Appendix E Technical Memorandum – Environmental Thresholds for Dredge-Related Impacts

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Technical Memorandum

Environmental Thresholds for Dredge-related Impacts

E1 Introduction

Environmental thresholds for water quality (turbidity) will be the key parameter for impact assessment associated with maintenance dredging and placement. Water quality threshold values are required for the following purposes:

- Thresholds for impact assessment purposes (e.g. to delineate zones of impact using modelling outputs). These threshold values are 'above background' values as modelling outputs are provided as excess suspended sediment above background values.
- Thresholds for validation monitoring during maintenance dredging. These threshold values are total turbidity values (i.e. background plus dredge plumes) as this is what is measured by deployed instruments.

The methodology and thresholds described in the following sections is similar to that presented in the CSDP EIS and applied successfully during the 2019 capital dredging campaign.

E1.1 Impact Assessment Thresholds

Threshold values were developed for the CSDP to assess potential impacts to marine water quality and ecologically sensitive areas. These impact predictions were presented as 'zones of impact' as recommended by the Western Australian *Environmental Assessment Guideline for Marine Dredging* (EPA, 2016). The zones included the following:

- Zone of High Impact = water quality impacts resulting in predicted mortality of ecological receptors with recovery time greater than 24 months.
- Zone of Low to Moderate Impact = water quality impacts resulting in predicted sub-lethal impacts to ecological receptors and/or mortality with recovery between 6 months (lower end of range) to 24 months (upper end of range).
- Zone of Influence = extent of detectable[1] plume, but no predicted ecological impacts.

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

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

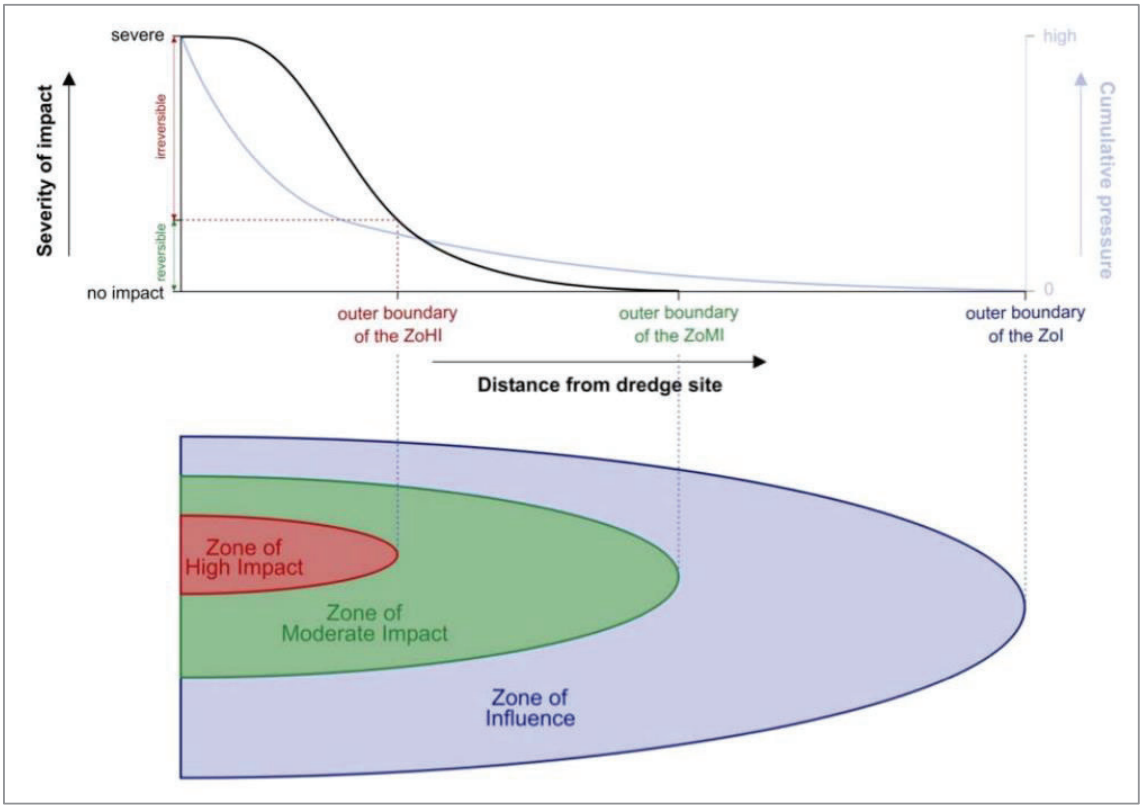

Figure E-1 Concept design of impact zones (WA EPA 2016)

To determine the threshold values to delineate the zones of impact, a combination of water quality (turbidity) and biological tolerances methods was used. This entailed using baseline water quality monitoring data to set initial threshold values. These values were then compared to biological tolerances from literature values as a 'reality check' to confirm that the threshold values were biologically meaningful.

Baseline data used to set thresholds included continuous turbidity data collected over a 12 month period (July 2013 to July 2014) for the CSD EIS at sites generally representing sensitive ecological receptor locations. The 12-month baseline data set underwent a quality control process whereby periods of data were quarantined to ensure the data represented baseline conditions. Periods of data were quarantined if there were obvious signs of sensor bio-fouling, equipment failure or any unusually large rainfall events (i.e. larger than 1 in 5-year recurrence interval).

The 12-month baseline data set was analysed over a moving 30-day window period to give a range of percentile values over different periods. These percentile curves provide an indication of magnitude of turbidity and combined duration/frequency metrics for a range of conditions.

As an example, Figure E-2 shows the percentile curves for data collected at Trinity Inlet as part of the EIS. This shows the natural variability measured around the median (50%ile) and other percentile values. The x-axis in Figure E-2 represents the different percentile values extracted from the moving 30-day window analysis moving from frequently exceeded on the left to rarely exceeded on the right. The different curves are statistics representing the variability of the percentile analysis results across the different 30 day periods (making up the

entire baseline monitoring period). The lower curve represents the least turbid conditions experienced across the baseline period while the upper limit is conversely the most turbid conditions. The solid green line is the mean of the different 30-day window conditions.

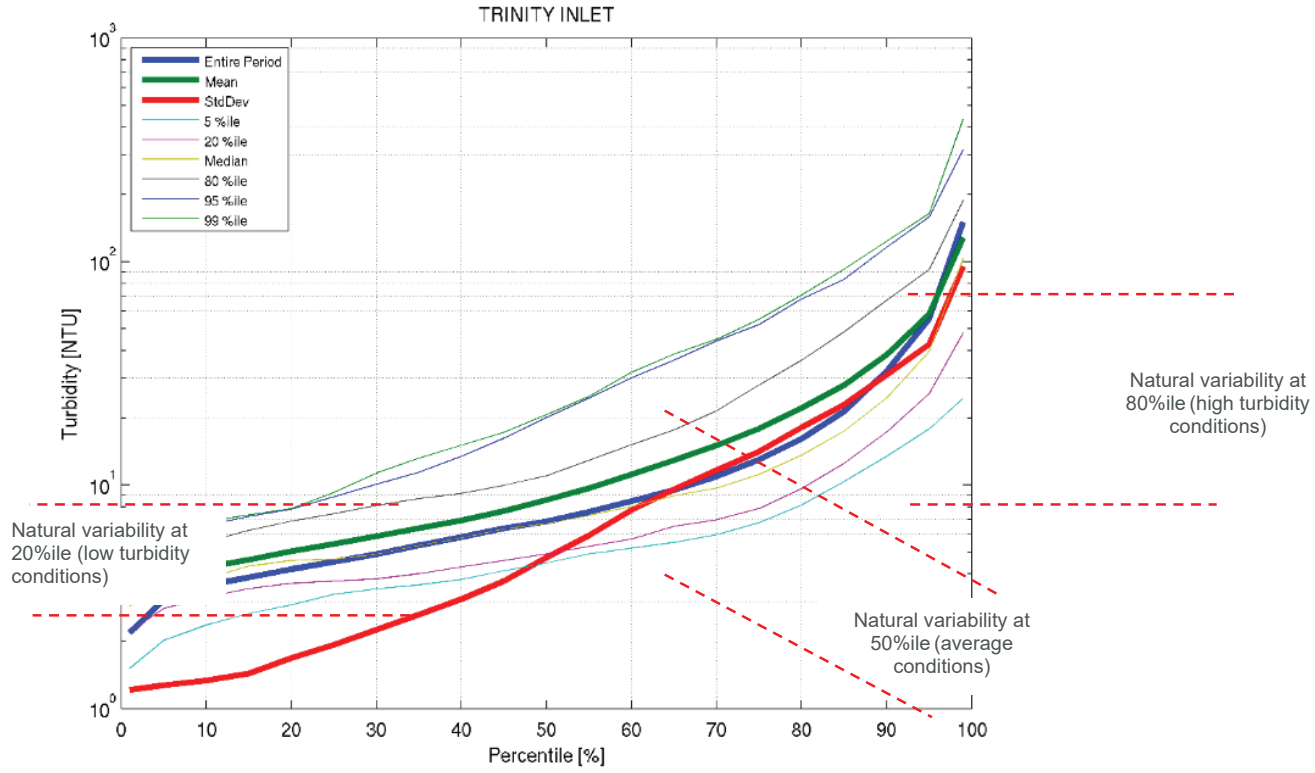

Figure E-2 Example summary analysis of baseline data for Site 4 at Trinity Inlet

Threshold values were derived from these percentile curves based on the natural variability around the 50th percentile (average conditions), 20th percentile (good conditions – low wind and waves) and the 80th percentile (poor conditions – moderate to high wind and waves). Therefore, this method considered both acute and chronic impacts.

The approach used to determine the threshold level for the 'zone of low to moderate impact' involved using one standard deviation from the natural background mean at each percentile (i.e. 20th, 50th and 80th percentiles). This is a similar approach developed by Orpin *et al.* (2004) to assess impacts from construction-related turbidity increases in Townsville.

Extending this method out, threshold levels for the 'zone of high impact' were determined using three standard deviations from the mean. The validity of this approach was tested using biological thresholds, as discussed below.

The 'zone of influence' was defined as the extent of detectable plumes due to the proposed dredging. Turbid plumes were assumed to become detectable once they were approximately 10-20% above background conditions (background conditions were conservatively assumed to be clearer waters in Trinity Inlet and offshore areas, as opposed to more turbid nearshore waters). To determine the extent of this zone, the following criteria are proposed:

- Greater than 0.5 NTU above 50th percentile conditions
- Greater than 2 NTU above 80th percentile conditions
- Greater than 5 NTU above 95th percentile conditions
- Greater than 10 NTU above 99th percentile conditions.

The output from the analysis of data are turbidity impact assessment threshold values for each impact zone at each CSDP EIS monitoring site. To test whether the threshold values developed using the above method are biologically meaningful, the turbidity thresholds were converted to PAR values and synthetically added to actual PAR monitoring data for three sites in Cairns monitored by JCU. The details of this testing are included in the CSDP EIS, with the outcome being the turbidity threshold values were considered suitable for impact assessment purposes.

The turbidity impact assessment threshold values are included in Table E-1. It is important to note that the threshold values presented in Table E-1 are suitable for impact assessment purposes but should not be used as trigger values for reactive monitoring during dredging.

The method described above using variability around percentile values to set thresholds is similar to that used by other ports (e.g. Hay Point) which proposed intensity, duration and frequency (IDF) thresholds for turbidity (Royal Haskoning, 2018). The issues with IDF thresholds are that they are difficult to use for impact assessment purposes (using modelling outputs above background) and are difficult to implement during reactive monitoring programs. The threshold values in Table E-1 have been developed for ease of use for impact assessment purposes, but also have been developed around IDF principles.

Table E-1 Turbidity threshold values (above background) for impact assessment purposes

Impact Zone	Description	Method	Percentile	Descriptor	Palm Cove	Yorkeys Knob	Trinity Bay	Trinity Inlet	False Cape	Cape Grafton	Offshore (DMPA)
					Turbidity Threshold Values (NTU) - *above background*						
Zone of High Impact	Excess turbidity *definitely* pushes total turbidity beyond natural variation	3 x standard deviations from 20%ile mean	20%ile	Exceeded 80% of the time	18	24	30	6	36	30	3
		3 x standard deviations from 50%ile mean	50%ile	Exceeded 50% of the time	48	39	66	15	75	123	6
		3 x standard deviations from 80%ile mean	80%ile	Exceeded 20% of the time	87	75	183	54	399	327	15
Zone of Low to Moderate Impact	Excess turbidity *may* push total turbidity beyond natural variation	One standard deviation from 20%ile mean	20%ile	Exceeded 80% of the time	6	8	10	2	12	10	1
		One standard deviation from 50%ile mean	50%ile	Exceeded 50% of the time	16	13	22	5	25	41	2
		One standard deviation from 80%ile mean	80%ile	Exceeded 20% of the time	29	25	61	18	133	109	5
Zone of Influence	Full extent of detectable plumes (including resuspension)	Dredging related turbidity exceeds 0.5 NTU	50%ile	Exceeded 50% of the time	0.5						
		Dredging related turbidity exceeds 2 NTU	80%ile	Exceeded 20% of the time	2						
		Dredging related turbidity exceeds 5 NTU	95%ile	Exceeded 5% of the time	5						
		Dredging related turbidity exceeds 10 NTU	99%ile	Exceeded 1% of the time	10						

E1.2 Validation Monitoring Thresholds

The Guidelines for Long-term Maintenance Dredging Management Plans (DTMR, 2018) state that real-time reactive monitoring is required when risk assessments indicates the potential for significant unplanned or uncertain impacts, and where there are opportunities to minimise or avoid these impacts. In this instance, the risk assessment has identified that there is a low risk to water quality or sensitive receptors from maintenance dredging. Therefore it is proposed that a validation monitoring exercise will be undertaken every five years (i.e. Year 1 and Year 6). Should the threshold values be exceeded, then the need for further monitoring will be reviewed.

Threshold values (or trigger levels) were used as part of the reactive monitoring programme as part of the 2019 CSDP capital dredging campaign. These threshold values were originally proposed to be derived using baseline turbidity plus the zone of low to moderate impact (ZLMI) threshold values (as per Table E-1) to provide a 'total' turbidity threshold value (as opposed to an above background value).

However, the Department of Environment and Science (DES) specified slightly different limits in the Environmental Authority (EA) which were derived from the 80th and 95th percentile values of site-specific baseline dry season data (as both capital and maintenance dredging is typically undertaken during the dry season in Cairns, to avoid the cyclone season). These 80th and 95th percentile values were used during dredging to assess 15-day and 6-day rolling medians, respectively.

As these EA limits were used successfully during the capital dredging campaign, it is proposed that threshold values for maintenance dredging campaigns should be similar, and are included in Table E-2.

Details of how these thresholds are to be implemented during the proposed validation monitoring associated with maintenance dredging under the LMDMP is outlined in the Chapter 9 – Monitoring Framework.

Table E-2 Reactive Monitoring Thresholds

Monitoring Location	Turbidity Threshold (NTU)	Threshold Type
Palm Cove (Double Island)	57	15-day rolling median
	125	6-day rolling median
Yorkeys Knob	58	15-day rolling median
	100	6-day rolling median
Trinity Bay	40	15-day rolling median
	173	6-day rolling median
Upper Trinity Inlet	12	15-day rolling median
	26	6-day rolling median
False Cape	82	15-day rolling median
	144	6-day rolling median
Cape Grafton	121	15-day rolling median
	248	6-day rolling median

E1.3 PAR

Photosynthetically Active Radiation (PAR) is often monitored as an indicator of light available to seagrass meadows. For the 2019 capital dredging campaign, the EA set PAR limits as follows:

- *Halodule uninervis* - 14-day rolling average of 5 mol/m^2/day.
- *Zostera muelleri* - 14-day rolling average of 6 mol/m^2/day.

During the 2019 capital dredging campaign, PAR at two compliance sites remained well above these minimum thresholds at approximately 12 to 30 mol/m^2/day.

However, PAR monitoring is fraught with difficulty (calibration, immersion coefficients, intertidal areas, etc) and PAR sensors are known to be provide diverse readings (e.g. there can be 20% difference in values at similar deployed sensors). Furthermore, there is some uncertainty with PAR threshold values. As discussed in Royal Haskoning (2018), recent research in Western Australia on thresholds and indicators of seagrass response to dredging pressures confirmed that there is still considerable uncertainty in the accuracy of predicting impacts on seagrasses.

As such, it is recommended that PAR monitoring is not included in the validation monitoring program during dredging. However, PAR monitoring will still continue as part of the ambient seagrass monitoring program undertaken by JCU.

E1.4 Deposition

Sediment deposition guideline values for the Great Barrier Reef Marine Park as per GBRMPA (2010) are as follows:

- Annual average daily rate of 3 mg/cm^2
- Maximum daily rate of 15 mg/cm^2.

However, monitoring of sediment deposition using conventional benthic instrumentation (e.g. sediment tubes) has typically been unreliable and not able to accurately measure net deposition and erosion of sediment. While there are emerging technologies being trialled in Queensland that appear to measure deposition more accurately (Royal Haskoning, 2018), this technology has not been proven yet and is not widely available.

Furthermore, as discussed in Royal Haskoning (2018), adaptive management using sediment deposition thresholds would be difficult due to the lack of clarity around effectiveness of measures on reducing deposition rates (i.e. current instrumentation is not able to provide erosion rates) and when dredging could re-commence.

Therefore, due to the difficulty and inaccuracy of sediment deposition measurements using currently available technology, it is recommended that deposition monitoring is not part of a validation monitoring program for maintenance dredging in Cairns.