PORT & COASTAL
SOLUTIONS

Technical Note

Date:	22nd April 2024
To:	Nadene Perry
From:	Andy Symonds, Rachel White
Subject:	Port of Hay Point, 2024 Environmental Thresholds Update
Classification:	Project Related
Version:	0.2

1. Introduction

As part of the Port of Hay Point Sustainable Sediment Management (SSM) assessment the water quality data collected between July 2014 and July 2017 (three years of data) by James Cook University (JCU) as part of the ongoing ambient water quality monitoring at the Ports of Hay Point and Mackay were analysed (RHDHV, 2018). The analysis provided a better understanding of the natural variability in water quality as well as allowing appropriate environmental thresholds for sensitive receptors in the region to be developed for use in adaptive monitoring and management plans. The environmental thresholds were most recently updated by PCS (2021) based on data collected from July 2014 to April 2021 (just under seven years of data).

The aim of this technical note is to provide a further update to the environmental thresholds for the Port of Hay Point so that the additional water quality data collected from April 2021 to January 2024 can be included in the analysis.

1.1. Background

Measured benthic turbidity (and suspended sediment concentration (SSC) when converted from turbidity), benthic photosynthetically active radiation (bPAR) (which indicates benthic light availability) and sedimentation data were analysed as part of the previous assessment at the Port of Hay Point by RHDHV (2018). A literature review was also undertaken to understand the relevant published environmental thresholds based on the sensitive receptors in the region (coral and seagrass) and how these relate to the natural water quality conditions in the region. The measured data showed that the natural conditions at the monitoring sites regularly exceeded the reported coral and seagrass thresholds for bPAR and deposition and as a result of this and difficulties in monitoring (there are reliability concerns relating to sedimentation data) and applying responsive management actions (bPAR thresholds typically relate to 7 or 14 day rolling averages which are not conducive to shorter term management actions) these parameters were not recommended for use in adaptive monitoring and management plans.

Published information on SSC/turbidity thresholds suggested that continuous exposure below 15-20 mg/l was likely to have no impact on coastal benthic communities such as those found in the Hay Point region (GBRMPA Water Quality Guidelines, 2010; Erftemeijer *et al.*, 2012). The measured data showed that an SSC intensity threshold of 15 mg/l would be appropriate at offshore coral locations such as Round Top Island which has lower SSC/turbidity than the other inshore sites, but would be too low for other inshore areas (RHDHV, 2018). Based on this, the percentile that 15 mg/l was equivalent to at Round Top Island was calculated for the wet and dry seasons and this same percentile was adopted as the intensity thresholds for the other monitoring sites. Consistently applying set percentile values for the wet and dry season across the monitoring sites enables a comparable interpretation of natural SSC/turbidity and dredge related changes in intensity and duration between sites. This intensity threshold was then adopted as part of a statistical intensity, duration and frequency (IDF) analysis to determine the duration of time that natural events have exceeded the SSC/turbidity threshold over the duration of the measured data. The update to the SSC/turbidity thresholds undertaken by PCS (2021) adopted the same percentile and IDF approach as the initial analysis by RHDHV (2018).

Out of the seven ambient water quality monitoring sites in the Hay Point and Mackay region, four sites were identified by RHDHV (2018) as adaptive management monitoring sites. The sites were:

- Round Top Island (Trigger Site): this is the sensitive receptor most likely to experience minor increases in SSC due to maintenance dredging at the Port of Hay Point and placement at the Hay Point dredge material placement area (DMPA). This site is more likely to experience minor increases in SSC due to the dredging during southerly wind conditions;
- Victor Island (Trigger Site): this is a sensitive receptor to the south of Hay Point and also the closest sensitive receptor to Half Tide Tug Harbour (HTTH). This site was identified as being a location which could experience minor increases in SSC due to maintenance dredging during northerly wind conditions;
- Freshwater Point (Control Site): this is an existing monitoring site which is not predicted to experience increases in SSC due to maintenance dredging and is located to the south of Hay Point; and
- Slade Islet (Control Site): this is an existing monitoring site which is unlikely to experience increases in SSC due to maintenance dredging at the Port of Hay Point.

These sites were used as monitoring sites for applying duration triggers for adaptive management during maintenance dredging in 2019 at the Port of Hay Point (PCS, 2019a). For reference the SSC/turbidity thresholds updated by PCS (2021) at these four sites based on measured data from July 2014 to April 2021 are shown in Table 1 based on a 20 day dredge duration.

Table 1. SSC/NTUe intensity and duration triggers developed by PCS (2021) based on data from July 2014 to April 2021 at the four monitoring sites around the Port of Hay Point, based on a 20 day period.

Site	Intensity (mg/l)	Intensity (NTUe)	Average Duration (hours)	90th Percentile Duration (hours)	Maximum Duration (hours)
Wet Season (91st percentile data)					
Slade Islet	53	45	43	120	248
Round Top Island	15	11	43	138	298
Victor Island	52	36	43	103	314
Freshwater Point	52	66	43	125	294
Dry Season (97th percentile data)					
Slade Islet	41	34	14	45	98
Round Top Island	16	12	14	51	103
Victor Island	40	28	14	55	106
Freshwater Point	41	52	14	41	271

PORT & COASTAL SOLUTIONS

2. Measured Data

JCU has been carrying out NQBP's ongoing ambient marine water quality monitoring around the coastal waters of the Ports of Hay Point and Mackay since July 2014. As part of the program, water quality sensors were deployed at seven locations (Figure 1 and Table 2), with each sensor returning data measured close to the seabed (i.e. benthic) on turbidity, benthic light (bPAR) and deposition at a ten-minute temporal resolution. As previously noted, four of the measurement locations were adopted as monitoring sites for adaptive management during the 2019 maintenance dredging at the Port of Hay Point. The focus of this technical note is on the data collected at the four adaptive management monitoring sites, although some high-level statistical analysis of the data collected at the other sites are included for reference.

Data from 2014 to 2017 was previously quality checked for use in an assessment of environmental thresholds for the Port of Hay Point (RHDHV, 2018), while data from 2017 to 2021 was quality checked for use in an extension to this assessment (PCS, 2021). The data collected pre-April 2021 is based on the dataset (including any modelled values) used by PCS (2021) for consistency with these earlier studies. The present study extends the period of data analysis to January 2024. The monitoring at the three sites not used for adaptive management was stopped in 2020/21, while the monitoring at the four adaptive management sites is ongoing.

A summary of the water quality data sites and periods of data availability is given in Table 2. Prior to being analysed as part of this assessment, any periods where the natural water quality conditions resulted in impacts to sensitive receptors (e.g. TC Debbie which resulted in a reduction in coral cover) or when anthropogenic activity could have resulted in local changes to water quality (e.g. at the monitoring sites closest to each Port during the 2019 Port of Hay Point and the 2020 Port of Mackay maintenance dredging programs) were removed from the measured data to ensure that it represented natural conditions which have not resulted in negative impacts to the sensitive receptors.

The data return for each instrument has been calculated and the results are presented in Table 3 and the periods of data return for SSC/turbidity are also shown graphically in Figure 2. The data return for SSC/turbidity at individual sites was between 32% and 76% during the wet season (November to April inclusive) and 54% to 84% during the dry season (May to October inclusive). The longest duration datasets are available at Victor Island and Freshwater Point, with SSC/turbidity data returns of between 71% and 84%. The data returns at Slade Islet and Round Top Island are lower, with returns of 64% and 72% during the wet and dry seasons at Slade Islet and 57% and 73% during the wet and dry seasons at Round Top Island. Based on these data returns there is a significant amount of data available for site characterisation with between 2,265 days (Round Top Island) and 2,777 days (Victor Island) available at the four adaptive management monitoring sites. The data returns for bPAR and deposition also varied with site, with the data return for bPAR generally slightly higher than the data return for turbidity, while the data return for deposition was lower.

Table 2. Summary of water quality data used in this study.

Site Name	TropWater Site ID	Latitude	Longitude	Period
Freshwater Point	AMB1	-21.42	149.34	Jul 2014 to Jan 2024
Hay Point/Reef	AMB2	-21.26	149.30	Jul 2014 to Sep 2020
Round Top Island	AMB3	-21.17	149.26	Jul 2014 to Jan 2024
Slade Islet	AMB5	-21.09	149.24	Jul 2014 to Jan 2024
Spoil Grounds	AMB8	-21.18	149.30	Jul 2015 to Jan 2021
Victor Island	AMB10	-21.32	149.32	Jul 2014 to Jan 2024
Keswick Island	AMB12	-20.93	149.42	Oct 2014 to Sep 2020

Table 3. Summary of data return at water quality monitoring stations.

Site Name	SSC/Turbidity				bPAR		Deposition Rates	
	Days of data		Percentage return		Percentage return		Percentage return	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Freshwater Point	1269	1412	71	83	85	87	46	49
Hay Point/Reef	401	764	32	62	31	62	38	54
Round Top Island	1013	1252	57	73	65	76	41	53
Slade Islet	1132	1229	64	72	72	84	42	51
Spoil Grounds	632	660	50	54	57	56	45	54
Victor Island	1347	1430	76	84	81	83	48	50
Keswick Island	856	700	68	57	65	68	64	56

** Percentage return quantified as the percentage of time readings were obtained between 5 July 2014 and 13 April 2021 (which is 1,251 wet season dats and 1,223 dry season days) for the non-adaptive monitoring sites and 5 July 2014 to 16 January 2024 (which is 1,775 wet season days and 1,708 dry season days) for the adaptive monitoring sites.*

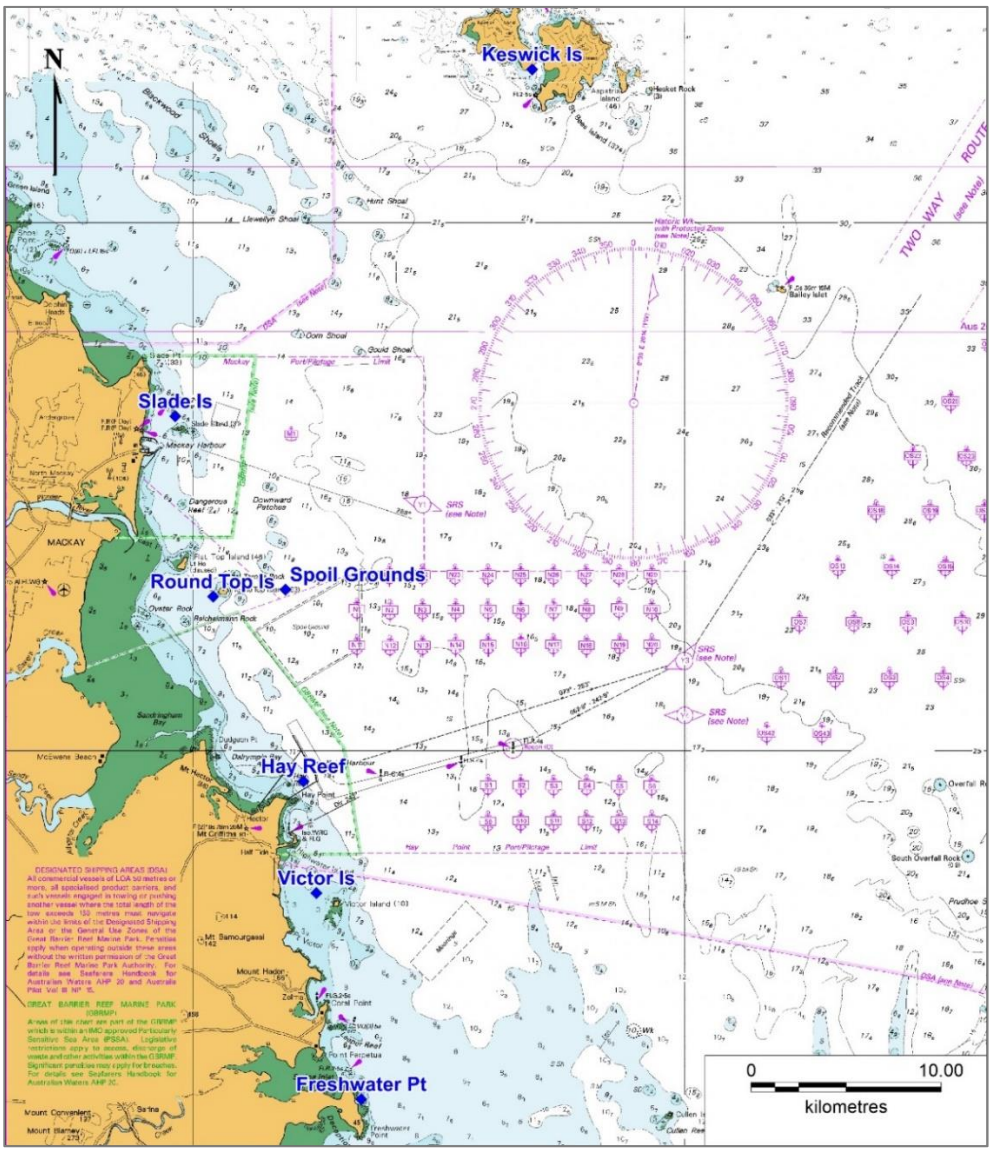

Figure 1. Location map of the water quality monitoring sites.

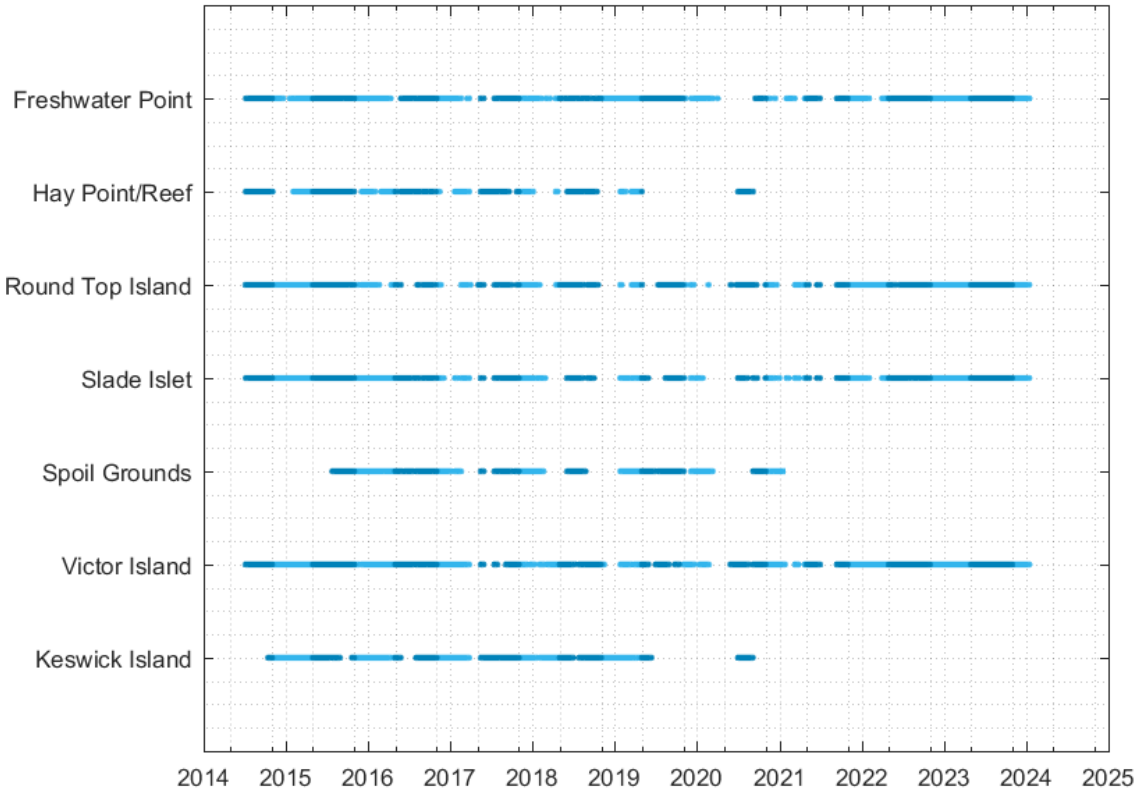

Figure 2. Periods of data return for turbidity. *Note: wet season shown as lighter colour, dry season as darker colour.*

The JCU turbidity loggers use 180 degree backscatter to measure turbidity. The international turbidity standard ISO7027 defines turbidity readings in Nephelometric Turbidity Unit (NTU) only for 90 degree scatter. However, the JCU instrumentation uses 180 degree backscatter as it allows for much more effective cleaning which is critical to avoid issues with bio-fouling during long deployment periods. Because particle size influences the angular scattering functions of incident light (Ludwig and Hanes 1990; Conner and De Visser 1992; Wolanski *et al.*, 1994; Bunt *et al.*, 1999) instruments using different scattering angles can give different measurements of turbidity (in NTU). In acknowledgement of this fact, the readings analysed in this study are referred to in units of NTU equivalent (NTUe), with the IDF analysis being performed directly on the turbidity data measured in NTUe.

To enable comparison of management triggers relative to published environmental thresholds which are typically given in SSC, conversion factors between SSC and NTUe were derived by JCU (2022). The conversion factors vary between the sites and were calculated based on laboratory testing by JCU using sediment samples collected at each monitoring site. The conversion factors have been updated by JCU over the duration of the monitoring, with a significant change in the conversion factors at the four adaptive management sites occurring in 2021. The conversion factors from 2014 to 2021 and 2021 to 2024 along with a time-weighted average over the whole period are shown in Table 4. The time-weighted average conversion factors have been adopted for this assessment to convert the measured NTUe to SSC. This is representative of adopting the 2014 to 2021 conversion factor for all data collected over this period and adopting the 2021 to 2024 conversion factor for all data collected over this period.

Timeseries of the measured turbidity data at the trigger sites of Round Top Island and Victor Island along with measured wave conditions from the Hay Point waverider buoy (WRB) are shown for the whole measurement period in Figure 3. In addition, the measured turbidity data at the same two sites along with the measured wave data and predicted water levels are shown for 2023 in Figure 4. The plots show that the turbidity is highly variable over time, with periods of elevated turbidity of more than 100 NTUe as well as prolonged periods of low turbidity when it remains below 25 NTUe. The 2023 plots show that the peaks in turbidity correlate with peaks in wave height at both sites, showing that the waves are the

dominant driver resulting in natural resuspension of bed sediment in the region. The astronomical tide can also influence the turbidity, with higher turbidity during spring tides compared with neap tides, but the relative influence is much lower than waves. In addition, the turbidity is typically lower during the dry season due to the calmer wave conditions over this period.

Table 4. Conversion factors between turbidity and SSC at each site.

Site Name	Conversion Factor (NTUe to mg/l): 2014 to 2021	Conversion Factor (NTUe to mg/l): 2021 to 2024	Conversion Factor (NTUe to mg/l): Time Weighted Average
Freshwater Point	**0.80**	**1.90**	**1.09**
Hay Point/Reef	1.24	-	1.24
Round Top Island	**1.32**	**1.68**	**1.41**
Slade Islet	**1.20**	**1.69**	**1.33**
Spoil Grounds	2.03	-	2.03
Victor Island	**1.46**	**1.90**	**1.58**
Keswick Island	1.49	-	1.49

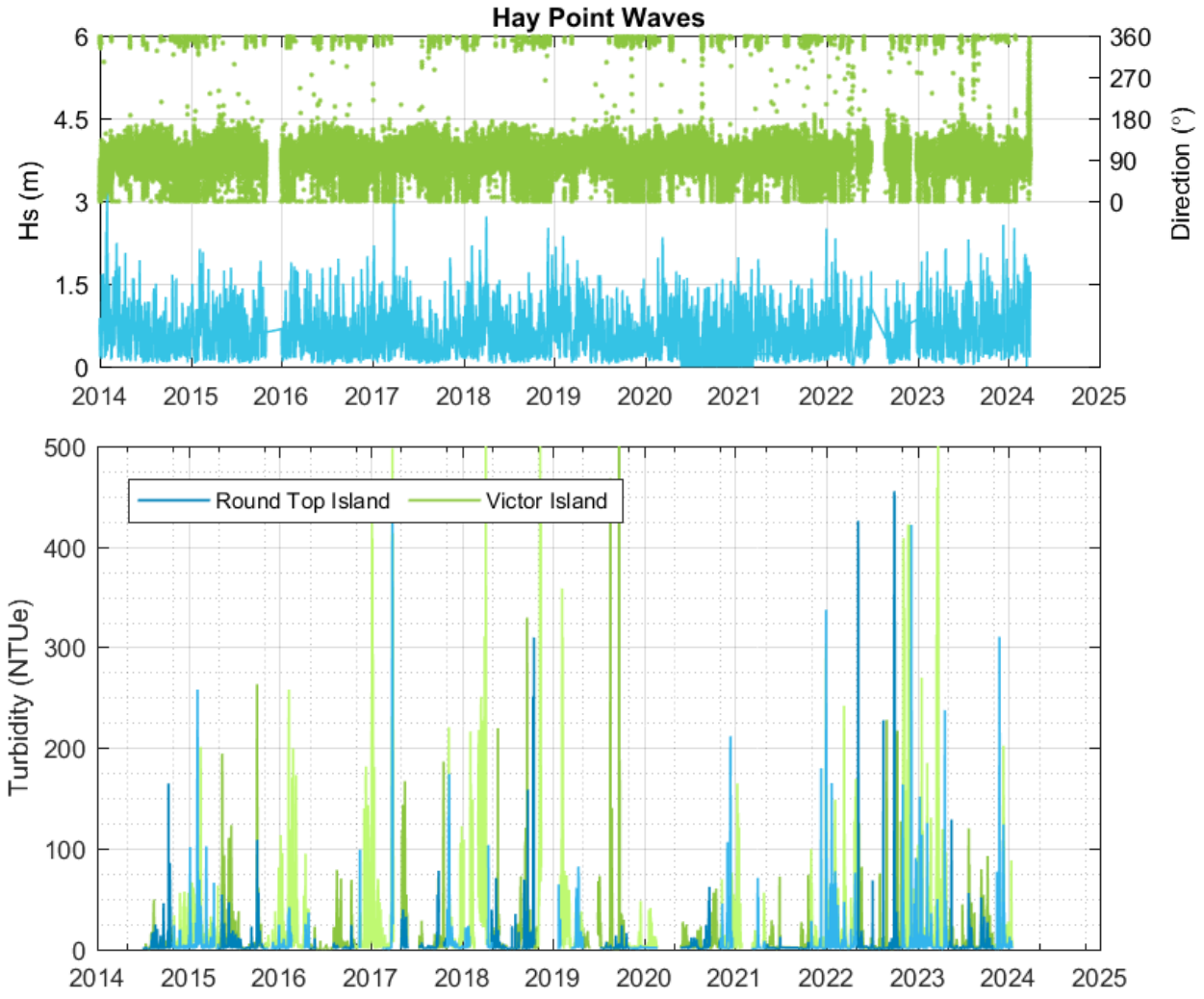

Figure 3. Timeseries of wave conditions (top) and all available turbidity data at Round Top Island and Victor Island (bottom). *Note: wet season shown as lighter colour, dry season as darker colour.*

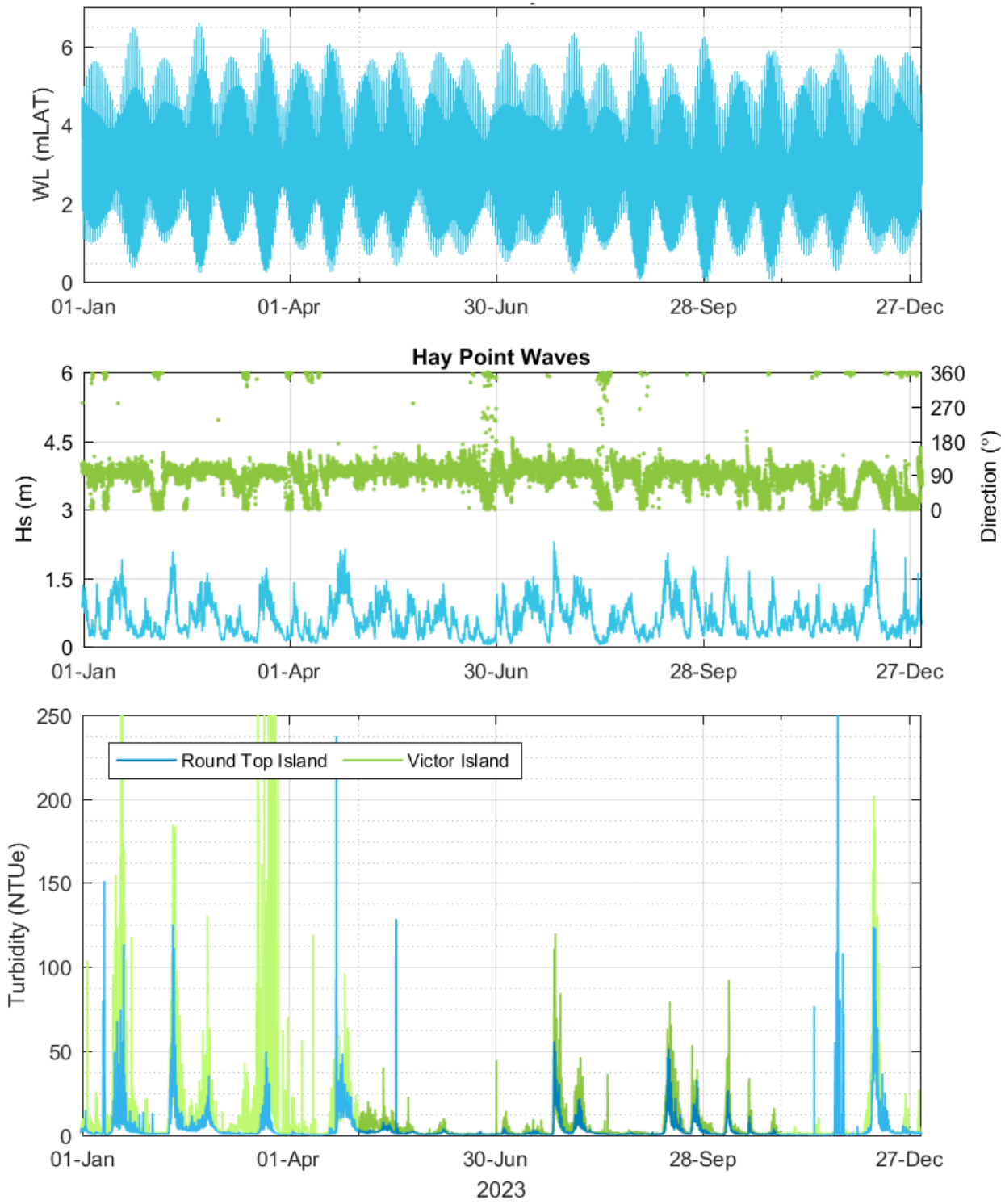

Figure 4. **Timeseries of water level, (top), wave conditions (middle) and turbidity data at Round Top Island and Victor Island (bottom) measured in 2023.** *Note: wet season shown as lighter colour, dry season as darker colour.*

PORT & COASTAL
SOLUTIONS

3. Ecological Thresholds

Ecological thresholds refer to the point at which changes or disturbance in external conditions can cause a rapid change in an organism or habitat, noted as tolerance limits of a particular receptor. When these points of tolerance have been exceeded, potentially irreversible impacts can occur. In the marine environment, where activities such as dredging or disposal can cause changes to water quality parameters, thresholds are generally expressed as concentrations, levels or rates, or calculated as an intensity, duration and frequency over relative periods of time.

To ensure that ecological thresholds are not exceeded during dredging operations, water quality management triggers can be adopted. Trigger values are typically defined at a precautionary level below ecological thresholds to account for the potential delay between exceedance occurring and a response (i.e. management measures), thus reducing the risk to habitats from a degradation of water quality conditions.

A thorough review of relevant literature was undertaken by RHDHV (2018) to provide an overview of threshold values relevant to the receptors at the Port of Hay Point. This information has not been duplicated here, but for further detail on relevant literature thresholds and justification for the approach adopted in this study please refer to RHDHV (2018).

The measured water quality data from July 2014 to January 2024 (or for the full duration of the dataset for the sites where monitoring has now ceased) at all monitoring sites have been processed to calculate percentiles for turbidity, bPAR and deposition data (Table 5 to Table 7). The results show that water quality varies spatially between the sites and temporally between the wet and dry seasons.

PORT & COASTAL SOLUTIONS

Table 5. Benthic turbidity percentiles for the Ports of Hay Point and Mackay monitoring sites.

Site	Percentile Turbidity Intensity (NTUe)					Data Duration (days)	15 mg/l in NTU
	50th	80th	90th	95th	99th		
Wet Season							
Freshwater Point	6.6	29.8	55.6	88.9	211.8	1269	13.8
Hay Point/Reef	4.5	17.2	33.3	55.4	130.1	401	12.1
Round Top Island	0.9	4.6	10.7	19	51	1013	10.6
Slade Islet	3.8	21.9	40.2	63.7	160.7	1132	11.3
Spoil Grounds	1.4	6.9	18.3	49.1	175.4	632	7.4
Victor Island	3.7	17.8	33.2	54.8	171.9	1347	9.5
Keswick Island	0.8	1.9	5.2	32.1	198.5	856	10.1
Dry Season							
Freshwater Point	2.5	9.2	18.1	31.1	79.6	1412	13.8
Hay Point/Reef	2	6.8	13.9	22.7	52.4	764	12.1
Round Top Island	0.6	1.9	4.2	7.9	22.2	1252	10.6
Slade Islet	1	4.8	11.9	22.1	54.4	1229	11.3
Spoil Grounds	0.8	2.5	5.2	9.5	72.3	660	7.4
Victor Island	1.6	5.4	10.4	18.1	45.6	1430	9.5
Keswick Island	0.6	1.2	1.9	3.6	24.4	700	10.1
All Data							
Freshwater Point	3.8	17.2	35.9	61	152.5	2681	13.8
Hay Point/Reef	2.5	10.1	20	34.2	87.5	1165	12.1
Round Top Island	0.7	2.8	6.8	13	36.9	2265	10.6
Slade Islet	1.8	11.4	26.7	43.9	112.4	2361	11.3
Spoil Grounds	1	4.2	9.7	25.7	133.1	1291	7.4
Victor Island	2.3	10	21.8	36.4	110.4	2778	9.5
Keswick Island	0.7	1.5	3.1	10.9	142.5	1555	10.1

PORT & COASTAL SOLUTIONS

Table 6. bPAR percentiles for the Ports of Hay Point and Mackay monitoring sites.

Site	Percentile PAR Intensity (mol photons/m^2/day)						Data Duration (days)
	1st	5th	10th	20th	50th	80th	
Wet Season							
Freshwater Point	8.1	4	2.8	1.8	0.4	0	1512
Hay Point/Reef	3.4	2.3	1.6	0.9	0.2	0	382
Round Top Island	10.1	7.3	5.8	4	1.4	0.2	1151
Slade Islet	7.9	5.7	4.6	2.9	0.8	0	1281
Spoil Grounds	4.2	2.7	2.1	1.3	0.4	0	708
Victor Island	11.9	7	5	3.3	0.9	0.1	1441
Keswick Island	8.4	6.6	5.6	4.4	2.3	0.9	820
Dry Season							
Freshwater Point	14.4	6.3	4.7	3.1	1	0.1	1482
Hay Point/Reef	6.2	3.4	2.5	1.7	0.6	0.1	756
Round Top Island	10.7	8.3	6.8	4.8	2.3	0.7	1301
Slade Islet	8.4	6.5	5.4	4.1	1.8	0.3	1428
Spoil Grounds	8.3	4.3	3.3	2	0.7	0.2	684
Victor Island	14.8	7.2	5.6	4.5	2.2	0.5	1420
Keswick Island	6.6	4.5	3.7	3	1.6	0.6	827
All Data							
Freshwater Point	10.3	5.3	3.8	2.4	0.7	0	2994
Hay Point/Reef	5.6	3	2.2	1.4	0.5	0	1138
Round Top Island	10.2	7.9	6.4	4.4	1.9	0.4	2452
Slade Islet	8.1	6.2	5	3.8	1.2	0.1	2709
Spoil Grounds	7.1	3.7	2.6	1.6	0.6	0.1	1392
Victor Island	13.2	7.1	5.4	3.9	1.6	0.3	2861
Keswick Island	8	5.8	4.7	3.6	1.9	0.7	1647

Table 7. Deposition rate percentiles for the Ports of Hay Point and Mackay monitoring sites.

Site	Percentile Deposition rate Intensity (mg/cm²/day)					Data Duration (days)
	50th	80th	90th	95th	99th	
Wet Season						
Freshwater Point	1.9	8	15.8	30	76.2	824
Hay Point/Reef	2.4	9.6	17.8	26.4	88.5	471
Round Top Island	1	6.9	13.6	21.7	77.8	726
Slade Islet	1.8	8	15	30	77.4	750
Spoil Grounds	1	3.5	7.4	12.4	59	629
Victor Island	2	8.5	22.3	41.9	475.3	846
Keswick Island	5.9	16.7	26.4	37	93.2	800
Dry Season						
Freshwater Point	2.5	11.2	22.5	35	72	837
Hay Point/Reef	1	3.6	6.3	9.6	51	661
Round Top Island	0.8	4.3	14.5	31.9	100.9	903
Slade Islet	1.7	6.9	14.4	34.3	88.9	864
Spoil Grounds	1.1	6.5	16.3	31.3	74.4	660
Victor Island	1.2	4.8	9.5	16.1	35.8	857
Keswick Island	2.5	7.5	13.5	17.3	34.6	686
All Data						
Freshwater Point	2.2	9.4	19.3	33.2	73.7	1661
Hay Point/Reef	1.5	5.7	10.3	18	70.8	1132
Round Top Island	0.9	5.4	14	26.9	89.8	1629
Slade Islet	1.8	7.5	14.6	32.9	88.4	1614
Spoil Grounds	1.1	4.8	10.7	24.2	69.1	1289
Victor Island	1.6	6.3	14	29.4	122.2	1703
Keswick Island	4	12.9	20.4	29.1	61.8	1486

Note: deposition data collection ceased in July 2021.

As previously noted in Section 1.1, the bPAR and deposition data were not recommended for use in adaptive monitoring and management plans, while the SSC/turbidity data were recommended (RHDHV, 2018). Therefore, the subsequent analysis presented in this technical note has been undertaken on the SSC/turbidity data collected at the four adaptive management monitoring sites at the Port of Hay Point (Round Top Island, Victor Island, Freshwater Point and Slade Islet).

A comparison of turbidity[1] percentiles based on three years of data (RHDHV, 2018), five years of data (PCS, 2019a), just under seven years of data (PCS, 2021) and nine and a half years of data at the four adaptive management monitoring sites is given in Table 8. This shows how the turbidity percentiles have changed over time due to the additional measured data and to give context as to how the updated triggers derived as part of this assessment may differ from previously developed triggers at the Port. The results show a gradual reduction in the turbidity percentiles as the record duration increases. This suggests that the turbidity from 2014 to 2017 was above average at the monitoring sites.

The reduction in turbidity percentiles is most notable at Freshwater Point where the 90th, 95th and 99th percentiles were almost halved when the dataset was extended from three years to nine and a half years. The reductions in turbidity percentiles at the two trigger sites (Round Top Island and Victor Island) were smaller than at Freshwater Point, with reductions to the 90th and 95th percentile turbidity ranging from 15% to 25% when the dataset was extended from three years to nine and a half years.

[1] These turbidity percentiles can be converted to SSC using the average conversion ratios detailed in Table 4.

Table 8. Comparison between benthic turbidity percentiles based on three, five, seven and nine and a half years of data.

Site	Turbidity Statistic (NTU)					Data Duration (days)
	Median	80th	90th	95th	99th	
RHDHV (2018) analysis (July 2014 to July 2017)						
Slade Islet	3.8	19.3	35.4	55.5	173.6	953
Round Top Island	0.9	3.9	9.2	15.3	38.0	802
Victor Island	3.4	14.0	27.7	45.5	142.7	957
Freshwater Point	4.4	26.6	60.8	112.0	272.9	973
PCS (2019a) analysis (July 2014 to July 2019)						
Slade Islet	2.6	17.0	32.9	50.7	130.9	1247
Round Top Island	0.8	3.3	7.4	12.8	33.8	1058
Victor Island	3.0	13.7	27.0	42.2	110.9	1408
Freshwater Point	3.9	22.3	44.3	72.9	174.0	1498
PCS (2021) (July 2014 to April 2021)						
Slade Islet	2.1	13.2	28.9	45.3	117.3	1583
Round Top Island	0.8	2.9	6.6	12.3	33.1	1420
Victor Island	2.6	11.2	23.5	37.3	101.2	1853
Freshwater Point	3.9	20.9	41.6	68.8	166.3	1813
Updated (July 2014 to Jan 2024)						
Slade Islet	1.8	11.4	26.7	43.9	112.4	2361
Round Top Island	0.7	2.8	6.8	13.0	36.9	2264
Victor Island	2.3	10.0	21.8	36.4	110.4	2778
Freshwater Point	3.8	17.2	35.9	61.0	152.4	2681

Results from the percentile analysis showed that at Round Top Island the 15 mg/l SSC intensity threshold was equivalent to a 90th percentile (previously 91st percentile) SSC/turbidity for the wet season and a 97th percentile (unchanged) SSC/turbidity for the dry season. These percentiles have been adopted as an SSC/turbidity intensity threshold and used to define site specific turbidity intensity and duration triggers which can be adopted for future maintenance dredging programs to ensure the SSC/turbidity remains within the natural range.

As the proposed 90th and 97th percentile turbidity/SSC intensity thresholds are on average only naturally exceeded for 10% and 3% of the time, they can be considered to be representative of a threshold for short duration acute impacts due to high turbidity/SSC, as opposed to longer duration chronic impacts due to prolonged periods of lower SSC.

The trigger development approach is based around the assumption that as long as the turbidity remains within the natural range, then the dredging will not have contributed to potential impacts. To allow adaptive management to be effective, it is important to define a range of triggers based on IDF analysis which consider discrete periods of time related to the likely range of durations of future dredging programs. For the previous Port of Hay Point thresholds analysis durations of 20 days and 40 days were adopted as these were approximately representative of the duration for 200,000 and 400,000 m^3 maintenance dredging programs (RHDHV, 2018). These same durations are still considered to be applicable and have been adopted for this update of the Port of Hay Point thresholds analysis.

Different duration thresholds are required to represent the limits/triggers when different management actions would be adopted. The duration thresholds have been defined in the same way as for the previous Port of Hay Point thresholds analysis. Details of how the duration thresholds have been defined are provided below using the 97th percentile turbidity intensity (dry season) as an example:

- average cumulative duration (as time in hours) that conditions exceed the 97th percentile turbidity (i.e. 3% of the time);
- the 90th percentile of all the cumulative durations (as time in hours) that conditions exceed the 97th percentile turbidity for the dry season, over typical periods equivalent to the dredge duration (20 days and 40 days). This provides an indication of a known duration that turbidity intensity limits have naturally exceeded over a period of time without resulting in known impacts to local receptors; and
- the maximum cumulative duration (as time in hours) that conditions exceed the 97th percentile turbidity for the dry season, over typical periods equivalent to the dredge duration (20 days and 40 days). This provides an indication of the maximum duration that intensity limits have naturally been exceeded over a period of time without resulting in known impacts to local receptors. Therefore, if these conditions are exceeded there is a potential that impacts to coral or seagrass could occur.

The duration limits/triggers which have been calculated consider both the intensity and duration of the natural conditions at the sites. The calculated IDF results for the NTUe (and SSC) data measured at the four monitoring sites during the wet and dry seasons are presented in Table 9 and Table 10. The results provide the basis for potential trigger limits if adaptive monitoring is required and have been defined over a 20 day and 40 day period (relevant to potential dredging program durations).

Table 9. Suggested SSC/NTUe intensity and duration triggers at the four monitoring sites around the Port of Hay Point, based on a 20 day period.

Site	Intensity (mg/l)	Intensity (NTUe)	Average Duration (hours)	90th Percentile Duration (hours)	Maximum Duration (hours)
Wet Season (90th percentile data)					
Slade Islet	53	40	48	137	258
Round Top Island	15	11	48	125	303
Victor Island	52	33	48	111	369
Freshwater Point	61	56	48	120	314
Dry Season (97th percentile data)					
Slade Islet	42	31	14	52	102
Round Top Island	16	12	14	55	114
Victor Island	39	25	14	45	128
Freshwater Point	47	43	14	31	313

PORT & COASTAL SOLUTIONS

Table 10. Suggested SSC/NTUe intensity and duration triggers at the four monitoring sites around the Port of Hay Point, based on a 40 day period.

Site	Intensity (mg/l)	Intensity (NTUe)	Average Duration (hours)	90th Percentile Duration (hours)	Maximum Duration (hours)
Wet Season (90th percentile data)					
Slade Islet	53	40	96	236	382
Round Top Island	15	11	96	198	347
Victor Island	52	33	96	186	547
Freshwater Point	61	56	96	230	520
Dry Season (97th percentile data)					
Slade Islet	42	31	29	89	196
Round Top Island	16	12	29	79	121
Victor Island	39	25	29	71	228
Freshwater Point	47	43	29	42	318

PORT & COASTAL SOLUTIONS

4. Adaptive Monitoring

For adaptive monitoring it is necessary to obtain real-time observations over the duration of a maintenance dredging program as well as pre- and post dredge periods. For the 2019 maintenance dredging program at the Port of Hay Point real-time surface turbidity monitoring was undertaken for the adaptive monitoring rather than benthic turbidity monitoring to reduce the risk of data loss and increase the confidence in the data (PCS, 2019b).

During the 2019 Port of Hay Point dredging program concurrent surface and benthic turbidity data were collected at the four adaptive management monitoring sites over the pre-, during and post-dredge periods (approximately three months from the start of March to the end of May, with two months of no dredging). The monitoring showed comparable benthic and surface turbidity during periods of low turbidity, while during periods with elevated turbidity the benthic turbidity became higher than the surface turbidity, with the magnitude of the difference increasing with turbidity (PCS, 2019a).

The concurrent surface and benthic turbidity data over the pre-, during and post-dredge periods were subsequently analysed to determine the surface turbidity intensity thresholds required for the duration exceedances to align with the benthic turbidity data over the entire pre-, during and post-dredge monitoring period (PCS, 2019a). Through this analysis site specific surface to benthic turbidity scaling factors were developed, these are presented in Table 11. The fact that the turbidity has not changed significantly at any of the four sites between the 2019 data analysis and the most recent analysis detailed in this technical note (see Table 8) indicates that the benthic environment at the sites has not changed and as a result it is expected that the surface to benthic turbidity scaling will not have changed significantly. Therefore, the 2019 scaling factors can be used to define updated surface turbidity intensity thresholds, these are shown in Table 11. These should be approximately equivalent to the wet season and dry season benthic turbidity intensity thresholds detailed in Table 9 and Table 10.

If surface turbidity measurements are utilised for adaptive management during future maintenance dredging programs at the Port of Hay Point it is recommended that the surface turbidity thresholds detailed in Table 11 are adopted. The duration that the surface turbidity thresholds are exceeded should also be checked with the benthic turbidity data during the monitoring period.

It is important to note that due to consistent strong winds during the 2019 maintenance dredging program at the Port of Hay Point, the 90th percentile duration trigger was exceeded at Round Top Island (PCS, 2019a). Analysis of the benthic and surface turbidity data, the metocean conditions and dredge logs showed that this was predominantly due to the natural conditions as opposed to maintenance dredging activity. Despite this, NQBP adopted a precautionary approach and applied adaptive management measures. This highlights how the natural turbidity conditions during dredge programs can result in exceedances of the specified duration triggers and this is important to consider when determining what, if any, adaptive management measures are required following a duration trigger exceedance.

Further details as to how the duration triggers defined in this study could be adopted as part of an adaptive management approach is provided in the Port of Hay Point Environmental Monitoring and Management Plan (EcoLogical, 2018).

Table 11. Equivalent surface turbidity intensity threshold values based on scaling between surface and benthic measurements obtained during the 2019 maintenance dredging program.

Location	Surface to Benthic Scaling Factor	Wet Season Surface Turbidity Intensity Threshold (NTUe)	Dry Season Surface Turbidity Intensity Threshold (NTUe)
Freshwater Point	3.2	17	13
Round Top Island	1.8	6	6
Slade Islet	5.6	7	6
Victor Island	2.7	12	9

PORT & COASTAL
SOLUTIONS

5. Summary

This technical note has provided an update to the environmental thresholds assessment for the Port of Hay Point which were defined by RHDHV (2018) and most recently updated by PCS (2021). The original assessment was based on three years of measured data, while the update presented in this note is based on nine and a half years of measured data. This update therefore ensures that the environmental thresholds defined for the Port of Hay Point are based on as much measured data as possible.

A statistical IDF analysis of the measured SSC/NTUe data from July 2014 to January 2024 has been undertaken and updated intensity and duration triggers at the four adaptive management monitoring sites for the Port of Hay Point have been defined (see Table 9 and Table 10).

PORT & COASTAL
SOLUTIONS

6. References

Bunt, J., Larcombe, P. and Jago, C. F., 1999. Quantifying the response of optical backscatter devices and transmissometers to variations in suspended particulate matter (SPM). Continental Shelf Research 19: 1199-1220.

Conner, C. S. and De Visser, A. M., 1992. A laboratory investigation of particle size effects on an optical backscatterance sensor. Marine Geology 108:151-159.

EcoLogical, 2018. Port of Hay Point Environmental Monitoring and Management Plan.

Erftemeijer., P.L.A., Riegl, B., Hoeksema, B.W. and Todd, P.A., 2012. Environmental impacts of dredging and other sediment disturbances on corals: A review. Marine Pollution Bulletin 64.

GBRMPA, 2010. Water quality guidelines for the Great Barrier Reef Marine Park. Revised Edition 2010. Great Barrier Reef Marine Park Authority, Townsville.

JCU, 2022. Turbidity (NTU) to Suspended Sediment Concentration (SSC) Conversion Protocol: Technical Report, James Cook University, Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER), July 2022.

Ludwig, K.A. and Hanes, D.M., 1990. A laboratory explanation of optical backscatterance suspended solids sensors exposed to sand-mud mixtures. Mar Geol 94:173-179

PCS, 2019a. Port of Hay Point, 2019 Maintenance Dredging: Environmental Monitoring Compliance Report. Report No. P019_R02D01.

PCS, 2019b. Port of Hay Point 2019 Maintenance Dredging: Turbidity Analysis, Note 1, March 2019.

PCS, 2021. Port of Hay Point, Environmental Thresholds Update, November 2021.

RHDHV, 2018. Port of Hay Point: Environmental Thresholds. Maintenance Dredging Management and Monitoring. M&APA1659R001F0.3

Wolanski, E., Delesalle, B. and Gibbs, R., 1994. Carbonate mud in Mataiva Atoll, French Polynesia: Suspension and export. Marine Pollution Bulletin 29:36-41.