MID WEST PORTS

Maintenance dredging

2021 ASSESSMENT OF POTENTIAL DREDGE MATERIAL PLACEMENT AREAS WITHIN CHAMPION BAY, WA

Prepared by BMT Clarity from complexity
June 2021

Purpose

This report provides an understanding of the marine environment, particularly seagrass species and population densities located within the potential dredge material placement site to:

- help inform an options analysis to select and define a preferred nearshore material placement area;
- identify potential environmental impacts to benthic habitats and seagrass communities as a result of placing dredge material nearshore; and
- recommend management controls which are appropriate for mitigating environmental risks to seagrasses associated with any material placement.

Linkages

- Informs the Environmental Impact Assessment.
- Makes recommendations for the Dredge Environmental Monitoring and Management Plans.

BASELINE DATA

- ✓ **Benthic habitat mapping**
- ✓ Seagrass health assessment
- **Hydrographic surveys**
- Sediment characterisation
- ✓ **Water quality and light data**
- Wind, waves, currents

Importance

Informs the Maintenance Dredge Environmental Impact Assessment & Plume Modelling through:

- identification of bare sandy areas for suitable placement of dredge material;
- understanding of the natural seabed light climate, water temperature, salinity, turbidity and total suspended solids (TSS);
- demonstration of spikes in turbidity and variable light conditions occuring naturally at the seabed as a result of wind and wave action; and
- confirmation that seagrass species have adapted to fluctuations in light and turbidity and therefore a dredge program of 8 weeks is unlikely to impact seagrass.

Recommendations

- Plume and Sediment Fate Modelling.
- Detailed Environmental Impact Assessment.
- Monitoring of Seagrass pre and post placement nearshore.
- Develop Dredge Environmental Monitoring and Management Plans in accordance with EPA guidelines.

Assessment of Potential Dredge Material Placement Areas within Champion Bay WA

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BMT Commercial Australia Pty Ltd Level 4, 20 Parkland Road Osborne WA 6017 Australia PO Box 2305, Churchlands, WA 6918 Tel: +61 8 6163 4900 ABN 54 010 830 421 www.bmt.org	**Document:**	R-10708-1
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	Project Manager:	Karina Inostroza
	Author:	Karina Inostroza
	Client:	Mid West Ports Authority
	Client Contact:	Kerenza Humphrey, Kylie Reynolds
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Acronyms

LAC	Light attenuation coefficient
MAFRL	Marine and Freshwater Research Laboratory
MWPA	Mid West Ports Authority
NTU	Nephelometric turbidity unit
PAR	Photosynthetic active radiation
ppt	Parts per thousand
TSS	Total suspended solids

1 Introduction

1.1 Background

Geraldton Port (hereafter; the Port) is located ~420 km north of Perth in the Mid West region of Western Australia. The Port, which is managed by Mid West Ports Authority (MWPA; previously Geraldton Port Authority), is comprised of seven berths in the inner harbour, a fishing boat harbour, wharfs and jetties, and towage services.

MWPA is proposing to undertake maintenance dredging of the Port's commercial harbour and shipping channel in 21/22 financial year to remove accumulated sediments and return the channel to original designed depths for safe vessel access. In the upcoming maintenance dredging campaign, MWPA intend to place up to 150 000 m^3 of clean dredged material inside Champion Bay from a small trailer suction hopper dredge over a 6 week period. The potential nearshore placement sites are adjacent to seagrass habitat. As such, MWPA requires an informal assessment for internal planning purposes of the likely environmental acceptability or impact of placement of dredged material near seagrass habitat.

This report has been prepared to support MWPA identify and define a suitable area for nearshore placement of clean dredge material. The characterisation of benthic habitats that occur on the seafloor and light attenuation data from within the potential placement sites and surrounding areas will inform a detailed environmental impact assessment.

1.2 Scope of works

BMT Commercial Australia (BMT) have been engaged by MWPA to obtain a better understanding of the marine environments, particularly seagrass species and population densities located within potential dredge material placement study sites (A, B and C) and the associated surrounding area.

A benthic habitat assessment was completed and described in Appendix A with key outcomes as follows:

- characterisation and mapping of benthic habitats; and
- assessment of percent cover of seagrasses and other benthic primary producers to determine the suitability of study sites for placement of dredge material.

Water quality loggers were deployed for ~four months with the key objective of:

- better understanding the natural seabed light climate, water temperature, salinity, turbidity and total suspended solids (TSS) within Champion Bay.

This report summarises the key findings of the two studies for the purpose of:

- identifying potential environmental impacts to benthic habitats and seagrass communities as a result of nearshore placement of dredge material; and
- recommending management controls which are appropriate for mitigating environmental risks to seagrasses associated with any material placement.

2 Methods

2.1 Survey locations

The potential nearshore placement sites are located ~2.5 and 4.8 km north of the Port, approximately 1.0 and 3.5 km south-west of Sunset Beach (Figure 2-1). To obtain a better understanding of the marine environments within and surrounding the potential placement sites, towed video footage was collected from Placement Sites A and B, and drop-down camera images were captured within Placement Site C (Figure 2-1). To understand the natural seabed climate in Champion Bay, water quality light loggers were installed in the marine environment at sites LL1 and LL2 (Figure 2-1). A third light logger (site LL3) was installed above water on top of a sea container in the MWPA Port area (Figure 2-1). The purpose of this logger was to provide surface light readings for calculation of light attenuation coefficients (LAC).

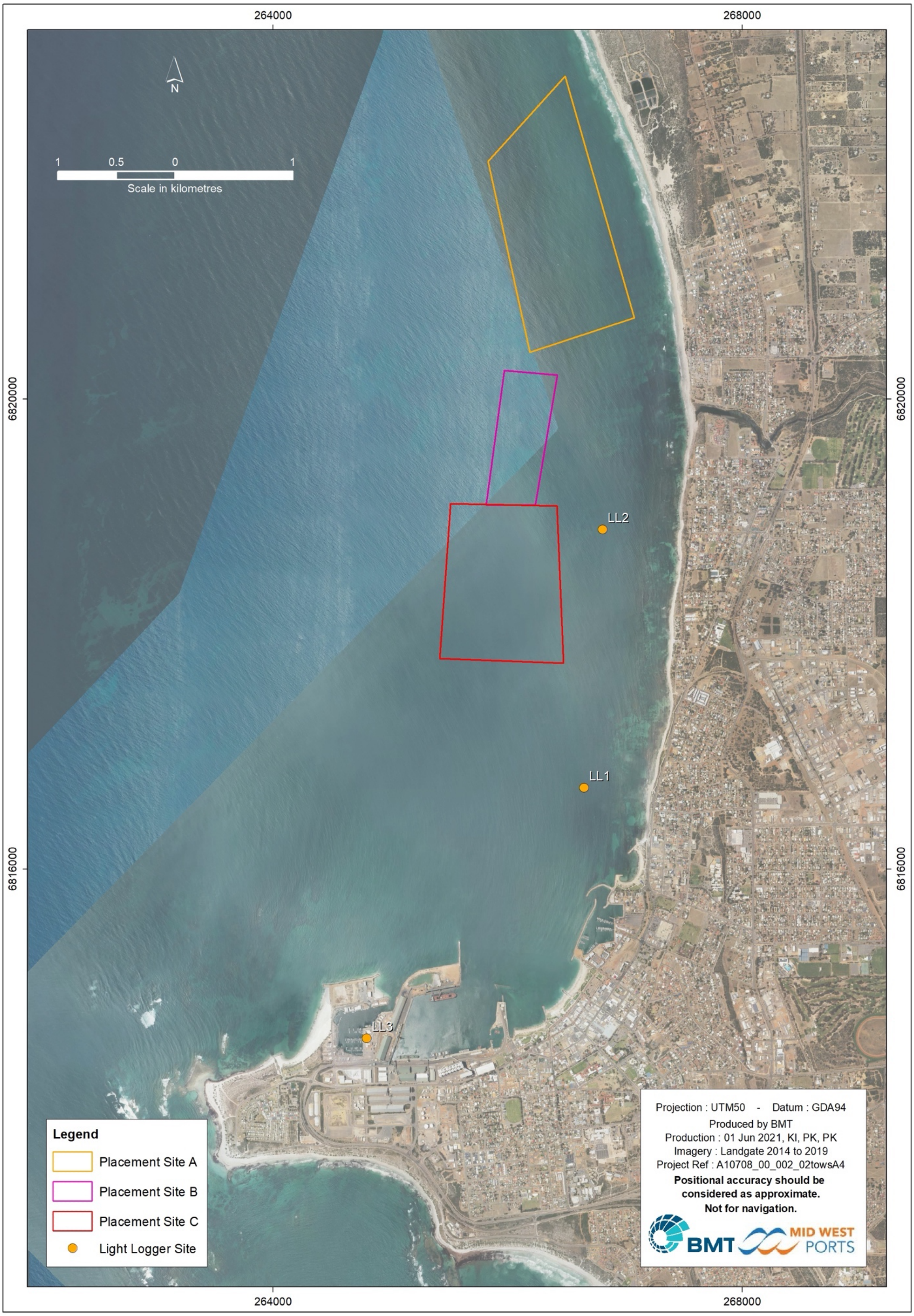


Figure 2-1 Location of potential placement and light logger study sites

2.2 Towed video and benthic habitat mapping

To characterise the benthic habitats and percent cover of seagrasses and other benthic primary producers within the three potential placement sites (A, B and C) and surrounding areas, BMT collected towed video between 14 and 19 January 2021 and drop-down camera images on 19 and 20 April 2021. A total of 18 transects were surveyed in the Placement Sites A and B and surroundings, spanning a total of 15.92 km. A total of 21 drop down camera videos were captured from random sites within Placement Site C.

Video footage and still images of the benthic habitat were analysed by an experienced marine scientific analyst using TransectMeasure software (SeaGIS 2020). The benthic habitat was categorised according to pre-determined categories and the benthic habitat data were synchronised to positional data and overlaid on aerial imagery to produce a map of the classified transects and drop-down camera sites.

Further details on the methods of benthic habitat collection are described in Appendix A.

2.3 Water quality loggers

2.3.1 Deployment and retrieval of loggers

On 15 and 18 January 2021, in-situ light logger frames were deployed at two offshore sites: LL1 and LL2; and a third logger (LL3) placed on land (Figure 2-1; Table 2-1). Site LL1 was located 750 m north of Beresford and approximately 600 m offshore, and site LL2 was located approximately 1 km south of Sunset Beach and ~700 m offshore (Table 2-2). The third logger (LL3; Figure 2-1) was placed on top of a sea container in the MWPA Port area (Table 2-2).

Table 2-1 Survey type and dates

Survey type	Date
Deployment	15–18 January 2021
Maintenance	29 March 2021
Cyclone check	19–20 April 2021
Retrieval	17 May 2021

Both LL1 and LL2 water quality frames contained a Seabird SBE 16V2 light logger equipped with a conductivity (salinity) unit, temperature, Photosynthetically Active Radiation (PAR) loggers (one WetLabs ECO PAR unit and one Odyssey unit), and one turbidity (Nephelometric Turbidity Unit; NTU) sensor. The two loggers offshore were positioned ~0.5 m above the sea floor and recorded data at ~20 minute intervals during daylight hours. The onshore logger (LL3) contained two Odyssey units recording PAR every ~20 minute intervals.

Table 2-2 Depth and coordinates of light logger sites

Site	Depth of instruments (m)	Coordinates (UTM50 GDA94)		Description of location installed
		Eastings	Northings	
LL1	8.5	266639	6816705	~750 m north of Beresford and ~600 m offshore
LL2	7.5	266693	6819282	~1 km south of Sunset Beach and ~700 m offshore
LL3	N/A	204618	7569274	On shipping container rooftop in the MWPA Port area

Following deployment, the light loggers were retrieved on 29 March 2021 for maintenance. During this maintenance survey, the wiper of the turbidity probe at site LL2 was obstructed with sand which prevented the turbidity probe from self-cleaning and compromised data collection between 24 January 2021 and 30 March 2021. All units were thoroughly cleaned, and a new wiper unit was installed on the turbidity probe at site LL2. All units on the loggers were checked to ensure they were logging and re-deployed on 30 March 2021.

Due to the passing of Tropical Cyclone Seroja that moved through the Geraldton coastline on 11 April 2021, which brought wind gusts of up to 170 km/hr and heavy rainfall (BOM 2021), an additional field survey on 19 and 20 April 2021 was organised by MWPA and BMT to inspect the condition of the loggers. Both loggers were retrieved and inspected for possible damage and to ensure they were continuously recording data. Prior to the arrival of Tropical Cyclone Seroja, the terrestrial logger was brought indoors between 9 to 14 April 2021 to protect it from the strong weather conditions.

All three loggers were retrieved on 17 May 2021 and data were downloaded and processed to remove any obvious data abnormalities/outliers. The loggers were deployed for a total of ~17 weeks (123 days).

2.3.2 Analysis of light data

PAR was recorded as instantaneous irradiance (µmol m^{-2} s^{-1}) in the spectral range of 400–700 nanometres every 20 minutes. A correction factor (derived during logger calibration prior to deployment) was applied to the data prior to analysis. Light data from the WetLabs ECO PAR and Odyssey units were compared as different instruments can produce different light measurements. A conversion factor between the WetLabs ECO PAR data and Odyssey data was determined, so that telemetered data from the WetLabs ECO PAR loggers can be used during dredging for comparison with literature thresholds (which are typically based on data collected using Odyssey loggers). The data were then converted to daily PAR (µmol m^{-2} d^{-1}) as per SoQ (2018) to allow for comparison as follows:

$$Daily\ PAR = \frac{(sum\ of\ all\ instantaneous\ values)}{(N\ \times\ D)} \times 0.0864$$

Where N is the number of samples taken in total (72 data points in one day), and D is the number of complete days of logger deployment (one day).

To calculate light attenuation coefficient (Kd_{PAR}), the following formula was used:

$$KdPAR = \frac{-Ln\ (\frac{Intensity\ lower}{Intensity\ upper})}{Depth\ (m)}$$

To estimate the light just below the water surface ($Intensity_{upper}$), the daily average of both terrestrial light loggers between 1000 and 1400 hours was calculated and then multiplied by 0.96. Light levels received by seagrasses is highest between 1000 and 1400, and allows for comparison with other seagrass monitoring programs. To calculate the $Intensity_{lower}$, the average daily light reaching the seabed for each site (LL1 and LL2) between 1000 and 1400 hours was calculated. The average daily water depth between 1000 and 1400 hours was 8.5 m for site LL1 and 7.5 m for site LL2.

2.4 Water quality profiles

Water quality profiles were collected from the vessel on all four field surveys at sites LL1 and LL2, using a YSI EXO or ProDSS profiler with the same set of parameters (temperature, salinity, turbidity, conductivity, dissolved oxygen and pH) as the light loggers. At each site, the profiler was slowly lowered into the water column until ~0.5 m above the seabed. These readings were compared to light logger collected by the Odyssey and WetLabs ECO probes.

2.5 Total suspended solids

TSS measurements cannot be collected from the Seabird loggers but can be calculated from the relationship between collected filtered water samples and turbidity results from the loggers and water quality profilers. Therefore, water samples were collected during all four field surveys. Water samples were collected using a water pump and hose deployed from the side of the vessel. At each site (LL1 and LL2), five samples were collected from 0.5 m above the seabed and stored into two 1 L samples containers. Due to malfunction of the wiper on the turbidity unit at site LL2 (see Section 2.3), the water samples collected during that field survey were also examined for NTU. All water samples were labelled and stored with ice bricks until transporting to Marine and Freshwater Research Laboratory (MAFRL) for analysis.

3 Results

3.1 Benthic habitat

To obtain a better understanding of the marine environments, particularly seagrass species and population densities located within and adjacent to Placement Sites A, B and C, a benthic habitat assessment was completed via towed video transects and drop-down camera images.

A technical note in Appendix A, was prepared to support MWPA's dredge material placement option analysis. The technical note characterises benthic habitats and provides the percent cover of seagrass and macroalgae within and adjacent to the placement study sites.

3.2 Light

To understand the natural seabed light climate within Champion Bay (at sites LL1 and LL2), PAR, daily light attenuation (K_dP_{AR}) and turbidity data was collected and analysed.

In summary, instantaneous irradiance data measured at the terrestrial site (LL3) slowly declined over the ~four months that may be linked to an increase in cloud cover from the summer to autumn austral period. During this period, PAR measured at the seagrass sites LL1 and LL2 showed a high degree of the variability. The peaks and drops in PAR levels that relate to fluctuations in light availability to seagrass meadows, were directly related to turbidity levels in the water column caused by strong winds experienced in Champion Bay.

3.2.1 Photosynthetically active radiation

Median instantaneous irradiance measured by the Odyssey loggers between 10:00 and 14:00 over 119 days ranged from 73.1–77.7 µmol m^{-2} sec^{-1} at sites LL1 and LL2 (Figure 3-1), and from 1285.5–1425.4 µmol m^{-2} sec^{-1} at the terrestrial logger site.

Instantaneous irradiance measured by the WetLabs ECO PAR loggers was approximately three times the instantaneous irradiance measured by the Odyssey loggers (Figure 3-1). However, a strong linear relationship ($y = 2.4051x + 15.295$; $R^2 = 0.8204$) was found between instantaneous irradiance measured by the Odyssey PAR logger and instantaneous irradiance measured by WetLabs ECO PAR loggers (Figure 3-2). Converted WetLabs ECO PAR data showed a good fit to the Odyssey PAR data (Figure 3-1).

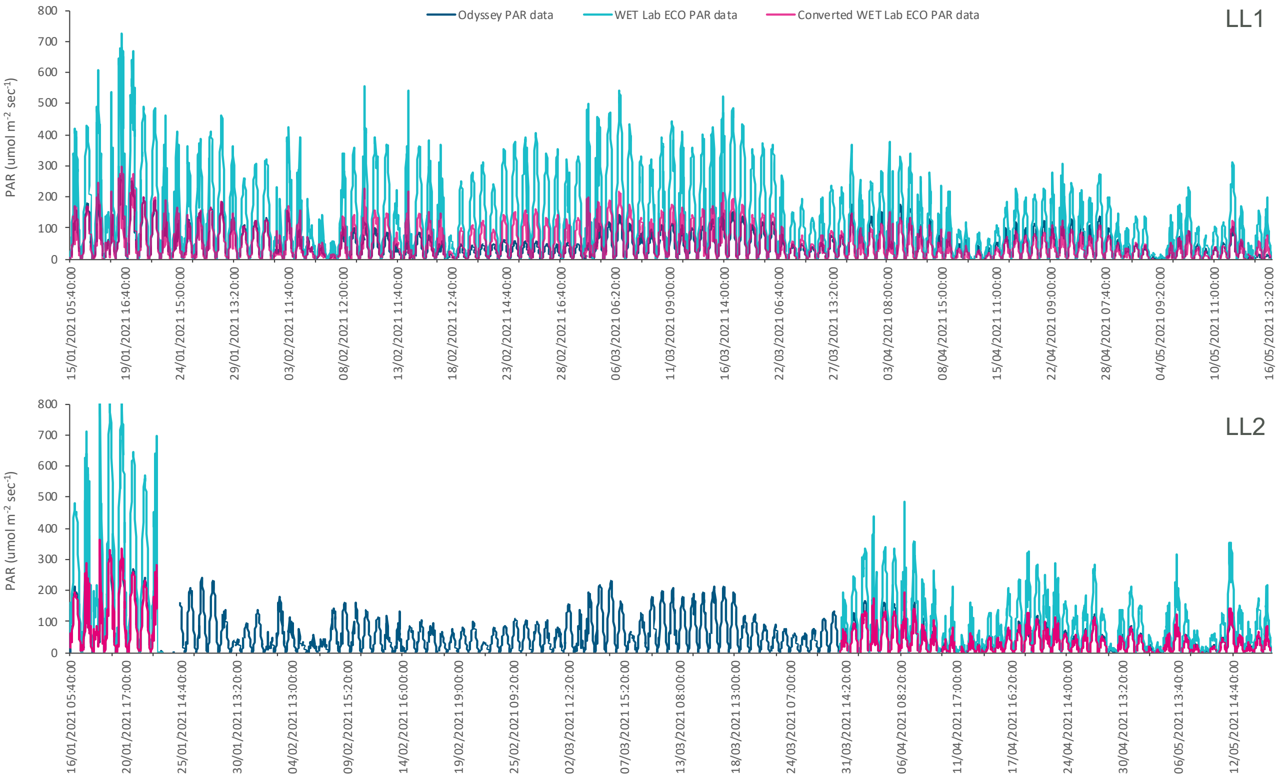


Figure 3-1 Odyssey PAR data, WetLabs ECO PAR data and converted WetLabs ECO PAR data for sites LL1 and LL2

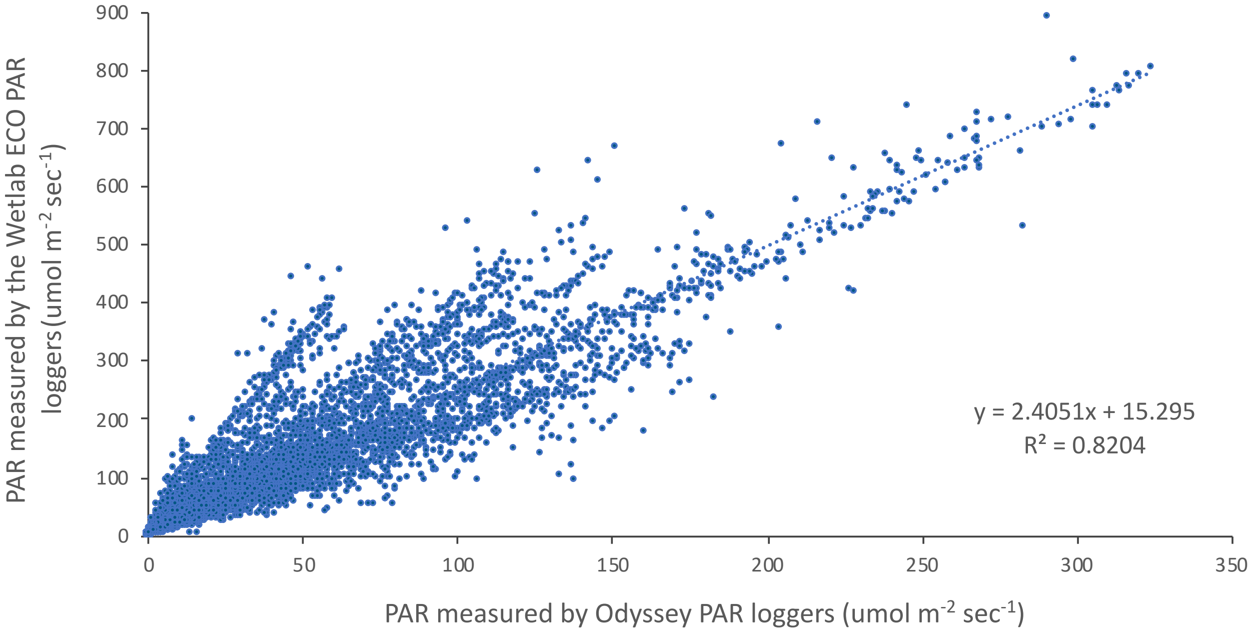


Figure 3-2 Linear relationship between PAR measured by Odyssey and WetLabs ECO PAR loggers

Daily PAR (as calculated from each full day of Odyssey logger data) at site LL1 ranged from 0–6.4 µmol m^{-2} d^{-1} with similar daily PAR at site LL2 (0.1–7.7 µmol m^{-2} d^{-1}; Figure 3-3). The similarities in light across the two sites (LL1 and LL2) are expected given that depths are relatively similar (8.5 m and 7.5 m, respectively). PAR levels across both sites (LL1 and LL2) showed a high degree of variability over the ~four months (Figure 3-3).

Daily PAR at the terrestrial site (Logger 1 and Logger 2) ranged from 5.5–58.0 µmol m^{-2} d^{-1}, with daily PAR slowly decreasing over time since deployment in January to time of retrieval in May (Figure 3-3). This gradual decline in daily PAR over the ~four months may be explained by a natural increase in cloud cover over the austral summer to autumn period.

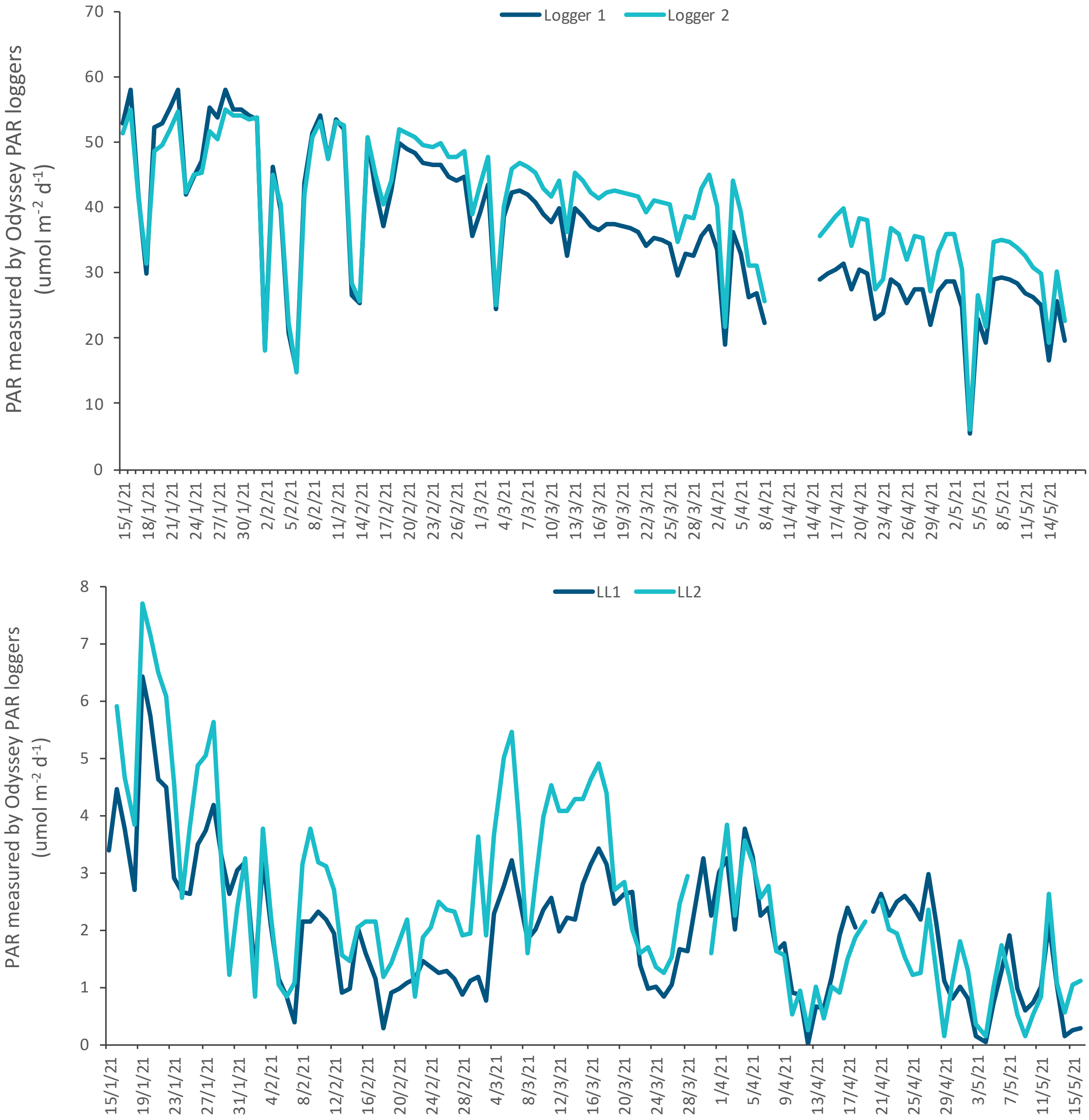


Figure 3-3 Daily PAR at terrestrial (top) and LL1 and LL2 (bottom) sites

3.2.2 Light attenuation coefficient

Daily light attenuation (Kd_{PAR}) for Odyssey, WetLabs ECO and converted WetLabs ECO logger data at sites LL1 and LL2 are presented in Figure 3-4. Kd_{PAR} for Odyssey loggers generally ranged between 0.2–0.8 m^{-1} (Figure 3-4).

Reductions in light availability (higher Kd_{PAR} values) in the water column near the seabed were detected at both sites LL1 and LL2 for short periods of time, mostly during conditions of increased winds and associated sea state in early-February 2021 (strong north and westerly winds reaching ~20 knots), and early and mid-May 2021 (strong north-easterly winds reaching speeds up to 24 knots; BOM 2021) (Figure 3-4). Higher Kd_{PAR} values were also recorded between 11–13 April 2021 that was caused by Tropical Cyclone Seroja that brought north to north-easterly winds gusts reaching up to 65 knots (BoM 2021; Figure 3-4).

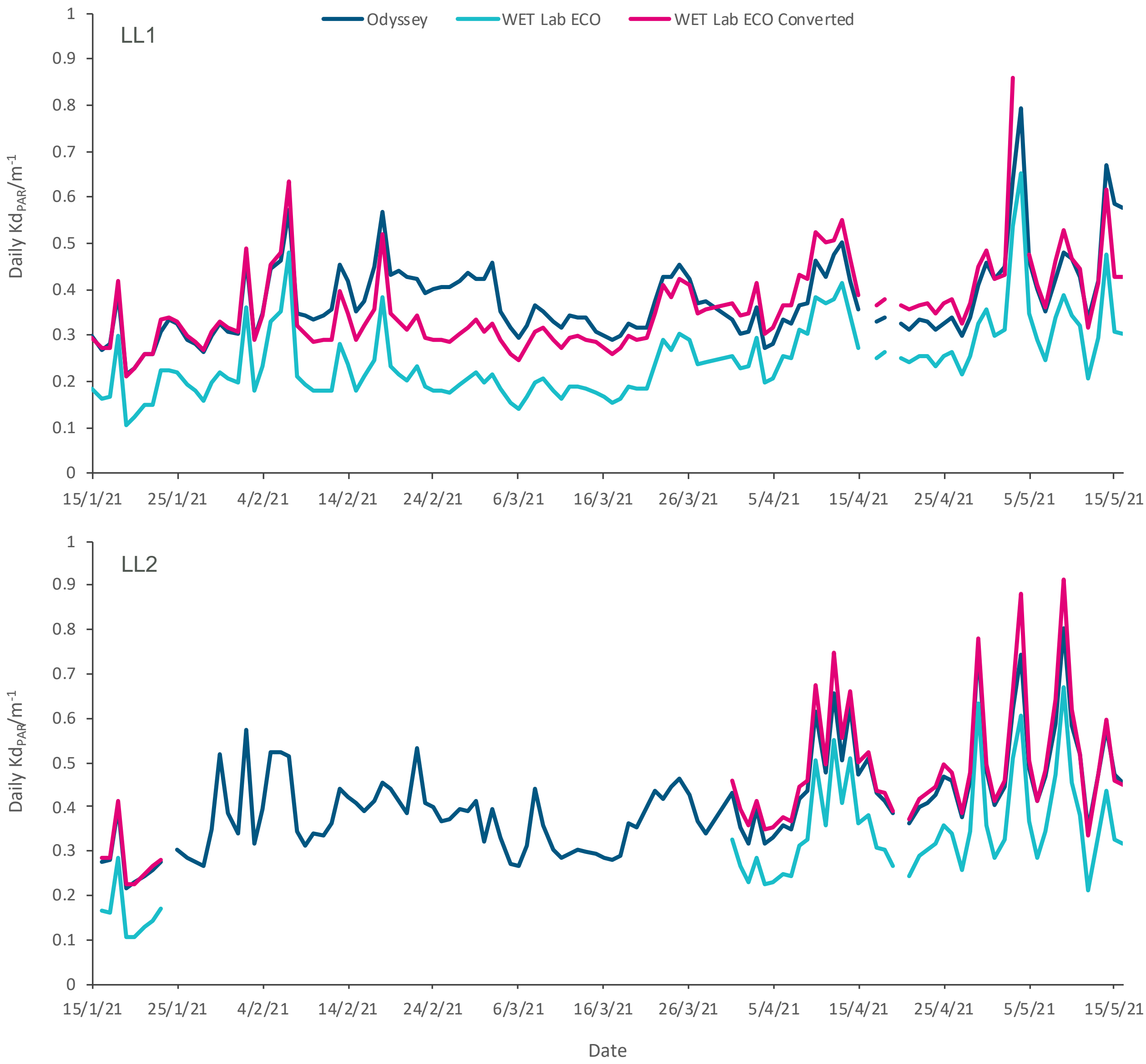


Figure 3-4 Daily Kd_{PAR} (m^{-1}) at sites LL1 (top) and LL2 (bottom)

3.3 Turbidity

The relationship between turbidity measured as NTU versus TSS measured as mg L^{-1} varies dependent on particle size, shape, density and composition, although it is generally agreed that there is linear correlation between NTU and TSS, and that 1 NTU equates to ~1–2 mg L^{-1} (Rügner et al. 2013).

On each field survey, water samples were collected to measure TSS and were compared to turbidity readings recorded near the seabed using the water quality profiler to determine the site-specific relationship between turbidity measured as NTU and TSS. A moderate linear relationship was found between NTU and concentrations of TSS for site LL1 ($y = 0.208x + 1.0251$; $R^2 = 0.6643$) and a relatively strong linear relationship for site LL2 ($y = 0.8302x + 0.5724$; $R^2 = 0.7586$; Figure 3-5). The NTU and TSS relationships were not similar to literature data and therefore to understand the amount of reduced light the seagrass each site receives, any calculation of TSS from measured turbidity (NTU) must be interpreted with caution. Average turbidity across both sites LL1 and LL2 ranged from 0.27–17.32 NTU, equating to an average calculated TSS ranging from -3.44–20.17 mg L^{-1} (Table 3-1; Figure 3-6). A full list of the laboratory results for TSS are provided in Appendix B.

Spikes in turbidity were evident at both sites (LL1 and LL2) throughout the ~four months (Figure 3-6). These increases of suspended particles in the water column, which may comprise of sediment, organic matter and dissolved substances, absorb light and contribute to the light reduction reaching the seabed and seagrass meadows. Many of these spikes in water column turbidity directly relate to weather conditions particularly increases in wind strength experienced in Champion Bay (BoM 2021).

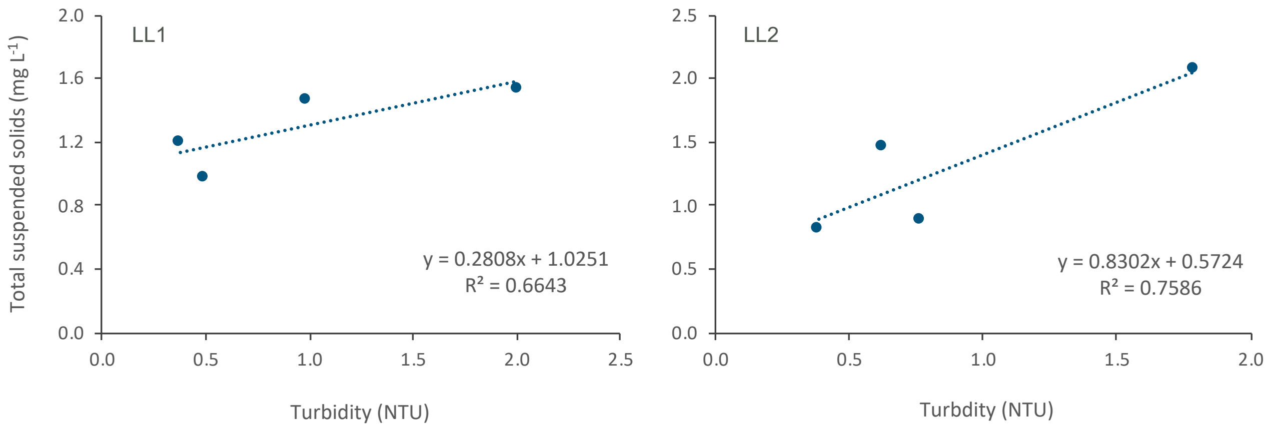


Figure 3-5 Relationship between turbidity and suspended solids at sites LL1 (left) and LL2 (right)

Table 3-1 Measured turbidity and calculated total suspended solids at sites LL1 and LL2

Site	Sample date	Turbidity (NTU)		TSS (mg L^{-1})	
		Average	Maximum	Average	Maximum
LL1	15/01/2021	0.90	0.90	-0.60	-0.60
	29/03/2021	2.32	3.86	6.23	13.63
	19/04/2021	0.45	0.83	-2.76	-0.94
	17/03/2021	0.31	0.35	-3.44	-3.25
LL2	18/01/2021	0.27	0.40	-0.36	-0.21
	29/03/2021	2.44	17.32	2.25	20.17
	20/04/2021	0.39	0.51	-0.22	-0.08
	17/03/2021	0.51	0.71	-0.08	0.17

Note:
(1) NTU = Nephelometric Turbidity Unit; TSS = Total suspended solids

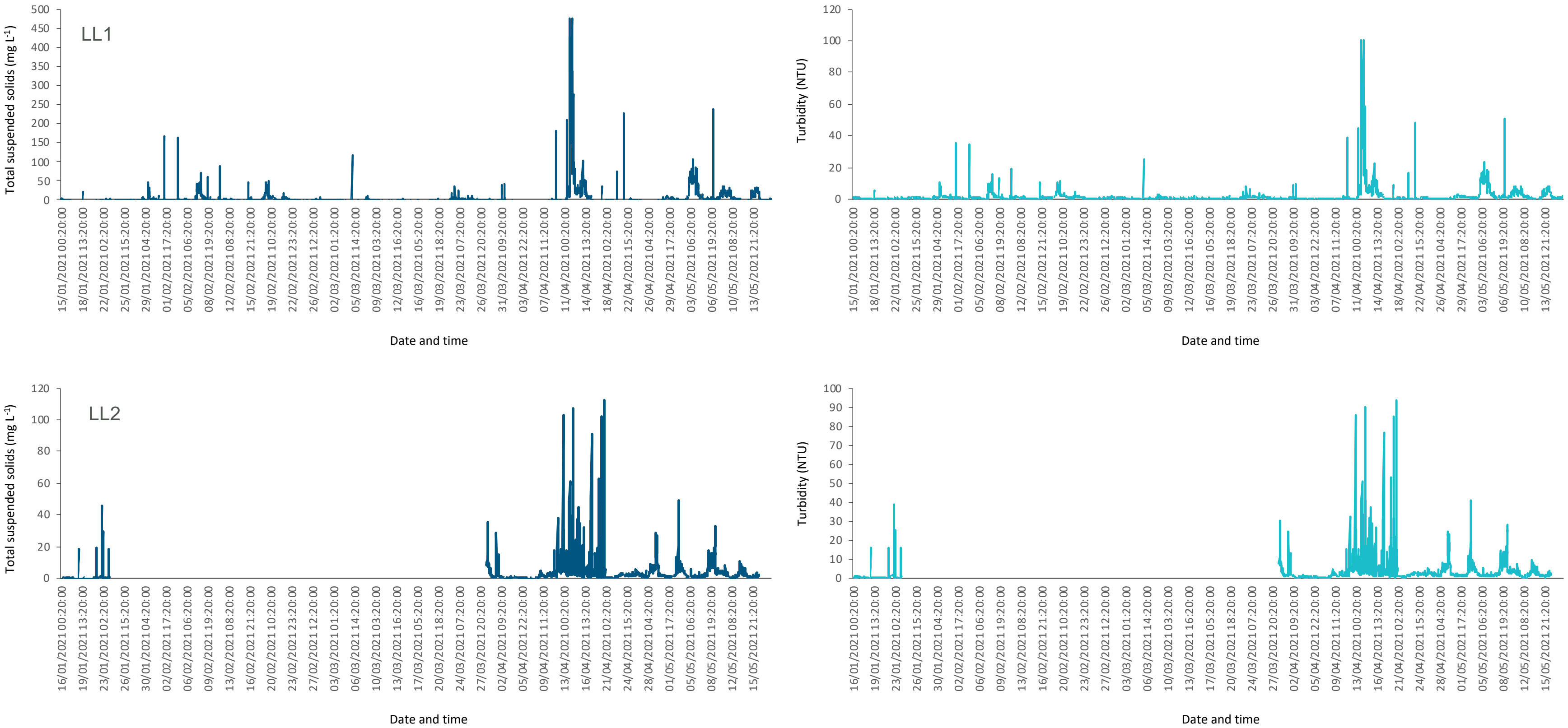


Figure 3-6 Measured turbidity and calculated total suspended solids at site LL1 (top) and site LL2 (bottom)

3.4 Temperature, salinity and conductivity

Temperature, salinity and conductivity at sites LL1 and LL2 varied on a daily basis but gradually declined over the ~four months (Figure 3-7). Water temperature near the seagrass meadows (~0.5 m above seabed) ranged from 20.71–26.82°C at sites LL1 and LL2, with lower temperatures recorded during mid-April to May 2021 (Figure 3-7; Table 3-2). Temperature readings were almost identical at both sites (Figure 3-7; Table 3-2).

Site LL1 recorded slightly lower salinity and conductivity levels than site LL2, with slightly lower levels measured at the end of deployment period (mid-April to May; Figure 3-7).

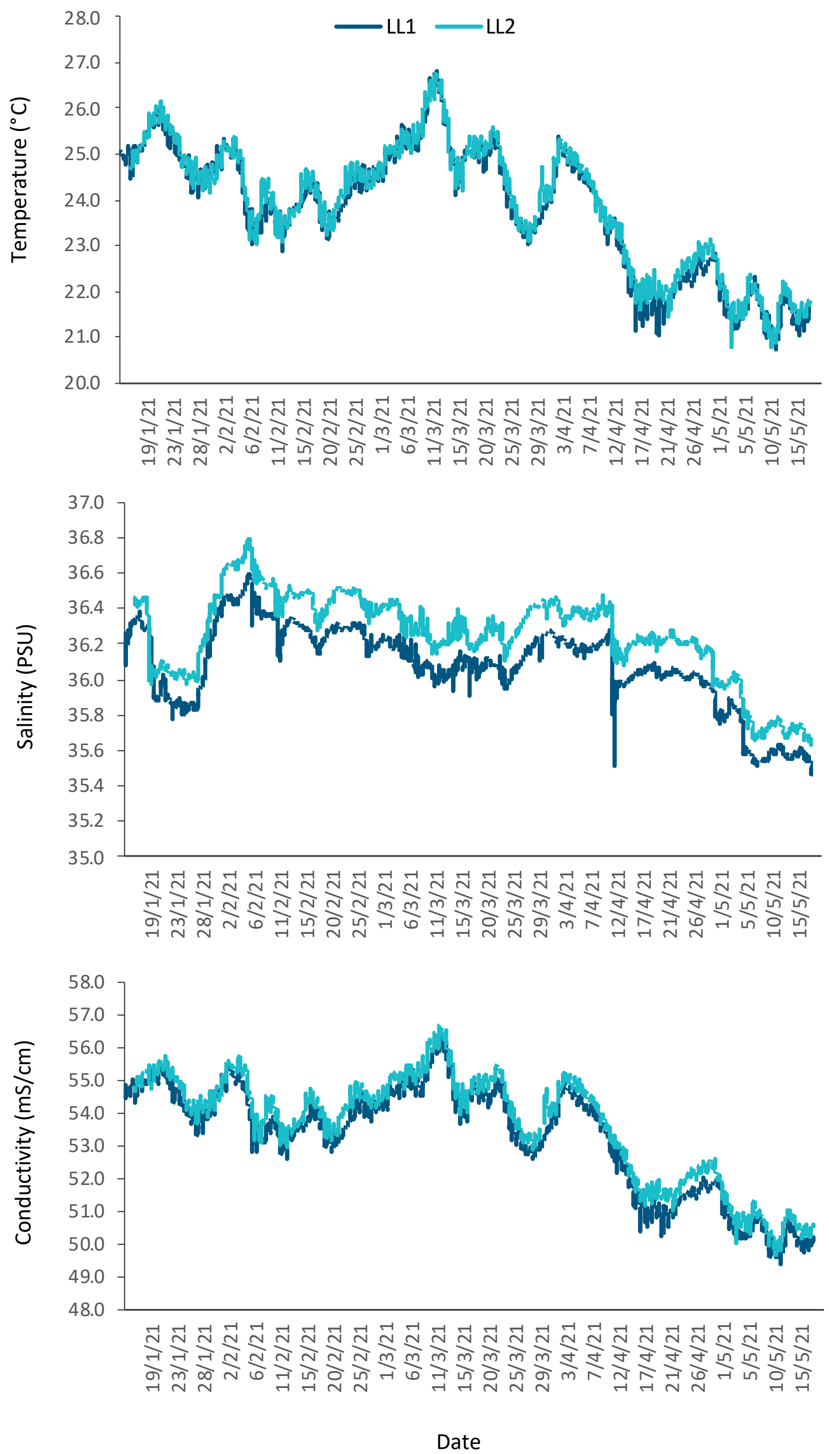


Figure 3-7 Daily measurements of temperature, salinity and conductivity at sites LL1 and LL2

Table 3-2 Summary of temperature, salinity and conductivity at sites LL1 and LL2

Site	Temperature (°C)			Salinity (PSU)			Conductivity (mS/cm)		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
LL1	20.71	23.80	26.82	35.46	36.08	36.59	49.40	53.26	56.42
LL2	20.79	23.91	26.79	35.63	36.25	36.80	49.67	53.60	56.62

In addition to water quality parameters measured in situ via logger units, triplicate water quality profiles were collected from the vessel on all four field surveys at sites LL1 and LL2. Temperature readings near the seagrass meadows were within range of temperature measured in situ (Table 3-3). Salinity (measured as parts per thousand (ppt) which is equivalent to PSU) also reported similar readings to those measured in situ (Table 3-3). Minor fluctuations in pH were recorded at each site over time, however, were within the normal readings of marine waters (Table 3-3). Dissolved oxygen in seawater ranged from 5.88–8.43 mg/L (Table 3-3).

Table 3-3 Summary of temperature, salinity and conductivity at sites LL1 and LL2 during each survey period

Site	Survey type	Temperature (°C)			Salinity (ppt)		
		Min	Mean	Max	Min	Mean	Max
LL1	Deployment	24.79	24.79	24.79	36.62	36.62	36.62
	Maintenance	23.17	23.17	23.17	38.87	38.88	38.88
	Cyclone check	21.62	21.63	21.64	36.20	36.21	36.22
	Retrieval	21.74	21.75	21.75	35.60	35.60	35.61
LL2	Deployment	25.33	25.50	25.54	36.49	36.63	36.66
	Maintenance	23.39	23.39	23.39	38.86	38.86	38.87
	Cyclone check	21.94	21.94	21.95	36.11	36.12	36.12
	Retrieval	21.73	21.73	21.74	35.60	35.61	35.61

Site	Survey type	pH			Dissolved oxygen (mg/L)		
		Min	Mean	Max	Min	Mean	Max
LL1	Deployment	7.97	7.97	7.97	5.88	5.88	5.88
	Maintenance	8.31	8.36	8.39	7.25	7.36	7.42
	Cyclone check	8.14	8.15	8.16	6.72	6.84	6.91
	Retrieval	8.28	8.28	8.28	7.46	7.48	7.48
LL2	Deployment	8.21	8.24	8.25	6.90	7.25	7.64
	Maintenance	8.34	8.39	8.40	8.18	8.36	8.43
	Cyclone check	8.15	8.15	8.16	6.45	6.49	6.56
	Retrieval	8.27	8.27	8.27	7.21	7.23	7.26

4 Conclusions and Management Controls

4.1 Considerations for further detailed environmental impact assessment

It is important to understand what type of benthic habitat, including sensitive species, occur in the potential nearshore placement areas and surroundings to ensure there are no adverse effects to benthic habitats from the placement of clean dredged material. Coloniser (e.g., *Syringodium isoetifolium* and *Halophila* spp.) and persistent (e.g., *Posidonia* spp. and *Amphibolis* spp.) seagrasses and macroalgae were identified in the three potential Placement Sites (A, B and C) in varying densities (Appendix A). Of the three placements sites, Site A contained a greater diversity and larger cover of seagrass and macroalgae than Placement Sites B and C (Appendix A). The southern end of Placement Site B and some northern sections of Placement Site C had larger sections of floating wrack and bare sand with ripples orientated in a south-westerly direction and a higher presence of coloniser seagrass species. The feature of bare sand ripples was also reported in AECOM's habitat survey report (AECOM 2020). The sand ripples and accumulated wrack on the seafloor indicate that these areas of Champion Bay are exposed to considerable wave energy and as a result, the distribution and biomass of colonising seagrass species can be expected to be highly variable (Appendix A). Therefore light, together with substrate type, stability and wave energy, are important and limiting factors controlling distribution and biomass of primary production by seagrasses and macroalgae.

This study has shown natural fluctuations in light availability near the seabed at sites LL1 and LL2 between January and May 2021. Seagrasses and other primary producers including macroalgae use PAR (wavelengths between 400–700 nanometres) that is part of the solar irradiance used for photosynthesis. Reductions in light availability in this study were likely caused by natural strong weather conditions (winds and sea state) that resuspended sediment into the water column, which caused with an increase in turbidity at that same time. The passing of Tropical Cyclone Seroja in early-May 2021 was evident in the light loggers, which measured reduced PAR concentrations and an increase in Kd_{PAR} values. Water conditions returned to natural background levels within a few days following a storm event.

To understand the effects a dredge plume may have on adjacent benthic communities and habitat, it is important to understand the particle size distribution of the clean dredged material. It is understood that the size of particles ranged from fine to medium sands with small amounts of coarse sands and gravel and silt (O2 Marine 2019). It is expected that larger particles (medium sands to gravel) may remain suspended in the water column for a short-term compared to longer periods with clays, silts and fine sand, and affect sedimentation rates and the smothering or reduced light penetration to nearby seagrass meadows during maintenance works. Given that a relatively small volume of clean dredged material (150 000 m^3) will be placed in a highly energetic embayment in Champion Bay over a short period (~6 weeks), the maintenance dredging campaign is expected to have a relatively low impact on adjacent seagrass habitat. However, further understanding the local hydrodynamics and metocean conditions of the region (prevailing winds and swell, currents, tides, etc.) will assist in determining the movement and fate of suspended solids and overall impact on seagrass meadows.

4.2 Considerations for dredge management and monitoring

Examination of morphological (e.g., number of leaves, leaf length, shoot density), physiological (e.g., starch, sucrose, carbohydrates) or community (e.g., epiphyte biomass) indicators of nearby seagrasses to the potential nearshore placement area prior to, during and post-maintenance dredging works will allow a better understanding of seagrasses responses to a disturbance over time. In early-2021, BMT examined seagrass characteristics in Champion Bay and surrounding areas in historically study sites, and results showed that some *A. griffithii* sites recovered within 5 to 7 years following capital dredging in 2002–2003 which reduced seagrass biomass and deprived seagrass of light for at least 6 months (BMT 2021). Monitoring seagrass meadow edges in the potential nearshore placement area using multi-beam back scatter or towed video surveys prior to and after dredging, will determine if seagrass areas change over time (i.e., seagrass meadows retreat).

An experimental study on *A. griffithii* in Jurien Bay (Lavery et al. 2009) highlights the importance time of year plays on seagrasses response to shading (e.g., potential dredge plumes). This study showed that following winter, *A. griffithii* showed little to no impacts when exposed to 80% shading of ambient light over a three-month duration (Lavery et al. 2009). It is recommended that maintenance dredging works are completed over the winter period. The austral winter period is the time of the year when light is naturally deprived, and plants are exhausting their reserves captured during summer. In summer, seagrasses are peaking in growth, increasing their photosynthetic rates and storing carbon in rhizomes (Alcoverro et al. 2001). Therefore, seagrass meadows in the vicinity of the potential nearshore placement area(s) will be less likely to photosynthesise and restore their carbohydrate reserves after winter. This would also coincide with an increase in storm events during winter, which further facilitates sediment movement; and beach use by the public will be minimal.

Depending on the scale and significance of impacts identified from dredge plume and sediment transport modelling, a framework of monitoring, management triggers, targets and responses should be developed for the maintenance dredging campaign that aligns with the relevant EPA (2018) environmental factors, in a specific dredging environment management plan. The monitoring and management methods of potential impacts such as direct impacts to benthic habitats, and increase in water column turbidity should be designed in line with a specific environmental impact assessment.

5 References

AECOM (2020) Benthic Habitat Mapping Report – Champion Bay and Surrounds. Prepared for Mid West Ports Authority by AECOM Australia Pty Ltd, Document No. R1889/M&C4168, Perth, Western Australia, September 2020

Alcoverro T, Manzanera M & Romer J (2001) Annual metabolic carbon balance of the seagrass Posidonia oceanica: The importance of carbohydrate reserves. Marine Ecology Progress Series 211:105–116

BMT (2021) Seagrass Communities in Champion Bay and Surroundings. Prepared for Mid West Ports Authority by BMT Commercial Australia. Report No. R-1799_00-3, Perth, Western Australia, June 2021

BOM (2021) Climate statistics for Australian locations – Weather and climate for Geraldton, Western Australia. Available at <http://www.bom.gov.au/climate/dwo/202104/html/IDCJDW6048.shtml> Accessed 18 May

EPA (2018) Statement of Environmental Principles, Factors and Objectives. Environmental Protection Authority, June 2018

Lavery PS, McMahon K, Mulligan M, Tennyson A (2009) Interactive effects of timing, intensity and duration of experimental shading on *Amphibolis griffithii*. Marine Ecology Progress Series 394:21–33

O2 Marine (2019) MWPA Baseline Sediment Characterisation Assessment. Prepared for Mid West Ports Authority by O2 Marine, Report No. A1369090, Perth, Western Australia

Rügner H, Schwientek M, Beckingham B, Kuch B, Grathwohl P (2013) Turbidity as a proxy for total suspended solids (TSS) and particle facilitated pollutant transport in catchments. Environmental Earth Sciences 69:373–380

SoQ (2018) Environmental Protection (Water) Policy 2009 – Monitoring and Sampling Manual: Guidance on using Photosynthetically Active Radiation (PAR) as a method to measure light availability for aquatic photosynthetic organisms facing acute impacts. State of Queensland, February 2018

Appendix A Technical note – Benthic habitat assessment of potential nearshore placement sites

Technical Note

From:	Karina Inostroza	To:	Kerenza Humphrey, Kylie Reynolds
Date:	4 May 2021	Cc:	Mark Westera
Subject:	Benthic habitat assessment of potential nearshore placement sites_Rev1		

1 Introduction

1.1 Background

Geraldton Port (hereafter; the Port) is located ~420 km north of Perth in the Mid West region of Western Australia. The Port, which is managed by Mid West Ports Authority (MWPA; previously Geraldton Port Authority), is comprised of seven berths in the inner harbour, a fishing boat harbour, wharfs and jetties, and towage services.

MWPA is proposing to undertake maintenance dredging of the Port's commercial harbour and shipping channel in 2021/22 financial year to remove accumulated sediments and return the channel to original designed depths for safe vessel access. In the upcoming maintenance dredging campaign, MPWA intend to dispose up to 150 000 m^3 of clean dredged material inside Champion Bay from a small trailer suction hopper dredge over a 6 week period. The potential nearshore placement sites are adjacent to seagrass habitat. As such, MWPA requires an informal assessment for internal planning purposes of the likely environmental acceptability or impact of placement of dredged material near seagrass habitat.

BMT Commercial Australia (BMT) have been engaged by MWPA to obtain a better understanding of the marine environments, particularly the seagrass species and population densities located within and particularly shoreward of the potential nearshore placement sites.

This technical note has been prepared to inform MWPA internal planning processes through an informal assessment of the likely environmental acceptability and impacts from the placement of dredged material near seagrass and nearshore benthic habitat.

1.2 Objectives

The objectives of this study included:

(1) to characterise and map the benthic habitats within and adjacent to the three placement study sites (A, B and C); and,

(2) assess percent cover of seagrasses and other benthic primary producers to determine the suitability of study sites for placement of dredge material.

2 Methods

Placement Sites A and B were identified as potential placement sites based on the broad scale benthic habitat mapping completed by AECOM in 2020. As a result of this first survey in January 2021, MWPA hydrographic surveys located a bare and sparsely covered substrate and a third potential placement site was identified. Placement Site C was then surveyed in April 2021 to ground truth assumptions and refine the placement area boundary.

2.1 Benthic habitat of Placement Sites A and B

2.1.1 Video acquisition

Towed video was collected by BMT between 14 and 19 January 2021. The towed video system was configured with a high-definition digital video camera mounted in a waterproof housing. The camera was attached to a towed video sled, which provided a live feed from the camera to the survey vessel and allowed the operator to adjust the height of the camera depending on water visibility and seafloor topography. A global positioning system (GPS) track was recorded concurrently to the video tows, recording a live position at one minute intervals.

Six transects were surveyed in Placement Site A and five transects within Placement Site B. An additional seven transects adjacent the two placement sites were also collected. Transects ranged in length from 0.46 to 1.54 km, spanning a total of 15.92 km (Table 2-1).

Table 2-1 Towed video cover in each Placement Site and adjacent areas

Location	Transect ID	Towed video path length (km)	Total towed video path length (km)
Within Placement Site A	TA1	1.15	5.28
	TA2	0.72	
	TA3	0.86	
	TA4	0.77	
	TA5	0.74	
	TA6	1.04	
Adjacent to Placement Site A	TA7	0.47	1.13
	SH2	0.66	
Within Placement Site B	TB1	0.93	3.91
	TB2	0.49	
	TB3	0.87	
	TB4	1.16	
	TB5	0.46	
Adjacent to Placement Site B	M1	0.56	2.68
	M2	0.68	
	SH1	1.46	
South of Placement Site B	LL1	1.54	2.92
	LL2	1.38	
Total			**15.92 km**

2.1.2 Video analysis and habitat classification

Video footage of the benthic habitat within the potential placement sites and adjacent areas were analysed using TransectMeasure software (SeaGIS 2020). The benthic habitat types visible on each frame of the video were determined by an experienced marine scientific analyst according to the categories listed in

Table 2-2. The benthic habitat data were synchronised to positional data from the GPS using the time stamps from the video footage and overlaid on aerial imagery to produce a map of the classified transects.

Table 2-2 Benthic habitat classifications

Substrate type	Category	Sub-category
Unconsolidated substrate: Mud Bare sand Flat profile Small ripples (1–10 cm undulations) Medium ripples (10–50 cm) Large ripples (50–100 cm) Gravel Consolidated reef: Low relief reef (<1 m) Medium relief reef (1-4 m) High relief reef (>4 m) Pavement Cobbles / rubble	Seagrass	*Amphibolis* spp.
		Posidonia spp.
		Thalassodendron spp.
		Halophila spp.
		Heterozostera spp.
		Syringodium spp.
		Zostera spp.
	Macroalgae	Brown algae – *Ecklonia* spp.
		Brown algae – *Sargassum* spp.
		Brown algae – Other
		Green algae
		Red algae
	Filter feeders	Sponges
	Coral	Hard
		Soft
	Mixed community	Seagrass and macroalgae
		Seagrass and filter feeders
		Seagrass and coral
		Macroalgae and coral
		Macroalgae and filter feeders
	Wrack	
	Unknown	

2.2 Benthic habitat of Placement Site C

2.2.1 Image acquisition

Images from the potential Placement Site C were collected by BMT on 19 and 20 April 2021 using the same high-definition digital video camera with live feed used for Placement Sites A and B (see Section 2.1.1). A total of 21 drop down camera videos were captured from random sites within Placement Site C (Figure 3-1). From each video, a still image was selected to enable benthic habitat classification (see Section 2.2.2). The camera, which was attached to a sled, was slowly lowered to ~0.5 m above the seabed and held stationary for at least one minute. At each site, a waypoint was taken on the handheld GPS.

2.2.2 Image analysis and habitat classification

One still image was taken from each drop down video using TransectMeasure software (SeaGIS 2021). For each image, 20 points were randomly overlaid and the benthic habitat types underneath each point was determined by an experienced marine scientific analyst according to the same categories listed in Table 2-2.

2.3 Percent cover of Placement Sites A and B

To determine percent cover of the seagrasses and other benthic primary producers (e.g., macroalgae) from the potential Placement Sites A and B and surrounding areas, the same video footage captured for benthic habitat was used. For each towed video, ten random frames were used. For each frame, percent cover of seagrass and macroalgae were determined by an experienced marine scientific analyst according to the percent cover standards as per Seagrass Watch (2004) listed in Table 2-3.

Table 2-3 Percent cover bins

Percent cover (%)	Description
0	Absent
<5	A single shoot or a few shoots
5–25	Some cover
25–50	Moderate cover
50–75	Majority cover
75–100	Total or near total cover

3 Results

3.1 Benthic habitat of Placement Sites A and B

Placement Site A was dominated by patches of bare sand and low relief reef (<1 m) with a mixed seagrass and macroalgal community. The seagrasses on low relief reefs included *Amphibolis antarctica*, *A. griffithii*, *Thalassodendron pachyrhizum*, sparse patches of *Halophila* spp. and *Syringodium isoetifolium*, with occasional *Posidonia australis* and *P. sinuosa*. The macroalgae growing on low relief reefs were *Sargassum* spp., *Ecklonia* spp., *Padina* spp. and other brown algae. Small patches to relatively large extensive meadows (ranging from 5–50 m) of *A. antarctica* and *A. griffithii* were recorded in some sections along transects TA3, TA4, TA5 and TA6 in Placement Site A, along with sparse meadows of *S. isoetifolium* and *Halophila* spp. (Figure 3-1; Table 3-1). The sections of bare sand observed throughout Placement Site A were either flat (no profile) or contained small ripples with undulations 1–10 cm arranged in a westerly to south-westerly direction.

The benthic habitat to the west of Placement Site A (transect TA7) was predominantly low relief reef (<1 m) with a mixed community of seagrasses including *A. antarctica*, *A. griffithii, S. isoetifolium* and *Halophila* spp. and macroalgae, such as *Sargassum* spp., *Ecklonia* spp. and brown macroalgae. Large extensive *A. griffithii* meadows were recorded in this area along with small patches of *P. coriacea*. On the east side of Placement Site A (transect SH2), *A. antarctica,* some *Halophila* spp. and very occasional *P. sinuosa* were observed on low relief reef (<1 m). Other low relief reefs (<1 m) in the area had a mixed community of seagrass (same seagrass species found along TA3, TA4, TA5 and TA6) and primarily *Sargassum* spp. Some bare sandy patches were also seen throughout the east side of Placement Site A (Figure 3-1; Table 3-1).

In Placement Site B, there were large sections of bare sand with small ripples (1–10 cm undulations) in a south-westerly direction and floating wrack comprised of primarily *Sargassum* spp., *Ecklonia* spp., other brown algae and some *Amphibolis* spp. leaves. Transect TB1 and TB3 on the southern end of Placement Site B had the largest sections of bare sand; ~0.47 km in TB1 and ~0.58 km in TB3, respectively. Low relief reefs (<1 m) were observed throughout Placement Site B with a mixed community of seagrass including *A. antarctica*, *A. griffithii*, *Halophila* spp., *T. pachyrhizum*, and *S. isoetifolium,* and macroalgae

(*Sargassum* spp., *Ecklonia* spp. and filamentous red algae). Dense and sparse patches of *A. antarctica* were observed throughout the site (Figure 3-1; Table 3-1).

To the east of Placement Site B (transects M1 and M2), the benthic habitat was primarily comprised of low relief reef (<1 m) with mixed community of seagrass (*A. antarctica*, *A. griffithii*, *Halophila* spp., *S. isoetifolium*, *P. coriacea*, and *P. sinuosa*) and macroalgae (*Sargassum* spp., *Dictyopteris* spp., other brown macroalgae and green algae). *Sargassum* spp., *Ecklonia* spp., other brown algae and red algae were the dominant macroalgae found on medium relief reef (1-4 m). A few extensive patches of bare sand with small ripples orientated westerly to south-westerly were observed between dense seagrass meadows. Along the coastline adjacent to Chapman River (transect SH1), low relief reef (<1 m) with *Sargassum* spp. and *Ecklonia* spp. (macroalgae) together with *P. sinuosa*, *A. antarctica*, *A. griffithii* and *T. pachyrhizum* (seagrass) were dominant in the area. Patches of bare low relief reef (<1 m, i.e. with no algal growth) and rubble were also observed in this area (Figure 3-1; Table 3-1).

The benthic habitat south of Placement Site B (transects LL1 and LL2) consisted of low relief reef (<1 m) with a mixed community of macroalgae (*Padina* spp., and filamentous green algae) and seagrass, along with small and extensive patches and meadows (between 5–20 m in length) of mixed seagrass species (*P. coriacea*, *P. sinuosa*, *A. antarctica*, *S. isoetifolium*, and *Halophila* spp.) over bare sand. Approximately 0.75 km of sand and wrack was recorded in the middle of transect LL2. Wrack comprising of detached macroalgae and seagrass were also found in depositional areas in the sand and among the low relief reefs (Figure 3-1; Table 3-1).

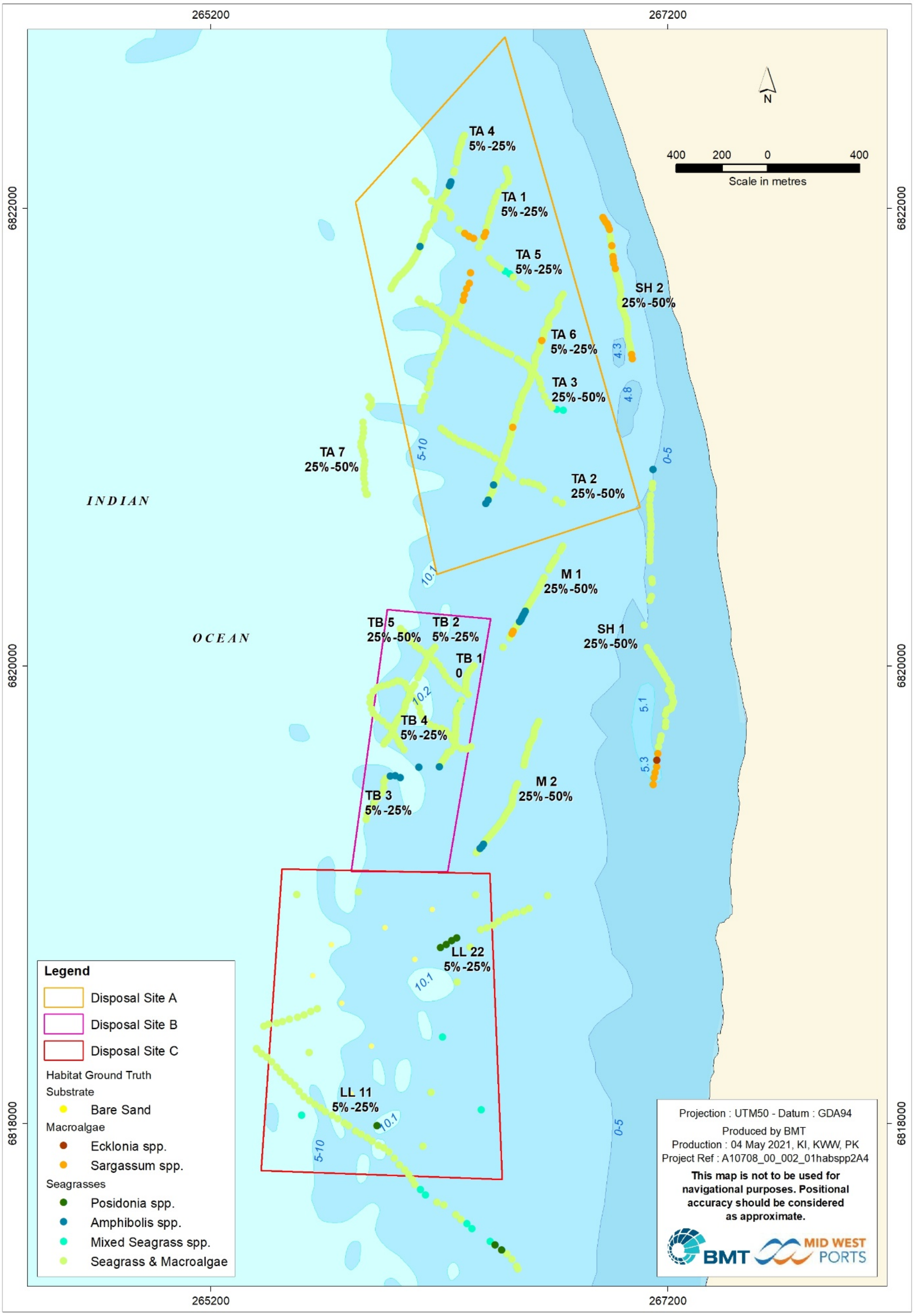


Figure 3-1 Classified benthic habitat tracklog of potential Placement Site A, Placement Site B and adjacent areas, and classified drop down images in potential Placement Site C

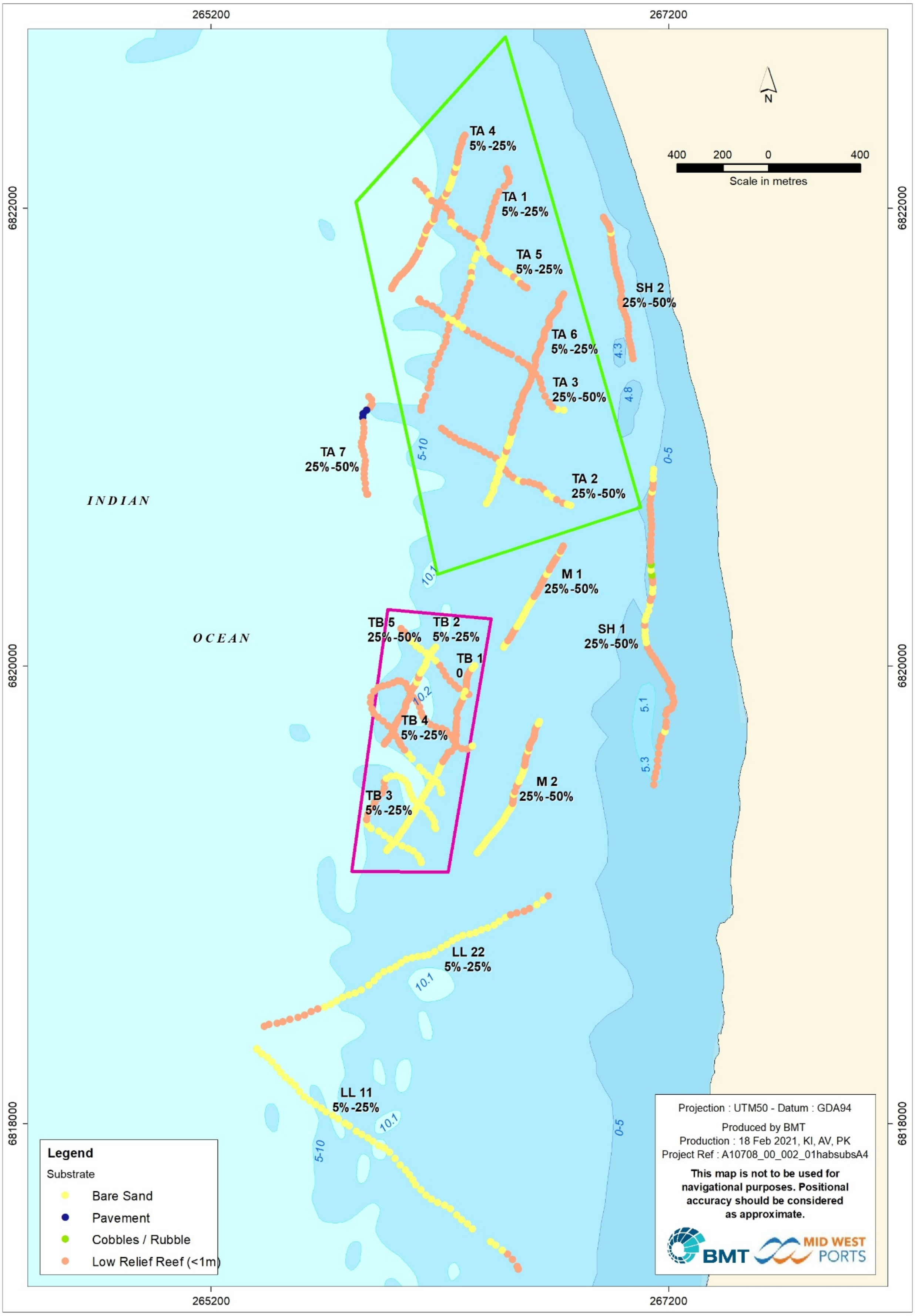
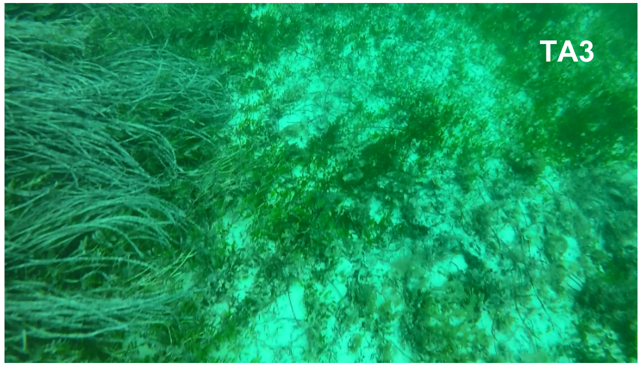
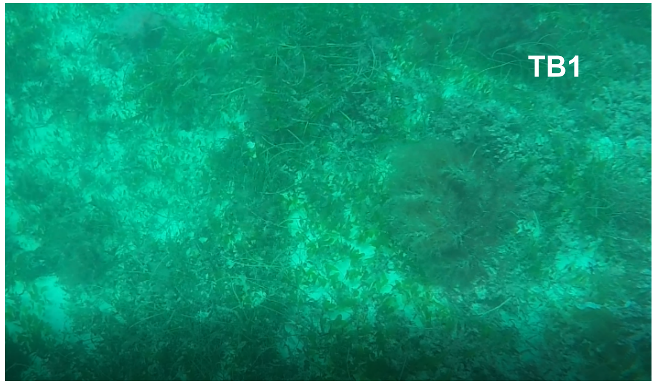
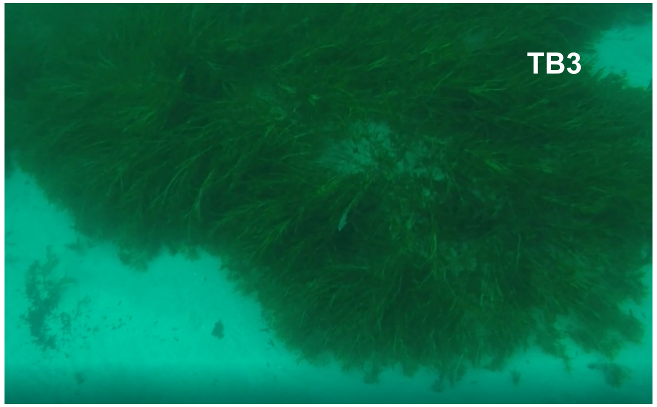


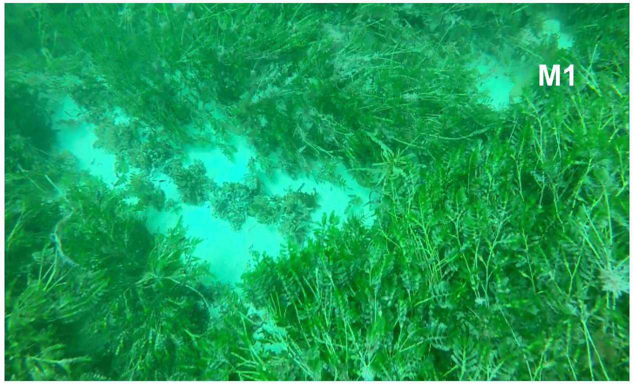
Figure 3-2 Classified benthic substrate tracklog of potential Placement Site A, Placement Site B and adjacent areas

Table 3-1 Benthic habitat classifications in potential Placement Site A, Placement Site B and adjacent areas with example images from towed video footage

Location	Dominant benthic habitat categories	Example images of benthic habitat categories
Within Placement Site A (TA1–TA6)	Bare sand (top left) *A. antarctica*, *A griffithii* (top right), *T. pachyrhizum*, *P. sinuosa* (middle left), *Halophila* spp. (middle right), and *S. isoetifolium* *Sargassum* spp., *Ecklonia* spp., *Padina* spp., and other brown algae (bottom left, bottom right) on low relief reefs (<1 m)	   

Location	Dominant benthic habitat categories	Example images of benthic habitat categories
		 
Adjacent to Placement Site A (TA7, SH2)	*A. antarctica* (top left), *A. griffithii, S. isoetifolium* (top right), and *Halophila* spp. *Sargassum* spp., *Ecklonia* spp., and brown curly macroalgae on low relief reef (<1 m; bottom left, bottom right)	   

Location	Dominant benthic habitat categories	Example images of benthic habitat categories
Within Placement Site B (TB1–TB5)	Bare sand with wrack (top left) *Halophila* spp., (top right), *A. antarctica* (bottom left), *A. griffithii*, *T. pachyrhizum*, and *S. isoetifolium* *Sargassum* spp. (bottom right), *Ecklonia* spp. on low relief reef (<1 m)	   

Location	Dominant benthic habitat categories	Example images of benthic habitat categories
Adjacent to Placement Site B (M1, M2, SH1)	*A. antarctica* (middle left, bottom right), *A. griffithii*, *Halophila* spp. (top left), *S. isoetifolium* (top right), *P. coriacea* (middle right), and *P. sinuosa* *Sargassum* spp., *Dictyopteris* spp., *Ecklonia* spp. (bottom left) on low (<1 m; bottom right) and medium relief reef (1-4 m)	     

Location	Dominant benthic habitat categories	Example images of benthic habitat categories
Other adjacent transects (LL1*, LL2*)	*P. coriacea* (top left), *P. sinuosa* (top right), *A. antarctica*, *S. isoetifolium*, and *Halophila* spp. (bottom left) over bare sand and on low relief reef (<1 m) Low relief reef (<1 m) with mixed macroalgae community (bottom right)	   

Note:
(1) Other adjacent transects LL1 and LL2 form part of Placement Site C

3.2 Benthic habitat of Placement Site C

The benthic habitat of Placement Site C consisted of unconsolidated sediments with few areas of low relief reef (<1 m). Benthic communities were largely dominated by mixed seagrasses and macroalgae (seagrass habitat identified in 62% of captured still images; Figure 3-1; Figure 3-3). The seagrasses identified throughout Placement Site C included *Posidonia sinuosa, Amphibolis antarctica*, *A. griffithii*, *Halophila* spp. and *Syringodium isoetifolium* (Figure 3-3). The macroalgae growing on low relief reefs were *Sargassum* spp., *Ecklonia* spp., *Padina* spp. and other brown and red algae. Dense meadows of *A. antarctica* were recorded in sections of drop-camera images (Figure 3-1) in Placement Site C. Furthermore, *S. isoetifolium* and *Halophila* spp. were present in 38% of all 21 sites analysed in Placement Site C, with dense meadows of both species identified in sections of drop-camera images (Figure 3-1). The sections of bare sand observed throughout Placement Site C were either flat (no profile) or contained small ripples with undulations 1–10 cm (Figure 3-1; Figure 3-3).

Figure 3-3 Drop down camera images of benthic habitat in Placement Site C

3.3 Percent cover

Placement Site A had a slightly greater overall percent cover of seagrass and macroalgae compared to Placement Site B (Table 3-2). There was a moderate percent cover of seagrass (25–50%) on the northern end of Placement Site A and decreased to 5–25% on the southern end (Table 3-2). Areas adjacent to Placement Site A and Placement Site B contained a moderate cover (25–50%) of seagrasses, while macroalgae cover at these locations ranged from some to major cover (5–75%). No seagrass and macroalgal cover were recorded on the southern end of Placement Site B (transect TB1; Table 3-2). The area east of Placement Site B near the shoreline (transect SH2) showed moderate seagrass and major macroalgal cover (Table 3-2). Transects LL1 and LL2 (south of Placement Site B) contained less seagrass and macroalgae cover compared to most of the other transects (Table 3-2).

Table 3-2 Percent cover of seagrass and macroalgae at all transects within potential Placement Site A, B and adjacent areas

Location	Transect	Percent cover of seagrass (%)	Percent cover of macroalgae (%)
Within Placement Site A	TA1	5–25	5–25
	TA2	25–50	25–50
	TA3	25–50	25–50
	TA4	5–25	25–50
	TA5	5–25	25–50
	TA6	5–25	25–50
Adjacent to Placement Site A	TA7	25–50	25–50
	SH2	25–50	25–50
Within Placement Site B	TB1	0	0
	TB2	5–25	25–50
	TB3	5–25	5–25
	TB4	5–25	25–50
	TB5	25–50	25–50
Adjacent to Placement Site B	M1	25–50	5–25
	M2	25–50	5–25
	SH1	25–50	50–75
South of Placement Site B	LL1	5–25	5–25
	LL2	5–25	5–25

3.4 Summary and recommendations

To obtain a better understanding of the seagrass species and population densities located within the potential nearshore placement sites, towed video and drop down camera images of the benthic habitat were collected within and surrounding the placement areas. While Placement Site A was the preferred site for placement of clean marine material, the results show that the site contained a greater diversity of seagrass (total of seven species) and had a slightly greater cover of seagrass and macroalgae than Placement Site B. In Placement Site B, five seagrass species were observed and contained a slightly lower percent of seagrass and macroalgal cover.

Drop down camera images in Placement Site C showed a mixture of seagrass and macroalgae on the southern side while bare sand was more predominant in the northern side of Placement Site C. It is important to note that Placement Site C had a higher presence of colonising seagrass species (*S. isoetifolium* and *Halophila* spp) compared with Placement Sites A and B. In particular, the colonising life history strategy of *Halophila* spp. mean this small-bodied species is relatively short-lived with a fast turnover rate which depends on a viable seed bank in surface sediments to persist. Enhanced deposition owing to the placement of clean marine material in Placement Site C may disrupt the efficacy of this seedbank and negative impact meadow health.

The area south of Placement Site B (LL1 and LL2) also recorded a lower seagrass and macroalgal cover than other adjacent areas. Therefore, it is recommended that of the sites surveyed, Placement Site B, some sections of Placement Site C and areas south of Placement Site B should be considered as the better placement option. It should be noted that the presence of ripples on bare sand which ranged from 10-100 cm in height and orientated south-westerly, are indicative of a dynamic environment where sediments are continually moving towards the coastline. These areas had a moderate to major cover of coloniser seagrass species and macroalgal cover. The sand ripples and accumulated wrack observed indicate that the seafloor of Champion Bay is exposed to considerable wave energy at times, and as a result, the distribution and mass of colonising seagrass species can be expected to be highly variable.

4 References

SeaGIS (2013) TransectMeasure – single camera biological analysis tool. SeaGIS Pty Ltd, Melbourne, Victoria. Available at <http://www.seagis.com.au/transect.html>

Seagrass Watch (2004) Seagrass percent cover standards. Western Pacific Manual for Community (citizen) Monitoring of Seagrass Habitat. Appendix II. Available at <https://www.seagrasswatch.org/wp-content/uploads/Methods/manuals/PDF/Seagrass-Watch%20monitoring%20guidelines%20-%202nd_Ed.pdf>

Appendix B Laboratory results for total suspended solids

Marine and Freshwater Research Laboratory Environmental Science
Tel: 08 93602907 Address: 90 South St, Murdoch, WA, 6150

Accreditation Number: 10603
Accredited for compliance with ISO/IEC 17025 - Testing.
The results of the tests, calibrations and/or measurements included is this document are traceable to Australian/national standards.

NATA WORLD RECOGNISED ACCREDITATION

Murdoch UNIVERSITY

WATER QUALITY DATA

Contact: Karina Inostroza
Customer: BMT
Address: Level 4, 20 Parkland Ave, Osborne Park, WA 6017

Date of Issue: 29/01/2021
Date Received: 21/01/2021
Our Reference: BMT21-6
Your Reference: A10708_002

METHOD SAMPLE CODE	Sampling Date	2540D TSS mg/L
Reporting Limit		**<0.5**
Analysis Date		**22/01/2021**
File		**210122**
FS1_LL1_1	15/01/2021	1.1
FS1_LL1_2	15/01/2021	1.2
FS1_LL1_3	15/01/2021	1.4
FS1_LL1_4	15/01/2021	2.0
FS1_LL1_5	15/01/2021	1.6
FS1_LL2_1	18/01/2021	0.7
FS1_LL2_2	18/01/2021	0.9
FS1_LL2_3	18/01/2021	1.2
FS1_LL2_4	18/01/2021	0.7
FS1_LL2_5	18/01/2021	0.6

Note: For results for compliance purposes uncertainity of measurement (MU) will sometimes affect the interpretation whether the result passes or fails the compliance limit.
Tables for measurement uncertainity are available online at www.mafrl.murdoch.edu.au

Signatory: Jamie Woodward
Date: 29/01/2021

The results only apply to the sample as received and to the sample tested.
Spare test items will be held for two months unless otherwise requested.

Marine and Freshwater
Research Laboratory
Environmental Science
Tel: 08 93602907 Address: 90 South St, Murdoch, WA, 6150

NATA
WORLD RECOGNISED ACCREDITATION

Accreditation Number: 10603
Accredited for compliance with ISO/IEC 17025 - Testing.
The results of the tests, calibrations and/or measurements included is this document are traceable to Australian/national standards.

Murdoch UNIVERSITY

WATER QUALITY DATA

Contact: Karina Inostroza
Customer: BMT
Address: 4/20 Parkland Rd, Osborne Park, 6017

Date of Issue: 8/04/2021
Date Received: 31/03/2021
Our Reference: BMT21-22
Your Reference: A10708_003

METHOD SAMPLE CODE	Sampling Date	5060 Turbidity NTU	2540D TSS mg/L
Reporting Limit		**<0.1**	**<0.5**
Analysis Date **File**		**31/03/2021** **210331**	**31/03/2021** **210331**
FS2_LL1_1	29/03/2021	0.6	1.7
FS2_LL1_2	29/03/2021	0.5	1.5
FS2_LL1_3	29/03/2021	0.8	1.6
FS2_LL1_4	29/03/2021	0.8	1.3
FS2_LL1_5	29/03/2021	0.8	1.6
FS2_LL2_1	29/03/2021	0.6	2.0
FS2_LL2_2	29/03/2021	0.6	1.1
FS2_LL2_3	29/03/2021	0.7	1.5
FS2_LL2_4	29/03/2021	0.6	1.2
FS2_LL2_5	29/03/2021	0.6	1.5

Note: For results for compliance purposes uncertainity of measurement (MU) will sometimes affect the interpretation whether the result passes or fails the compliance limit.
Tables for measurement uncertainity are available online at www.mafrl.murdoch.edu.au

Signatory: Jamie Woodward
Date: 8/04/2021

The results only apply to the sample as received and to the sample tested.
Spare test items will be held for two months unless otherwise requested.

Marine and Freshwater Research Laboratory Environmental Science
Tel: 08 93602907 Address: 90 South St, Murdoch, WA, 6150

NATA WORLD RECOGNISED ACCREDITATION
Accreditation Number: 10603
Accredited for compliance with ISO/IEC 17025 - Testing.
The results of the tests, calibrations and/or measurements included is this document are traceable to Australian/national standards.

Murdoch UNIVERSITY

WATER QUALITY DATA

Contact: Karina Inostroza
Customer: BMT
Address: 4/20 Parkland Road, Osborne Park 6017

Date of Issue: 27/04/2021
Date Received: 21/04/2021
Our Reference: BMT21-26
Your Reference: A10708_003

METHOD SAMPLE CODE	Sampling Date	2540D TSS mg/L
Reporting Limit		**<0.5**
Analysis Date		**22/04/2021**
File		**210422**
FSAD2_LL1_1	19/04/2021	0.9
FSAD2_LL1_2	19/04/2021	1.3
FSAD2_LL1_3	19/04/2021	0.8
FSAD2_LL1_4	19/04/2021	0.9
FSAD2_LL1_5	19/04/2021	1.0
FSAD2_LL2_1	20/04/2021	0.8
FSAD2_LL2_2	20/04/2021	1.0
FSAD2_LL2_3	20/04/2021	0.8
FSAD2_LL2_4	20/04/2021	0.9
FSAD2_LL2_5	20/04/2021	0.9

Note: For results for compliance purposes uncertainity of measurement (MU) will sometimes affect the interpretation whether the result passes or fails the compliance limit.
Tables for measurement uncertainity are available online at www.mafrl.murdoch.edu.au

Signatory: Jamie Woodward
Date: 27/04/2021

The results only apply to the sample as received and to the sample tested.
Spare test items will be held for two months unless otherwise requested.

Marine and Freshwater Research Laboratory Environmental Science
Tel: 08 93602907 Address: 90 South St, Murdoch, WA, 6150

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Murdoch UNIVERSITY

WATER QUALITY DATA

Contact: Karina Inostroza
Customer: BMT
Address: 4/20 Parkland Road, Osborne Park, WA 6017

Date of Issue: 21/05/2021
Date Received: 18/05/2021
Our Reference: BMT21-32
Your Reference: A10708_004

METHOD SAMPLE CODE	Sampling Date	2540D TSS mg/L
Reporting Limit		<0.5
Analysis Date		19/05/2021
File		21051901
FS3_LL1_1	17/05/2021	0.9
FS3_LL1_2	17/05/2021	1.1
FS3_LL1_3	17/05/2021	1.2
FS3_LL1_4	17/05/2021	1.2
FS3_LL1_5	17/05/2021	1.6
FS3_LL2_1	17/05/2021	2.0
FS3_LL2_2	17/05/2021	1.9
FS3_LL2_3	17/05/2021	1.8
FS3_LL2_4	17/05/2021	2.0
FS3_LL2_5	17/05/2021	1.7

Note: For results for compliance purposes uncertainity of measurement (MU) will sometimes affect the interpretation whether the result passes or fails the compliance limit.
Tables for measurement uncertainity are available online at www.mafrl.murdoch.edu.au

Signatory: Vaughan Gregory
Date: 21/05/2021

The results only apply to the sample as received and to the sample tested.
Spare test items will be held for two months unless otherwise requested.

Brisbane	Level 8, 200 Creek Street, Brisbane QLD 4000 PO Box 203, Spring Hill QLD 4004 Tel +61 7 3831 6744 Fax +61 7 3832 3627 Email brisbane@bmtglobal.com Web www.bmt.org
Denver	8200 S. Akron Street, #B120 Centennial, Denver Colorado 80112 USA Tel +1 303 792 9814 Fax +1 303 792 9742 Email denver@bmtglobal.com Web www.bmt.org
London	International House, 1st Floor St Katharine's Way, London E1W 1UN Tel +44 20 8090 1566 Fax +44 20 8943 5347 Email london@bmtglobal.com Web www.bmt.org
Melbourne	Level 5, 99 King Street, Melbourne 3000 Tel +61 3 8620 6100 Fax +61 3 8620 6105 Email melbourne@bmtglobal.com Web www.bmt.org
Newcastle	126 Belford Street, Broadmeadow 2292 PO Box 266, Broadmeadow NSW 2292 Tel +61 2 4940 8882 Fax +61 2 4940 8887 Email newcastle@bmtglobal.com Web www.bmt.org
Northern Rivers	5/20 Byron Street, Bangalow 2479 Tel +61 2 6687 0466 Fax +61 2 66870422 Email northernrivers@bmtglobal.com Web www.bmt.org
Perth	Level 4, 20 Parkland Road, Osborne, WA 6017 PO Box 2305, Churchlands, WA 6918 Tel +61 8 6163 4900 Email perth@bmtglobal.com Web www.bmt.org
Sydney	Suite G2, 13-15 Smail Street, Ultimo, Sydney, NSW, 2007 PO Box 1181, Broadway NSW 2007 Tel +61 2 8960 7755 Fax +61 2 8960 7745 Email sydney@bmtglobal.com Web www.bmt.org
Vancouver	Suite 401, 611 Alexander Street Vancouver, British Columbia V6A 1E1 Canada Tel +1 604 683 5777 Fax +1 604 608 3232 Email vancouver@bmtglobal.com Web www.bmt.org