Port of Gladstone
Gatcombe and Golding Cutting
Channel Duplication Project

Environmental Impact Statement

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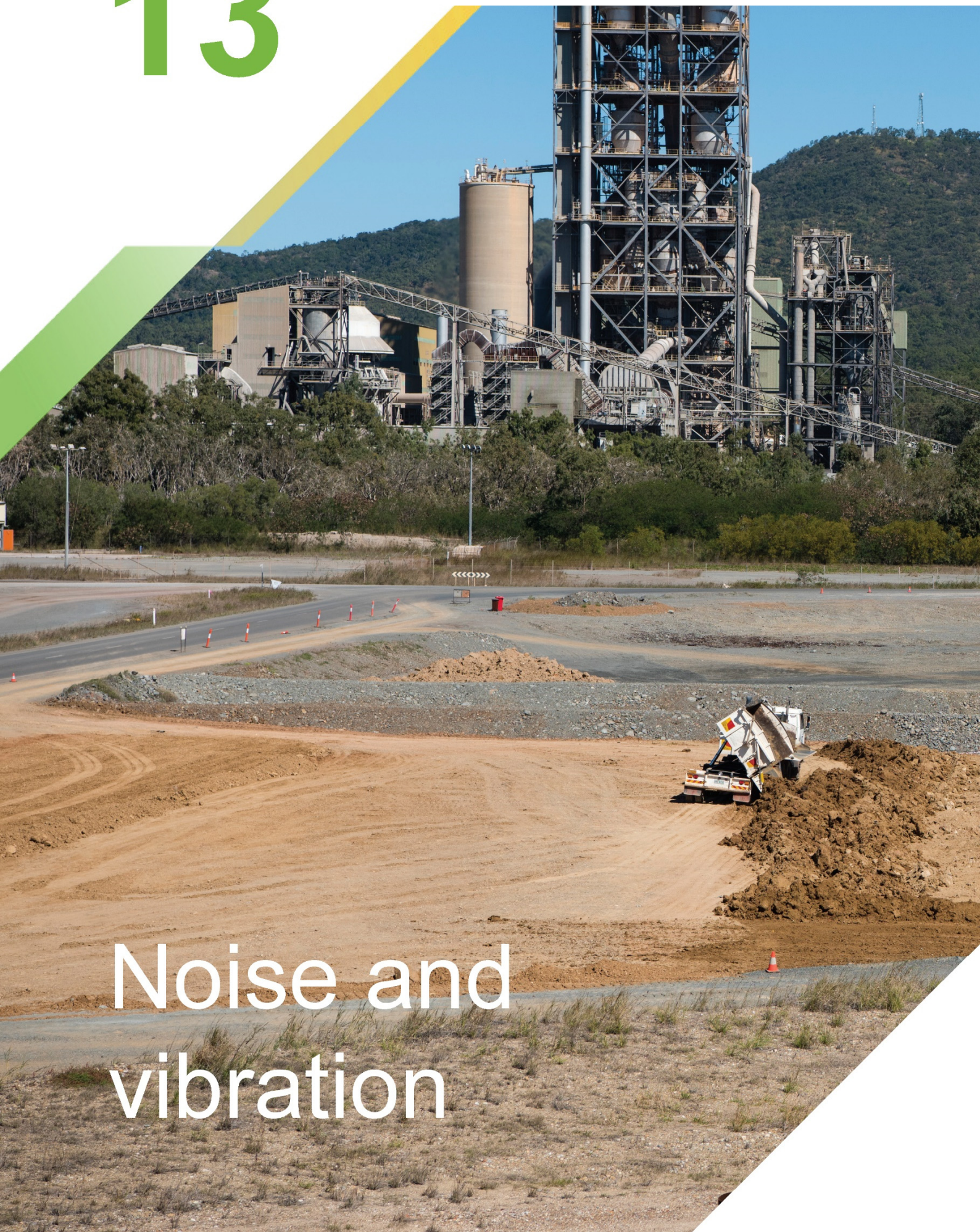

Noise and vibration

Contents

13 Noise and vibration

13.1 Chapter purpose

The purpose of this chapter is to assess the potential noise and vibration impacts on the terrestrial and underwater environments associated with the construction and maintenance phases of the Project.

In terms of the terrestrial environment, the airborne noise levels have been assessed at nearby sensitive receptors, while the assessment of ground vibration levels has considered potential impacts relating to human comfort and cosmetic damage to buildings and structures arising from Project activities.

The assessment process for the underwater environment has involved the identification of noise sensitive marine fauna species which are likely to inhabit/frequent the Project direct and indirect impact areas, and development of assessment criteria. The characterisation of the existing underwater noise environment was informed by baseline noise monitoring at representative locations.

Elements of the noise and vibration assessment include:

- Identification of the terrestrial noise sensitive receptors and land uses, including terrestrial fauna (refer Section 13.4.1)
- Identification of potentially sensitive marine fauna receptor species (refer Section 13.4.2)
- Description the existing noise environment and ambient noise monitoring undertaken for both terrestrial noise and vibration, and underwater noise (refer Section 13.4)
- Confirmation of the environmental value and assessment criteria against which airborne noise and vibration from the Project is to be assessed (refer Section 13.5.1)
- Confirmation of the environmental value and assessment criteria against which underwater noise from the Project is to be assessed (refer Sections 13.5.2.1 and 13.5.2.2)
- Assessment of potential noise and vibration impacts during the construction and maintenance phases of the Project for both the terrestrial and underwater environments (refer Section 13.6.1 and Section 13.6.2, respectively)
- Identification of mitigation measures to be implemented to minimise the potential noise and vibration impacts from the Project (refer Section 13.7).

The noise and vibration assessment also informs the Project description and other impact assessment chapters in the EIS, including:

- Nature conservation (Chapter 9)
- Social impact assessment (Chapter 18)
- Cumulative impact assessment (Chapter 21).

13.2 Methodology

13.2.1 Terrestrial noise and vibration

The assessment of terrestrial noise and vibration for the construction and maintenance phases of the Project has involved the following tasks:

- Based on the Project description, noise and vibration assessment scenarios were established for the key stages of construction and maintenance phases of the Project

- A baseline noise monitoring survey was undertaken to quantify and characterise the existing noise environment at locations representative of the communities near to the proposed construction and maintenance activities of the Project
- Noise assessment criteria were determined with reference to the monitored existing noise levels to provide criteria specific to the local environment and communities
- The identification of noise sensitive terrestrial fauna (migratory shorebirds) and assessment criteria with respect to behavioural responses and physiological effects associated with the auditory system from existing data sources
- The principal sources of noise and vibration associated with the construction and maintenance of the Project were identified and each source was assigned an appropriate emission level
- A noise prediction model was developed to calculate airborne noise levels at the noise sensitive receptors for each of the assessment scenarios. The noise model provided calculated noise levels accounting for the commonly occurring meteorological conditions in the Project impact areas.
- Road traffic noise levels with the inclusion of the Project road traffic were calculated to identify the potential change in the existing road traffic noise during the construction of the WBE reclamation area and BUF
- Ground vibration levels were qualitatively assessed at nearby receptors based on the likely emission of vibration from plant and equipment, and the separation distance to the nearby receptors
- The predicted noise and vibration levels were evaluated against the adopted assessment criteria to demonstrate compliance to relevant acoustic standards, policy and guidelines
- The predicted noise levels and monitored existing noise levels were referenced to identify the potential for impacts associated with audible noise from Project activities
- The assessment of noise and vibration levels was applied to identify the measures necessary to reduce noise and vibration levels and potentially mitigate impacts.

The various detailed assessment methodologies, including noise prediction modelling, source noise emission levels, adopted meteorological conditions, typical vibration levels and the road traffic movements are explained further in Appendix K1 (Section 6).

13.2.2 Underwater noise

The assessment of underwater noise for the construction and maintenance phases of the Project has involved the following tasks:

- Based on the Project description, identification of the noise sensitive marine fauna species potentially occurring within the Project impact areas
- The identification of assessment criteria for the noise sensitive marine fauna species with respect to behavioural responses and physiological effects associated with marine fauna auditory systems from existing data sources
- The characterisation of existing underwater acoustic environment with monitoring of existing underwater noise levels at four representative locations with the installation of a noise logger at each location to continuously measure ambient noise levels over a consecutive three-month period, as well as in-depth temporal and spectral analysis of the noise data
- The identification of major noise sources and their noise emission characteristics
- A noise prediction model was developed to calculate potential Project noise levels and potential noise impacts on the marine fauna species using bathmetry data, sound speed profiles and seafloor geodata
- The determination of zones of impact by comparison of the predicted received levels to the noise exposure criteria

- The assessment of potential underwater noise impacts on aquatic fauna during the construction and maintenance phases of the Project, as well as the implication of the baseline noise environment in relation to the noise impacts
- The assessment of noise and vibration levels was applied to identify the measures necessary to reduce potential noise impacts on marine fauna and mitigate impacts.

The various detailed assessment methodologies, including bathymetry and seafloor geo acoustic modelling and sound speed profiling are explained further in Appendix K2 (Section 6).

13.3 Legislative and policy context

13.3.1 Terrestrial noise and vibration

The EP Act seeks to protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends. It describes environmental contamination, harm and nuisance, and provides default noise standards by which these effects are expected to be avoided.

The EPP (Noise) which is prepared in accordance with the EP Act, identifies environmental values to be enhanced or protected and defines acoustic quality objectives. It provides a framework for making consistent, equitable and informed decisions about acoustic environments within Queensland.

The EPP (Noise) prescribes acoustic quality values to protect the health and diversity of ecosystems, and the amenity of the community as well as for human health and wellbeing, by ensuring suitable environments for individuals' sleep, study, recreation and relaxation.

Schedule 1 of the policy confirms those activities and land uses which it defines as noise sensitive receptors, namely:

- Residential dwellings
- Library and educational institutions
- Childcare or kindergarten centres
- Hospitals, surgery or other medical institutions
- Commercial and retail land areas
- Protected areas or an area identified under a conservation plan under the NC Act as a critical habitat or an area of major interest
- Park or garden that is open to the public for the use other than for sport or organised entertainment.

The EPP (Noise) sets acoustic quality objectives for each of these sensitive receptor categories and these have been used in the noise assessment for this Project. These objectives are confirmed in Table 13.1.

Table 13.1 Acoustic quality objectives

Receptor type	Time of day	Acoustic quality objectives (dBA)		
		$L_{Aeq,adj,\ 1hr}$	$L_{A10,adj,\ 1hr}$	$L_{A1,adj,\ 1hr}$
Residential dwelling (outdoors)	Day time and evening	50	55	65
Residential dwelling (indoors)	Daytime and evening	35	40	45
	Night-time	30	35	40
Library and education institutions (indoors)	When open for business or when classes offered	35	-	-
Childcare centre or kindergarten (indoors)	When open for business, other than when children usually asleep	35	-	-
Childcare centre or kindergarten (indoors)	When children usually asleep,	30	-	-
School or playground (outdoors)	When the children usually play outside	55	-	-
Hospital, surgery or other medical institution (indoors)	Visiting hours	35	-	-
Hospital, surgery or other medical institution (indoors)	Anytime, other than visiting hours	30	-	-
Commercial and retail activity (indoors)	When the activity is open for business	45	-	-
Park or garden that is open to the public for use other than for sport or organised entertainment	Anytime	The level of noise that preserves the amenity of the existing park or garden		
Protected area, or an area identified under a conservation plan under the NC Act as a critical habitat or an area of major interest	Anytime	The level of noise that preserves the amenity of the existing area or place to protect the health and biodiversity of ecosystems		

Table notes:

dBA = A-weighted decibel

$L_{Aeq,adj,1hr}$ means an A-weighted sound pressure level of a continuous steady sound, adjusted for tonal character, that within a 1 hour period has the same mean square sound pressure of a sound that varies with time

$L_{A10,adj,1hr}$ means the A-weighted sound pressure level, adjusted for tonal character or impulsiveness, that is exceeded for 10% of a 1 hour period when measured using time-weighting 'F'.

$L_{A1,adj,1hr}$ means the A-weighted sound pressure level, adjusted for tonal character or impulsiveness, that is exceeded for 1% of a 1 hour period when measured using time-weighting 'F'.

Source: EPP (Noise) Schedule 1

While the migratory shorebird habitat in proximity to the Project impact areas is not listed as a protected area under the provisions of the NC Act, it is known to regularly support migratory shorebirds, including species of conservation significance as listed under the provisions of the NC Act and the EPBC Act. As such, the EPP (Noise) objectives have been considered in the assessment of noise impacts on terrestrial fauna species.

Ecoaccess Guideline: Planning for Noise Control (PNC) (EPA 2004) provides a framework for conditions related to noise emissions from a variety of sources and guidance on steady state noise (e.g. heavy trucks). The guideline is applicable to sounds from all sources, individual and in combination, which contribute to the total noise at a sensitive receptor. This guideline is currently under review.

13.3.2 Underwater noise

There is no Commonwealth legislation or regulatory guidelines in Australia for the assessment of underwater noise impacts on marine fauna.

It is noted that the GBRMPA is in the process of developing guidelines in relation to underwater noise, however, only a discussion and options process paper (McPherson et al. 2017) is currently available from which draft guidelines are expected to be advanced. This paper does not contain any commentary or draft objectives or criteria to which regard may be given in the absence of any regulations.

There are currently no Queensland guidelines on acceptable underwater noise exposure levels for marine fauna derived from construction activities.

The Government of South Australia has produced *Underwater Piling Noise Guidelines* (2012) which are a useful point of reference. These include a framework for the management and mitigation of underwater noise from piling impact, incorporating:

- Safety zones – these are observation and shut-down zones based on the likely noise levels produced by the piling activity
- Standard management and mitigation procedures – these procedures are recommended for all piling activities, irrespective of location and time of year, when marine mammal species may potentially be present within the noise footprint of the piling activity
- Additional management and mitigation procedures – to be used when the impacts of the piling activity on listed marine mammal species are likely to be significant.

13.4 Description of existing environment

13.4.1 Terrestrial noise and vibration

13.4.1.1 Sensitive terrestrial receptors

Communities and land uses

The communities of Gladstone, Boyne Island, Tannum Sands and Facing Island are all located within proximity of the Project activities. These communities contain a range of noise sensitive receptors as defined by the EPP (Noise).

Table 13.2 and Figure 13.1 show representative terrestrial noise sensitive receptors (residential and non-residential) up to 30km from the Project area and their distance to specific components of the Project activities. The selection of terrestrial noise receptors was based on the proximity to the Project impact areas and providing a cross section of the different receptor types for the assessment of potential impacts at the communities on the mainland and nearby islands.

The nearest terrestrial noise sensitive receptors to the Project activities are located at Facing Island being approximately 1km from the channel duplication area to be dredged, while those in Targinnie are approximately 4km from the WBE reclamation area and BUF.

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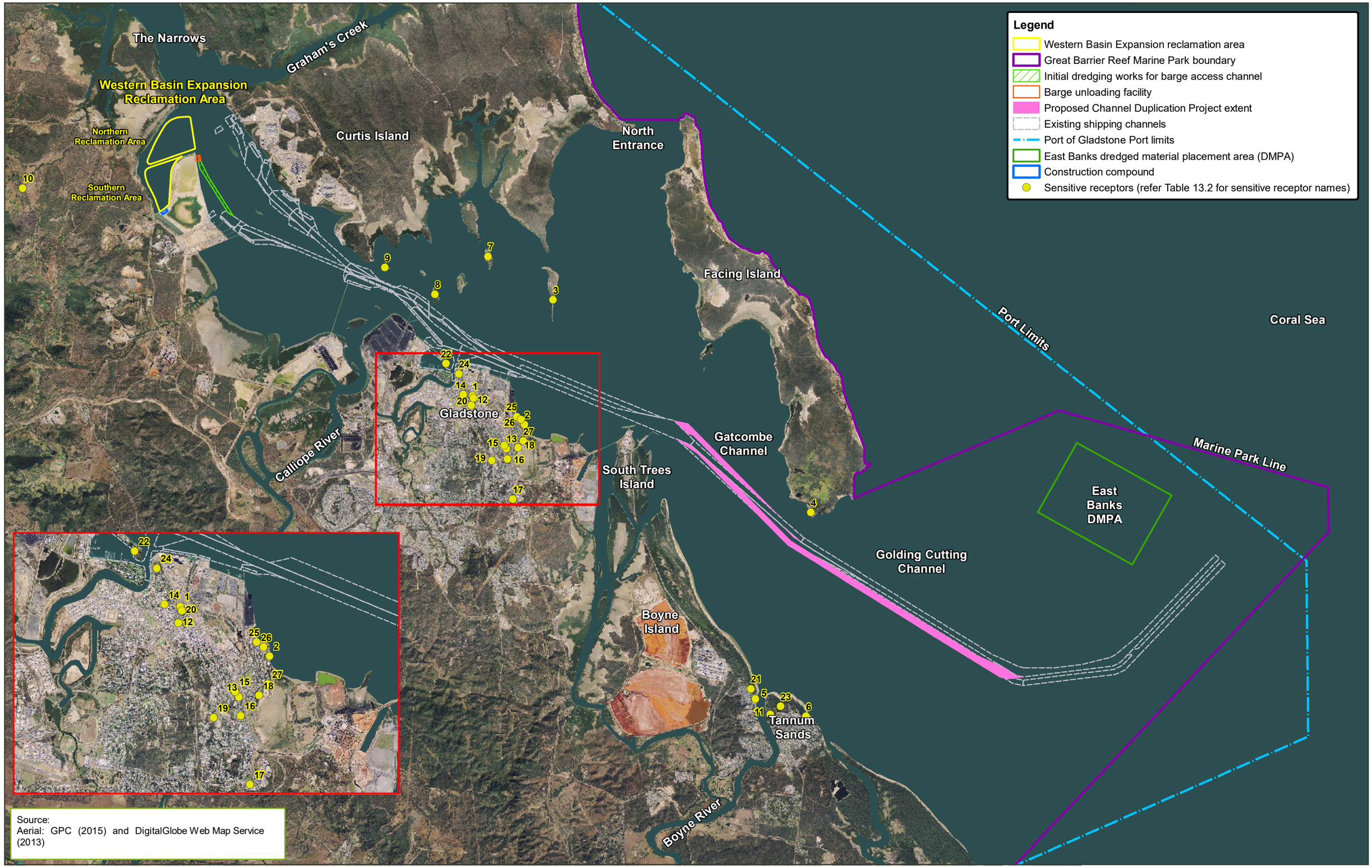

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Coordinate system: GDA_1994_MGA_Zone_56

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Figure 13.1: Representative terrestrial noise sensitive receptors

Table 13.2 Representative terrestrial noise sensitive receptors

ID	Sensitive receptor area/name	Approximate distance to Project areas			
		Barge access channel	BUF	WBE reclamation area	Channel duplication
Residential receptors and land use					
1	Gladstone City	6.2km	11.9km	12.5km	7.0km
2	Barney Point	8.2km	13.9km	14.6km	5.2km
3	Quoin Island	7.3km	12.7km	13.5km	6.0km
4	Facing Island (northwest and south)	18.3km	24.0km	24.8km	0.9km
5	Boyne Island	20.7km	26.4km	26.8km	5.1km
6	Tannum Sands	22.4km	28.1km	28.5km	4.7km
7	Turtle Island	5.0km	10.1km	10.9km	8.5km
8	Witt Island	2.7km	8.0km	9.0km	10.1km
9	Tide Island	1.4km	6.7km	7.9km	11.3km
10	Targinnie	6.4km	6.6km	4.3km	24.1km
Library, educational, childcare or health uses					
11	St. Francis Catholic Primary School, Tannum Sands	21.4km	27.0km	27.5km	5.3km
12	Stepping Stones Child Care Centre, Gladstone	6.5km	12.1km	12.7km	7.1km
13	Goodstart Early Learning, Gladstone	8.4km	14.0km	14.5km	5.9km
14	Gladstone City Library, Gladstone	6.0km	11.7km	12.2km	7.4km
15	Harbour City Medical Centre, South Gladstone	8.3km	13.9km	14.4km	5.9km
16	Gladstone South State School, South Gladstone	8.7km	14.3km	14.8km	5.9km
17	Toolooa State High School, Gladstone	9.9km	15.4km	15.8km	6.0km
18	Kareeba Scout Hall, Barney Point	8.6km	14.3km	14.8km	5.5km
19	CQ University Gladstone Campus, Gladstone	8.4km	13.9km	14.4km	6.4km
20	Gladstone Central State School, Gladstone Central	6.1 km	11.8km	12.4 km	7.1 km
Park or nature conservation					
21	Wyndam Park, Boyne Island	20.3km	26.0km	26.4km	4.9km
22	Spinnaker Parklands	4.8km	10.5km	11.2km	8.1km
23	Canoe Point Botanic Reserve and Environmental Park	21.5km	27.2km	27.6km	4.9km
24	James Cook Park, Gladstone	5.4km	11.1km	11.7km	7.7km
25	Barney Point Park, Barney Point	7.9km	13.6km	14.6km	5.2km
26	Friend Park, Barney Point	8.0km	13.8km	14.4km	5.3km
27	Hector Johnson Park, Barney Point	8.6km	14.2km	14.9km	5.3km
Commercial/retail					
28	Gladstone City	6.3km	11.9km	12.5km	7.2km

As evident from Table 13.2 and Figure 13.1, many of the potential terrestrial noise sensitive receptors are located at distances greater than 1km from potential sources of noise and vibration associated with the Project activities. The only sensitive receptors within 1km of the Project activities are those noted at Facing Island.

There is a range of industrial land uses on mainland Gladstone and on Curtis Island. While offices associated with these industrial land uses can be defined as noise sensitive receptors, due to the noise levels currently experienced within these sites, the offices are not considered terrestrial noise sensitive receptors for the purpose of this assessment.

Terrestrial fauna

The coastline of Gladstone and the local islands, particularly the coastal habitats, provide migratory shorebird habitat. As confirmed in the terrestrial ecology information collated as part of the Project EIS (refer Chapter 9 (nature conservation), Figure 9.61), the WBE reclamation area, BUF and the barge access channel are generally located within 500m of confirmed roost sites for migratory shorebirds, while other roosting areas are located at least 1km from the channel duplication area to be dredged.

The potential habitat shown on Figure 9.51 is also considered suitable habitat for resident shorebird species, including the Beach stone curlew and other non-conservation significant resident shorebirds. Non-migratory shorebirds may utilise coastal habitats adjacent to the Project impact areas although nesting sites have not been confirmed.

The potential acoustic effects on terrestrial fauna relate to behavioural responses such as:

- Behaviour changes to avoid noise sources or impaired communication
- Increased energy expenditure or physical injury to avoid noise sources
- Physiological effects associated with the auditory system which could temporarily or permanently affect hearing.

13.4.1.2 Background noise environment

To determine the existing terrestrial noise environment for communities and land uses, monitoring was undertaken at three locations below. These locations are considered to be representative of the nearest residential communities to the Project activity areas as shown on Figure 13.2. The three noise monitoring sites were selected at residential areas within 3km of the proposed Project impact areas to quantify the noise environment at locations representative of the nearest residential communities. Monitoring locations were selected for their proximity to the noise sensitive receptors and being readily and safely accessible. The locations were set back from main roads and local industry to quantify the existing noise environment in the residential communities.

- Location 1 – Sutton Street, Barney Point, representative of nearest receptors to the west of the area to be dredged
- Location 2 – Alkina Crescent at Boyne Island, approximately 4.9km from the area to be dredged, representative of the residential communities near Boyne Island, Tannum Sand and Facing Island
- Location 3 – Sea Belle Esplanade, Facing Island, located approximately 0.9km from the area to be dredged and the installation of new navigation aids adjacent to the shipping channels.

Table 13.3 provides the daytime measured noise levels and description of existing noise sources for each location.

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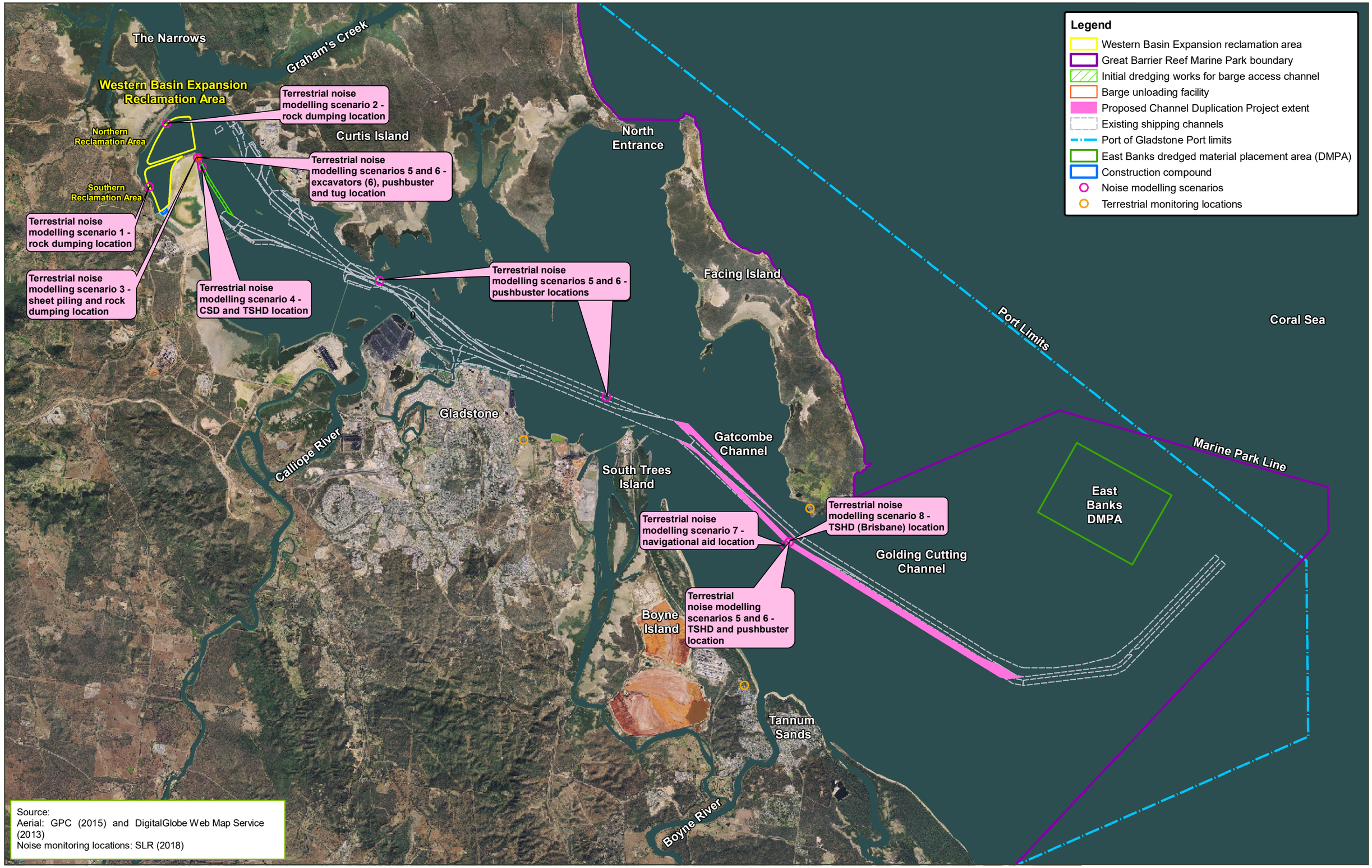

Source:
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Noise monitoring locations: SLR (2018)

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Figure 13.2: Terrestrial noise monitoring and modelling scenario locations

Table 13.3 Daytime noise measurements

Location	Date/time	Measured noise level (dBA)				Comments
		L_{A90}	L_{Aeq}	L_{A10}	L_{A1}	
Location 1 Barney Point	11 September 2014 5.30pm	39	46	47	57	Industrial noise (hum) from existing facilities audible. Local road traffic vehicle and bird noise occasionally audible.
	4 November 2014 10.50am	51	55	58	62	Noise levels affected by local wind conditions. During lull in the wind, the existing industrial premises on Curtis Island were audible as an industrial 'hum'.
Location 2 Boyne Island	11 September 2014 2.40pm	40	44	46	52	Industrial noise (hum) from existing industrial plant audible. Local road traffic vehicle, bird calls and breeze blown vegetation occasionally audible.
	4 November 2014 12.00pm	49	52	54	59	Noise levels affected by local wind conditions. During lull in the wind bird noise and breeze blown vegetation were dominant. Industrial noise from the existing sites just audible.
Location 3 Facing Island	12 September 2014 8.15am	41	43	45	47	Beach breaks and wave noise dominant. Industrial noise (hum) from Gladstone was just audible. Other sources include recreational boats and bird calls.
	4 November 2014 8.50am	48	51	54	56	Noise levels affected by local wind conditions resulting in dominant noise from waves and wind-blown vegetation.

Table notes:

dBA = A-weighted decibel

$L_{Aeq,adj,1hr}$ means an A-weighted sound pressure level of a continuous steady sound, adjusted for tonal character, that within a 1 hour period has the same mean square sound pressure of a sound that varies with time

$L_{A10,adj,1hr}$ means the A-weighted sound pressure level, adjusted for tonal character or impulsiveness, that is exceeded for 10% of a 1 hour period when measured using time-weighting 'F'.

$L_{A1,adj,1hr}$ means the A-weighted sound pressure level, adjusted for tonal character or impulsiveness, that is exceeded for 1% of a 1 hour period when measured using time-weighting 'F'.

As shown in Table 13.3, the monitoring at Barney Point (Location 1) confirmed a measured steady-state noise level of L_{A90} 39 dBA as representative of existing daytime industrial noise. The monitoring at Boyne Island (Location 2) confirmed a measured steady-state noise level of L_{A90} 40 dBA as representative of existing daytime industrial noise. However, the monitoring at Facing Island (Location 3) determined that existing industrial noise was not a primary contributor to the measured noise levels.

Table 13.4 provides a summary of the analysed noise levels monitored for each location.

Table 13.4 Long term monitoring noise levels

Location	Time period[1]	Rating background level (dBA)	Ambient noise level ($L_{Aeq, 1hr}$ dBA)
Location 1 Barney Point	Daytime	41	52
	Evening	41	46
	Night-time	43	53
Location 2 Boyne Island	Daytime	37	50
	Evening	37	46
	Night-time	35	51
Location 3 Facing Island	Daytime	36	52
	Evening	38	49
	Night-time	38	52

Table notes:

Daytime is 7.00am to 6.00pm, evening is 6.00pm to 10.00pm and night-time is 10.00pm to 7.00am

$L_{Aeq, 1hr}$ means an A-weighted sound pressure level of a continuous steady sound, that within a 1 hour period has the same mean square sound pressure of a sound that varies with time

As shown in Table 13.4, the Rating Background Level (RBL) only varies between 1 dBA to 2 dBA over daytime, evening and night-time period for all three locations. This indicates that when the coastal wind conditions are not influencing the measured ambient noise levels, the RBL can be considered indicative of the steady-state contribution from the existing industrial facilities in the region.

13.4.1.3 Regional meteorological conditions

Weather conditions have the potential to affect noise propagation by either enhancing or suppressing it and therefore, can influence both the level of noise experienced at a receptor location and the perception of specific sources of noise.

Consistent with DES' PNC guideline wind conditions are considered in noise assessments when the source to receptor wind speeds of 3m/s or less (at 10m above ground level) occur for 30% or more of the time in any assessment period (daytime, evening or night-time) in any season. Temperature is considered when the air temperature increases with height (temperature inversion).

The local weather conditions at Gladstone are complex due to the influence of the open water along the coastline and landmass of Curtis Island and Facing Island.

Weather data is collected at the Gladstone Airport weather station and the DES's South Gladstone weather station. Although these weather monitoring stations are located approximately 13km from the WBE reclamation area and 9km from the areas to be dredged, it is not considered appropriate to solely rely on this data to determine the specific meteorological conditions for the Project impact areas.

Consequently, meteorological modelling was undertaken to provide specific meteorological conditions for the region of the WB and WBE reclamation areas, BUF, barge access channel and the channel duplication area to be dredged. From analysis of the modelling results the following conclusions have been reached:

WB and WBE reclamation areas, BUF and barge access channel

- Temperature inversion conditions are not a feature because the coast location does not result in calm, stable atmospheric conditions necessary for a temperature inversion to form
- East northeast is the most commonly occurring prevailing wind direction for the daytime
- Southeast is the most commonly occurring prevailing wind direction for night-time
- Daytime wind speed conditions are commonly above 3m/s and therefore, daytime wind conditions do not need to be considered for the noise assessment for this area

- Night-time wind speeds are up to 3m/s and therefore, night-time wind conditions do need to be considered for the noise assessment for this area.

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- Temperature inversion conditions are not a feature because the coastal location does not result in calm, stable atmospheric conditions necessary for a temperature inversion to form
- South southeast is the most commonly occurring prevailing wind direction of up to 3m/s for night-time. Therefore, night-time wind conditions do need to be considered for the noise assessment for this area
- The night-time would be the most sensitive period for the proposed 24 hour activities for the duplication of the Gatcombe and Golding Cutting Channels on the nearby communities of Facing Island, Boyne Island and Gladstone.

13.4.2 Underwater noise

13.4.2.1 Sensitive marine fauna receptors

A number of marine fauna species of environmental significance occur or have the potential to occur in proximity to the Project impact areas, with reference to the marine ecology information collated as part of Chapter 9 (nature conservation) and Appendix I1. Table 13.5 provides a list of marine fauna species, their conservation status with respect to the NC Act and EPBC Act, and their likelihood of occurrence within the Project impact areas.

Table 13.5 Conservation significant and migratory marine fauna species that potentially occur within the Project area

Marine fauna species	Scientific name	Conservation status		Likelihood of occurrence in the Project area
		EPBC Act	NC Act	
Megafauna (marine mammals)				
Humpback whale	*Megaptera novaeangliae*	Vulnerable Migratory	Vulnerable	Confirmed
Southern right whale	*Eubalaena australis*	Endangered Migratory	Least Concern	Low
Bryde's whale	*Balaenoptera edeni*	Migratory	Least Concern	Low
Sei whale	*Balaenoptera borealis*	Vulnerable Migratory	Least Concern	Low
Sperm whale	*Physeter macrocephalus*	Migratory	Least Concern	Low
Killer whale	*Orcinus orca*	Migratory	Least Concern	Low
Australia snubfin dolphin	*Orcaella heinsohni*	Migratory	Vulnerable	Low
Australian humpback dolphin	*Sousa sahulensis*	Migratory	Vulnerable	Confirmed
Dugong	*Dugong dugon*	Migratory	Vulnerable	Confirmed
Marine turtles				
Flatback turtle	*Natator depressus*	Vulnerable	Vulnerable	Confirmed
Green turtle	*Chelonia mydas*	Vulnerable	Vulnerable	Confirmed
Loggerhead turtle	*Caretta caretta*	Endangered Migratory	Endangered	Moderate
Hawksbill turtle	*Eretmochelys imbricate*	Endangered Migratory	Endangered	Moderate

Marine fauna species	Scientific name	Conservation status		Likelihood of occurrence in the Project area
		EPBC Act	NC Act	
Olive Ridley turtle	*Lepidochelys olivacea*	Endangered Migratory	Endangered	Low
Leatherback turtle	*Dermochelys olivacea*	Endangered Migratory	Endangered	Low
Fish, sharks and rays				
Estuary stingray	*Dasyatis fluviorum*-	-	Near threatened	Moderate
Giant manta ray	*Manta biorostris*	Migratory	Least Concern	Moderate
Great white shark	*Carcharodon carcharias*	Vulnerable Migratory	Vulnerable	Moderate
Longfin mako shark	*Isurus paucus*	Migratory	Least Concern	Moderate
Porbeagle shark	*Lamna nasus*	Migratory	Least Concern	Moderate
Reef manta ray	*Manta alfredi*	Migratory	Least Concern	Moderate
Shortfifn mako shark	*Isurus oxyrinchus*	Migratory	Least Concern	Moderate

13.4.2.2 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 (decibel (dB) re 1 micropascal (µPa)), are used to represent marine fauna species' sensitivity to sounds emitted from different frequencies. Using audiograms, standard frequency weighting functions for marine species groups can be derive where a frequency weighting function refers to the filtering of noise to reflect the sensitivity of an animal or group of animals to noise at different frequencies. This is required as marine fauna species do not hear equally well at all frequencies.

Fish species have highly variable sensitivity to sound energy and hearing sensitivity that can range from 20 Hertz (Hz) to several kilohertz (kHz). The highest sensitivity is typically in the mid frequency range (100Hz to 1kHz) (Nedwell et al. 2004; Popper et al. 2014). In comparison to fish, marine mammals, including cetaceans (e.g. whales and dolphins) and pinnipeds (e.g. seals and sea lions), have much broader hearing sensitivity ranges, from a few Hz up to 180kHz, with very sensitive hearing up to relatively high frequencies (10kHz to 100kHz). (Southall et al. 2007).

More limited audiogram information is available for marine turtles and this indicates a hearing range centred at low frequencies, extending approximately between 50Hz and 1,200Hz with most noise sensitivity experienced at frequencies of about 100Hz to 400Hz (Ketten et al. 2005; Popper et al. 2014). However, some studies have concluded that fish hearing, rather than mammalian hearing, is a better model to use for marine turtles until more research data becomes available. (Popper et al. 2014).

Audiogram data are not available for dugongs. As manatees have the same species classification (sirenians) as dugongs, their audiograms are expected to be similar. Studies indicate that hearing sensitivity for manatees ranges between 8kHz and 32kHz (Gerstein et al. 1999; Gaspard et al. 2012).

The hearing sensitivity ranges for marine fauna species as inferred from the available studies and data sources are shown in Table 13.6.

Table 13.6 Marine fauna hearing sensitivity

Species of interest	Estimated auditory bandwidth
Humpback whale, Southern right whale, Bryde's whale, Blue whale and Minke whale	7Hz to 22kHz
Australian snubfin dolphin, Bottlenose dolphin, Australian humpback dolphin, Risso's dolphin, Spotted dolphin and Common dolphin	150Hz to 160kHz
Dugong*	8kHz and 32kHz
Marine turtle	50Hz and 1,200Hz
Fish	20Hz to several kilohertz

Table note:

* Audiogram data are not available for dugongs. Since dugongs and manatees are both classified as sirenians, it is expected that their audiograms may be similar and therefore, manatee data has been used.

13.4.2.3 Background underwater noise environment

General ocean underwater noise

Ocean ambient noise limits the use of sound by marine species as communication (signal) must be detected against this background noise. The level and frequency characteristics of the ambient noise environment are the two major factors that control how far away a given sound signal can be detected (Richardson et al. 2013).

Ocean ambient noise consists of a variety of sounds of different origin at different frequency ranges, having both temporal and spatial variations. It primarily comprises of noise from natural physical events, noise produced by marine biological species and anthropogenic noise. These sources are summarised in Table 13.7.

Table 13.7 Ocean underwater noise sources

Source type	Components	Associated frequency noise
Natural events	Major natural physical events contributing to ocean ambient noise: ■ Wave/turbulence interactions ■ Wind ■ Precipitation (rain and hail) ■ Breaking waves ■ Seismic events (e.g. earthquakes/tremors)	■ The interactions between waves/turbulence can cause very low frequency noise in the infrasonic range (below 20Hz). Seismic events such as earthquakes/tremors and underwater volcanos also generate noise predominantly at low frequencies from a few hertz to a few hundred hertz. ■ Wind and breaking waves, as the prevailing noise sources in much of the world's oceans, generate noise across a very wide frequency range, typically dominating the ambient environment from 100Hz to 20kHz in the absence of biological noise sources. The wind-dependent noise spectral levels also strongly depend on sea states which are essentially correlated with wind force. ■ Precipitation, particularly heavy rainfall, can produce much higher noise levels over a wider frequency range of approximately 500Hz to 20kHz.

Source type	Components	Associated frequency noise
Bioacoustic production	Marine animal produced sounds (e.g. calls, whistles) for different purposes (e.g. communication, navigation or detection)	■ Baleen whales (e.g. humpback whales) regularly produce intense low-frequency sound (whale songs) that can be detected at long range in the open water. Odontocete whales, including dolphins, can produce rapid burst of high-frequency clicks (up to 150kHz) that are primarily for echolocation purposes. ■ Some fish species produce sounds individually, and some species also make noise in choruses. Typically, fish chorusing sounds depend on species, time of day and time of season. ■ Snapping shrimp are important contributors among marine biological species to the ocean ambient noise environment, particularly in shallow coastal waters. The noise from snapping shrimp is extremely broadband in nature, covering a frequency range from below 100Hz to above 100kHz. Snapping shrimp noise can interfere with other measurement and recording exercises, for example it can adversely affect sonar performance.
Anthropogenic	Noise from human activities contributing to ocean ambient noise: ■ General vessel movements ■ Offshore seismic explorations ■ Marine industrial developments and operations ■ Marine equipment (e.g. sonar and echo sounders)	■ Shipping traffic from various sizes of ships is the prevailing man-made noise source around nearshore port areas. Shipping noise is typically due to cavitation from propellers and thrusters, with energy predominantly below 1kHz. ■ Pile driving and offshore seismic exploration generate repetitive pulse signals with intense energy at relatively low frequencies (hundreds of hertz) that can potentially cause physical injuries to marine species close to the noise source. ■ Dredging activities and other marine industry operations are additional man-made sources, generating broadband noise over relatively long durations.

While most information on ambient ocean noise has been derived from studies conducted in the North Atlantic, some research in Australian waters has been undertaken. This indicates that ambient noise spectra are influenced by the tropical waters, particularly in respect to noise from marine animals. Wind-generated noise and the traffic noise due to shipping activities are generally consistent in level range between the two studies (Wenz 1962; Cato 1997). Figure 13.3 summarises the main components of ambient noise for the Australian regions.

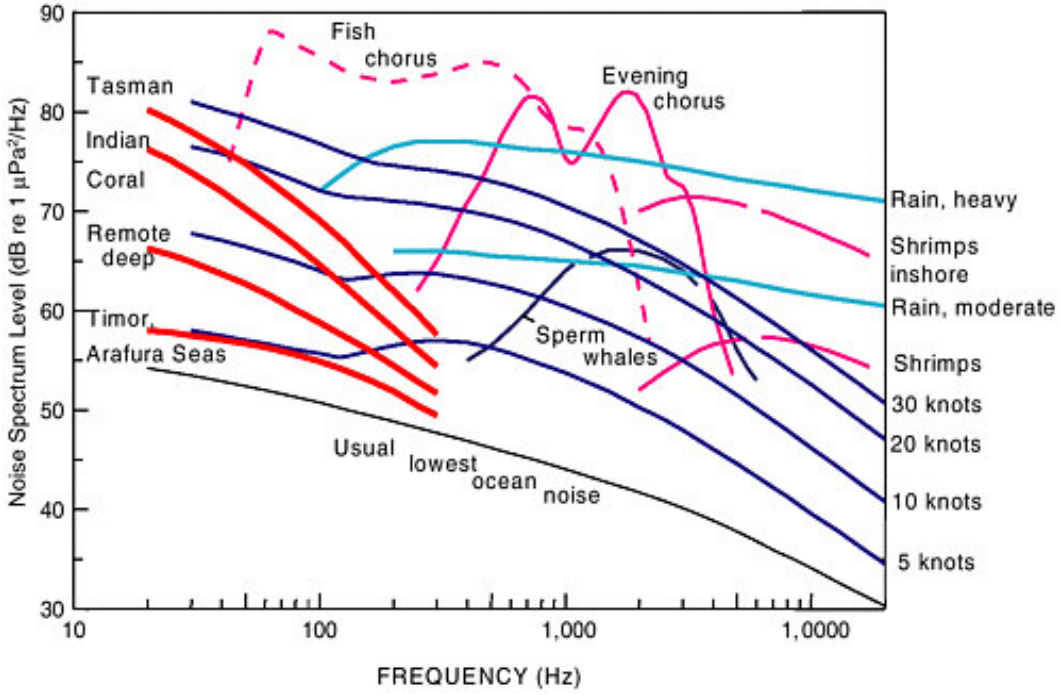

Figure 13.3 Summary of ocean ambient noise spectra for the Australian region

Source: Cato (1997)

Baseline underwater noise monitoring

To determine the existing noise environment for the Project impact areas, a baseline underwater noise monitoring program was carried out at four locations which were selected as being spatially representative of the four Project area types. The monitoring locations are provided below and identified on Figure 13.4:

- Location 1 – Port Central, 23°50.94’ S, 151°17.59’ E
- Location 2 – Port Channel/West Bank, 23°53.09’ S, 151°21.32’ E
- Location 3 – Outer Harbour, 23°52.62’ S, 151°26.92’ E
- Location 4 – Western Basin, 23°45.78’ S, 151°09.94’ E.

Data was collected via an anchor weighted noise logger deployed for a 3 month period at each location. This duration is considered a sufficient period in which various ocean ambient noise sources would be encountered. This allowed for a typical baseline noise environment to be characterised based on the monitoring program results.

Underwater noise levels were monitored from 10 September to 31 October 2014 at locations 1 to 3 and between 27 February and 16 April 2015 for location 4.

The percentile value variation ranges from the monitoring period are presented in Table 13.8. The data analysis results are represented in the series of spectrograms and spectral levels figures (within each bandwidth for PSD and one-third octave band spectrum) which are provided in Appendix K2.

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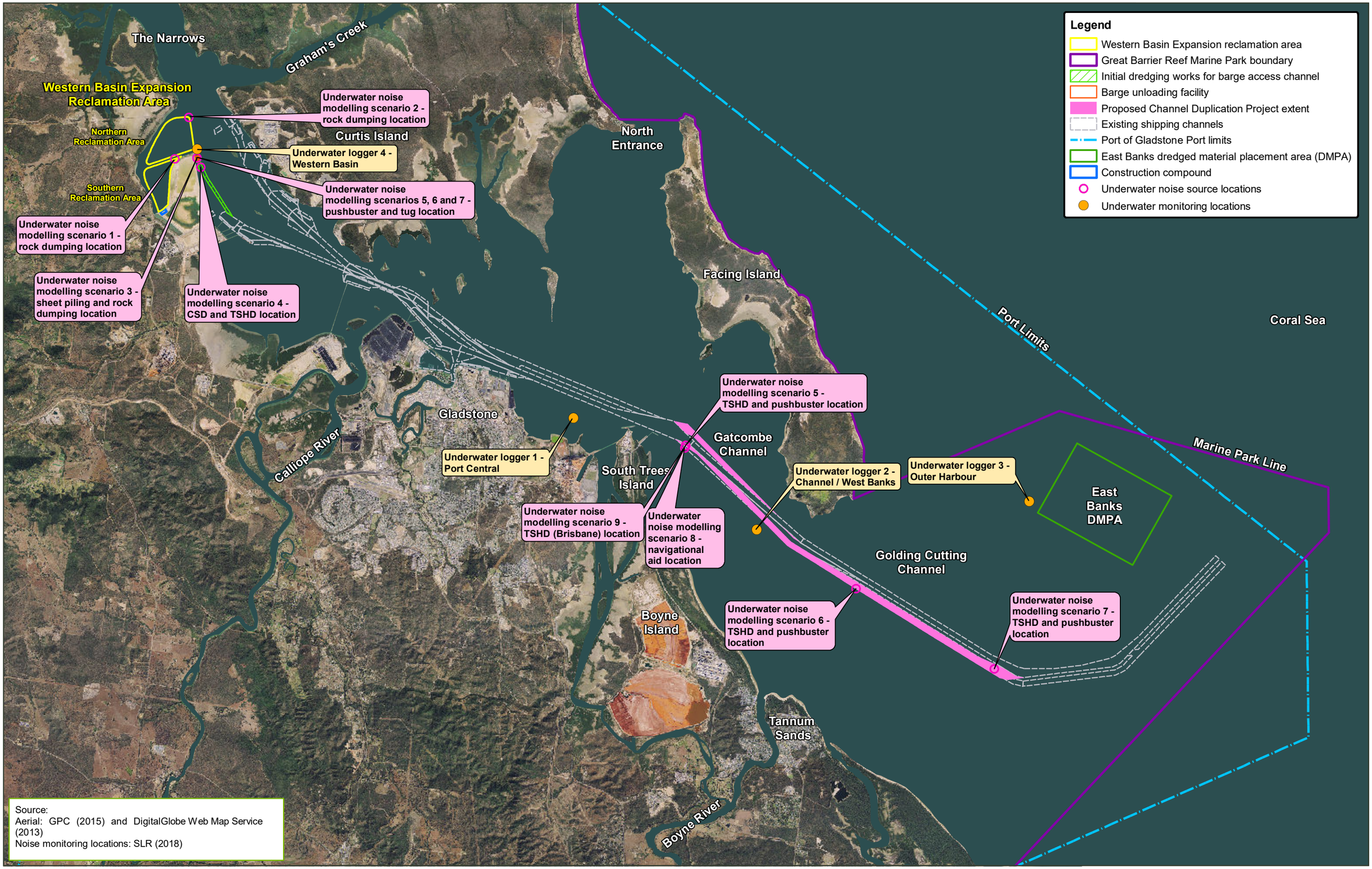

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)
Noise monitoring locations: SLR (2018)

Map by: RB P:\GIS\Projects\237374_GPC_Channel_Duplication_EIS\237374_EIS_149.mxd 31/01/2019 10:31

0 1,500 3,000 Metres

Date: 31/01/2019 Version: 9 Job No: 237374

Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 13.4: Underwater noise monitoring and modelling scenario locations

Table 13.8 Ranges of overall noise level variations

Logger location	Range of overall noise level variations (dB)			
	90%, 15min	50%, 15min	10%, 15min	RMS, 15min
Location 1 – Port Central	103 to 125	104 to 128	106 to 137	105 to 130
Location 2 – Port Channel/West Banks	106 to 126	107 to 133	110 to 138	108 to 135
Location 3 – Outer Harbour	100 to 108	101 to 114	104 to 120	102 to 116
Location 4 – Western Basin	110 to 118	101 to 124	114 to 130	112 to 125

Table note:
RMS = root-mean-square

For locations 1, 2 and 4 (i.e. in the inner harbour area), the anthropogenic noises associated with marine operations are the prevailing sources, dominating the low-frequency component below a few kilohertz at the monitoring locations. It is expected that these transient events are from vessel movements through the nearby shipping channel at location 1 and from bulk carriers travelling in and out of the Port with respect to location 2. At location 4, the dominant low frequency noise sources are likely to be the continuous marine operation activities adjacent to the monitoring location.

For location 3 (i.e. outer harbour area), the measured noise levels strongly correlate with weather and sea-state variations (waves breaks) and the dominant frequency components ranging from approximately 100Hz to 2kHz. The occasional occurrence of significant variations in noise level is noted and these are likely to have arisen from ad-hoc marine operations or vessel movements in close proximity to the monitoring location.

Biological noise, particularly noise from snapping shrimp, is an additional major noise source covering the mid to high frequency ranges from a few kilohertz up to 10kHz. It is the prevalent ambient noise source in the absence of vessel movements at locations 1 and 2, and dominates the existing noise environment at location 4 (Western Basin) in the absence of noise from marine operations.

The results show no clear correlation between the overall noise levels and weather conditions (i.e. wind speed and rainfalls) at any of the locations (refer Appendix K2 (Section 5.2.6)).

13.5 Environmental values and assessment criteria

13.5.1 Terrestrial assessment criteria

13.5.1.1 Noise assessment criteria – construction noise

In Queensland, the current State and local government legislation, policies and guidelines do not prescribe numerical noise limits or noise criteria for construction activities. Although the EPP (Noise) does not apply to construction works, consideration has been given to the acoustic quality objectives to provide target criteria to assist in the assessment of noise during the Project's construction phase.

The acoustic quality objectives of the EPP (Noise) were considered an appropriate target, on the basis that:

- The construction plant would be operated over work stages of at least nine months and the objectives would inform the long term management of noise to control potential impacts to long term health and wellbeing
- The noise emission characteristics for construction activities using the dredgers would be similar to the noise emission characteristics of the numerous daily vessel movements within the Port
- Due to the long period of construction, the noise impacts may be deemed similar by the sensitive receptors

- The objectives provide noise management targets for the daytime, evening and night-time periods which are applicable to some construction activities which are proposed to be undertaken over a 24 hour period.

Acoustic quality objectives have been used to inform the need for management and mitigation construction noise measures where noise is a potential consequence of the Project activities.

13.5.1.2 Noise assessment criteria – maintenance activities

The Project post-construction maintenance activities have been assessed against the acoustic quality objectives of the EPP (Noise) provided in Table 13.1. The environmental values are considered to be achieved where the overall level of noise at the receptors from sources (but excluding road and rail transport noise) are within the acoustic quality objectives threshold.

The assessment has adopted the 1 hour L_{Aeq} acoustic quality objectives to assess the noise emissions from fixed and mobile noise sources. To assess maintenance dredging noise emissions against the acoustic quality objectives reference has been given to noise levels from existing industrial premises of L_{Aeq} 40 dBA at residential receptors as determined by the noise monitoring survey.

To assess noise levels during night-time periods, an outdoor acoustic quality objective of L_{Aeq} 39 dBA was adopted to achieve the indoor night-time acoustic quality objective of L_{Aeq} 30 dBA.

In addition to the acoustic quality objectives, the EPP (Noise) also seeks to control intrusive noise, with 'background creep' noise level requirements. The noise emissions levels adopted to manage background creep for the Project are detailed in Table 13.9.

Table 13.9 Intrusive noise assessment criteria

Noise survey area	Rating background level (dBA)			Intrusive noise criteria $L_{Aeq,adj,1hr}$ (dBA)		
	Daytime	Evening	Night-time	Daytime	Evening	Night-time
Location 1 – Barney Point	41	41	43	46	46	46
Location 2 – Boyne Island	37	37	35	42	42	40
Location 3 – Facing Island	36	38	38	41	41	41

Table notes:

Rating background levels as determined by the 2014 noise monitoring survey.

$L_{Aeq, 1hr}$ means an A-weighted sound pressure level of a continuous steady sound, that within a 1 hour period has the same mean square sound pressure of a sound that varies with time.

13.5.1.3 Noise assessment criteria – road traffic

The potential changes in road traffic noise due to light and heavy construction vehicles was also assessed. The DMTR provide guidance on the assessment of road traffic noise in the *Transport Noise Management - Code of Practice, Volume 1 – Road Traffic Noise (2013*). The code recommends that:

- Overall road traffic noise level is controlled such that construction traffic does not increase the existing hourly L_{A10} road traffic noise by more than 3 dBA
- Increases in road traffic noise due to construction traffic is considered against the median minimum $L_{A10, 1hr}$ noise levels for each of the relevant hours within each work period
- An assessment area of 500m minimum beyond a project area boundary.

13.5.1.4 Noise assessment criteria - terrestrial fauna

In situations where statutory regulations or policies do not nominate numerical limits for a particular ecosystem, such as terrestrial fauna, it is common practice to refer to relevant Australian or internationally recognised standards and published literature that define noise criteria for similar contexts and relevant species/taxa.

Despite the difficulties associated with assessing noise impacts on terrestrial fauna, there are some studies which can assist in developing guideline noise criteria which can be used as triggers for potential noise-related impacts. The literature in this field has been collated in a number of reviews which have been considered, including:

- AMEC Americas Limited 2005, *Mackenzie Gas Project Effects of Noise on Wildlife,* prepared for Imperial Oil Resources Ventures Limited
- Dawe, G, & Goosem, M 2008, *Noise Disturbance along Highways: Kuranda Range Road Upgrade Project,* report to the Marine and Tropical Sciences Research Facility, Reef and Rainforest Research Centre Limited, Cairns
- Manci, KM, Gladwin, DN, Villella, R & Cavendish, MG 1988, *Effects of aircraft noise and sonic booms on domestic animals and wildlife; a literature synthesis,* U.S. Fish and Wildlife Service, National Ecology Research Centre, Fort Collins, Colorado, NERC-88/29
- U.S. Department of Transportation Federal Highway Administration 2004, *Synthesis of Noise Effects on Wildlife Populations,* Publication No. FHWA-HEP-06-016
- Wright, MD, Goodman, P & Cameron, TC 2010, *Exploring behavioural response of shorebirds to impulsive noise*, Wildfowl 60.

The noise criteria in Table 13.10 have been developed with reference to the above literature, and have been applied in this assessment as guideline thresholds for the evaluation of potential noise-related impacts to shorebirds.

Table 13.10 Likely effects on shorebirds due to noise levels

Disturbance effect	Steady or continuous noise sources L_{Aeq}	Episodic single or short term noise sources L_{Amax}	Typical bird activities potentially impacted
Occasional alert – minor impacts on habitat use for most species	50 to 65 dBA	45 to 60 dBA	Nesting of non-migratory shorebirds and foraging of migratory and non-migratory shorebirds
Frequent alarm or flight – moderate impacts on habitat use	65 to 85 dBA	60 to 80 dBA	Nesting of non-migratory shorebirds and foraging of migratory and non-migratory shorebirds
Avoidance of area by most of the population of some species	≥ 85 dBA	≥ 80 dBA	Nesting of non-migratory shorebirds and foraging of migratory and non-migratory shorebirds

Table notes:

$L_{Aeq,}$ means a sound pressure level of a continuous steady sound
L_{Amax} means the maximum A -Weighted sound pressure level recorded over the period stated.

13.5.1.5 Vibration assessment criteria

The mobile plant and equipment proposed for the construction and maintenance phases of the Project are a potential source of vibration. However, they are considered intermittent sources because, being mobile and not required to be in use all the time, they will not be a continuous source of vibration emissions.

There is no current noise legislation in Queensland which prescribes specific ground vibration limits. To establish ground vibration assessment criteria, regard has been given to standards and guidelines, typically adopted by industry in Australia for the assessment of impacts of ground vibration, including:

- New South Wales Department of Environment and Climate Change *Assessing Vibration: a technical guideline*, 2006
- *British Standard BS5228-2:2009 Code of Practice for Noise and Vibration Control on Construction and Open Site – Part 2: Vibration*

- *British Standard BS6472-2008: Evaluation of Human Exposure to Vibration in Buildings (1kHz to 80Hz)*
- *British Standard BS7385-1993: Evaluation and Measurement for Vibrations in Buildings – Part 2 Guide to Damage Levels from Ground-Borne Vibration*
- *German Standard DIN 4150, Part 3-1999: Structural Vibration in Buildings: Effects on Structures.*

Ground vibration experienced at sensitive receptors can be associated with two main types of impacts, namely disturbance to occupants of buildings, and cosmetic structural damage to buildings.

An individual's response to vibration is subjective and depends very strongly on previous experience and expectations. British Standard BS5228-2:2009 provides the peak particle velocity (PPV) levels of vibration to assist in the management of perceivable vibration levels. Based on this standard, a vibration level of 0.14mm/s has been adopted as a trigger for the management of vibration levels and control of potential impacts from perceptible vibration at all sensitive receptors. The adopted trigger level is consistent with guidance from the NSW Assessing Vibration: A Technical Guideline and German Standard DIN4150 for managing perceptible vibration.

The assessment of vibration effects on buildings is based on the British Standard BS7385-1993: These standards recommend vibration limits to minimise risk of cosmetic damage to residential and commercial buildings and are presented in Table 13.11.

Table 13.11 Guide values for intermittent vibration – minimal risk of cosmetic damage

Type of building	PPV in frequency range of the predominant pulse	
	4Hz to 15Hz	15Hz and above
Reinforced or framed structures Industrial and heavy commercial buildings.	50mm/s at 4Hz and above	
Unreinforced or light framed structures Residential or light commercial type buildings	15mm/s at 4Hz increasing to 20mm/s at 15Hz	20mm/s at 15Hz increasing to 50mm/s at 40Hz and above

13.5.2 Underwater assessment criteria

13.5.2.1 Underwater environmental values

The key environmental values for marine fauna relate to maintaining an environment that supports health and wellbeing. Therefore, the following characteristics and effects need to be taken into account:

- Behavioural responses such as vocalisation, resting, diving and breathing patterns, mother-infant relationships and specific behaviour changes to avoid underwater noise sources
- Physiological effects associated with the auditory system which could temporarily or permanently affect hearing as well as non-auditory physiological effects to the vestibular system, reproductive system, nervous system, liver or organs with high levels of dissolved gas concentrations and gas filled spaces.

13.5.2.2 Underwater assessment criteria

In the absence of national legislation, regulatory guidelines or assessment criteria concerning noise impact for marine fauna species, consideration has been given to recognised scientific studies and research concerning the development of quantitative links between marine noise (sound types e.g. pulses (e.g. piling noise) and non-pulses (e.g. vessel and dredging noise)) and impacts on marine fauna species. Based on the findings of this body of work, the assessment criteria set out in Table 13.12 to Table 13.15 has been adopted for the underwater noise impact assessment.

Table 13.12 Proposed permanent hearing threshold shift and temporary hearing threshold shift criteria for individual marine mammals exposed to "discrete" noise events (either single or multiple exposures within a 24 hour period)

Marine mammal hearing group	Injury (PTS-Onset) threshold levels			
	Single/multiple pulses		Non-pulses (including continuous noise)	
	Peak SPL, flat (dB re 1µPa)	SEL, 24 hour, weighted, (dB re 1µPa^2·S)	Peak SPL, flat (dB re 1µPa)	SEL, 24 hour, weighted, (dB re 1µPa^2·S)
Injury (PTS-Onset) Criteria				
Low-frequency cetaceans	230 (flat)	198 (M_{lf})	230 (flat)	215 (M_{lf})
Mid-frequency cetaceans		198 (M_{mf})		215 (M_{mf})
High-frequency cetaceans		198 (M_{hf})		215 (M_{hf})
TTS (TTS-Onset) Criteria				
Low-frequency cetaceans	224 (flat)	183 (M_{lf})	224 (flat)	195 (M_{lf})
Mid-frequency cetaceans		183 (M_{mf})		195 (M_{mf})
High-frequency cetaceans		183 (M_{hf})		195 (M_{hf})

Table notes:

SPL means sound pressure level
PTS means permanent hearing threshold shift
TTS means temporary hearing threshold shift
SEL means sound exposure level

Table 13.13 Proposed criteria for the onset of possible behavioural changes for individual marine mammals

Marine mammal hearing group	Behavioural changes threshold levels	
	Pulses – pile driving	Non-pulses (including continuous noise)
	RMS SPL (dB re 1µPa)	
All cetaceans	160	120

Table 13.14 Proposed piling noise assessment criteria for marine turtles and dugongs

Noise impacts on marine turtles and dugongs	Impact threshold levels	
	Peak SPL (dB re 1µPa)	SEL (dB re 1µPa^2·S)
Mortality and potential mortal injury	207	210 (cum)
Avoidance	N/A	164 (per strike)
Behavioural changes		155 (per strike)

Table note:

cum = cumulative

Table 13.15 Proposed assessment criteria for fish species

Noise impacts on fish species	Impact threshold levels			
	Pulses – pile driving		Non-pulses (including continuous noise)	
	Peak SPL, (dB re 1µPa)	SEL (dB re 1µPa^2·S)	Peak SPL (dB re 1µPa)	SEL 24 hour (dB re 1µPa^2·S)
Mortality and potential mortal injury	207	207 (cum)	N/A	N/A
Recoverable injury	207	203 (cum)		216 (cum)
TTS	N/A	186 (cum)		204 (cum)
Avoidance	N/A	150 (per strike)		N/A
Behavioural changes		145 (per strike)		

13.6 Potential impacts

13.6.1 Terrestrial noise and vibration impacts

13.6.1.1 Noise emissions inventory

To understand the terrestrial noise impacts of the Project activities in both the construction and maintenance phases, the following eight scenarios were modelled (refer Figure 13.2):

Construction

- Scenario 1 – Bund wall construction at WBE reclamation area (southern area)
- Scenario 2 – Bund wall construction at WBE reclamation area (northern area)
- Scenario 3 – Construction of the BUF
- Scenario 4 – CSD and TSHD dredging of the barge access channel and direct placement into the existing WB reclamation area
- Scenario 5 – TSHD dredging of the Channel Duplication area and placement of dredged material at the existing WB and WBE reclamation area (southern area)
- Scenario 6 – TSHD dredging of the Channel Duplication area and placement of dredged material at the existing WB and WBE reclamation area (northern area)
- Scenario 7 – Installation of the navigational aids near to Facing Island

Maintenance

- Scenario 8 – Maintenance dredging of the duplicated channels and the barge access channel.

Additional details and equipment assumptions for the above scenarios is provide in Appendix K1.

Predicted noise levels associated with the Project activities (construction and maintenance phases) have been calculated for the representative sensitive receptors and are presented in Table 13.16.

Table 13.16 Predicted noise levels from construction and maintenance activities at representative sensitive receptors

Sensitive receptor	Predicted $L_{Aeq,adj,1hr}$ noise levels (dBA)							
	Construction scenarios							
	1	2	3	4	5	6	7	8
Residential receptor locations								
Gladstone City and Barney Point	<10	<10	<10	<10	31	31	13	<10
Quoin Island	19	17	17	15	31	31	19	<10
Facing Island (northwest and south)	<10	<10	<10	<10	44	44	43	38
Boyne Island and Tannum Sands	<10	<10	<10	<10	16	16	35	<10
Turtle Island	20	19	18	16	27	27	15	<10
Witt Island	20	19	17	17	32	32	12	<10
Tide Island	18	17	15	17	41	41	10	<10
Targinnie	25	22	20	24	27	25	<10	<10
Library, educational, childcare or health uses								
St. Francis Catholic Primary School, Tannum Sands	<10	<10	<10	<10	14	14	33	<10
Stepping Stones Child Care Centre, Gladstone	<10	<10	<10	<10	23	23	11	<10
Goodstart Early Learning, Gladstone	<10	<10	<10	<10	21	21	15	<10
Gladstone City Library, Gladstone	10	<10	11	11	23	24	<10	<10
Harbour City Medical Centre, South Gladstone	<10	<10	<10	<10	22	22	15	<10
Gladstone South State School, South Gladstone	<10	<10	<10	<10	20	20	15	<10
Toolooa State High School, Gladstone	<10	<10	<10	<10	15	15	16	<10
Kareeba Scout Hall, Barney Point	<10	<10	<10	<10	23	23	19	<10
CQ University Gladstone Campus, Gladstone South	<10	<10	<10	<10	18	18	13	<10
Gladstone Central State School, Gladstone Central	<10	<10	<10	<10	25	25	13	<10
Park or nature conservation								
Wyndam Park, Boyne Island	<10	<10	<10	<10	17	17	36	<10
Spinnaker Park, Boyne Island	17	17	14	16	26	26	12	<10
Canoe Point Botanic Reserve and Environmental Park	<10	<10	<10	<10	25	25	17	<10
James Cook Park, Gladstone	<10	<10	<10	<10	16	16	35	<10
Barney Point Park, Barney Point	16	15	13	15	25	25	13	<10
Friend Park, Barney Point	11	12	<10	11	30	30	20	<10
Hector Johnson Park, Barney Point	<10	<10	<10	<10	25	25	17	<10
Commercial or retail								
Gladstone City	<10	<10	<10	<10	23	23	11	<10

Table note:

Bold numbers represent predicted noise levels above the EPP (Noise) objectives

The predicted noise levels shown in Table 13.16 for the construction works under Scenarios 4, 5 and 6 are based on the anticipated worst-case activity during the night-time period.

During the daytime, construction works to manage dredged material at the reclamation areas include the additional operation of a medium sized excavator. A review of predicted noise levels with this additional plant item and east northeast prevailing wind conditions was undertaken which identified that all noise levels during the daytime would not increase by more than 0.5 dBA at any of the assessed receptors.

The noise model shows that the pushbusters moving the barges, are the noise sources that are likely to dominate as construction noise sources, however it should be noted that they are not stationary noise sources and will not be a continuous source of noise at the receptor locations. The predicted noise levels should therefore be considered as a worst-case scenario where the pushbusters work hard against the tide and progress at a relatively slow speed.

The predicted noise levels would be below typical daytime ambient noise levels and would, therefore, not trigger a requirement for noise management.

Predicted noise levels for maintenance dredging of the duplicated channels (Scenario 8) show levels would be below the EPP (Noise) objectives at all sensitive receptors. It is noted, however, that when the maintenance dredging would be undertaken adjacent to Facing Island, the operations may result in noise that could be clearly audible at the nearest residences on Facing Island.

The potential for the Project activities to have noise impacts, such as disturbance or loss of acoustic amenity, at the sensitive receptors has been assessed against the construction scenarios and the maintenance dredging activity. Table 13.17 provides a summary of the likely degree of effect per representative scenario.

Table 13.17 Assessment of noise impacts

Scenario	Time	Noise impact assessment
Scenario 1 Bund wall construction at WBE reclamation area (southern area)	Daytime	Predicted noise levels at the receptors are very low and well within the referenced acoustic quality objectives. Noise impacts are unlikely to be experienced at the sensitive receptors.
Scenario 2 Bund wall construction at WBE reclamation area (northern area)	Daytime	Predicted noise levels at sensitive receptors are very low (<25 dBA) and well within the referenced acoustic quality objectives, therefore, noise impacts are unlikely to be experienced at the sensitive receptors.
Scenario 3 Construction of the BUF	Daytime	Predicted noise levels at the receptors are very low (<25 dBA) and well within the referenced acoustic quality objectives. Noise impacts are unlikely to be experienced at the sensitive receptors.
Scenario 4 CSD and TSHD dredging of the barge access channel and direct placement into existing WB reclamation area	24/7	Predicted noise levels at sensitive receptors are very low (<25 dBA) and well within the referenced acoustic quality objectives. Noise impacts are unlikely to be experienced at the sensitive receptors.

Scenario	Time	Noise impact assessment
Scenario 5 TSHD dredging of the Channel Duplication area, barge movements and placement of dredged material at the WBE reclamation area (southern area)	24/7	Predicted noise levels at most receptors are low (<35 dBA) or very low (<25 dBA) and well within the referenced acoustic quality objectives. Noise impacts are unlikely to be experienced at the majority of sensitive receptors. The predicted noise levels are above 35 dBA at two residential areas (i.e. Facing Island and Tide Island). At Facing Island and Tide Island, the predicted noise levels during the daytime and evening are within the acoustic quality objectives. During the night-time, construction noise at Facing Island would potentially be audible at levels above the background noise environment and for this reason may cause some noise impacts. The community on the two islands may have experience with noise from existing commercial shipping and maintenance dredging activities. Familiarity with similar noise characteristics can reduce the potential for noise impacts.
Scenario 6 TSHD dredging of the Channel Duplication area, barge movements and placement of dredged material at the WBE reclamation area (northern area)	24/7	Predicted noise levels at most receptors are low (<35 dBA) or very low (<25 dBA) and well within the referenced acoustic quality objectives. Noise impacts are unlikely to be experienced at the majority of sensitive receptors. The predicted noise levels are above 35 dBA at two residential areas (i.e. Facing Island and Tide Island). At Facing Island and Tide Island, the predicted noise level during the daytime and evening are within the acoustic quality objectives. During the night-time, construction noise at Facing Island would potentially be audible at levels above the background noise environment and for this reason may cause some noise impacts. The community on the two islands may have experience with noise from existing commercial shipping and maintenance dredging activities. Familiarity with similar noise characteristics can reduce the potential for noise impacts.
Scenario 7 Installation of the navigational aids near Facing Island	Daytime	Predicted noise levels at most receptors are low (<25 dBA) and well within the referenced acoustic quality objectives. Noise impacts are unlikely to be experienced at the majority of sensitive receptors. At Facing Island, impact piling would potentially be audible at levels above the daytime background noise environment and for this reason may cause some noise impacts. The community at Facing Island may have experience with noise from existing commercial shipping and maintenance dredging activities. Familiarity with similar noise characteristics can reduce the potential for noise impacts. At Boyne Island, impact piling may be audible during the daytime above the background noise environment, but not at levels sufficient to suggest noise would be a significant impact.
Scenario 8 Maintenance dredging of the Duplicated Channels	24/7	Predicted noise levels at all the receptors comply with the EPP (Noise) 'background creep' criteria and acoustic quality objectives. On this basis noise impacts are unlikely to be experienced at the majority of sensitive receptors. At Facing Island, operations would potentially be audible at levels commensurate of the background noise environment and for this reason may cause some perceptible noise impact where noise from the maintenance dredging is clearly audible. The community at Facing Island may have experience with noise from existing commercial shipping and maintenance dredging activities which can reduce the potential for noise impacts.

It is concluded from the above assessment that the majority of construction activities are unlikely to cause noise impacts at the sensitive receptors. The TSHD dredging works, including the use of pushbusters for manoeuvring the barges during the night-time (Scenarios 5 and 6) and the installation of navigational aids (Scenario 7), are identified as potential noise generating sources that could be audible at the nearest receptors on Facing Island, Tide Island and Boyne Island and thus create noise disturbance or amenity nuisance.

Outdoor noise levels of up to L_{Aeq} 38 dBA at sensitive receptors on Facing Island during the night-time dredging with the TSHD operating and up to LAeq 44 dBA are predicted where both the TSHD and a pushbuster are operating nearest to the receptors on Facing Island. Noise levels of up to 44 dBA are commensurate to the existing night-time background noise environment on Facing Island, notwithstanding noise from the TSHD may be audible at night and accordingly noise management measures are proposed (refer Section 12.1)

13.6.1.2 Noise impact assessment for shorebirds

The WBE reclamation area, BUF and the barge access channel are generally located within 500m of important migratory shorebird roosting areas identified by the migratory shorebird surveys undertaken within the Port Curtis region. Potential noise impacts have been considered for the construction of the reclamation bund walls (Scenario 2) and the dredging of the Channel Duplication area, barge movements and placement of dredged material at the WBE reclamation area (northern) (Scenario 6) as the higher noise generating work activities associated with the Project.

Other migratory shorebird roost sites are located at least 1km from the Channel Duplication extent which represents a sufficient distance to minimise potential Project noise levels and these sites are already exposed to similar noise sources as part of existing shipping activities in the Port. On this basis, further noise assessment at these roost sites was deemed not to be required.

The noise levels predicted in the SoundPLAN noise model have been referenced based on the nearest sensitive wetlands areas being:

- The area around The Narrows Shorebird Roost Site (NAR1) is located 200m to 500m from the WBE reclamation area (northern area)
- The area around Six Mile Island Shorebird Roost Site (SMIS) is located 500m to 2,000m from the barge access channel and BUF, respectively.

The potential noise impacts, based on the L_{Aeq} noise levels are summarised in Table 13.18. The assessment has identified that potential noise impacts to the shorebirds are likely to only be occasional alert responses, which can be considered a minor impact on the use of the habitats.

Furthermore, the majority of shorebird species are migratory which means they will not be present all year round. This means that during certain times of the year the Project will not have an impact on migratory shorebird species.

Table 13.18 Assessment of potential noise impacts to shorebirds

Scenario	Project stage	Predicted noise level	Review of possible noise impacts to shorebirds
2	WBE reclamation area (northern area) Construction of reclamation bund walls	<55 dBA to 70 dBA at shorebird habitat NAR1	Noise levels suggest alert reactions may be experienced which would be a minor impact on the habitat use for most species utilising the shorebird habitat surrounding NAR1
		<50 dBA at shorebird habitat SMIS	Noise levels are not expected to result in impacts to shorebirds utilising suitable habitat at SMIS

Scenario	Project stage	Predicted noise level	Review of possible noise impacts to shorebirds
6	TSHD dredging of the Channel Duplication area, barge movements and placement of dredged material in the WBE reclamation area (northern area)	<50 dBA to 65 dBA at shorebird habitat NAR1	Noise levels suggest alert reactions may be experienced which would be a minor impact on the habitat use for most species utilising the shorebird habitat surrounding NAR1
		<55 dBA at shorebird habitat SMIS	Noise levels suggest alert reactions may be experienced which would be a minor impact on the habitat use for most species utilising the shorebird habitat surrounding SMIS

For the construction equipment proposed at the WBE reclamation area the L_{Amax} noise levels are typically 8 dBA greater than the L_{Aeq} noise level. Applying a +8 dBA adjustment to the predicted L_{Aeq} noise levels, the potential L_{Amax} noise events have been assessed against the guideline criteria in Table 13.10.

The predicted noise levels of up to L_{Amax} 78 dBA at the nearest shoreline to the WBE reclamation area identifies potential for single event or sudden short term noise events to cause alert responses and sometimes an alarm or flight reaction. Given the Project will involve the intermittent use of mobile equipment the potential impacts would be temporary and not expected to affect all individuals of a species.

There are two relevant elements to the responses of terrestrial fauna to noise event, including:

- Masking – where noise affects communication between individuals of a species
- Individual reactions – ranging from mild alert response through to avoidance (or abandonment) of habitat.

The responses of individual birds to the noise events which will arise from the Project will depend in part on the timing of noise in relation to the bird activities. As discussed widely in the literature, and as regularly observed, many species become habituated to noise disturbances, particularly continuous noise. There is potential for some initial alert or alarm response to the start-up or arrival of noise sources.

It is noteworthy that the shorebirds visit the Gladstone area as part of their migratory journey and, with the exception of the non-migratory Beach stone curlew, the shorebird species do not breed or nest during their time in the region.

Following the initial stages of the WBE reclamation area construction activities, an equilibrium is likely to be reached, involving:

- Likely changes in species composition near the work areas
- Selection for more noise-tolerant individuals within the populations of species close to the work areas
- Habituation of some species and individuals to the noise impacts.

As a guide, where works are undertaken approximately 400m from known or potential migratory shorebird habitat the noise levels are predicted to be within the guideline criteria in Table 13.10 to minimise occasional alert reactions by shorebirds. Furthermore, as noted above, it is likely that where the shorebirds are tolerant of the noise from the Project activities, it is expected that there would be no potential impacts to the use of the habitat.

13.6.1.3 Compliance impact assessment

To assess and appropriately manage the potential noise impacts as a result of the Project, a compliance impact assessment process has been implemented (refer Figure 13.5). The compliance impact assessment focuses on assessing the extent of compliance with the pertinent terrestrial noise objectives contained in the EPP (Noise) relevant to the Project activities.

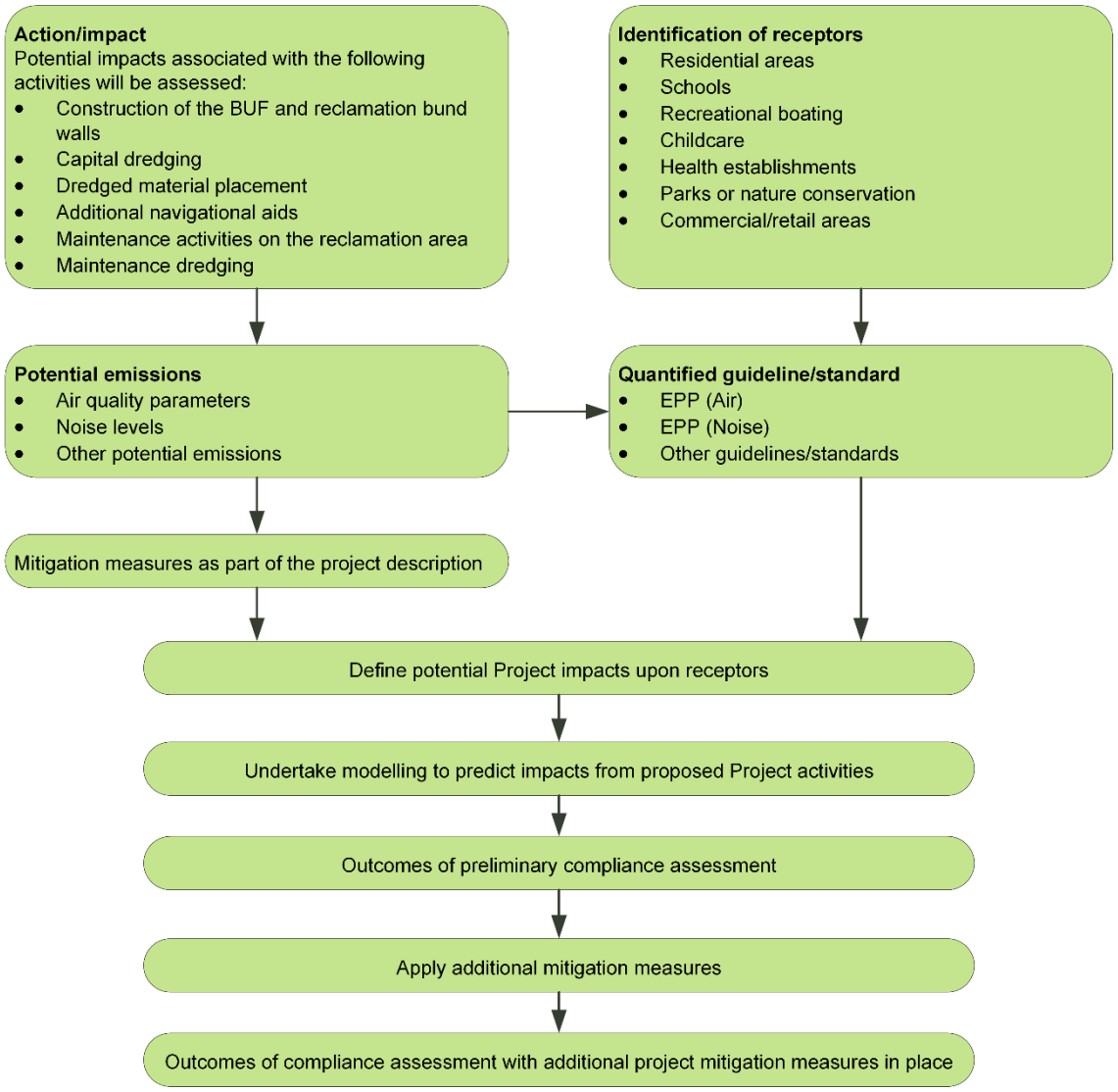

Figure 13.5 Terrestrial noise compliance impact assessment methodology

Having regard to the acoustic quality objectives of Schedule 1 of the EPP (Noise) (refer Table 13.1) and the predicted noise levels from construction and maintenance activities provided in Table 13.16, the maintenance dredging works are predicted to comply with the relevant acoustic quality objectives for all sensitive receptors.

It is recognised, however, that the night-time TSHD dredging works, including the use of pushbusters for manoeuvring barges when undertaken adjacent to Facing Island, may result in noise that could be clearly audible at the nearest residences on Facing Island and therefore, would exceed the relevant acoustic quality objectives for residential sensitive receptors.

The installation of the navigational aids near to Facing Island and Boyne Island has the potential to result in noise that could be clearly audible at the nearest residences in these areas and therefore would exceed the relevant acoustic quality objectives for residential sensitive receptors. The predicted noise levels at the other receptors are very low and as such are predicted to comply within the referenced acoustic quality objectives being well within the quality thresholds.

Predicted noise levels at all the sensitive receivers are predicted to comply within the EPP (Noise) 'background creep' criteria and acoustic quality objectives for maintenance dredging of the duplicated channels.

13.6.1.4 Road traffic noise

The nearest assessed receptors to traffic noise emissions are located approximately 2.5km from Landing Road. Traffic noise emissions from Landing Road are calculated to increase by 1.5 dBA as a consequence of road traffic from the Project. Due to low traffic volumes, Guerassimoff Road would not be a principal source of road traffic noise.

Applying the DTMR guidelines, indicates that the change in noise level from the road traffic associated with the Project would be insignificant. For those nearest receptors to Landing Road, the potential increase in road traffic noise would likely be undetectable. Hence, it is concluded the Project would not result in adverse traffic noise impacts.

13.6.1.5 Ground vibration

The main potential source of vibration is from the construction works associated with the WBE reclamation area and BUF. Machinery such as rollers and excavators are typically principal sources of vibration. However, they are usually only significant sources of vibration if operated at least 50m from receptors. Given the nearest sensitive receptors are at least 3.6km from the WBE reclamation area and BUF, there will be no impacts from ground vibration on these sensitive receptors.

The channel duplication area to be dredged is located approximately 0.9km from the nearest sensitive receptors at Facing Island. At this distance, there will be no disturbance impacts or cosmetic damage to buildings from ground vibration as vibration will be localised to the immediate dredging area.

Heavy vehicle movements are also a source of vibration. However, the nearest sensitive receptors are located at least 2.5km from the proposed haul route between the Targinnie/Yarwun quarry area and WBE reclamation area and the BUF. At this distance, there would be no ground vibration impacts associated with heavy vehicle movements on the haul road.

13.6.2 Underwater noise impacts

13.6.2.1 Modelling prediction results

To understand the underwater noise impacts as a result of the relevant Project activities in both the construction and maintenance phases, nine scenarios were modelled (refer Table 13.19) at seven representative source locations for the Project activities during both the construction and maintenance phases (refer Figure 13.4).

Table 13.19 Underwater noise modelling scenarios

Scenario number	Project component	Project activity and justification for modelling location	Underwater noise assessment scenarios	Noise source/ equipment (number)
1	Bund wall construction at WBE reclamation area (southern area)	Construction of reclamation bund walls (marine environment) involving the placement of core material Northern bund wall location to be modelled is located in the marine environment adjacent to intertidal seagrass meadows and closer to The Narrows than other areas	Modelling underwater noise from the WBE reclamation area construction activities, primarily from rock dumping in the marine environment	Rock fill/ dumping only
2	Bund wall construction at WBE reclamation area (northern area)			

Scenario number	Project component	Project activity and justification for modelling location	Underwater noise assessment scenarios	Noise source/ equipment (number)
3	Construction of the BUF	Use of a sheet piling rig to create U shaped barge dock adjacent to the WB reclamation area Works are proposed the marine environment adjacent to intertidal seagrass meadows and close to The Narrows	Vibratory sheet piling and rock dumping at the BUF location	Sheet piling Rock dumping
4	CSD and TSHD dredging for the barge access channel and transfer of dredged material into the WBE reclamation area	CSD and TSHD dredging for the barge access channel	Modelling underwater noise from the small CSD and TSHD operating during initial dredging works for the barge access channel	CSD (1) (small sized), and TSHD (1) (small sized dredger (most likely the Brisbane TSHD))
5	TSHD dredging of Gatcombe Channel (northern end)	TSHD operation at an area to be dredged which is located adjacent to the South Trees Island seagrass meadows potentially used by dugongs and turtles	Modelling underwater noise from the Gatcombe Channel dredging and barges (pushbusters (4) and tug (1)) operating during the Stage 2 campaign, primarily from dredging operations: 1) pushbuster assisting barges 2) travelling to BUF 3) travelling back to shipping channels 4) waiting for barges to be filled by TSHD	TSHD (1) (large sized dredger (e.g. Rotterdam)) Barges (4) Pushbusters (4) Tug (1)
6	TSHD dredging of Golding Cutting Channel (middle area)	TSHD operation at an area to be dredged which is located adjacent to seagrass meadows used by dugongs and marine turtles	Modelling underwater noise from the Golding Cutting Channel dredging and barges (pushbusters (4) and tug (1)) operating during Stages 1 and 2 campaigns, primarily from dredging operations	
7	TSHD dredging of Golding Cutting Channel (southern end)	Modelling underwater noise from the Golding Cutting Channel dredging during Stages 1 and 2 campaigns, primarily from dredging operations	Modelling underwater noise from the TSHD and barges (pushbusters (4) and tug (1)) operating during Stages 1 and 2 campaigns, primarily from dredging operations	
8	Navigation aid installation - Golding Cutting Channel (mid-point of channel length)	Installation of repositioned navigation aid that is located closest to seagrass meadows potentially used by dugongs and marine turtles	Modelling underwater noise from the installation of a relocated navigation aid for Golding Cutting Channel, primarily from the impact piling activity during the installation (only one pile modelled)	Barge (1) Junttan hydraulic impact hammer (1)
9	Project maintenance dredging	TSHD operation in the duplicated Golding Cutting Channel adjacent to seagrass meadows potentially used by dugongs and marine turtles	Modelling underwater noise from the TSHD maintenance dredging activities during the maintenance phase	TSHD (1) (small sized dredger (most likely the Brisbane TSHD))

13.6.2.2 Zones of impact

Based on the noise modelling prediction results, zones of impact for marine fauna have been developed for each of the nine modelled scenarios.

The most significant noise impacts from the development activities on the assessed marine fauna species are from impact piling events during the installation of the navigation aids, due to the high piling source noise emissions, and the impulsive characteristics of piling noise.

The zones of impact from the impact piling noise (i.e. modelling scenario 8) for marine mammals, marine turtles/dugongs and fish species (refer Appendix K2 (Section 4.4)) are summarised in Table 13.20, while the zones of impact from all other eight modelling scenarios involving non-pulse noise events are provided in Table 13.21.

Table 13.20 Zones of impact (maximum distances from source to impact threshold levels) from navigation aid impact piling noise

Piling noise impacts	Zones of impact – maximum distances from source to impact threshold levels							
	Criteria – Peak SPL (dB re 1µPa)	Zones of Impact (m)	Criteria – SEL (dB re 1µPa^2·S)	Zones of impact (m) (per strike number/time period)				
				1	10	100 (1min)	1,000 (10min)	6,000 (1hr)
On marine mammals								
PTS on-set	230	N/A	198	N/A	<10	50	310	1,400
TTS on-set	224	<10	183	18	120	700	2,200	6,000
Behavioural changes	160 (RMS SPL, dB re 1µPa)	3,400	N/A	N/A				
On marine turtles/dugongs								
Mortality and potential non-recoverable injury	207	35	210 (cum)	N/A	N/A	<10	30	160
Avoidance	N/A	N/A	164 (per strike)	600				
Behavioural changes			155 (per strike)	2,000				
On fish species								
Mortality and potential non-recoverable injury	207	35	207 (cum)	N/A	N/A	N/A	70	270
Recoverable injury			203 (cum)	N/A	<10	20	80	500
TTS	N/A	N/A	186 (cum)	10	80	450	1,800	4,200
Avoidance			150 (per strike)	3,400				
Behavioural changes			145 (per strike)	5,500				

Table 13.21 Zones of impact (maximum distances from source to impact threshold levels) from non-pulses development activities

Scenario number	Project component	Noise source/ equipment (number)	Zones of impact (m) – maximum distances from source to impact threshold levels		
			Marine mammals – behavioural changes	Marine turtles and dugongs	Fish species - TTS
1, 2 and 3	WBE reclamation area (southern and northern area) and BUF construction	Rock fill/dumping only	4,000	Not applicable	Not applicable
3	BUF construction	Vibratory sheet pilling	5,500		
4	Initial dredging works – CSD and TSHD dredging of the barge access channel and placement into the WB reclamation area	CSD (1) (medium sized dredger) and TSHD (1) (small sized dredger (most likely the Brisbane TSHD))	4,500 for CSD and 3,500 for TSHD		
5, 6 and 7	TSHD dredging of Golding Cutting Channel (northern end, middle area and southern end)	TSHD (1) (large sized dredger (e.g. Rotterdam))	12,000		
8	Project maintenance dredging	TSHD (1) (small sized dredger (most likely the Brisbane TSHD))	3,500		

Marine mammals

The summary of zones of impact for marine mammals in Table 13.20 suggests that noise from a single piling strike would not cause injury (PTS-onset) for assessed marine mammal species. However, due to cumulative noise impact, the zones of impact for PTS-onset extend up to 50m for 100 strikes (1 minute duration) to up to 310m for 1,000 strikes (10-minute duration). Piling strikes in the order of 6,000 (1 hour duration) can cause PTS-onset for assessed animals that remain within 1.4km of a piling location for that duration.

Noise from one single piling strike is predicted to cause TTS-onset for marine mammals within 18m of the piling location. Marine mammals remaining within a distance of 120m from a piling location are predicted to experience TTS-onset due to the cumulative noise exposure of 10 piling strikes. The zones of TTS-onset increase up to 700m, to 2.2km and 6.0km for piling exposure duration of 1 minute (100 strikes), 10 minutes (1,000 strikes) and 1 hour (6,000 strikes), respectively.

It should be noted that the zones of impact due to the cumulative SEL levels are based on worst case assumptions, including that marine mammals remain within certain distances from the source location for the defined period of time. In reality, high level impulsive noise such as piling noise would be expected to cause animals to avoid or move away from the noise source.

The zone of impact for possible behavioural changes is predicted to be up to 3.4km from the impact piling location.

Marine turtles and dugongs

As summarised in Table 13.20, noise from one single piling strike could potentially have significant adverse effects on marine turtles and dugongs within a distance of up to 35m from a piling location. Avoidance of the source may occur at a distance of up to 600m but within 2km of a piling location behavioural changes may occur.

An extended duration of piling noise exposure at further distances can also potentially cause adverse effects for marine turtles and dugongs. It is predicted that the maximum zone of impact for a 1 hour exposure duration (6,000 strikes) can be up to 160m from a piling location.

Fish species

As for marine turtles and dugongs, noise from one single piling strike can potentially result in adverse impact on fish species within a distance of up to 35m from a piling location, as summarised in Table 13.20. Noise from one piling strike is also predicted to cause avoidance at a distance of up to 3.4km and behavioural changes at a distance of up to 5.5km from a piling location for fish species.

The zones of impact for cumulative SEL levels are up to 80m for injuries with exposure duration of 10 minutes (1,000 strikes). If the exposure duration increases to 1 hour (6,000 strikes), then a maximum distance from the source location of up to 270m is predicted for potential non-recoverable injury, and up to 500m for recoverable injury. The threshold level for TTS-onset is much lower for fish species compared with physical injury thresholds. Therefore, the TTS zones of impact are much wider for the same exposure duration. For example, an exposure duration of 10 minutes (1,000 strikes) has a zone of TTS impact of up to 1.8km, while an 1 hour exposure duration (6,000 strikes) is predicted to have a zone of TTS impact of up to 4.2km from a piling location.

Non-pulse development activities

As summarised in Table 13.21 scenarios with non-pulse development activities such as rock dumping, dredging operations, support vessels and vibratory sheet piling (for BUF construction) are not expected to result in significant adverse noise impacts to marine turtles, dugongs and fish species. This is due to the relatively low noise emissions from these activities.

For marine mammal species, behavioural changes might occur. The assessed impact zones, therefore, extend from 3.5km to 4.5km from the source locations for rock dumping, medium sized CSD and small sized TSHD initial dredging activities, 5.5km for vibratory sheet piling at the BUF and up to 12km for large sized TSHD channel duplication dredging activities.

13.7 Mitigation measures

13.7.1 Terrestrial noise and vibration mitigation

13.7.1.1 Mitigation requirements

Based on the assessment undertaken at Section 13.6.1, no ground vibration impacts are expected given the substantial distances between vibration sources and the nearest sensitive receptors. In addition, the assessment concludes that the majority of construction activities and the maintenance dredging can be undertaken without noise-related impacts upon the sensitive receptors. Therefore, noise and vibration mitigation is not required for these Project activities. Nevertheless, general management measures for all construction and maintenance noise are recommended in Section 13.7.1.2.

At night-time, during some scenarios, there is potential for noise from some Project activities to be audible and discernible to nearby sensitive receptors.

The navigational aid installation piling is predicted to generate up to L_{Aeq} 43 dBA for those nearest sensitive receptors on Facing Island.

The noise assessment predicted outdoor noise levels of up to L_{Aeq} 38 dBA at sensitive receptors on Facing Island during the night-time channel duplication dredging with the TSHD operating and up to LAeq 44 dBA where both the TSHD and a pushbuster are operating nearest to the receptors on Facing Island.

A noise level of LAeq 44 dBA is above the existing night-time background noise environment on Facing Island. The existing night-time background noise environment on Facing Island is 38 dBA and it is therefore expected that noise from the TSHD and the pushbusters would be heard, where these are operating in close vicinity to Facing Island.

It is predicted that the noise level as a result of TSHD and pushbuster activity at the residents on Facing Island will be LAeq 38 dBA when the TSHD and pushbusters are operating 2.4 km or more from the noise sensitive receivers.

Noise levels of up to 38 dBA are commensurate to the existing night-time background noise environment on Facing Island, notwithstanding noise from the TSHD and the pushbusters may be audible at night. As such, specific noise management measures to mitigate potential noise impact will be implemented for:

- Receptors on Facing Island during night time TSHD dredging activities including pushbuster movements (Scenarios 5 and 6)
- Receptor on Facing Island and Boyne Island during the piling works associated with the installation of navigational aids (Scenario 7).

The noise assessment for terrestrial fauna has concluded that construction works undertaken within 400m of the WBE reclamation area would potentially cause minor noise-related impacts for known or potential migratory shorebird habitat, being within the guideline criteria. While some individuals may have greater noise tolerance, the implementation of noise mitigation measures will occur to minimise potential Project noise impacts on migratory and resident shorebirds.

13.7.1.2 Noise management measures

Navigational aid installation

When the impact piling rig is used within 1km of nearby sensitive receptors on Facing Island and Boyne Island, the following measures will be implemented:

- Undertake impact trials to determine the minimum required drop height to install the piles as small drop heights can reduce/control noise
- Installation of piling ‘cushions’ at the point of impact to reduce the energy (sound emission) during each impact event.

Night-time channel duplication dredging with the TSHD and pushbusters

To manage night-time noise impacts, the planning and design of the dredging campaign with the TSHD and pushbusters will implement the following measures:

- Include noise attenuation measures for the TSHD pumps, power generation plant and motors that would be on-deck sources of noise. Such measures could include:
  - Installing plant with the lowest available noise emission
  - Utilise on-deck structures to screen noise emissions from neighbouring plant
  - Install plant with acoustic enclosures, acoustic exhaust mufflers, acoustic louvers to limit noise emission levels
- Where practical, plan and manage the dredging program to utilise the less sensitive daytime and evening periods when dredging adjacent to residences on Facing Island. This would limit the requirement to operate the TSHD during the night-time at the closest distance to residences
- Where practical, pushbusters would not be run at full speed when passing by, or within 2.4km of, noise sensitive receptors on Facing Island

General noise management for Project

As best practice, general management controls will be adopted and adhered to for the duration of the construction phase, particularly for all works outside the standard day time hours of construction (6.30am to 6.30pm Monday to Saturday), as follows:

- Brief the Project work team to raise awareness of migratory shorebirds and the importance of minimising noise emissions
- Use mobile plant with efficient acoustic mufflers on the exhausts
- Where practical, adjust reversing alarms on plant to limit the acoustic range to the immediate operational area
- Selection of the quietest plant and equipment that can economically undertake the work
- Regular maintenance of equipment to ensure that it remains in good working order
- Where practical, avoid the coincidence of plant and equipment working simultaneously close together near sensitive receivers
- Mobile plant such as excavators, front end loaders and other diesel-powered equipment are to be fitted with residential class mufflers
- Where work is proposed within at least 1km of residences, the community should be notified at least 2 weeks prior to the commencement of works. Notifications will describe the potential noise and vibration levels and the proposed management measures to control environmental impacts.
- Broadband reversing alarms are to be used instead of tonal reversing alarms where sensitive receptors are within 1km of proposed construction works. This will be a requirement when outside standard working hours and included as a contractual requirement for contractors.
- Equipment which is used intermittently is to be shut down when not in use and all engine covers are to be kept closed while equipment is operating
- During site inductions and toolbox talks, all site workers (including subcontractors and temporary workforce) are to be made aware of the hours of construction and how to apply practical, feasible and reasonable measures to minimise noise and vibration when undertaking construction activities
- The site manager (as appropriate) will provide a community liaison phone number and permanent site contact so that noise and/or vibration-related complaints, if any, can be received and addressed in a timely manner. Consultation and cooperation between the site(s) and neighbours to the site(s) would assist in limiting uncertainty, misconceptions and adverse reactions to noise and vibration.

13.7.1.3 Noise and vibration management plan and monitoring

A Noise and Vibration Management Plan (NVMP) has been prepared as part of the Project EMP to document the management and control of noise and vibration associated with the Project. The NVMP requires the following actions:

- Monitor construction noise levels at the commencement of the construction phase to verify the outcomes of the noise assessment and confirm the noise from the Project activities will not cause unacceptable impacts at sensitive receptors
- Implement a rolling spot check regime of noise intensive plants and equipment
- Undertaken all monitoring in accordance with relevant Australian Standards and regulatory guidelines for the measurement of environmental noise
- Conduct supplementary noise and/or vibration monitoring, as warranted, to identify issues of concern in response to any noise complaints.

13.7.2 Underwater noise mitigation

13.7.2.1 Need for mitigation

Based on the impact assessment results as detailed in Section 13.6.2, there is potential for impact piling events during the installation of the navigation aids to cause injury to marine fauna species associated with the high piling source noise emissions and the impulsive characteristics of impact piling noise, if left unmitigated. Appendix K2 (Section 7.2) provides additional detail on this matter.

Consequently, specific underwater noise mitigation measures are required for impact piling noise associated with the Project. Considering the large offset distances to sensitive habitat areas as well as the temporary short duration of impact piling activities, the behavioural impacts on listed species are considered unlikely to be significant. The mitigation measures, therefore, proposed for the Project are the application of safety zones coupled with standard management and mitigation measures intended to prevent injury to marine fauna, in particular, for fish species, dugong and marine turtles. This approach is consistent with the guidance contained in the *Underwater Piling Noise Guidelines*.

13.7.2.2 Mitigation measures for impact piling

Safety zones

The Project proposes to implement the safety zones presented in Table 13.22.

Table 13.22 Proposed safety zones for continuous impact piling durations

Noise exposure threshold based on cumulative SEL (within a 24 hour period)		Observation zone	Shut-down zone
Duration with continuous piling @ 100 strikes/min	Cumulative SEL (< 198dB re 1µPa^2·S)		
≤ 1 min	≤ 50m	1.0km	50m
10 min	310m	1.0km	310m
60 min	1.4km	2.0km	1.4km

Standard management and mitigation measures

In conjunction with the proposed safety zones, the following management and mitigation measures will be implemented:

- Contract documentation – include these requirements for piling noise management and mitigation measures in the contract documentation
- Timing and duration – avoid conducting impact piling during times when marine mammals are likely to be breeding, calving, feeding or resting in biologically important habitats nearby. Where practical, avoid piling during whale migration season.
- Trained crew – ensure a suitably qualified person is available during piling to conduct the recommended standard operational procedures to manage noise impacts
- Standard operational procedures – standard operating procedures to be undertaken by contractors during piling activities include pre-start, soft start, normal operation, stand-by operation, and shut-down procedures, including:
  - Pre-start monitoring – the presence of marine turtles and marine mammals will be visually monitored by a suitably trained crew member for at least 30 minutes before piling commences using a soft start procedure

- Soft start – if marine turtles and marine mammals have not been observed inside the shut-down zone during the pre-start observations, soft start may commence with piling impact energy gradually increased over a 10 minute time period. A soft start will also be used after long breaks of more than 30 minutes in piling activity
- Normal piling – if marine turtles and marine mammals have not been observed inside the shut-down or observation zones during the soft start, piling at full impact energy may commence. Visual observations will continue throughout the piling activities
- Stand-by – if marine turtles or marine mammals are sighted within the observation zone during the soft start or normal operation piling, the operator of the piling rig will be placed on stand-by to shut down the piling rig, while visual monitoring of the animal continues
- Shut-down – if marine turtle or marine mammals are sighted within or are about to enter the shut-down zone, piling activity should be stopped immediately. If the animal is observed to move outside the zone again, or 30 minutes have elapsed with no further sightings, piling activities will recommence following the soft start procedure. If a marine turtle or marine mammal is detected in the shut-down zone during a period of poor visibility, operations will stop until visibility improves.

- Compliance and sighting report – the contractor will maintain a record of procedures employed during piling, including information on any marine mammals or marine turtles sighted, and their reaction to the piling activity. The report will include
  - Location, date, start and completion time of piling
  - Information on the piling rig (hammer weight and drop height), pile size, number of piles, number of impacts per pile
  - Details of the trained crew members conducting the visual observations
  - Times when observations were hampered by poor visibility or high winds, times when start-up delays or shut-down procedures occurred, and the time and distance of any marine mammal or marine turtle sightings.

Additional mitigation measures for fish, dugong and marine turtles

Due to the limitation of visual surveys for marine turtle, dugong and fish species, measures based on safety zones are not as effective as for other marine mammals. The following additional mitigation measures will be implemented:

- Lower piling duration/piling strike number per day. As per presented in Section 13.6.2.2, lower number of piling strikes within a 24 hour period results in lower cumulative SELs, and therefore has smaller impact zones.
- Use of piling noise attenuation measures. Various attenuation measures have been developed to attenuate underwater piling noise to minimise exposure of marine fauna species during piling activities (ICF Jones & Stokes and Illingworth & Rodkin 2009). These measures include but not limited to:
  - Air bubble curtains. Air bubble curtains are designed to infuse the water column surrounding the pile with air bubbles, generating a bubble screen that attenuate the sound propagation from the pile. For a mid-sized steel pile as used in this Project (with a dimension greater than 24 inches but less than 48 inches), the previous experiment data indicates that an air bubble curtain will provide about 10 dB of noise reduction (ICF Jones & Stokes and Illingworth & Rodkin 2009)
  - Isolation casings. Isolation casings are hollow casing slightly larger in diameter than the pile to be driven. The casing is inserted into the water column and bottom substrate, and then dewatered so that the work area could be isolated from the surrounding water column in order to attenuate the sound propagation. Dewatered isolation casings generally can be expected to provide attenuation that is at least as great as the attenuation provided by air bubble curtains.

- Cushion blocks. Cushion blocks consist of blocks of material atop a pile during piling to minimise the noise generated during impact hammering. Materials typically used for cushion blocks include wood, nylon and micarta blocks. The resulted noise reduction could be from a few dB to over 20 dB. This measure can be used in conjunction with air bubble curtains or isolated casings as above.

13.8 Summary

The noise impact assessment has investigated terrestrial and underwater noise impacts on nearby sensitive receptors and sensitive terrestrial fauna and marine species.

The terrestrial noise impact assessment identified nearby sensitive receptors within the Project impact areas, and measured the current noise levels at representative locations. The assessment then modelled eight construction and maintenance activities which are being undertaken as part of the Project to determine the noise impacts on nearby sensitive receptors. The terrestrial noise and vibration assessment concluded the following:

- Due to the separation distances, the predicted noise levels on sensitive receptors for the majority of Project activities will be well below the current ambient noise levels
- Specific noise management measures for the TSHD dredging, including the use of pushbusters close to residential receptors (Scenario 5 and 6) and for the installation of new navigational aids (Scenario 7), are required to control potential audible noise levels at the closest sensitive receptors
- All construction activities and operational activities will be undertaken in accordance with the management measures set out in the NVMP to minimise potential noise and vibration impacts to the surrounding sensitive receptors
- Due to the separation distance of at least 3.6km from sources of ground vibration and sensitive receptors, the assessment has determined that vibration impacts are not expected to occur during the Project
- Road traffic noise impacts are also not expected as the transport route is 2.5km from nearby residential sensitive receptors.

Consequently, the Project can be controlled in accordance with the relevant legislative and regulatory acoustic requirements with respect to potential terrestrial noise and vibration impacts.

The underwater noise assessment has shown the following:

- The impact piling events associated with the installation of the navigational aids are predicted to result in the highest noise impacts on the assessed marine fauna species, due to the high piling source noise emissions and the impulsive characteristics of impact piling noise. Impact piling noise is predicted to potentially cause injury to marine fauna species if in close proximity to the piling location for sustained periods.
- Other development activities such as rock dumping, dredging, supporting vessels and vibratory sheet piling for the BUF construction are unlikely to result in significant adverse underwater noise impacts to assessed marine fauna species, due to their relatively low noise emissions, the non-impulsive characteristics, and relatively higher baseline underwater noise environment within the inner harbour area
- The acoustic monitoring and relevant mitigation measures will be implemented to minimise the piling noise impact on assessed marine fauna species.