2016 is shown in Figure 6-2. This shows that the most significant impacts occur in the immediate lee of the causeway and floating wharf structure. The blockage from the structures serves to reduce the wave heights in these regions. Some small directional changes are also observed for the residual wave energy. The zone of reduced wave height conditions extends approximately 2 to 3 times the causeway/wharf structure length, that is around 500 to 750 m.

Figure 6-4 shows a timeseries comparison of base and developed case significant wave height at a point located inshore of the proposed floating wharf structure. The timeseries shows that wave height is typically reduced by around 30-50% at this particular location in close proximity to the proposed wharf. Further to the east at the nearest active Yumbah intake (Intake 1), the wave height timeseries comparison (Figure 6-5) shows only a very slight (<5%) reduction in wave height.

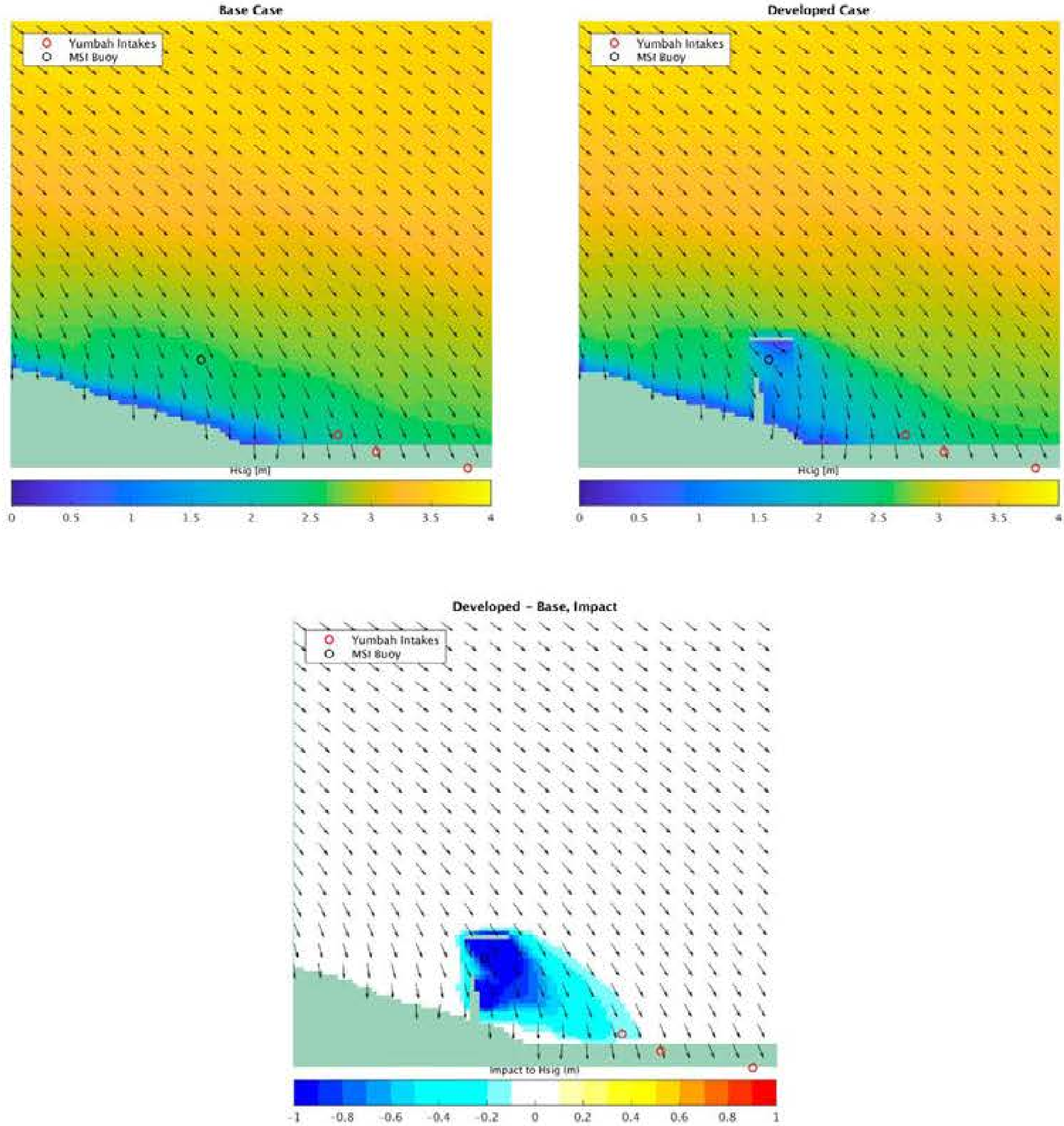


Figure 6-2 Base (Top-Left), Developed (Top-Right) and Impact (Bottom) to significant wave height during large North-West waves

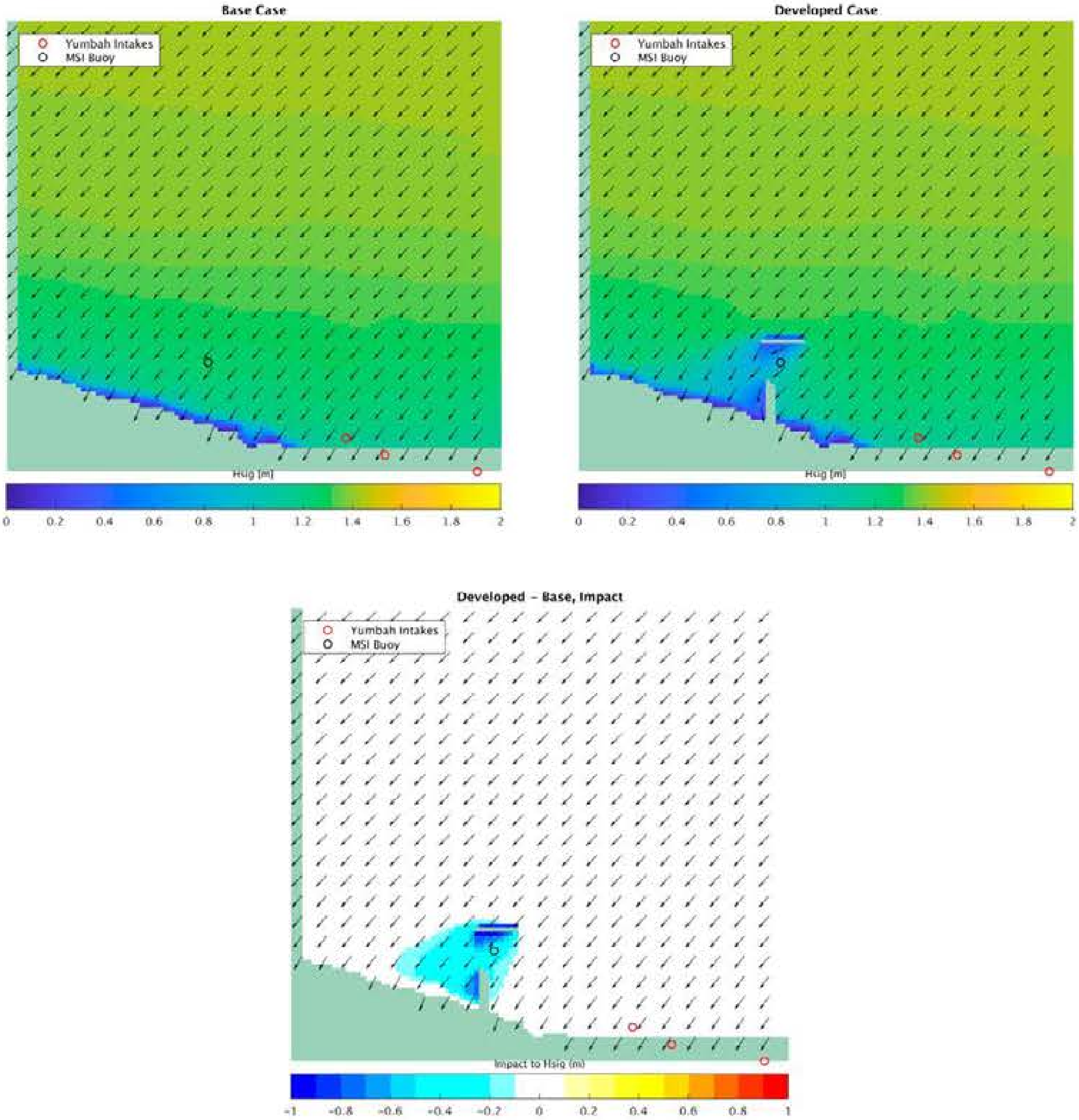


Figure 6-3 Base (Top-Left), Developed (Top-Right) and Impact (Bottom) to significant wave height during North-East waves

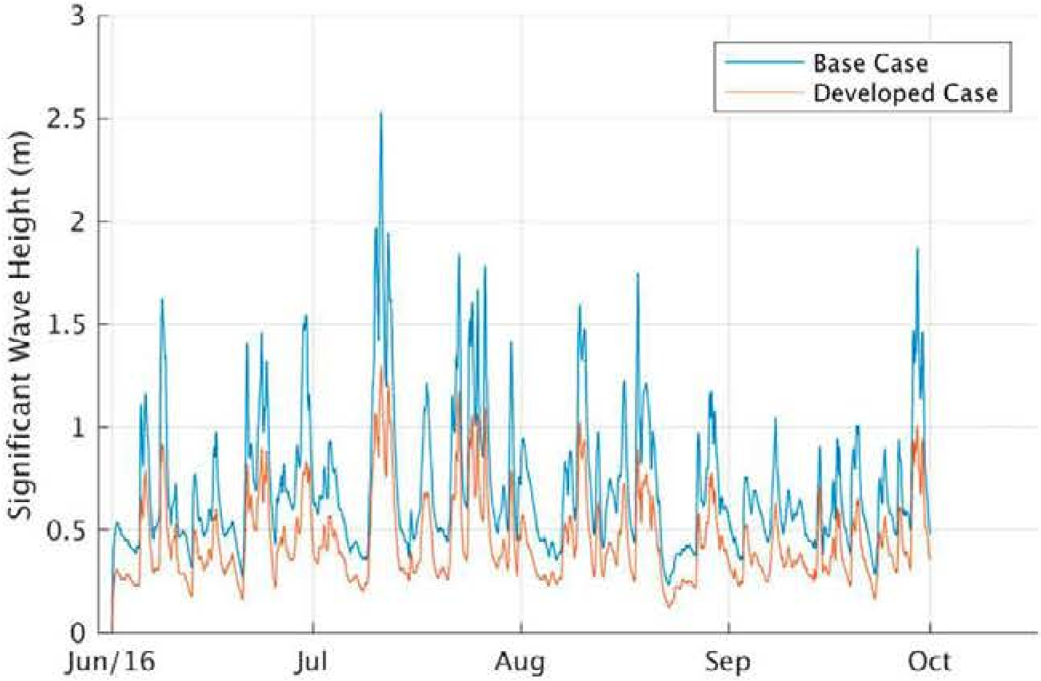


Figure 6-4 Significant wave height comparison behind floating wharf (MSI Buoy Location)

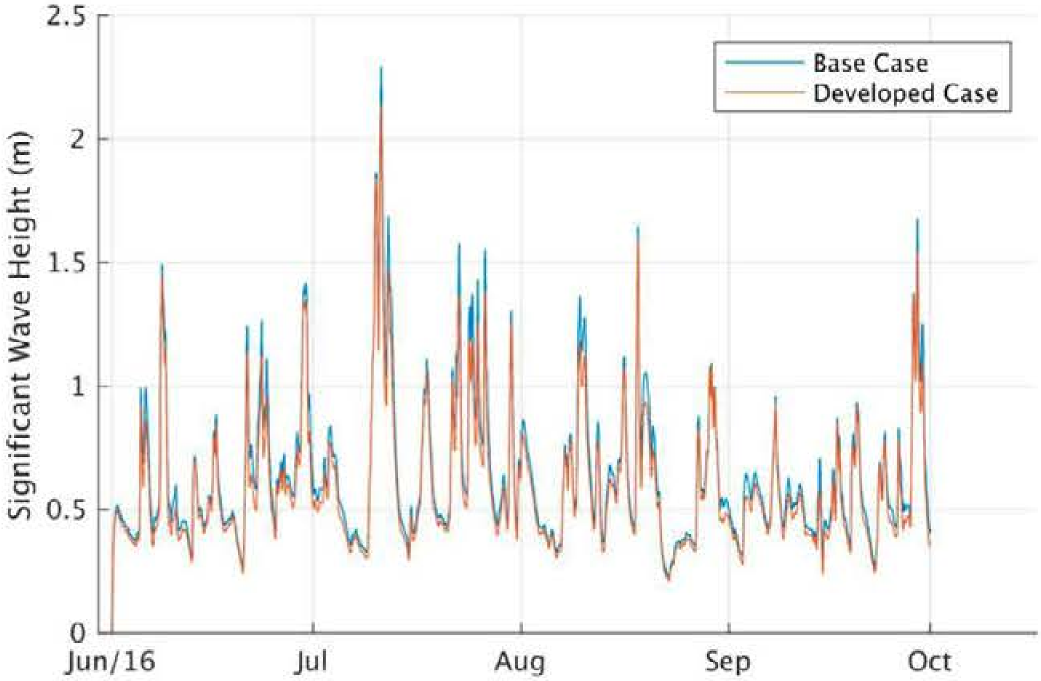


Figure 6-5 Significant wave height comparison at Yumbah West Intake

6.3 Circulation Impacts

6.3.1 Water Level Impacts

The coastal infrastructure proposed for the KIPT wharf facility would be unlikely to result in any significant impacts to Smith Bay water levels, either in terms of tidal amplitudes or timing. Figure 6-6 compares water level timeseries at the Yumbah Intake 3 location and demonstrates that base case and developed case water levels are essentially the same. Figure 6-7 shows the water levels for the base and developed cases (and impacts) during a large storm surge event (11th July 2016). Changes in the water level at this time are minimal.

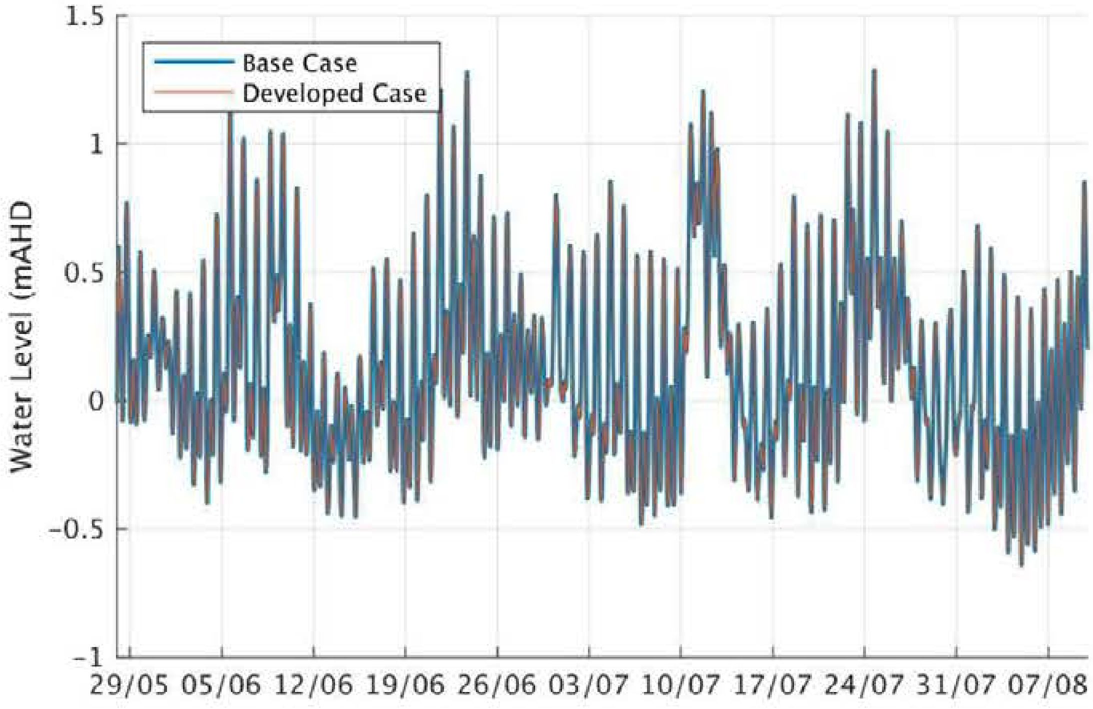


Figure 6-6 Water level comparison at Yumbah Intake 3 (Winter 2016)

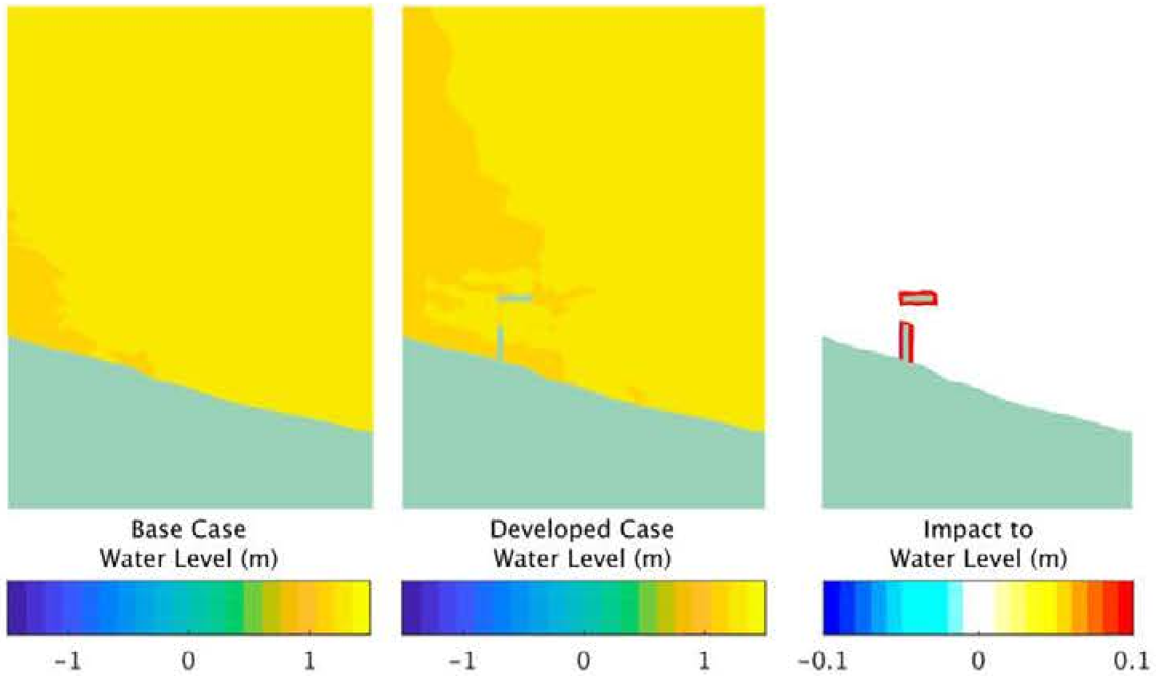


Figure 6-7 Water level impacts

6.3.2 Current Field Impacts

Currents in Smith Bay are generally driven shore parallel by a combination of water level gradients (tidal and storm surge) and wind stress. Refer to Figure 4-4 for an illustration of the prevailing current speeds and directions. The proposed shore-normal causeway structure has the potential to interrupt the alongshore current flow. The localised deepening associated with the dredging and the blockage associated with the roughly shore-parallel floating wharf structure also have some limited potential to modify the flow fields.

Figure 6-8 and Figure 6-9 show the current fields during typical spring- flooding and ebbing tides respectively. The causeway and floating wharf block the flow of currents near to the coastline and reduce the peak current magnitudes by ~0.1 m/s, predominantly in the lee of the structure. The timeseries comparison at the Yumbah Intake Weset location (Figure 6-10) shows that current speed reductions represent around 15-40% of the base case condition.

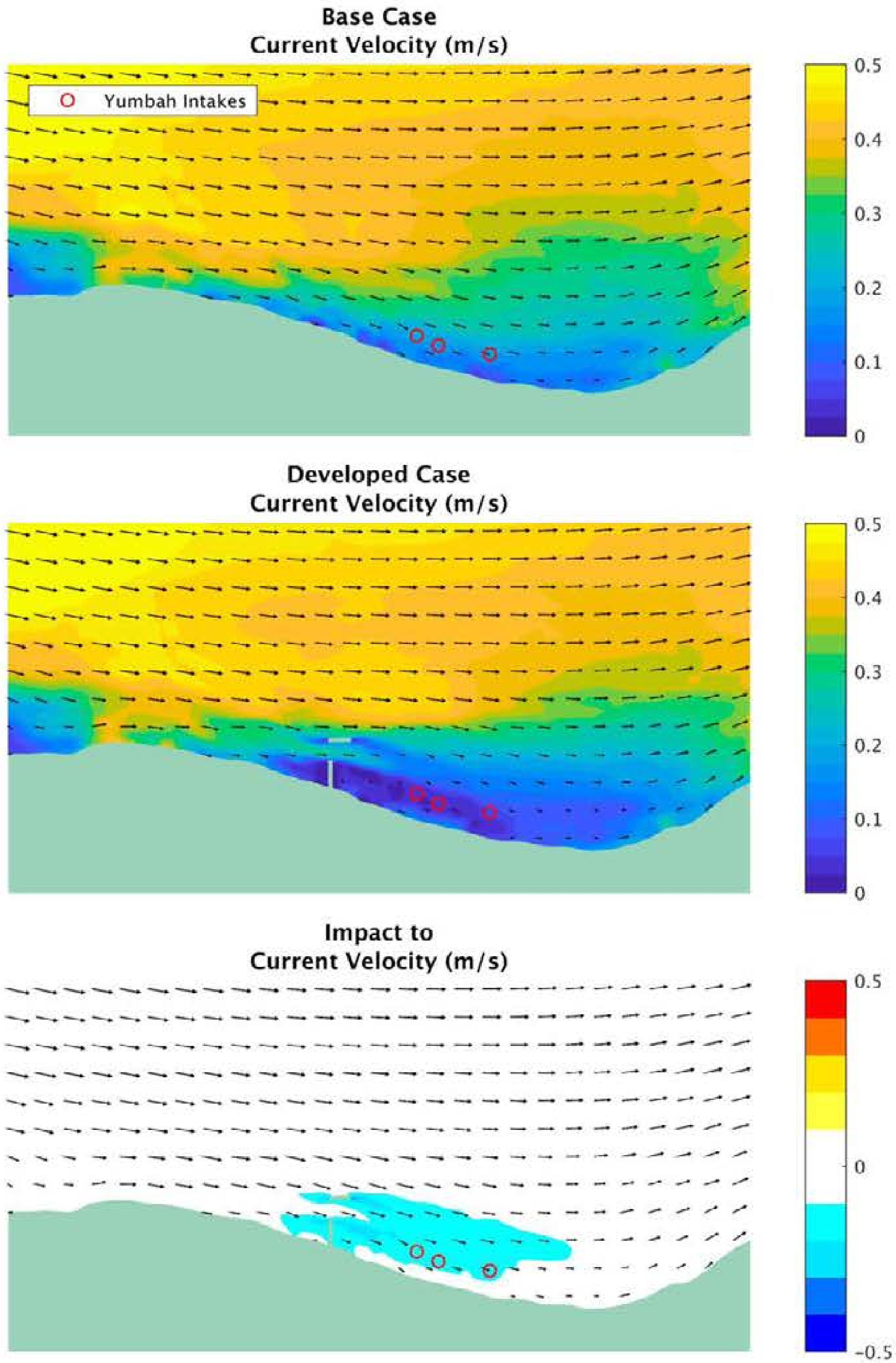


Figure 6-8 Flood-tide currents impacts

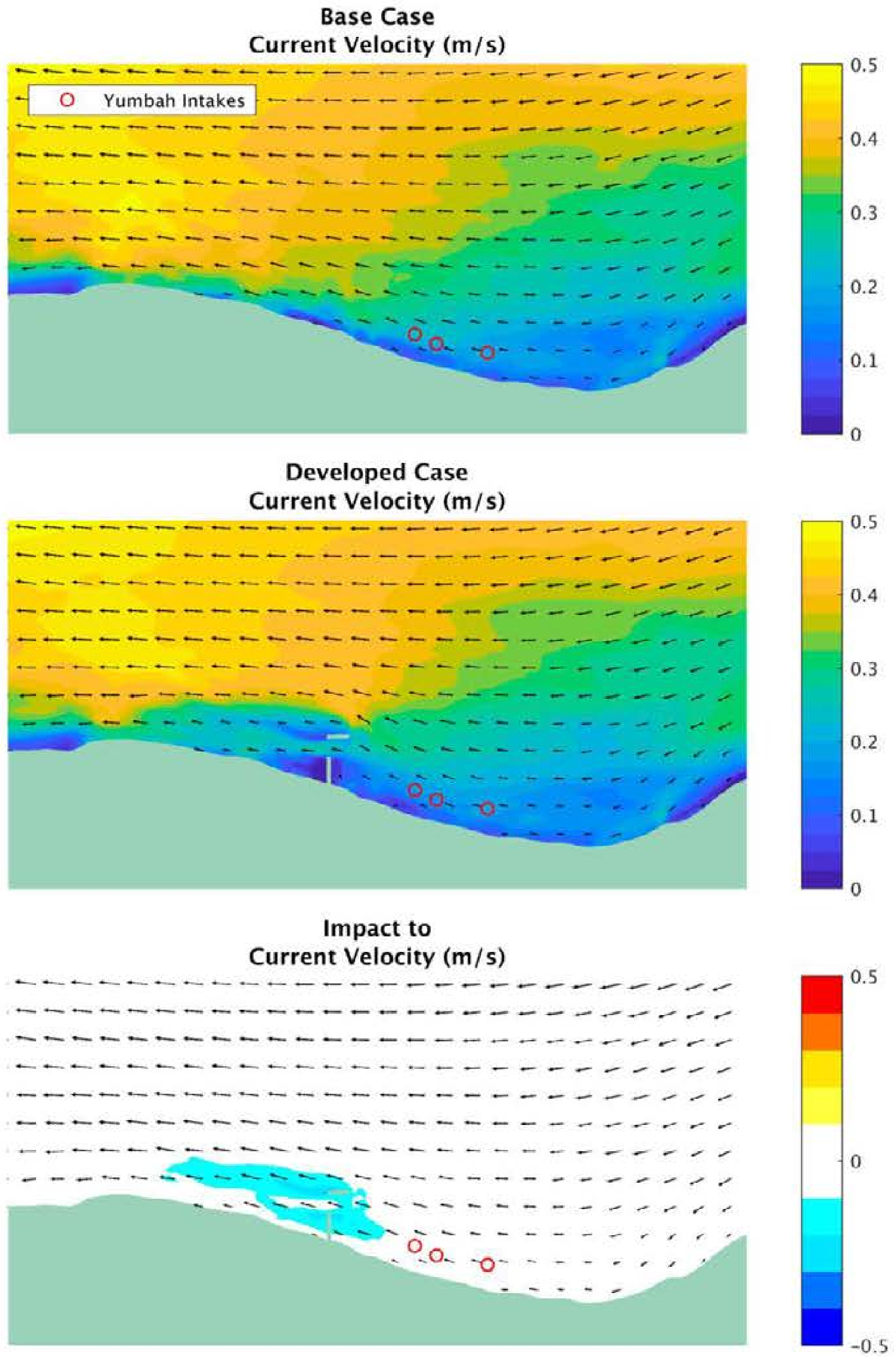


Figure 6-9 Ebb-tide currents impacts

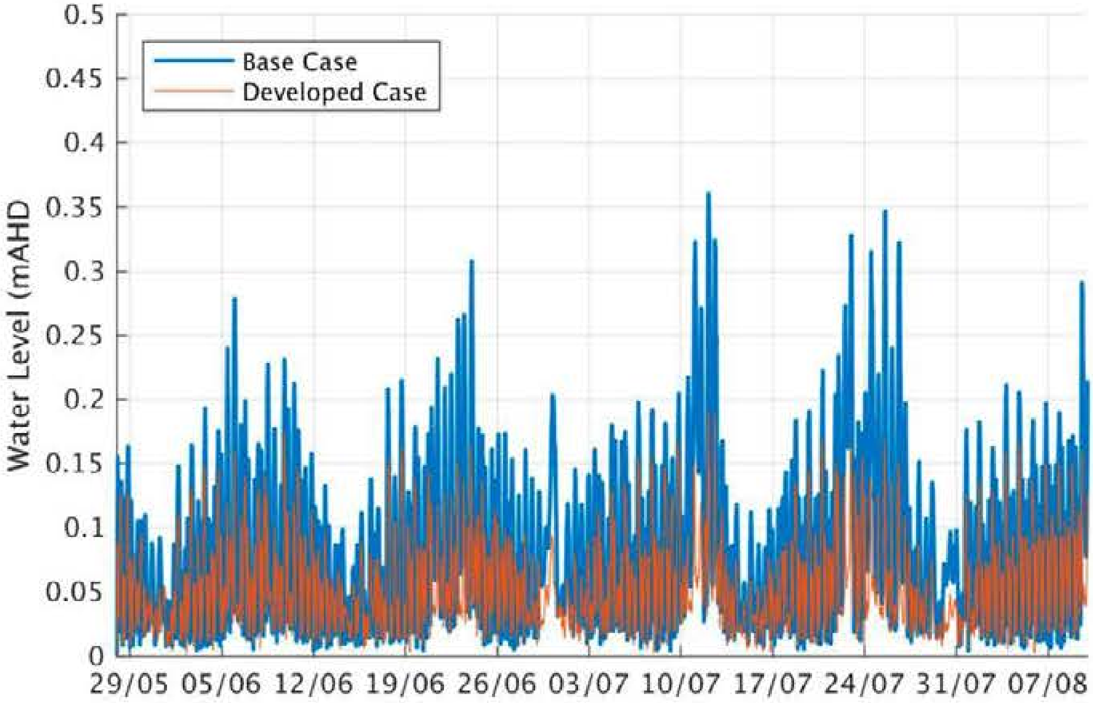


Figure 6-10 Depth-averaged current timeseries comparison at Yumbah Intake 3

6.4 Temperature Impacts

The current circulation impacts show a slight reduction in current speeds flowing through Smith Bay nearshore waters as a result of the proposed development. The potential risk of elevated water temperatures as a result of these minor flow circulation changes was modelled. A timeseries comparison of modelled water temperature at Yumbah Intake West is shown in Figure 6-11 and shows that base and developed case predictions are almost indistinguishable. This comparison is further assessed using a base versus developed scatter plot in Figure 6-12. Again, this shows that the base and developed case are very close to identical, with the developed case result sometimes slightly higher and at other times slightly lower than the base case results, with no persistent warming bias predicted as a result of the causeway.

The maximum water temperature over the entire summer simulation period was also derived and is spatially mapped for both the base and developed case in Figure 6-13. Maximum temperatures are predicted to increase slightly in nearshore waters to the east of the proposed causeway, with a corresponding slight decrease predicted to the west. The predicted temperature increases are typically less than 0.2 degrees in shallow nearshore waters and even less further offshore where the aquaculture intakes are located.

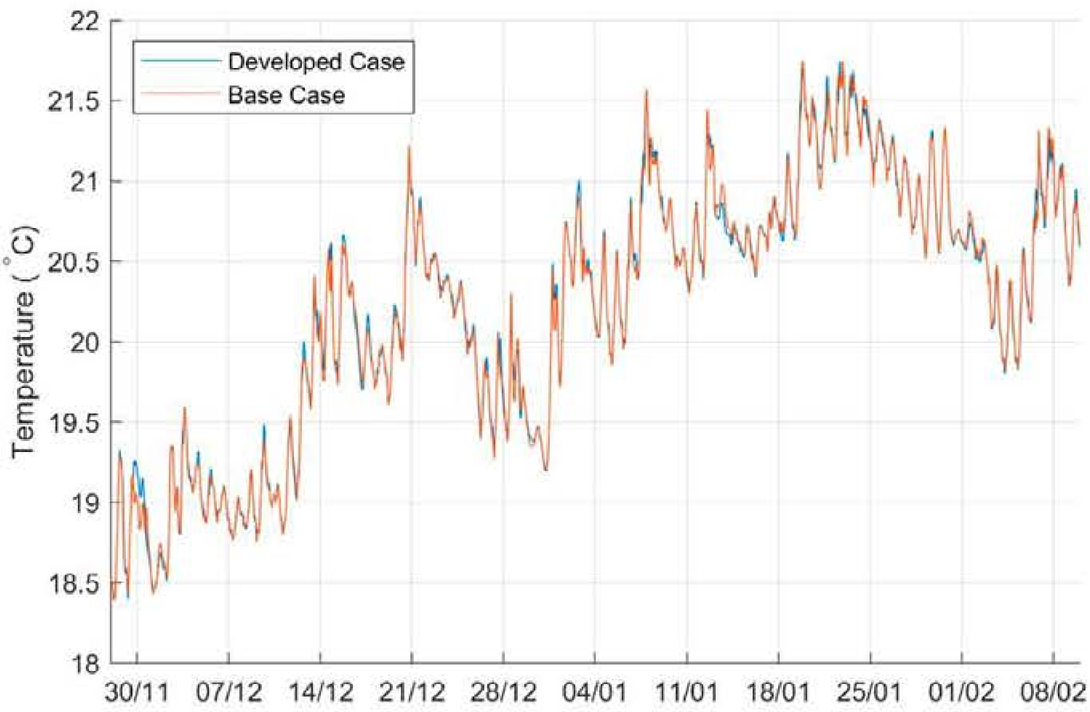


Figure 6-11 Timeseries comparison of depth-averaged temperature at Yumbah Intake West

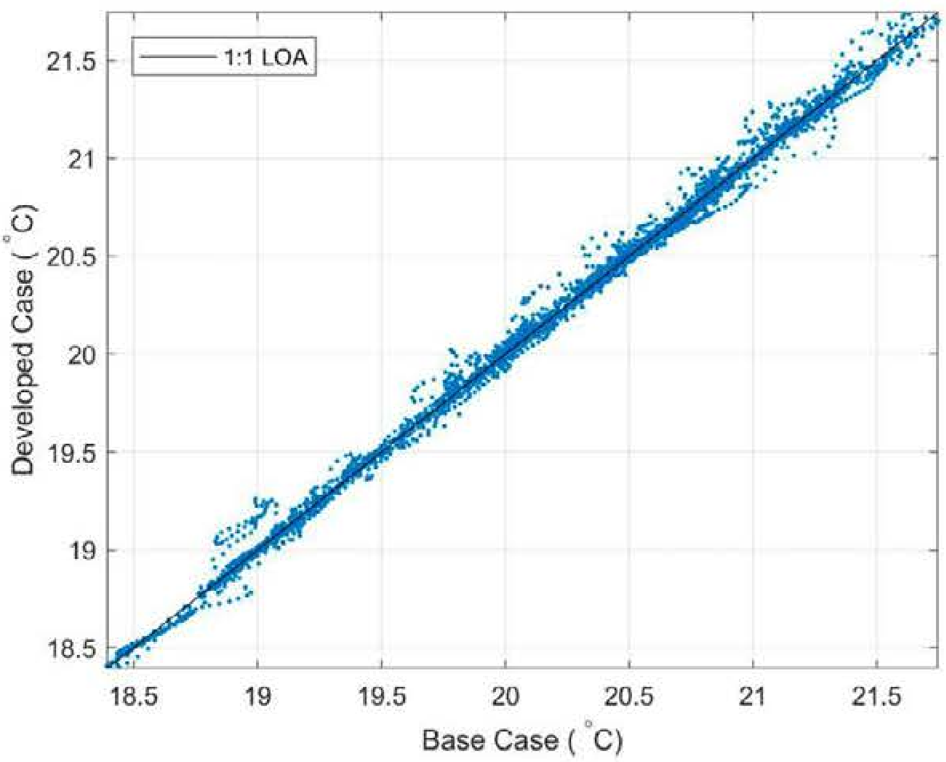


Figure 6-12 Scatter plot comparison of depth-averaged temperature at Yumbah Intake West

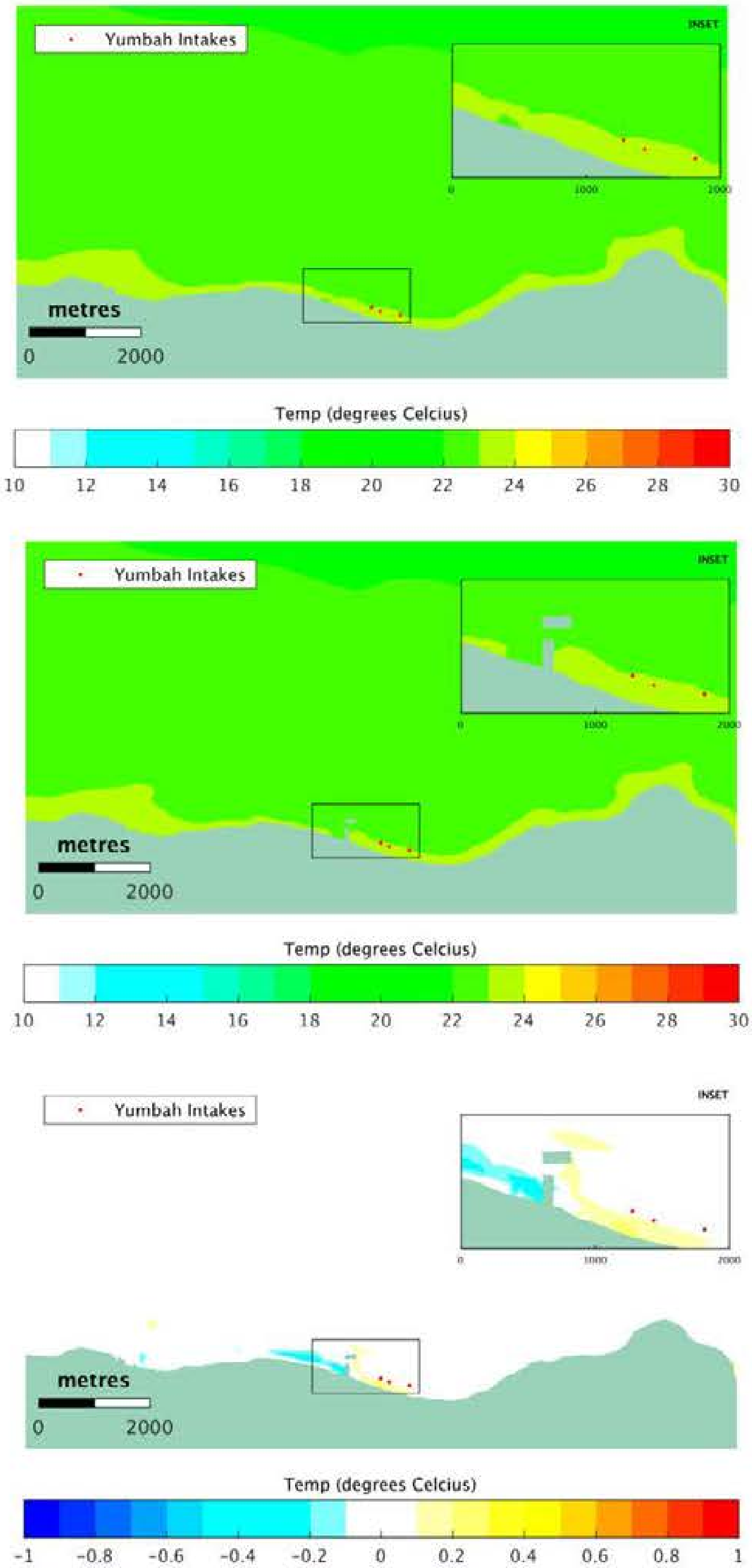


Figure 6-13 Maximum depth-averaged temperature, base case (Top); developed case (Mid) and impact (Bottom)

6.5 Smith Creek Flow Scenario

6.5.1 Methodology

This assessment was undertaken in order to predict the impact of the proposed development on the mixing of flood-plumes from Smith Creek into the Smith Bay marine waters. Smith Creek discharges immediately to the west of the proposed wharf and therefore the causeway might be expected to affect how the creek plume disperses into nearshore waters.

The wave energy at Smith Bay is too high, particularly during energetic winter conditions, to allow for stable deposits of terrestrial silt. The principal line of effect related to Smith Creek discharge is the short-term water quality impacts from the creek plumes comprising freshwater, sediment and other terrestrial pollutants. A single large flood event (1-in-10 AEP) adopted to assess the quality of the creek plume connectivity with Smith Bay sensitive receptors, in particular the Yumbah seawater intakes.

A 1-in-10 AEP flood discharge hydrograph for Smith Creek (described in Section 2.6) was applied to the TUFLOW FV coastal hydrodynamic-sediment transport model. This creek source had an event mean suspended solids concentration of 140 mg/L considered likely for agricultural and grazing runoff (Chiew F and Scalon P, 2002) and a peak flow rate of 58 m^3/s. The associated sediment release was split evenly between clay and silt fractions with a total of 165 tonnes of fines released during the flood. This flood release was simulated over the relatively energetic Winter and Summer periods for both the existing bathymetry and the fully-developed scenarios.

6.5.2 Results

The 99th percentile of the base (existing condition) case, developed case and the impact to the 99th percentile depth-averaged TSS from the flood plume is shown in Figure 6-14. This shows that the constructed causeway causes the flood plume to be constrained near the creek mouth and then directed further offshore. This results in an increased TSS to the west of the causeway and further offshore in the Bay, but a decreased TSS in the nearshore zone to the east of the causeway, including at the locations of the Yumbah intakes.

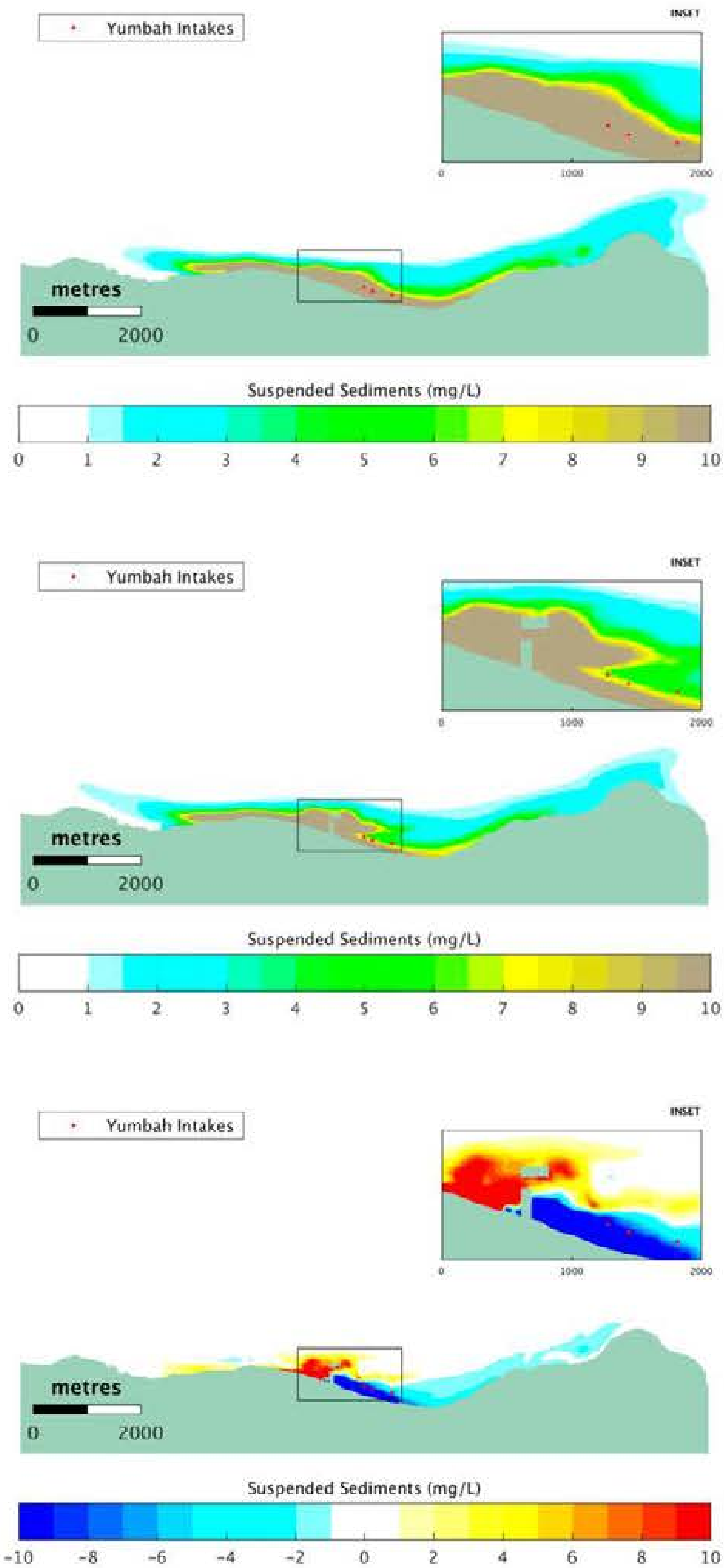


Figure 6-14 Depth-averaged flood plume TSS (99th percentile) for base case (Top), developed case (Middle), and impact (Bottom)

6.6 Sediment Transport Impacts

6.6.1 Assessment Methodology

The sub-aerial beach and dune system at the Project site is formed by predominantly cobble-sized sediments. Offshore of the inter-tidal beach the seabed is generally covered by dense macroalgae and seagrass assemblages. These characteristic features of the Smith Bay littoral zone will tend to strongly limit the active littoral sediment transport within this coastal compartment. The range of nearshore environments from the sub-aerial beach to depths of around 10 m is illustrated in Figure 6-15.

In this context, numerical modelling of littoral sediment transport quantities is of limited value in assessing the risk from the Project to nearshore morphological changes. Instead, the potential for coastal sediment transport impacts and associated changes to seabed sediment characteristics was assessed based on modelling of combined wave and current bed shear stresses.

Figure 6-15 Nearshore coastal environment. Littoral sediment transport is limited by predominantly coarse beach sediments and dense macroalgae and seagrass assemblages

6.6.2 Bed Shear Stress Impacts

The root-mean-square (RMS) bed shear stress due to combined wave and current action on the seabed was calculated within the TUFLOW FV sediment transport module using the procedure of Soulsby (1997). The 50th and 95th percentile statistics of the calculated bed shear stress was summarised from the base and developed case simulations. The bed shear stress impact results are shown in Figure 6-16 and Figure 6-17.

The assessment shows that bed shear stress offshore of Smith Bay is broadly in excess of 0.5 Pa under both median and more-energetic conditions. This result is consistent with the predominantly coarse sand and cobble size of the surface sediments. In shallower offshore reef areas and in the immediate nearshore zone (depths <5 m) the 95th percentile bed shear stress values are typically in excess of 1 Pa as would be expected in regions of depth-limited (breaking) waves.

The proposed development results in a region of reduced bed shear stress in the lee of the floating wharf and causeway structures (Figure 6-17). The deepened (dredged) berth and approach footprint could also potentially experience reduced bed shear stresses and thereby become a zone of sediment deposition.

However, despite the predicted reductions the 95th percentile bed shear stresses remain in excess of 0.5 Pa in the lee of the structure. This result indicates that it would be unlikely for this region to become an area of silt deposition in the developed case, as the shear stress remains too high for fine sediment fractions to form stable deposits.

Only very minimal changes to bed shear stress are apparent within the dredge footprint area and for this reason it is also unlikely that this area would experience net fine sediment deposition necessitating regular or substantial maintenance dredging operations.

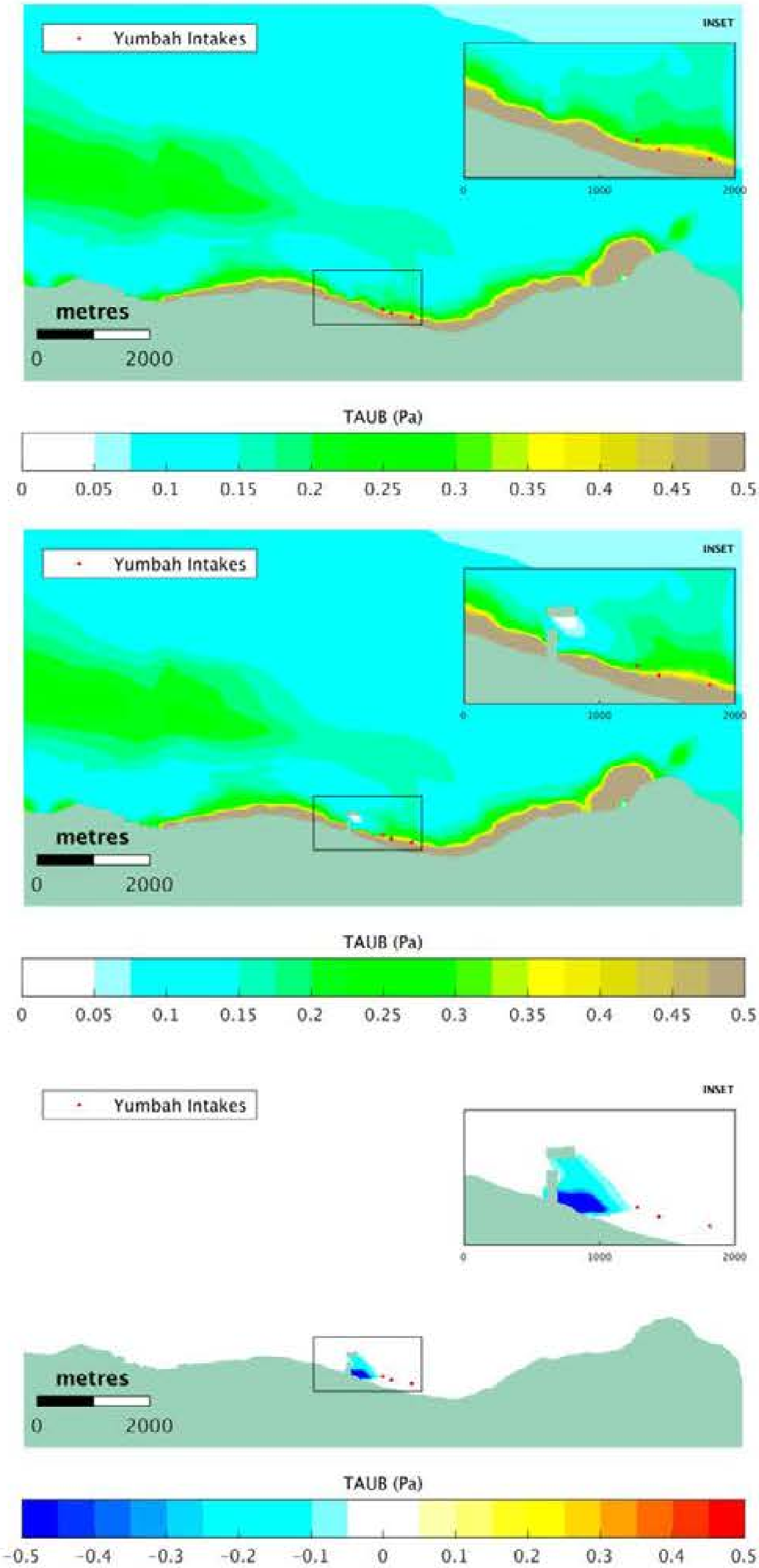


Figure 6-16 50th Percentile bed shear stress, Base Case (Top); Developed Case (Mid) and Impact (Bottom)

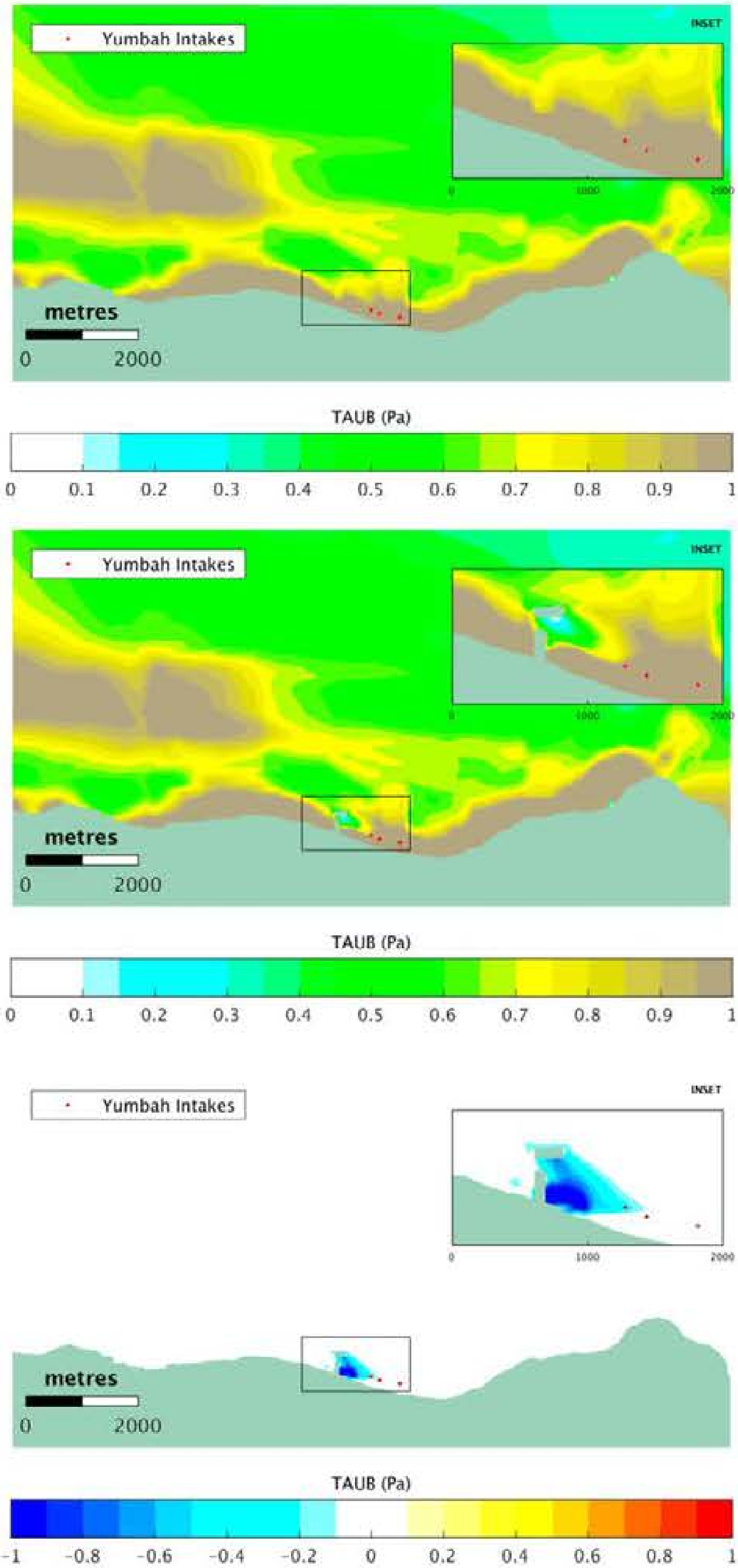


Figure 6-17 95th Percentile bed shear stress, Base Case (Top); Developed Case (Mid) and Impact (Bottom)

6.7 Summary

Based on the coastal process modelling assessment the following conclusions can be made:

- Generally, impacts on coastal circulation are highly localised and in the immediate vicinity of the Project infrastructure where some local realignment and modification of current speeds will occur.
- Coastal circulation impacts are not expected to result in reduced flushing of Smith Bay waters nor to increased potential for elevated water temperatures.
- There will be minor modification to wave propagation in the immediate vicinity of Project infrastructure but no detectable impact to wave conditions elsewhere within Smith Bay.
- There will be no significant impact to sediment transport pathways and beach processes outside the immediate Project area.
- The Project dredged footprint and areas adjacent to the causeway structure are unlikely to experience persistent fine sediment deposition which would require ongoing management.

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Appendix A Dredge Campaign Nearbed TSS Timeseries

Summer 2015 Benthic TSS

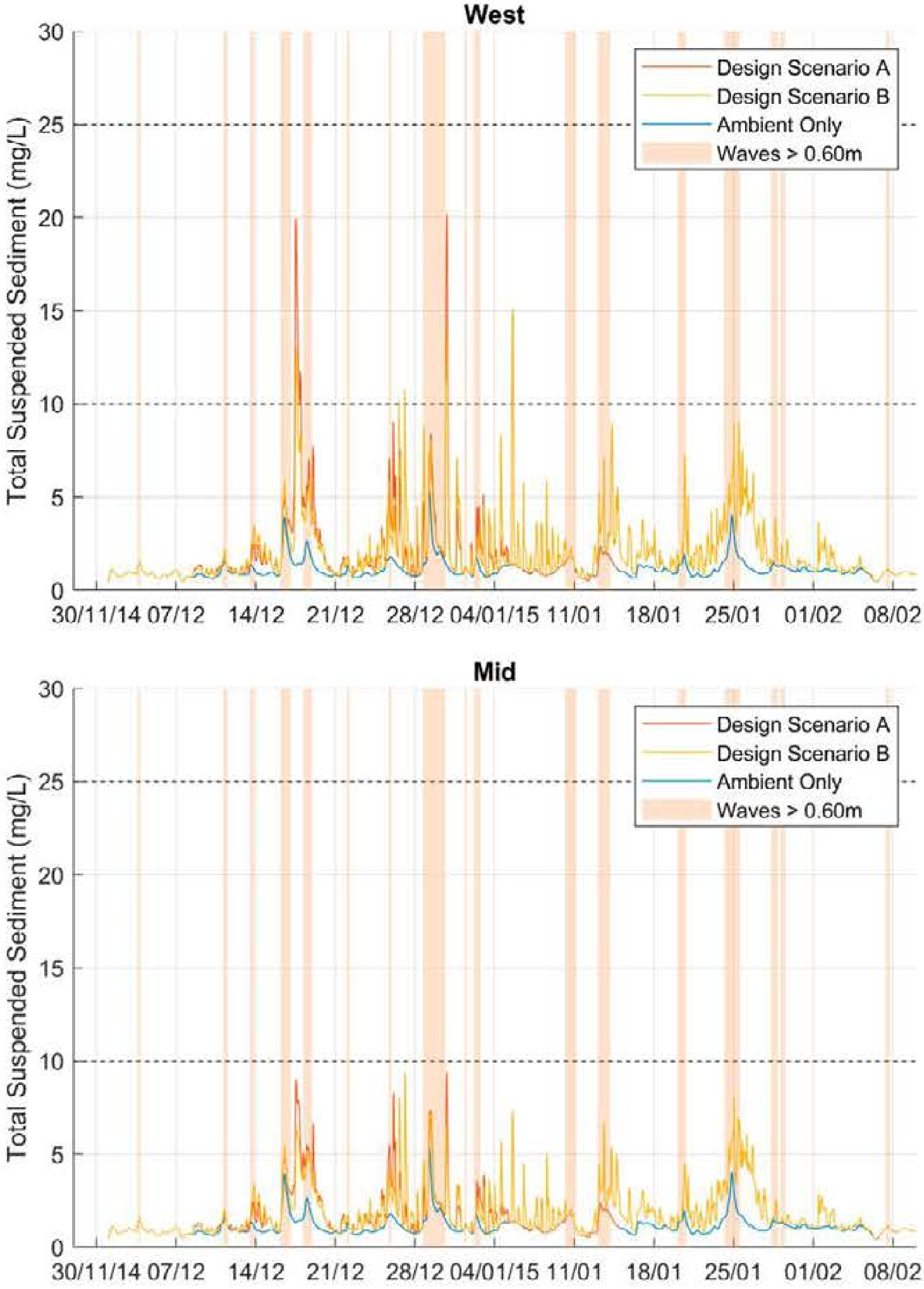

Figure A-1 Summer 2015 Bottom 1m Sediment Timeseries

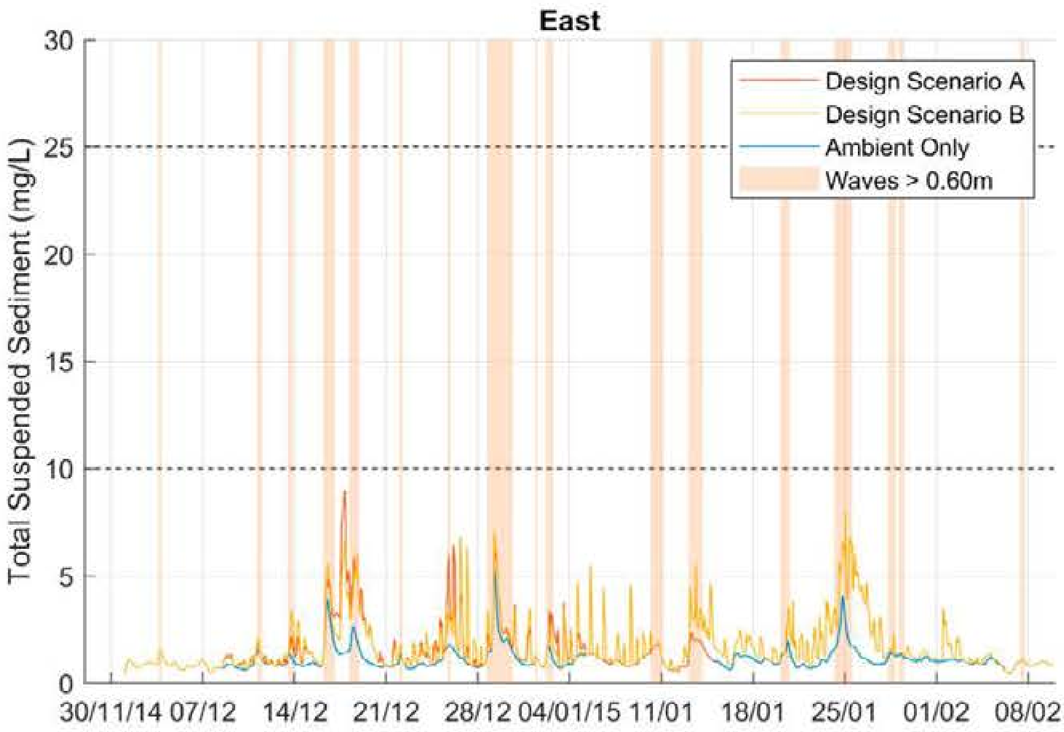

Figure A-2 Summer 2015 Bottom 1m Sediment Timeseries

Winter 2015 Benthic TSS

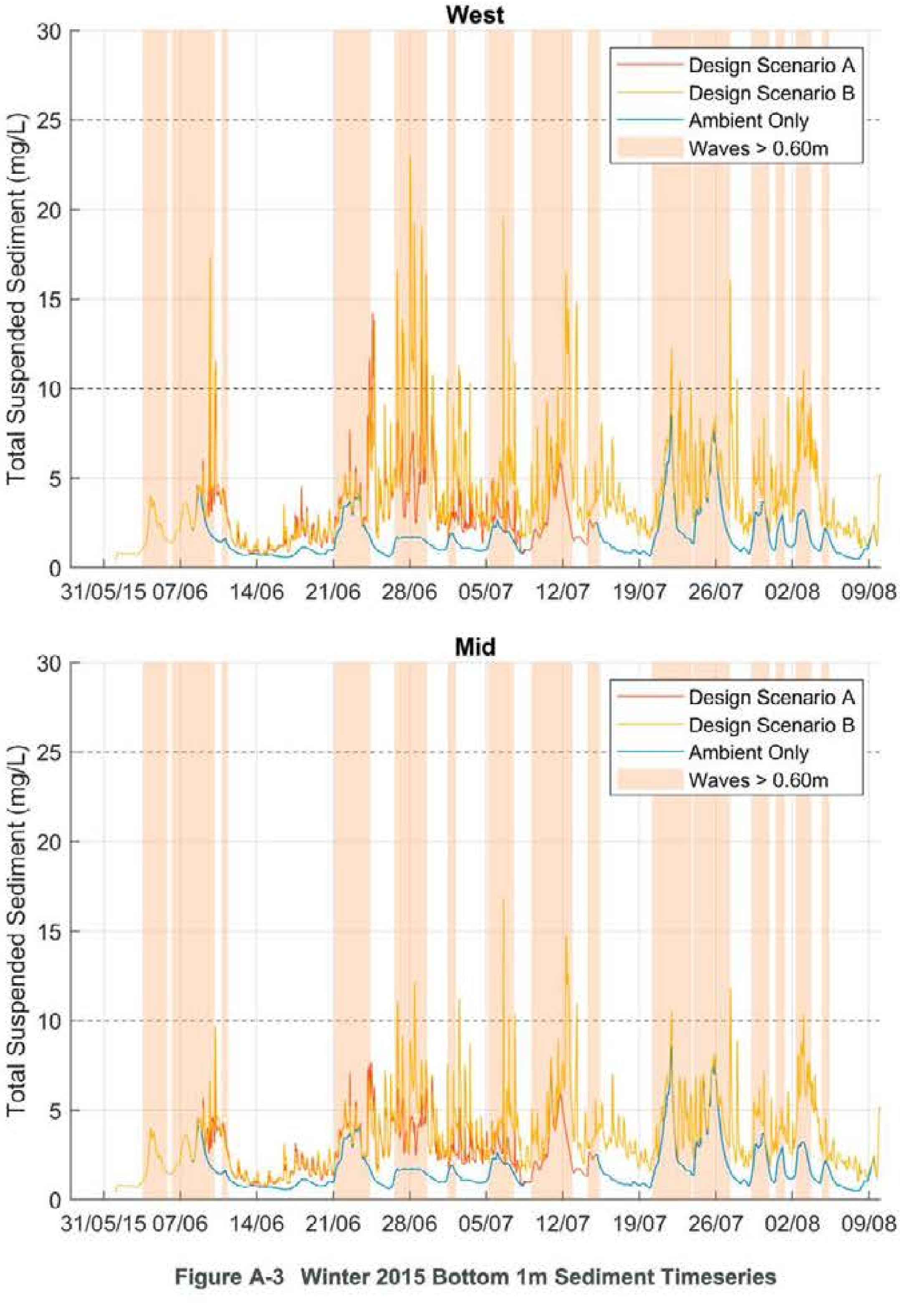

Figure A-3 Winter 2015 Bottom 1m Sediment Timeseries

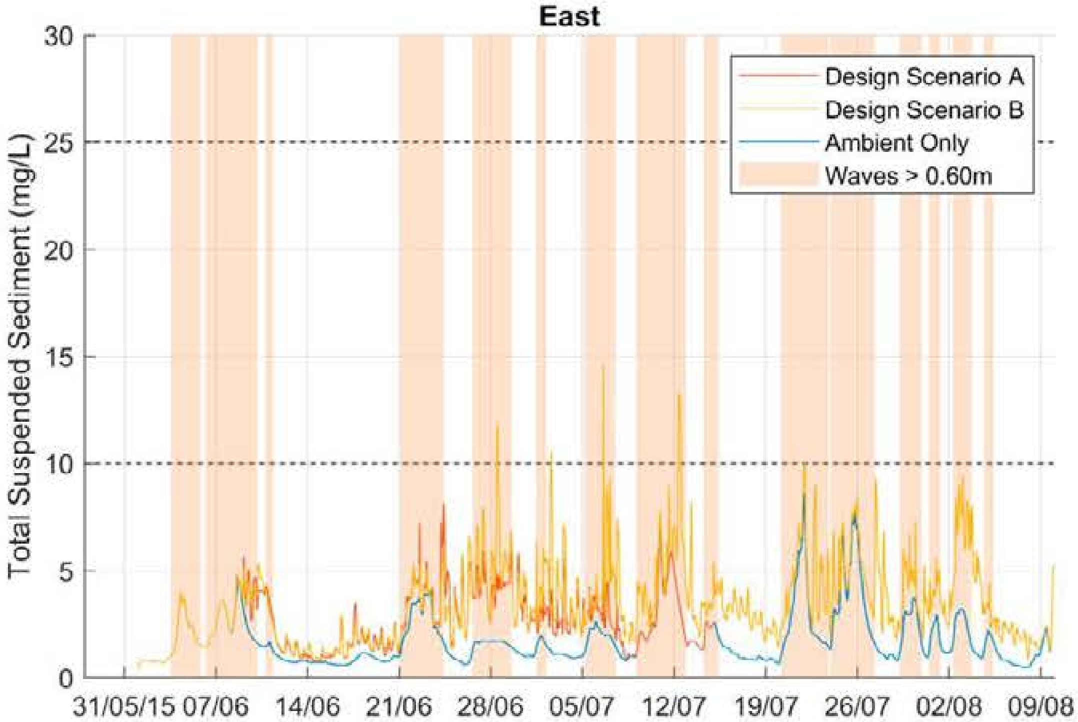

Figure A-4 Winter 2015 Bottom 1m Sediment Timeseries

Summer 2016 Benthic TSS

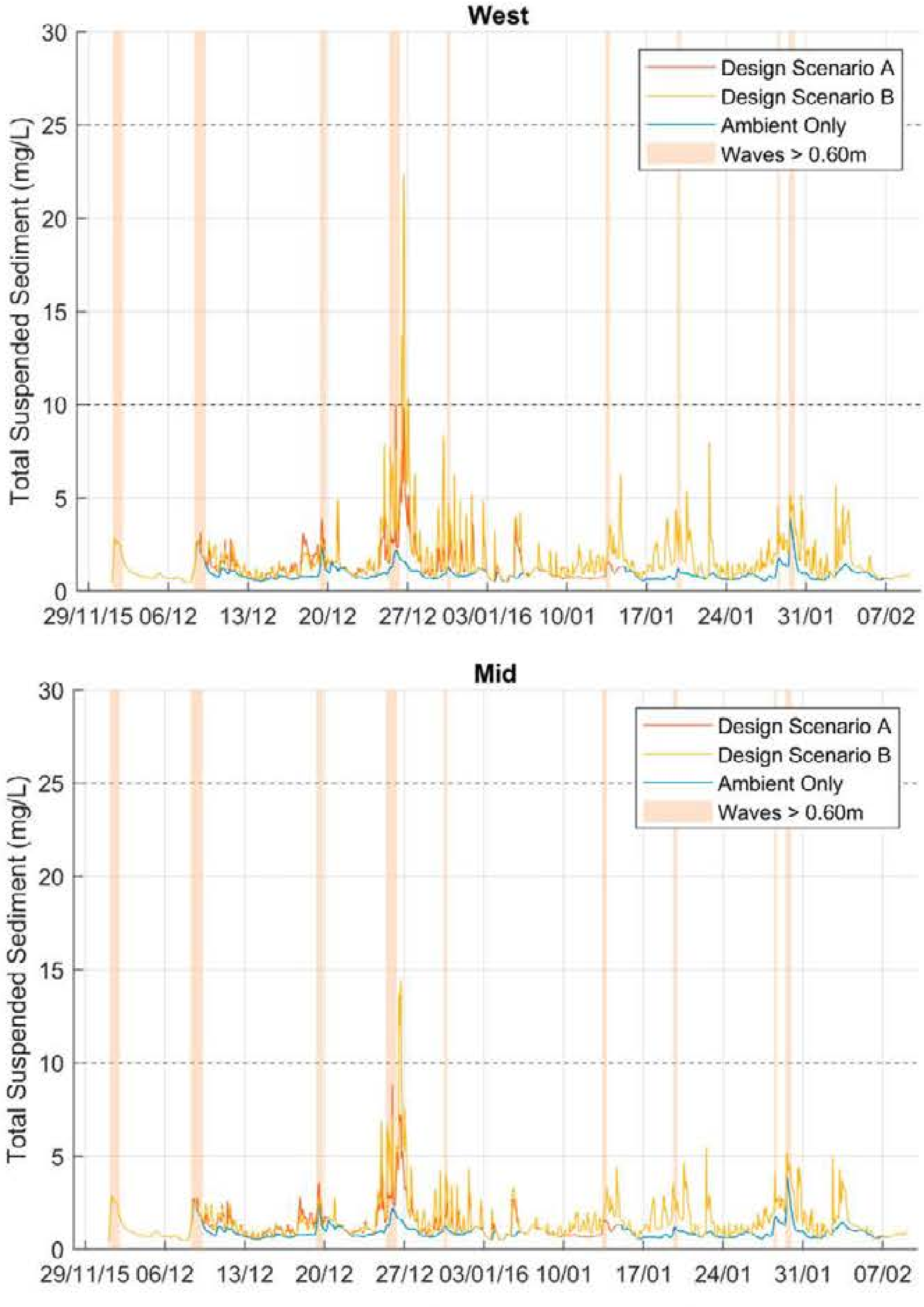

Figure A-5 Summer 2016 Bottom 1m Sediment Timeseries

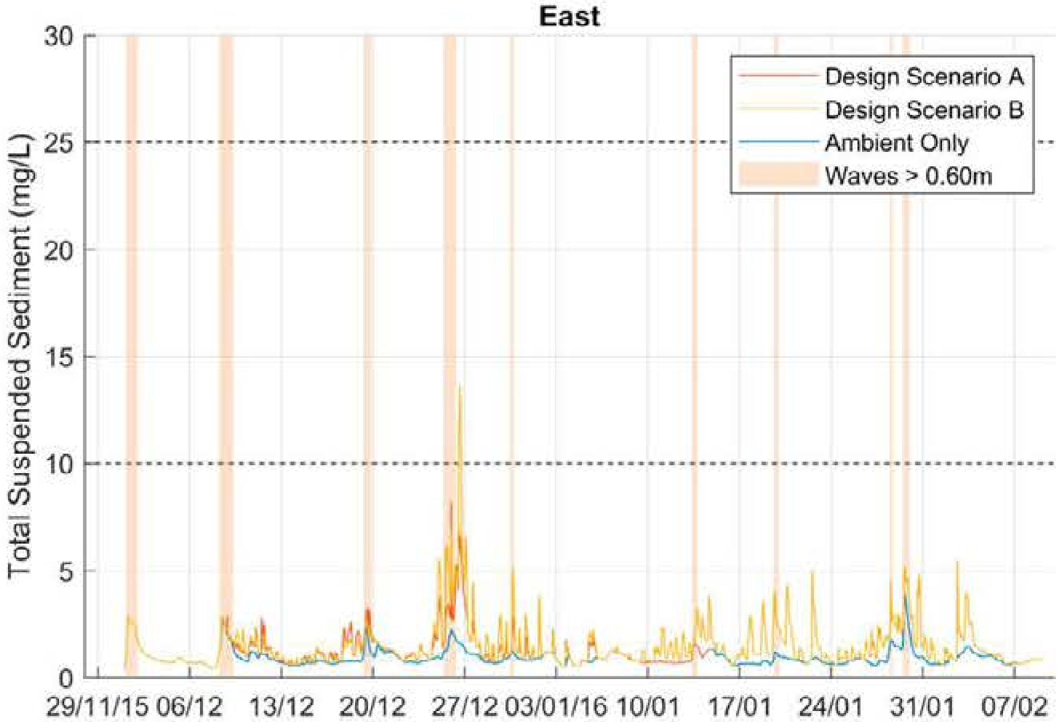

Figure A-6 Summer 2016 Bottom 1m Sediment Timeseries

Winter 2016 Benthic TSS

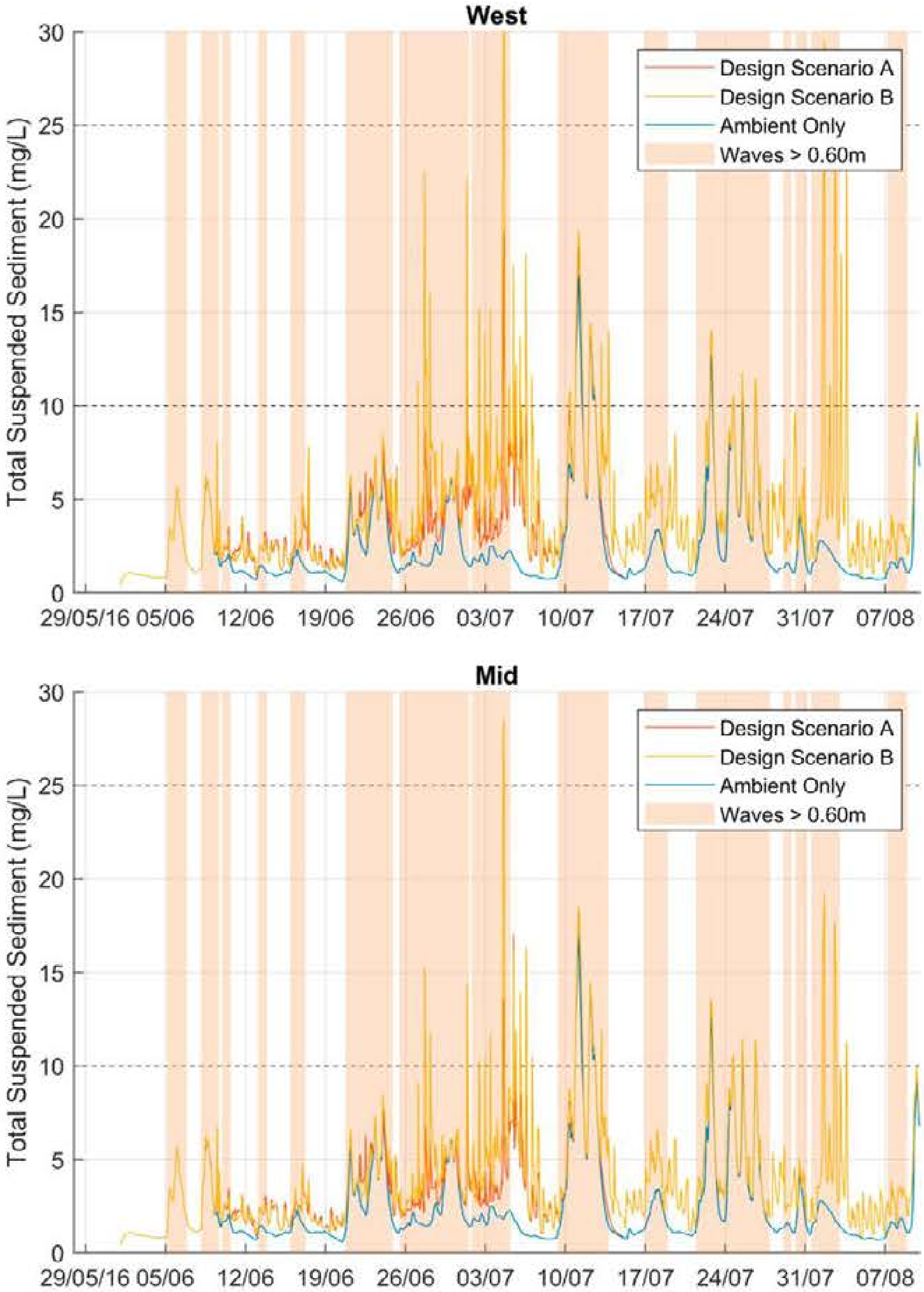

Figure A-7 Winter 2016 Bottom 1m Sediment Timeseries

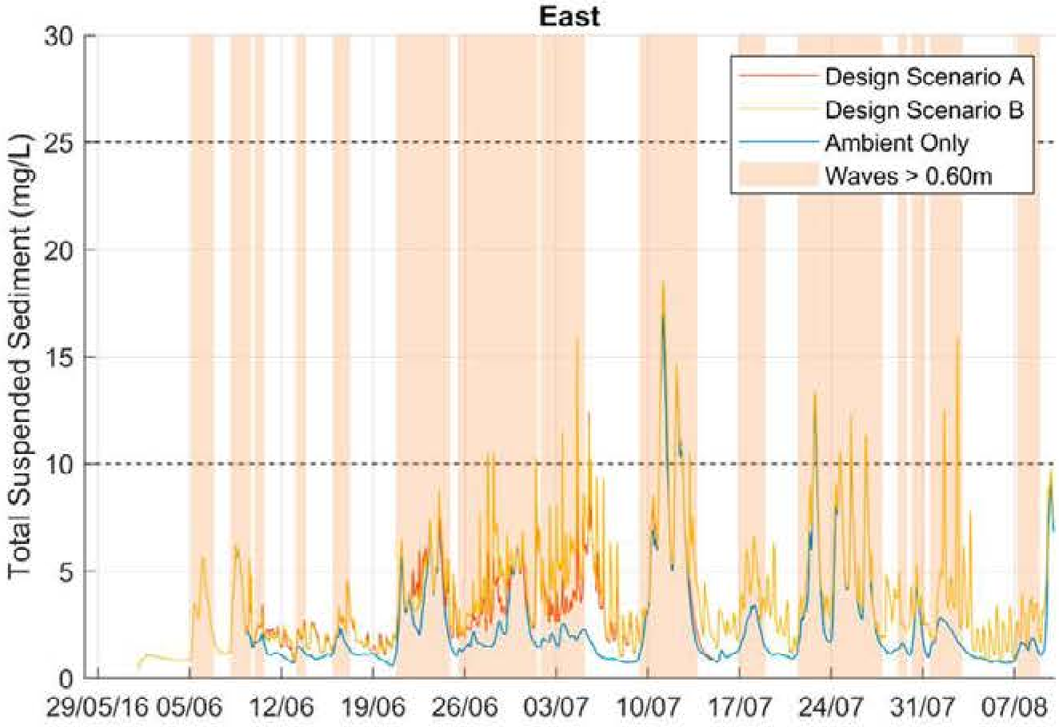

Figure A-8 Winter 2016 Bottom 1m Sediment Timeseries

Appendix B Smith Creek Flood Nearbed TSS Timeseries

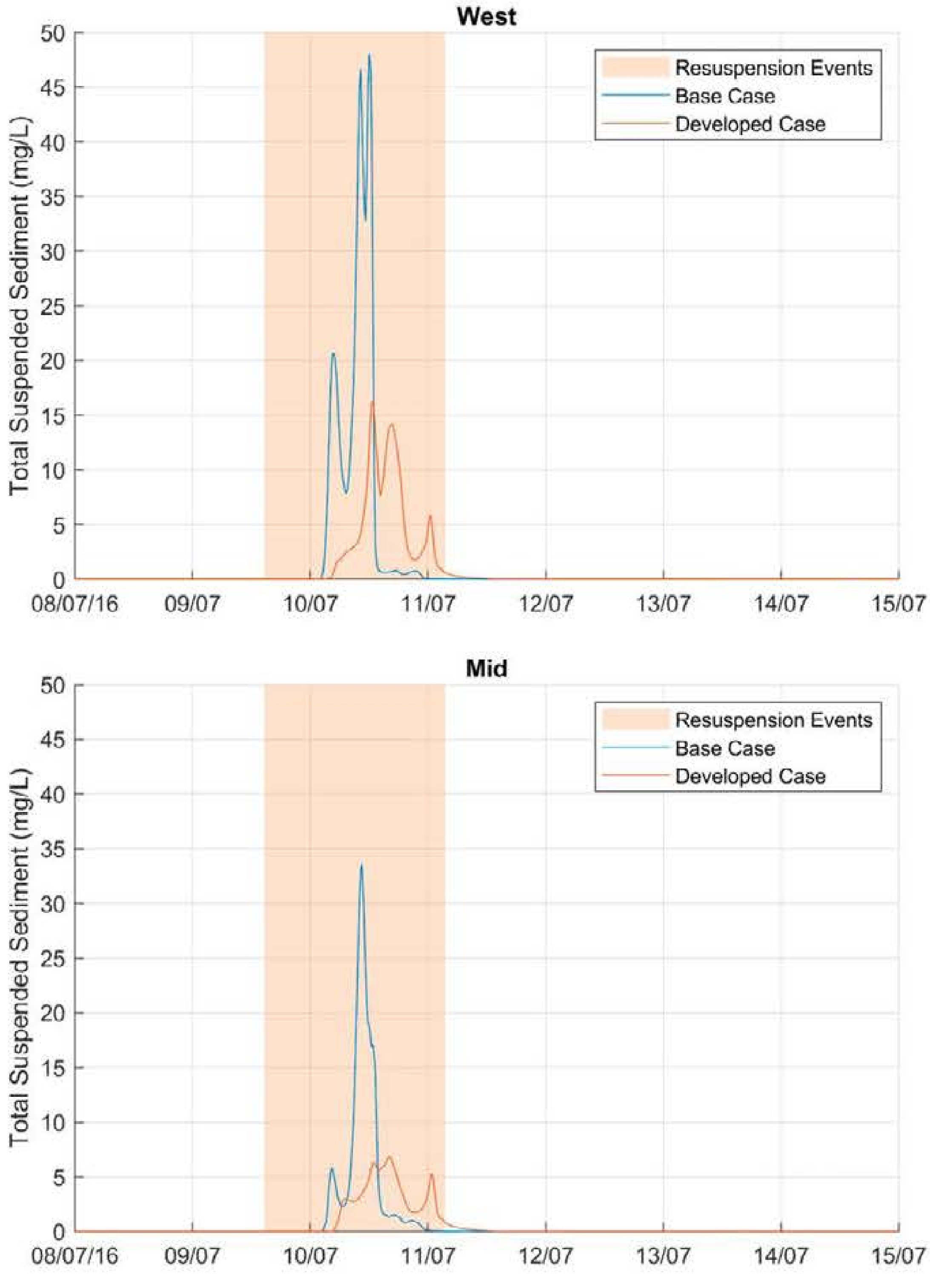

Figure B-1 Winter Bottom 1m Creek Plume TSS at West (Top) and Mid (Bottom) Intakes

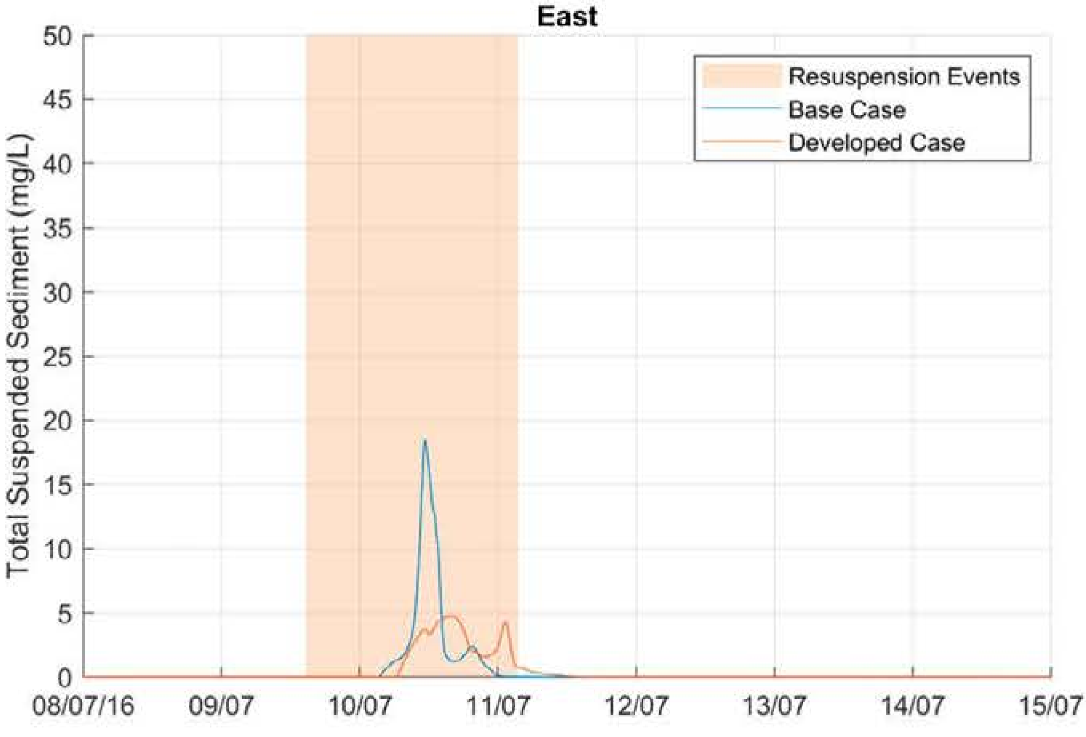

Figure B-2 Winter Bottom 1m Creek Plume TSS at East Intake

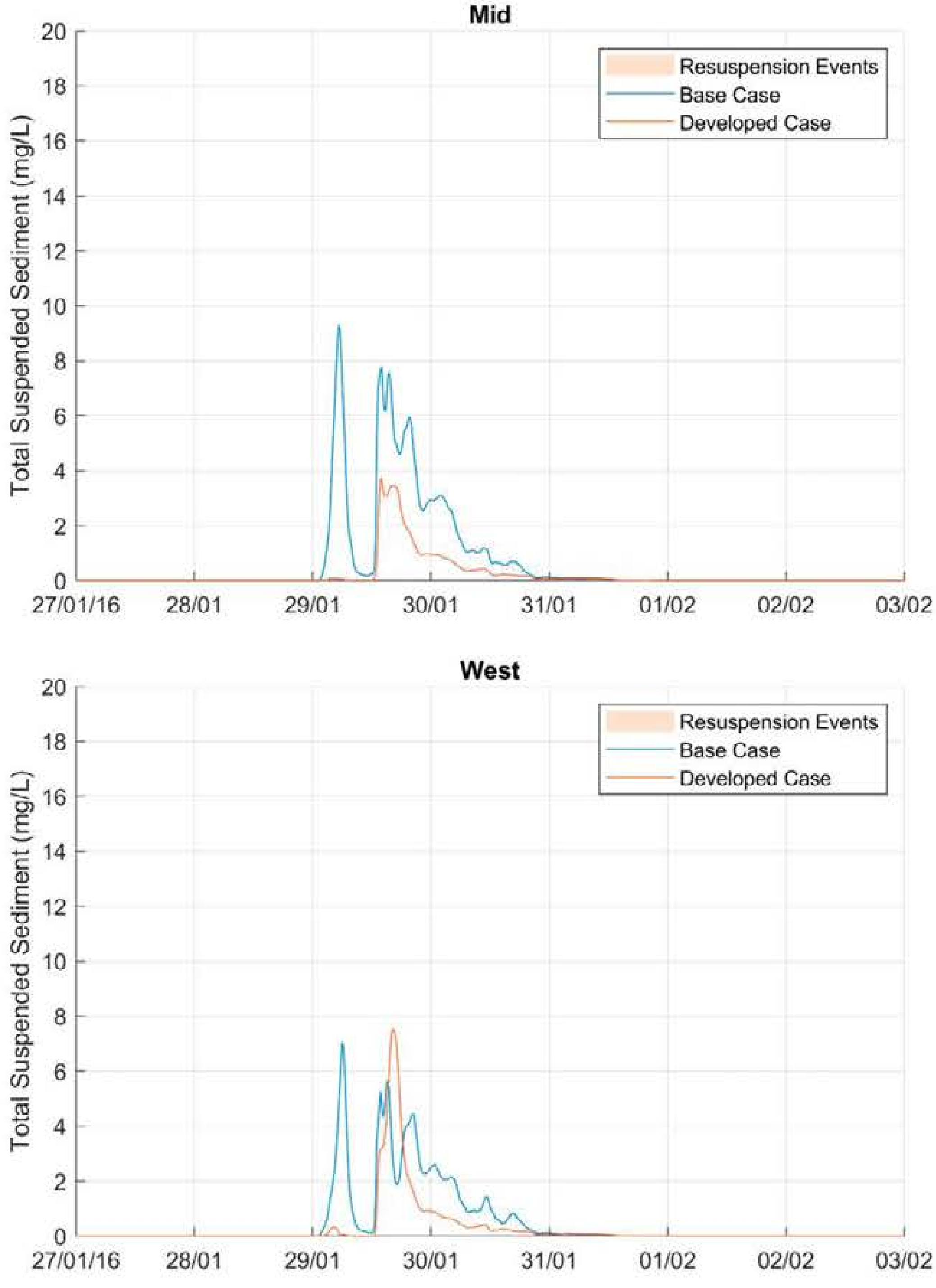

Figure B-3 Summer Bottom 1m Creek Plume TSS at West (Top) and Mid (Bottom) Intakes

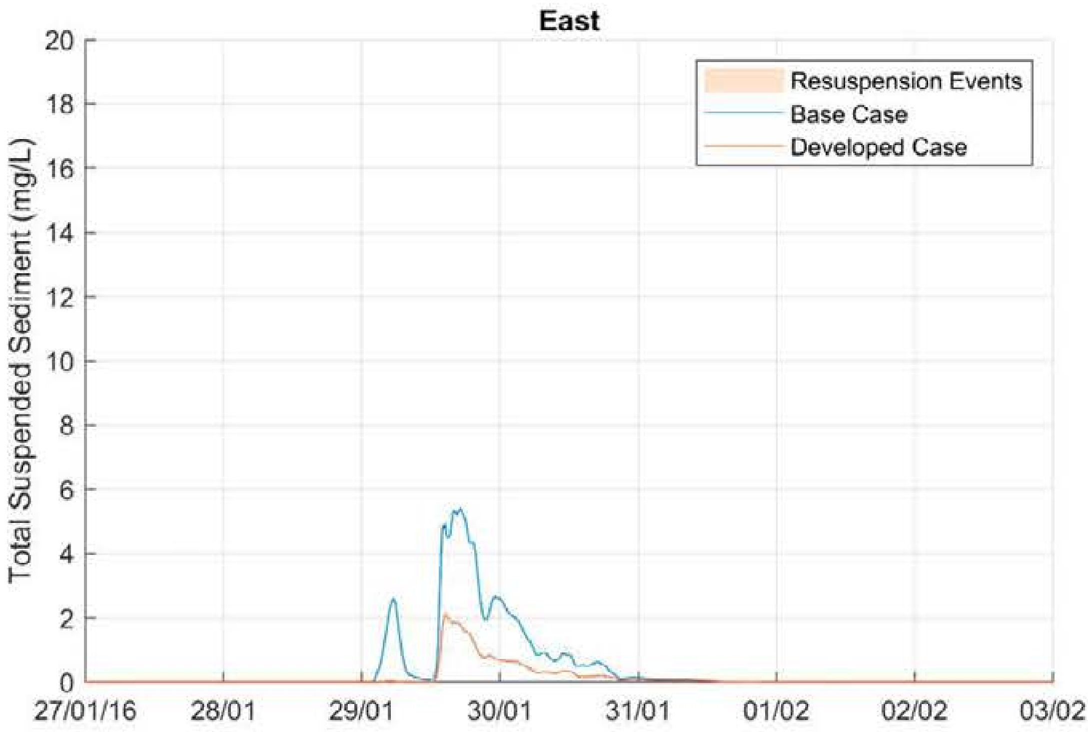

Figure B-4 Summer Bottom 1m Creek Plume TSS at East Intake

Appendix C External Peer Review Report

Environmental Projects
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Ref:	Init:	Date:
43802837	JANT	11 Jan 2019

Concerning – Smith Bay Wharf Project: Peer Review of Hydrodynamic Modelling

Dear Maria

DHI was engaged to conduct a peer review of the hydrodynamic modelling studies undertaken by BMT WBM associated with the above project. The review was conducted on technical reports delivered to DHI. No review was conducted of the actual model input files, model configuration files or model output files.

This peer review involved three stages of review in May, September and December 2018, with comments to each stage logged in an electronic record and subsequently responded to by BMT WBM. These comments have been closed out to my satisfaction as of the above date.

The review considered the following items:

- The suitability of the model software suite selected for the study.
- The configuration of that model software suite, and the input data used to drive it.
- The suitability of the calibration and validation of the hydrodynamic model, relative to industry norms.
- Sensitivity of the model results to input data and configuration.
- The communication of model results.

I am satisfied that the modelling work is appropriate and consistent with the level of care and skill typically exercised by practitioners in this field, and that the conclusions of the work are valid.

Best regards

DHI

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BMT has a proven record in addressing today's engineering and environmental issues.

Our dedication to developing innovative approaches and solutions enhances our ability to meet our client's most challenging needs.

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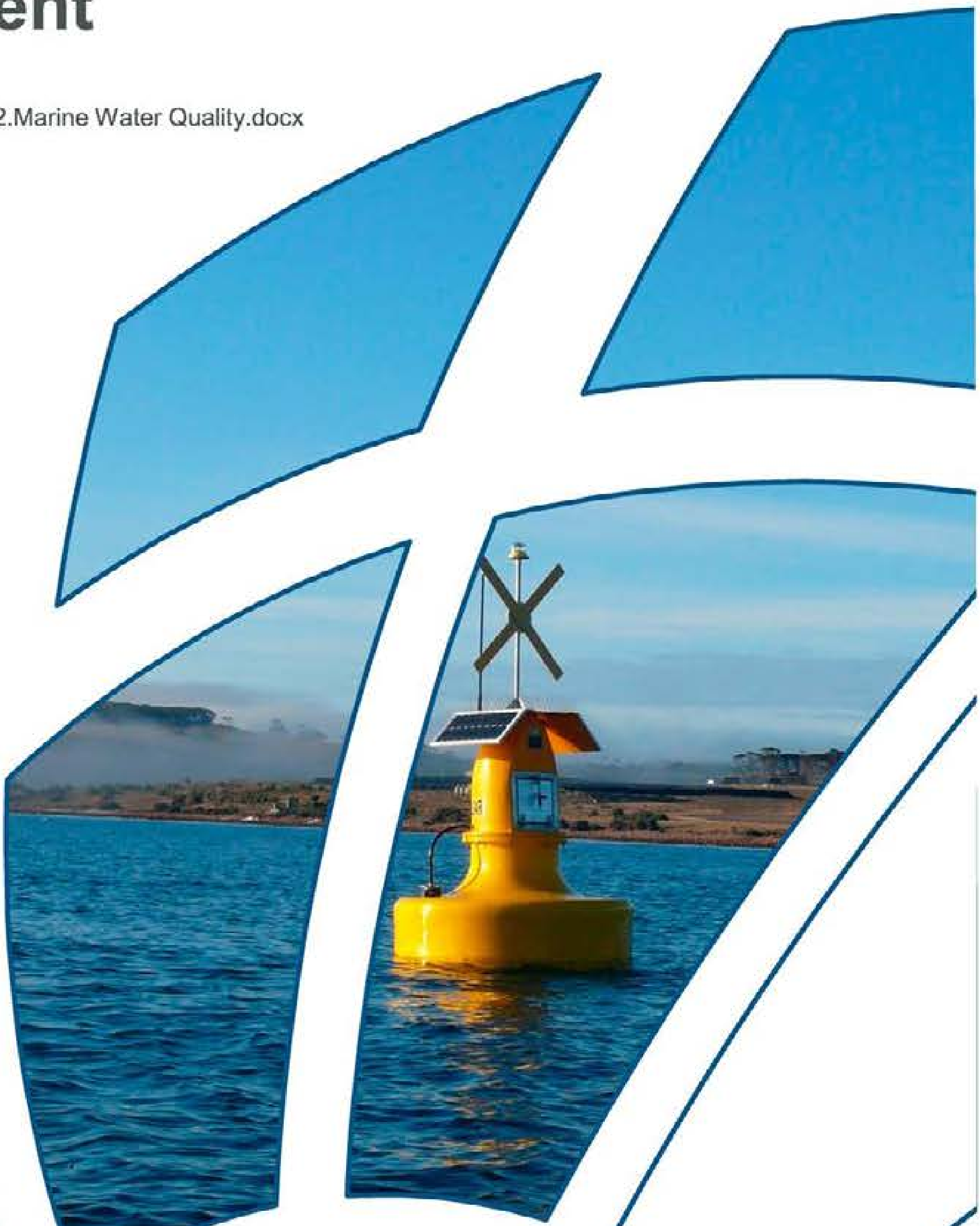
Appendix F3 – Marine Water Quality Baseline and Impact Assessment – BMT

Smith Bay EIS - Marine Water Quality Baseline and Impact Assessment

Reference: R.B22454.004.02.Marine Water Quality.docx
Date: December 2018



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Document:	R.B22454.004.02.Marine Water Quality.docx
Title:	Smith Bay EIS - Marine Water Quality Baseline and Impact Assessment
Project Manager:	Ian Teakle
Author:	Brad Grant
Client:	Environmental Projects
Client Contact:	Maria Pedicini
Client Reference:	

Synopsis: This report presents the baseline marine water quality data for Smith Bay, Kangaroo Island, SA, along with impact assessment findings in relation to the proposed project.

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1 Introduction

Kangaroo Island Plantation Timbers (KIPT) proposes to develop a deepwater wharf at Smith Bay on the north coast of Kangaroo Island (Figure 1). The wharf will be capable of accommodating Handymax (30,000 DWT) to Panamax (60,000 DWT) bulk carrier ships. The primary purpose of the wharf will be to export timber from plantations on the island.

The main features of the development at Smith Bay will be:

- The construction of a causeway to a floating wharf moored approximately 250 m offshore at a depth of 10 m at its seaward edge; and
- The dredging of a 200 x 50 m berthing pocket adjacent to the wharf to depth of 13 m.

The onshore component of the development at Smith Bay will entail constructing several level tiers over an area of approximately 8 ha to store logs and woodchips, access roads and associated amenities.

This report presents the baseline (existing environment) marine water quality for the study location of Smith Bay, along with an assessment of impacts to marine water quality from the proposed project.

1.1 Study Location

Smith Bay is located on the northern coast of Kangaroo Island (refer Figure 1-1).

Title:

Study Location

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Figure: 1-1

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2 Existing Environment

2.1 Methodology

2.1.1 Review of Existing Data

The following existing water quality data for the Smith Bay area was available for review:

- **Environmental Projects** – water quality data was collected in September 2017 by Environmental Projects staff during geotechnical drilling works for the Project. *In-situ* water quality readings were recorded adjacent to the BMT water quality monitoring buoy (Section 2.1.2.1), and water samples were collected for laboratory analysis of total suspended solids (TSS), nutrients and metals.
- **Tanner & Bryars (2007)** – results from a study of the impacts of land-based abalone aquaculture discharges on the adjacent marine environment was reported by Tanner & Bryars (2007). For this study, water samples were collected at a number of sites in Smith Bay (refer to Figure 2-1 for locations), including subtidal surveys undertaken at two farms sites (F1 and F2) adjacent to the main farm and three non-farm sites (NF1-3) that were >1 km away from F1 and F2. Intertidal surveys were undertaken at one farm site (F1), one site at the new farm (New F) and two non-farm sites (NF2 and NF4). Samples were analysed for nutrients.
- **Environment Protection Authority (EPA)** – turbidity and nutrient water quality data was made available for two sites (m0081 and m0082) near to Smith Bay (refer to Figure 2-2 for locations). This data was collected by EPA staff in May 2017.

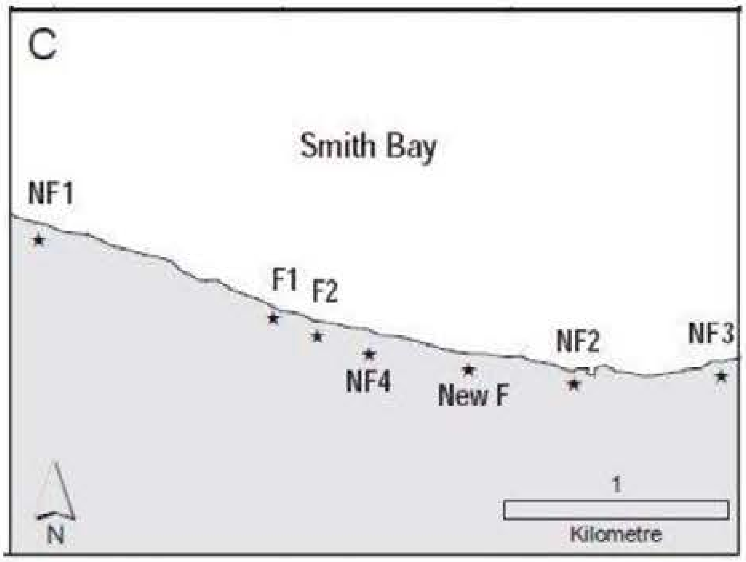

Figure 2-1 SARDI monitoring sites (source: Tanner & Bryars 2007). Location of proposed KIPT site is approximately 500 m west of site F1

Legend

△ **EPA Monitoring Site**

Title:

EPA Monitoring Sites

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2.1.2 Data Collection

2.1.2.1 Water Quality Monitoring Buoy – 12 Months

To collect additional baseline data, a water quality monitoring buoy was deployed by BMT in Smith Bay for a period of approximately 12 months (31 January 2017 to 20 February 2018).

Water quality measurements were recorded using a YSI EXO2 multi-parameter water quality instrument (Figure 2-3). The instrument was fitted with an anti-fouling wiper, and measurements of conductivity, temperature, depth, and turbidity were logged every 10 minutes.

The water quality instrument was deployed in a buoy (Figure 2-4) located approximately 200 m offshore (refer to Figure 2-7 for location) in a water depth of approximately 7-8 m. The sensors were located approximately 1 m below the water surface, and the buoy was fitted with telemetry for remote access of data.

The monitoring buoy was serviced approximately every six weeks, with sensors cleaned and calibrated. During each servicing trip, water quality profiles and water samples were taken adjacent to the buoy. The monitoring buoy data was checked for sensor drift or biofouling using spot measurement data collected by BMT during the servicing trips and also from spot measurements collected by Environmental Projects (Section 2.1.1).

Figure 2-3 YSI EXO2 Water Quality Instrument

Figure 2-4 Water quality monitoring buoy (BMT)

2.1.2.2 Bed-Mounted Instrument Deployment – 6 Weeks

Additional instruments were deployed at three locations in Smith Bay for a 6-week period during Jan-Feb 2018. The purpose of this additional instrument deployment was to collect a concurrent Metocean and water quality dataset at Smith Bay. In terms of water quality data, the instrument deployment included the following:

- Measurements of near-bed turbidity (at three depths) to augment the continuous measurements from the water quality monitoring buoy (which measured water quality 1 m below the surface).
- Measurements of benthic Photosynthetically Active Radiation (PAR).
- Analysis of ambient sedimentation to determine approximate (average) rate, particle size and origin (inorganic vs organic).
- Establishment of a total suspended solids (TSS) to turbidity relationship for *in-situ* seabed surface fine-sediments.

The instruments were deployed on seabed mounted frames (Figure 2-5) at three sites: Site 1 in 6 m of water, Site 2 in 10 m of water and Site 3 in 14 m of water – refer to Figure 2-7 for locations. The following instrumentation was deployed on each frame:

- Water quality instrument (YSI 6000) measuring temperature, conductivity and turbidity in 15-minute intervals.
- Benthic PAR sensors (Odyssey) with automatic wiper, logging measurements in 15-minute intervals.
- One site (Site 2) had an array of benthic PAR sensors mounted 1 m vertically apart in the water column to assess light attenuation.

- Sedimentation tubes to collect settled sediment particles.

An additional PAR logger was also installed at the Smith Bay house to measure surface (terrestrial) PAR.

Sedimentation tube specimen analysis was undertaken through a certified laboratory, with analysis of the Particle Size Distribution, including inorganic vs organic fraction analysis.

During the instrument deployment trip, representative surface sediment samples were collected and mixed with seawater in order to prepare varying suspended sediment concentration samples. These samples were analysed for TSS and turbidity, with the results used to establish a TSS to turbidity relationship.

Figure 2-5 Instrument deployment using bottom-mounted frames

2.1.2.3 Quality Assurance / Quality Control – Instrument Data

2.1.2.3.1 Quality Assurance Procedures

Quality Assurance (QA) during monitoring involved:

- Use of suitably qualified and competent staff experienced in water quality sampling and use of instrumentation.
- Water quality loggers were cleaned, serviced and calibrated regularly as recommended by the manufacturer.

2.1.2.3.2 Quality Control (QC) Procedures

Water quality instruments in the marine environment are subjected to harsh conditions so it is necessary to check data for quality and rigour to ensure only reliable data is retained. To do this, it must be determined whether recorded data are real and representative of actual conditions, or whether they may be affected by instrument anomalies or non-representative outlier events. Data anomalies may be caused by, for example:

- Temporary spikes created by drifting material or animals, or disturbance of sediments by boats, animals or humans;
- Sensor malfunction;
- Sensor siltation;
- Invertebrate/algal fouling of sensors; and
- Human error (e.g. calibration error).

The following quality control procedures were implemented during daily download of data *via* telemetry:

- Raw data were plotted as a time series and suspected outliers investigated with the following process:
  - Suspected outliers were compared to data within the same instrument dataset from a similar period of time to determine if data were correct. For example, if human or animal interaction is suspected in the event of short-term, single event turbidity spikes when turbidity readings either side of these spikes were >10% lower.
  - Data was then examined with consideration to the meteorological conditions at the time (with data from Bureau of Meteorology) to determine whether rainfall or wind conditions may have affected the measurements in question. If high rainfall or strong winds did not accompany spikes in turbidity, the data was considered potentially erroneous and subjected to further scrutiny.
  - The data was also compared with data from spot measurements and water samples collected adjacent to the instruments to determine if there was any sensor drift or biofouling. Data was adjusted accordingly if required.
- Any potentially erroneous data was quarantined from the data set.

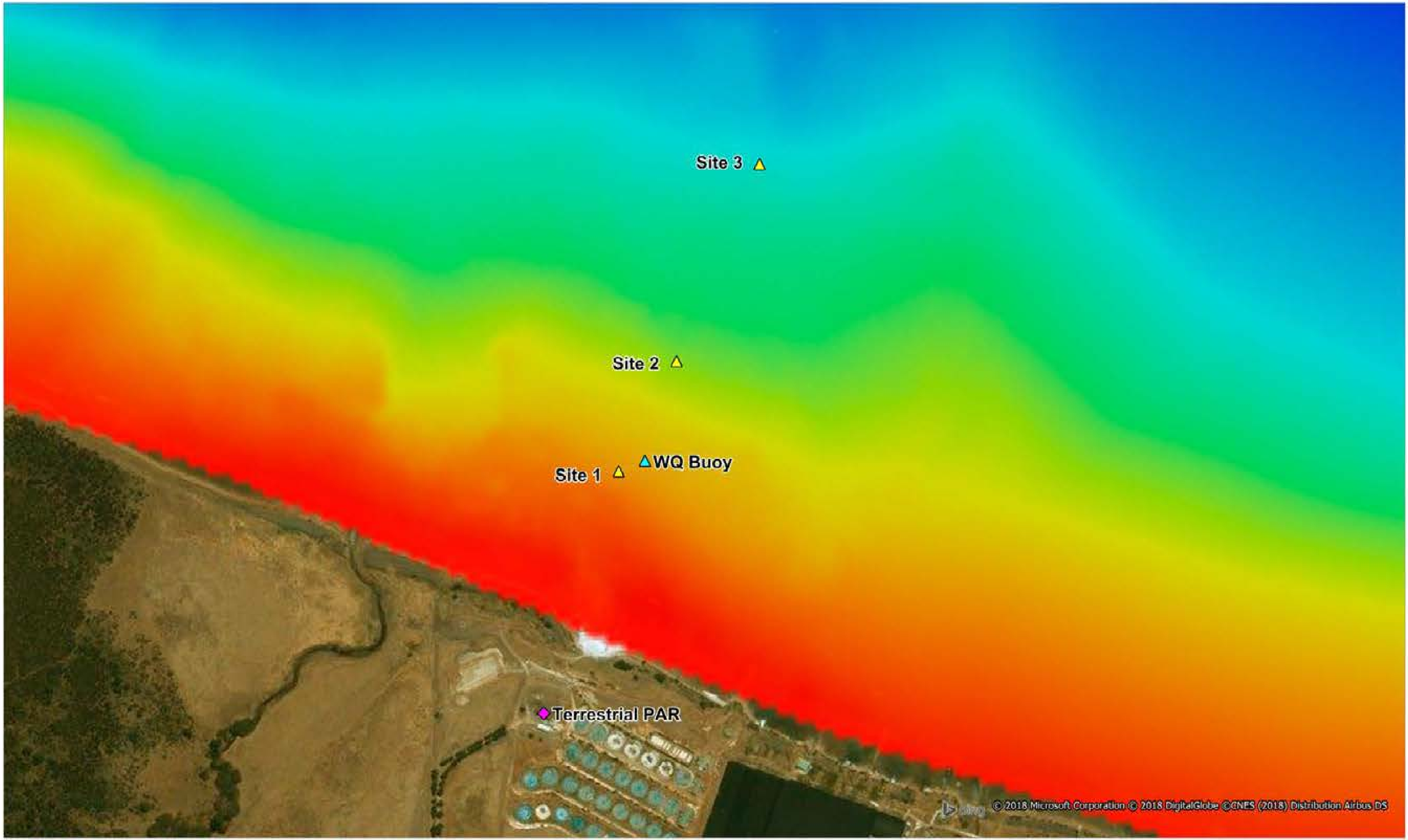
2.1.2.4 Grab sample data

During each monitoring buoy servicing trip from July 2017 onwards, *in-situ* water quality readings (depth profiling through the water column) were recorded by BMT staff adjacent to the water quality monitoring buoy. Also, water samples were collected adjacent to the monitoring buoy at the surface and near the seabed. The water samples were sent to a laboratory for analysis of TSS, nutrients, metals (total and dissolved) and particle size distribution (PSD).

It is important to note that servicing trips were only undertaken during calm conditions (for safety reasons), hence the water quality data collected during these trips is representative of calm conditions with low turbidity and suspended sediments.

The day after the monitoring buoy was retrieved on 21/2/18, there were strong northerly winds over night which resulted in visibly turbid conditions in Smith Bay. During these conditions, the field team took the opportunity to collect water samples from the shoreline for analysis of TSS and turbidity (refer to Figure 2-6) to provide an indication of water quality during adverse conditions.

Figure 2-6 Collection of water samples during turbid conditions on 22/2/18



Legend

- Water Quality Monitoring Buoy
- Bottom-Mounted Instruments (Turbidity and PAR)
- Terrestrial PAR

Water depth (m)

Title:
Smith Bay Instrument Locations

Figure: 2-7

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2.2 Environmental Values and Water Quality Guidelines

2.2.1 Environmental Values

The *Environment Protection (Water Quality) Policy 2015* specifies the environmental values that apply in relation to marine waters in South Australia (SA). These are shown in Table 2-1 and indicate the following environmental values are applicable to the marine waters of Smith Bay:

- Aquatic ecosystems;
- Recreation and aesthetics; and
- Primary industries - aquaculture and human consumption of aquatic foods.

Table 2-1 Environmental values for marine waters in South Australia

Aquatic ecosystem	✓
Recreation and aesthetics	✓
Drinking water for human consumption	×
Primary industries—irrigation and general water uses	×
Primary industries—irrigation and general water uses	×
Primary industries—aquaculture and human consumption of aquatic foods	✓

2.2.2 Water Quality Guidelines

2.2.2.1 South Australian Guidelines

The *Environment Protection (Water Quality) Policy 2015* provides the structure for regulation and management of water quality in South Australian inland surface waters, marine waters and groundwaters.

The policy declares environmental values for the protection of streams, rivers, oceans and groundwater. In terms of water quality guideline values, the policy refers to the ANZECC/ARMCANZ (2000) water quality guidelines as part of the guidance regarding the general environmental duty. In this context, the ANZECC/ARMCANZ (2000) guidelines are used as trigger values for aquatic ecosystems and primary industries. These trigger values indicate where the receiving environment is potentially at risk of being harmed and so a site-specific investigation may be required to assess the risk and/or evaluate options for environmental performance improvement.

For protection of the aquatic ecosystem environmental value, the *Environment Protection (Water Quality) Policy 2015* specifies that guideline values in Chapter 3 of ANZECC/ARMCANZ (2000) are applicable, while for protection of aquaculture, the guideline values in Chapter 4.4 of ANZECC/ARMCANZ (2000) are applicable.

2.2.2.2 National Guidelines – ANZECC/ARMCANZ (2000)

The Australian and New Zealand Environment and Conservation Council/Agriculture and Resource Management Council of Australia and New Zealand (ANZECC/ARMCANZ) Australian and New

Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ 2000) guidelines can be used where regional guidelines are not adequate or available, for example, when assessing toxicants such as metals and metalloids.

The ANZECC/ARMCANZ (2000) guidelines are intended to be used for assessing and managing ambient water quality, according to designated environmental values. The guidelines are not intended to be applied as mandatory standards but do provide guidelines for recognising and protecting water quality.

The water quality parameters in the ANZECC/ARMCANZ (2000) guidelines can be divided into those that have direct toxic effects on organisms and animals (e.g. insecticides, herbicides, heavy metals and temperature) and those that indirectly affect ecosystems causing a problem for a specified environmental value (e.g. nutrients, turbidity and enrichment with organic matter). As such, there are toxicity trigger values (TTVs) for toxicants, and trigger values for physico-chemical stressors that can have indirect effects.

With respect to toxicants (metals and pesticides) in marine waters, the ANZECC/ARMCANZ (2000) guidelines provide four levels of protection for different ecosystems (80 percent, 90 percent, 95 percent and 99 percent). For environments (such as Smith Bay) which are considered to be 'slightly to moderately disturbed'[1], the 95 percent protection is commonly applied, and as recommended by ANZECC/ARMCANZ (2000), the 99 percent level is applied for certain toxicants (e.g., cadmium, mercury and nickel) to protect vulnerable biota or to mitigate bioaccumulation.

The ANZECC/ARMCANZ (2000) water quality guideline values are presented in Table 2-2.

[1] As specified in the *Environment Protection (Water Quality) Policy 2015*

Table 2-2 Water quality guideline values

Parameter	Units	ANZECC/ARMCANZ (2000) Guidelines for Marine Waters		
		Aquatic Ecosystem Protection		Protection of Aquaculture [3]
		Toxicity Trigger Values [1]	Physico-chemical Stressors [2]	
Temperature	°C	-	-	-
Turbidity	NTU	-	0.5 (marine) to 10 (estuarine)	-
pH	-	-	-	-
Total Suspended Solids	mg/L	-	-	10
Arsenic (As)	µg/L	-	-	30
Cadmium (Cd)	µg/L	0.7 ^	-	0.5 - 5 (depending on hardness)
Chromium (Cr)	µg/L	4.4	-	20
Copper (Cu)	µg/L	1.3	-	5
Iron (Fe)	µg/L	300 *	-	10
Mercury (Hg)	µg/L	0.1 ^	-	1
Zinc (Zn)	µg/L	15	-	5
Lead (Pb)	µg/L	4.4	-	1 – 7 (depending on hardness)
Nickel (Ni)	µg/L	7 ^	-	100
Total Nitrogen	mg/L	-	1.0	-
Total Phosphorus	mg/L	-	0.1	-
Ammonia	mg/L	0.46 **	0.05	-
Nitrate	mg/L	0.7 *	-	100
Nitrite	mg/L	-	-	0.1
NOx	mg/L	-	0.05	-
Reactive phosphorus	mg/L	-	0.01	-

Note:

[1] ANZECC/ARMCANZ (2000) toxicity trigger values (TTVs) values for metals/metalloids are for dissolved metals/metalloids, and are based on marine waters at 95% level of species protection for metals/metalloids in typical slightly–moderately disturbed systems except: ^ cadmium, mercury and nickel values which are for protection of 99% of species in typical slightly–moderately disturbed systems as per ANZECC/ARMCANZ (2000).

[2] Trigger values for physico-chemical stressors are sourced from Table 3.3.8 of ANZECC/ARMCANZ (2000) - default trigger values for South central Australia (applicable to South Australia).

[3] Guideline values for protection of aquaculture sourced from Table 4.4.2 and Table 4.4.3 of ANZECC/ARMCANZ (2000).

* Marine guideline value of low reliability; indicative guideline only

** Latest ammonia guideline value based on Batley and Simpson (2009)

2.3 Study Area Overview

Smith Bay is located on the north coast of Kangaroo Island, about 20 km west of Kingscote, between Emu Bay and Cape Cassini. Smith Bay is a 5 km wide, open, north facing bay, backed by cliffs rising to 100 m at either end, with the lower central 3 km section occupied by a continuous boulder beach.

The north coast of Kangaroo Island is a relatively moderate to low energy environment as it is largely sheltered from the prevailing south westerly swells in the Southern Ocean (Edyvane 1999). Nevertheless, it does at times receive relatively small westerly swells that refract around the island and decline in size and energy as they travel east along the north coast. Smith Bay is also exposed to northerly waves generated by occasional strong northerly winds which typically occur in winter (Section 2.4).

A large land-based abalone farm is located on the coast of Smith Bay adjacent to the proposed project location. This abalone farm pumps seawater directly from two hundred metres offshore into an onshore gravity-fed flow-through farming system. The seawater from the abalone farm is then discharged above the high tide mark of the adjacent intertidal environment (Figure 2-8).

Figure 2-8 Outfall pipes discharging land-based abalone farm seawater to intertidal shoreline at Smith Bay (source: Tanner & Bryars, 2007)

2.4 Climate

The climate in Kangaroo Island is typically warm (typically 15-23°C) and dry during the summer months (Dec to Feb), while the winter months (Jun to Aug) are cool (typically 8-15°C) and wet. Most of the rainfall on Kangaroo Island (recorded at Kingscote) typically occurs from April through September (see Figure 2-9).

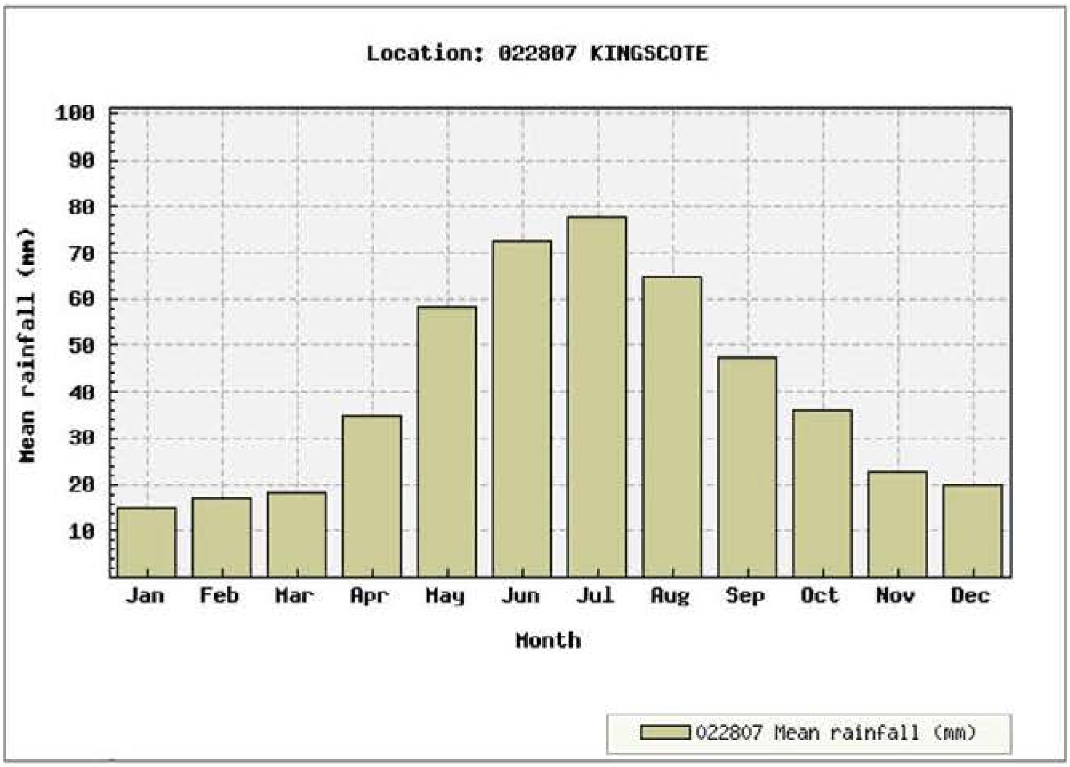


Figure 2-9 Mean annual rainfall at Kingscote (source: BOM station 022807)

As shown in the windroses in Figure 2-10, the prevailing winds during the summer are light to moderate from the south (south-west to south-east direction), while during the winter months the wind directions are more variable, but strong northerly (onshore) winds can occur during passing frontal systems.

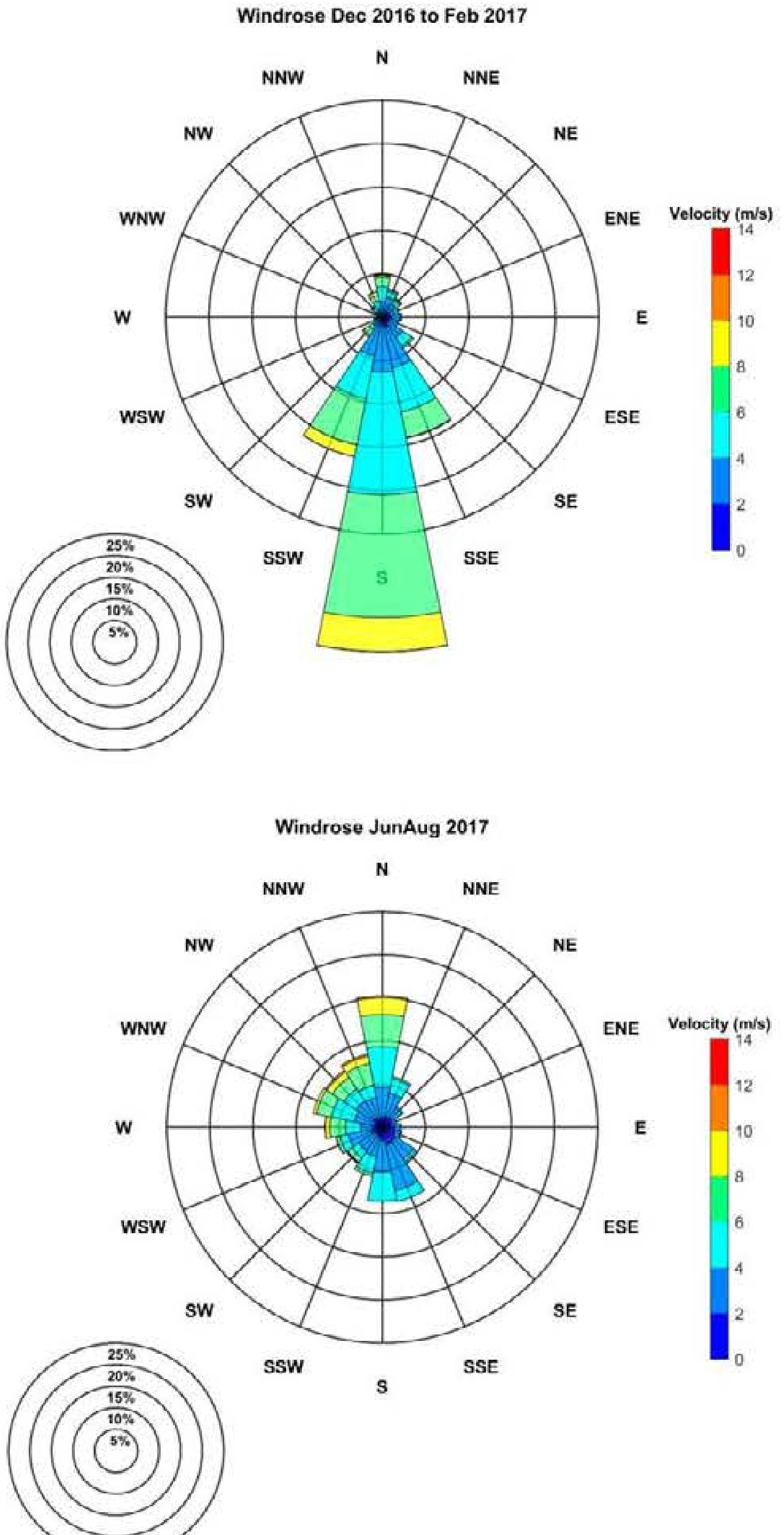


Figure 2-10 Typical wind patterns at Smith Bay – summer (top) and winter (bottom)

Wave height and direction data was made available from the waverider buoy deployed in Smith Bay in 2016/2017. This data, summarised in the waverose plot in Figure 2-11), indicates that the ambient wave climate at Smith Bay is dominated by waves from the NNW (70% coming from the 300-360 degree sectors). The remaining 30% of the time waves come from the NNE.

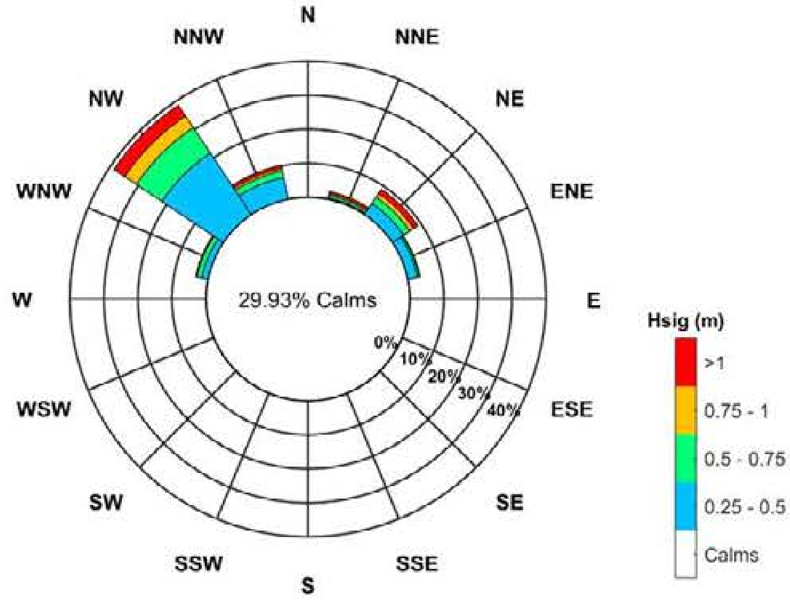


Figure 2-11 Smith Bay waverose plot (Metocean buoy data)

2.5 Turbidity

2.5.1 Deployed Instruments

Following the quality control processes described in Section 2.1.2.3.2, any data of suspect quality was quarantined from the data set. This produced a 'QA-checked' validated data set from which further analysis could be undertaken.

The 10-minute surface turbidity data from the monitoring buoy (12-month monitoring period) is presented in Figure 2-12. Despite a period of sensor fouling between 27/5/17 and 21/6/17 (which was quarantined from the data set), the data collected over the 12-month period was of sound quality.

Figure 2-12 indicates turbidity in Smith Bay mostly remained below 1 NTU for the 12-month monitoring period. There were frequent elevated turbidity periods coincident with weather patterns, but turbidity did not exceed 10 NTU at any time. Turbidity was slightly higher between the months of April and November, which coincides with the predominant northerly wind patterns during the winter months. Seasonality and effects of wind and waves on turbidity is discussed in Sections 0 and 2.5.3.

The 15-minute turbidity data from the bed-mounted instruments (6-week monitoring period) at Site 1 and Site 2 is presented in Figure 2-13 (note that the turbidity sensor at Site 3 malfunctioned and did not record any data). Figure 2-13 indicates that near-bed turbidity was slightly higher than surface turbidity (Figure 2-12), with turbidity mostly around 1-3 NTU. The nearshore site (Site 1) had slightly higher turbidity than the mid-shore site (Site 2) due to the shallower water and increased wave action/resuspension. Note the increased turbidity towards the end of the 6-week deployment period which coincided with a sustained northerly wind (and wave) period.

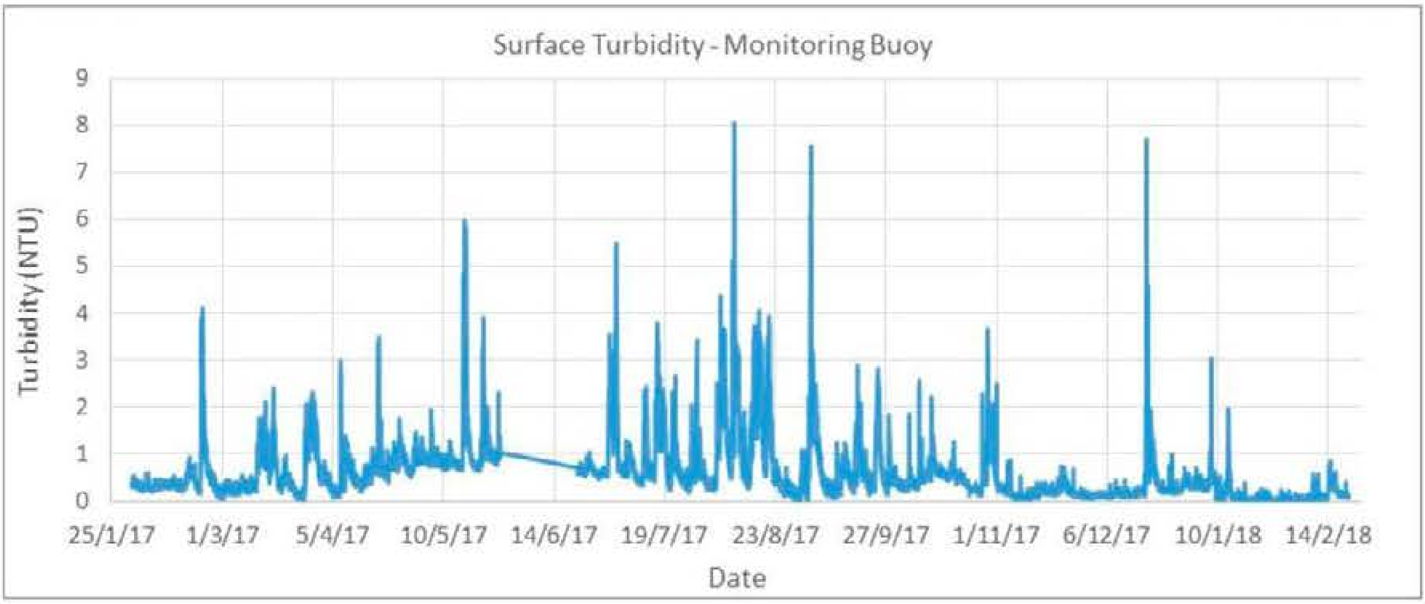


Figure 2-12 Surface turbidity data (NTU) – monitoring buoy (12 Months)

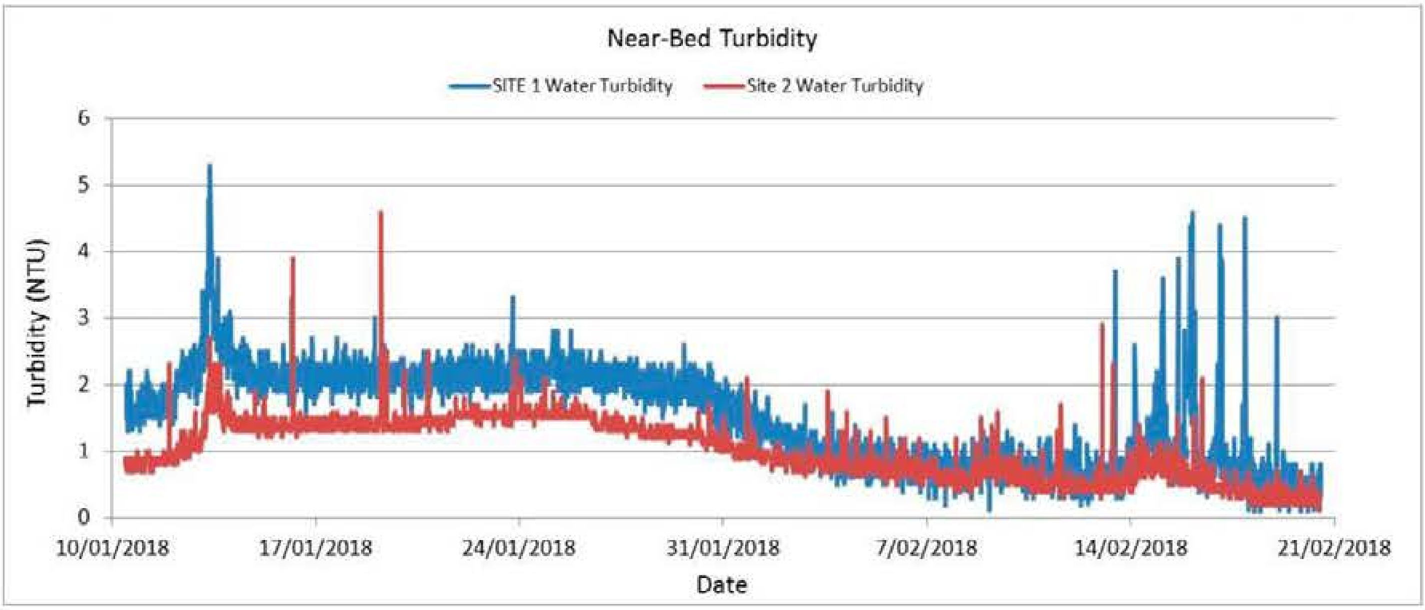


Figure 2-13 Near-bed turbidity data (NTU) – bottom-mounted Instruments

2.5.2 Seasonality

The continuous turbidity data from the monitoring buoy and bed-mounted instruments was analysed to produce turbidity percentiles for the full 12 months and for each season. The results presented in Table 2-3 show that turbidity was lower during the spring and summer months (Sep – Feb) when rainfall is lower and the winds are predominantly from the south (i.e. when calm conditions prevail in Smith Bay). During the winter months when rainfall is higher and winds are predominantly from the north, the turbidity was noticeably higher. This is illustrated in Figure 2-14, which presents the seasonal turbidity percentiles from the monitoring buoy.

Compared to the ANZECC/ARMCANZ (2000) guideline value for turbidity (which is a physico-chemical stressor, and as such the annual median value of monitoring data is typically used for assessment), the median turbidity from the monitoring buoy data for the full year, along with the summer and spring months were below the ANZECC/ARMCANZ (2000) guideline value (0.5 NTU) – refer to Table 2-3 and Figure 2-14. During the autumn and winter months, the median turbidity (0.7 NTU) slightly exceeded the guideline value.

In contrast, the near-bed median turbidity measured during the summer months exceeded the ANZECC/ARMCANZ (2000) guideline value at both the 5 m depth contour (1.7 NTU) and 10 m depth contour (1 NTU).

Table 2-3 Summary of turbidity data

Season	Location	Turbidity (NTU) Percentiles				ANZECC guideline value
		20th	50th (median)	80th	99th	
Full Year	Monitoring buoy (surface)	0.2	0.4	0.9	3.1	0.5
Summer (Dec – Feb)	Monitoring buoy (surface)	0.1	0.2	0.4	1.9	
	5 m depth contour (near bed)	0.8	1.7	2.2	3.8	
	10 m depth contour (near bed)	0.6	1.0	1.5	2.7	
Autumn (Mar – May)	Monitoring buoy (surface)	0.4	0.7	1.0	3.3	
Winter (Jun – Aug)	Monitoring buoy (surface)	0.4	0.7	1.6	3.6	
Spring (Sep – Nov)	Monitoring buoy (surface)	0.2	0.4	0.6	2.3	

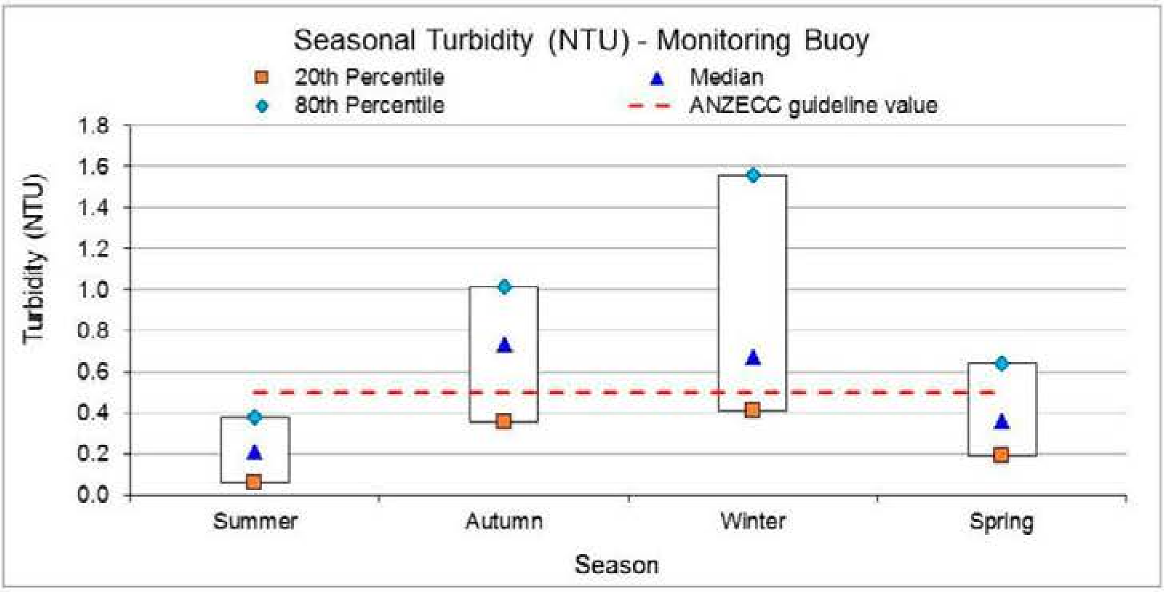


Figure 2-14 Seasonal turbidity percentiles – monitoring buoy

2.5.3 Effect of Wind/Waves on Turbidity

The effect of wind and waves on turbidity in Smith Bay was analysed. Turbidity is typically influenced by wind-generated waves which cause resuspension of sediment particles in the water column. As such, the wave data (significant wave height Hs) from the Metocean Services International (MSI) waverider buoy (for the period Jan 2017 to Nov 2017) and the deployed ADCP instruments (for the period Jan to Feb 2018) was overlain over the 12-month surface turbidity data from the monitoring buoy.

The results are shown in Figure 2-15, which indicates a strong relationship between wave height and turbidity. Turbidity percentiles were calculated for various wave heights, with results presented in Figure 2-16 and Table 2-4. This demonstrates that in Smith Bay, there is an increase in turbidity with increasing wave height. As discussed in Section 2.4, higher energy wave conditions are experienced in Smith Bay during winter due to the prevailing northerly (onshore) winds during this season.

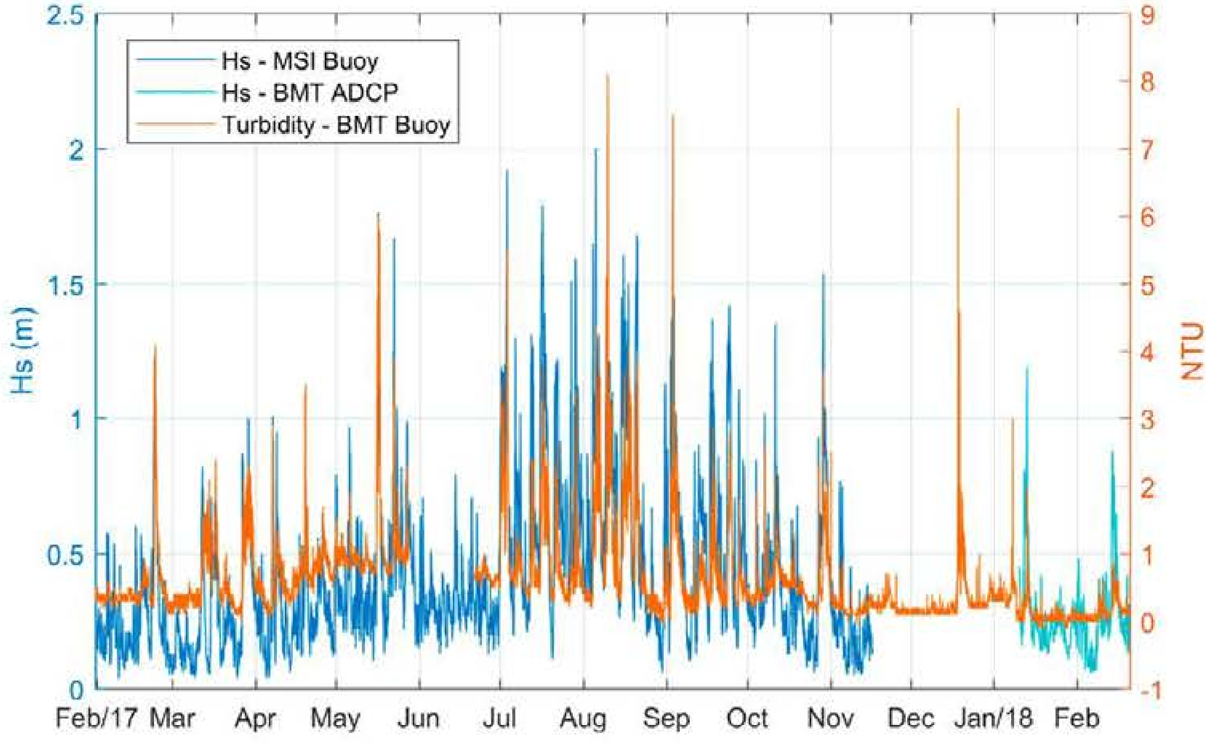


Figure 2-15 Wave height (Hs) and turbidity (NTU)

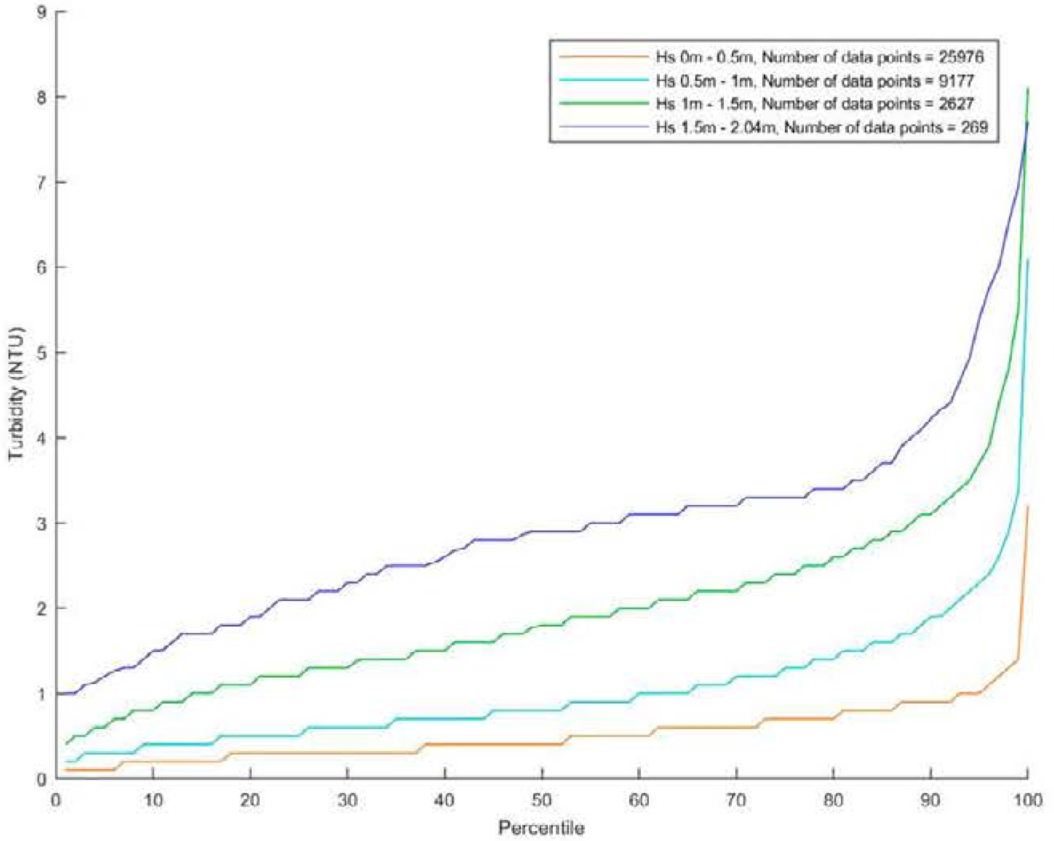


Figure 2-16 Turbidity percentiles based on wave height (Hs)

Table 2-4 Summary of turbidity data for various wave heights

Wave Height (Hs)	Turbidity (NTU) Percentiles			
	20%ile	50%ile (median)	80%ile	100%ile (maximum)
0 – 0.5 m	0.3	0.4	0.7	3.2
0.5 – 1.0 m	0.5	0.8	1.4	6.1
1.0 – 1.5 m	1.1	1.8	2.6	8.1
1.5 – 2.0 m	1.9	2.9	3.4	7.7

2.5.4 Depth Profiling

During monitoring buoy servicing trips from July 2017 onwards, and during the bed-mounted instrument retrieval at Sites 1-3 (20/2/18), *in-situ* water quality readings (depth profiling through the water column) were recorded by BMT staff.

The turbidity profiling data is presented in Figure 2-17, and shows that turbidity was relatively consistent through the water column during each profiling. Turbidity was mostly below 0.5 NTU, except for the monitoring buoy on 21/7/17 and 19/10/17 when turbidity was recorded around 0.8 NTU through the water column.

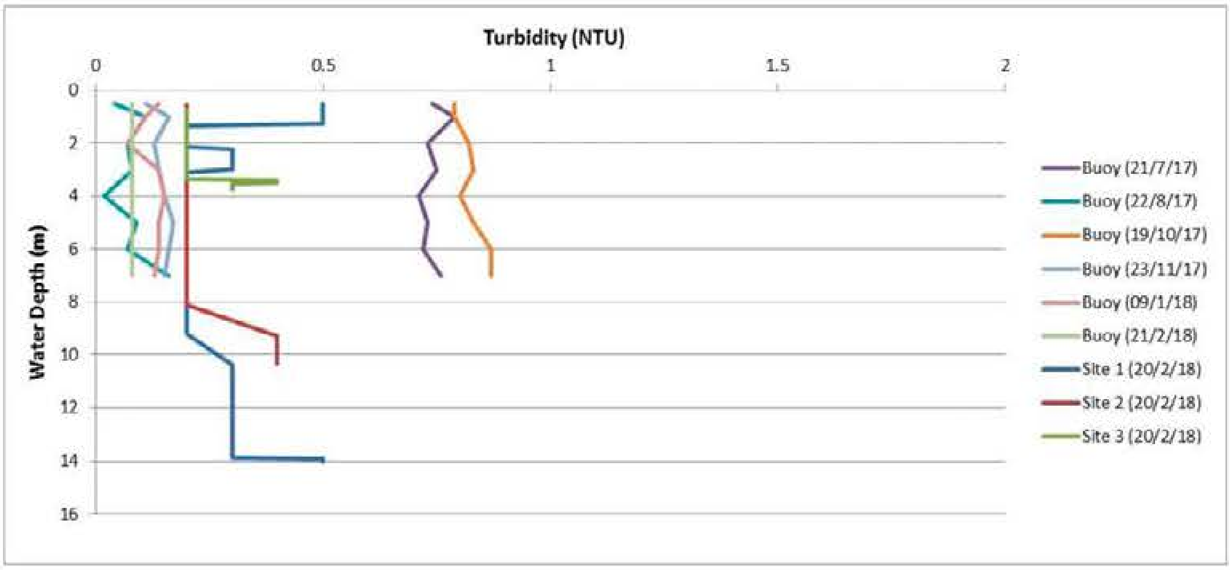


Figure 2-17 Turbidity profiling data

2.5.5 Spot Measurements

Spot measurements of turbidity (*in-situ readings* and laboratory analysed from water samples) from a number of sources were collated and summarised in Table 2-5. Similar to the monitoring buoy data (Section 2.5.1) and the turbidity profiling data (Section 2.5.4), turbidity in the Smith Bay area was mostly below 1 NTU. The exception to this was elevated turbidity (7.8 NTU) measured near the seafloor (at 8 m water depth) adjacent to the buoy by Environmental Projects staff on 8/9 Sep 2017. Note that turbidity in the upper layers (0-6 m water depth) was below 1 NTU, indicating either bed sediment disturbance from the water quality instrument or a turbid layer close to the seafloor.

Table 2-5 Turbidity (NTU) spot measurement data

Date	Data Source	Location	Turbidity (NTU)	
			In-situ	Laboratory Analysed
21 Jun 2017	BMT	Near monitoring buoy - surface	0.7	-
		Near monitoring buoy - bottom	0.7	-
25 May 2017	EPA	Site m0081	0.3	-
		Site m0082	0.3	-
22 Aug 2017	BMT	Near monitoring buoy - surface	0.1	0.5
		Near monitoring buoy - bottom	0.1	0.6
8/9 Sept 2017	Environmental Projects	Near monitoring buoy - surface	0.0 – 0.1	0.1 – 0.3
		Near monitoring buoy - bottom	0.2 – 7.8	-
19 Oct 2017	BMT	Near monitoring buoy - surface	0.8	0.4
		Near monitoring buoy - bottom	0.9	0.5
23 Nov 2017	BMT	Near monitoring buoy - surface	0.1	0.1
		Near monitoring buoy - bottom	0.2	0.1
10 Jan 2018	BMT	Near monitoring buoy - surface	0.1	<0.1
		Near monitoring buoy - bottom	0.1	<0.1
21 Feb 2018	BMT	Near monitoring buoy - surface	0.1	<0.1
		Near monitoring buoy - bottom	0.1	<0.1

2.6 Temperature

The 10-minute surface water temperature data (°C) from the monitoring buoy (12-month monitoring period) is presented in Figure 2-18. This data shows that water temperature in Smith Bay ranged from approximately 14°C during the winter months up to around 21-22°C during the summer months. The spikes in water temperature up to 25°C during the summer months coincided with high atmospheric temperatures associated with heat waves.

Temperature profiling data (*in-situ* water quality readings through the water column), summarised in Figure 2-19, indicates a similar range of water temperature (i.e. 14°C in winter and around 21°C in summer).

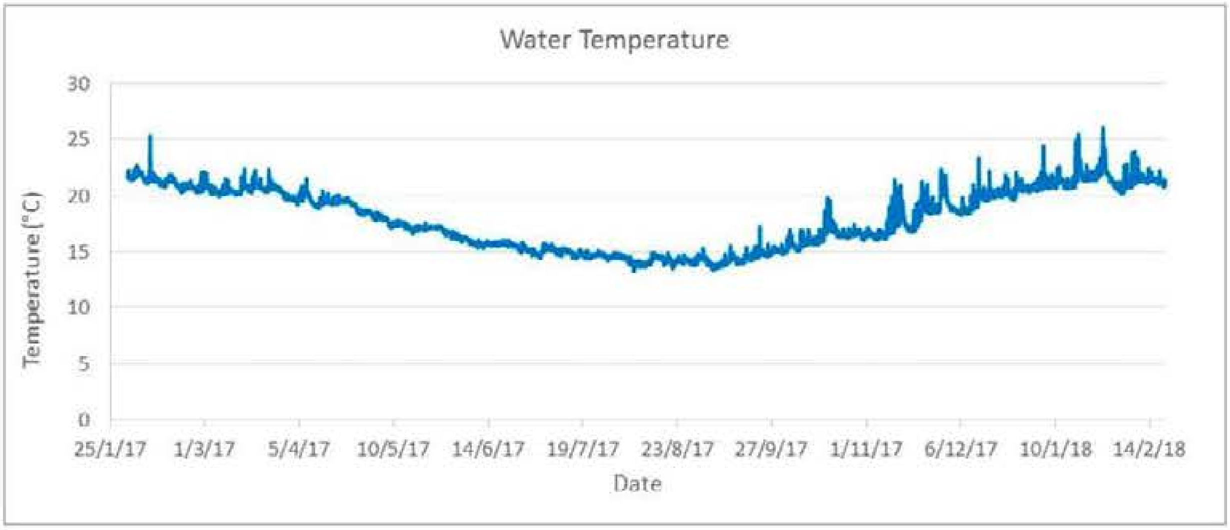


Figure 2-18 Surface temperature (°C) data – monitoring buoy (12 Months)

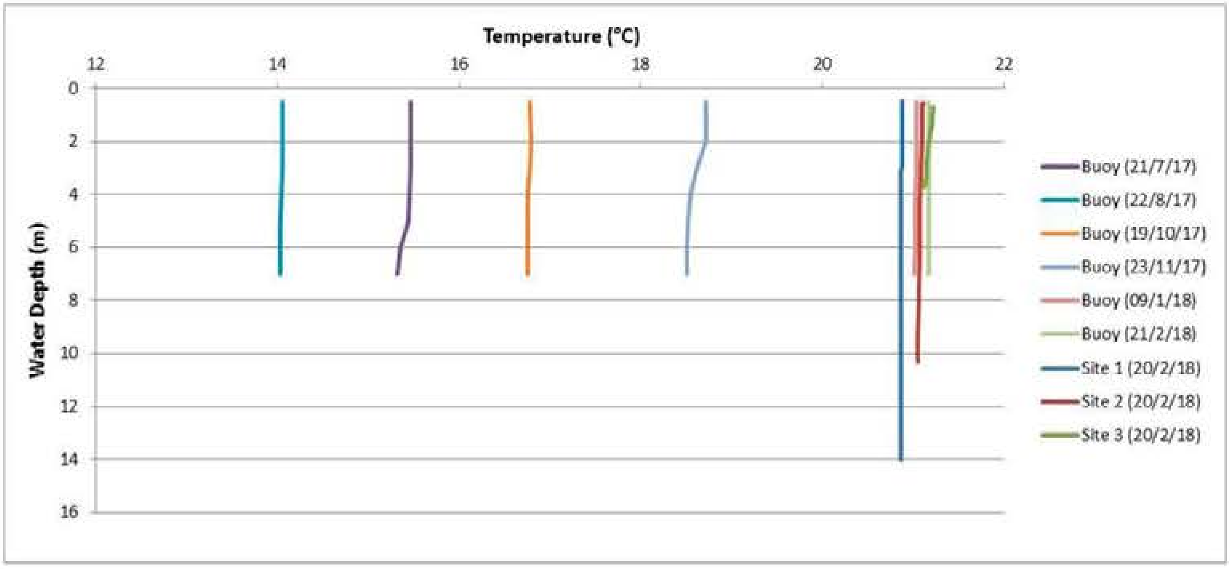


Figure 2-19 Temperature profiling data

2.7 Electrical Conductivity / Salinity

The 10-minute electrical conductivity data (µS/cm) from the monitoring buoy (12-month monitoring period) is presented in Figure 2-20. As expected of a marine environment, this data shows that electrical conductivity in Smith Bay remained relatively consistent between 53,000 µS/cm and 56,000 µS/cm. Electrical conductivity in surface waters was slightly lower during the winter months when the highest rainfall typically occurs.

Salinity profiling data (*in-situ* water quality readings through the water column), summarised in Figure 2-21, indicates a similar pattern of salinity (i.e. lower salinity of 34-35 ppt in winter and slightly higher salinity of 36-39 ppt in summer).

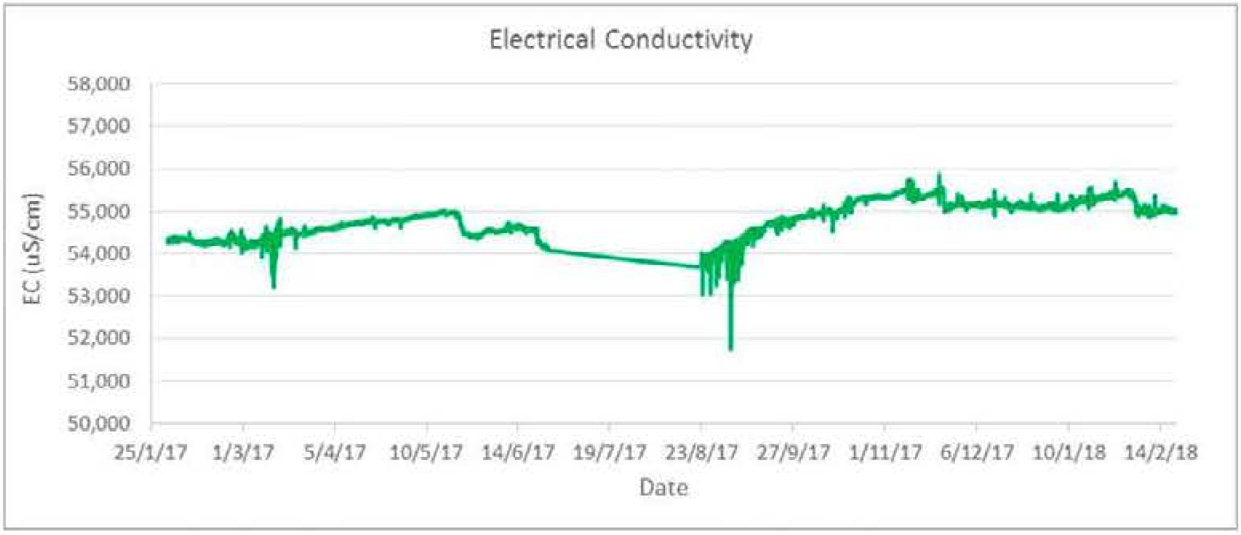


Figure 2-20 Surface electrical conductivity (µS/cm) data – monitoring buoy (12 Months)

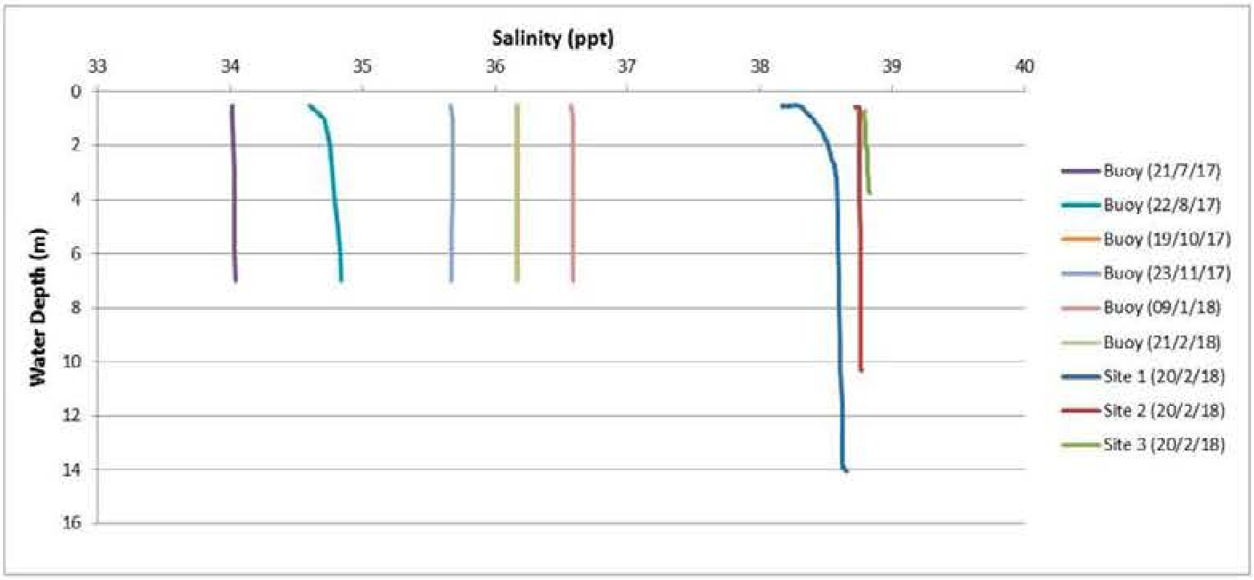


Figure 2-21 Salinity profiling data

2.8 pH

Spot measurements of pH (*in-situ* readings) were taken by BMT staff during some of the monitoring buoy servicing trips in 2017/2018, and Environmental Projects staff on 8/9 Sep 2017. This data is presented in Table 2-5, and indicates that pH of marine water in Smith Bay ranged from 7.9 to 8.6, which is similar to the typical pH of marine water of around 8.2.

Table 2-6 Spot measurement data - pH

Date	Data Source	Location	pH
8/9 Sept 2017	Environmental Projects	Near monitoring buoy - surface	7.9 – 8.0
		Near monitoring buoy - bottom	7.9 – 8.0
19 Oct 2017	BMT	Near monitoring buoy - surface	8.5
		Near monitoring buoy - bottom	8.5
23 Nov 2017	BMT	Near monitoring buoy - surface	8.6
		Near monitoring buoy - bottom	8.6
21 Feb 2018	BMT	Near monitoring buoy - surface	8.1
		Near monitoring buoy - bottom	8.1

2.9 Suspended Sediments

2.9.1 Total Suspended Sediments (TSS)

Grab samples of TSS were collected by BMT during the baseline monitoring program as part of routine equipment servicing for the monitoring buoy. Water samples were also collected and analysed for TSS by Environmental Projects on 8/9 Sep 2017.

The results are shown in Table 2-7, along with the ANZECC/ARMCANZ (2000) aquaculture guideline value. Most TSS values in Table 2-7 are below the guideline value of 10 mg/L, with most values being less than 5 mg/L. The exception was the water sample collected on 22/2/18, which had a TSS value of 41 mg/L. However, this sample was collected at the shoreline following a period of strong northerly winds which resulted in visibly turbid conditions in Smith Bay. Samples collected on other dates in Table 2-7 were collected at the monitoring buoy during calm conditions when suspended sediment concentrations in the water column are typically low.

Table 2-7 Grab sample data – TSS (mg/L)

Date	Data Source	Location	TSS (mg/L)	ANZECC guideline value (Aquaculture)
8 Sept 2017	Environmental Projects	Near monitoring buoy - surface	<1	10
9 Sept 2017			<1	
19 Oct 2017	BMT	Near monitoring buoy - surface	1	
		Near monitoring buoy - bottom	5	
23 Nov 2017	BMT	Near monitoring buoy - surface	3	
		Near monitoring buoy - bottom	2	
10 Jan 2018	BMT	Near monitoring buoy - surface	<1	
		Near monitoring buoy - bottom	<1	
21 Feb 2018	BMT	Near monitoring buoy - surface	<1	
		Near monitoring buoy - bottom	<1	
22 Feb 2018	BMT	Shoreline (inshore from buoy)	41	

2.9.2 Particle Size Distribution (PSD)

Some of the water samples collected by BMT during monitoring buoy servicing trips were analysed for particle size distribution (PSD). These samples included:

- Bottom waters at monitoring buoy collected on 21/8/2017 (Figure 2-22).
- Surface and bottom waters at monitoring buoy collected on 19/10/2017 (Figure 2-23).
- Nearshore waters collected during turbid conditions on 22/2/2018 (Figure 2-24).

The PSD data indicates that sediment particles in near-bed (bottom) waters sampled on 21/8/17 and 19/10/17 ranged from 30 μm to 200 μm, with a median sediment particle size (D50) of 103 μm. Sediment particles in surface waters sampled on 19/10/17 were more variable, with sediment sizes ranging from 0.2 μm to 300 μm in size, with a median sediment particle size (D50) of 26 μm. Sediment particles in bottom waters sampled on 19/10/17 mostly ranged from 30 μm to 300 μm (with some larger particles around 1,000-3,000 μm), with a median sediment particle size (D50) of 89 μm.

Nearshore waters sampled during turbid conditions on 22/2/18 had a broad range of sediment particle sizes, ranging from 1 μm up to 3,000 μm, with a median sediment particle size (D50) of 145 μm.

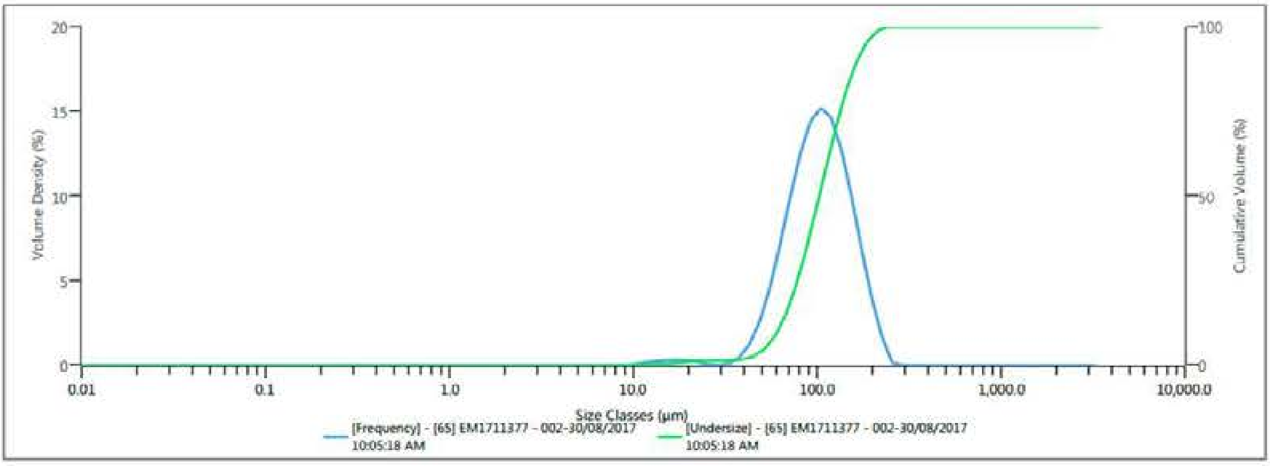


Figure 2-22 PSD of sediment in water sample collected in bottom waters at monitoring buoy on 21/08/2017

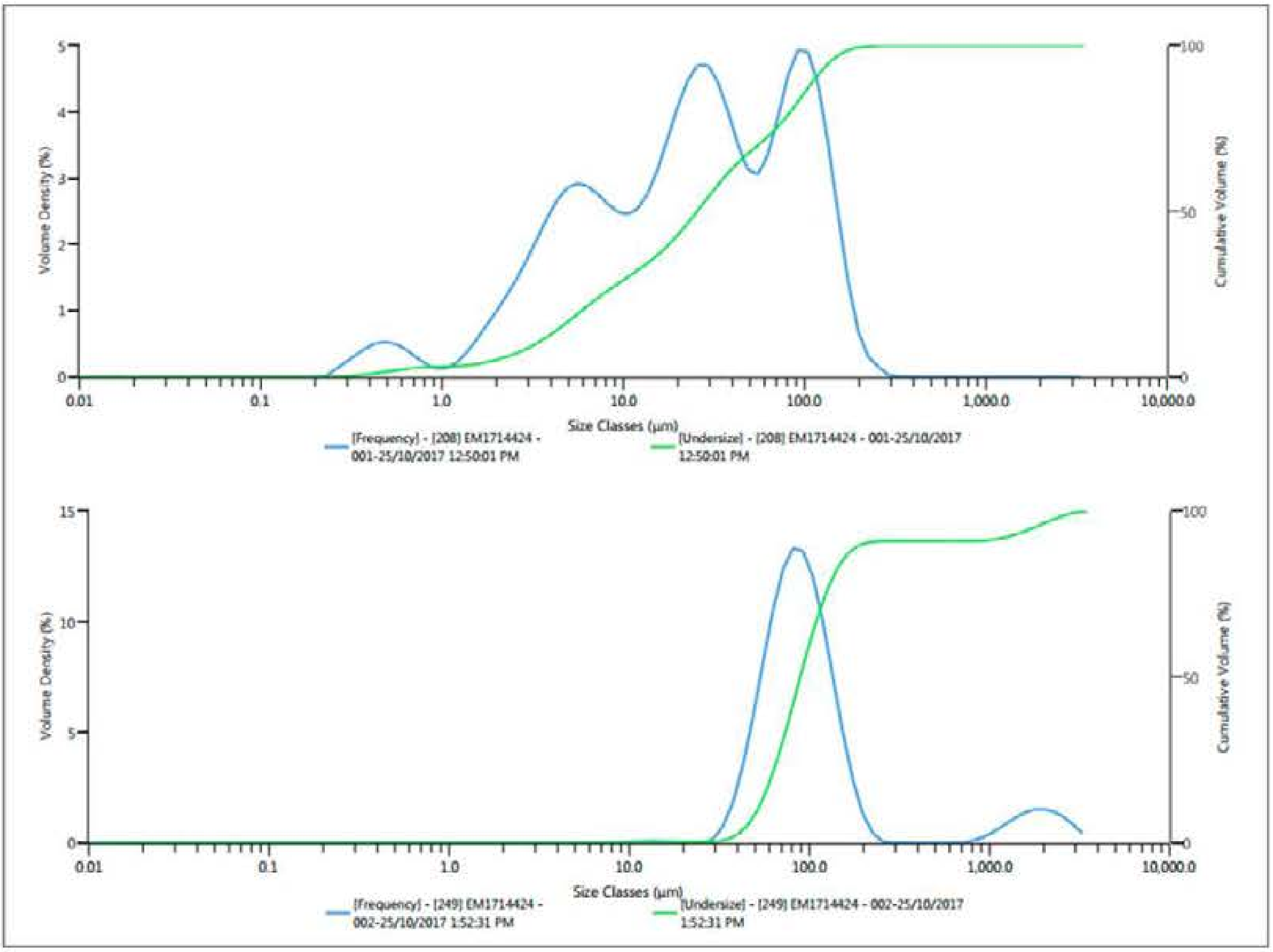


Figure 2-23 PSD of sediment in water samples collected in surface waters (top) and bottom waters (bottom) at monitoring buoy on 19/10/2017

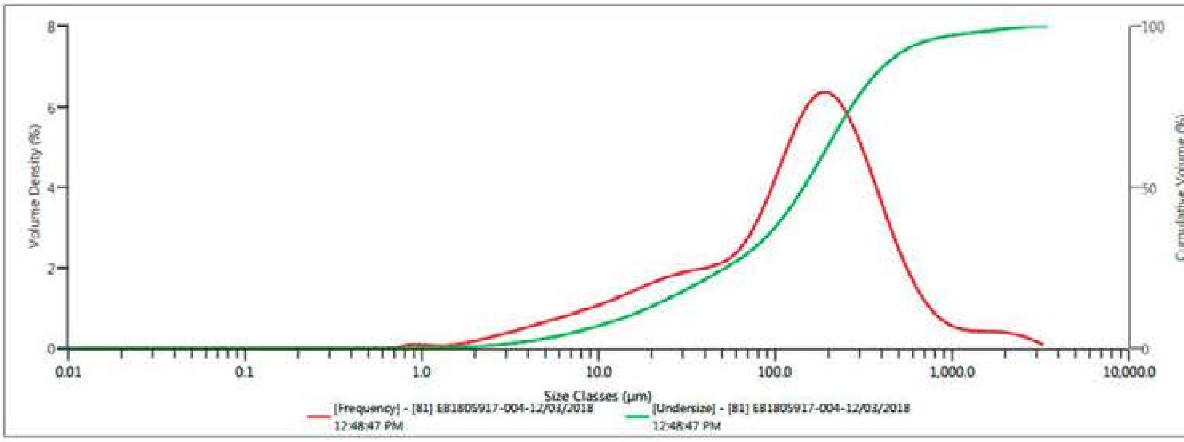


Figure 2-24 PSD of sediment in nearshore water sample collected during turbid conditions on 22/02/2018

2.9.3 Sedimentation Tubes

Sedimentation tubes were deployed with the bed-mounted instruments for a period of six weeks (Jan-Feb 2018). During retrieval, the 110 mm diameter sedimentation tubes were capped and brought to the surface. The capped tubes, containing a 2.65-litre volume of seawater and sediment, were shipped to a certified laboratory (ALS) for analysis of turbidity, PSD, and TSS (including inorganic vs organic fraction analysis). The analysis of organic TSS involved heating the sample in the laboratory up to 550°C and analysing the volatile fraction (organic particles burnt off in the process) and the fixed fraction that remained (inorganic particles).

The results are presented in Table 2-8, and show that TSS at the three sites ranged from 202 mg/L (deeper waters at Site 3) up to 445 mg/L (nearshore waters at Site 1). There was a higher proportion of inorganic sediment particles in the samples (53-65%) compared to organic sediment particles (34-46%).

Average sedimentation rates over the deployment period were inferred from the Total Suspended Solids data and the tube dimensions. The inferred sedimentation rates were varied between 0.13 and 0.30 mg/cm²/day, with the highest rates at the inshore location.

PSD data from each of the three sites is shown in Figure 2-25. This data indicates that the nearshore site (Site 1) had largest sediment particle sizes (median sediment particle size of 94 µm), followed by the mid-shore site (Site 2) with median sediment particle size of 40 µm, while the deeper site (Site 3) had the smallest sediment particle sizes with a median sediment particle size of 28 µm.

Table 2-8 Sedimentation tube analysis data

Parameter	Units	Site		
		1	2	3
Turbidity	NTU	71	130	75
Total Suspended Solids	mg/L	445	313	202
Sedimentation rate	mg/cm^2/day	0.30	0.21	0.13
Organic Suspended Solids	mg/L	165	146	70
	%	37	46	34
Inorganic Suspended Solids	%	63	53	65

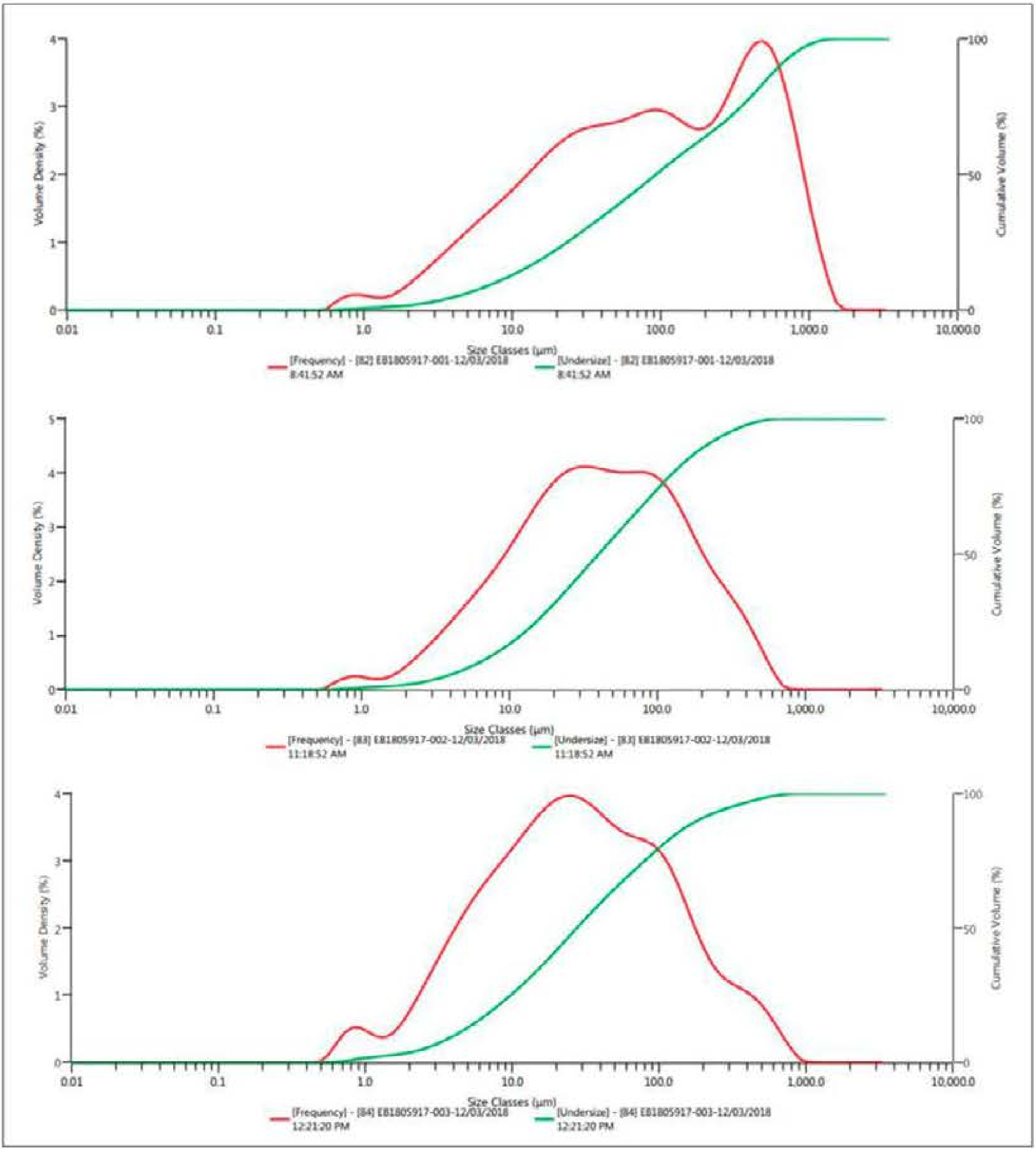


Figure 2-25 PSD of sediment collected in sedimentation tubes from Site 1 (top), Site 2 (middle) and Site 3 (bottom) on 22/02/2018

2.9.4 Turbidity/TSS Correlation

TSS is an important parameter of concern with regard to water quality as it is what is typically measured and monitored to determine compliance with water quality objectives.

Turbidity, however, is the general parameter often used as a surrogate for TSS because it is easier and more cost-efficient to monitor. Therefore, there is the need to establish a relationship between turbidity and TSS such that the conversion of turbidity data to TSS concentrations can be made without the need to monitor for TSS.

Typically, to assess the relationship between TSS and turbidity in the water column, a number of water samples are collected at a site during various conditions (i.e. high and low suspended sediments) and analysed for TSS and turbidity. However, with the consistently low suspended sediments in the water column at Smith Bay, measurements covering the range of TSS-turbidity of interest for the Project impact assessment would be difficult to obtain. Therefore, bed sediment samples were collected from the seafloor at Smith Bay, and the fine sediment fraction from these samples (passing 75 μm sieve) was mixed with seawater to produce a range of water samples with varying concentrations of suspended sediment. These samples were then analysed for TSS and turbidity.

Figure 2-26 shows the linear correlation between TSS and turbidity for the study area. This relationship is based on the analysis of TSS and turbidity in 16 sediment-water mixture samples, diluted from a single prepared sample of around 100 mg/L. The relationship established using this method is 0.92 mg/L of TSS per 1 NTU of turbidity.

A second completely independent test was undertaken using a different seabed sediment sample which was used to undertake a large-scale settling test (Appendix A). Samples were taken over time from above the settled sediment-suspension interface. These samples were analysed for turbidity and TSS, with the results of the test shown in Figure 2-27. Initially the ration of TSS to turbidity was high due to the presence of sand-sized particles in the recently agitated suspension. After 20-30 minutes when only fine sediment fractions remained in suspension the ratio of TSS to turbidity in the suspension approached 0.74 to 1.2 mg/L of TSS per 1 NTU of turbidity.

In addition to the synthesised sampling and testing described above, sediment-water mixture samples from the opportunistic sampling on the 22/2/2018 and samples obtained from the sedimentation tubes (refer Section 2.9.3) were concurrently analysed for TSS and turbidity in the laboratory. The results of this testing are provided in Table 2-9. The ratio of TSS to turbidity based on this analysis ranged between 2.4 and 14, which is much higher than the ratio of 0.92 obtained from the synthesised sampling and testing. Further enquiries identified that standard laboratory turbidity testing procedures allow for the instrument reading to stabilise and that initial readings can be much higher than the stable reading, particularly where the sample includes sand-sized sediment particles. Therefore the results based on the sedimentation tube analysis are not suitable for characterising the TSS to turbidity relationship for Smith Bay.

Aside from the sensitivity to testing methods, it is also accepted that the relationship between TSS and turbidity is dependent on particle size (Larcombe *et al*, 1995), with finer sediment contributing more to light-scattering (i.e. turbidity) than coarser particles. This particle size dependence is reflected in the median particle sizes provided in the final column of Table 2-9.

Based on the testing and analysis undertaken it is recommended that a 1 : 1 (TSS : turbidity) ratio is used for converting from turbidity to TSS and vice-versa for the Smith Bay environment. This relationship is appropriate where the sediment in suspension is predominantly fine particle fractions but will become inaccurate where there is sand-sized particles in suspension. Medium to far-field dredge plumes will be almost entirely fine sediment particles in suspension, as the sand sized particles will rapidly settle.

Table 2-9 Additional TSS-turbidity sample analysis

Description	TSS (mg/L)	Turbidity (NTU) [1]	Initial Turbidity (NTU) [2]	TSS : Turbidity Ratio	D50 (µm) [4]
Serial dilution test	0 – 100	0.8 – 105	–	0.92	9.4
Settling test (after 20 min)	86 – 370	63 – 300	–	0.96	6.3 – 8.7
Sedimentation tube, site 1	445	71	–	6.3	94
Sedimentation tube, site 2	313	130	–	2.4	40
Sedimentation tube, site 3	202	75	–	2.7	28
Nearshore sampling, 22 Feb 2018	41	3.0	20	2.0 – 14 [3]	145

Notes:

[1] Standard laboratory turbidity testing procedure allows for turbidity reading to stabilise before taking measurement.

[2] Initial turbidity levels (prior to stabilisation) were also provided for certain samples.

[3] Upper value is based on initial turbidity reading, while lower value is based on the stable turbidity reading.

[4] D50 refers to the median sediment particle size

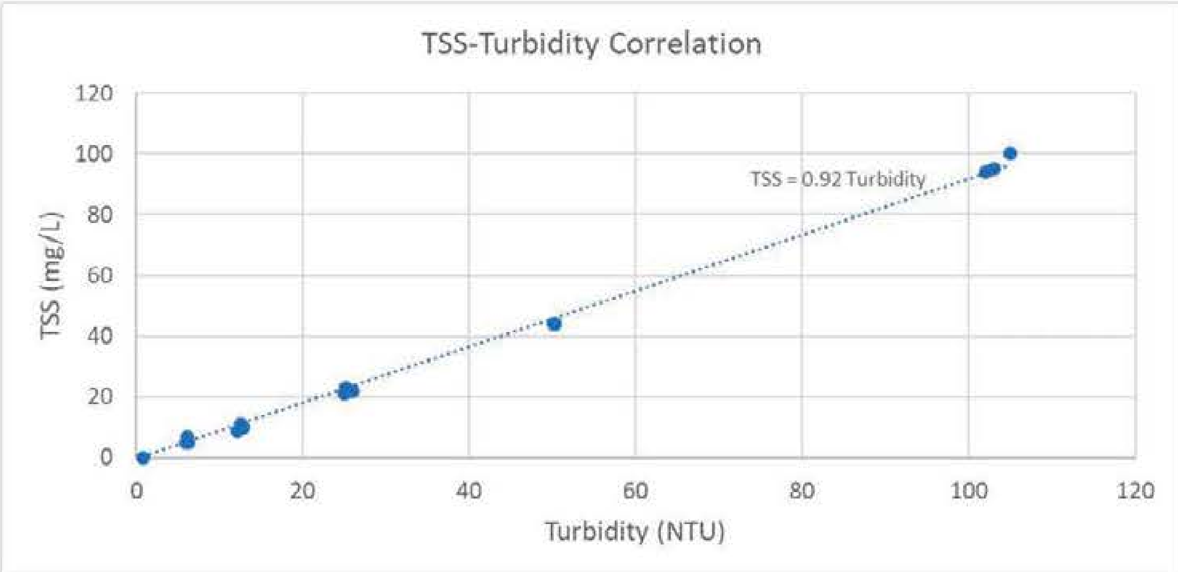


Figure 2-26 TSS-turbidity correlation (serial dilution test)

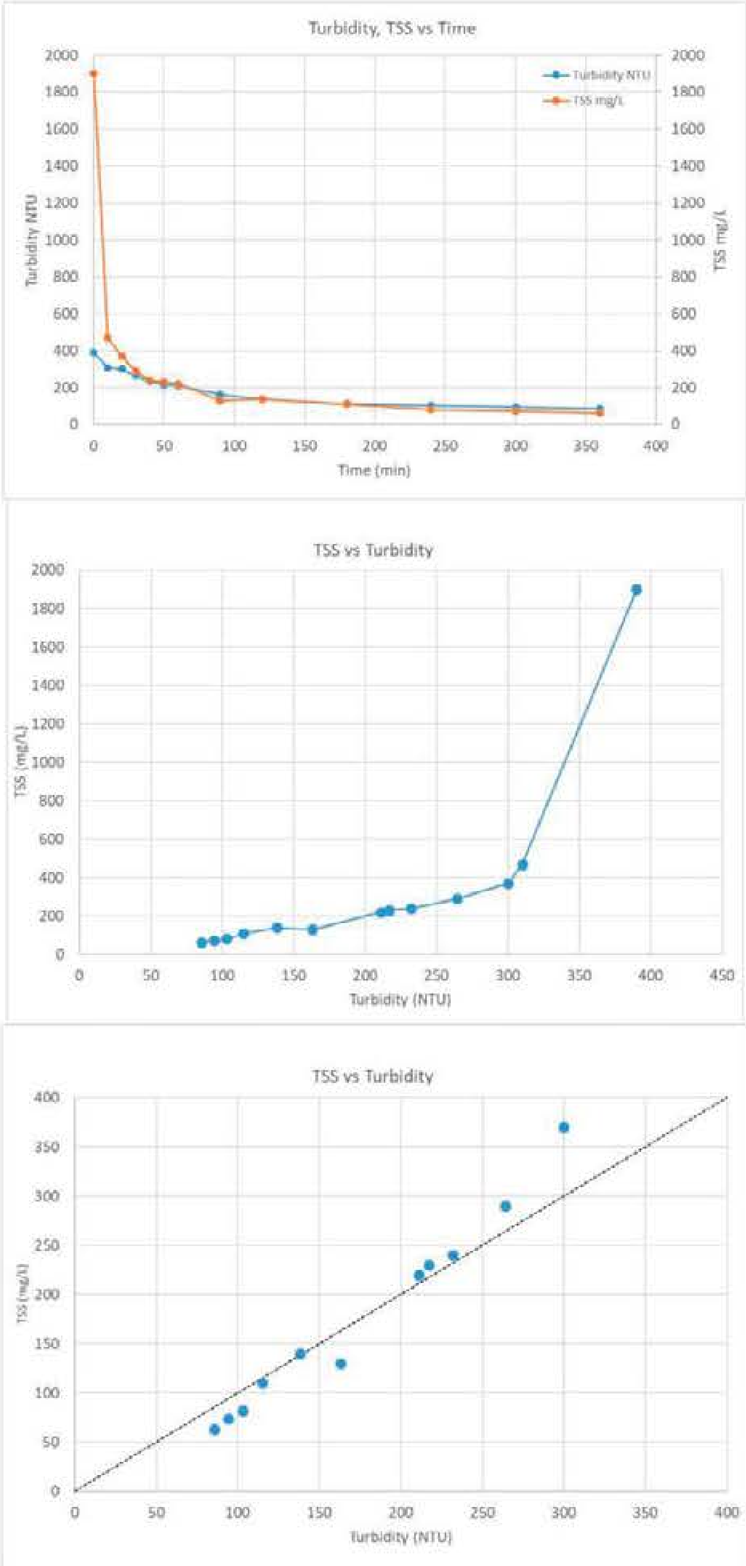


Figure 2-27 TSS-turbidity correlation (settling test – refer Appendix A).

2.10 Nutrients

Water samples collected during a number of studies (as described in Section 2) were analysed for ammonia, nitrate, nitrite, oxidised nitrogen (NOx), total kjeldahl nitrogen, total nitrogen, total phosphorus and reactive phosphorus. This nutrients data is summarised in Table 2-10.

Relevant ANZECC/ARMCANZ (2000) water quality guideline values (as per Section 2.2.2) are included at the bottom of Table 2-10 for comparison of data. Note that in ANZECC/ARMCANZ (2000), ammonia has a physico-chemical stressor guideline value for indirect effects, and a Toxicity Trigger Value (TTV) for direct effects to aquatic biota.

Overall, the data indicate that Smith Bay is characterised by relatively low levels of nutrients. All data were below the ANZECC/ARMCANZ (2000) TTVs for ammonia and nitrate, and below the aquaculture guideline values for nitrate and nitrite. Ammonia concentrations were at the physico-chemical stressor guideline value of 0.05 mg/L on 19/10/17 in surface and bottom waters at the monitoring buoy. Also, reactive phosphorus was at the physico-chemical stressor guideline value of 0.01 mg/L in surface waters on 19/10/17 and bottom waters on 22/8/17 at the monitoring buoy. However, all other data were below the relevant guideline levels.

Table 2-10 Nutrients data

Location	Data Source	Date	Ammonia (mg/L)	Nitrite (mg/L)	Nitrate (mg/L)	NOx (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Reactive Phosphorus (mg/L)
WQ Monitoring Buoy - Surface	BMT	22/08/2017	<0.02	<0.01	<0.01	<0.01	0.2	0.2	*ND*	<0.01
		19/10/2017	0.05	<0.01	<0.01	<0.01	<0.1	<0.1	< 0.05	0.01
		23/11/2017	<0.005	<0.005	<0.005	<0.005	*ND*	0.6	0.03	<0.005
		10/01/2018	0.006	<0.005	0.016	0.016	*ND*	0.4	0.02	<0.005
	Environmental Projects	8/09/2017	<0.005	*ND*	*ND*	<0.003	0.18	0.18	0.018	<0.003
		9/09/2017	<0.005	*ND*	*ND*	0.005	0.11	0.11	0.017	<0.003
WQ Monitoring Buoy - Bottom	BMT	22/08/2017	0.04	<0.01	<0.01	<0.01	<0.1	<0.1	*ND*	0.01
		19/10/2017	0.05	<0.01	<0.01	<0.01	<0.1	<0.1	< 0.05	<0.01
		23/11/2017	<0.005	<0.005	<0.005	<0.005	*ND*	0.6	0.03	0.005
		10/01/2018	0.009	<0.005	0.029	0.029	*ND*	0.3	0.02	<0.005
Site m0081	EPA	25/05/2017	0.014	<0.005	0.018	0.019	0.2	0.22	<0.05	*ND*
Site m0082			0.017	<0.005	0.018	0.019	0.17	0.2	<0.05	*ND*
Intertidal zone near Yumbah (F1, New F)	Tanner & Bryars (2007)	Feb – Jun 2005	0.044	*ND*	*ND*	0.03	*ND*	0.2	0.008	*ND*
Subtidal zone near Yumbah (F1, F2)			0.014	*ND*	*ND*	0.02	*ND*	0.12	0	*ND*
Control sites (NF1-3)			0.001	*ND*	*ND*	0.008	*ND*	0.08	0	*ND*
ANZECC Guideline Values	*Aquatic Ecosystem*	*TTV*	*0.46*	-	*0.7*	-	-	-	-	-
		Phys-chem Stressors	*0.05*	-	-	*0.05*	-	*1.0*	*0.1*	*0.01*
	Aquaculture		-	*0.1*	*100*	-	-	-	-	-

Note: Blue highlighted cells indicate exceedance of the toxicity trigger values (TTVs) under the aquatic ecosystem guideline values, green highlighted cells indicate exceedance of the physico-chemical stressors under the aquatic ecosystem guideline values, while yellow highlighted cells indicate exceedance of the aquaculture guideline values.

ND = No data (or poor quality data)

2.11 Photosynthetically Active Radiation (PAR)

Photosynthetically active radiation (PAR) is a measure of the amount of light available for photosynthetic processes of the benthic marine community (e.g. seagrasses). PAR reaching the seabed is impacted by the water depth and the amount of suspended material in the water column that leads to light attenuation.

As discussed in Section 2.1.2.2, benthic PAR was measured at three sites (Sites 1-3) in Smith Bay for a period of six weeks (Jan-Feb 2018). Site 2 had two PAR sensors deployed 1 m vertically apart in the water column, and surface (terrestrial) PAR was also measured by an additional PAR logger installed onshore at Smith Bay.

2.11.1 Benthic PAR

The data from the PAR monitoring sites is presented in Figure 2-28, which shows the total daily benthic PAR (mol/m^2/day) for the bed-mounted instruments, and the total daily surface PAR (mol/m^2/day) for the terrestrial sensor. This data indicates that total daily benthic PAR ranged from 2–8 mol/m^2/day at the nearshore site (Site 1 – located in 6 m of water), 1–5 mol/m^2/day at the mid-shore site (Site 2 - located in 10 m of water), and 1–4 mol/m^2/day at the deeper site (Site 3 - located in 14 m of water).

Using the surface and benthic PAR data sets, the percentage of surface PAR reaching the seabed (i.e. benthic PAR) at each monitoring site was assessed. The benthic PAR data are presented in Figure 2-29 as % surface irradiance, and indicates that benthic PAR as % surface irradiance was approximately the following at each site:

- Site 1 (6 m water depth): 8-18%.
- Site 2 (9 m water depth): 5-12%.
- Site 2 (10 m water depth): 3-10%.
- Site 3 (14 m water depth): 3-8%.

Near-bed turbidity data (average daily turbidity) is also shown in Figure 2-29 to provide context to the fluctuations in benthic PAR. This shows that during periods of higher turbidity (e.g. increase in turbidity from 0.1 NTU up to 0.6 NTU), the benthic PAR is noticeably reduced.

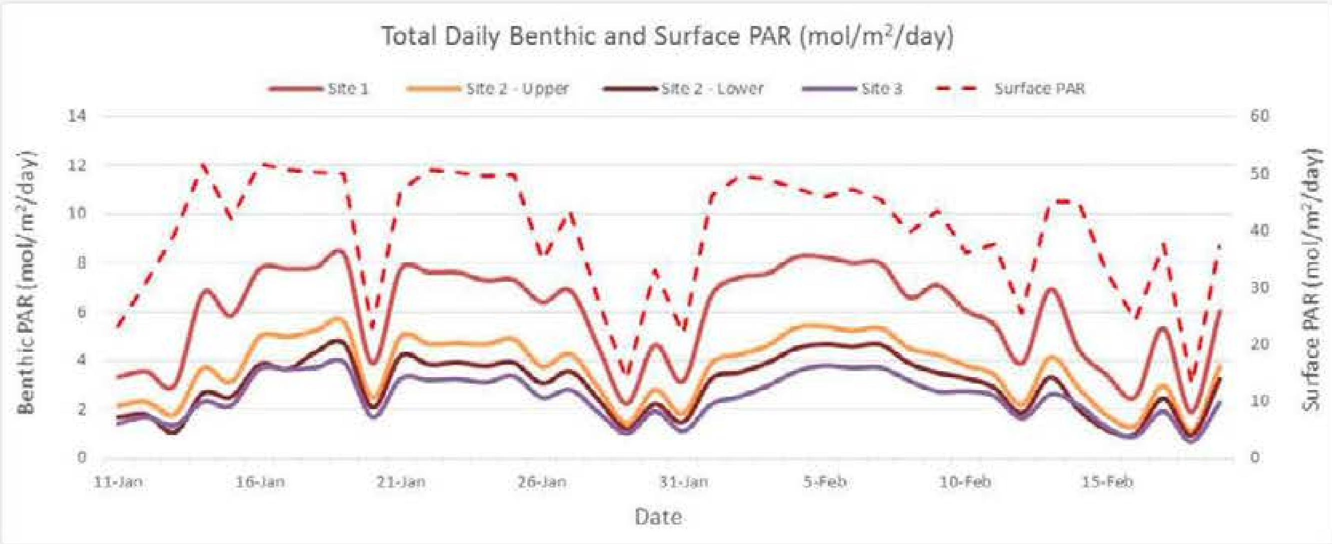


Figure 2-28 Daily benthic PAR and surface PAR (mol/m²/day)

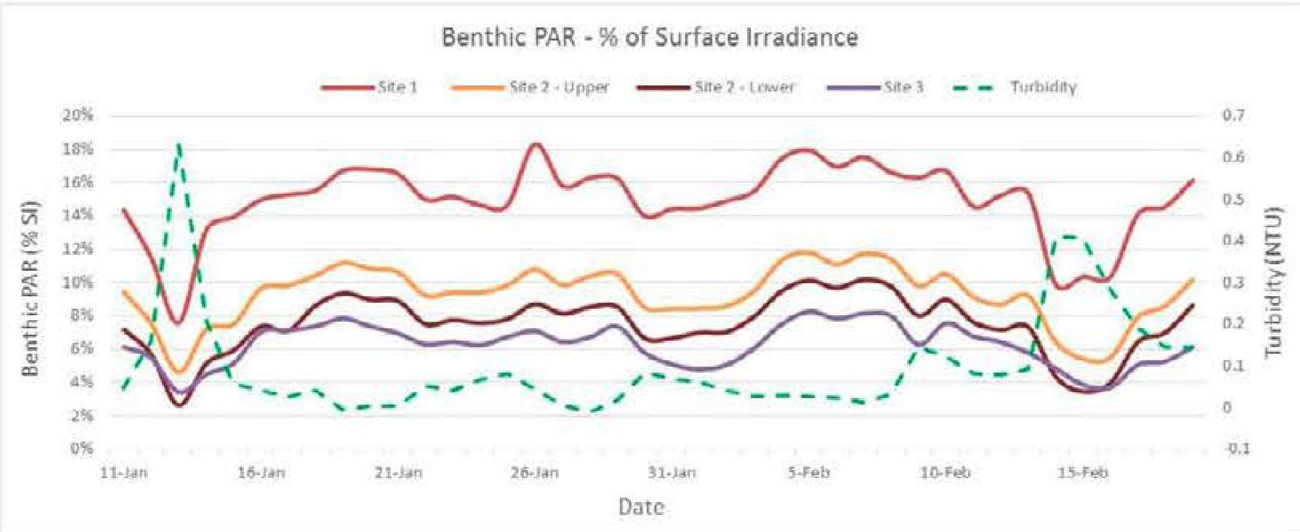


Figure 2-29 Daily benthic PAR as % surface irradiance and near-bed turbidity (NTU)

2.11.2 Light Attenuation

Using the data from the duplicate PAR sensors at Site 2 (deployed 1 m apart in the water column), a light attenuation coefficient (Kd) was able to be calculated. This coefficient provides an indication of attenuation of light per metre of water at the monitoring site. Light attenuation (Kd) was calculated using the following formula derived from Anthony et al. (2004):

$$Kd = \ln\left(\frac{E(s)}{E(z)}\right)/z$$

In this equation, E(s) is the PAR at the upper sensor, E(z) is the PAR at the lower sensor, and z is the distance between the sensors (in this case 1 m).

The average daily light attenuation at Site 2 for the 6-week monitoring period is shown in Figure 2-30, along with average daily turbidity (from the turbidity sensor deployed next to the PAR loggers at Site 2). This figure shows that light attenuation fluctuated between 0.18 and 0.6 m^{-1}, with light attenuation increasing during periods of increased turbidity.

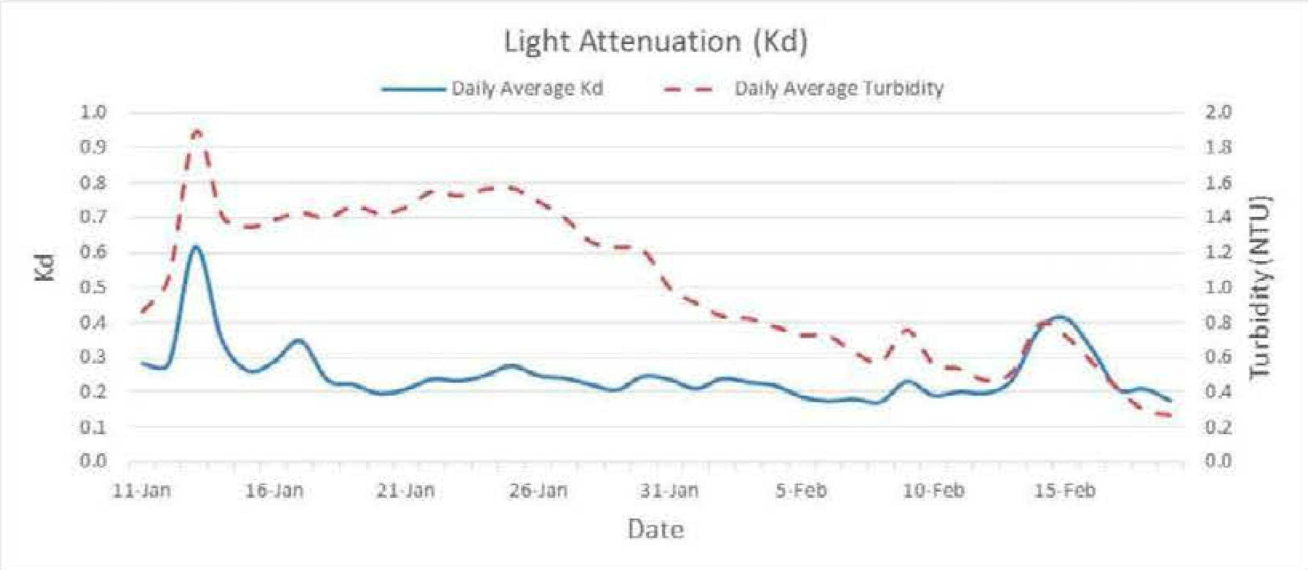


Figure 2-30 Daily average light attenuation (Kd) and near-bed turbidity (NTU)

To further understand the relationship between turbidity and PAR, average daily light attenuation data from Site 2 were plotted against average daily turbidity data from Site 2 (Figure 2-31). As shown in Figure 2-31, there is a general trend of increasing light attenuation with increasing turbidity. Note that the correlation of light attenuation to turbidity data is relatively poor (R^2 of 0.158). However, this poor correlation is typical of turbidity to PAR correlations due to other factors influencing light attenuation in the water column besides turbidity.

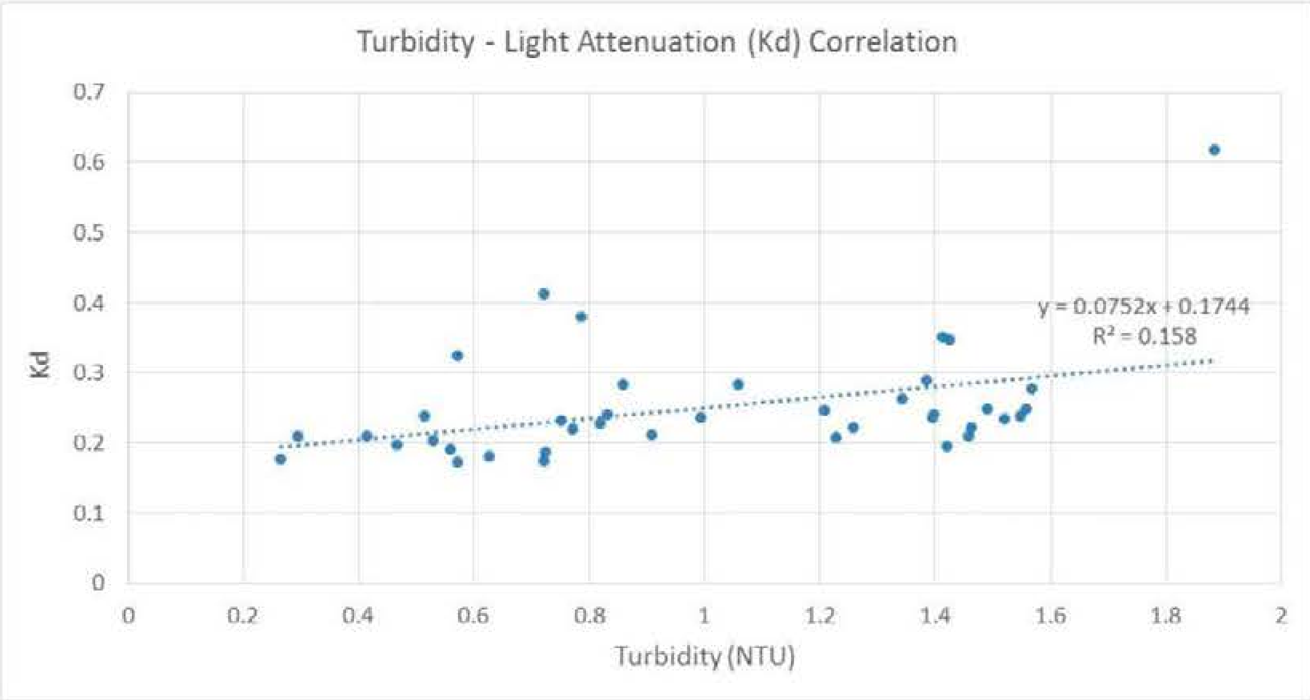


Figure 2-31 Turbidity to light attenuation correlation

2.12 Metals/Metalloids

Grab samples of metals/metalloids were collected by BMT during the baseline monitoring program as part of routine equipment servicing for the monitoring buoy. Water samples were also collected and analysed for metals/metalloids by Environmental Projects on 8/9 Sep 2017. These samples included both dissolved and total concentrations.

The monitoring data are summarised in Table 2-11, with the relevant ANZECC/ARMCANZ (2000) water quality guideline values (TTV for aquatic ecosystem protection and guideline values for aquaculture as per Section 2.2.2) included at the bottom of the table for comparison of data. It should be noted that ANZECC/ARMCANZ (2000) guideline values are relevant to the dissolved fraction of metals/metalloids.

The data in Table 2-11 indicates that Smith Bay is characterised by relatively low levels of metals/metalloids throughout the water column, with total and dissolved metals/metalloids mostly below laboratory limit of reporting (LOR). There were some slight detections of arsenic, copper and nickel, however all concentrations were below the relevant ANZECC/ARMCANZ (2000) guideline values. The only exceedance above guideline values was dissolved zinc which exceeded the aquaculture guideline value of 0.005 mg/L on a number of occasions. However, the aquatic ecosystem protection guideline value of 0.015 mg/L for dissolved zinc was not exceeded.

Table 2-11 Total and dissolved metals/metalloids (mg/L)

Monitoring Location	WQ Monitoring Buoy – Surface Waters					WQ Monitoring Buoy – Bottom Waters					WQ Monitoring Buoy – Surface Waters		ANZECC Guideline Values	
Data Source	BMT					BMT					Enviro Projects			
Date	22/08/17	19/10/17	23/11/17	10/01/18	21/02/18	22/08/17	19/10/17	23/11/17	10/1/18	21/2/18	8/9/17	9/9/17	Aquatic Ecosystem	Aqua-culture
Total Metals/Metalloids (mg/L)														
Arsenic	<0.002	<0.002	0.002	<0.002	0.002	<0.002	<0.002	0.002	<0.002	0.002	0.002	0.002	-	-
Cadmium	<0.0002	<0.0002	<0.0001	<0.0002	<0.0001	<0.0002	<0.0002	<0.0001	<0.0002	<0.0001	<0.0002	<0.0002	-	-
Chromium	<0.002	<0.002	<0.001	<0.002	<0.001	<0.002	<0.002	<0.001	<0.002	<0.001	<0.002	<0.002	-	-
Copper	<0.002	<0.002	0.002	<0.002	<0.001	<0.002	<0.002	0.001	<0.002	<0.001	<0.002	<0.002	-	-
Lead	<0.002	<0.002	<0.001	<0.002	<0.001	<0.002	<0.002	<0.001	<0.002	<0.001	<0.002	<0.002	-	-
Nickel	<0.002	<0.002	<0.001	<0.002	<0.001	<0.002	<0.002	<0.001	0.003	0.003	<0.002	<0.002	-	-
Zinc	<0.010	<0.010	0.005	0.004	0.007	<0.010	<0.010	0.004	0.059	0.01	0.004	0.008	-	-
Mercury	<0.0001	<0.0001	<0.00005	<0.00005	<0.00005	<0.0001	<0.0001	<0.00005	0.00077	0.00009	<0.00005	<0.00005	-	-
Dissolved Metals/Metalloids (mg/L)														
Arsenic	<0.002	<0.002	0.002	0.002	0.002	<0.002	<0.002	0.002	0.002	0.002	<0.002	<0.002	-	0.03
Cadmium	<0.0002	<0.0002	<0.0001	<0.0002	<0.0001	<0.0002	<0.0002	<0.0001	<0.0002	<0.0001	<0.0002	<0.0002	0.0007	0.0005
Chromium	<0.002	<0.002	<0.001	<0.002	<0.001	<0.002	<0.002	<0.001	<0.002	<0.001	<0.002	<0.002	0.0044	0.02
Copper	<0.002	<0.002	0.001	<0.002	<0.001	<0.002	<0.002	<0.001	<0.002	<0.001	<0.002	<0.002	0.0013	0.005
Lead	<0.002	<0.002	<0.001	<0.002	<0.001	<0.002	<0.002	<0.001	<0.002	<0.001	<0.002	<0.002	0.0044	0.001
Nickel	<0.002	<0.002	<0.001	<0.002	<0.001	<0.002	<0.002	<0.001	0.003	0.002	<0.002	<0.002	0.007	0.1
Zinc	<0.010	<0.010	0.002	<0.002	0.011	<0.010	<0.010	0.005	0.013	0.003	0.011	0.012	0.015	0.005
Mercury	<0.0001	<0.0001	<0.00005	<0.00005	<0.00005	<0.0001	<0.0001	<0.00005	0.00036	<0.00005	<0.00005	<0.00005	0.0001	0.001

Note: Green highlighted cells indicate exceedance of the aquatic ecosystem guideline values while yellow highlighted cells indicate exceedance of the aquaculture guideline values

2.13 Key Findings

In summarising the previous sections, the key findings in regard to baseline marine water quality conditions in Smith Bay are as follows:

- Marine water quality in Smith Bay is influenced by the wind and wave climate, with higher turbidity recorded with increasing wave height from waves generated during northerly winds.
- Turbidity was lower during the spring and summer months (Sep – Feb) when rainfall is lower and the winds are predominantly from the south (i.e. when calm conditions prevail in Smith Bay). During the winter months when rainfall is higher and winds are predominantly from the north, the turbidity was noticeably higher. Compared to the ANZECC/ARMCANZ (2000) guideline value of 0.5 NTU, median turbidity over the full year, summer and spring was below the guideline value, while median turbidity during autumn and winter slightly exceeded the guideline value.
- Water quality depth profiling (i.e. readings taken through the water column) indicated that marine waters in Smith Bay are generally well mixed with relatively consistent water quality from surface down to the bottom. However, there was evidence of increased turbidity levels near the seabed.
- Water temperature ranged from 14°C during the winter months up to 21-22°C during the summer months, while salinity ranged from 34-35 ppt during the wetter winter months up to 36-39 ppt during the summer months.
- Total suspended solids (TSS) data were below the ANZECC/ARMCANZ (2000) aquaculture guideline value of 10 mg/L, with most values being less than 5 mg/L. The exception was a nearshore water sample collected during visibly turbid conditions following strong northerly winds on 22/2/18, which had a TSS value of 41 mg/L.
- Suspended sediment particles sizes in water samples ranged from 0.2 µm up to 3,000 µm, with most particle sizes around 100-200 µm. There was a higher proportion of inorganic sediment particles (53-65%) compared to organic sediment particles (34-46%) analysed in samples collected from sedimentation tubes.
- Nutrient data indicated that Smith Bay is characterised by relatively low levels of nutrients, with all data at or below relevant water quality guideline values.
- Benthic photosynthetically active radiation (PAR) ranged from 2-8 mol/m^2/day (8-18% surface irradiance) in nearshore waters (~6 m water depth), 1-5 mol/m^2/day (3-10% surface irradiance) in mid-shore waters (~10 m water depth), and 1-4 mol/m^2/day (3-8% surface irradiance) in deeper waters (~14 m water depth).
- The light attenuation coefficient (Kd) fluctuated between 0.18 and 0.6 m^{-1}, with light attenuation increasing during periods of increased turbidity.
- Smith Bay is charactered by relatively low levels of metals/metalloids, with total and dissolved metals/metalloids mostly below laboratory limit of reporting (LOR). There were some slight detections of arsenic, copper and nickel, however all concentrations were below the relevant ANZECC/ARMCANZ (2000) guideline values. The only exceedance above guideline values was

dissolved zinc which exceeded the aquaculture guideline value of 0.005 mg/L but did not exceed the aquatic ecosystem protection guideline value of 0.015 mg/L.

3 Assessment of Potential Impacts

3.1 Overview

This section outlines the potential impacts the project may have on the marine water quality. This section describes:

- Potential impacts on marine water quality from the construction and operation of the wharf facilities.
- Options for managing and mitigating identified impacts during both construction and operation.

In this section, potential impacts are discussed in terms of the construction and operational stages, as follows:

- Construction stage – primarily focusing on capital dredging and placement activities.
- Operational stage - operation of the wharf facilities and maintenance dredging.

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

- Consequence of Impact – made up of assessment of the intensity, scale (geographic extent), duration of water quality impacts and sensitivity of environmental receptors to the impact. Table 3-1 is a summary of the categories used to define impact significance.
- Duration of impact - the duration of identified impacts is classified as per Table 3-2.
- Likelihood of Impact – which assesses the probability of the impact occurring. Table 3-3 is a summary of the categories used to define impact likelihood.

Risk rating – which assesses the level of risk for key impacting processes. The risk table (Table 3-4) adopted is generated from the Consequence and Likelihood scores, based on the overall matrix presented in Part A.

Table 3-1 Categories used to define consequence of impact (water quality)

Impact Consequence	Description for Water Quality (includes magnitude, duration, and sensitivity of receiving values)
Disastrous	Very long term permanent effects to marine water quality extending beyond the project area. Recovery is likely to take decades and complete recovery may not occur. Severe ecological or social consequences. Significant regional decrease in the diversity and/or abundance of biota. Generally corresponds to the 'Zone of High Impact' in terms of dredge-related turbidity as per Section 3.2 below.
Major	Long term permanent effects to marine water quality, potentially extending beyond the project area. Recovery is likely to take years and complete recovery may not occur. Major ecological or social consequences. Significant local decrease in the diversity and/or abundance of biota. Generally corresponds to the 'Zone of High Impact' in terms of dredge-related turbidity as per Section 3.2 below.

Impact Consequence	Description for Water Quality (includes magnitude, duration, and sensitivity of receiving values)
Moderate	Medium term effects to marine water quality within the project area. Recovery likely to occur within months. Moderate ecological or social consequences. Moderate local decrease to the diversity and/or abundance of biota Generally corresponds to the 'Zone of Low to Moderate Impact' in terms of dredge-related turbidity as per Section 3.2 below.
Minor	Short term effects to marine water quality within the project area. Recovery will occur within weeks. Minor ecological or social consequences. Minor local decrease to the diversity and/or abundance of biota Generally corresponds to the 'Zone of Low to Moderate Impact' in terms of dredge-related turbidity as per Section 3.2 below.
Negligible	Very short term or no effects to marine water quality within the project area. Recovery will occur within days. No ecological or social consequences. Generally corresponds to the 'Zone of Influence' in terms of dredge-related turbidity as per Section 3.2 below.
Beneficial	Existing water quality is improved in the project area and surrounds.

Table 3-2 Classifications of the duration of identified impacts

Relative duration of impacts	
Temporary	Days to months
Short Term	Up to one year
Medium Term	From one to five years
Long Term	From five to 50 years
Permanent / Irreversible	In excess of 50 years

Table 3-3 Categories used to define likelihood of impact (water quality)

Likelihood	Categories
Virtually impossible	Has almost never occurred elsewhere in similar situations, but is conceivable over the next 100 years.
Unlikely	Has occurred a few times elsewhere in similar situations. May occur within decades.
Possible	An occasional occurrence elsewhere in similar situations. May occur within the next few years.
Likely	A regular occurrence elsewhere in similar situations. Likely to occur within months.
Virtually certain	A very frequent occurrence elsewhere in similar situations. Expected to occur within days to weeks, or ongoing.

Table 3-4 Risk matrix for water quality

			Likelihood				
			1	2	3	4	5
			Virtually impossible	Unlikely	Possible	Likely	Virtually certain
Consequence	1	Negligible effect	1 (Low)	2 (Low)	3 (Low)	4 (Low)	5 (Medium)
	2	Minor effect	2 (Low)	4 (Low)	6 (Medium)	8 (Medium)	10 (High)
	3	Moderate effect	3 (Low)	6 (Medium)	9 (Medium)	12 (High)	15 (Extreme)
	4	Major effect	4 (Low)	8 (Medium)	12 (High)	16 (Extreme)	20 (Extreme)
	5	Disastrous effect	5 (Medium)	10 (High)	15 (Extreme)	20 (Extreme)	25 (Extreme)

Table 3-5 Risk rating legend

>=0	0 - Low	> Low risks will be maintained under review but it is expected that existing controls will be sufficient and no further action will be required to treat them unless they become more severe.
>=5	5 - Medium	> Medium risks can be expected to form part of routine operations but they will be explicitly assigned to relevant managers for action, maintained under review and reported upon at senior management level.
>=10	10 - High	> High risks demand attention at the most senior management level to ensure that they are mitigated and controlled as rapidly as possible. They are reported upon at the executive level.
>=17	17 - Extreme	> Extreme risks demand urgent attention at the most senior (including executive) level and must be immediately controlled. Operations must cease if the risk cannot be controlled.

3.2 Methodology

The typical approach to assessing the predicted impacts from construction and operations works is to assess compliance against water quality guideline values. This method allows a direct comparison of the likely compliance with established guidelines to ensure protection and/or enhancement of environmental values for the waters of concern.

As the actual capital dredging works are anticipated to occur only over a span of approximately 30 days (depending on the final design used and not including mobilisation and demobilisation), impacts over this short duration are problematic to compare for compliance against annual median water quality guidelines. Specifically, calculation of an annual median from only 30 days of impact would result in underestimation of potential impacts.

Given this, two levels of assessment were undertaken to support assessment of the potential impacts from the proposed dredging and placement works.

Firstly, percentile exceedance plots of dredging related turbidity are presented. These percentile plots are direct outputs from the modelling and provide an indication of excess sediment from dredging activities (these plots are discussed further in Section 3.3).

Secondly, project-specific threshold values were developed to assess potential impacts to marine water quality. These impact predictions are presented as 'zones of impact' which are derived using the percentile exceedance plots described above. The zone of impact approach is recognised as 'best practice' in dredging environmental assessments, building on the methodologies set out in the dredging environmental assessment guidelines produced by the WA EPA (2016).

The zones adopted for the current assessment, include the following:

- **Zone of High Impact** = water quality impacts resulting in predicted mortality of ecological receptors with recovery time greater than 24 months, and/or *likely* adverse impacts to aquaculture.
- **Zone of Low to Moderate Impact** = water quality impacts resulting in predicted sub-lethal impacts to ecological receptors and/or mortality with recovery between 6 months (lower end of range) to 24 months (upper end of range), and/or *potential* adverse impacts to aquaculture.
- **Zone of Influence** = extent of detectable[2] plume, but no predicted ecological impacts or impacts to aquaculture.

It is important to note that the recovery times outlined for the various zones should be considered as indicative only, noting that such timeframes are dependent on a range of factors that are extremely complex and difficult to accurately predict. The zones and their 'recovery timeframes' represent a means for comparing the likelihood that significant, detectable impact to sensitive receptors could occur, and are based on the assumption that recovery timeframes are dependent on the magnitude of impact.

A concept design of the zones of impact (sourced from WA EPA 2016) is shown in Figure 3-1.

[2] 'Detectable' plume in terms of detectable above background conditions by instrumentation deployed in the water column

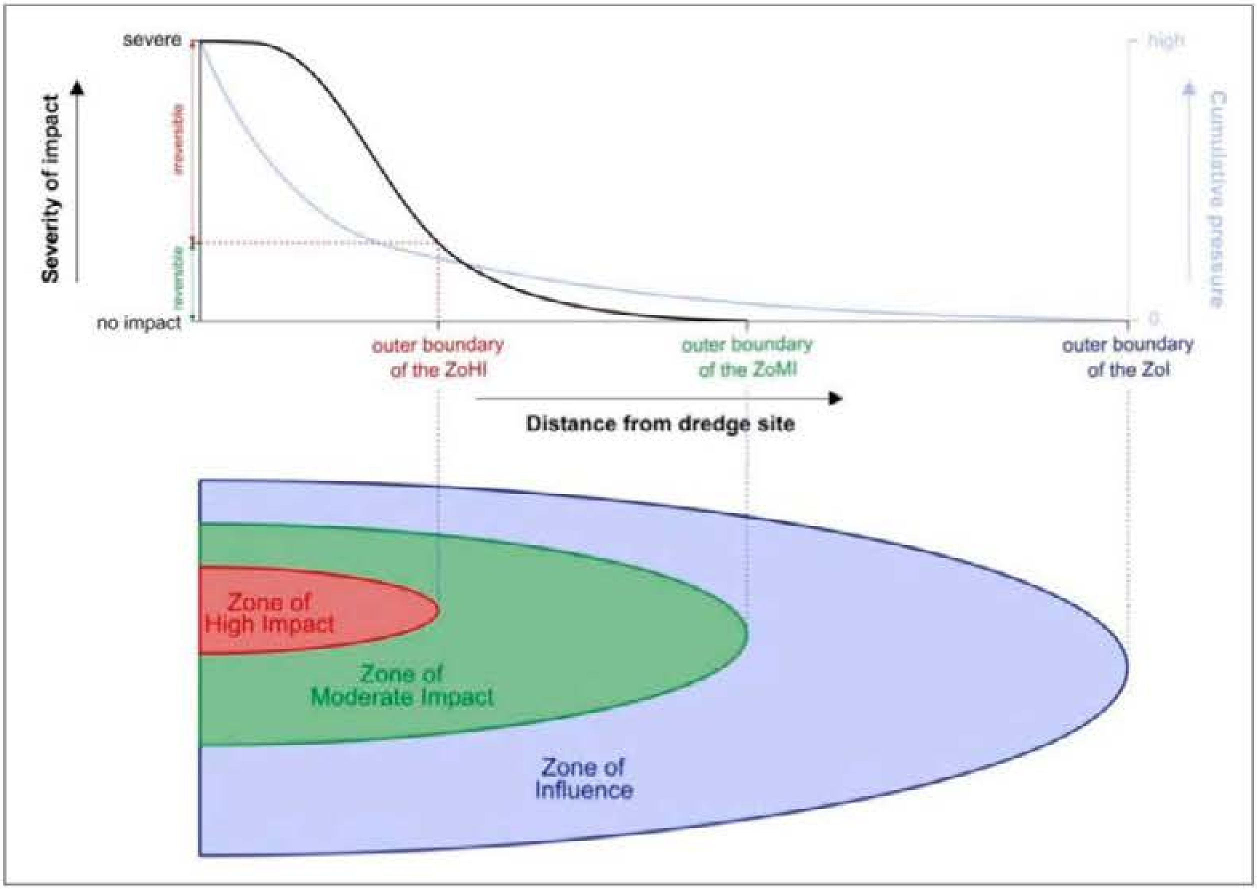


Figure 3-1 Concept design of impact zones (WA EPA 2016)

3.2.1 Impact Assessment Threshold Values

To determine impact assessment threshold values, the 12-month baseline water quality (turbidity) monitoring data set (Section 2) was analysed and percentile curves were produced. These percentile curves provide an indication of magnitude of turbidity and combined duration/frequency metrics for a range of conditions.

The 12-month baseline data was analysed over a moving 30-day window period to give a range of percentile values over different periods. The 30-day moving window analysis was undertaken by moving the 30-day window by 10 day increments over the entire dataset. This method provides an indication of natural variability around each percentile value and provides context for excess turbidity from dredging.

Figure 3-2 shows the percentile curves for continuous 12-month turbidity data collected at Smith Bay. This shows the natural variability measured around the median (50%ile) and other percentile values. The x-axis in Figure 3-2 represents the different percentile values extracted from the moving 30-day window analysis moving from frequently exceeded on the left to rarely exceeded on the right. The different curves are statistics representing the variability of the percentile analysis results across the different 30-day periods (making up the entire baseline monitoring period). The lower curve represents the least turbid conditions experienced across the baseline period while the upper limit is conversely the most turbid conditions. The solid red line is the mean of the different 30-day window conditions.

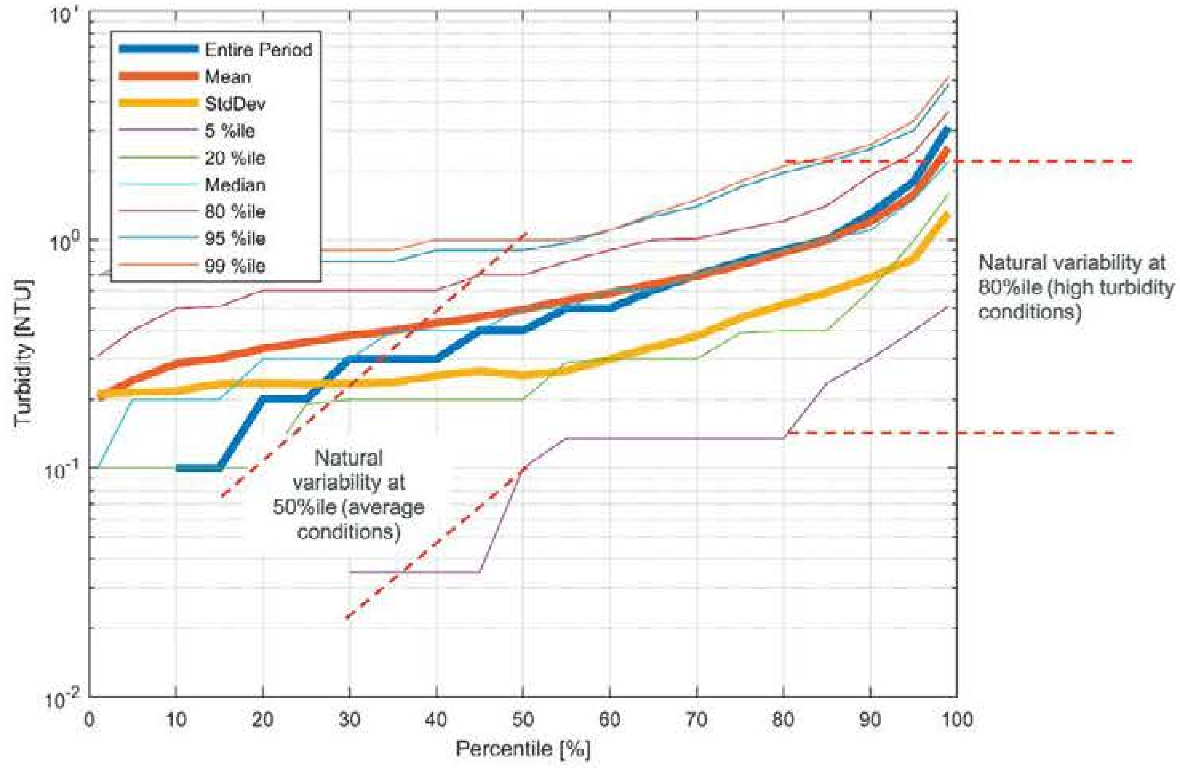


Figure 3-2 Summary analysis of baseline data for Smith Bay

Threshold values were derived from these percentile curves based on the natural variability around the 50th percentile (average conditions) and the 80th percentile (poor conditions – moderate to high wind and waves). As such, this method considers both acute and chronic impacts.

The approach used to determine the threshold level for the 'zone of low to moderate impact' (i.e. when water quality extends beyond natural variation and impacts to ecological receptors may begin to occur) involved using five standard deviations from the natural background mean at each percentile (i.e. 50th and 80th percentiles).

Extending this method out, threshold levels for the 'zone of high impact' were determined using 10 standard deviations from the mean. These threshold values were benchmarked against other studies, as discussed below.

The Yumbah seawater intakes represent a set of sensitive receptors located between 350 and 1 km to the east of the dredging footprint. Threshold values based around the 99th percentile turbidity (near-maximum turbidity) were developed taking into consideration water quality guideline values for protection of aquaculture values (refer to Table 2-2). The 99th percentile threshold value for the 'zone of low to moderate impact' was derived from the TSS guideline value of 10 mg/L (assumed to be equivalent to turbidity of 10 NTU). The threshold value for the 'zone of high impact' was assumed to be 50% higher than this guideline value – 15 mg/L (15 NTU).

As the water quality guideline values are for total sediment in the water, and the modelling outputs are provided in excess sediment 'above background', an assumption of background turbidity was required to apply the 99th percentile threshold values. Therefore, assuming a background turbidity of 1 NTU, the 99th percentile threshold values were 9 mg/L (9 NTU) and 14 mg/L (14 NTU) for the 'zone of low to moderate impact' and the 'zone of high impact' respectively.

The 'zone of influence' was defined as the extent of detectable plumes due to the proposed dredging. Turbid plumes were assumed to become 'detectable' once they were approximately 30-50% above background conditions. To determine the extent of this zone, the following criteria were used:

- Greater than 0.2 NTU above 50th percentile conditions.
- Greater than 0.5 NTU above 80th percentile conditions.
- Greater than 2 NTU above 99th percentile conditions.

Descriptions of the zones of impact and how they relate to water quality (turbidity) thresholds and aquaculture thresholds are included in Table 3-6.

Table 3-6 Description of impact assessment threshold values

Zone of Impact	Water Quality (Turbidity)	Aquaculture Limits
Zone of High Impact	• Excess turbidity causes total turbidity to go beyond natural variation • Threshold value = excess turbidity greater than 10 standard deviations from the natural background mean	99th percentile TSS/turbidity exceeds 14 mg/L (or 14 NTU) at the intake pipes - based on 50% higher than ANZECC/ARMCANZ (2000) aquaculture guideline value (minus background of 1 NTU)
Zone of Low to Moderate Impact	• Excess turbidity *may* push total turbidity beyond natural variation • Threshold value = excess turbidity greater than five standard deviations from the natural background mean	99th percentile TSS/turbidity exceeds 9 mg/L (equivalent to 9 NTU) at the intake pipes - based the ANZECC criteria (minus background of 1 NTU)
Zone of Influence	• Extent of detectable plumes • Dredging related turbidity exceeds 0.2 NTU above 50th percentile conditions, 0.5 NTU above 80th percentile conditions	99th percentile TSS/turbidity exceeds 2 mg/L (equivalent to 2 NTU)

The output from the analysis of data was turbidity impact assessment threshold values for each impact zone. These values represent turbidity above background levels and are included in Table 3-7. It is important to note that the threshold values presented in Table 3-7 are suitable for impact assessment purposes but are not proposed at this stage as the actual trigger values during dredging.

Table 3-7 Turbidity threshold values (above background) for impact assessment purposes

Impact Zone	Description	Method	Percentile	Descriptor	Turbidity Threshold Values (NTU) - *above background*
Zone of High Impact	Excess turbidity *definitely* pushes total turbidity beyond natural variation	10 x standard deviations from 50%ile mean	50%ile	Exceeded 50% of the time	2.5
		10 x standard deviations from 80%ile mean	80%ile	Exceeded 20% of the time	5.2
		Dredging related turbidity exceeds 14 NTU	99%ile	Exceeded 1% of the time	14
Zone of Low to Moderate Impact	Excess turbidity *may* push total turbidity beyond natural variation	5 x standard deviations from 50%ile mean	50%ile	Exceeded 50% of the time	1.3
		5 x standard deviations from 80%ile mean	80%ile	Exceeded 20% of the time	2.6
		Dredging related turbidity exceeds 9 NTU	99%ile	Exceeded 1% of the time	9

Impact Zone	Description	Method	Percentil e	Descriptor	Turbidity Threshold Values (NTU) - *above background*
Zone of Influence	Full extent of detectable plumes (including resuspension)	Dredging related turbidity exceeds 0.2 NTU	50%ile	Exceeded 50% of the time	0.2
		Dredging related turbidity exceeds 0.5 NTU	80%ile	Exceeded 20% of the time	0.5
		Dredging related turbidity exceeds 2 NTU	99%ile	Exceeded 1% of the time	2

3.2.1.1 Benchmarking to Other Studies

Due to the low turbidity environment of Smith Bay, and the presence of an aquaculture facility adjacent to the project, impact assessment threshold values developed for this project are more conservative than other similar dredging projects.

For example, threshold values developed by DHI (2010) for seagrass in low turbidity waters were as follows:

- Zone of total mortality (high impact) = 50th percentile value of 10 mg/L, and 80th percentile turbidity threshold of 25 mg/L.
- Zone of partial mortality (low to moderate impact) = 50th percentile value of 5 mg/L, and 80th percentile value of 10 mg/L.

Similarly, thresholds values are more conservative than water quality thresholds developed for Townsville Port Expansion Project EIS (POTL, 2016) for low turbidity offshore waters at Geoffrey Bay on the coast of Magnetic Island, as follows:

- Zone of low to moderate impact – 50th percentile value of 2 NTU and 80th percentile value of 5 NTU.
- Zone of high impact - 50th percentile value of 5 NTU and 80th percentile value of 10 NTU.

3.2.2 Development of Impact Zones

To delineate the zones of impact, the impact threshold values were interpolated spatially across the study area using GIS mapping software to produce 3-dimensional threshold grids. These threshold grids were then analysed against the 3-dimensional model output grids. This produced impact zone maps which indicate areas where modelled turbidity is higher than the relevant impact threshold value.

3.2.3 Sediment Deposition Threshold Values

There is currently limited data available on sediment deposition thresholds for seagrasses. There are literature values developed by DHI (2010) which were applied to a dredging project in north west Australia. While the applicability of the DHI thresholds to seagrass in the Smith Bay region is unknown, sediment deposition threshold values generally based on DHI thresholds are presented in Table 3-8.

These sediment deposition threshold values are presented in Table 3-8, and were used to develop the sediment deposition zones of impact presented in Section 3.4.2.

Table 3-8 Impact thresholds for sediment deposition (above background)

Impact zone	50%ile i.e. 15 days per month		95%ile i.e. 1.5 days per month		Final Deposition	
	Mass/area (mg/cm²/day)	Depth[1] (mm/day)	Mass/area (mg/cm²/day)	Depth[1] (mm/day)	Mass/area (mg/cm²)	Depth[1] (mm)
Zone of High Impact	>70	>1.4	>700	>14	>700	>14
Zone of Low to Moderate Impact	20 - 70	0.4 – 1.4	200 - 700	4 – 14	200 - 700	4 – 14
Zone of Influence	3 - 20	0.06 – 0.4	30 - 200	0.6 - 4	30 - 200	0.6 - 4

[1] Sediment depth assumes a dry sediment density of 500 kg/m³, i.e. 500 mg/cm² is approximately equivalent to a sediment deposition depth of 10 mm

3.3 Modelling Outputs

To assist with the impact assessment, dredge plume modelling results were used. These modelling results consist of time series results and percentile contour plots.

When interpreting percentile contour plots presented throughout this report, it is important to note that these are not snap-shots in time and therefore do not represent the spatial extent of the dredge plume at any given time. Instead, these plots indicate the areas where turbidity was elevated at some point during the dredge campaign. The type of percentile plot (e.g. 50th, 80th or 99th percentile) indicates the amount of time that the turbidity was exceeded at a particular location.

Percentile contour plots included in this report represent depth-averaged turbidity (i.e. turbidity averaged vertically in the water column from surface to sea bed). Percentile plots also showing near-bed turbidity are presented in the modelling report (BMT 2018).

Note that due to the TSS/turbidity correlation close to 1 (0.92 – refer to Section 2.9.4), TSS and turbidity in the modelling outputs can be considered interchangeable. That is, TSS of 1 mg/L can be considered as approximately the same as turbidity of 1 NTU.

Further details on modelling outputs and assumptions are provided in the modelling report (BMT 2018).

3.4 Construction Phase Impacts

3.4.1 Turbid Plumes from Capital Dredging

A key concern regarding water quality for the project is from the release of sediment particles to the water body during the capital dredging program. Turbid plumes may occur to some extent as a result of dredging activities.

The proposed dredging would be undertaken using a Cutter Suction Dredge (CSD) pumping material into a confined Dredge Material Placement Area (DMPA) situated on adjacent Smith Bay land. Dredged material would be dewatered within the DMPA and suitable material recycled as causeway core construction material. Treated tailwater from the DMPA would be returned to Smith Bay nearshore waters via a controlled discharge point.

Turbid plumes have the potential to migrate and impact upon nearby sensitive ecological and aquaculture receptors. The extent of the plume will depend on a range of factors including season, wind strength and direction, currents, tide status, location of dredge, as well as working methods and productivity. The total duration of the capital dredging campaign is expected to be at least 30 days but may take longer depending on operational methodologies and weather conditions.

3.4.1.1 Plume Modelling Scenarios

In accordance with the WA EPA guidelines for dredge plume risk assessments (WA EPA 2016), the modelling assessment has considered a number of scenarios in order to characterise the range of potential impacts that may be associated with the Project construction phase. As described in the modelling report (BMT 2018) these scenarios have considered two different design options related to offshore distance of the wharf and have also covered a range of environmental conditions across both summer and winter seasons.

The two design options considered cover the range of likely wharf positions and capital dredging volumes for the Project. The modelling report describes the sensitivity of the plume predictions to the design option assumptions and concludes that the plume impacts are not strongly dependent on the size or location of the dredge footprint (within the assessed bounds). The impact predictions were more sensitive to the range of environmental conditions than the design assumptions.

In order to describe the range of impacts assessed by the full ensemble of plume modelling scenarios the predictions were aggregated into **Expected** (average) and **Worst** (upper-bound) case results as described below:

- **Expected**: for a given percentile, the mean level across all simulations was assessed as the 'expected case. Given the distinct seasonality of the model predictions, summer and winter averages were assessed separately and the maximum level across both seasons was derived as the 'expected' case.
- **Worst**: For a given percentile, the maximum concentration of all ensemble simulations was taken as the 'worst' level at a given location.

To provide an indication of effects of seasonality on impact predictions, each scenario (expected and worst case) was modelled across both seasons (summer and winter) and summer only.

3.4.1.2 Percentile Plots

The following percentile contour plots (Figure 3-3 to Figure 3-8) show depth-averaged dredging-related turbidity above background levels. Plots presented are for expected case and worst case scenarios, for both seasons (summer and winter) and summer only.

Note that the scales used on the plots differ between the 50th, 80th and 99th percentiles to reflect ambient turbidity during these varying conditions. Plots shown are based on the following percentile values:

- 50th percentile plots - typical (median) turbidity levels which occur 50 percent of the time.
- 80th percentile plots – less frequent periods of higher turbidity which occur 20 percent of the time.
- 99th percentile plots - infrequent periods of near-maximum turbidity (occurring one percent of the time).

Figure 3-3 to Figure 3-8 indicate that as a result of capital dredging, turbid dredge plumes are predicted to extend east and west along the coastline for approximately 5 km for the expected case (summer and winter) and 6 km for the worst case (summer and winter). Median (50th percentile) TSS/turbidity is predicted to increase by up to 1.5 mg/L (1.5 NTU) within approximately 500 m of the dredge footprint for the expected case, with these increases extending a further 2 km to the east under worst case conditions.

Figure 3-4 and Figure 3-7 indicate that 80th percentile TSS/turbidity is predicted to increase by approximately 3-5 mg/L (3-5 NTU) within a few hundred metres of the dredge footprint for the expected case (summer and winter), with plumes of similar magnitude extending further to the east under worst case conditions (summer and winter).

Figure 3-5 indicates that near-maximum (99th percentile) TSS/turbidity is predicted to increase by approximately 7-10 mg/L (7-10 NTU) within a few hundred metres of the dredge footprint for the expected case (summer and winter), with increases up to 3 mg/L (3 NTU) extending east and west along the coast for approximately 2-3 km. Under worst case conditions (Figure 3-8), increases to near-maximum (99th percentile) TSS/turbidity of up to 7-10 mg/L (7-10 NTU) is predicted to extend to the east for up to 2 km. Near-maximum turbidity (depth-averaged) is predicted to increase at the Yumbah intakes by approximately 4 mg/L (4 NTU) for the expected case, and up to 7 mg/L (7 NTU) under worst case conditions.

In comparison to the summer/winter simulations, the summer only simulations (bottom of Figure 3-3 to Figure 3-8) show that dredge plumes are predicted to be mobilised predominantly to the west of the dredge footprint due to the prevailing weather conditions during the summer period.

The impact significance of these results is interpreted using time series plots and zones of impact in the following section.

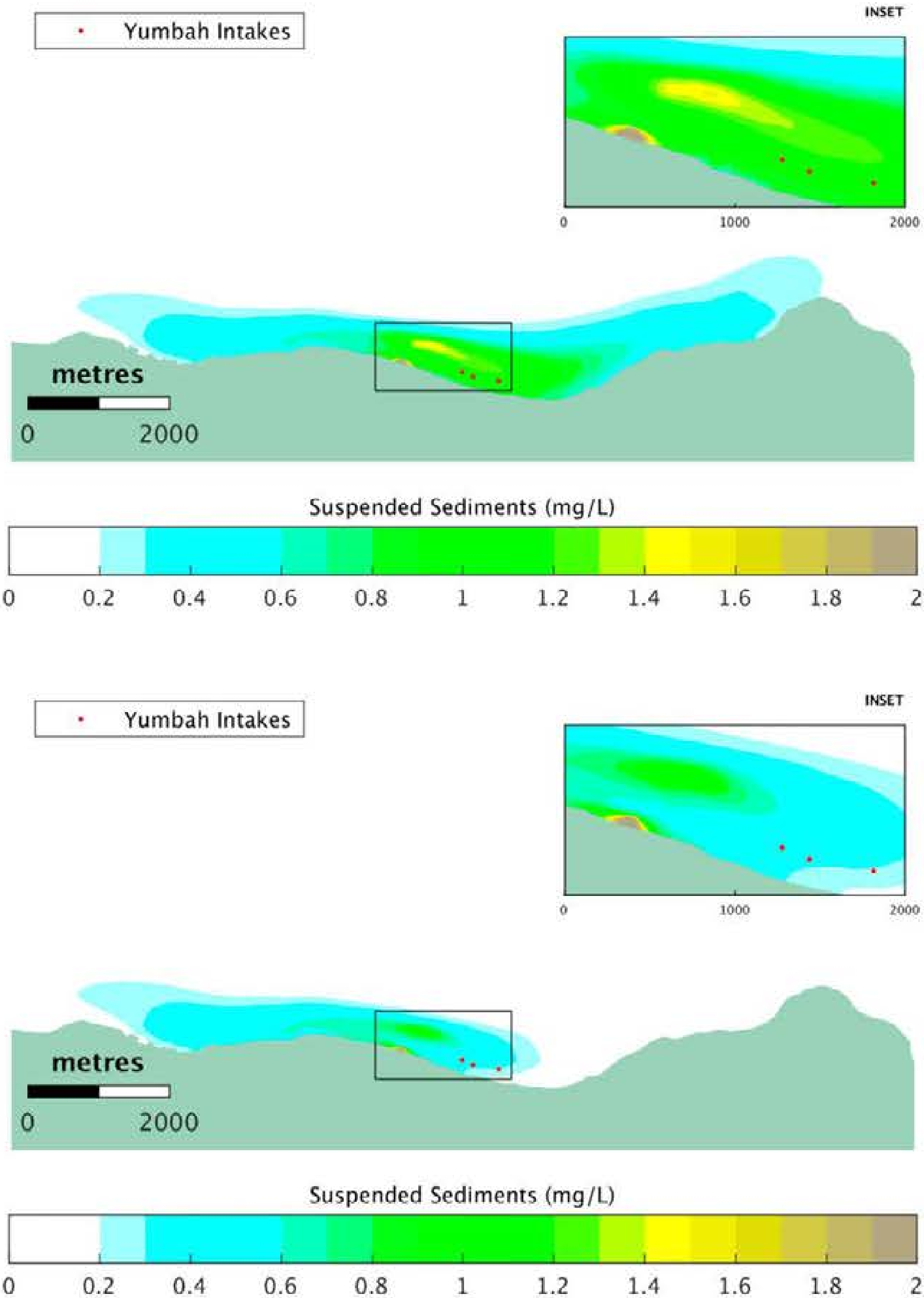
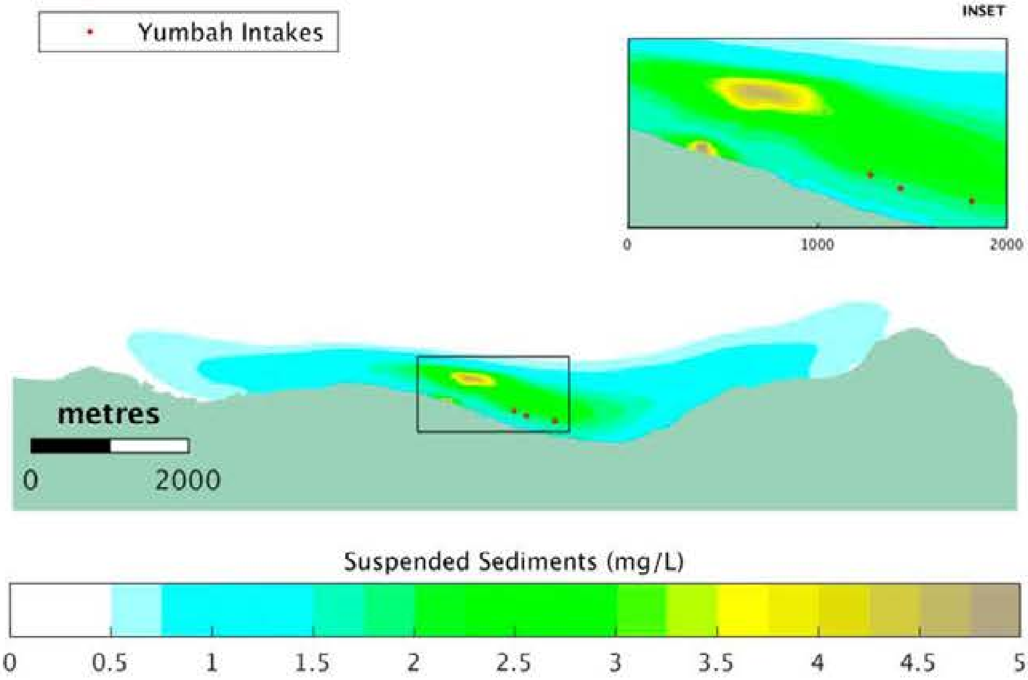


Figure 3-3 Dredge Plume TSS 50th Percentile – Expected Case – Summer and Winter (top) and Summer only (bottom)



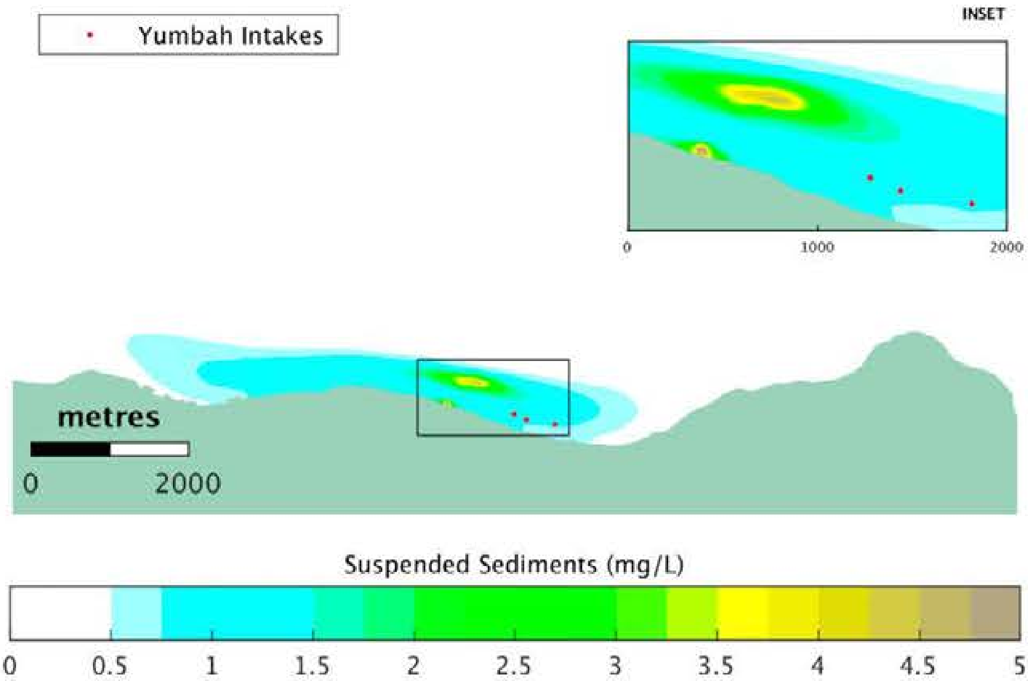


Figure 3-4 Dredge Plume TSS 80th Percentile – Expected Case – Summer and Winter (top) and Summer only (bottom)

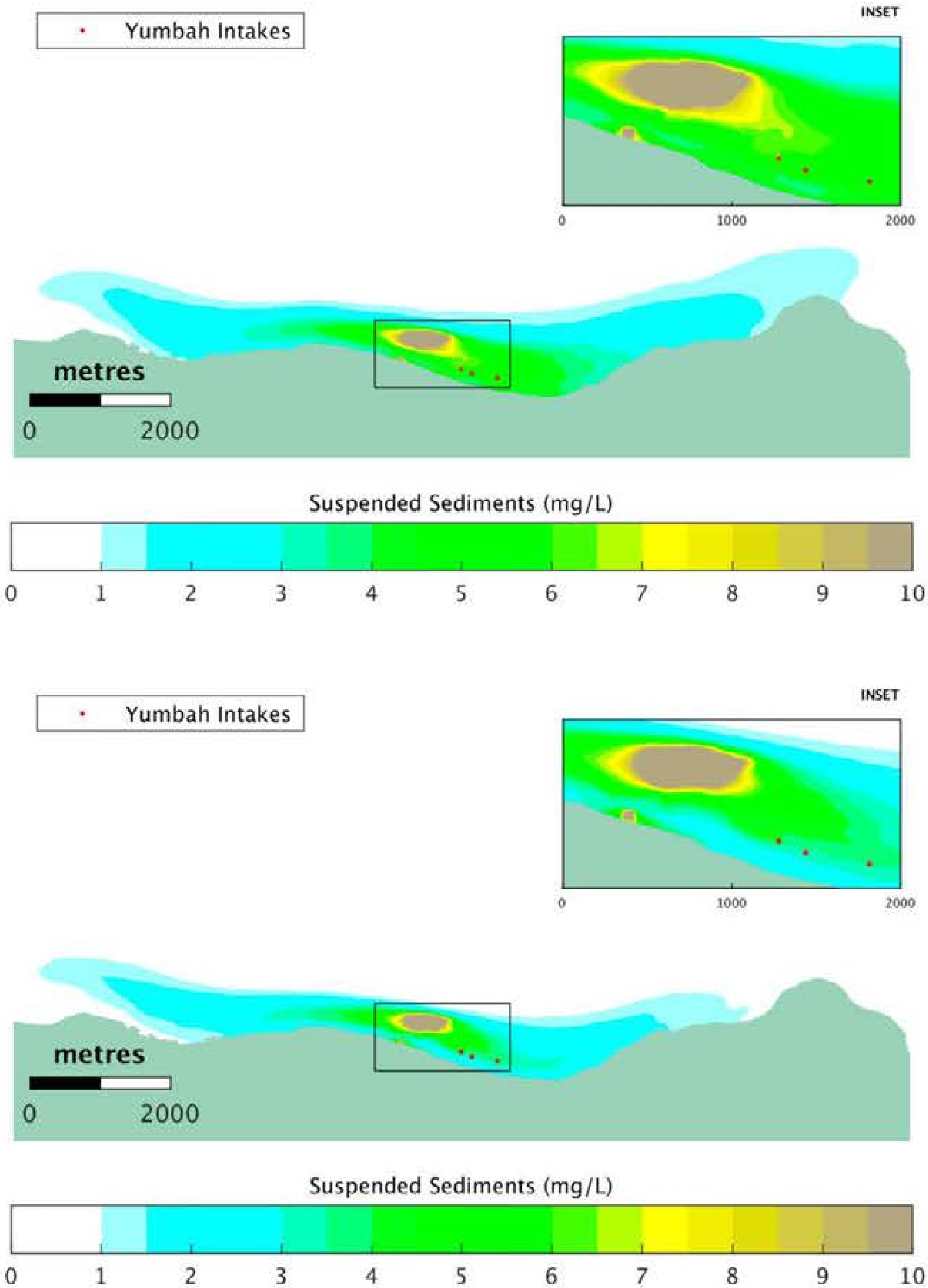


Figure 3-5 Dredge Plume TSS 99th Percentile – Expected Case – Summer and Winter (top) and Summer only (bottom)

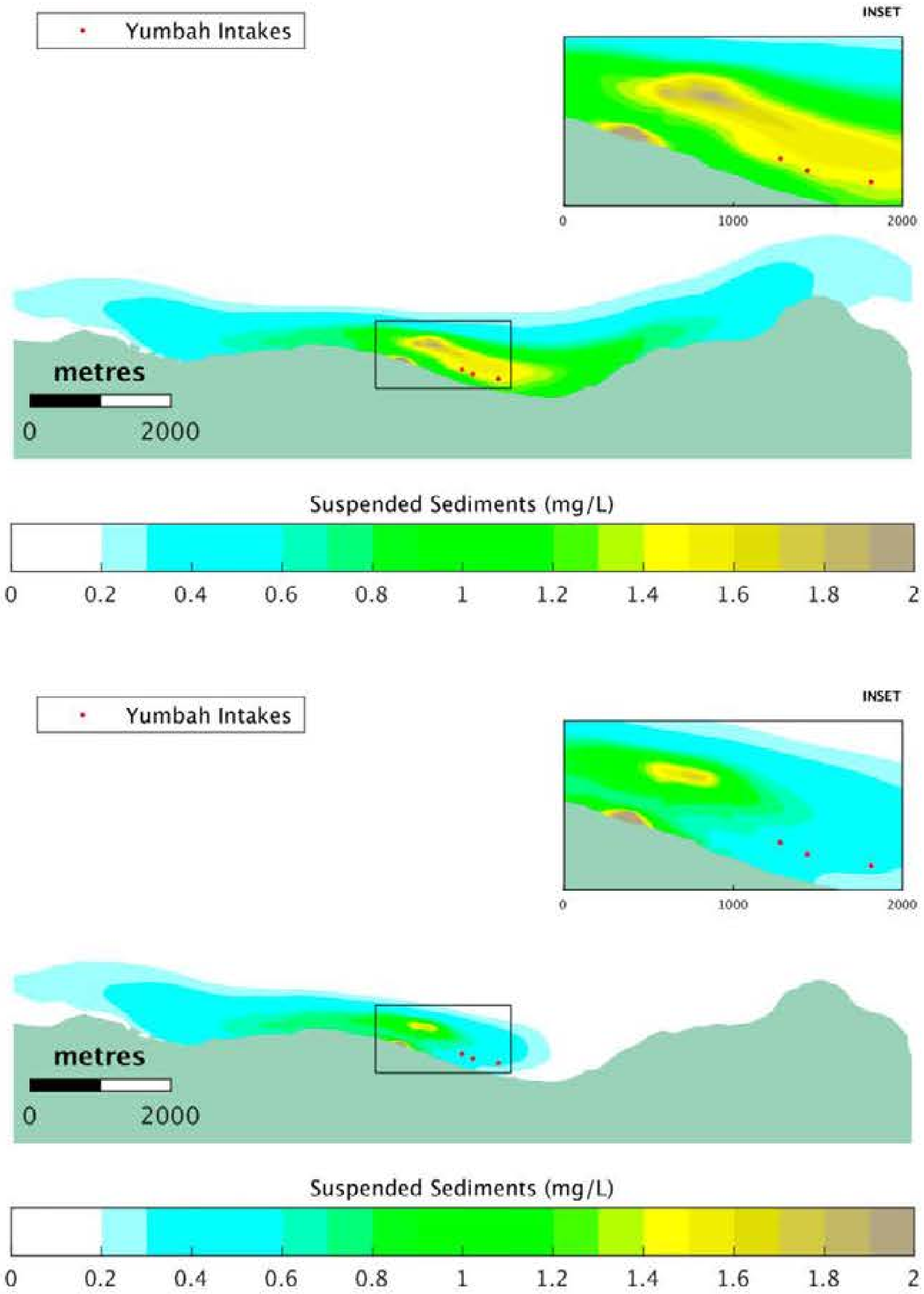
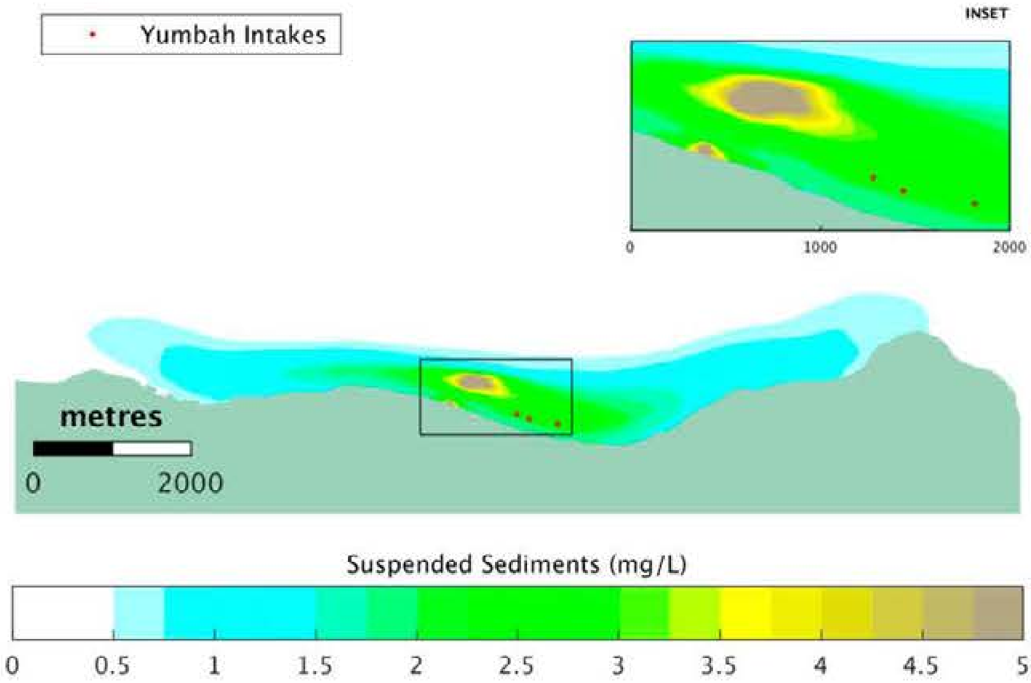


Figure 3-6 Dredge Plume TSS 50th Percentile – Worst Case – Summer and Winter (top) and Summer only (bottom)



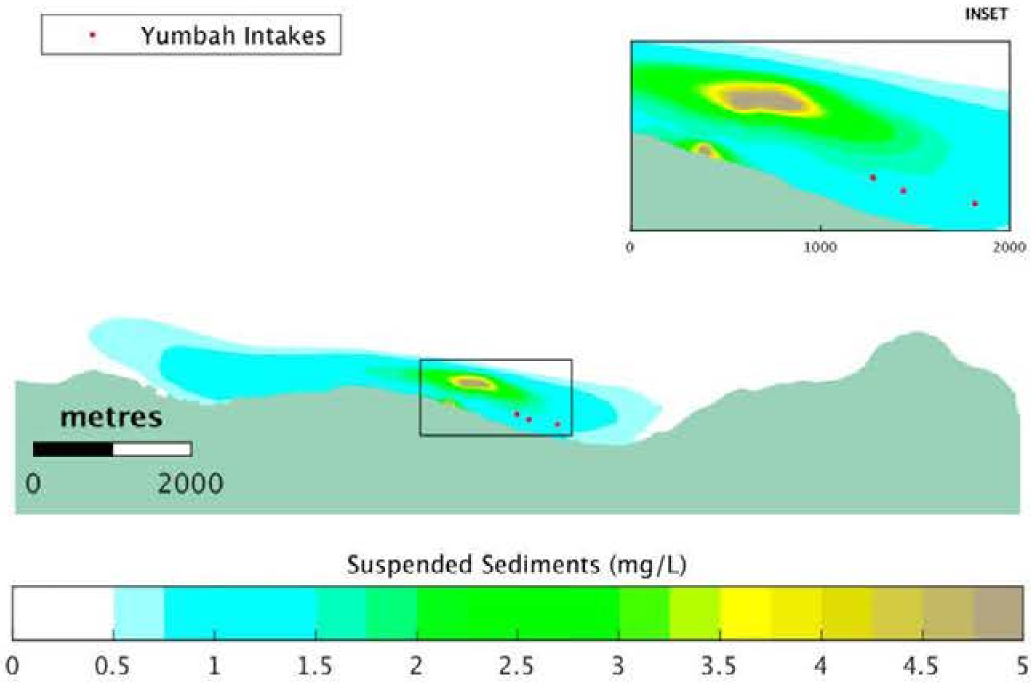


Figure 3-7 Dredge Plume TSS 80th Percentile – Worst Case – Summer and Winter (top) and Summer only (bottom)

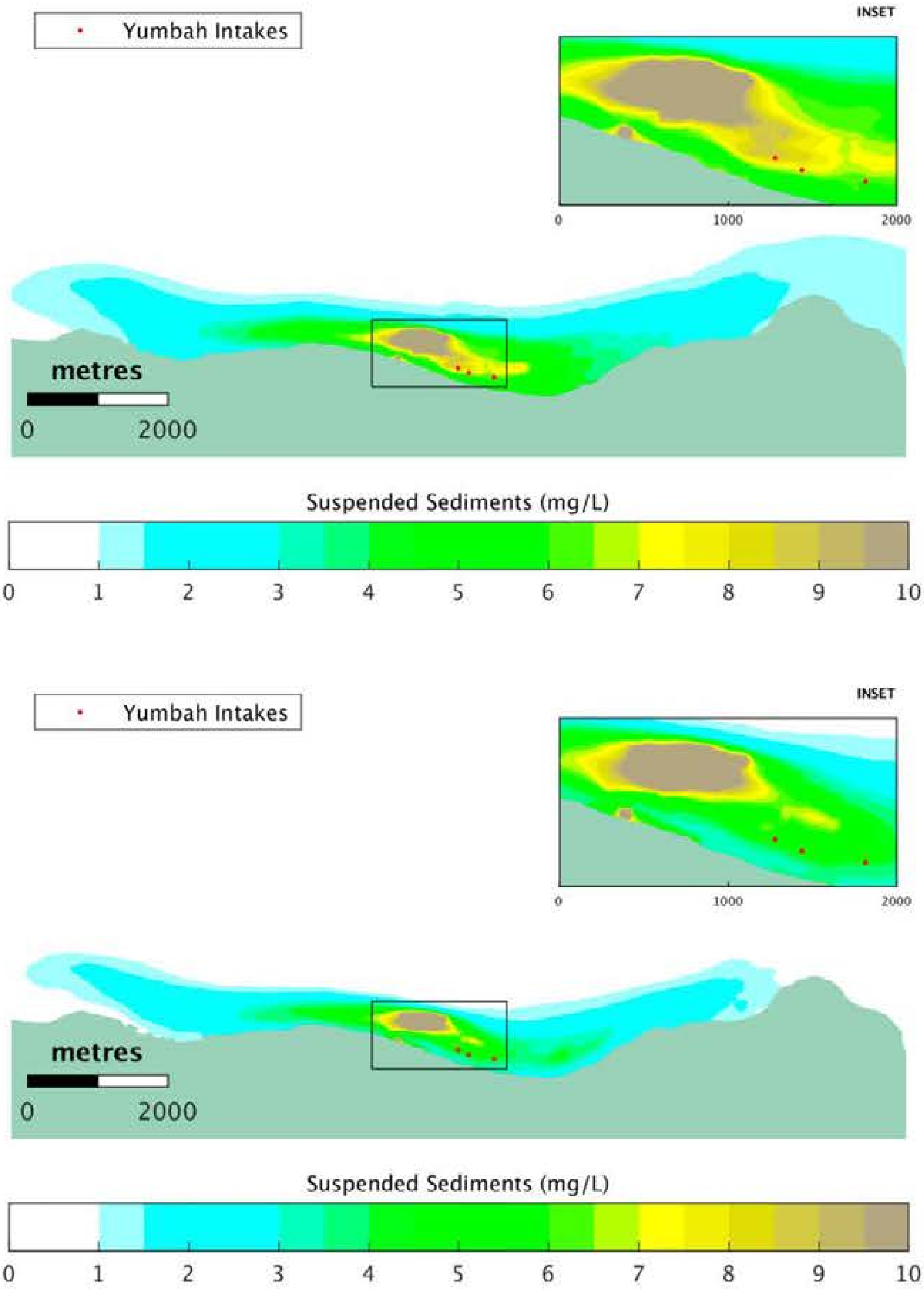


Figure 3-8 Dredge Plume TSS 99th Percentile – Worst Case – Summer and Winter (top) and Summer only (bottom)

3.4.1.3 Time Series Results

The percentile plots presented in the previous section showed above-ambient, depth-averaged turbidity (i.e. turbidity averaged vertically in the water column from surface to sea bed). To assess near-bed TSS at the Yumbah intake pipes, time series outputs from the model were assessed. The timeseries results were extracted from the bottom 1 m of the water column and are inclusive of both ambient plus the dredge-plume component.

Time series results for all scenarios and intake pipes are presented in the modelling report (BMT 2018). However, to provide an indication of worst case results, the time series results for Yumbah Intake West are shown in Figure 3-9 as this intake pipe has the highest predicted TSS levels of all intake pipes. Results are shown for summer and winter 2015 for dredge scenario A (100,000 m^3) and dredge scenario B (200,000 m^3) – refer to the modelling report (BMT 2018) for further information on these scenarios.

The previous section indicated that near-maximum turbidity (depth-averaged) is predicted to increase above-ambient at the Yumbah intakes by approximately 4 mg/L (4 NTU) for the expected case, and up to 7 mg/L (7 NTU) under worst case conditions. However, the time series results in Figure 3-9 shows that total near-bed TSS at Yumbah Intake West is predicted to peak for brief periods at around 20 mg/L (20 NTU) in summer and 30 mg/L (30 NTU) in winter. Figure 3-9 indicates that over the duration of dredging, near-bed TSS at Yumbah Intake West is predicted to be maintained at around 1-5 mg/L (1-5 NTU) in summer and 1-7 mg/L (1-7 NTU) in winter.

As can be seen by these results, near-bed suspended sediments at the Yumbah intake pipes are predicted to be higher than the depth-averaged results representing the entire water column. During the summer period TSS exceedances above 10 mg/L (10 NTU) are infrequent, occurring 2-3 times during the dredging campaign, and typically persist for around 2-5 hours. The modelling report (BMT 1018) commented that these acute plume instances correspond with periods of 'high-connectivity' hydrodynamic conditions associated with Dodge tides and light to moderate westerly winds. It was recommended to employ active measures to forecast such periods of adverse environmental conditions and actively manage dredge plume sources at these times. This and other capital dredging mitigation options are discussed further in Section 4.1.1. The timeseries presented here do not include either predictive or reactive management measures and therefore represent an upper-bound in the absence of mitigation.

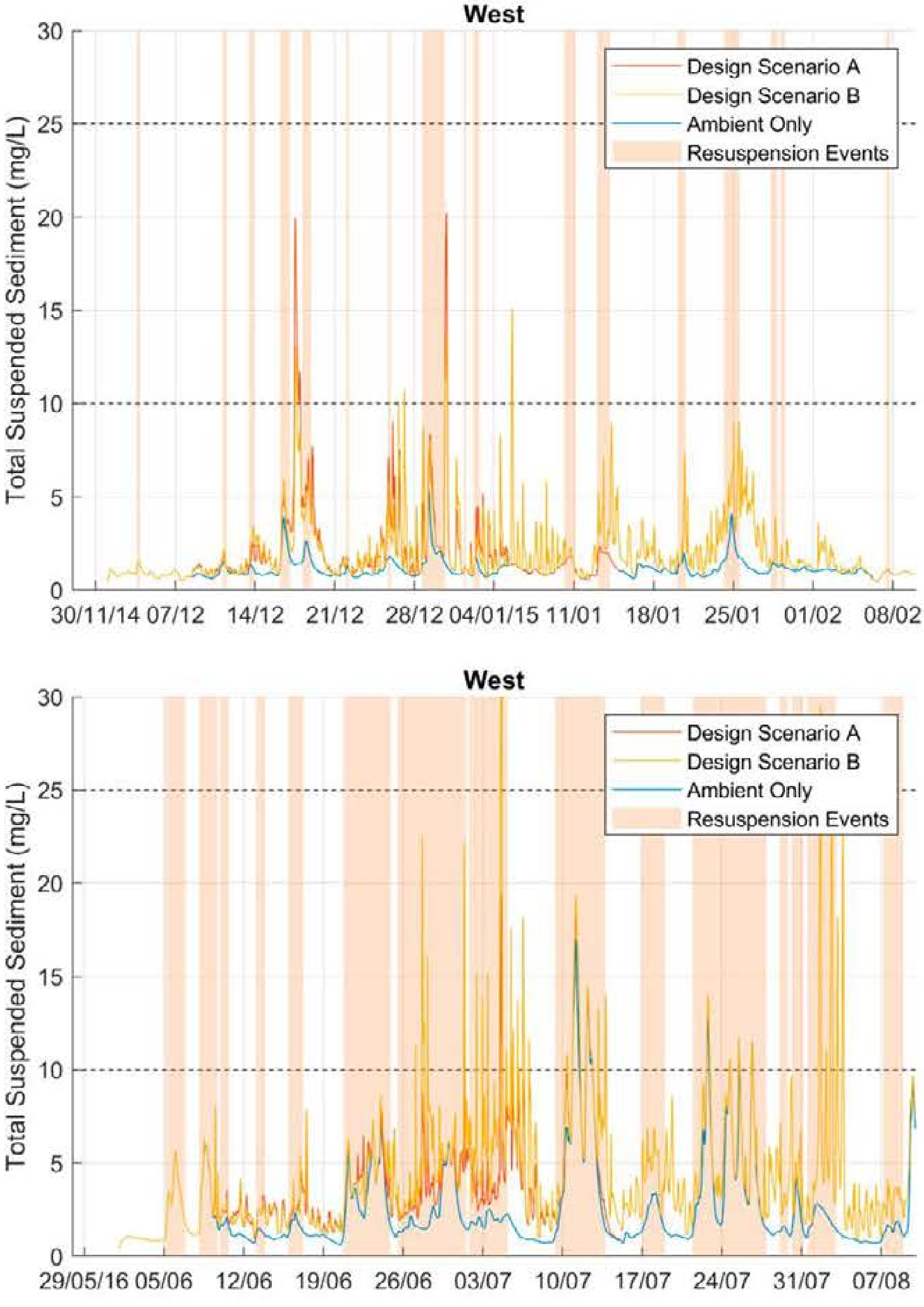


Figure 3-9 Time series results for Yumbah Intake West – Summer 2015 (top) and Winter 2016 (bottom). Design scenario TSS is near-bed and includes ambient plus dredge-plume component.

3.4.1.4 Zones of Impact

In accordance with the methodology discussed earlier, spatial zones of predicted impact were developed using project-specific impact threshold values (described in Section 3.2). These impact zone maps indicate areas where modelled TSS/turbidity is higher than the relevant impact threshold value. The impact zone maps are shown in Figure 3-10 to Figure 3-13, with the expected case and worst case shown to provide an indication of the lower and upper bounds of impact predictions for capital dredging. Both seasons (summer/winter) are presented for both cases, along with summer only for both cases to provide an indication of effects of seasonality. The impact zones are described as follows:

- Zone of Influence - extent of detectable plume, but no predicted ecological impacts or impacts to aquaculture.
- Zone of Low to Moderate Impact – water quality impacts resulting in predicted sub-lethal impacts to ecological receptors and/or mortality with recovery between 6 months (lower end of range) to 24 months (upper end of range), and/or *potential* adverse impacts to aquaculture.
- Zone of High Impact – water quality impacts resulting in predicted mortality of ecological receptors with recovery time greater than 24 months, and/or *likely* adverse impacts to aquaculture.

For the summer/winter expected case (Figure 3-10), the 'zone of influence' (i.e. extent of detectable plumes but no predicted ecological impact) is predicted to extend east and west along the coastline for approximately 5-6 km (Figure 3-10). The 'zone of low to moderate impact' is predicted to be restricted to within 400 m of the dredge footprint for the summer/winter expected case, as well as a small area adjacent to the coastline at the tailwater discharge point (Figure 3-10). A 'zone of high impact' for the summer/winter expected case is predicted to be restricted to the dredge footprint and areas directly adjacent. The Yumbah intakes are not predicted to be within any zones of impact for the summer/winter expected case.

For the summer only expected case (Figure 3-11), the extent of the 'zone of influence' is predicted to reduce to the east of the dredge footprint (from 5-6 km down to approximately 3 km) relative to the summer/winter expected case. The zones of 'low to moderate impact' and 'high impact' are also slightly reduced for the summer only expected case.

Under summer/winter worst case conditions (Figure 3-12), the 'zone of influence' is predicted to extend east and west along the coastline for approximately 8 km. The 'zone of low to moderate impact' is predicted to extend approximately 2 km to the east of the dredge footprint encompassing the Yumbah intakes, while the 'zone of high impact' is predicted to be restricted to the dredge footprint and areas directly adjacent (Figure 3-12).

For the summer only worst case (Figure 3-13), the extent of the 'zone of influence' is predicted to reduce to the east of the dredge footprint (from 8 km down to approximately 5 km) relative to the summer/winter worst case. Furthermore, the 'zone of low to moderate impact' for the summer only expected case is significantly reduced in comparison to the summer/winter worst case, with the 'zone of low to moderate impact' predicted to be restricted to within 400 m of the dredge footprint, with the impact zone no longer encroaching near the Yumbah intakes. The 'zone of high impact' is predicted to be slightly reduced relative to the summer/winter worst case.

Therefore, based on the zones of impact and the relatively short duration of the capital dredge campaign (~30 days), turbid plumes from capital dredging are predicted to present a temporary minor impact to marine water quality.

Comparing the zones of impact for the summer/winter and summer only indicates that seasonality has an influence on hydrodynamics within Smith Bay. As shown in the zone of impact figures, the plume extent to the east of the dredge footprint can be minimised if dredging is undertaken during summer months.

Legend

Yumbah Aquaculture Intake Pipes

Zones of Impact - TSS/Turbidity

Zone of Influence (no ecological impacts)

Zone of Low to Moderate Impact

Zone of High Impact

Proposed Wharf Design and Dredge Footprint

Title:

Zones of Impact - TSS/Turbidity Expected Case - Summer and Winter

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Scale - Inset

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Scale - Main Map

Figure:
3-10

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A

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Legend

Yumbah Aquaculture Intake Pipes

Zones of Impact - TSS/Turbidity

Zone of Influence (no ecological impacts)

Zone of Low to Moderate Impact

Zone of High Impact

Proposed Wharf Design and Dredge Footprint

Title:

Zones of Impact - TSS/Turbidity Expected Case - Summer Only

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Figure:
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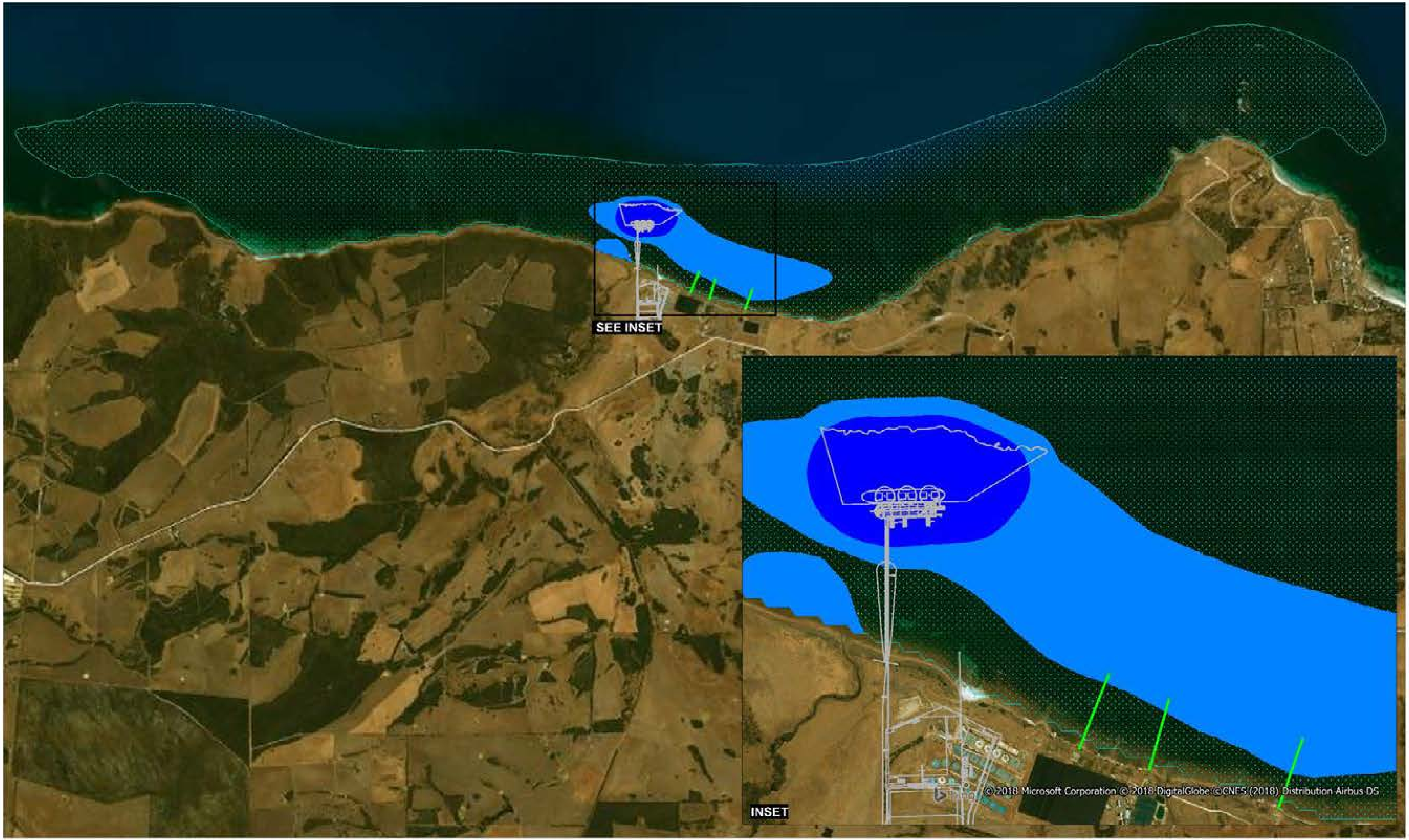

Legend

- Yumbah Aquaculture Intake Pipes

Zones of Impact - TSS/Turbidity

- Zone of Influence (no ecological impacts)
- Zone of Low to Moderate Impact
- Zone of High Impact
- Proposed Wharf Design and Dredge Footprint

Title:
Zones of Impact - TSS/Turbidity Worst Case - Summer and Winter

Figure: 3-12

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Legend

Yumbah Aquaculture Intake Pipes

Zones of Impact - TSS/Turbidity

Zone of Influence (no ecological impacts)

Zone of Low to Moderate Impact

Zone of High Impact

Proposed Wharf Design and Dredge Footprint

Title:

Zones of Impact - TSS/Turbidity Worst Case - Summer Only

Figure: 3-13

Rev: A

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3.4.2 Sediment Deposition from Capital Dredging

While the previous section assessed impacts to water quality from suspended sediments in the water column as a result of turbid dredge plumes, this section assesses the potential impacts in terms of sediment deposition from the settlement of these suspended sediments.

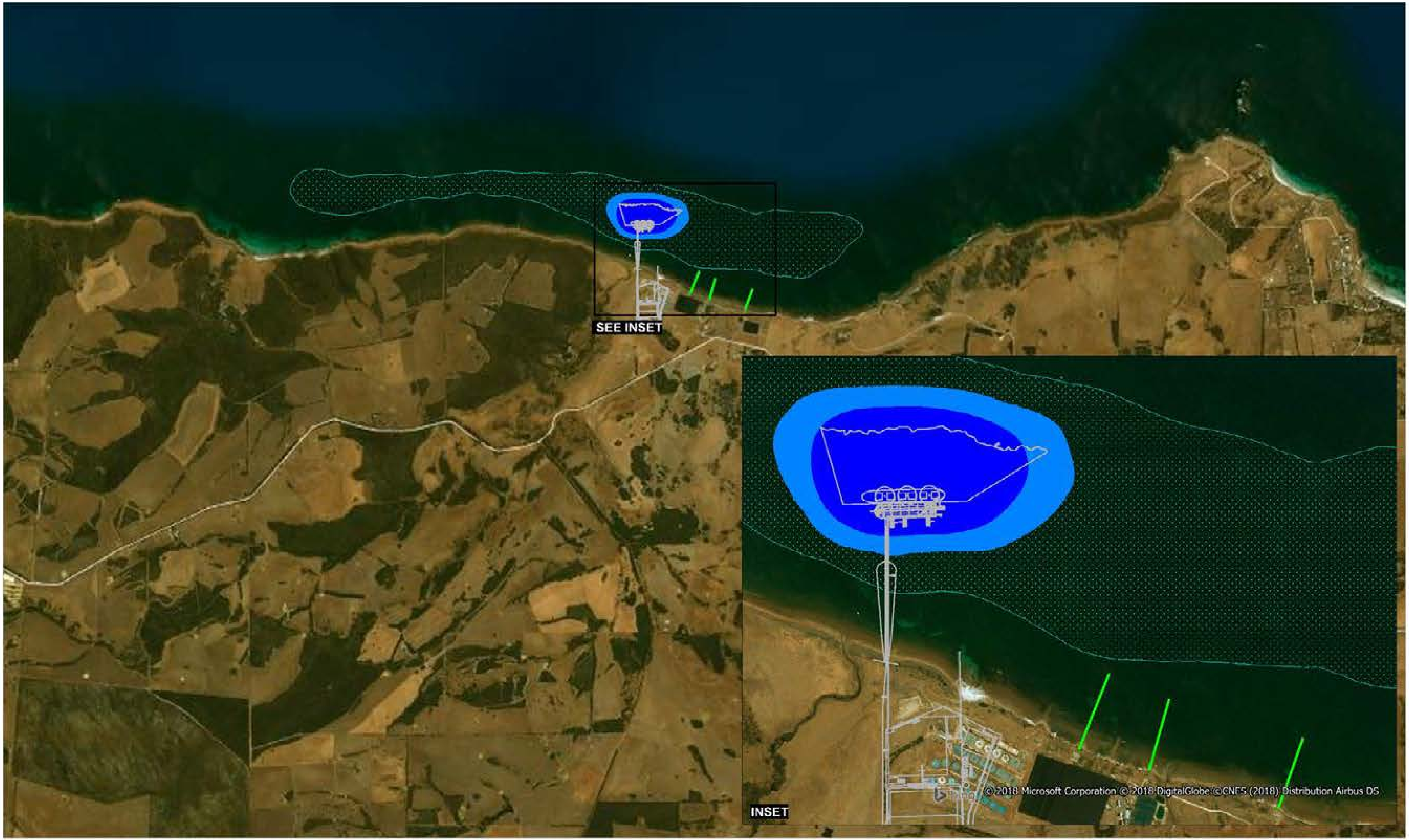
Dredging related (above ambient) sediment deposition outputs are provided in the modelling report (BMT 2018) as dry sediment mass per unit area i.e. mg/cm^2. As an approximate rule of thumb, 500 mg/cm^2 can be converted to an equivalent sediment deposition depth of 10 mm. This conversion assumes a freshly deposited dry sediment density of 500 kg/m^3.

The impact significance of the modelled sediment deposition results is interpreted using sediment deposition zones of impact as described in Section 3.2.3. These sediment deposition zones of impact use sediment deposition rates (mg/cm^2/day and cm/day) and final deposition at the end of the model simulation (mg/cm^2 and cm).

The sediment deposition zones of impact are shown in Figure 3-14 and Figure 3-15 for the expected case (summer/winter and summer only), and Figure 3-16 and Figure 3-17 for the worst case (summer/winter and summer only). These figures indicate that the zones of impact are predicted to be fairly similar between all scenarios, with sediment deposition zones of impact restricted to the dredge footprint and areas immediately adjacent.

Seasonality has minimal impact on sediment deposition zones of impact, with the only noticeable difference being a slightly reduced 'zone of influence' to the east of the dredge footprint for the summer only cases (Figure 3-15 and Figure 3-17) relative to summer/winter cases.

Therefore, based on the zones of impact and the relatively short duration of the capital dredge campaign (~30 days), sediment deposition from capital dredging is predicted to present a temporary minor impact.



Legend

Yumbah Aquaculture Intake Pipes

Zones of Impact - TSS/Turbidity

Zone of Influence (no ecological impacts)

Zone of Low to Moderate Impact

Zone of High Impact

Proposed Wharf Design and Dredge Footprint

Title:

Zones of Impact - Sediment Deposition Expected Case - Summer and Winter

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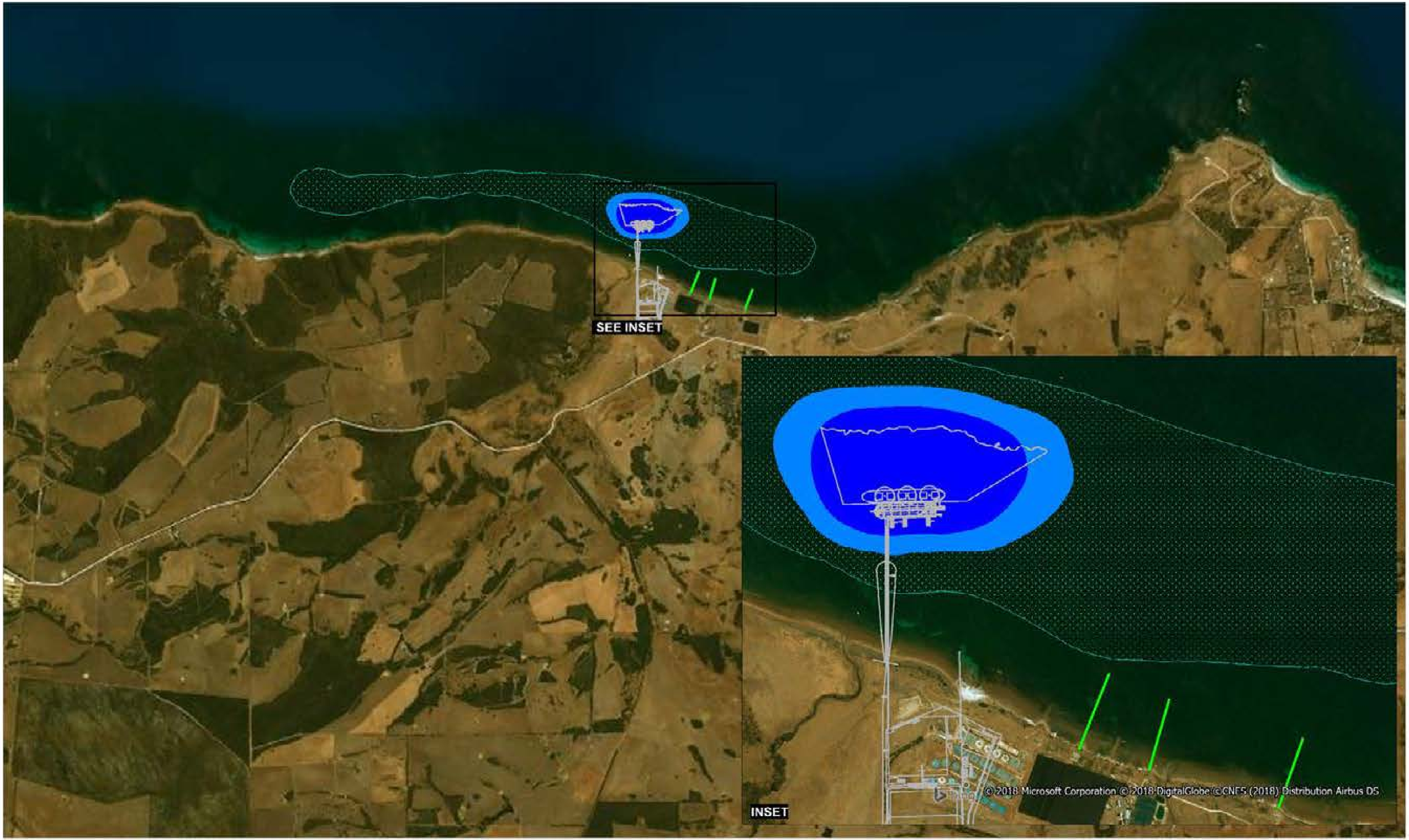

Legend

Yumbah Aquaculture Intake Pipes

Zones of Impact - TSS/Turbidity

- Zone of Influence (no ecological impacts)
- Zone of Low to Moderate Impact
- Zone of High Impact

Proposed Wharf Design and Dredge Footprint

Title:

Zones of Impact - Sediment Deposition Expected Case - Summer Only

Figure: 3-15

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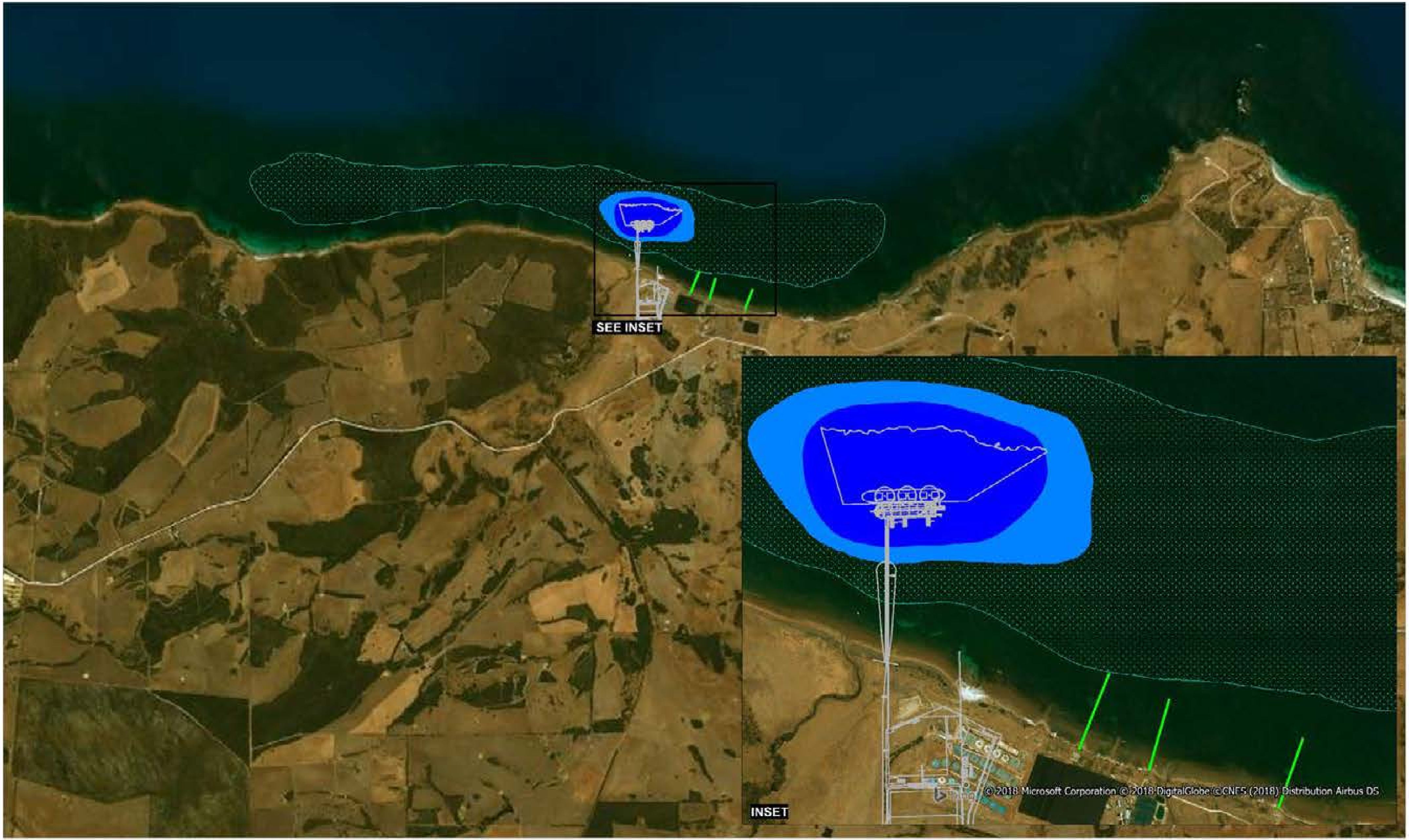

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Yumbah Aquaculture Intake Pipes

Zones of Impact - TSS/Turbidity

Zone of Influence (no ecological impacts)

Zone of Low to Moderate Impact

Zone of High Impact

Proposed Wharf Design and Dredge Footprint

Title:

Zones of Impact - Sediment Deposition WorstCase - Summer and Winter

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Scale - Main Map

Figure: 3-16

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Legend

Yumbah Aquaculture Intake Pipes

Zones of Impact - TSS/Turbidity

Zone of Influence (no ecological impacts)

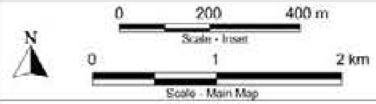
Zone of Low to Moderate Impact

Zone of High Impact

Proposed Wharf Design and Dredge Footprint

Title:

Zones of Impact - Sediment Deposition WorstCase - Summer Only



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3.4.3 Mobilisation of Contaminants from Capital Dredging

Mobilisation of contaminants such as nutrients and metals/metalloids is a potential impact which could result from disturbance or dredging of marine sediments.

To assess marine sediment composition in Smith Bay, COOE collected sediment samples from 12 locations within the proposed dredge footprint in 2017 (COOE 2017). These samples were analysed for a comprehensive suite of physical and chemical parameters. Based on the assessment of marine sediment samples, COOE (2017) reported the following:

- Sediment samples consisted mostly of sand and gravel (70-90%), with a smaller proportion (10-25%) of fine sediments (silt and clay). Deeper sediment layers near the middle of the dredge footprint had a higher proportion of fines (59%) and organic matter content.
- Metals and metalloids were found in low concentrations at all sites, with concentrations well below sediment quality guideline levels.
- No synthetic chemicals (including phenols, petroleum hydrocarbons and organotins) were detected in any sediment samples.
- Potential acid sulfate soils were not expected in the coarse sand sediments of Smith Bay. The pH of deeper organic marine sediments near the middle of the dredge footprint was near neutral (pH 6.5).
- Nutrient concentrations in sediment samples were generally low in the dredge footprint, with total nitrogen mostly between 110 and 690 mg/kg. The exception was one sample in deeper organic sediments near the middle of the dredge footprint which had higher concentrations (2,850 mg/kg). Total phosphorus in all sediment samples ranged from <0.1 to 2.1 mg/kg.
- Organic matter content in sediment samples ranged from 0.17 mg/kg to 0.76 mg/kg, apart from deeper organic sediments near the middle of the dredge footprint had organic matter content of 4.47 mg/kg.

In summary, the COOE (2017) findings suggest that proposed dredge footprint in Smith Bay is relatively pristine with no synthetic or natural pollutants. Therefore, the potential for mobilisation of contaminants during capital dredging presents a temporary negligible impact to marine water quality.

3.4.4 Dredging and Construction Plant and Equipment

Due to the need for construction plant and equipment to build the wharf infrastructure, and the use of dredging plant and equipment for the dredging works, there is potential that fuel/oil spills and other contaminants may pollute marine waters if not appropriately managed.

Dredge operators and construction contractors must, by law, comply with established fuel/oil storage and handling standards and protocols to reduce the risk of incidents. Appropriate operational procedures are included in the Construction Environmental Management Plan (CEMP) and the Dredge Management Plan (DMP) which sets out management measures to reduce that the risk of fuel/oil spills and contaminants, and if they occur, how they are managed to minimise impact.

If managed appropriately, the potential for fuel/oil spills as part of the construction phase of the project presents a temporary negligible impact to marine water quality.

3.4.5 Causeway Construction

The core of the proposed causeway is to be constructed from the de-watered and settled dredged material. It has been assumed that the causeway will be constructed over a similar period to the dredging (30 days). There are two key risks during causeway construction: (1) the fines released during the initial placement of the core material; and (2) the potential for fines to be released from the exposed core during a large wave event.

A model simulation of the causeway construction was undertaken during adverse weather events during the summer and winter. Model results are provided in the modelling report (BMT 2018). Similar to the assessment of turbid plumes from capital dredging, zones of impact for TSS/turbidity were developed using model outputs from simulation of the causeway construction.

The zones of impact presented in Figure 3-18 indicate that potential impacts from turbid plumes generated from the causeway construction are predicted to be much lower than capital dredging plumes. While there is a zone of influence (i.e. extent of detectable plumes but no predicted ecological impact) extending out from the causeway construction area approximately 1 km east and west along the coastline, there is no 'zone of low to moderate impact' or 'zone of high impact' predicted to occur due to the causeway construction.

Therefore, based on the zones of impact and the relatively short duration of the causeway construction (~30 days), turbid plumes from the causeway construction are predicted to present a temporary negligible impact to marine water quality.

Legend

Yumbah Aquaculture Intake Pipes

Zones of Impact - TSS/Turbidity

- Zone of Influence (no ecological impacts)
- Zone of Low to Moderate Impact
- Zone of High Impact

Proposed Wharf Design and Dredge Footprint

Title:

Zones of Impact - TSS/Turbidity - Causeway Construction

Figure: 3-18

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3.5 Operational Phase Impacts

Potential impacts on the marine environment associated with the upgraded wharf will be addressed and mitigated with the implementation of the port's Environmental Management System for port operational activities. Further details are provided in the following sections for shipping operations and maintenance dredging, as these operations are considered to be two key areas with the potential to impact marine waters during the operational phase of the project.

3.5.1 Operational Shipping

Once operational, shipping activity (and associated refuelling activity) will marginally increase in Smith Bay, with shipping activity predicted to consist of approximately one bulk carrier ship (Handymax 30,000 DWT to Panamax 60,000 DWT) visit per month.

The shipping and refuelling activity has the potential for shipping-related contaminants to enter the marine environment. Shipping operations may introduce contaminants from:

- Hydrocarbons, from refuelling or vessel sourced discharges;
- Ballast water;
- Antifouling systems;
- Black water and grey water release;
- Other wastewater;
- Airborne contaminants from exposed materials entering the water column; and
- Solid waste such as packaging materials.

Ballast water, antifouling, waste and wastewater are regulated by the following conventions and legislation which vessels operating in Australia need to comply with:

- International Obligations:
  - *Convention for the Prevention of Pollution from Ships 1973;*
  - *Convention on the Control of Harmful Antifouling Systems on Ships (IMO-AFS Convention) 2001; and*
  - *Convention for the Control and Management of Ship's Ballast Water and Sediments 2004.*
- Commonwealth Legislation:
  - *Biosecurity Act 2016* for management of introduced pests in ballast water, managed by the Department of Agriculture.
- State Legislation:
  - *Environmental Protection Act 1993;*
  - *Environment Protection Water Quality Policy 2015; and*
  - *Fisheries Management Act 2007.*

South Australia's Environment Protection Authority (EPA) also has in place recommended practices for biofouling and ballast water as part of its *Code of Practice for Vessel and Facility Management (Marine and Inland Waters)*.

On 1 July 2001, Australia introduced mandatory ballast water management requirements to reduce the risk of introducing harmful aquatic organisms into Australia's marine environment through ballast water from international vessels. These requirements are enforceable under the *Quarantine Act 1908*. The requirements are consistent with the International Maritime Organisation (IMO) Ballast Water Convention 2004 that aims to minimise the translocation of harmful aquatic species in ships' ballast water and ballast tank sediments.

The discharge of high-risk ballast water in Australian ports or waters is prohibited. All internationally plying vessels intending to discharge ballast water anywhere inside the Australian territorial sea must manage their ballast water in accordance with Australia's mandatory ballast water management requirements. This would apply to all international ships visiting the wharf facility.

Fuel handling and storage procedures will need to be developed as part of wharf's operational activities. Assuming these procedures are effectively developed and implemented, the potential for introduced contaminants from increased shipping presents a long-term minor impact to marine water quality. Mitigation of these potential impacts will be addressed by compliance with the above legislation administered by the above authorities, and implementation of the wharf's operational procedures.

3.5.1.1 Operational Propwash

Turbid plumes caused by propwash from shipping traffic arriving and departing from the operational wharf was modelled (refer to BMT 2018). Model outputs showed that propwash is predicted to cause very minor (<0.2 mg/L) impacts to the marine environment in Smith Bay.

Therefore, operational propwash presents a long-term negligible impact to marine water quality.

3.5.2 Future Maintenance Dredging

As discussed further in the Coastal Processes Chapter, sedimentation in Smith Bay is generally low due to the minimal suspended sediments in the water column during most of the year. Consequently, the need for future maintenance dredging to maintain dredged depths is likely to be minimal and infrequent.

If maintenance dredging is required during the life of the project, impacts to marine water quality are likely to be much less than those predicted for capital dredging due to smaller maintenance dredge volumes and shorter dredging timeframes compared to capital dredging. As such, future maintenance dredging presents a short-term minor impact to marine water quality.

4 Recommended Mitigation Measures

4.1 Mitigation Measures – Construction Phase

4.1.1 Capital Dredging

To minimise potential turbidity impacts generated by capital dredging works, the following mitigation measures are to be implemented:

- Dredging is to be conducted in accordance with the EPA dredging licence.
- The impact assessment indicates that seasonality has a strong influence on hydrodynamics within Smith Bay. Dredging during the summer months would reduce dredge plume impacts to the east of the dredge footprint. Therefore, it is suggested that dredging should be limited to the period from October to April.
- The plume modelling has indicated that short periods of high connectivity between the dredge footprint and the Yumbah intakes are associated with Dodge tides in combination with light to moderate westerly winds. These periods produced the highest predicted acute plume intensities at the Yumbah intakes. Therefore, it is suggested that numerical model forecasting is undertaken to anticipate and plan management actions around these potentially adverse periods.
- Develop and implement a reactive water quality monitoring program which includes the following:
  - The monitoring program will be implemented during the dredge campaign to monitor water quality between the dredge footprint and sensitive receptors (e.g. Yumbah intakes).
  - Monitoring data will be collected and downloaded regularly and the data assessed against threshold triggers, with appropriate management actions implemented if threshold triggers are exceeded.
  - The monitoring program will be used in real time to guide the dredging campaign and to monitor the effectiveness of the above mitigation measures. If trigger levels are exceeded, the dredge contractor will be responsible for taking actions to ensure impacts are avoided at sensitive receptors.
  - The reactive water quality monitoring program will be detailed further in the Dredge Management Plan.

As demonstrated in the Potential Impacts section, other potential impacts (e.g. mobilisation of contaminants in sediment) are negligible and no mitigation measures are required.

4.1.2 Dredging and Construction Plant and Equipment

Standard operational mitigation measures are to be implemented to reduce the risk of fuel/oil spills and other contaminants entering the marine waters, including:

- Development and implementation of a Construction Environment Management Plan (CEMP) to include established management procedures covering vessel maintenance, reporting of leaks and use of spill kits in the event of a spill.

- Development and implementation of a Dredge Management Plan (DMP) which includes management measures to be followed by dredge staff. This document is to be kept as on-board dredge equipment and readily accessible to dredge staff.
- A hydrocarbon spill kit is to be located on the dredge and transport barges. This spill kit is to contain such items as absorbent material for spills on deck and also floating booms to contain hydrocarbon slicks if spills manage to enter the water. This spill kit is to be maintained regularly to ensure contents are fully stocked and in good condition.
- First strike spill response equipment and appropriately trained staff are accessible and able to respond to events and have access to more spill response resources if the event escalates.
- All fuel and chemical supplies on the dredge and transport barges are to be stored in bunded areas as per the requirements of AS1940:2004 - The storage and handling of flammable and combustible liquids 2004, and applicable WHS Act requirements.

4.2 Mitigation Measures – Operational Phase

4.2.1 Operational Shipping

It is assumed that compliance with relevant legislation in regard to shipping will be employed as part of standard mitigation measures. To further reduce the potential risk to marine water quality, additional mitigation proposed include the following:

- Preparation and implementation of a Fuel and Chemical Storage and Handling Plan;
- Placement of containment bunds around fuel storage tanks and drums, and lining of bunds with impervious material;
- Clean up any spills in a timely manner;
- Provision of spill kits on site;
- Ensure that correct ballast disposal protocols are followed (i.e. ballast water is disposed of offshore);
- Ensure that ships come to Smith Bay directly from a controlled port; and
- Implementing a strict Pest/Disease Control Management Plan prepared in consultation with BioSecurity SA.

4.3 Monitoring

Water quality monitoring during the construction phase of the project will be undertaken in accordance with the reactive monitoring programs described above and detailed in the Dredge Management Plan.

5 Residual Impacts and Assessment Summary

In accordance with the methodology described in Section 3.1, Table 5-1 summarises the marine water quality issues identified by the impact assessment in the previous sections. This assessment table also includes the significance of each of the identified impacting processes, the likelihood of the impact occurring, and the resulting risk rating.

The standard and additional mitigation measures discussed in previous sections are also summarised in Table 5-1, with a risk rating indicated for the residual impacts after mitigation. As indicated in this assessment table, all residual impacts are rated as either a low or negligible risk. Construction phase residual impacts would be temporary (days to months) in duration, while operational phase residual impacts would be long-term in duration extending over the life of the project.

Table 5-1 Risk assessment summary – marine water quality

Ref	Activity	Hazard (Environmental Aspect)	Potential Impact	Consequence	Likelihood	Inherent risk level	Management / mitigation measures	Consequence	Likelihood	Residual risk level
	Construction Phase									
1	Capital dredging	Generation of turbid plumes	Degradation in marine water quality causing adverse impacts to sensitive ecological receptors (e.g. seagrass) and aquaculture receptors	Minor	Possible	Medium	• Dredging to be conducted in accordance with EPA dredging licence, including water quality monitoring plan (approved by independent third-party) and stop-work procedures if water quality thresholds are exceeded • Dredging should be limited to the period from October to April to reduce dredge plume impacts to the east of the dredge footprint	Minor	Unlikely	Low
2		Sediment deposition	Seagrass and benthic community decline due to smothering by dredged sediments	Minor	Possible	Medium	• Dredging to be conducted in accordance with EPA dredging licence, including water quality monitoring plan (approved by independent third-party) and stop-work procedures if water quality thresholds are exceeded	Minor	Unlikely	Low
3		Mobilisation of contaminants into water column	Degradation in marine water quality causing adverse impacts to sensitive ecological receptors (e.g. seagrass) and aquaculture receptors	Negligible	Unlikely	Low	• Nil	Negligible	Unlikely	Low

Ref	Activity	Hazard (Environmental Aspect)	Potential Impact	Consequence	Likelihood	Inherent risk level	Management / mitigation measures	Consequence	Likelihood	Residual risk level
4		Use of dredging and construction plant and equipment	Hydrocarbon spills cause adverse impacts to marine water quality and sensitive ecological receptors	Minor	Possible	Medium	• CEMP to include established management procedures covering vessel maintenance, reporting of leaks and use of spill kits in the event of a spill • Development and implementation of a Dredge Management Plan by the Contractor. • Hydrocarbon spill kit is to be located on the dredge and transport barges. • First strike spill response equipment and staff are accessible and able to respond to events and have access to more spill response resources if the event escalates. • All fuel and chemical supplies to be stored appropriately.	Minor	Unlikely	Low
5	Causeway construction	Generation of turbid plumes	Degradation in marine water quality causing adverse impacts to sensitive ecological receptors (e.g. seagrass) and aquaculture receptors	Negligible	Possible	Low	• Water quality monitoring plan (approved by independent third-party) and stop-work procedures if water quality thresholds are exceeded	Negligible	Unlikely	Low
Operational Phase										

Ref	Activity	Hazard (Environmental Aspect)	Potential Impact	Consequence	Likelihood	Inherent risk level	Management / mitigation measures	Consequence	Likelihood	Residual risk level
6	Operational shipping	Hydrocarbon spills	Hydrocarbon spills cause adverse impacts to marine water quality and sensitive ecological receptors	Minor	Possible	Medium	• Preparation and implementation of a Fuel and Chemical Storage and Handling Plan • Placement of containment bunds around storage tanks and drums • Lining of bunds with impervious material • Clean up any spills in a timely manner • Provision of spill kits on site	Minor	Unlikely	Low
7		Ballast water	Introduction of pest species and diseases into marine waters of Smith Bay	Minor	Unlikely	Low	• Ensure that correct ballast disposal protocols are followed (i.e. ballast water is disposed of offshore) • Ensure that ships come to Smith Bay directly from a controlled port • Implementing a strict Pest/Disease Control Management Plan prepared in consultation with BioSecurity SA	Minor	Unlikely	Low
8		Propwash	Degradation in marine water quality from turbid plumes from propwash	Negligible	Possible	Low	• Nil	Negligible	Possible	Low
9	Future maintenance dredging	Generation of turbid plumes and sediment deposition	Degradation in marine water quality causing adverse impacts to sensitive ecological receptors (e.g. seagrass) and aquaculture receptors	Minor	Unlikely	Low	• Nil	Minor	Unlikely	Low

6 References

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Western Australia Environmental Protection Authority (WA EPA) 2016. *Technical Guidance – Environmental Impact Assessment of Marine Dredging Proposals*

Appendix A Laboratory analysis of TSS, Turbidity and PSD

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enquiries@envirolabservices.com.au
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Envirolab Services Reference: 207229

Attn: Joe Pedicini

environmentalprojects reference: Smith Bay Sediment Settling Project

Monitoring of Smith Bay sediment settling for Total Suspended Solids (TSS), Turbidity and Particle Size Distribution (PSD)

Methodology

Clear PVC Pipe (114mm diameter) 1.2m in length was used to create a column of seawater mixed with Smith Bay sediment at a 1:20 sediment to seawater ratio. An end cap was secured at the base and the column was mounted to a frame as per Photo 1 below:-

Picture 1

400g of sediment was mixed with 8L of seawater (from Sydney Harbour) in a 20L bucket before being poured into the column above. The sample was continuously mixed by agitation/swirling until just before sub-samples were taken. Picture 1 shows the mix just before the first sample was taken.

In order to take samples at 50% of the original water column depth (the PVC column was marked up at the 4L mark, 8L was of seawater was used), a sampler was made from a 1m stick of bamboo with a 250mL HDPE bottle taped to the base (the 1m bamboo stick was marked to indicate the depth at which to take samples). In order to sample at the required depth, a champagne cork was fashioned to fit snuggly into the 250mL bottle, with a pull string wrapped around it. Once the bottle was submerged to the correct depth, the string was pulled and the bottle allowed to fill. The bottle was then slowly removed from the column of water and sediment until the next sampling period. See sampling bottle in Picture 2 below:-

Picture 2

Samples were taken at a frequency as per table 1 below. The turbidity was measured from a sub-sample immediately after sampling. The remaining sample was sent for TSS analysis. Every odd sample was sub-sampled for PSD by Microanalysis.

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Table 1 – Turbidity and TSS at Time Points 0 mins to 360 mins

Lab No.	Time Point (mins)	Estimated Volume remaining (mL)	Turbidity (NTU)	TSS mg/L	TSS/Turbidity Ratio
207229-1	0	8000	390	1900	4.872
207229-2	10	7750	310	470	1.516
207229-3	20	7500	300	370	1.233
207229-4	30	7250	264	290	1.098
207229-5	40	7000	232	240	1.034
207229-6	50	6750	217	230	1.060
207229-7	60	6500	211	220	1.043
207229-8	90	6250	163	130	0.798
207229-9	120	6000	138	140	1.014
207229-10	180	5750	115	110	0.957
207229-11	240	5500	103	82	0.796
207229-12	300	5250	94	74	0.787
207229-13	360	5000	86	63	0.736

Envirolab Services Pty Ltd
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Comments

1. Please note, the sedimentation trial herein are not covered by NATA accreditation.
2. Please see PSD graphs attached as individual Excel files at 0, 20, 40, 60, 120, 240, 360 minutes.

Reported by: Simon Mills

Authorised by: David Springer

Date: 19th December 2018

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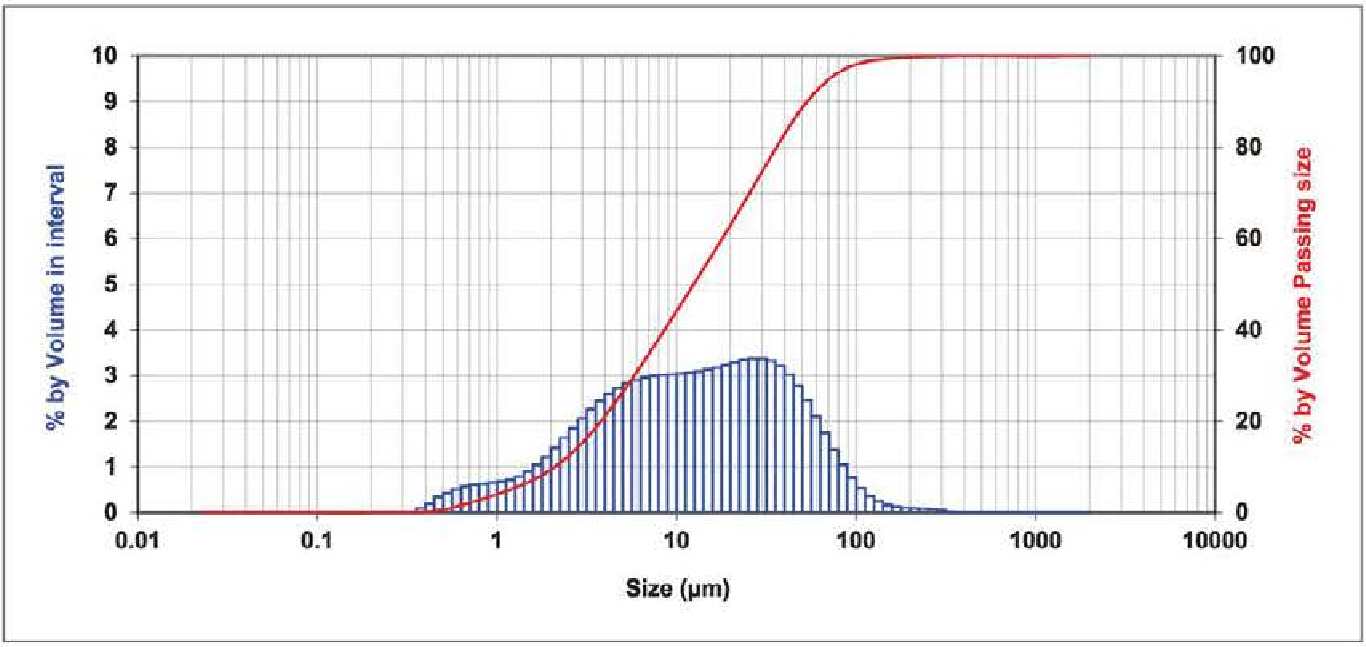
37 Kensington Street
East Perth
WA 6004

Client:	Envirolab Services
Client ID:	0 mins water neutral/saline 07/12//2018
Job No :	18_2113
Lab ID No :	18_2113_01

Analysis: Laser diffraction size distribution following ISO13320-1:1999

Dispersant:	Water	**RI/ABS:**	1.544 / 0.1
Additives:	10 millilitres sodium hexametaphosphate	**Analysis Model:**	General purpose
Sonication:	0 min sonication	**Result units:**	Volume

Concentration:	0.0107 % vol	**Vol. Weighted Mean D[4,3]:**	22.173 µm	**d(0.1):**	2.103	µm
Obscuration:	13.8 %	**Surface Weighted Mean D[3,2]:**	4.982 µm	**d(0.5):**	12.49	µm
Weighted Residual:	1.091 %	**Specific Surface Area:**	1.2 m^2/cc	**P80:**	36.027	µm
				d(0.9):	53.415	µm



Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %
0.020	0.00	0.142	0.00	1.002	4.05	7.096	35.11	50.238	88.65	355.656	100.00
0.022	0.00	0.159	0.00	1.125	4.73	7.962	38.10	56.368	91.11	399.052	100.00
0.025	0.00	0.178	0.00	1.262	5.45	8.934	41.12	63.246	93.22	447.744	100.00
0.028	0.00	0.200	0.00	1.416	6.25	10.024	44.16	70.963	94.96	502.377	100.00
0.032	0.00	0.224	0.00	1.589	7.14	11.247	47.21	79.621	96.34	563.677	100.00
0.036	0.00	0.252	0.00	1.783	8.19	12.619	50.27	89.337	97.39	632.456	100.00
0.040	0.00	0.283	0.00	2.000	9.41	14.159	53.37	100.237	98.15	709.627	100.00
0.045	0.00	0.317	0.00	2.244	10.83	15.887	56.50	112.468	98.69	796.214	100.00
0.050	0.00	0.356	0.00	2.518	12.46	17.825	59.68	126.191	99.05	893.367	100.00
0.056	0.00	0.399	0.10	2.825	14.31	20.000	62.91	141.589	99.29	1002.374	100.00
0.063	0.00	0.448	0.29	3.170	16.38	22.440	66.20	158.866	99.46	1124.683	100.00
0.071	0.00	0.502	0.63	3.557	18.64	25.179	69.55	178.250	99.58	1261.915	100.00
0.080	0.00	0.564	1.06	3.991	21.08	28.251	72.93	200.000	99.69	1415.892	100.00
0.089	0.00	0.632	1.57	4.477	23.68	31.698	76.31	224.404	99.79	1588.656	100.00
0.100	0.00	0.710	2.15	5.024	26.41	35.566	79.63	251.785	99.87	1782.502	100.00
0.112	0.00	0.796	2.76	5.637	29.24	39.905	82.85	282.508	99.94	2000.000	100.00
0.126	0.00	0.893	3.40	6.325	32.15	44.774	85.87	316.979	99.99		

Analyst: Sumudu Ariyawansa, B.Sc.(Agriculture)(Hons), Dip.(Laboratory Technology)
Reported: Hoklam Suen, B.Eng. (Metallurgy)
Approved: Nimue Pendragon, B.Sc.(Nanotechnology)

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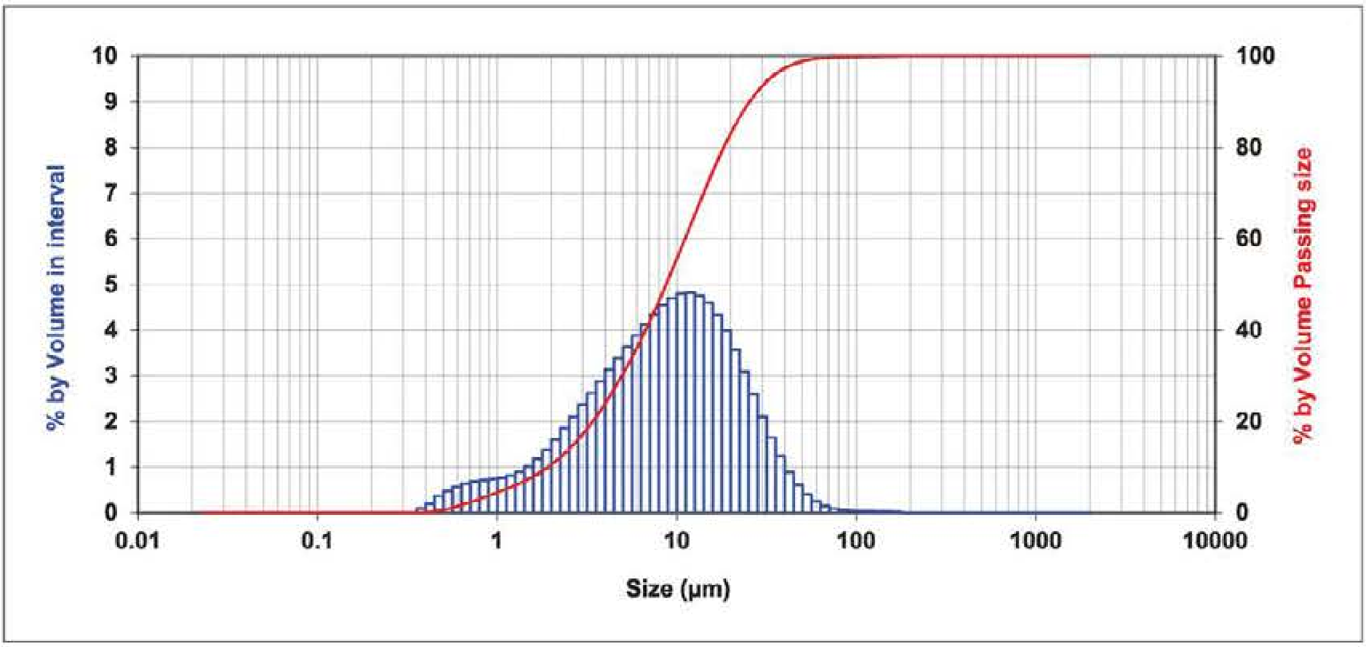
microanalysis australia

Client:	Envirolab Services
Client ID:	20 mins water neutral/saline 07/12//2018
Job No :	18_2113
Lab ID No :	18_2113_02

Analysis: Laser diffraction size distribution following ISO13320-1:1999

Dispersant:	Water	**RI/ABS:**	1.544 / 0.1
Additives:	10 millilitres sodium hexametaphosphate	**Analysis Model:**	General purpose
Sonication:	0 min sonication	**Result units:**	Volume

Concentration:	0.0089 % vol	**Vol. Weighted Mean D[4,3]:**	11.903 µm	**d(0.1):**	1.922	µm
Obscuration:	13.35 %	**Surface Weighted Mean D[3,2]:**	4.296 µm	**d(0.5):**	8.705	µm
Weighted Residual:	1.196 %	**Specific Surface Area:**	1.4 m^2/cc	**P80:**	18.277	µm
				d(0.9):	25.429	µm



Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %
0.020	0.00	0.142	0.00	1.002	4.47	7.096	42.13	50.238	98.85	355.656	100.00
0.022	0.00	0.159	0.00	1.125	5.23	7.962	46.49	56.368	99.25	399.052	100.00
0.025	0.00	0.178	0.00	1.262	6.05	8.934	51.04	63.246	99.50	447.744	100.00
0.028	0.00	0.200	0.00	1.416	6.94	10.024	55.75	70.963	99.66	502.377	100.00
0.032	0.00	0.224	0.00	1.589	7.95	11.247	60.56	79.621	99.75	563.677	100.00
0.036	0.00	0.252	0.00	1.783	9.12	12.619	65.39	89.337	99.81	632.456	100.00
0.040	0.00	0.283	0.00	2.000	10.50	14.159	70.15	100.237	99.85	709.627	100.00
0.045	0.00	0.317	0.00	2.244	12.11	15.887	74.76	112.468	99.89	796.214	100.00
0.050	0.00	0.356	0.00	2.518	13.96	17.825	79.10	126.191	99.92	893.367	100.00
0.056	0.00	0.399	0.10	2.825	16.06	20.000	83.09	141.589	99.95	1002.374	100.00
0.063	0.00	0.448	0.29	3.170	18.43	22.440	86.66	158.866	99.98	1124.683	100.00
0.071	0.00	0.502	0.66	3.557	21.06	25.179	89.75	178.250	100.00	1261.915	100.00
0.080	0.00	0.564	1.13	3.991	23.94	28.251	92.35	200.000	100.00	1415.892	100.00
0.089	0.00	0.632	1.70	4.477	27.08	31.698	94.46	224.404	100.00	1588.656	100.00
0.100	0.00	0.710	2.34	5.024	30.47	35.566	96.11	251.785	100.00	1782.502	100.00
0.112	0.00	0.796	3.02	5.637	34.11	39.905	97.35	282.508	100.00	2000.000	100.00
0.126	0.00	0.893	3.74	6.325	38.00	44.774	98.24	316.979	100.00		

Analyst: Sumudu Ariyawansa, B.Sc.(Agriculture)(Hons), Dip.(Laboratory Technology)
Reported: Hoklam Suen, B.Eng. (Metallurgy)
Approved: Nimue Pendragon, B.Sc.(Nanotechnology)

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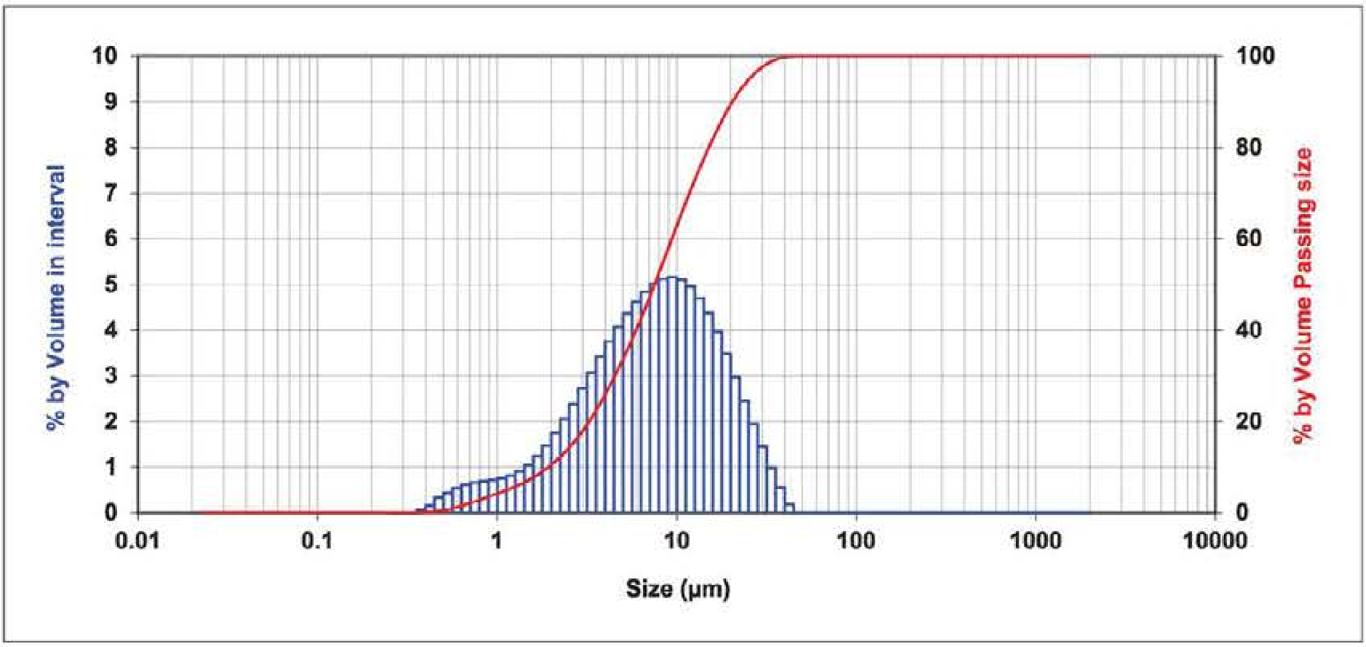
Client:	Envirolab Services
Client ID:	40 mins water neutral/saline 07/12//2018
Job No :	18_2113
Lab ID No :	18_2113_03

Analysis:	Laser diffraction size distribution following ISO13320-1:1999		
Dispersant:	Water	**RI/ABS:**	1.544 / 0.1
Additives:	10 millilitres sodium hexametaphosphate	**Analysis Model:**	General purpose
Sonication:	0 min sonication	**Result units:**	Volume

Concentration:	0.0073 % vol	**Vol. Weighted Mean D[4,3]:**	9.602 µm	**d(0.1):**	1.935	µm
Obscuration:	11.73 %	**Surface Weighted Mean D[3,2]:**	4.128 µm	**d(0.5):**	7.508	µm
Weighted Residual:	1.305 %	**Specific Surface Area:**	1.45 m^2/cc	**P80:**	15.051	µm
				d(0.9):	20.395	µm



Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %
0.020	0.00	0.142	0.00	1.002	4.22	7.096	47.56	50.238	100.00	355.656	100.00
0.022	0.00	0.159	0.00	1.125	4.97	7.962	52.58	56.368	100.00	399.052	100.00
0.025	0.00	0.178	0.00	1.262	5.78	8.934	57.71	63.246	100.00	447.744	100.00
0.028	0.00	0.200	0.00	1.416	6.69	10.024	62.86	70.963	100.00	502.377	100.00
0.032	0.00	0.224	0.00	1.589	7.74	11.247	67.96	79.621	100.00	563.677	100.00
0.036	0.00	0.252	0.00	1.783	8.98	12.619	72.92	89.337	100.00	632.456	100.00
0.040	0.00	0.283	0.00	2.000	10.45	14.159	77.63	100.237	100.00	709.627	100.00
0.045	0.00	0.317	0.00	2.244	12.20	15.887	82.01	112.468	100.00	796.214	100.00
0.050	0.00	0.356	0.00	2.518	14.26	17.825	85.97	126.191	100.00	893.367	100.00
0.056	0.00	0.399	0.07	2.825	16.65	20.000	89.46	141.589	100.00	1002.374	100.00
0.063	0.00	0.448	0.23	3.170	19.38	22.440	92.43	158.866	100.00	1124.683	100.00
0.071	0.00	0.502	0.56	3.557	22.45	25.179	94.88	178.250	100.00	1261.915	100.00
0.080	0.00	0.564	0.99	3.991	25.87	28.251	96.82	200.000	100.00	1415.892	100.00
0.089	0.00	0.632	1.53	4.477	29.63	31.698	98.27	224.404	100.00	1588.656	100.00
0.100	0.00	0.710	2.14	5.024	33.71	35.566	99.26	251.785	100.00	1782.502	100.00
0.112	0.00	0.796	2.80	5.637	38.08	39.905	99.82	282.508	100.00	2000.000	100.00
0.126	0.00	0.893	3.49	6.325	42.71	44.774	100.00	316.979	100.00		

Analyst: Sumudu Ariyawansa, B.Sc.(Agriculture)(Hons), Dip.(Laboratory Technology)
Reported: Hoklam Suen, B.Eng. (Metallurgy)
Approved: Nimue Pendragon, B.Sc.(Nanotechnology)

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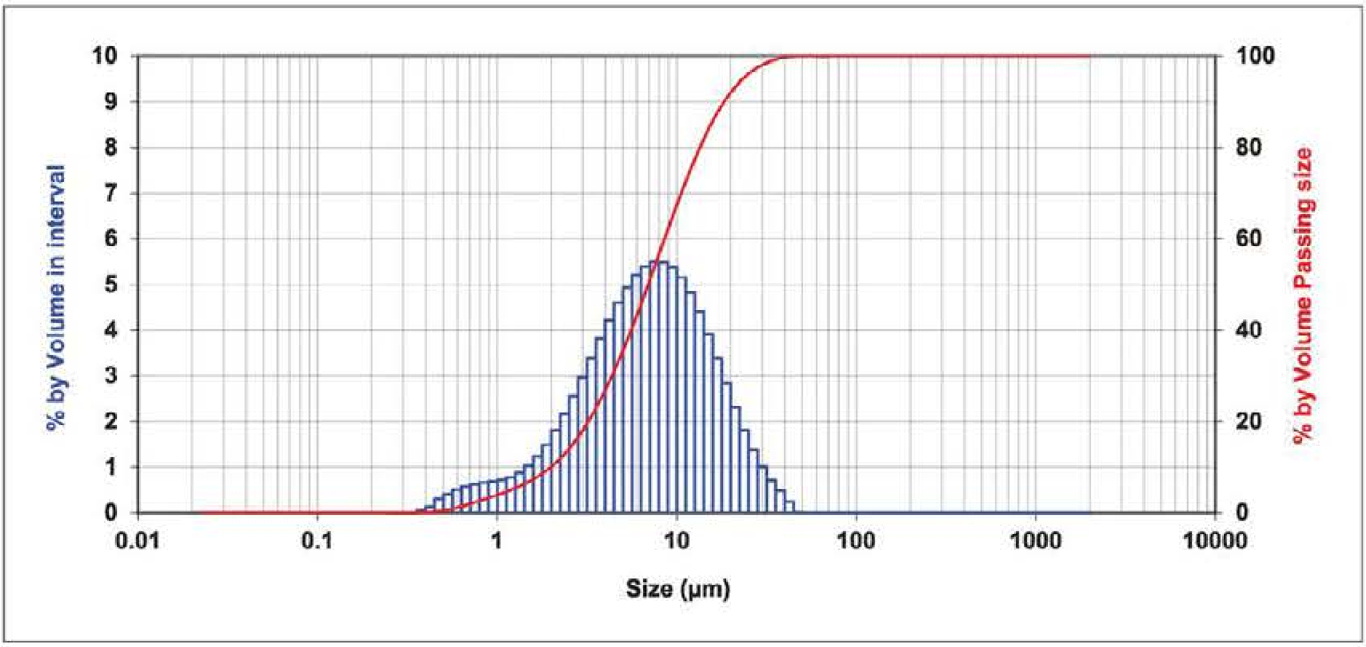
Client:	Envirolab Services
Client ID:	60 mins water neutral/saline 07/12//2018
Job No :	18_2113
Lab ID No :	18_2113_04

Analysis:	Laser diffraction size distribution following ISO13320-1:1999		
Dispersant:	Water	**RI/ABS:**	1.544 / 0.1
Additives:	10 millilitres sodium hexametaphosphate	**Analysis Model:**	General purpose
Sonication:	0 min sonication	**Result units:**	Volume

Concentration:	0.0075 % vol	**Vol. Weighted Mean D[4,3]:**	8.868 µm	**d(0.1):**	1.99	µm
Obscuration:	12.26 %	**Surface Weighted Mean D[3,2]:**	4.082 µm	**d(0.5):**	6.926	µm
Weighted Residual:	1.288 %	**Specific Surface Area:**	1.47 m^2/cc	**P80:**	13.454	µm
				d(0.9):	18.369	µm



Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %
0.020	0.00	0.142	0.00	1.002	3.94	7.096	51.15	50.238	100.00	355.656	100.00
0.022	0.00	0.159	0.00	1.125	4.66	7.962	56.64	56.368	100.00	399.052	100.00
0.025	0.00	0.178	0.00	1.262	5.44	8.934	62.13	63.246	100.00	447.744	100.00
0.028	0.00	0.200	0.00	1.416	6.32	10.024	67.51	70.963	100.00	502.377	100.00
0.032	0.00	0.224	0.00	1.589	7.35	11.247	72.66	79.621	100.00	563.677	100.00
0.036	0.00	0.252	0.00	1.783	8.58	12.619	77.49	89.337	100.00	632.456	100.00
0.040	0.00	0.283	0.00	2.000	10.07	14.159	81.90	100.237	100.00	709.627	100.00
0.045	0.00	0.317	0.00	2.244	11.88	15.887	85.82	112.468	100.00	796.214	100.00
0.050	0.00	0.356	0.00	2.518	14.04	17.825	89.21	126.191	100.00	893.367	100.00
0.056	0.00	0.399	0.05	2.825	16.59	20.000	92.04	141.589	100.00	1002.374	100.00
0.063	0.00	0.448	0.18	3.170	19.57	22.440	94.35	158.866	100.00	1124.683	100.00
0.071	0.00	0.502	0.48	3.557	22.96	25.179	96.16	178.250	100.00	1261.915	100.00
0.080	0.00	0.564	0.89	3.991	26.78	28.251	97.54	200.000	100.00	1415.892	100.00
0.089	0.00	0.632	1.39	4.477	31.01	31.698	98.55	224.404	100.00	1588.656	100.00
0.100	0.00	0.710	1.97	5.024	35.61	35.566	99.26	251.785	100.00	1782.502	100.00
0.112	0.00	0.796	2.60	5.637	40.55	39.905	99.75	282.508	100.00	2000.000	100.00
0.126	0.00	0.893	3.26	6.325	45.75	44.774	99.99	316.979	100.00		

Analyst: Hoklam Suen, B.Eng. (Metallurgy)
Reported: Hoklam Suen, B.Eng. (Metallurgy)
Approved: Nimue Pendragon, B.Sc.(Nanotechnology)

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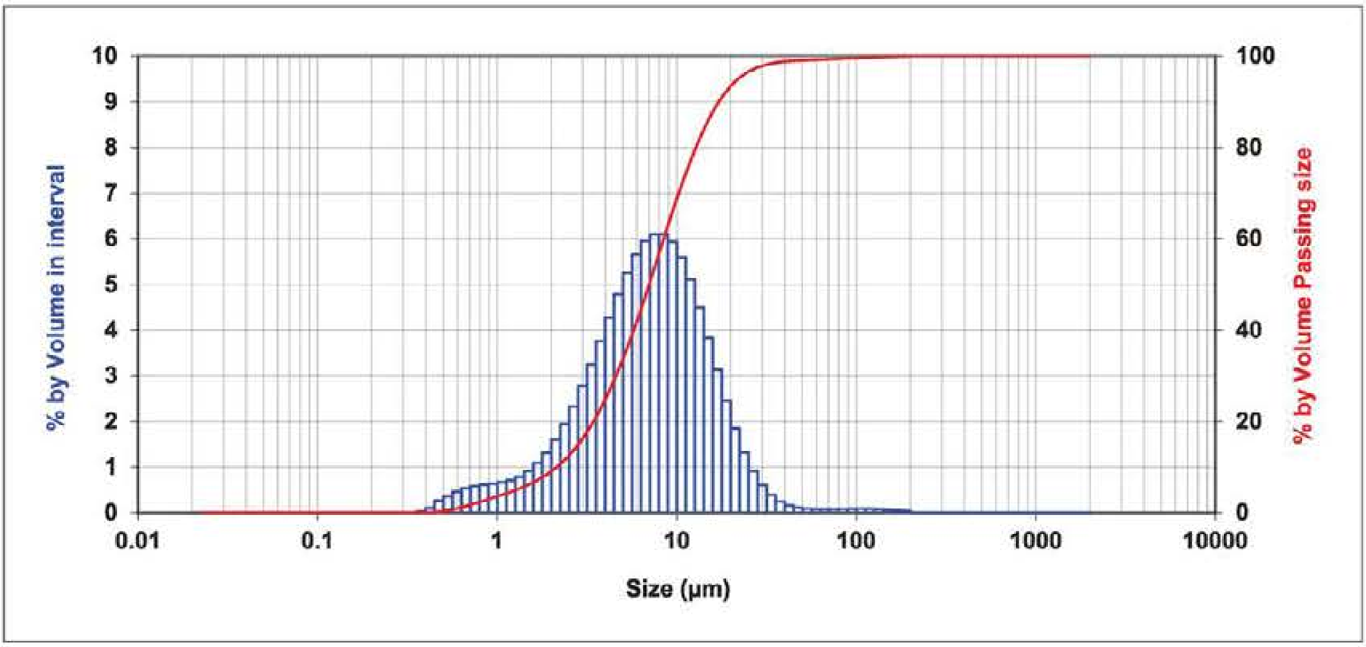
East Perth
WA 6004

Client:	Envirolab Services
Client ID:	120 mins water neutral/saline 07/12//2018
Job No :	18_2113
Lab ID No :	18_2113_05

Analysis: Laser diffraction size distribution following ISO13320-1:1999

Dispersant:	Water	**RI/ABS:**	1.544 / 0.1
Additives:	10 millilitres sodium hexametaphosphate	**Analysis Model:**	General purpose
Sonication:	0 min sonication	**Result units:**	Volume

Concentration:	0.0075 % vol	**Vol. Weighted Mean D[4,3]:**	9.359 µm	**d(0.1):**	2.143	µm
Obscuration:	11.92 %	**Surface Weighted Mean D[3,2]:**	4.249 µm	**d(0.5):**	7.005	µm
Weighted Residual:	1.387 %	**Specific Surface Area:**	1.41 m^2/cc	**P80:**	12.765	µm
				d(0.9):	17.136	µm



Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %
0.020	0.00	0.142	0.00	1.002	3.59	7.096	50.68	50.238	99.05	355.656	100.00
0.022	0.00	0.159	0.00	1.125	4.26	7.962	56.78	56.368	99.15	399.052	100.00
0.025	0.00	0.178	0.00	1.262	4.97	8.934	62.88	63.246	99.23	447.744	100.00
0.028	0.00	0.200	0.00	1.416	5.76	10.024	68.82	70.963	99.31	502.377	100.00
0.032	0.00	0.224	0.00	1.589	6.68	11.247	74.41	79.621	99.39	563.677	100.00
0.036	0.00	0.252	0.00	1.783	7.76	12.619	79.52	89.337	99.48	632.456	100.00
0.040	0.00	0.283	0.00	2.000	9.08	14.159	84.03	100.237	99.57	709.627	100.00
0.045	0.00	0.317	0.00	2.244	10.68	15.887	87.86	112.468	99.66	796.214	100.00
0.050	0.00	0.356	0.00	2.518	12.62	17.825	91.00	126.191	99.75	893.367	100.00
0.056	0.00	0.399	0.03	2.825	14.95	20.000	93.45	141.589	99.84	1002.374	100.00
0.063	0.00	0.448	0.13	3.170	17.73	22.440	95.30	158.866	99.90	1124.683	100.00
0.071	0.00	0.502	0.40	3.557	20.98	25.179	96.63	178.250	99.96	1261.915	100.00
0.080	0.00	0.564	0.76	3.991	24.74	28.251	97.54	200.000	100.00	1415.892	100.00
0.089	0.00	0.632	1.22	4.477	29.02	31.698	98.14	224.404	100.00	1588.656	100.00
0.100	0.00	0.710	1.75	5.024	33.82	35.566	98.53	251.785	100.00	1782.502	100.00
0.112	0.00	0.796	2.34	5.637	39.08	39.905	98.78	282.508	100.00	2000.000	100.00
0.126	0.00	0.893	2.95	6.325	44.73	44.774	98.94	316.979	100.00		

Analyst: Hoklam Suen, B.Eng. (Metallurgy)
Reported: Hoklam Suen, B.Eng. (Metallurgy)
Approved: Nimue Pendragon, B.Sc.(Nanotechnology)

microanalysis
australia

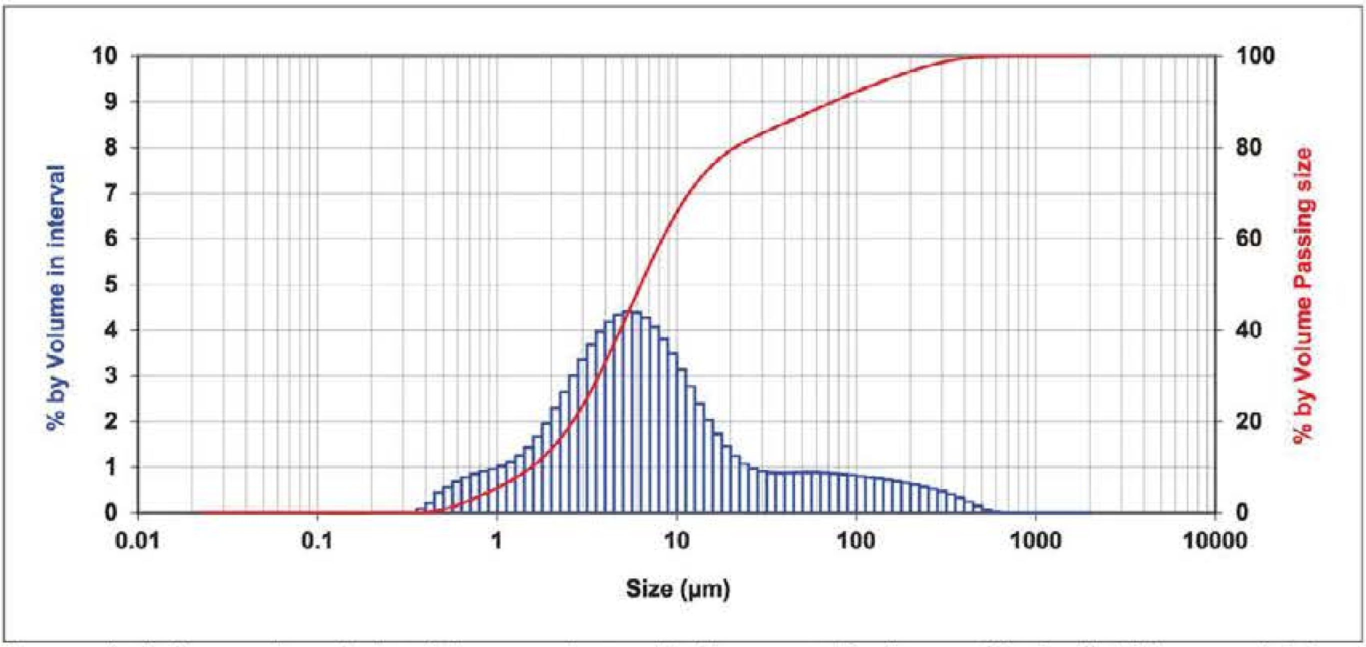
37 Kensington Street
East Perth
WA 6004

Client:	Envirolab Services
Client ID:	240 mins water neutral/saline 07/12//2018
Job No :	18_2113
Lab ID No :	18_2113_06

Analysis: Laser diffraction size distribution following ISO13320-1:1999

Dispersant:	Water	**RI/ABS:**	1.544 / 0.1
Additives:	10 millilitres sodium hexametaphosphate	**Analysis Model:**	General purpose
Sonication:	0 min sonication	**Result units:**	Volume

Concentration:	0.006 % vol	**Vol. Weighted Mean D[4,3]:**	27.358 µm	**d(0.1):**	1.553	µm
Obscuration:	10.97 %	**Surface Weighted Mean D[3,2]:**	3.63 µm	**d(0.5):**	6.29	µm
Weighted Residual:	1.498 %	**Specific Surface Area:**	1.65 m^2/cc	**P80:**	21.138	µm
				d(0.9):	73.856	µm



Please note that some elongated particles were observed in the coarser fraction, contributing to higher uncertainty.

Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %
0.020	0.00	0.142	0.00	1.002	5.49	7.096	54.48	50.238	87.06	355.656	99.21
0.022	0.00	0.159	0.00	1.125	6.51	7.962	58.56	56.368	87.95	399.052	99.53
0.025	0.00	0.178	0.00	1.262	7.62	8.934	62.37	63.246	88.83	447.744	99.77
0.028	0.00	0.200	0.00	1.416	8.87	10.024	65.87	70.963	89.70	502.377	99.92
0.032	0.00	0.224	0.00	1.589	10.30	11.247	69.01	79.621	90.56	563.677	99.98
0.036	0.00	0.252	0.00	1.783	11.97	12.619	71.77	89.337	91.40	632.456	100.00
0.040	0.00	0.283	0.00	2.000	13.93	14.159	74.17	100.237	92.22	709.627	100.00
0.045	0.00	0.317	0.00	2.244	16.22	15.887	76.21	112.468	93.02	796.214	100.00
0.050	0.00	0.356	0.00	2.518	18.86	17.825	77.93	126.191	93.79	893.367	100.00
0.056	0.00	0.399	0.09	2.825	21.86	20.000	79.38	141.589	94.54	1002.374	100.00
0.063	0.00	0.448	0.31	3.170	25.22	22.440	80.62	158.866	95.27	1124.683	100.00
0.071	0.00	0.502	0.75	3.557	28.91	25.179	81.70	178.250	95.96	1261.915	100.00
0.080	0.00	0.564	1.31	3.991	32.88	28.251	82.66	200.000	96.62	1415.892	100.00
0.089	0.00	0.632	2.00	4.477	37.07	31.698	83.57	224.404	97.24	1588.656	100.00
0.100	0.00	0.710	2.78	5.024	41.42	35.566	84.44	251.785	97.81	1782.502	100.00
0.112	0.00	0.796	3.63	5.637	45.82	39.905	85.31	282.508	98.33	2000.000	100.00
0.126	0.00	0.893	4.53	6.325	50.21	44.774	86.18	316.979	98.80		

Analyst:	Hoklam Suen, B.Eng. (Metallurgy)
Reported:	Hoklam Suen, B.Eng. (Metallurgy)
Approved:	Nimue Pendragon, B.Sc.(Nanotechnology)

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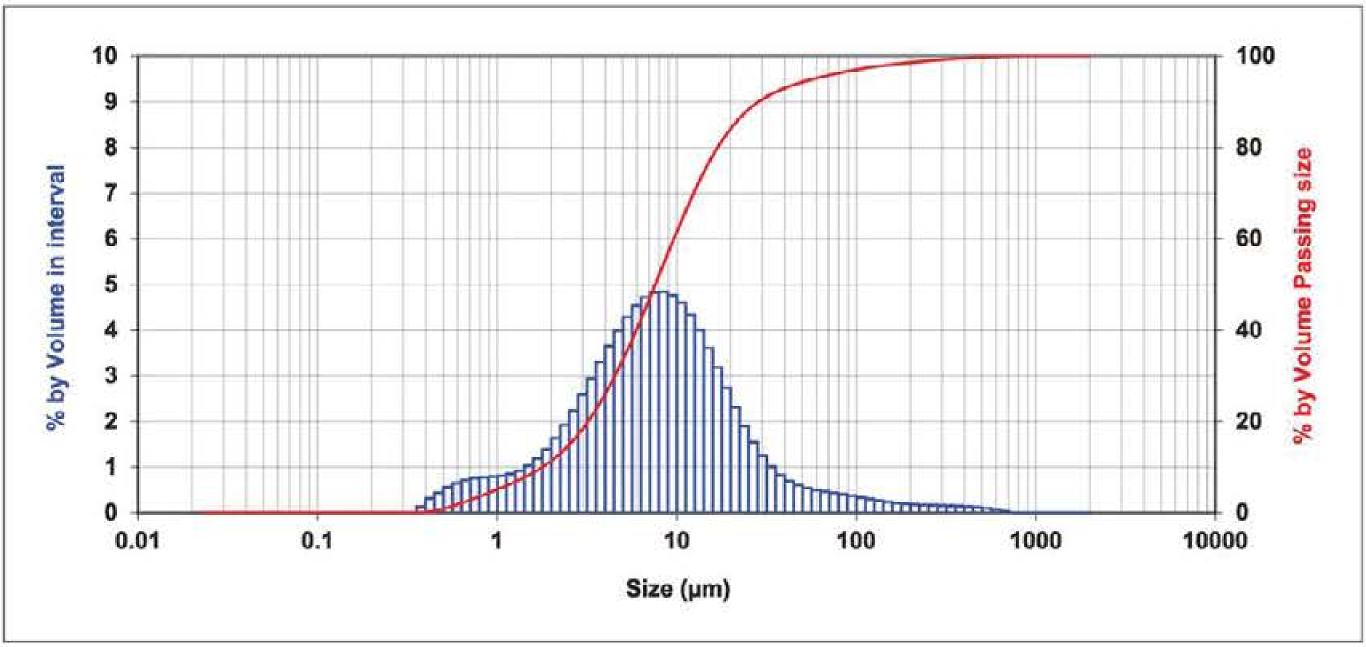
37 Kensington Street
East Perth
WA 6004

Client:	Envirolab Services
Client ID:	360 mins water neutral/saline 07/12//2018
Job No :	18_2113
Lab ID No :	18_2113_07

Analysis: Laser diffraction size distribution following ISO13320-1:1999

Dispersant:	Water	**RI/ABS:**	1.544 / 0.1
Additives:	10 millilitres sodium hexametaphosphate	**Analysis Model:**	General purpose
Sonication:	0 min sonication	**Result units:**	Volume

Concentration:	0.0068 % vol	**Vol. Weighted Mean D[4,3]:**	18.226 µm	**d(0.1):**	1.789	µm
Obscuration:	11.09 %	**Surface Weighted Mean D[3,2]:**	3.973 µm	**d(0.5):**	7.586	µm
Weighted Residual:	1.287 %	**Specific Surface Area:**	1.51 m^2/cc	**P80:**	16.902	µm
				d(0.9):	28.451	µm

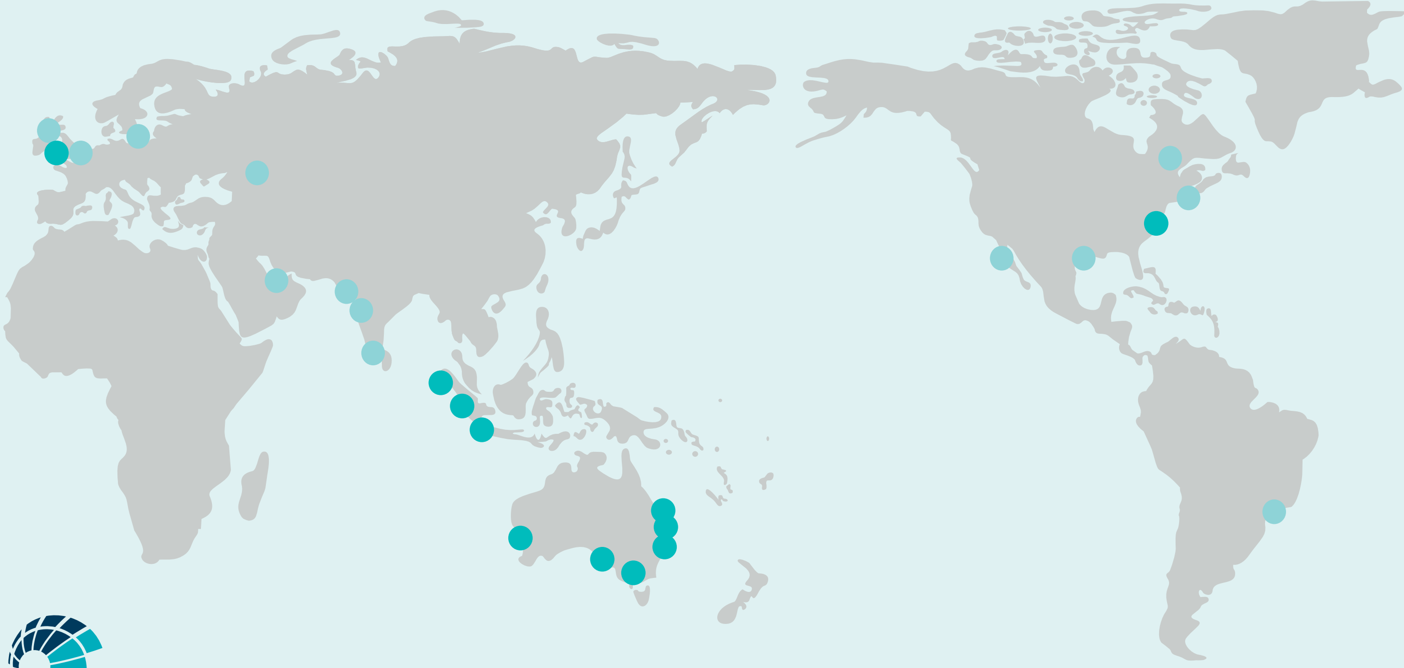


Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %
0.020	0.00	0.142	0.00	1.002	5.15	7.096	47.21	50.238	94.30	355.656	99.39
0.022	0.00	0.159	0.00	1.125	5.97	7.962	52.04	56.368	94.85	399.052	99.54
0.025	0.00	0.178	0.00	1.262	6.82	8.934	56.89	63.246	95.35	447.744	99.67
0.028	0.00	0.200	0.00	1.416	7.74	10.024	61.66	70.963	95.81	502.377	99.79
0.032	0.00	0.224	0.00	1.589	8.77	11.247	66.26	79.621	96.25	563.677	99.89
0.036	0.00	0.252	0.00	1.783	9.96	12.619	70.60	89.337	96.65	632.456	99.97
0.040	0.00	0.283	0.00	2.000	11.35	14.159	74.61	100.237	97.02	709.627	100.00
0.045	0.00	0.317	0.00	2.244	12.99	15.887	78.23	112.468	97.36	796.214	100.00
0.050	0.00	0.356	0.00	2.518	14.91	17.825	81.42	126.191	97.65	893.367	100.00
0.056	0.00	0.399	0.14	2.825	17.15	20.000	84.16	141.589	97.92	1002.374	100.00
0.063	0.00	0.448	0.45	3.170	19.74	22.440	86.47	158.866	98.16	1124.683	100.00
0.071	0.00	0.502	0.89	3.557	22.68	25.179	88.37	178.250	98.37	1261.915	100.00
0.080	0.00	0.564	1.45	3.991	25.98	28.251	89.92	200.000	98.56	1415.892	100.00
0.089	0.00	0.632	2.10	4.477	29.64	31.698	91.16	224.404	98.74	1588.656	100.00
0.100	0.00	0.710	2.82	5.024	33.64	35.566	92.17	251.785	98.91	1782.502	100.00
0.112	0.00	0.796	3.57	5.637	37.94	39.905	93.00	282.508	99.08	2000.000	100.00
0.126	0.00	0.893	4.36	6.325	42.48	44.774	93.70	316.979	99.24		

Analyst: Hoklam Suen, B.Eng. (Metallurgy)
Reported: Hoklam Suen, B.Eng. (Metallurgy)
Approved: Nimue Pendragon, B.Sc.(Nanotechnology)

BMT has a proven record in addressing today's engineering and environmental issues.

Our dedication to developing innovative approaches and solutions enhances our ability to meet our client's most challenging needs.



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Appendix F4 – External Hydrodynamic Modelling Peer Review – Testimonial Letter

Environmental Projects
Level 3, 117 King William St
Adelaide SA 5000

Att: Maria Pedicini

DHI Water & Environment Pty Ltd
Suite 146, Equus Centre
580 Hay Street
AU-6000 Perth
Australia

61 8 9225 4622 Telephone

dhi@dhigroup.com
www.dhigroup.com.au

Ref:	Init:	Date:
43802837	JANT	11 Jan 2019

Concerning – Smith Bay Wharf Project: Peer Review of Hydrodynamic Modelling

Dear Maria

DHI was engaged to conduct a peer review of the hydrodynamic modelling studies undertaken by BMT WBM associated with the above project. The review was conducted on technical reports delivered to DHI. No review was conducted of the actual model input files, model configuration files or model output files.

This peer review involved three stages of review in May, September and December 2018, with comments to each stage logged in an electronic record and subsequently responded to by BMT WBM. These comments have been closed out to my satisfaction as of the above date.

The review considered the following items:

- The suitability of the model software suite selected for the study.
- The configuration of that model software suite, and the input data used to drive it.
- The suitability of the calibration and validation of the hydrodynamic model, relative to industry norms.
- Sensitivity of the model results to input data and configuration.
- The communication of model results.

I am satisfied that the modelling work is appropriate and consistent with the level of care and skill typically exercised by practitioners in this field, and that the conclusions of the work are valid.

Best regards

DHI

Dr Jason Antenucci
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Head of Department, Marine
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