SLR

global environmental solutions

Abbot Point Growth Gateway Project

Underwater Noise Impact Assessment

Report Number 622.10190-R6R1

13 July 2015

Advisian

60 Albert Street

Brisbane QLD 4000

Version: Revision 1

Abbot Point Growth Gateway Project

Underwater Noise Impact Assessment

PREPARED BY:

SLR Consulting Australia Pty Ltd
ABN 29 001 584 612
Level 2, 15 Astor Terrace
Spring Hill QLD 4000 Australia
(PO Box 26 Spring Hill QLD 4004)
T: +61 7 3858 4800   F: +61 7 3858 4801
brisbane@slrconsulting.com   www.slrconsulting.com

DOCUMENT CONTROL

Reference	Status	Date	Prepared	Checked	Authorised
622.10190-R6R1	Revision 1	13 July 2015	Binghui Li	Luke Zoontjens	Steve Henry
622.10190-R6	Revision 0	10 July 2015	Binghui Li	Luke Zoontjens	Steve Henry

Executive Summary

SLR Consulting Australia Pty Ltd (SLR) has been engaged by Advisian to assess potential underwater noise impacts in relation to the dredging activities and associated supporting vessel movements for the proposed Abbot Point Growth Gateway Project (the Project).

The Project plans to undertake capital dredging for a new berth pocket and ship apron area within the Port of Abbot Point for Terminal 0 (T0) using a medium to large Cutter Suction Dredger (CSD). During the dredging process, the dredging activities and the associated supporting vessel movements are expected to generate underwater noise which would potentially adversely impact the marine environment, particularly marine fauna species of significance surrounding the dredging locations. This study aims to assess the underwater noise impacts on relevant marine fauna species as a result of the proposed dredging process.

To implement the assessment study, the following scope elements have been proposed and carried out:

- Conducting a brief literature review of noise impacts on marine fauna and noise, and outlining the relevant noise impact assessment criteria.
- Characterising underwater noise emitted from typical dredging activities, including its spectral and temporal variations as well as source levels.
- Investigating existing underwater noise environment for the study area based on literature review and relevant site specific conditions.
- Undertaking underwater noise propagation modelling to predict received noise levels at surrounding waters.
- Defining zones of noise impact based on noise prediction results, and assessing the consequent noise impacts.

On the basis of the information provided, this assessment study has found that:

- It is unlikely that the noise generated by the proposed dredging activities and associated supporting vessel movements will cause physical injuries or hearing damage (including permanent and/or temporal hearing threshold shift (PTS and/or TTS)) to any assessed marine fauna species.
- The proposed dredging activities and associated supporting vessel movements can potentially cause behavioural responses from assessed marine fauna species within a 3.0 km range. However, the consequent disturbance is expected to be limited, considering the ecological characteristics of assessed marine fauna species, as well as the existing ambient noise environment within the study area.

On the basis of the results of this assessment study, no specific noise monitoring and/or mitigation measures are recommended.

Table of Contents

TABLES

FIGURES

Table of Contents

1 INTRODUCTION

SLR Consulting Australia Pty Ltd (SLR) has been engaged by Advisian to assess potential underwater noise impacts in relation to the dredging activities and associated supporting vessel movements for the proposed Abbot Point Growth Gateway Project (the Project).

This report summarises the methodology and relevant findings of the assessment study. The acoustic terminology used in this report is listed in **Appendix A**.

1.1 Project Description

The Port of Abbot Point is located approximately 25 km North of Bowen of the North Queensland coast. The existing Terminal (T1) at the Port commenced operations in 1984, with infrastructure developed to support the export of coal from the Bowen Basin. Further expansion is required to meet the increasing demand for coal export through the Port.

To support the development of the new Terminal 0 (T0), it is necessary to undertake capital dredging for new berth pockets and ship apron areas. As such, the Abbot Point Dredging and Onshore Placement Project is proposed.

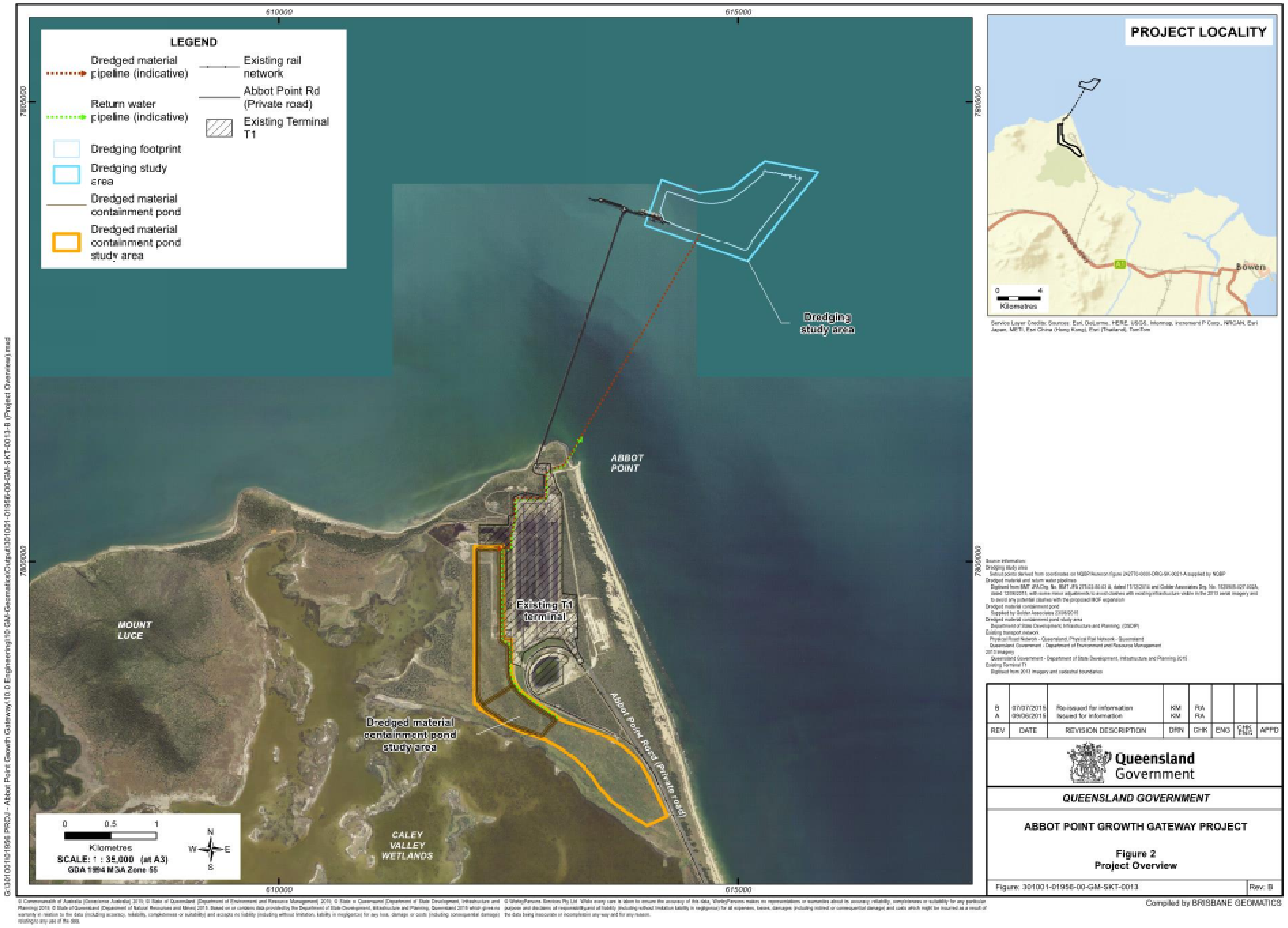
The proposed actions associated with the Project include:

- Construction of an onshore dredged material containment pond (DMCP) within the area previously allocated for the development of Terminal 2 (T2).
- Dredging of approximately 1.1 million m^3 (Mm^3) of previously undisturbed seabed within the Port of Abbot Point using a medium to large Cutter Suction Dredger (CSD) to dredge all materials;
- Relocation of the dredge material via pipeline to the DMCP and offshore discharge of return water;
- Ongoing management of the dredged material including its removal, treatment and beneficial reuse within the port area and the State Development Area.

The relevant areas of the proposed actions are detailed in **Figure 1**.

During the dredging process, the dredging activities and the associated supporting vessel movements are expected to generate underwater noise which would potentially adversely impact marine environment, and more specifically marine fauna species of significance surrounding the dredging location.

Figure 1 Proposed Dredging and Onshore Placement Area



1.2 Structure of this Report

This assessment study report is structured as follows:

- Section 1 of the report provides an overview of the Project and the associated dredging activities.
- Section 2 of this study gives a brief review of noise impacts on marine fauna, and outlines the relevant noise impact assessment criteria.
- Section 3 of the report describes in detail the characteristics of noise associated with dredging activities and the source spectral levels.
- Section 4 of this assessment study investigates the existing underwater noise environment for the project area, based on literature review and relevant site specific conditions.
- Section 5 of this report details the noise modelling methodology, modelling procedure and noise prediction results. This section also defines zones of noise impact based on noise prediction results and subsequently assesses likely consequent impacts on significant marine fauna species.

2 MARINE FAUNA AND UNDERWATER NOISE

2.1 Significant Marine Fauna Species near Abbot Point

The following marine fauna species of significance have been identified in proximity to the Port of Abbot Point and may potentially be impacted by underwater noise generated from dredging activities and the associated supporting vessel movements:

- Marine mammal species
  - Humpback whales (Megaptera novaeangliae)
  - Indo-Pacific dolphin (Sousa chinensis)
  - Australia snubfin dolphin (Orcaella heinsohni)
  - Dugong (Dugong dugon)
- Sea turtles
  - Green Turtle (*Chelonia mydas*)
  - Flatback Turtle (*Natator depressus*)
  - Hawksbill Turtle (*Eretmochelys imbricate*)
  - Loggerhead Turtle (*Caretta caretta*)
  - Olive Ridley Turtle (*Lepidochelys olivacea*)
- Fish species
  - Giant Manta Ray (*Manta birostris*)
  - Green sawfish (*Pristis zijsron*)
- Other species
  - Saltwater crocodile (*Crocodylus porosus*)

The hearing characteristics of these marine fauna species, the potential effects from the marine noise and the relevant assessment criteria are discussed in the following sections.

2.2 Marine Fauna Hearing Sensitivities

Acoustic energy propagates in water more efficiently than almost any other form of energy. Therefore, many marine fauna species primarily rely on sound and their auditory system to perform various functions associated with their life cycle such as communication, navigation, foraging and sensing their surrounding environment (Whitlow et al, 2008).

The hearing sensitivity of marine fauna species varies with frequency. Audiograms, defined as the frequency-dependent absolute hearing threshold (dB re 1µPa), are normally used to represent marine fauna species' sensitivity to sounds of different frequencies.

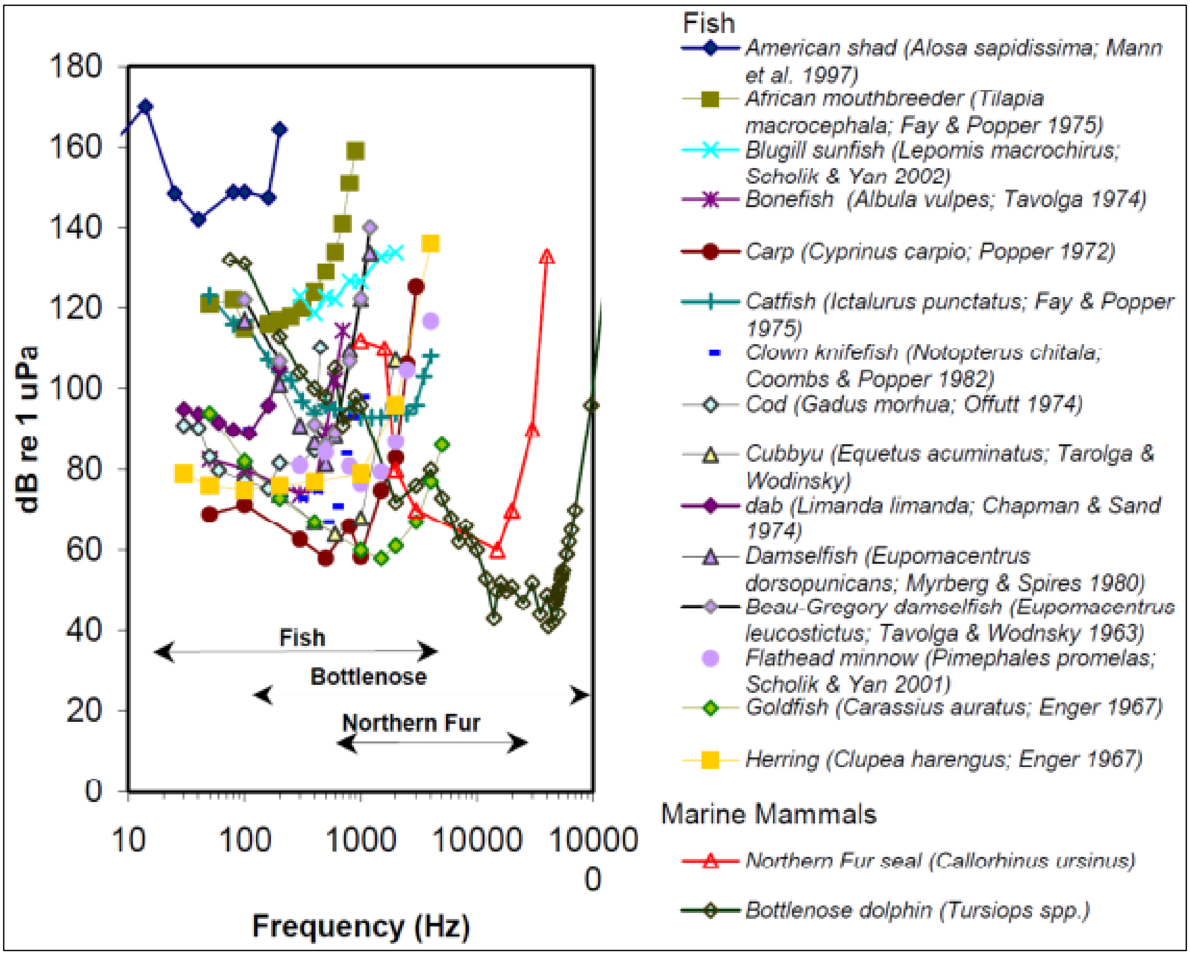
Nedwell et al (2004) gave a summary of hearing sensitivity as presented in **Figure 2**, based on measured audiograms of fifteen fish species and three marine mammals. Typically, general fish species have highly variable sensitivity to sound energy, with hearing sensitivity ranging from 20 Hz to several kHz, and with highest sensitivity at mid frequency range (100 Hz to 1 kHz). Marine mammal species, including cetaceans (e.g. whales and dolphins) and pinnipeds have much broader hearing sensitivity range, from a few Hz up to 180 kHz, with the very sensitive hearing centred at high frequencies (10 – 100 kHz).

For Dugong species, currently there is no publication in regards to its audiogram. Considering that dugongs and manatees are relatives under the sirenia species, it is expected that their audiograms are similar. The literature suggests that the best hearing sensitivity for manatees are between 3 and 25 kHz (Popov et al, 1990).

Sea turtles have the hearing range at low frequencies, approximately between 50 Hz and 800 Hz, with the highest sensitivity range between 200 Hz and 400 Hz (Ketten et al, 2005).

There are no publications in regards to the audiograms for green sawfish and saltwater crocodiles.

Figure 2 Summary of Estimated Hearing Range based on Audiograms of Fifteen Fish Species and Three Marine Mammals



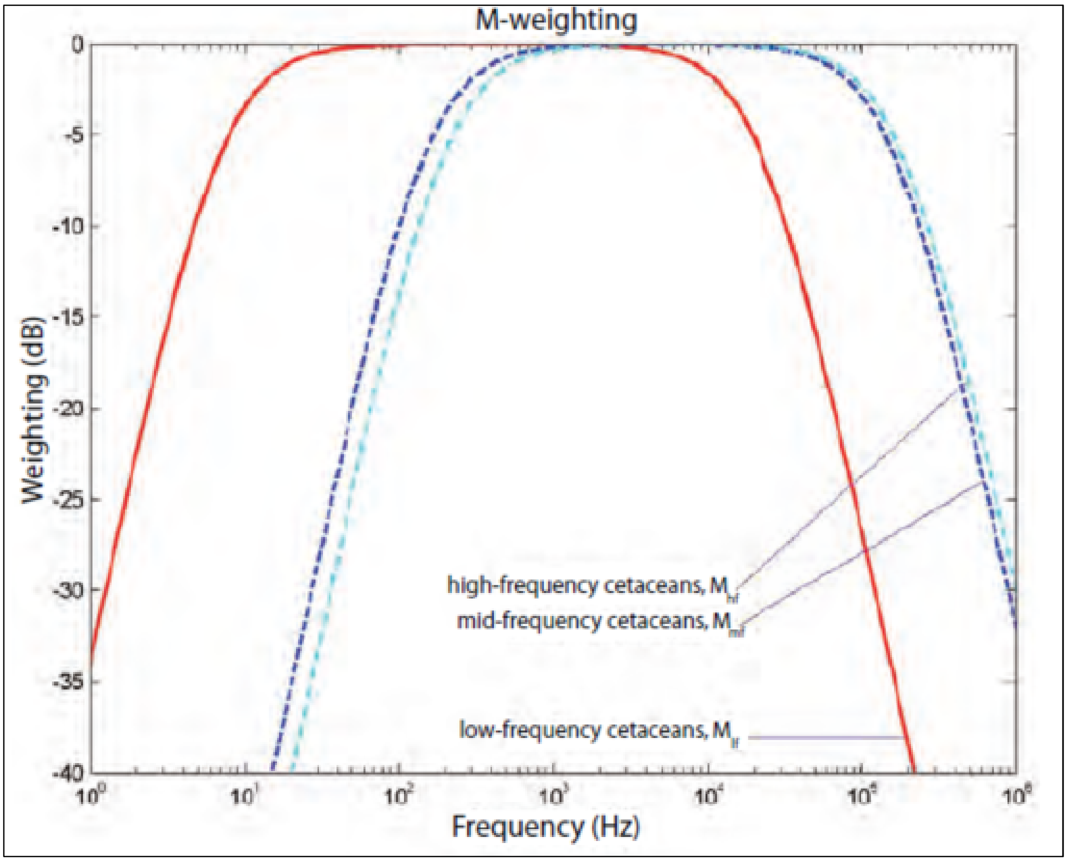
2.2.1 Frequency weighting function for marine mammal hearing group

Based on a comprehensive literature review study of marine mammal hearing and on physiological and behavioural responses to anthropogenic sound, Southall et al (2007) proposed standard frequency weighting functions, referred to as M-weighting functions, for the following functional groups of marine mammals:

- Low-frequency cetaceans (LFCs) with auditory bandwidth 7 Hz to 22 kHz – M_{lf};
- Mid-frequency cetaceans (MFCs) with auditory bandwidth 150 Hz to 160 kHz – M_{mf};
- High-frequency cetaceans (HFCs) with auditory bandwidth 200 Hz to 180 kHz – M_{hf};

The standard M-weighting function for mid-frequency marine mammal hearing group is illustrated in **Figure 3**.

Figure 3 The M-weighting Functions for Low-, Mid- and High-frequency Cetaceans



2.3 Impacts of Noise on Marine Fauna Species

The effects of noise and the ranges over which they happen depend on the acoustic characteristics of the noise (level, spectral contents, temporal characteristics etc.). The potential impacts of noise on marine fauna species include mortality, hearing damage, masking of communication and other biological important sounds, and alteration of behaviour (Richardson et al, 1995; Hasting and Popper, 2005). In general, underwater noise impacts on marine fauna species may be divided into the following two categories:

2.3.1 Behavioural Impacts

Behavioural responses to noise include changes in vocalisation, resting, diving and breathing patterns, changes in mother-infant relationships, and avoidance of the noise sources. Masking of biologically important sounds may interfere with communication and social interaction (with secondary effects such as inhibiting reproduction cycles), and cause changes in behaviour as well.

2.3.2 Physiological Impacts

Physiological effects of underwater noise are primarily associated with the auditory system which is likely to be most sensitive to noise. The exposure of the auditory system to a high level of noise for a specific duration can cause a reduction in the animal's hearing sensitivity, or an increase in hearing threshold. If the noise exposure is below some critical sound energy level, the hearing loss is generally only temporary, and this effect is called temporary hearing threshold shift (TTS). If the noise exposure exceeds the critical sound energy level, the hearing loss can be permanent, and this effect is called permanent hearing threshold shift (PTS).

In a broader sense, physiological impacts also include non-auditory physiological effects. Other physiological systems of marine animals potentially affected by noise include the vestibular system, reproductive system, nervous system, liver or organs with high levels of dissolved gas concentrations and gas filled spaces. Noise may cause concussive effects, physical damage to tissues and organs, cavitation or result in rapid formation of bubbles in venous system due to massive oscillations of pressure.

2.4 Noise Exposure Criteria for Marine Fauna Species

There have been extensive scientific studies and research efforts to develop quantitative links between marine noise and impacts on marine fauna species. For example, Southall et al (2007) have proposed noise exposure criteria associated with various sound types (e.g. pulses and non-pulses) for certain marine mammal species (i.e. cetaceans and pinnipeds), based on review of expanding literature on marine mammal hearing and on physiological and behavioural responses to anthropogenic sounds. McCauley et al (2000a&b) investigated responses of various marine fauna species (including fish and turtles) to the marine seismic airgun noise through extensive observation and experiments.

The marine noise associated with dredging activities and supporting vessels, as described in detail in **Section 3**, is continuous in nature and a low-level emission in comparison to construction activities such as offshore piling and blasting activities. Therefore, the most relevant assessment parameters include sound exposure level (SEL, dB re 1µPa·s) and root-mean-square sound pressure level (SPL, dB re 1µPa RMS) in particular.

Table 1 outlines the consolidated impact assessment criteria proposed by the client for all significant marine fauna species identified to be assessed as listed in **Section 2.1**. It should be noted that the proposed SEL criteria for PTS and TTS do not consider the frequency weighting functions applied for marine mammal species, and therefore are considered to be conservative. The proposed SPL criteria for behavioural response have been widely used for marine mammal species, as well as for other marine fauna species where there is no relevant established criterion available (McCauley et al, 2012).

Table 1 Dredging Noise Impact Assessment Criteria

Permanent hearing threshold shift (PTS) or physical injury	Temporary hearing threshold shift (TTS)	Behavioural response
SEL, **dB re 1 µPa^2·s** **(Within a 24-hour period)**	**SEL,** **dB re 1 µPa^2·s** **(Within a 24-hour period)**	**SPL,** **dB re 1 µPa RMS**
215	195	120

2.5 Zones of Bioacoustics Impact

The received noise levels at receiving locations can be predicted using known source levels and modelling sound propagation transmission loss between the source and the receivers. The zones within which impacts are expected to occur can be determined by comparison of the predicted received levels to the noise exposure criteria.

Predicted zones of impact define the environmental footprint of the noise generating activities and indicate the locations within which the activities may have an impact on a marine fauna species, either behaviourally or physiologically. Considered in collaboration with ecological information such as the habitat significance and species abundance within the defined zones, this information can be used to assess the risk of the potential noise impacts.

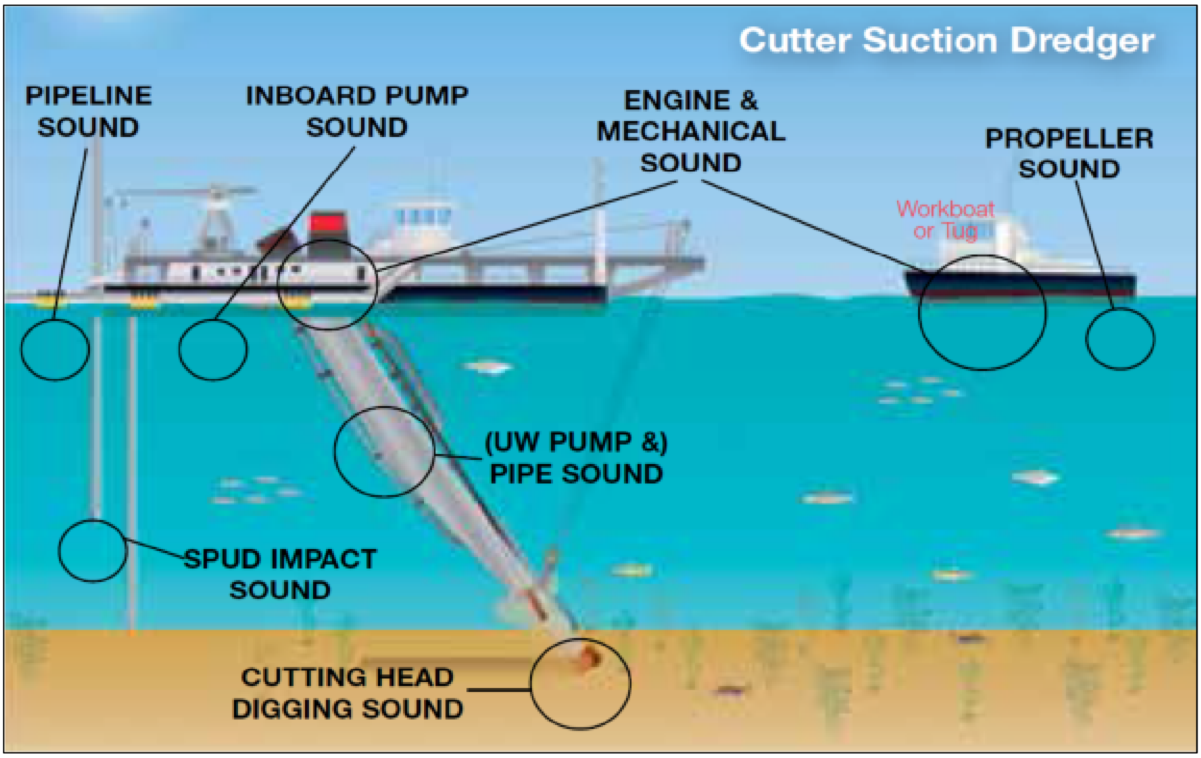
3 UNDERWATER NOISE SOURCES

The main underwater noise-generating activities associated with the Project are expected to be dredging activities and the associated supporting vessel movements.

It has been proposed that a medium to large Cutter Suction Dredger (CSD) will be used to dredge all materials. A CSD is a stationary or self-propelled vessel that uses a rotating cutter heard to loosen the material in the seabed. A suction inlet located beneath the cutter head is connected by a suction tube directly to one or more centrifugal pumps. The vacuum force at the suction inlet sucks up the loosened material. This material will then be pumped onshore by a part floating and part submerge pipeline.

Multiple elements during the dredging process can potentially emit noise into the water column, including vessel propeller operation, inboard engine and pump, underwater pump and pipes, and cutting head digging process, as depicted in **Figure 4**. Among these elements, cutting head operations and vessel propeller are expected to be the dominant noise sources during the sediment excavation process. Typically the noise generated during dredging operation is continuous in nature.

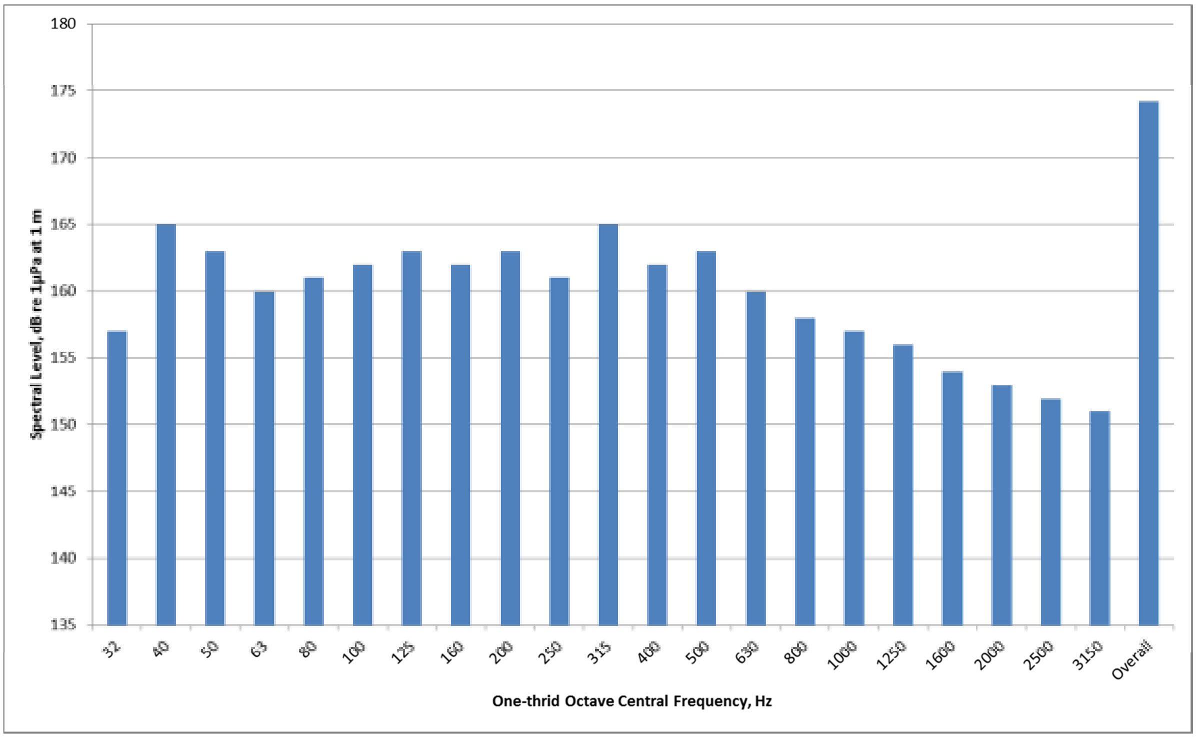
Figure 4 Potential Noise Sources from Cutter Suction Dredger (WODA, 2013)



SLR has undertaken multiple site measurements on a large CSD dredger during its operation in a previous project (October 2013) and the 1/3 octave source spectral levels of the dredging noise, derived based on a geometrical spreading estimation, are presented in **Figure 5**.

As can be seen from the figure, the noise energy from dredging operations is highest at frequencies typically below 1,000Hz, with peak frequencies at both 315 Hz and at very low frequency of 40 Hz. The overall root-mean-square (RMS) source level derived from the measurements is estimated as 174 dB re 1µPa at 1 metre. The spectral characteristics and the overall noise levels resulting from this particular measurement are comparable with other CSD noise measurements documented in the literature (e.g. Reine et al, 2012), and therefore considered appropriate for use in underwater noise modelling predictions for this study. Compared with the hearing sensitivities of the assessed marine fauna species as described in **Section 2.2**, the spectrum of the dredging noise largely overlaps with the sensitive range of the audiograms of these species.

Figure 5 Measured 1/3 Octave Source Spectral Levels during Dredging Operation



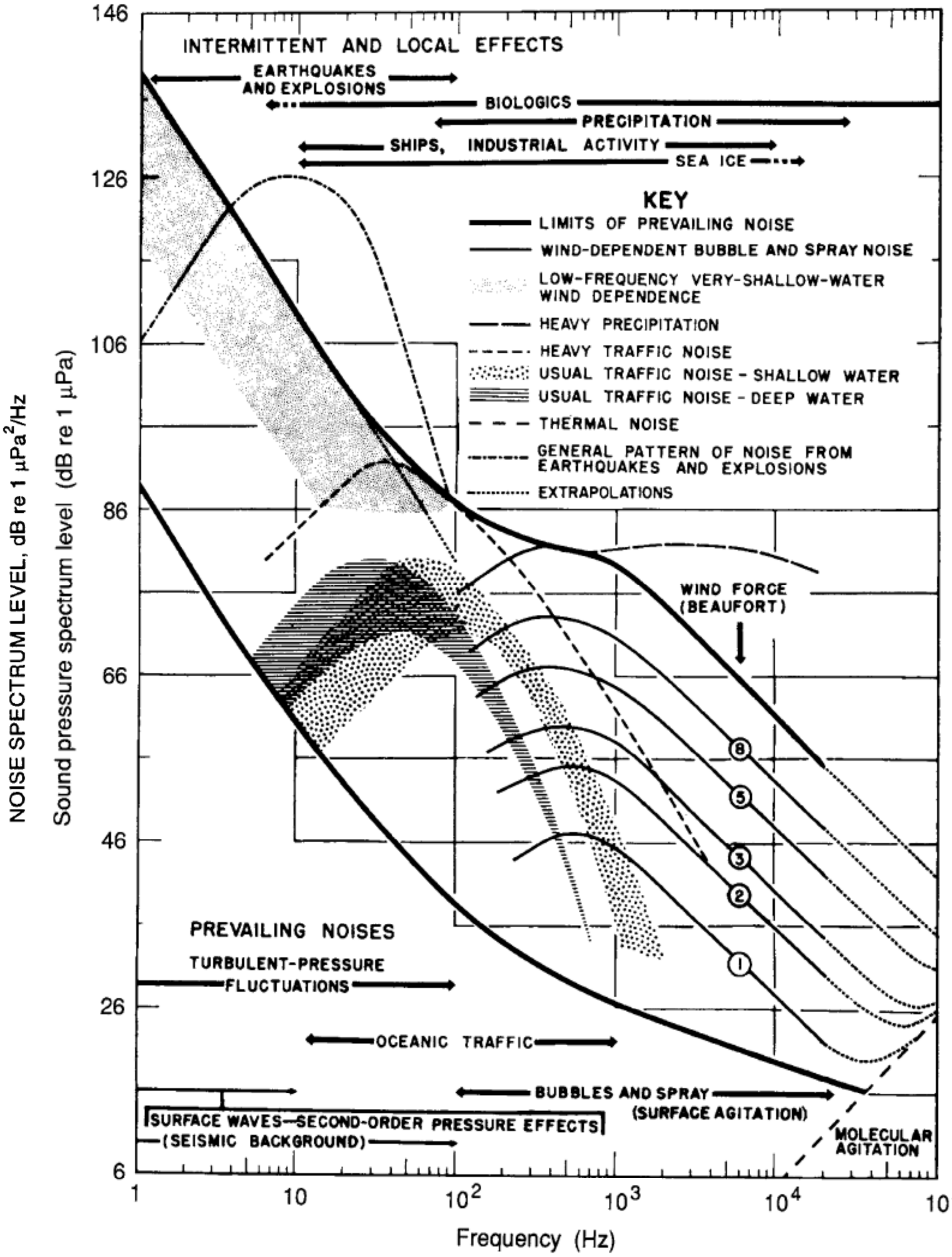
The supporting vessel movements associated with dredging activities include a small transfer vessel (normally 12 – 15 metres) operating between the dredging vessel and Bowen, as well as a workboat or tug as used for assembly of the dredge pipeline. Considering the size of these supporting vessels and their relevant operating conditions, and according to the existing noise measurement data for vessels of similar sizes and uses (Roy, 2008), the noise emissions from these vessels are expected to be much lower than the noise from the dredging operations. This study conservatively assumes an overall source level of 170 dB re 1µPa at 1 metre for both transfer vessel and supporting workboat or tug.

4 EXISTING UNDERWATER AMBIENT NOISE ENVIRONMENT

Underwater ambient noise poses a basic limitation on the use of sound by marine animals since signals of interest must be detected against a noise background. The level and frequency characteristics of the ambient noise environment are two factors that control how far away a given sound signal can be detected (Richardson et al, 1995).

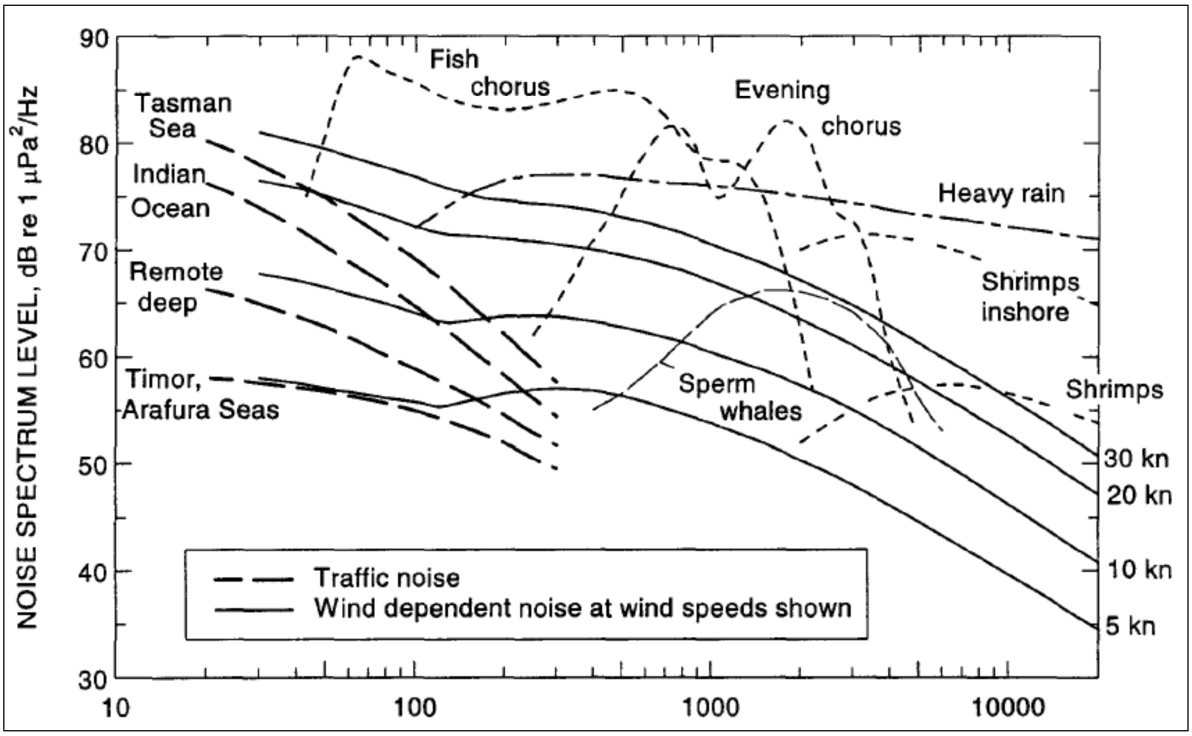
Underwater ambient noise comprises a variety of both natural and man-made sounds. The man-made noise primarily consists of noise from shipping, sonar activities and offshore rigs. Natural sounds are predominantly wind-generated noise and biological noise from a variety of sources such as fish chorus and snapping shrimps. Other environmental sources include surf noise typically localised near the coast, precipitation noise from rain and hail, seismic noise from volcanic and tectonic activities, and thermal noise. A summary of the spectra of these ambient noise sources is shown in **Figure 6**.

Figure 6 Composite of ambient noise spectra (Wenz, 1962)



Studies in Australian waters have shown that there are significant differences in the ambient noise compared to the colder Northern Hemisphere waters where most measurements have been made. **Figure 7** summarises the main components of ambient noise for the Australian regions, where the differences from the Wenz predictions are due to the different environment of tropical waters, particularly in respect to noise from marine animals.

Figure 7 Summary of Ambient Noise Spectra for the Australian Region (Cato, 1997)



The major sources of ambient noise in the shallow waters around the Abbot Point Port are likely to include shipping noise, wind-generated noise, fish chorus and snapping shrimp noise, precipitation noise from rain and hail, and thermal noise.

Commercial vessels and bulk carriers are expected to dominate the shipping contribution to the ambient noise environment around Abbot Point Port area. Shipping noise generally has dominant energy below 1 kHz and is typically generated by propellers and thrusters. The received shipping noise levels are dependent on the distance to the shipping channel. The dredging area for Terminal T0 is within 2 km of the existing terminal T1. Considering the typical bulk carriers with source levels normally above 180 dB re 1µPa at 1 m (Alexander et al, 2014), the noise levels from the shipping activities around the proposed dredging areas can be as high as 120 dB re 1µPa.

Wind and wave generated noise has an extremely wide frequency range, typically dominating the ambient environment from 500 Hz to up to 100 kHz, with the absence of biological noise sources. Ambient ocean noise due to wind and wave is often described in relation to sea state. Wenz (1962) determined an empirical rule as an approximation for spectrum levels of wind-generated ambient noise. A number of measurements of ambient noise have been made by CMST, Curtin University (2012) in locations around Australia with the absence of man-made and biological sources. It is concluded that the overall ambient noise levels typically range from low values of 80 – 85 dB re 1µPa in calm sea conditions to 100 - 110 dB re 1µPa in high-wind conditions, which are generally in line with the wind and wave generated noise spectra shown in **Figure 7.**

Fish chorus and snapping shrimps are likely to be an important contributor to the ambient noise environment in the waters around Abbot Point Port area, covering frequency range from below 100 Hz to as high as above 100 kHz, and resulting overall noise levels can be well above 100 dB re 1µPa during the active chorus period.

5 UNDERWATER NOISE MODELLING PREDICTIONS AND IMPACT ASSESSMENT

5.1 Modelling methodology

Underwater noise propagation models predict the sound transmission loss between a noise source and receiver(s). Providing the source level (SL) of the noise source is known, the predicted transmission loss (TL) is then used to predict the received level (RL) at the receiver location as RL = SL – TL.

The Range-dependant Acoustic Model (RAM) (Jensen et al, 2000) developed based on parabolic equations was used to predict the transmission of the noise from dredging and vessel activities in this study. The RAM model has been proven to be reliable in predicting transmission loss in a long-range range-dependent environment with fluid seabed properties.

The model requires various environmental parameter inputs as detailed in the following sections. It should be noted that some of these environmental parameters are directly referenced from a comprehensive noise modelling study that has been undertaken by CMST, Curtin University (2012) predominately for piling activities associated with Abbot Point Port development.

The propagation modelling was undertaken along 36 tracks originating from the source location with an increment of 10 degrees and a maximum range of 30 km, at the 1/3 octave bands from 16 Hz to 4 kHz.

5.1.1 Bathymetry

Three bathymetry datasets covering the project area have been provided by the client. The dataset *(AbbotPoint_bathymetry.shp)* that covers the larger coastal ocean region was sourced from North Queensland Bulk Ports Corporation (NQBP). A limitation to this dataset is that it is several years old. The other two datasets *(AbbotPoint_bathymetry_Mapset_D.shp* and *AbbotPoint_bathymetry_ Mapset_F.shp*) are derived digitised charts that cover the smaller region with high resolution bathymetry information. The three datasets are all in MGA94 Zone 55 the bathymetric values are relative to low astronomical tide (LAT).

The three datasets were merged and interpolated with a regular spatial grid in 100m resolution. The bathymetric values were converted as relative to mean sea level (MSL). The conversion factor between LAT and MSL for the study area is 1.75 m, estimated by averaging tidal data for neighbouring Bowen and Cape Upstart regions (McCauley et al, 2012).

The coverages of the three datasets and the bathymetry contour map resulting from the final merged dataset are presented in **Appendix B**.

Bathymetric profile along each track to be modelled was interpolated from merged bathymetry data in a sufficient grid resolution for the convergence of the modelling calculation.

5.1.2 Sound speed profile

A sound speed profile as shown in **Figure 8**, derived based on the World Ocean Atlas 2005 from the nearest grid point with sufficient water depth, was used in the noise model. Based on a conservative consideration, the upward refracting profile was selected to represent winter season condition in Southern Hemisphere, and will results in relatively lower transmission loss compared with the profiles of other three seasons.

Figure 8 Sound Speed Profile Derived from WOA05 (World Ocean Atlas, 2005)

5.1.3 Seabed properties

The geophysical data from geotechnical surveys around the study area demonstrated that the seabed contains multiple layers with elastic characteristics. An equivalent fluid seabed model matching the reflection characteristics of the realistic elastic seabed model, particularly for low-grazing angle, was derived in the previous study (McCauley et al, 2012) and predominately formed as the seabed model used in the noise model. The fluid seabed layers and corresponding properties are listed in **Table 2**.

Reduced compressional attenuation values were used for the second layer of seabed model, to reflect the realistic correlation between the compressional velocity and attenuation value for the layer material properties. The resultant equivalent fluid seabed model has a higher reflection coefficient at low-grazing angle across the modelled frequency range, and is expected to result in a more conservative propagation prediction.

Table 2 Equivalent Fluid Seabed Model for the Model Input

Material	Thickness, m	Density, kg/m^3	Compressional Velocity, m/s	Compressional Attenuation, dB/λ
Silty-clay to clayey-sand (stiff)	12	1700	400	1.0
Weathered rock granite and granodorite (weathering decreasing with depth)	50	2200	1700	1.2
		2700	2400	1.4
Basalt halfspace	Infinite in value			

5.2 Modelling Scenarios

In order to understand the underwater noise impacts in relation to the dredging activities, as well as to the associated supporting vessel movements, modelling scenarios were established as listed in **Table 3**. The source levels of these noise sources are detailed in **Section 3.**

Table 3 Modelling Scenarios

Scenario	Source Location, m		Nominal Source Depth, m	Comments
	Easting	Northing		
Dredging activities for T0	615868	7804239	20 (i.e. one metre above seabed)	Only one dredger operating at one time for T0
Supporting vessel (workboat/tug) in anchorage for T0	612624	7804920	2	Workboat and/or tug operating near T0 for assembly of the dredge pipeline
Transfer vessel in transit	622138	7800851	2	A small transfer vessel (nominally 12 – 15 m) operating between the dredge vessel and Bowen along the possible transfer route

5.3 Modelling Prediction Results

The underwater noise contour maps depicting the received sound pressure level predictions for the three modelling scenarios are included in **Appendix C**. The contour maps are generated based on far-field noise modelling prediction results, with the maximum range up to 30 km from the noise source locations. Based on a conservative consideration in terms of the subsequent noise impact assessment, the contour maps present the highest predicted noise levels over the water column for each modelled grid point.

The noise contour maps illustrate that:

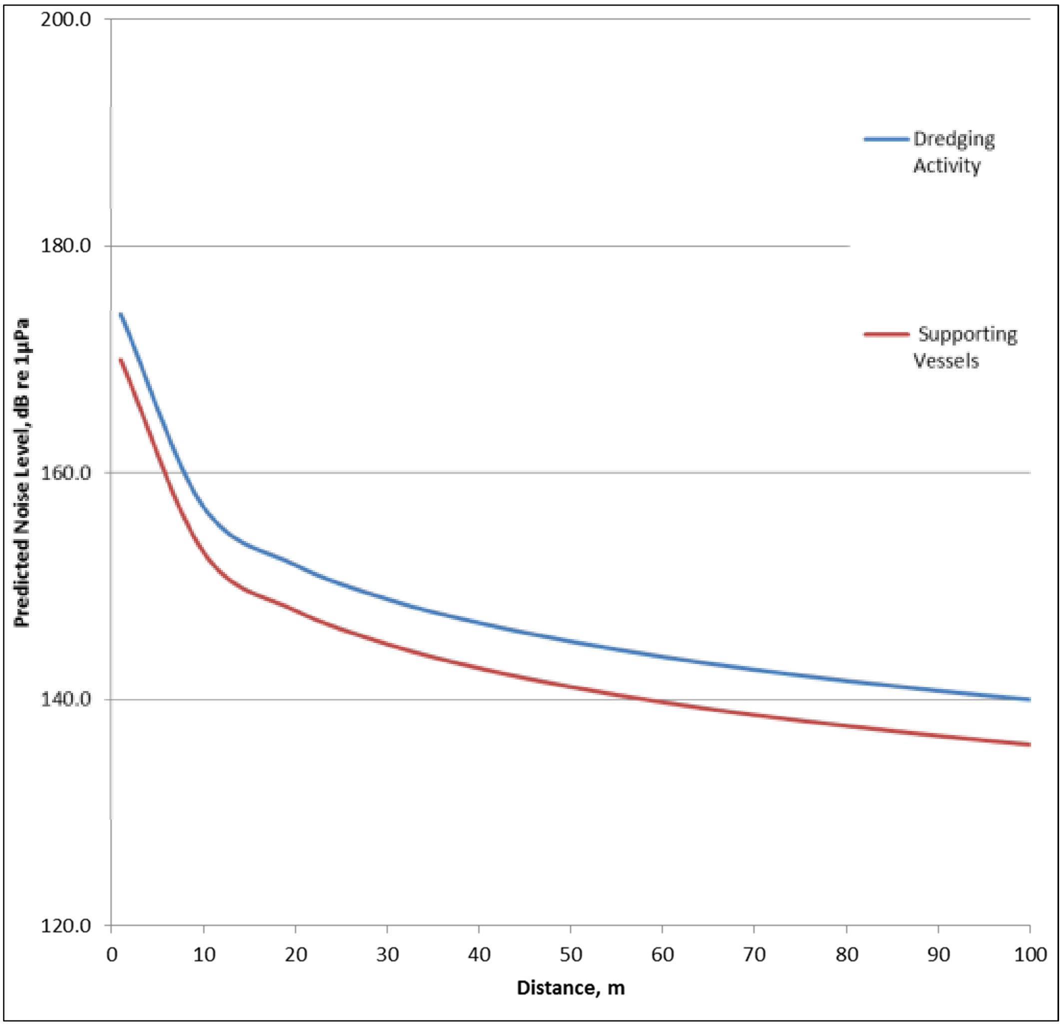
- strong transmission loss occurs when the noise propagates towards the water region which exhibits rapid upward sloping seabed in the shoreline directions,
- noise propagation is more efficient towards the open deeper water directions.

The contour maps also demonstrate the relative lower transmission loss for noise propagating along the paths with relatively constant water depth (i.e. in the directions roughly parallel to the shoreline) in comparison to noise propagating along the paths towards the deeper water region. This is because that under the condition of very reflective seabed properties as used in the noise model, the acoustic energy disperses more over the deeper water column which results in lower received noise level than over a shallower water column.

Received noise levels at close range to the noise sources are predicted based on much finer grid steps (20 m – 30 m) during the modelling process, and the prediction results for both dredging and vessel sources are shown in **Figure 9**. In general, the transmission loss in the near field within a few hundred meters to the noise sources is approximately equivalent to 17log(R), where R is the horizontal distance between the source and the receiver locations.

The near-field received sound exposure levels with different exposure time period are also predicted for both dredging and supporting vessel noise sources. As an illustration, **Figure 10** presents predicted sound exposure levels for dredging activities with exposure time periods of 1 hour, 2 hours and 24 hours respectively together with the comparisons against PTS and TTS assessment criterion.

Figure 9 Predicted Near-field Noise Levels



5.4 Zones of Noise Impact

Zones of hearing damage/threshold shifts (PTS and TTS) and behavioural response impacts for the considered marine fauna species are presented in **Table 4**, based on predicted received sound pressure levels and exposure levels as presented in Section **5.3**.

Table 4 Predicted Zones of Impact for Dredging Activities and Supporting Vessels

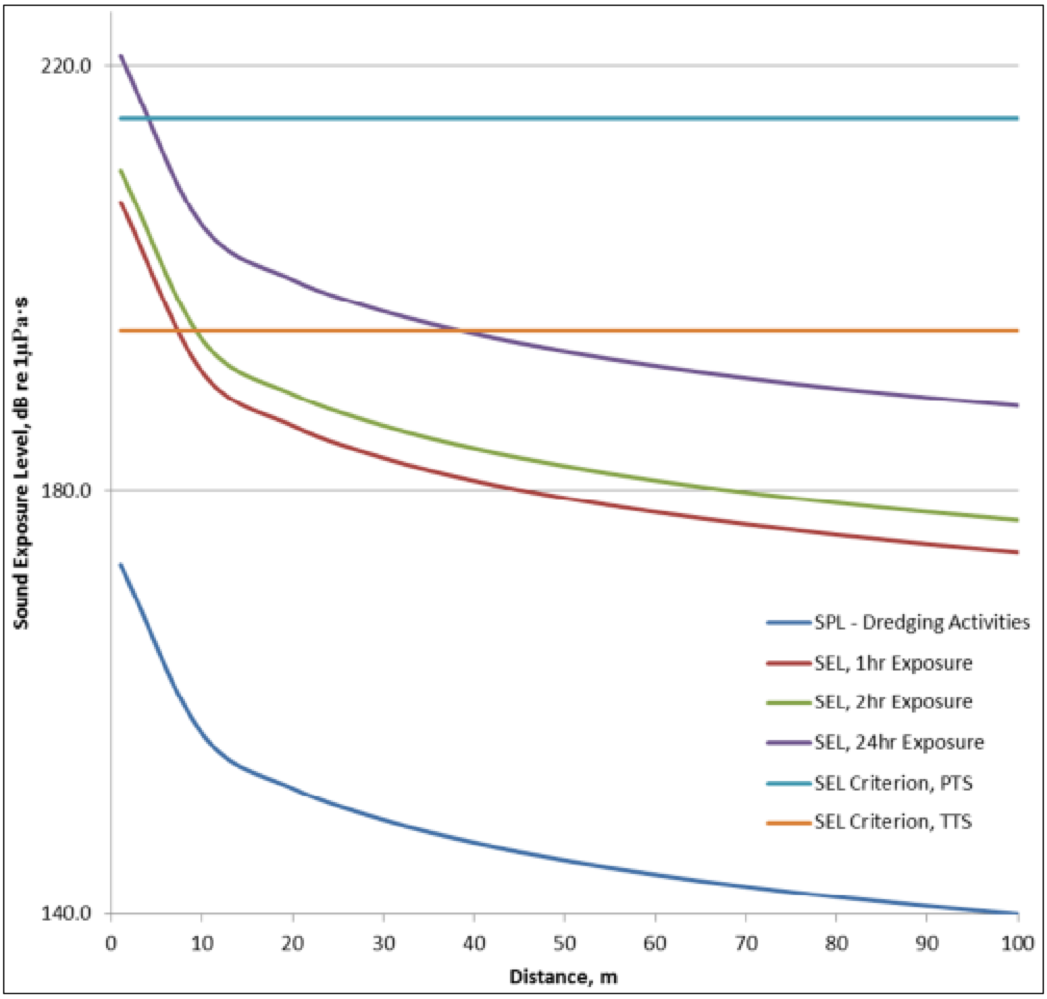
Scenarios	Zones of Noise Impact				
	PTS		**TTS**		**Behavioural Response**
	Exposure Time				
	< 2hr	> 2hr	< 2hr	> 2hr	
Dredging at T0	Not Occurring	< 10m	< 10m	< 40m	~ 3.0 km
Workboat/tug at T0				< 20m	~ 1.5 km
Transfer Vessel in Transit					~ 1.5 km

For the majority of directions, behavioural response impacts are expected to occur within 3.0 km of the dredging activities, and within 1.5 km of the supporting vessel movements respectively.

The PTS and TTS impacts are unlikely to occur unless the marine animals are exposed to the noise at very close range to the sources. For example, marine animals will suffer PTS impact if they stay more than two hours within 10 m range to the noise sources, and are expected to experience TTS effects if they stay over two hours within 20 m range to the supporting vessels and within 40 m range to the dredging activities.

The zones of cumulative impacts are also estimated under different noise source arrangement scenarios. Due to the noise emission difference between the dredging activities and supporting vessel movements, no noticeable changes for the zones of impacts are expected for a scenario in which dredging activities and supporting vessel are operating simultaneously at close range. If the two sources are distant from each other, then the zones of impact would be the cumulative zones of the two individual sources.

Figure 10 Predicted Near-field Sound Exposure Level for Dredging Activities vs PTS&TTS Criterion



5.5 Impact Assessment and Discussions

As demonstrated in the previous section, marine animals will only experience PTS or TTS impacts if they stay in close proximity to the noise sources (10 m – 40 m) with long exposure periods (more than 2 hours). This is considered an unrealistic scenario. Therefore, it is unlikely that PTS or TTS impacts will occur to any assessed marine fauna species as a result of the dredging activities and associated supporting vessel movements. As such, no monitoring and noise mitigation measures are recommended.

The operations of the proposed dredging activities and associated workboat or tug can potentially cause behavioural responses from assessed marine fauna species within a 3.0 km range. Based on the available marine ecology information provided by Advisian (WorleyParsons 2015), while mega fauna were found on occasion near the project area during targeted surveys, the area and its close surroundings were not used as resting grounds for any assessed marine fauna species. Moreover, the proposed dredging operation is within close proximity to the existing T1 terminal which can potentially elevate the ambient noise levels in the surrounding waters significantly, as described in **Section 4**. Therefore, the disturbance effect caused by the proposed dredging activities to the assessed marine fauna species is expected to be limited.

The noise stress caused by the transfer vessel supporting the dredging operations travelling between Bowen and Abbot Point is only transient in nature, and the consequent disturbance effect to the assessed marine fauna species is expected to be minimal.

6 REFERENCES

Alexander et al. (2014). Modelling Underwater Shipping Noise in the Great Barrier Reef Marine Park Using AIS Vessel Track Data. Inter.Noise Melbourne Australia.

Cato, D.H. (1997). Ambient Sea Noise in Australian Waters, Proc. Fifth International Congress on Sound and Vibration, Adelaide, Vol. 5, P2813-2818.

EPBC Act Referral – Abbot Point Dredging and Onshore Placement of Dredged Material, Australian Government, Department of Sustainability, Environment, Water, Population and Communities, 2014.

Hastings, M.C. and Popper, A.N. (2005). Effects of Sound on Fish. Sacramento, CA: California Department of Transport.

Jensen et al. (2000). Computational Ocean Acoustics. Springer-Verlag New York, Inc.

Ketten, D.R. and Bartol, S.M. (2005). Functional measures of sea turtle hearing (ONR Award No. N00014-02-1-0510).

McCauley et al. (2000a). Marine Seismic Surveys: Analysis and Propagation of Air Gun Signals, and Effects of Exposure on Humpback Whales, Sea Turtles, Fishes and Squid. Prepared for the APPEA. CMST, Curtin University.

McCauley et al. (2000b). Marine Seismic Surveys: A Study of Environmental Implications, APPEA Journal 40, 692-708.

McCauley et al. (2012). Underwater Noise Prediction from Port Development at Abbot Point QLD, Centre for Marine Science and Technology, Curtin University, Project CMST 1044 Report R2012-18.

McCauley et al. (2013). Final Report: July 2013 Survey – Monitoring Aquatic Ambient Noise and Associated Pressure Impacts in Port Curtis and Port Alma – CA130043, Blue Planet Marine, Document Reference Number: BPM-NSW-13-GPC-Report_CA130043-Aquatic Noise Monitoring-V1.3.

Nedwell et al. (2004). Fish and Marine Mammal Audiograms: A Summary of Available Information, Subacoiustech Report No. 534R0214.

Popov et al. (1990). Electrophysiological studies of hearing in some cetaceans and a manatee. In J.A.Thomas & R.A. Kastelein (Eds.), Sensory abilities of cetaceans: Laboratory and field evidence (PP. 405 - 415). New York: Plenum Press. 710 pp.

Reine et al, Characterization of underwater sounds produced by a hydraulic cutter head dredge fracturing limestone rock. DOER Technical Notes Collection ERDC TN-DOER-E34, U.S. Army Engineer Research and Development Centre, Vicksburg, Mississippi, USA.

Richardson et al. (1995). Marine Mammals and Noise, San Diego: Academic Press.

Roy Wyatt. (2008). Joint Industry Programme on Sound and Marine Life Review of Existing Data on Underwater Sounds Produced by the Oil and Gas Industry, Issue 1, Seiche Measurements Limited.

Technical Guide on Underwater Sound in Relation to Dredging, World Organisation of Dredging Association (WODA), June 2013.

Wenz, G.M. (1962). Acoustic Ambient Noise in the Ocean: Spectra and Sources. Journal of the Acoustical Society of America, 34 (12), 1936-1956.

Whitlow et al. (2008). Principles of Marine Bioacoustics. Springer Science+Business Media, LLC.

World Ocean Atlas 2005. http://www.nodc.noaa.gov/OC5/WOA05/pr_woa05.html

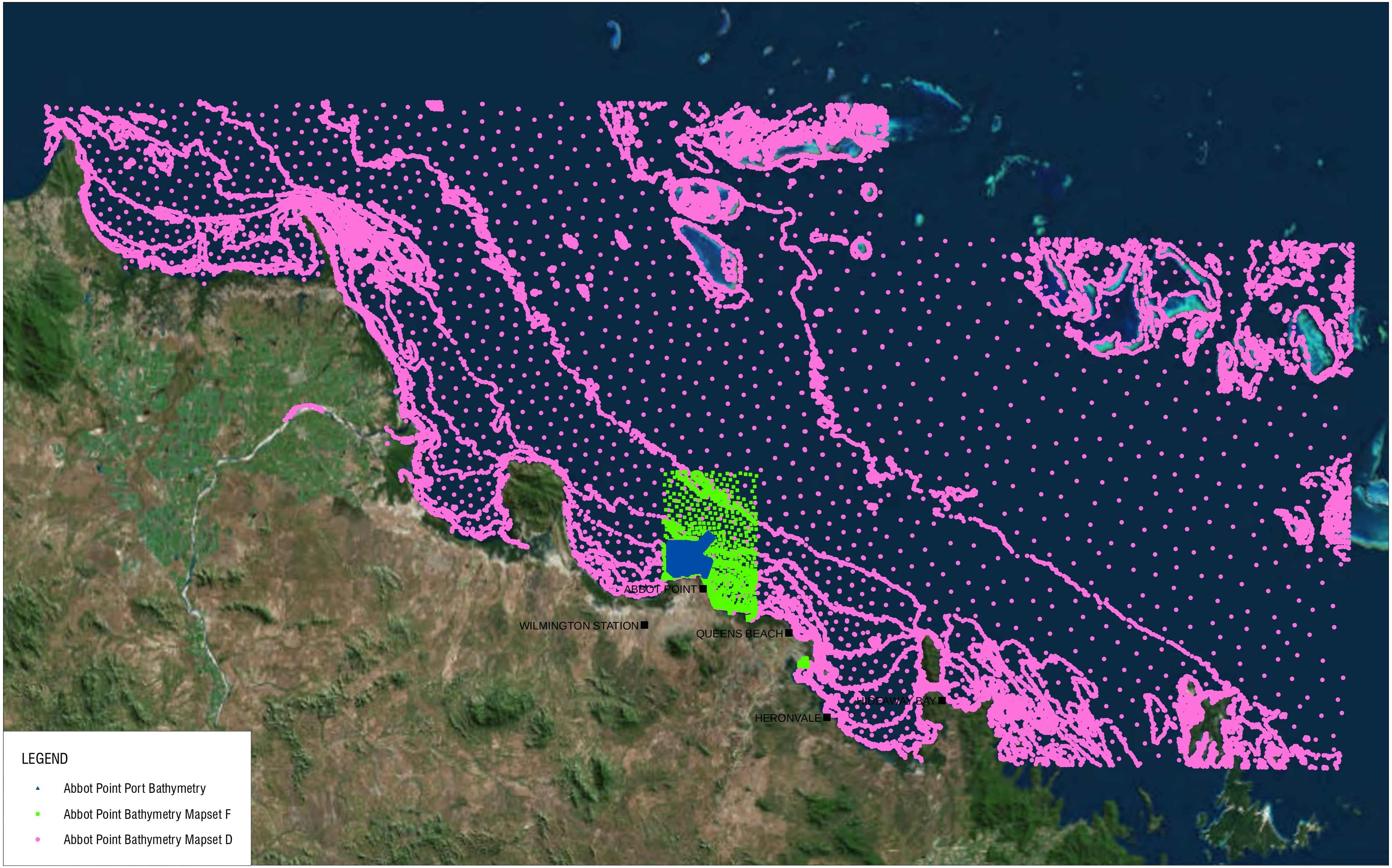
WorleyParsons (2015). Marine Ecology Technical Report, Abbot Point Growth Gateway Project. Report prepared for the Department of State Development.

Acoustic Terminology

Sound Pressure	A deviation from the ambient hydrostatic pressure caused by a sound wave
Sound Pressure Level (SPL)	The logarithmic ratio of sound pressure to reference pressure. The reference pressure underwater is P_{ref} = 1 μPa
Root-Mean-Square Sound Pressure Level (RMS SPL)	The mean-square sound pressure is the average of the squared pressure over some duration. The root-mean-square sound pressure level is the level of the root of the mean-square pressure against the reference pressure
Sound Exposure Level (SEL)	SEL is a measure of energy. Specifically, it is the dB level of the time integral of the squared instantaneous sound pressure normalised to a 1-s period
Source Level (SL)	The acoustic source level is the level referenced to a distance of 1m from a point source
1/3 Octave Band Levels	The energy of a sound split into a series of adjacent frequency bands, each being 1/3 of an octave wide.
Sound Speed Profile	A graph of the speed of sound in the water column as a function of depth

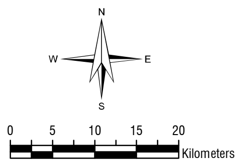
Appendix B

Bathymetric Data Coverage and Contour Map



SLR
10 KINGS ROAD
NEW LAMBTON
NEW SOUTH WALES 2305
AUSTRALIA
T: 61 2 4037 3200
F: 61 2 4037 3201
www.slrconsulting.com

Project No.:	622.10190.00300
Date:	10/07/2015
Drawn by:	NT
Scale:	1:900,000
Sheet Size:	A4
Projection:	GDA 1994 MGA Zone 55

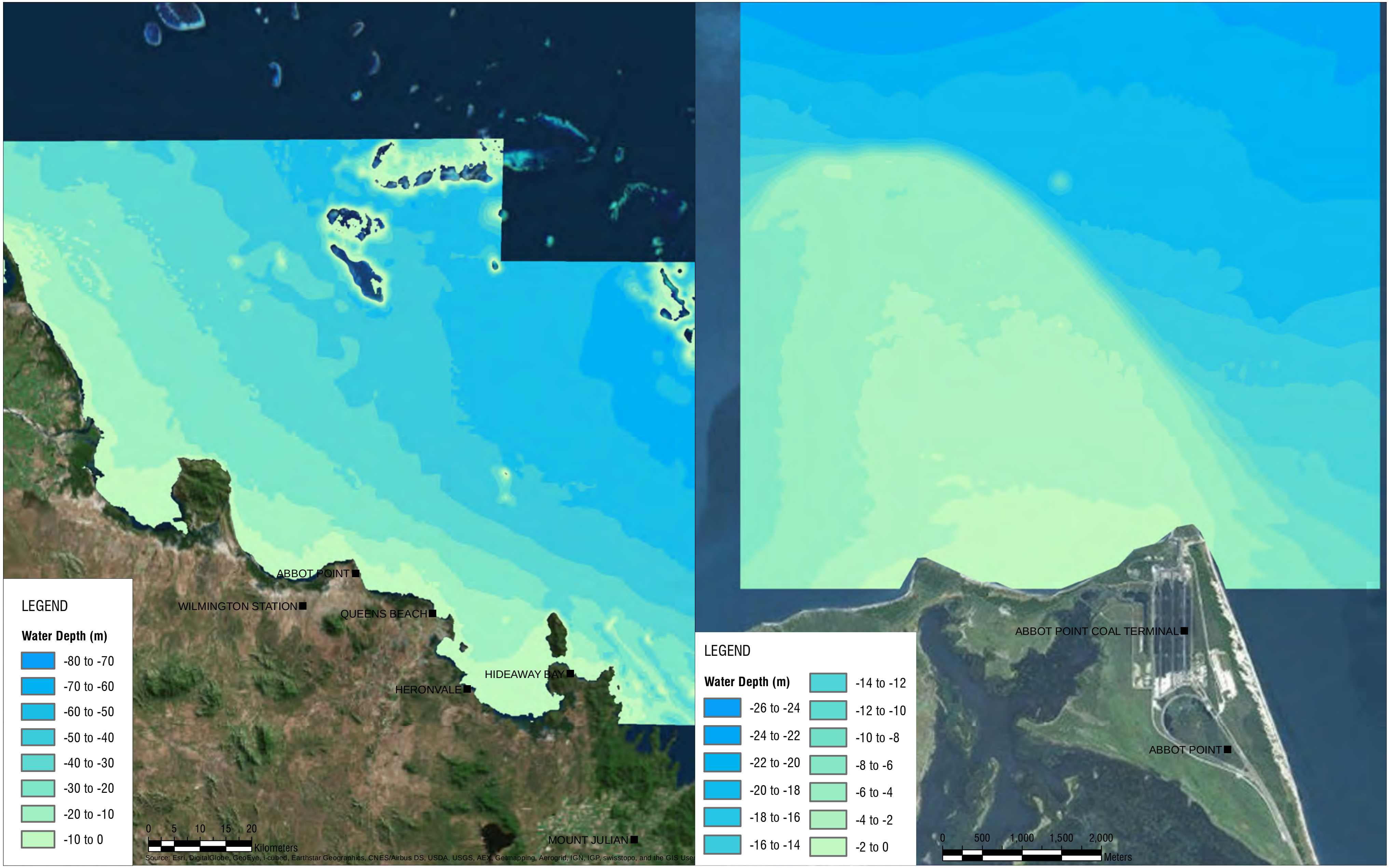


WorleyParsons

Abbot Point Growth Gateway Project

Bathymetry Dataset Coverages

FIGURE B – 1



H:\Projects-SLR\630-SrvNTL\622-TOW\622.10190 Onshore Disposal Assessment\Figures\ArcGIS\SLR62210190_B2_BathymetryDepths_03.mxd

SLR
10 KINGS ROAD
NEW LAMBTON
NEW SOUTH WALES 2305
AUSTRALIA
T: 61 2 4037 3200
F: 61 2 4037 3201
www.slrconsulting.com

The content contained within this document may be based on third party data.
SLR Consulting Australia Pty Ltd does not guarantee the accuracy of such information.

Project No.:	622.10190.00300
Date:	10/07/2015
Drawn by:	NT
Scale:	
Sheet Size:	A4
Projection:	GDA 1994 MGA Zone 55

WorleyParsons

Abbot Point Growth Gateway Project

Bathymetry Contour

FIGURE B - 2

Appendix C

Report Number 622.10190-R6R1

Underwater Noise Modelling Prediction Contour Maps

H:\Projects-SLR\630-SrvNTL\622-TOW\622.10190 Onshore Disposal Assessment\Figures\ArcGIS\SLR62210190_C1_Noise_02.mxd

SLR
10 KINGS ROAD
NEW LAMBTON
NEW SOUTH WALES 2305
AUSTRALIA
T: 61 2 4037 3200
F: 61 2 4037 3201
www.slrconsulting.com

The content contained within this document may be based on third party data. SLR Consulting Australia Pty Ltd does not guarantee the accuracy of such information.

Project No.:	622.10190.00300
Date:	10/07/2015
Drawn by:	NT
Scale:	1:300,000
Sheet Size:	A4
Projection:	GDA 1994 MGA Zone 55

WorleyParsons

Abbot Point Growth Gateway Project

Dredging Activities for T3

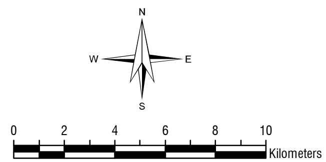
FIGURE C - 1

H:\Projects-SLR\630-SrvNTL\622-TOW\622.10190 Onshore Disposal Assessment\Figures\ArcGIS\SLR62210190_C2_Noise_02.mxd

SLR

10 KINGS ROAD
NEW LAMBTON
NEW SOUTH WALES 2305
AUSTRALIA
T: 61 2 4037 3200
F: 61 2 4037 3201
www.slrconsulting.com

Project No.:	622.10190.00300
Date:	10/07/2015
Drawn by:	NT
Scale:	1:300,000
Sheet Size:	A4
Projection:	GDA 1994 MGA Zone 55



WorleyParsons

Abbot Point Growth Gateway Project

Dredging Activities for T0

FIGURE C - 2

H:\Projects-SLR\630-SrvNTL\622-TOW\622.10190 Onshore Disposal Assessment\Figures\ArcGIS\SLR62210190_C3_Noise_02.mxd

SLR
10 KINGS ROAD
NEW LAMBTON
NEW SOUTH WALES 2305
AUSTRALIA
T: 61 2 4037 3200
F: 61 2 4037 3201
www.slrconsulting.com

Project No.:	622.10190.00300
Date:	10/07/2015
Drawn by:	NT
Scale:	1:300,000
Sheet Size:	A4
Projection:	GDA 1994 MGA Zone 55

WorleyParsons

Abbot Point Growth Gateway Project

Supporting Vessel (Workboat/Tug) in Anchorage for T3

FIGURE C - 3

H:\Projects-SLR\630-SrvNTL\622-TOW\622.10190 Onshore Disposal Assessment\Figures\ArcGIS\SLR62210190_C4_Noise_02.mxd

SLR

10 KINGS ROAD
NEW LAMBTON
NEW SOUTH WALES 2305
AUSTRALIA
T: 61 2 4037 3200
F: 61 2 4037 3201
www.slrconsulting.com

Project No.:	622.10190.00300
Date:	10/07/2015
Drawn by:	NT
Scale:	1:300,000
Sheet Size:	A4
Projection:	GDA 1994 MGA Zone 55

WorleyParsons

Abbot Point Growth Gateway Project

Transfer Vessel in Transit

FIGURE C - 4