walker

TOONDAH HARBOUR

CHAPTER 12

TERRESTRIAL AND UNDERWATER NOISE AND VIBRATION

saunders havill group

12. Terrestrial and Underwater Noise and Vibration

12.1. Introduction

Terrestrial and underwater noise and vibration technical studies were completed by Simpson Engineering Group (SEG) and included as Appendix 2-J. Details of the key personnel involved in the study are provided in Appendix 1-F.

12.1.1 Scope of Study

The EPBC Act EIS Guidelines contains the following statement in relation to noise and vibration:

> *"The EIS must include an assessment of the impacts of noise and vibration associated with the construction (for example pile driving and dredging), and ongoing operations of the development (e.g., noise from residents, businesses and visitors to the site) on all matters of national environmental significance (MNES). This must include an assessment of short-term and long-term impacts, including measured background noise levels that take into account seasonal variations. The magnitude, duration and frequency of any vibration must be discussed.*
>
> *The locations of sensitive sites must be identified on a map at a suitable scale. Details of the results of baseline monitoring of noise and vibration in the proposed vicinity of the development must be included.*
>
> *Sufficient data must be gathered to provide a baseline for later studies. The daily variation of background noise levels at nearby sensitive sites must be monitored and reported in the EIS, with particular regard given to detailing variations at different periods of the night. Any current activities near the development that may cause a background level of ground vibration (for example: roads, boating and ferry activities, etc.) must be described."*

Specific requirements for the noise and vibration assessment to address the EPBC Act EIS Guidelines and other legislative requirements include:

- Detailed measurements of the existing noise environment;
- Proposed noise level goals in accordance with community expectations;
- Numerical modelling of noise levels from proposed construction activities;
- Assessment of construction noise impacts; and
- Recommendations for noise mitigation.

12.1.2 Acoustic Quality Objectives

Acoustic Quality Objectives set out by the *Environmental Protection (Noise) Policy 2019* (EPP (Noise) 2019) seek to protect the amenity of an acoustic environment. The indoor night-time goals effectively address sleep disturbance and sleep awakenings, while during the day it protects conversation. It should be noted that these are not strictly design limits for individual sources, but objectives that are considered to provide acceptable health and wellbeing for the community. Acoustic quality objectives are expressed as indoor noise level goals for dwellings at Night (10 pm to 7 am) and outdoor noise level goals during the Day (7 am to 6 pm) and Evening (6 pm to 10 pm). These objectives are included in Table 12-1.

Table 12-1: EPP (Noise) 2019 Acoustic Quality Objectives for Dwellings.

Location	Time of Day	Acoustic Quality Objectives (Measured at the receptors) dB(A)			Environmental Value
		$L_{Aeq, adj, 1 hr}$	$L_{A10, adj, 1 hr}$	$L_{A1, adj, 1 hr}$	
Residence outdoors	Daytime & evening	50	55	65	Health and wellbeing
Residence indoors	Daytime & evening	35	40	45	Health and wellbeing
Residence indoors	Night-time	30	35	40	Health and wellbeing in relation to the ability to sleep
Library and educational institution (including a school, college and university) (for indoors)	When open for business and classes offered	35			Health and wellbeing
Childcare centre or kindergarten (for indoors)	When open for business, other than when the children usually sleep	30			Health and wellbeing
School or playground (for outdoors)	When the children usually play outside	55			Health and wellbeing, and community amenity
Park or garden for use other than for sport or organised entertainment	Anytime	the level of noise that preserves the amenity of the existing park or garden			Community amenity
Protected area or critical area	anytime	the level of noise that preserves the amenity of the existing area or place			Health and biodiversity of ecosystems
Marine Park	anytime	the level of noise that preserves the amenity of the existing marine park			Health and biodiversity of ecosystems

12.1.2.1 *Noise Level Goals*

The Project will involve some occasions when dredging will be undertaken on a 24-hour basis so as to enable the dredging activity to occur without disrupting existing passenger and vehicle ferry operations. That noise would likely be audible outside of the regulated construction hours, therefore would not be compliant with the objective identified in Table 12-1.

In this instance it is proposed to adopt noise level goals based on the *Environmental Protection Act 1994* (EP Act) with a construction noise level based on background data and comparison of like parameters for operations lasting less than two weeks, between two weeks and six months and longer than six months. The noise level goals for this method are contained in Table 12-2. The external noise level goals for the future residential development within the PDA are to be based on site-specific background data (refer to Section 12.3). These goals may be problematic given construction of buildings within the Project footprint will be ongoing while completed residential buildings are being utilised as occurs in most master planned community projects. Consequently, buildings will be constructed incorporating noise control to comply the indoor acoustic quality objectives, namely an internal noise level from construction of 35 dB(A) during the day and evening and 30 dB(A) at night.

Table 12-2: Noise Level Goals $L_{Aeq,adj,T}$ [dB(A)].

Site	Day			Evening			Night		
A - Noise Goal based on Rating Background Noise Level for Period [dB(A)]									
Site 1	36			29			26		
Site 2	42			33			30		
Site 3	37			30			28		
B – Noise Goal Based Min LAeq Noise Level for Period [dB(A)]									
Duration of Construction Activities	<2 weeks	>2 weeks and <6 months	>6 months	<2 weeks	>2 weeks and <6 months	>6 months	<2 weeks	>2 weeks and <6 months	>6 months
Site 1	51	46	41	46	41	36	36	31	26
Site 2	61	56	51	54	49	44	40	35	30
Site 3	51	46	41	40	35	30	38	33	28
Adopted Noise Level Goal Based on maximum of A and B									
Duration of Construction Activities	<2 weeks	>2 weeks and <6 months	>6 months	<2 weeks	>2 weeks and <6 months	>6 months	<2 weeks	>2 weeks and <6 months	>6 months
Site 1	51	46	41	46	41	36	36	31	26
Site 2	61	56	51	54	49	44	40	35	30
Site 3	51	46	41	40	35	30	38	33	28

12.1.2.2 *Vibration Goals*

Vibration criteria for both human comfort and building damage due to ground borne vibration caused by construction activities (for example, pile driving, compaction and blasting) are addressed in this section. It should be noted that in most cases compliance with the human comfort criteria would also achieve compliance with the building damage criteria.

British Standard BS 5228-2:2009 - *Code of practice for noise and vibration control on construction and open sites* - is historically used to assess human comfort requirements presented in British Standard BS 6472-1:2008 - *Guide to evaluation of human exposure to vibration in buildings. Vibration sources other than blasting*. While BS 6472-1 provides guidance on human response to vibration in buildings in terms of vibration dose value, BS 5228-2 provides guidance on the use of peak particle velocity (PPV) which is typically measured to determine potential building damage.

For human comfort, to minimise annoyance due to ground borne construction vibration, it is proposed to adopt vibration levels with lower and upper limits as presented in Table 12-3. The lower limits are generally considered to be just perceptible. The upper limits are considered to cause significant annoyance if exceeded. All reasonable and practicable measures should be implemented to achieve the lower limit. Exceedance of the upper limit would require immediate action and extensive community consultation to determine further mitigation measures.

Table 12-3: Proposed Vibration Limits - Human Comfort.

Building	Work Period	Resultant PPV, mm/s	
		Lower Limit	Upper Limit
Dwellings (including hotels and motels)	Day	1.0	2.0
	Evening	0.3	1.0
	Night	0.3	1.0

No guidelines or criteria exist for underwater noise and vibration directly applicable to the Project. EPBC Act Policy Statement 2.1 - Interaction between offshore seismic exploration and whales provides guidance on management of underwater noise and vibration on marine species. The Government of South Australia's Underwater Piling Noise Guidelines (2012) provide information on noise sources and marine mammal responses based on scientific literature as well as recommending management measures and procedures that can be put in place to mitigate impacts on marine fauna. These guidelines reference underwater noise criteria adopted by the US National Oceanic and Atmospheric Administration (NOAA) for behavioural and physiological impacts to cetaceans (whales, dolphins and porpoise species) and Pinnipeds (i.e., seal species). Behavioural responses occur at lower thresholds than physiological responses, with sound pressure level noise exposure criteria of 160 dB re 1 μPa for impact pile driving and SPL 120 dB re 1 μPa for vibration pile driving.

This chapter provides a description of underwater noise and vibration impacts resulting from the Project and recommends management measures for reducing source levels of noise. Potential impacts on marine fauna and specific management and monitoring measures for species with potential to be impacted are addressed in Chapter 16.

12.1.3 Activities that May Result in Impacts

Project activities with the potential to impact on ambient and underwater noise and vibration levels include:

- Reclamation and maritime construction works:
  - Installation of permanent and temporary sheet piling for the bund walls;
  - Installation of vertical piles within the marina and harbour areas;
  - Increased truck movements to and from the site to import clean rock for the bund walls;
  - Creation of ambient and underwater noise and vibration during construction activities, such as pile driving and excavation;
- Dredging:
  - Creation of ambient and underwater noise and vibration during the dredging process;
- Building and civil works (onshore and within the reclamation):
  - Ambient noise from structural piling, building and civil works;
  - Increased vehicle traffic to and from the construction site, in particular during building construction;
- Ongoing operation of the ferry terminal, marina and urban development:
  - Increased human use of the foreshore parks, walking tracks and open space, including increase in domestic pets present in these facilities;
  - Increase in vehicle traffic to and from Toondah Harbour;
  - Increase in the size and frequency of boat movements in Toondah Harbour.

12.2. Assessment Methodology

12.2.1 Background Noise Level Measurements

The EPP (Noise) requires existing noise levels be obtained in accordance with Queensland's Noise Measurement Manual (State of Queensland 2020). The existing noise levels in the area surrounding Toondah Harbour have been obtained through a series of attended noise measurements. The measurements were obtained over several months in public areas near sensitive receptors adjacent to Toondah Harbour. Measurements were taken when activity was at a minimum to provide lower ambient noise levels than for long-term unattended noise monitoring since the operator excludes almost all nearby noise sources. By way of example, if a neighbour was using a leaf blower or a vehicle was parked with an engine idling, the measurements were suspended until the activity ceased. Taking measurements in this way provides a conservative estimate of background noise for comparison.

The date and times of measurements are contained in Table 12-4. There was no rain during the monitoring period and wind speeds were low and well below 5 m/s.

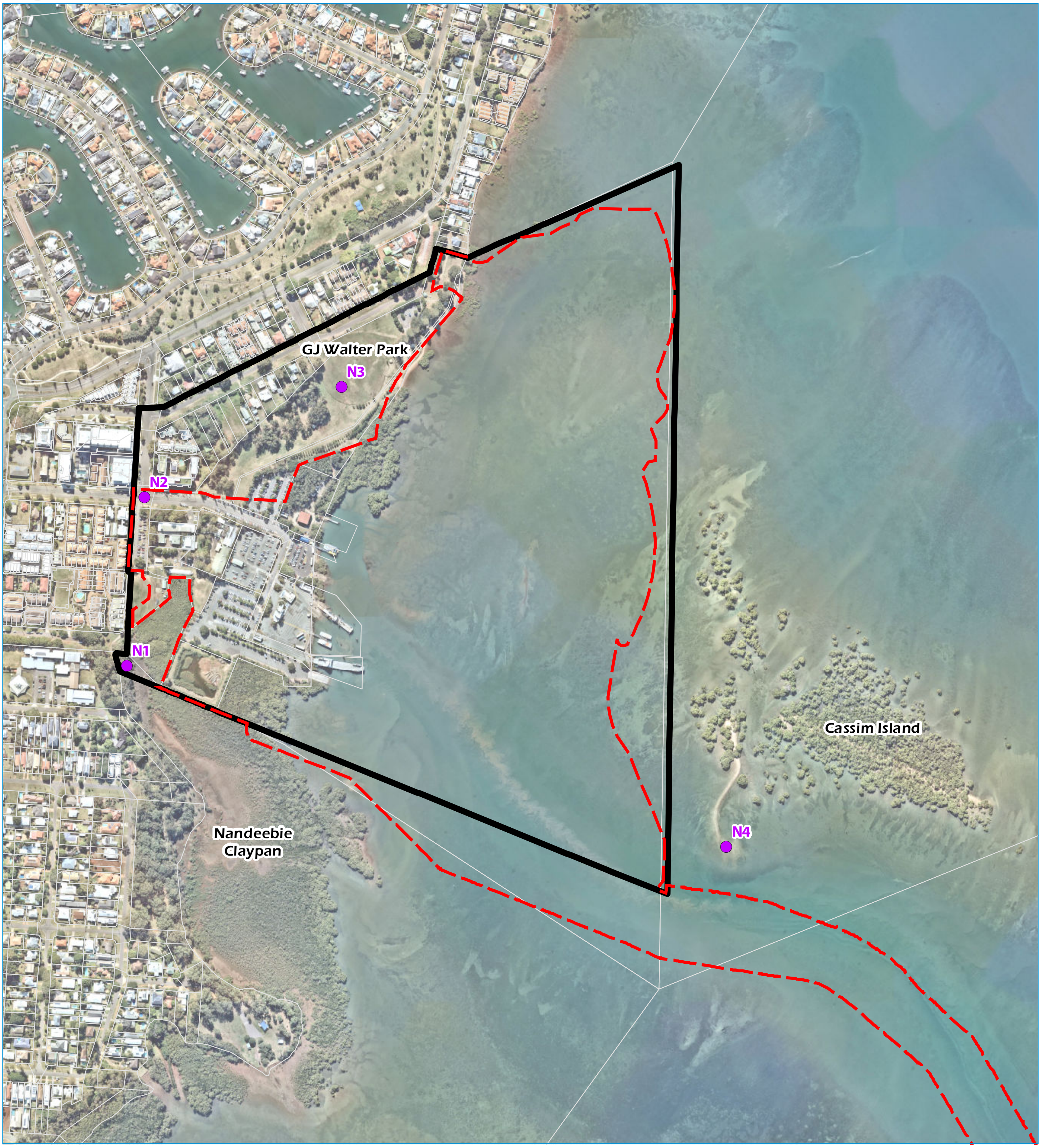
Table 12-4: Attended Noise Measurements Dates and Times.

Date	Time Period
Thursday 11 June 2020	10 pm to midnight
Friday 12 June 2020	midnight to 1 am
Thursday 18 June 2020	1 am to 3 am
Thursday 25 June 2020	3 am to 6 am
Sunday 13 Sept 2020	8 pm to 10 pm
Monday 14 Sept 2020	1 pm to 6 pm
Wednesday 16 Sept 2020	6 am to 1 pm and 6 pm to 8 pm
Monday 21 March 2022	4 am to 7 am - Cassim Island only

Noise level measurements were obtained in each hour over a period of 10 minutes at three locations shown on Figure 12-1 and described below:

- Site N1 was in parklands at the eastern end of Queen Street. This location is representative of the Star of the Sea primary school, kindergarten, the nearby units and dwellings south of Longland Street. At night, the monitoring was relocated away from the unlit parkland to a location close to the intersection of Queen Street and Passage Street. This site was situated some distance from occupied buildings. The parkland location was not suitable as an attended noise monitoring location at night since attendance at this location would have changed the noise environment;
- Site N2 in Wharf Street is representative of the multi-storey residential unit developments close to and west of Toondah Harbour;
- Site N3 in GJ Walter Park represents the park and the closest dwellings to the north of Toondah Harbour; and
- Site N4 at Cassim Island is included as a sensitive receptor to address background noise at the roost site, Moreton Bay Marine Park and MBRS.

Figure 12-1: Attended Noise Monitoring Locations



Toondah Harbour EIS

Legend

Toondah Harbour PDA

Qld DCDB

Project area/footprint

Attended Noise Monitoring Locations

TOONDAH HARBOUR

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N

0 100 200 300 400 m

GDA 1994 MGA zone 56

Scale (A4): 1:8,600

12.2.2 Noise Modelling

A digital terrain noise model of the site and surroundings has been developed using PEN3D V2.6.2.3 software. The PEN3D General Prediction Model (GPM) is based on the method by Bies and Hansen (1988). The implementation is a more complex variation of the approach to sound propagation described in Concawe (1981). Concawe is one of the most commonly used methodologies to predict outdoor noise propagation from industrial sites. PEN3D also draws on aspects from ISO 9613-2. The PEN3D software was originally developed in 1993 and since then has been in constant development and review.

12.2.2.1 *High Noise Construction Stages*

For the purposes of the assessment, construction has been divided into two overarching stages of development:

- The northern reclamation which includes:
  - Reclamation and development of the northern residential area and mixed-use node;
  - Upgrade of the ferry terminal including marine infrastructure, new buildings and car parking;
  - Northern residential areas, foreshore park and upgraded Middle Street access;
  - Turning basin and internal waterway dredging;
- The southern reclamation which includes:
  - Reclamation and development of the southern residential area;
  - Deep water access for the marina coves;
  - Roadworks, underground and utility services.

Both stages involve a series of similar activities and operations including:

- Installation of sheet piling (includes delivery of sheet piles);
- Installation of rock revetment bunds (includes delivery of rock);
- Dewatering of basin;
- Excavation of upper weak materials within reclamation area;
- Remediation of upper weak materials (marine) (comprising drying, mixing with lime, spreading and compaction);
- Dredging of marine sediments and transfer to reclamation area;
- Remediation of dredged materials (comprising drying, mixing with lime, spreading and compaction);
- Installation of sheet piling and revetment for marina, within reclamation area of site;
- Impact piling of circular piles for wharves, pontoons and marina;
- Excavation of marina and internal waterways, followed by opening and flooding.

Building works will take place after the reclaimed landform meets key stability criteria. However, project staging means that some buildings and roads will be constructed at the same time as reclamation is occurring in other parts of the Project footprint. These works will occur progressively from north to south for the duration of both stages. During the later phases of the Project, the residential buildings to the north will be constructed and then occupied at the same time as the more southern areas are being developed. The foreshore park in the north will be open for public use when the northern subdivision works are complete.

During the northern reclamation works, the rock required for revetment walls will be delivered by truck in two phases each lasting approximately three months and comprising up to 60 vehicle trips per day. The lime required for remediation of weak materials will be delivered by truck over two phases each lasting four months. There is possibility of some minor overlap of these two tasks. Additionally, there will be five truck deliveries per day outside the import phases. Conservatively, it is assumed that the southern reclamation has a similar requirement for rock and lime delivery.

Contrasting with the perimeter works, the driving of both sheet piles and circular piles within the marina coves will take place without connection to Moreton Bay. Thus, there will not be any vibrations or underwater sound exiting the site into the bay during these internal works.

Activities that either generate high noise levels or occur for an extended period are described below.

Northern and southern reclamation perimeter sheet piling and rock revetments
The first high noise generating activity on the site will be sheet piling and rock revetment. These activities will create the perimeter of an impermeable basin to allow for the Stage 1 reclamation. Installation of the sheet piling has an advance rate of 15 m to 30 m per day. The northern reclamation perimeter is approximately 2 km, hence would take between 65 days and 130 days to complete. Completion of the southern reclamation perimeter would take a similar timeframe. At the same time as sheet piling is underway, soft material on the seaward side of the sheet pile will be excavated and rock revetment constructed.

Internal earthworks and revetments including marina structures
The next high noise generating activity will occur when the internal marina structures and internal waterways are being constructed (sheet piling and rock revetment). Concurrently, earthworks will transfer sediments from the excavated marina onto the landform. The marina revetment works are expected to last three months and represent the maximum time these activities occur simultaneously.

This is an airborne noise only without any noise into the waters of Moreton Bay.

Northern and southern reclamation dredging and landforming
Material will be dredged from the turning basin and Fison Channel and transferred to the reclamation area for drying, treatment, spreading and compaction. These combined works are unlikely to take place during any piling or revetment works and are expected to occur simultaneously for up to four months during both the northern and southern reclamation stages.

12.2.2.2 *Noise Emitting Construction Plant*

Construction plant likely to be utilised during high noise operations are identified in Table 12-5 along with their power and pressure levels.

The sound power levels mathematically describe the total sound energy for the system. Additionally, the table also includes the sound pressure level at 10 m from the noise source, excluding any screening effects. These may be compared with typical noise levels experienced in the environment.

Table 12-5: Typical Construction Plant Sound Power Levels (LAeq) in dB(A) and Numbers of Plant per Phase.

Noise Source	Sound Power Levels (dB(A))	Sound Pressure Levels at 10m (dB(A))	Number of Items of Plant Operating Simultaneously per Construction Operation				
			Sheet Piling	Rock Revetment	Dredging	Remediation of Soft Material	Excavation
Piling Rig (vibration)	112	84	1	-	-	-	-
Franner crane (20t)	198	70	1	-	-	-	-
Excavator (40t)	110	82	-	1	-	1	1
Moxy (Off road dump truck)	110	82	-	2	-	-	-
Backhoe Dredge	110	82	-	-	1	-	-
Work Boat	105	77	-	-	1	-	-
Unloading Excavator	108	80	-	-	1	-	-
Dozer D9	116	88	-	-	-	1	1
Grader	113	85	-	-	-	1	1
Compactor	106	78	-	-	-	1	1
Road Truck	108	80	1	1	1	1	1
Vibratory Roller	109	81	-	-	-	1	1
Light Vehicle (4wd)	103	75	2	2	1	1	2
Light Towers	95	67	1	1	2	-	-

12.2.3 Construction Vibration

The main vibration source will be the vibratory sheet piling rig. This method is quick, efficient and ideal for soft, uncompacted materials. Unlike an impact hammer, the vibratory piling rig does not have an impact but uses a short period of strong vertical oscillatory motion to force the pile into position. Typical vibration levels at 10 m from the piling rig is 1 mm/s in silty clays (Athanasopoulos 2000). The soils surrounding the piling are silty clays and saturated fine sands and these types of soils are known to highly attenuate vibrations. If it is conservatively assumed the geometric attenuation is 6 dB/doubling, then the vibration levels at 20 m would be 0.25 mm/s, which is below the lower human comfort limit for evening and night (0.3 mm/s) and well below the lower human daytime comfort limit 1.0 mm/s. All sheet piling works will be carried out during daytime hours.

12.2.3.1 *Vibration-Generated Underwater Noise*

Piles are driven using various methods, such as gravity, vibration and hammering. The method that is used depends on the dimensions of the pile and the substrate into which the pile is being driven. For this project the sheet piles will be driven by vibration and the circular marina piles by hammering. Hammering a pile produces an intense impulsive underwater noise whereas vibratory pile driving produces a lower level or almost continuous noise.

There are three main mechanisms which generate noise in water when a pile is struck by a hammer:

- Direct radiation of sound into the water by a vibrating pile;

- Sudden displacement of the pile in the seabed resulting from shear and compression waves in the seabed and these then couple back into the water; and
- The motion and vibration off the pile generates surface (Scholte) waves that propagate along the water seabed interface but also produce pressure fluctuations in the water column.

There is no currently available numerical software that can adequately model the complexities of this process from first principles for realistic scenarios. The main mechanism for producing underwater noise at this site will be direct radiation of sound into the water by a (transverse) vibrating pile.

When a pile is driven into the seabed the reaction of the seabed onto the pile excites a “bendy” wave in the pile and that will propagate along the length of the pile. The bendy wave comprises a compression wave, forcing the pile into the seabed and transverse wave. It is the transverse wave component which creates a sound in the water.

A gravity driven pile does not generate any transverse waves and hence is essentially silent.

The sheet driven pile generates low levels of transverse waves and produces very low levels of noise into the water. Since vibration driven sheet piling is mostly used in shallow water, it has a very low potential to generate noise in the water.

Hammering a pile has the highest potential to generate transverse waves since there is considerable reactive force on the piles from the ocean bottom. Additionally, this is usually combined with large surface area of pile in the water which provides good coupling and a high potential for noise generation in the water.

The underwater sound levels from piling have been based on previous monitoring by others but modified according to surface area of the pile exposed to water (Table 12-6). It is conservatively assumed that the peak noise from vibratory piling is 30 dB quieter than that of impact driving.

Table 12-6: Sound Pressure Levels from Pile Driving

Metric	**Distance**	**Sound Pressure Levels (dB re 1µPa)**		
		Impact Piling (steel 500mm diameter)	Impact Piling (timber 500mm diameter)	Vibratory Sheet Piling
L_{p-p}	38	195	190	145
L_{p-p}	260	177	172	127
L_{Sel}	38	160	155	143
L_{Sel}	260	145	140	128

Source: Measurement and Modelling of Underwater Noise from Pile Driving, AJ Duncan *et al* Proceedings of 20th International Congress on Acoustics, ICA 201023-27 August 2010

12.3. Existing Values

12.3.1 Background Terrestrial Noise

The existing noise levels for sites N1 to N3 are presented in terms of the L_{Aeq}, L_{A01}, L_{A10} and L_{A90} in Figure 12-2 to Figure 12-4 respectively. These terms are described below:

- **L_{Aeq}** - The equivalent continuous 'A' weighted sound level is the energy average of the varying noise over the sample period and is equivalent to the level of a constant noise which contains the same energy as the varying noise environment. This measure is also a common measure of environmental noise and road traffic;
- **L_{A10} -** The 'A' weighted L_{A10} level is the sound level which is exceeded for 10% of the sample period. During the sample period, the noise level is below the L_{A10} level for 90% of the time. The LA10 is a common noise descriptor for environmental noise and road traffic noise; and
- **L_{A90}** - The 'A' weighted L_{A90} level is the sound level which is exceeded for 90% of the sample period. During the sample period, the noise level is below the L_{A90} level for 10% of the time. This measure is commonly referred to as the background noise level.

An inspection of the L_{A90} background noise levels reveals that the precinct around Site N1 and Site N3 experience similar background noise levels for most of the time. The background noise levels are slightly louder at Site N2 which is mostly due to mechanical plant (air conditioning noise) and additional road traffic.

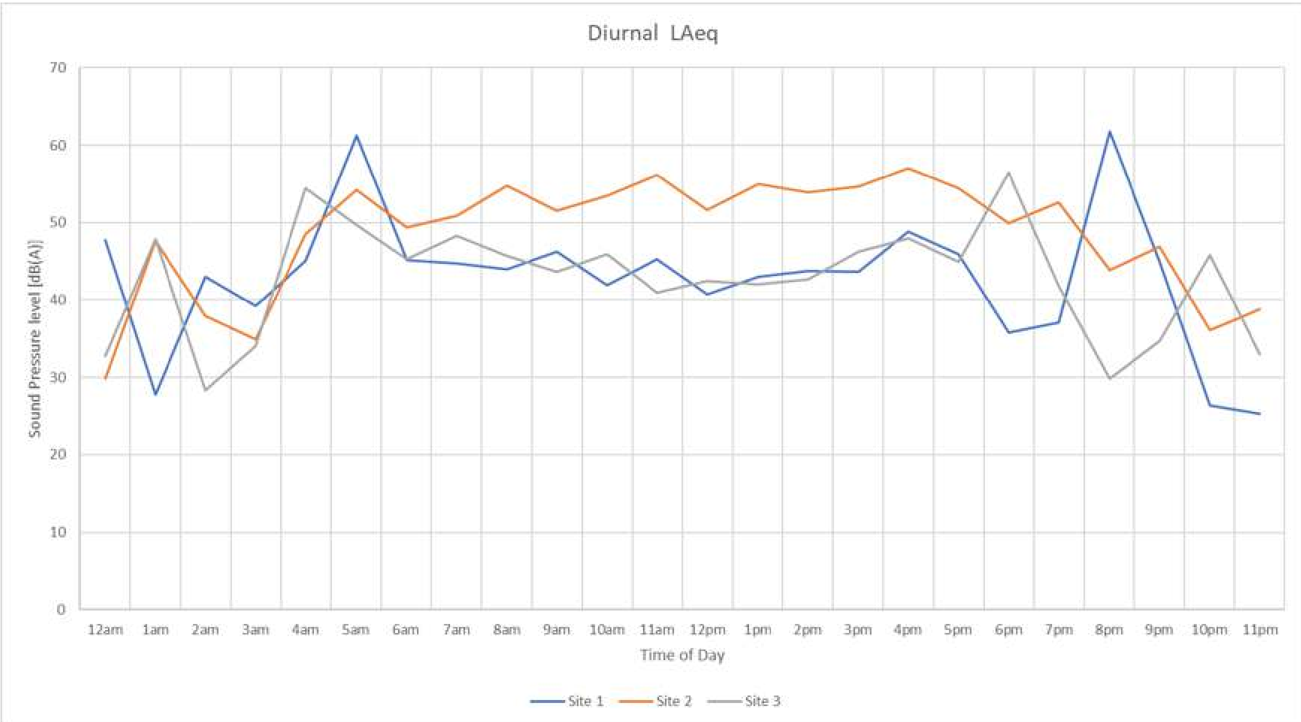

Figure 12-2: Measured L_{Aeq}.

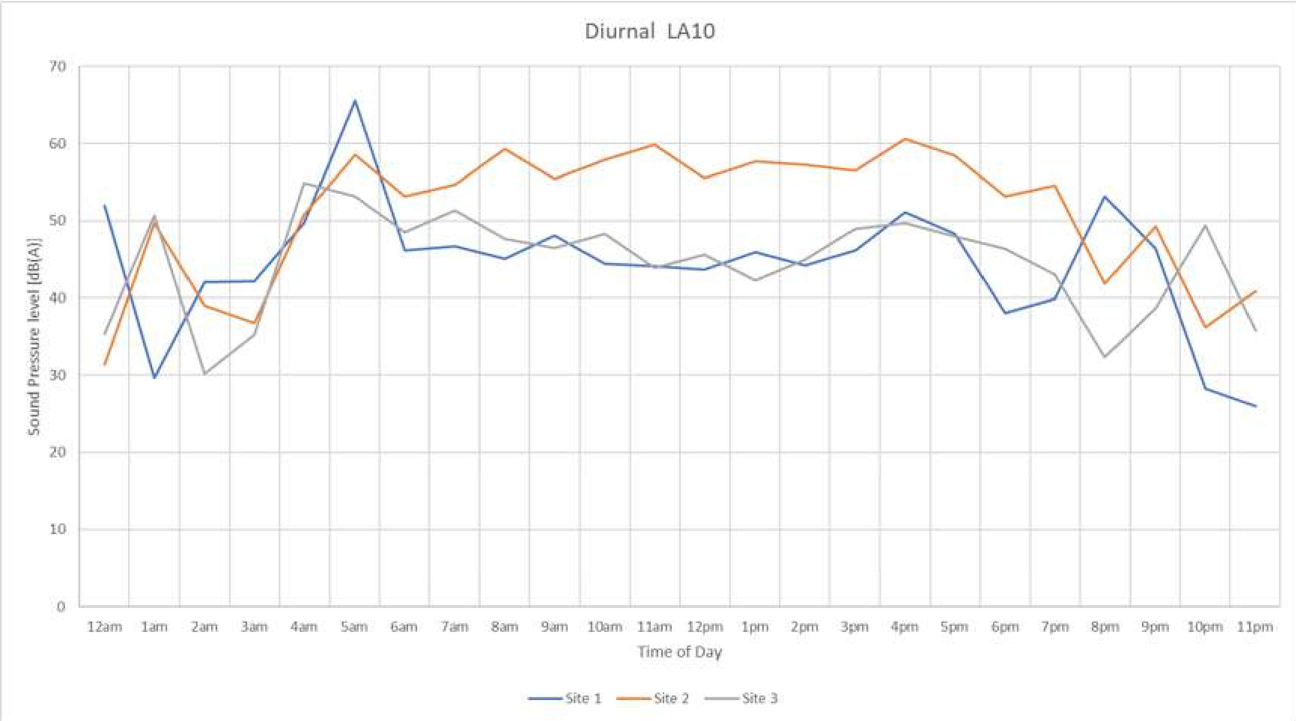

Figure 12-3: Measured L_{A10}.

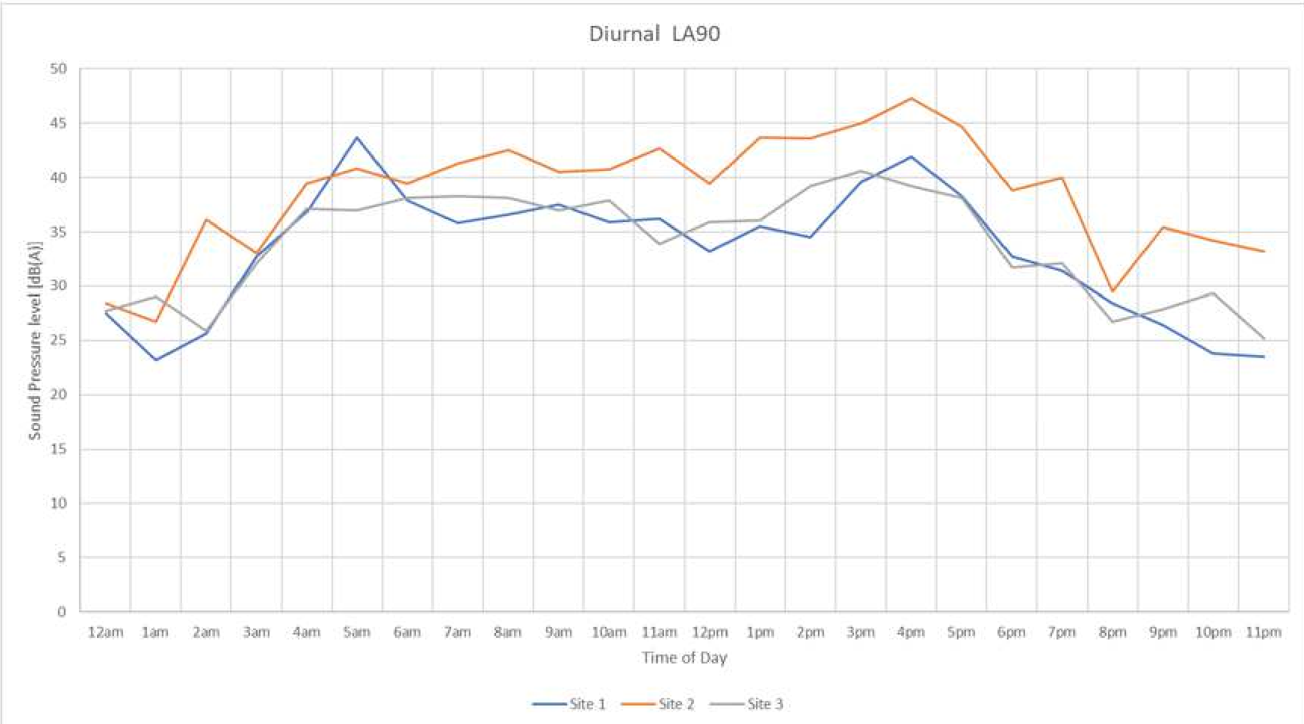

Figure 12-4: Measured L_{A90} - Background Noise Level.

The existing rating background noise level (RBNL) at each site is taken to be the lowest measured background noise level during the day evening and night periods (Table 12-7). The min L_{Aeq} (minimum L_{Aeq} over the time period) is also provided in the above measurements can be used to develop a rating background noise level (RBNL) at each site. The RBNL is taken to be the lowest measured background noise level during the day evening and night periods (Table 12-7).

Table 12-7: Rating Background Noise Level [dB(A)].

Site	Rating Background Noise Level for Period [dB(A)]		
	Day	Evening	Night
Site N1	33	26	23
Site N2	39	30	27
Site N3	34	27	25

Existing ambient noise levels were obtained at Cassim Island on Monday, 21 March 2022. The tide was at a low ebb and Cassim Island was linked to the foreshore. The wind speed was approximately 5 m/s from the south and there were small waves lapping on the shoreline of Cassim Island. During high tide the waves would be higher (due to increased fetch) and the noise from waves would be greater. Bird noise was not evident at 4 am. This was in complete darkness and prior to nautical dawn. There was no visible marine traffic near the site and most noise (except for wave lapping noise) appeared to originate from Cleveland. It is considered the noise levels obtained at Cassim Island are representative of the lowest noise levels likely to occur. It is noted the noise levels at Cassim Island are similar to and slightly greater than obtained at Sites N1 to N3. It is considered the noise from waves lapping and wind are the reasons for the slight increase over noise levels obtained at Sites N1 to N3. Background noise levels at Cassim Island are included in Table 12-8.

Table 12-8: Attended Noise Levels at Cassim Island

Time of day	L_{90} (Background)	L_{10}	L_{Aeq}
4am	37	48	45
7am	39	58	52

12.3.2 Background Underwater Noise

Acoustic energy propagates efficiently in water. Many marine fauna species rely on sound to perform communication, navigation, foraging and sensing the local environment. Humans typically hear noise between 50 Hz and 10 kHz with 500 Hz to 1 kHz important for speech. By comparison, fish species are sensitive from 20 Hz to several kHz. Marine mammals have broader hearing from a few Hz up to 180 kHz, with high sensitivity between 10 Hz to 100 kHz. Like humans, marine mammals do not have equal sensitivity at all frequencies. There are generally considered to be three marine mammal groups each with their own frequency-weighting network as outlined in Table 12-9.

Table 12-9: Attended Noise Levels at Cassim Island

Cetaceans Frequency Group	Auditory Range	Selected Species in Group
Low	7 Hz – 22 kHz	Humpback whale, Southern right whale, Bryde's whale, Blue whale and Minke whale
Mid	150 Hz – 160 kHz	Australian snubfin dolphin, Bottlenose dolphin, Australian humpback dolphin, Risso's dolphin, Spotted dolphin and Common dolphin
High	200 Hz – 180 kHz	Harbor porpoise, Finless porpoise, River porpoise, Southern fur seal, sea lions

The ambient noise levels in deep Australian Oceanic Waters have been described in Cato 1997 "Ambient Sea Noise in Australian Waters". There are a wide range of oceanic conditions around Australia resulting in wide variation in the characteristics and levels of ambient sea noise. Because of low levels of traffic noise in many areas, sea surface generated noise is often dominant at low frequencies (below about 200 Hz) in contrast to most northern hemisphere observations. Biological noise is usually dominant in tropical waters, except during conditions of high winds or heavy rain. Biological choruses that result when countless fish or invertebrates are calling are widespread in tropical and temperate waters, some showing regular diurnal variation. These choruses often rise more than 20 dB above the background noise. Intense transient signals from whales also make significant contributions to the ambient noise.

The main sources of noise in shallow water comprises:

- water motion near the sea surface (breaking waves);
- marine life; and
- shipping.

Traffic noise is defined as the background noise from distant shipping, in which no single ship is detectable. Noise from the sea surface was found to correlate better with wind speed than with surface wave properties and so is known as "wind dependent noise". Typical ambient noise in Australian Waters is shown in Figure 12-5.

Shipping (traffic noise) is typically below 300 Hz, however, closer inshore and in Moreton Bay the prevalence of high-speed propellers (compared with large slow speed propellers of ocean-going ships) would indicate higher frequencies are likely close to the Project footprint. The high frequency component of wind generated noise in enclosed waters, such as Moreton Bay is less likely to occur; however, the low frequency component will remain. Heavy rain generates significant noise over a very wide frequency range and would occur in Moreton Bay. The evening fish chorus, typically occurs for a few hours following sunset, is the most widespread and has been observed almost everywhere in shallow water, including Moreton Bay. Similar choruses are sometimes observed near sunrise and occasionally at other times of day.

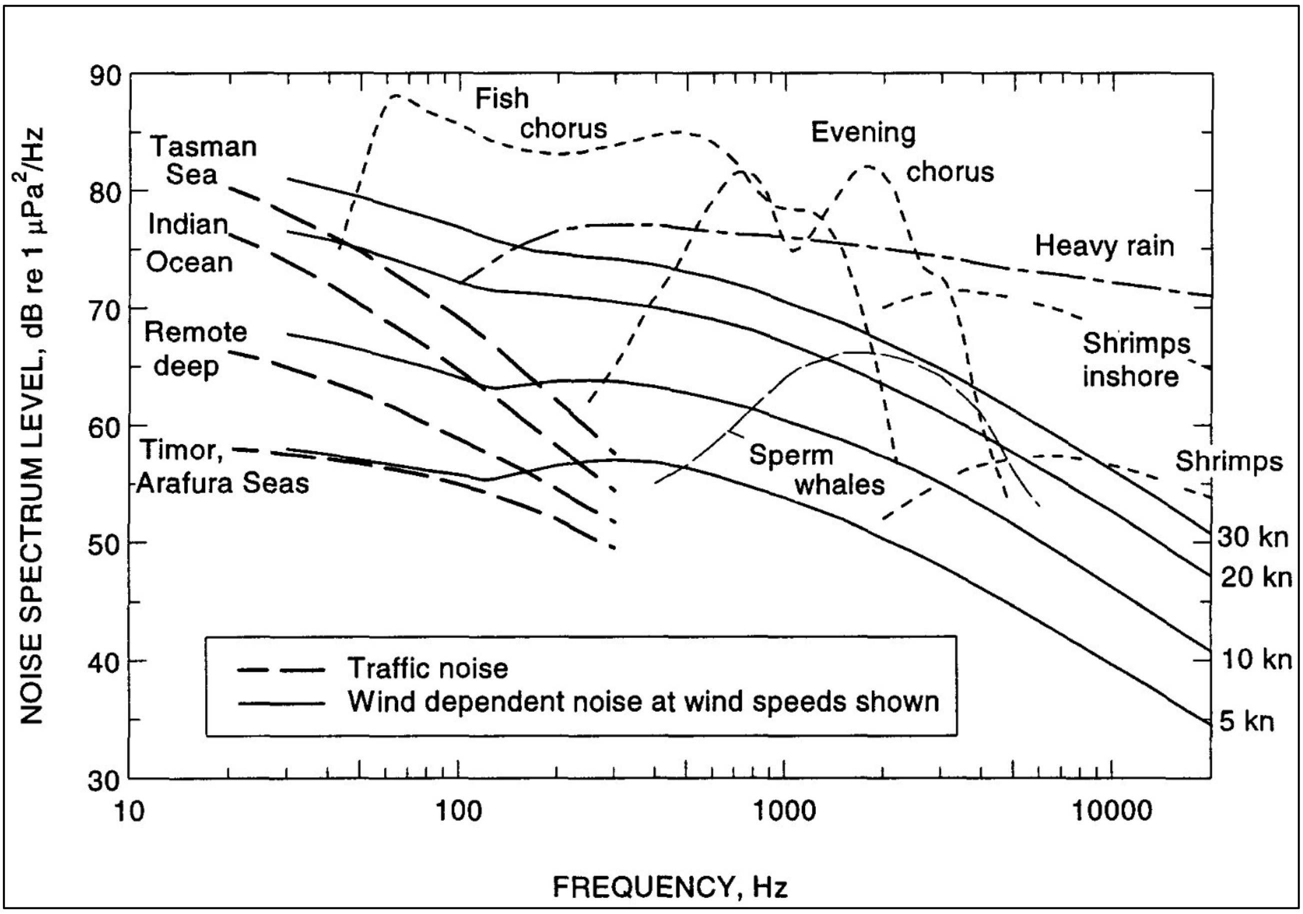

Figure 12-5: Representative components of ambient noise in Australian waters (Source: Cato 1997).

In 2008, Jasco Applied Sciences undertook an assessment of underwater noise from pile driving in Moreton Bay for construction of the Houghton Highway Bridge duplication. As part of that assessment, the ambient noise was measured close to construction works (near the piers) and the existing Houghton Highway and at two distant locations. Monitoring found the ambient noise in Moreton Bay is approximately 104 (dB MML re 1 μPa^2.s) including snapping shrimp and 94 (dB MML re 1 μPa^2.s) excluding snapping shrimp.

12.4. Potential Impacts

12.4.1 Noise Impacts on Sensitive Receptors

Noise levels predicted by modelling range between reported at sensitive receptors range between 40 and 60 dB(A). By way of comparison, noise levels for common noise sources reported by Safe Work Australia (2015) include:

- 30 dB – Whispering;
- 40 dB – Quiet radio music; and
- 60 dB – Normal conversation.

12.4.1.1 *Predicted Construction Noise Levels from Perimeter Sheet Piling and Rock Revetments*

Typical noise contours are presented for works on the northern reclamation near Cassim Island (Figure 12-6). These works are located on the eastern perimeter of the containment bund. The distance from these operations to the 50 dB(A) noise contour is approximately 650 m. At the closest approach of these construction activities to Cassim Island, the noise levels will be between 50 dB(A) and 55 dB(A). When these operations take place on the northern part of the reclamation area, the noise levels will be 45 dB(A) to 50 dB(A) on Cassim Island. Hence over the 90 days these activities take place, the construction noise levels are predicted to be between 45 dB(A) and 55 dB(A) on Cassim Island.

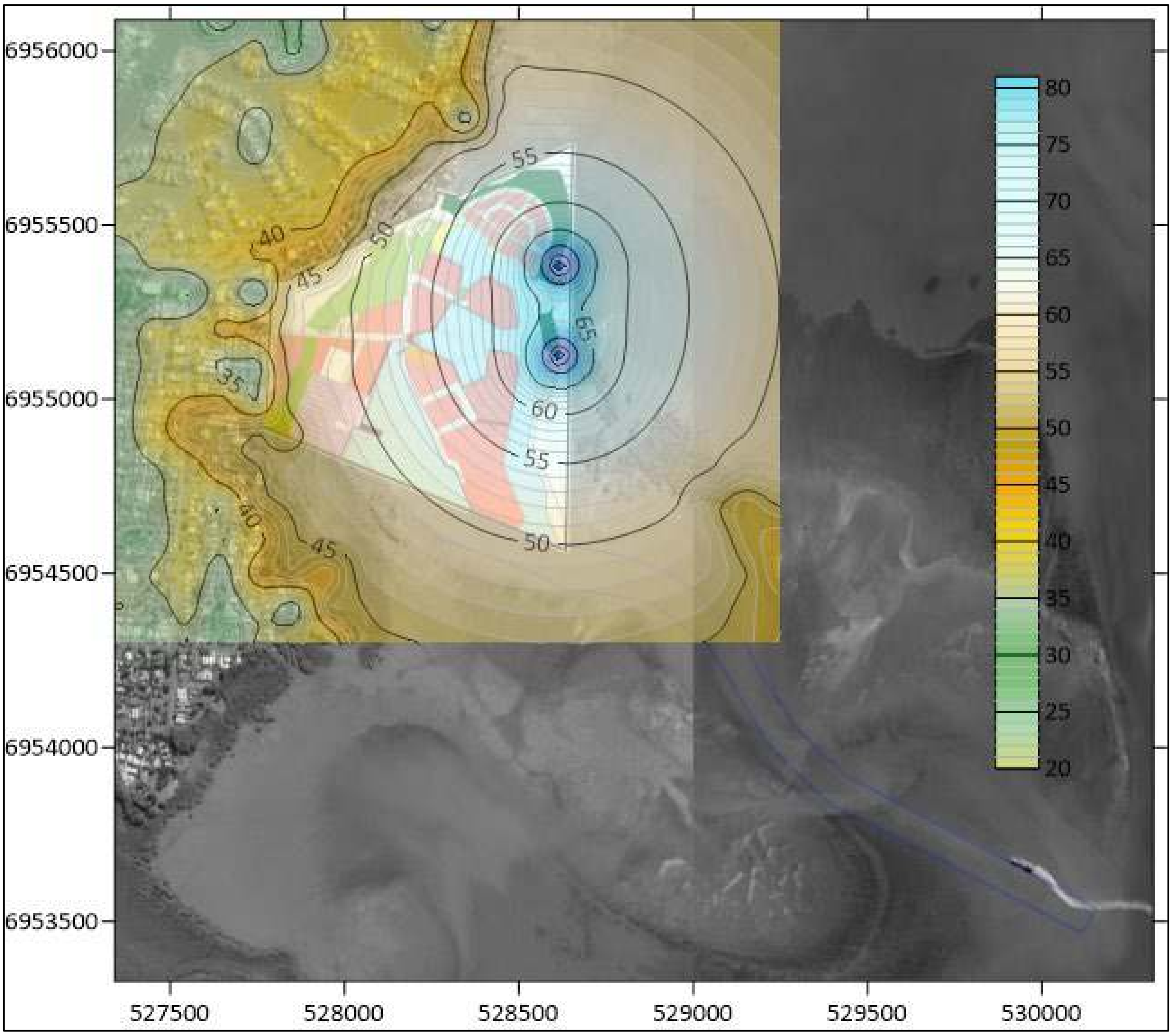

Figure 12-6: Noise from Perimeter Sheet Piling and Rock Revetment – Works on Northern Reclamation Eastern Perimeter

Typical noise contours are presented for works on the southern reclamation near Cassim Island (Figure 12-7). At closest approach of the perimeter sheet piling to Cassim Island, the noise levels are likely to be between 50 dB(A) and 58 dB(A). When these operations take place on the western part of the reclamation area, the noise levels will be 48 dB(A) to 53 dB(A) on Cassim Island. Hence over the 90 days these activities take place, the construction noise levels are predicted to be between 48 dB(A) and 58 dB(A) on Cassim Island. Once buildings are constructed on the northern reclamation area, there will be significant attenuation of noise levels to areas north of the Project.

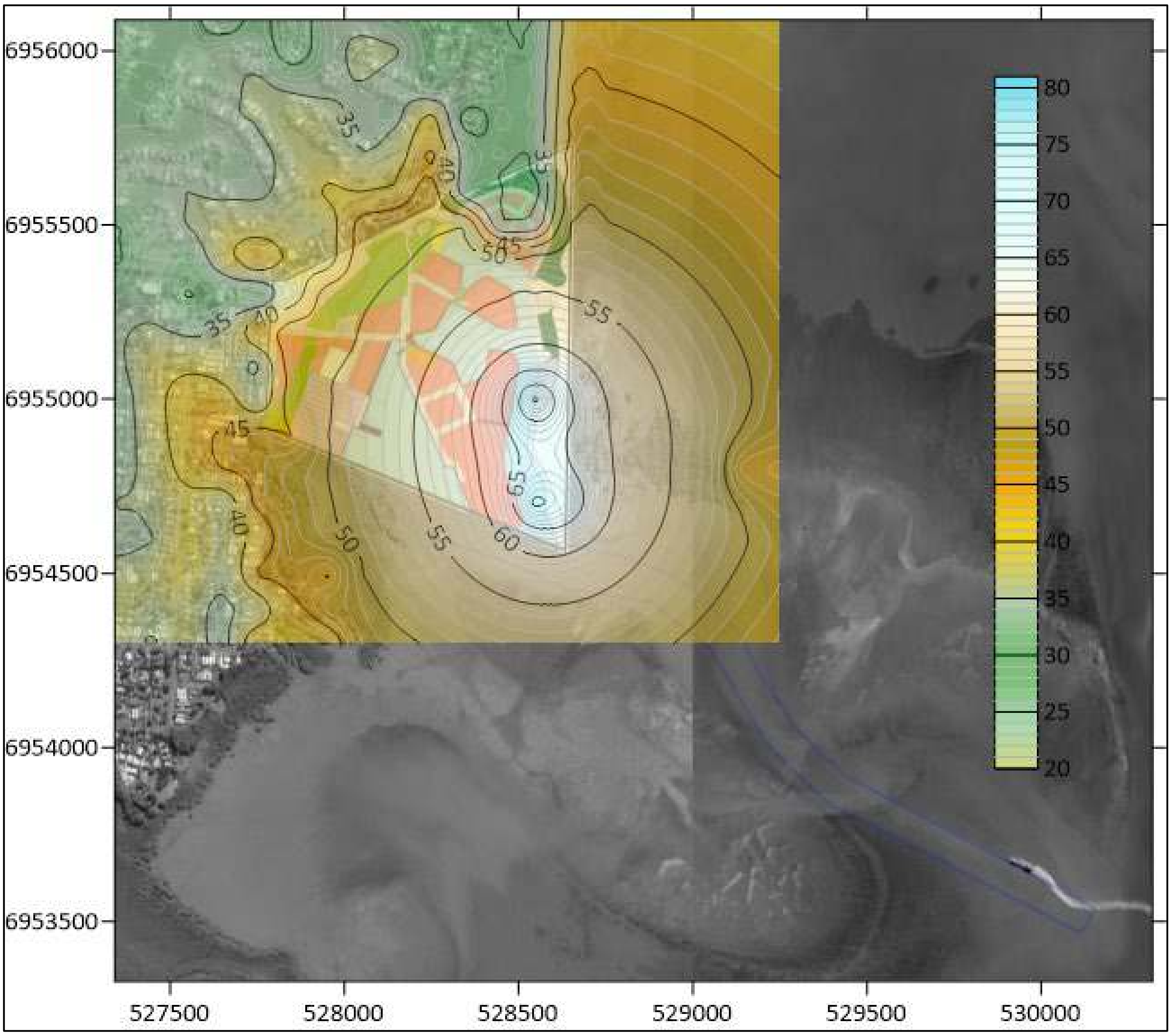

Figure 12-7: Noise from Perimeter Sheet Piling and Rock Revetment – Works on Southern Reclamation Eastern Perimeter

12.4.1.2 *Predicted Construction Noise from Internal Earthworks and Revetments including Marina Structures*

Typical noise contours are presented for construction works within the marina precinct (Figure 12-8). Typical construction noise levels on Cassim Island will be between 45 dB(A) to 53 dB(A). Hence over the 90 days these activities take place, the construction noise levels are predicted to be between 45 dB(A) and 55 dB(A) on Cassim Island.

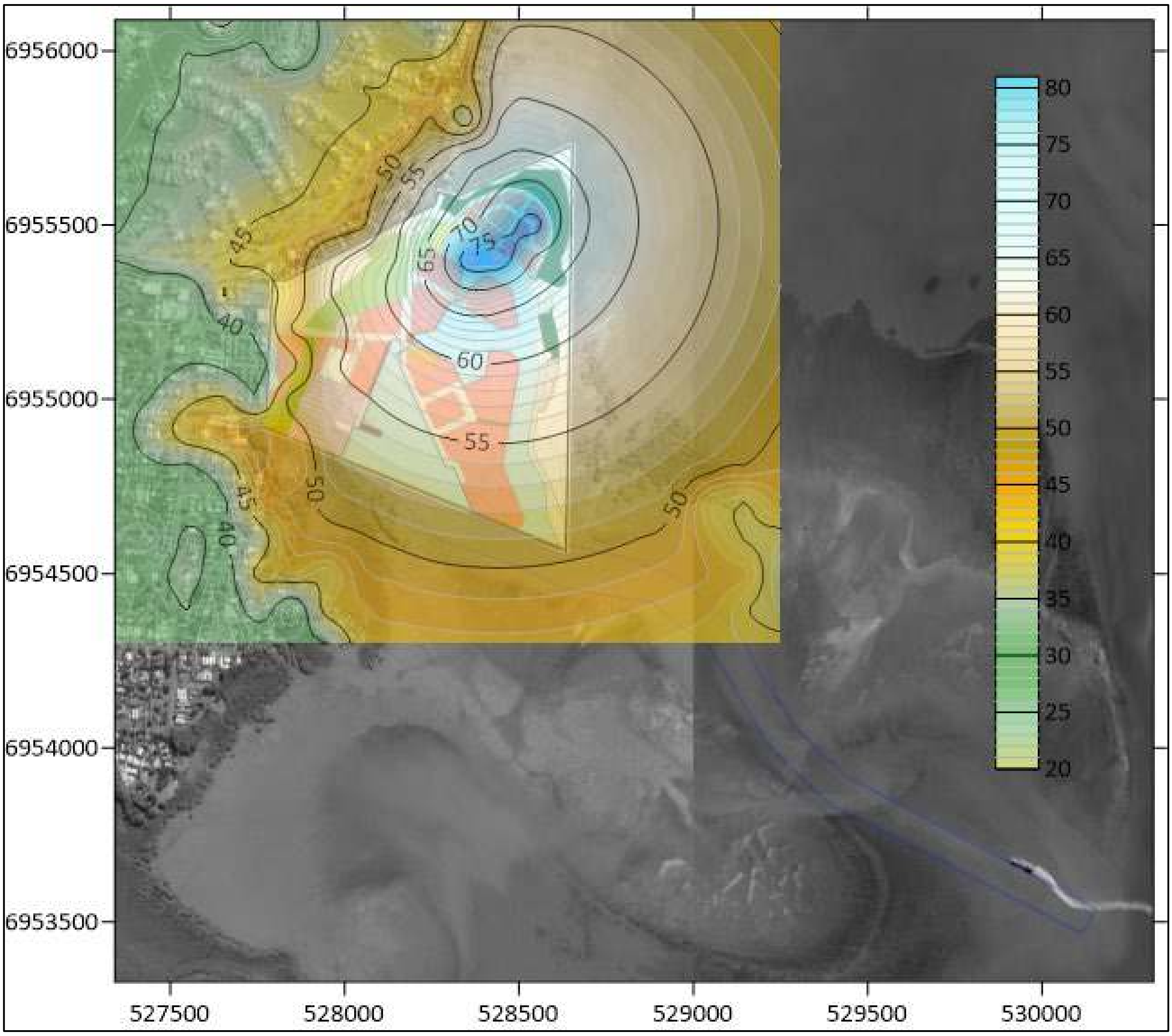

Figure 12-8: Noise from Internal Earthworks and Revetments – Northern Reclamation Earthworks and Marina.

Typical noise contours are presented for the works within the southern reclamation, including revetments and marine structures in the internal waterways in Figure 12-9. Typical noise levels on Cassim Island are calculated to be between 52 dB(A) to 59 dB(A) and these levels are expected to last three months. The dominant noise is associated with internal earthworks rather than the revetment for the channel.

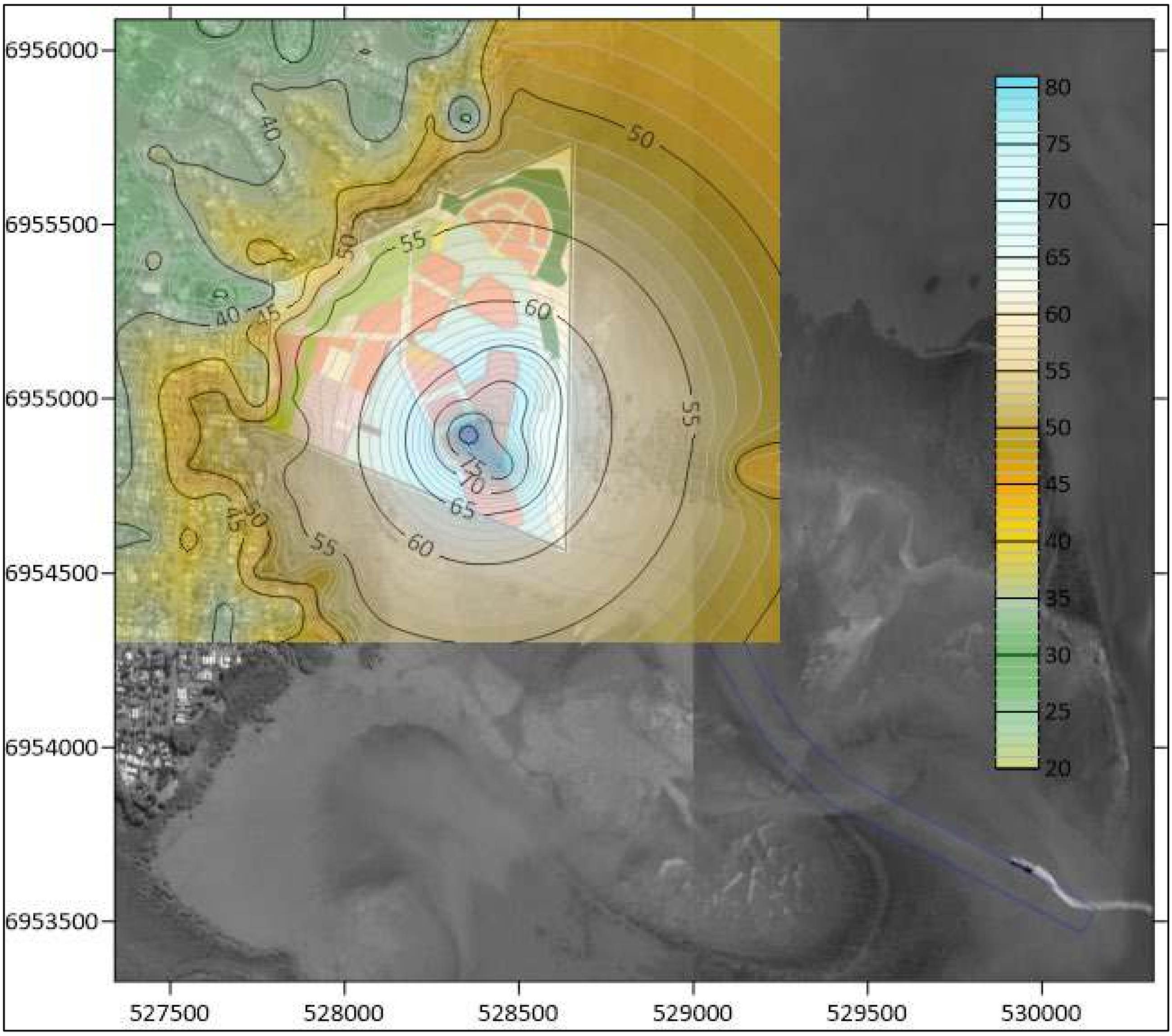

Figure 12-9: Noise from Internal Earthworks and Revetments – Southern Reclamation Earthworks and Internal Channels.

12.4.1.3 *Predicted Construction Noise from Dredging and Reclamation Landforming*

Typical noise contours are presented for the dredge operations including unloading and transfer of material at the northern reclamation in Figure 12-10. The distance from the dredge to the 50 dB(A) contour is approximately 500 m. Typical noise levels on Cassim Island will be between 50 dB(A) and 57 dB(A), with the surface works (rather than the dredge) being the major noise source.

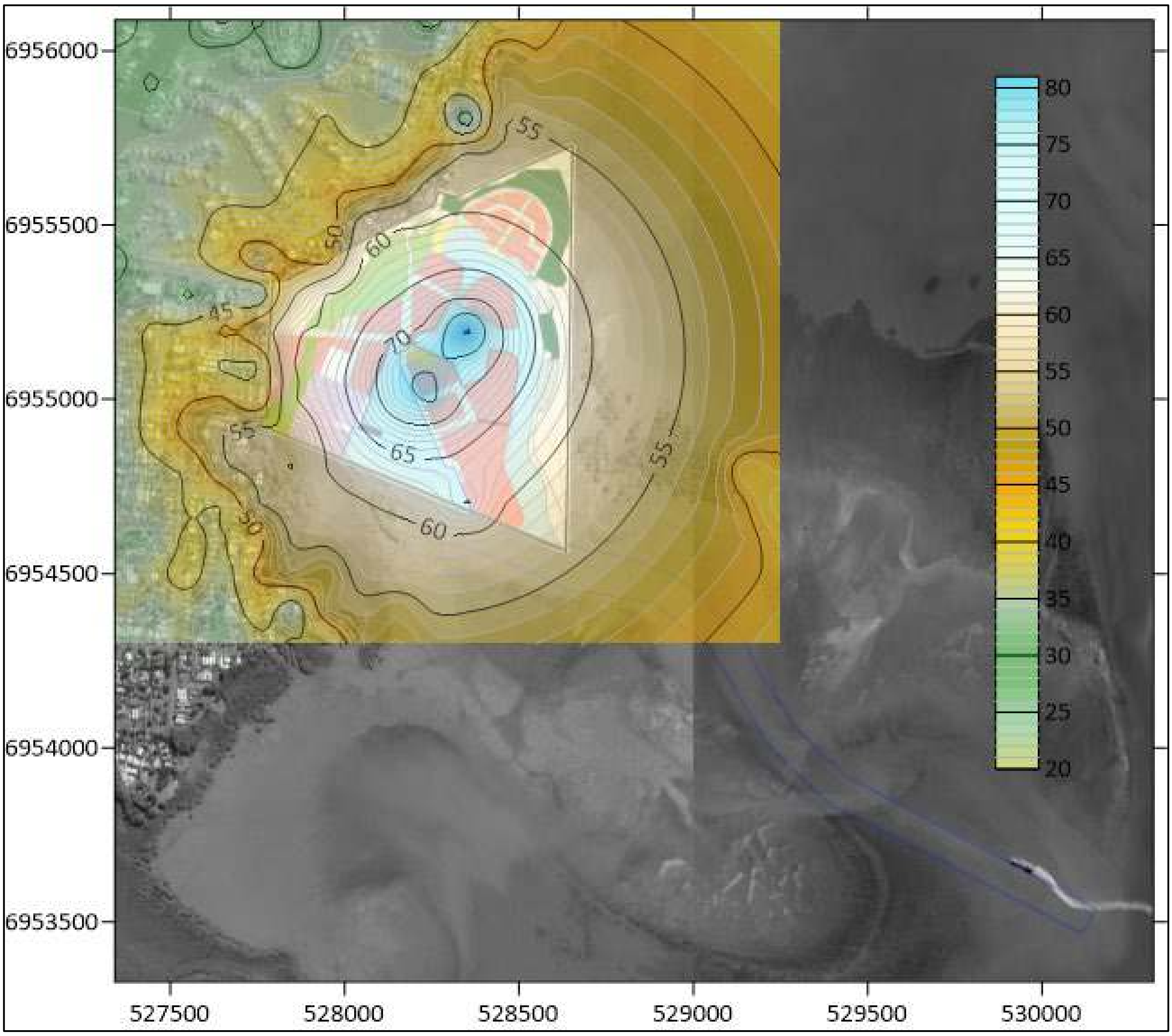

Figure 12-10: Noise from Dredging and Reclamation Landforming – Stage 1 Dredging and Northern Reclamation.

Typical noise contours are presented for the dredge operations including unloading and transfer of material at the temporary loading dock for the northern reclamation in Figure 12-11. The distance from the dredge to the 50 dB(A) noise contour is approximately 500 m. Typical noise levels on Cassim Island will be between 53 dB(A) and 60 dB(A), with the surface works (rather than the dredge) being the major noise source. Hence over the 120 days these activities take place, the construction noise levels are predicted to be between 53 dB(A) and 60 dB(A) on Cassim Island.

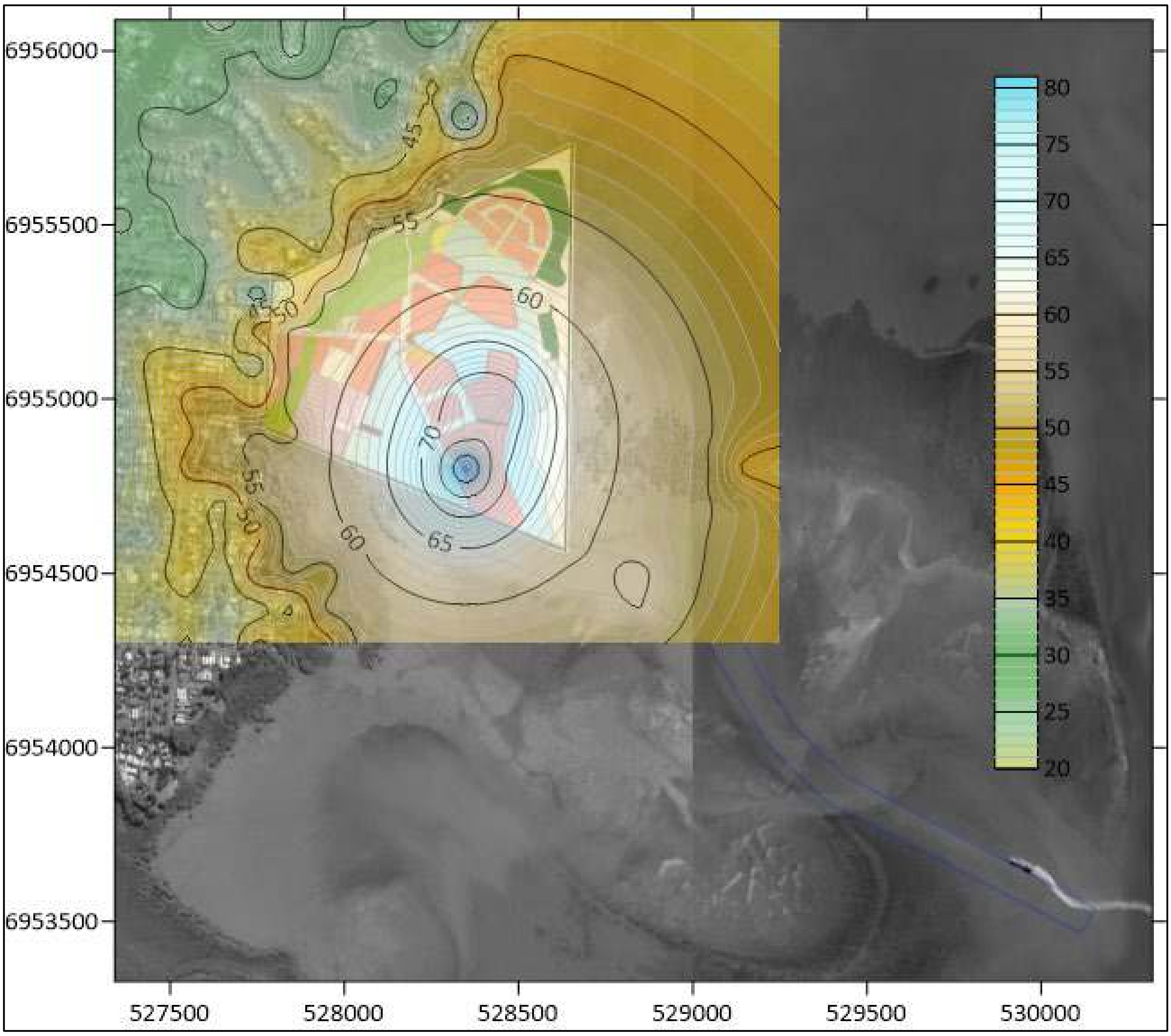

Figure 12-11: Noise from Dredging and Reclamation Landforming – Stage 2 Dredging and Southern Reclamation.

12.4.1.4 *Dredge Only Noise (Night Dredging)*

Dredging is the only activity proposed to occur at night, including unloading of barges. Noise contours for these works are shown on Figure 12-12. The modelling has included numerous locations for the dredge up to nominally 1 km from the coastline, combined in one figure. The noise levels on Cassim Island are 45 dB(A) to 52 dB(A) when the dredge is immediately adjacent to the island. The noise levels in the residential areas are likely to reach 45 dB(A) due to the unloading operation. The dredge alone is likely to cause noise levels less than 30 dB(A) in the residential areas.

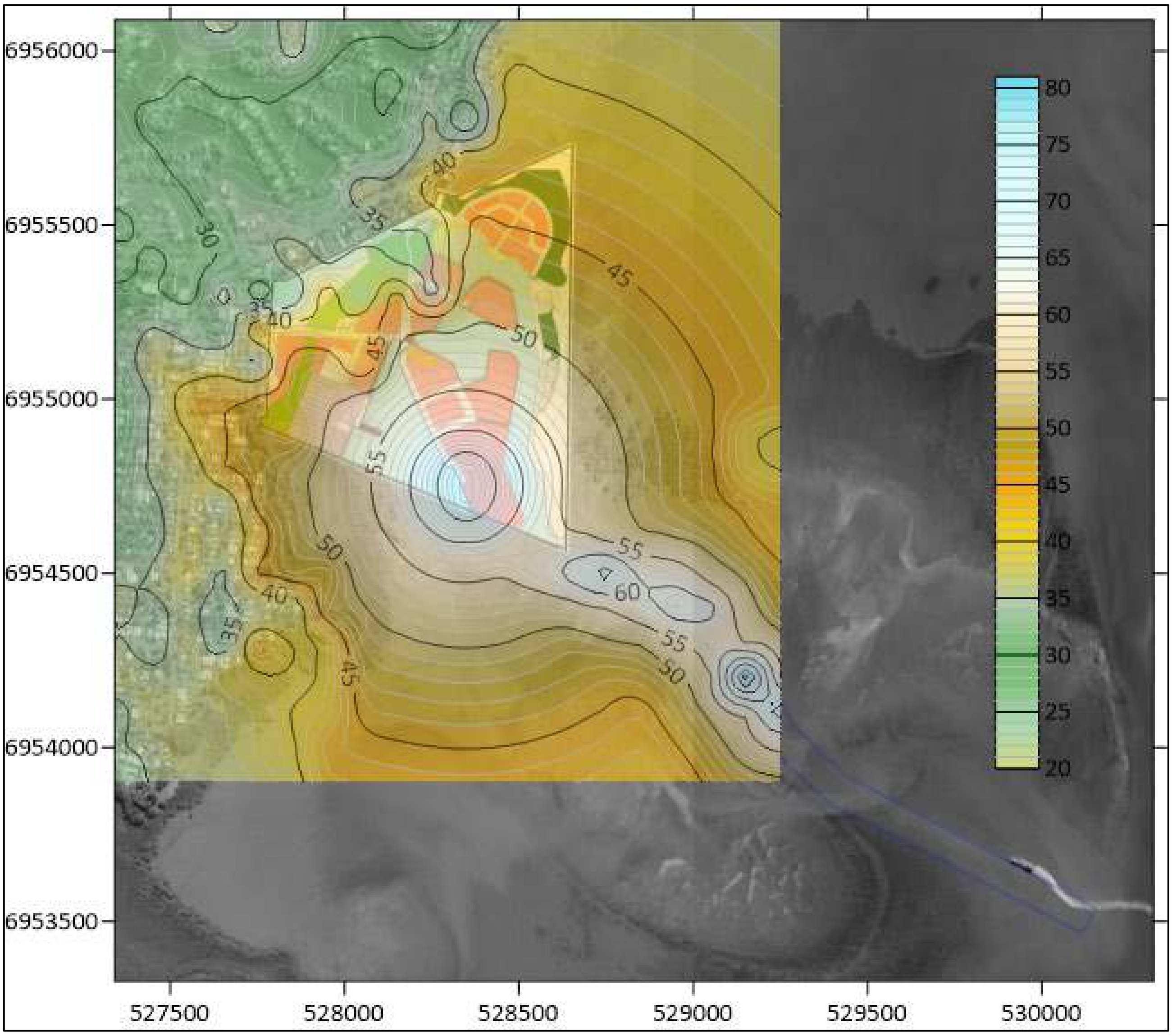

Figure 12-12: Noise from Dredging Alone including Workboat and Unloading Barge.

12.4.1.5 *Predicted Construction Noise in Residential Areas*

The duration of the construction works is longer than six months, hence the most stringent noise level goals apply. The noise modelling indicates that the construction works are likely to cause periods when noise levels are in excess of the residential noise level goal (Table 12-10). The range in noise levels generally refer to levels expected at the closest row of residences within the modelled precinct.

The acoustic quality objectives will be exceeded at some sensitive receptors for brief periods during construction. Although the noise modelling has identified high noise levels at nearby sensitive receptors, these higher levels will be short lived and will not be maintained at the modelled levels throughout the entire construction phase. The peak levels are only likely to last for a matter of days. The highest noise levels generally occur during construction of the perimeter sheet pile bunds and rock revetments for the northern reclamation then during stage 1 dredging while reclamation works are also occurring. This means the highest noise levels will occur intermittently over two separate, approximately 3 month, periods near the start of the Project. Noise levels will only exceed 60 db(A) in GJ Walter Park and not within residential areas. As previously noted, this is comparable to voice levels during a normal conversation.

The future residential uses at Toondah Harbour are expected to be subjected to high noise levels for longer periods due to the proximity to the construction works. Thus, noise control will be incorporated into the building envelope to ensure the internal noise level goals are met.

Table 12-10: Comparison of Predicted Noise Levels at Noise Sensitive Receptors.

Item	**Noise Levels Expressed in dB(A)**								
Receptors close to Site [1]	1			2			3		
	<2 weeks	>2 weeks and <6 months	>6 months	<2 weeks	>2 weeks and <6 months	>6 months	<2 weeks	>2 weeks and <6 months	>6 months
Noise Level Goal - Day	51	46	41	61	56	51	51	46	41
Noise Level Goal - Evening	46	41	36	54	49	44	40	35	30
Noise Level Goal - Night	36	31	26	40	35	30	38	33	28
Construction Noise Level Range	40 to 58			40 to 50			36 to 65		

The range in noise levels represent the noise levels at multiple sensitive receptors close to the monitoring sites.

12.4.2 Predicted Underwater Noise Levels

Typical underwater sound levels are shown for the vibratory sheet piling during the northern reclamation in Figure 12-13 and the southern reclamation in Figure 12-14. These contours apply when the pile is driven through water. At other times, when the pile is driven into exposed mudflats, the sound levels would be significantly lower. Typical tidal range at Toondah Harbour is 1.8 m and maximum depth of water during sheet piling is 1 m. Hence underwater noise from sheet piling will occur for up to 3.25 hours either side of high tide when piling furthest from the shore. When sheet piling is occurring closer to the shore, the water is shallower and the duration in the water will be less.

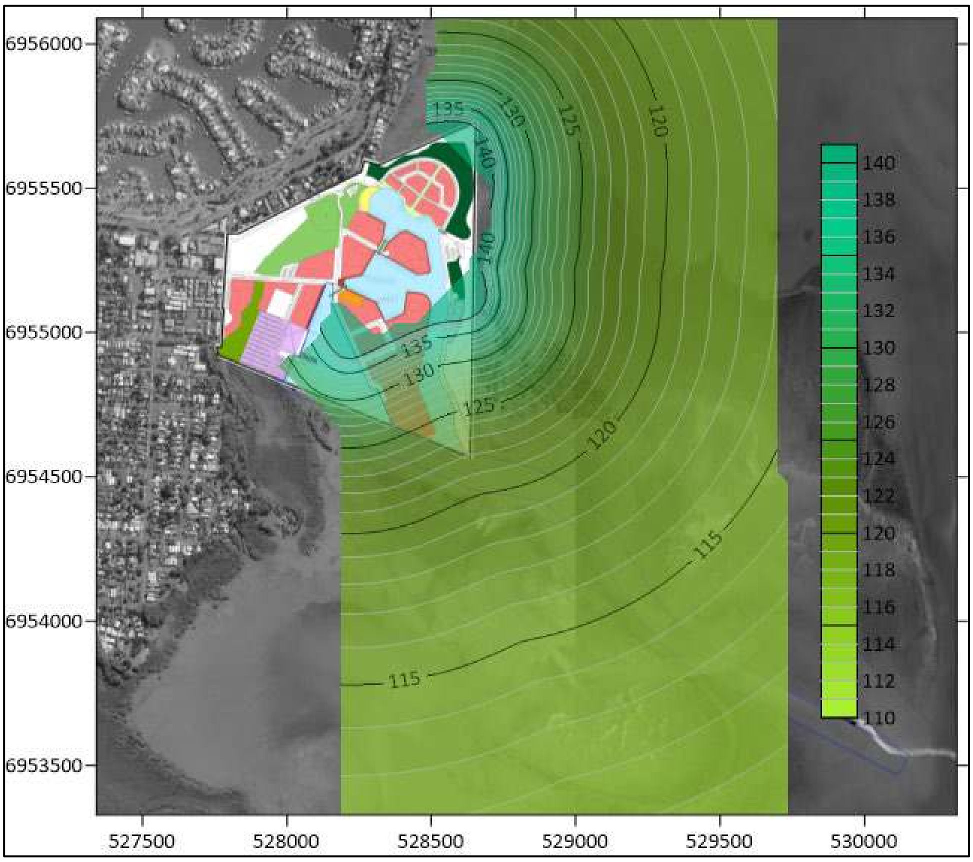

Figure 12-13: Underwater Noise from Northern Reclamation Vibratory Piling (When in Water).

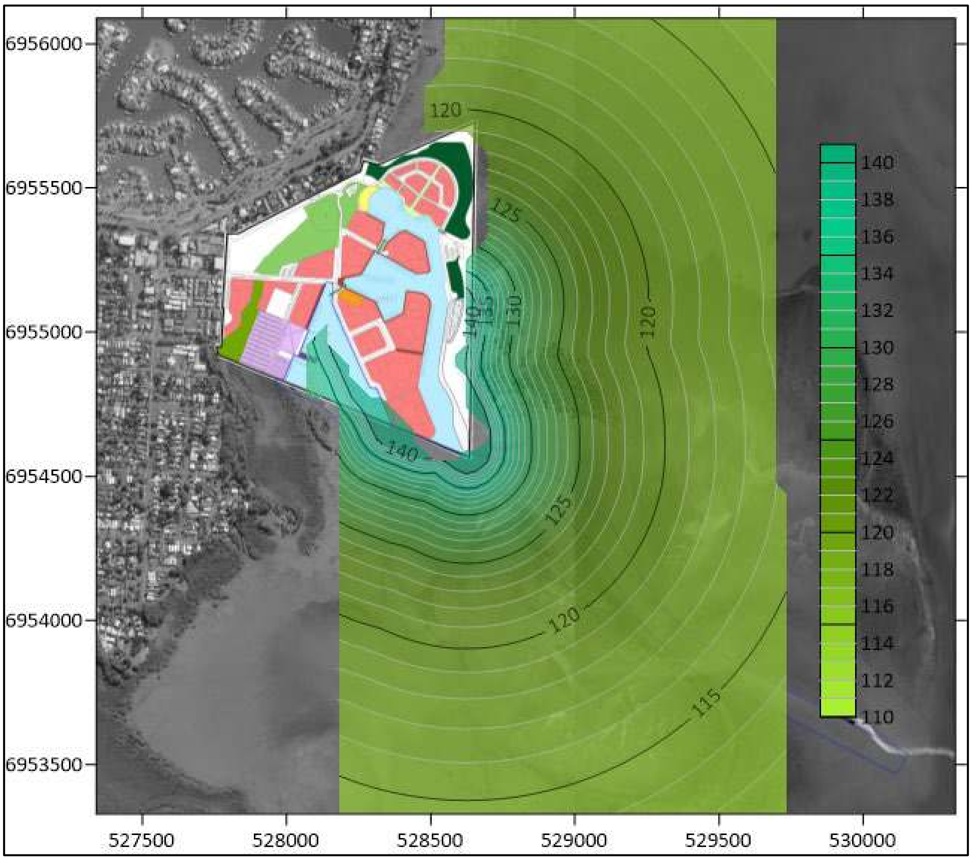

Figure 12-14: Underwater Noise from Southern Reclamation Vibratory Piling (When in Water).

Typical underwater sound levels are shown for the impact piling of circular piles at the ferry terminal in Figure 12-15. The impact piling in the marina will not generate sound levels outside of the marina basin since it is a fully enclosed body of water with only a narrow shallow connection to Moreton Bay at that stage of the Project.

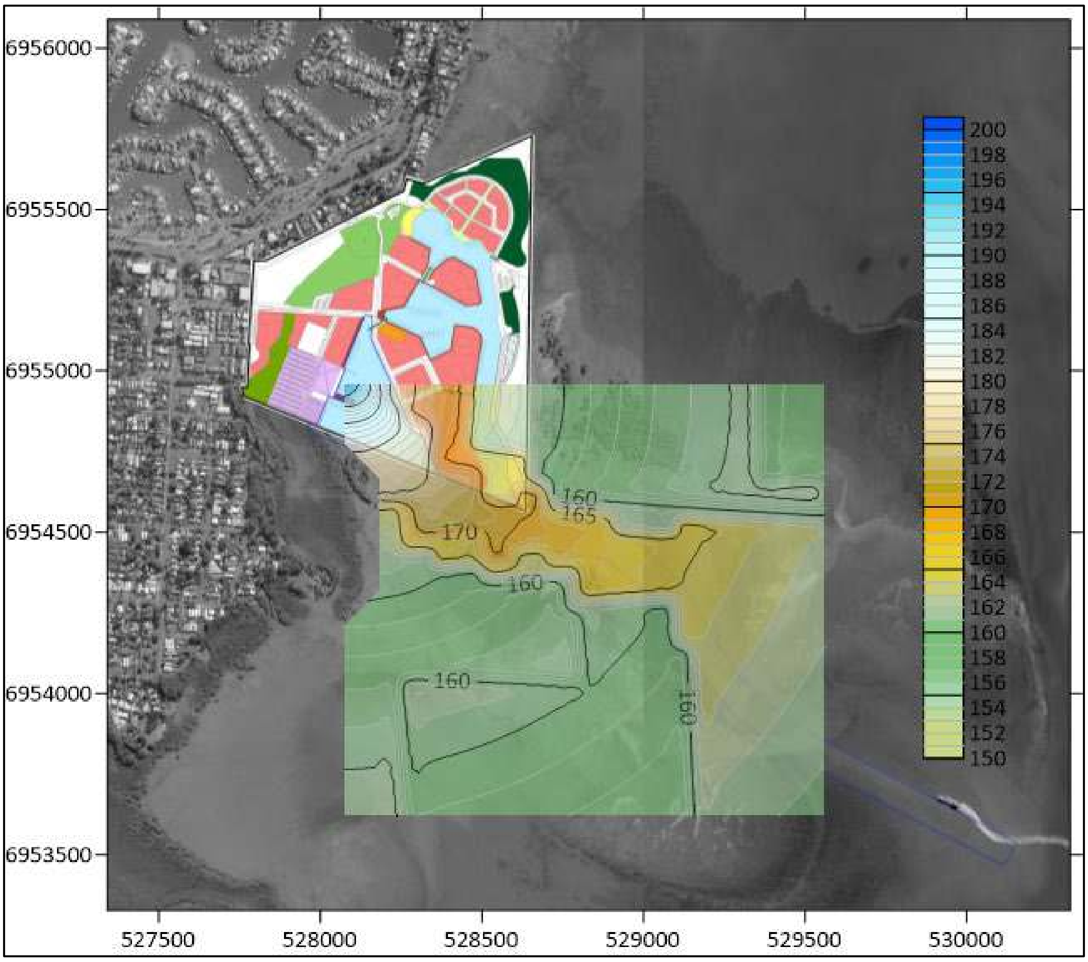

Figure 12-15: Underwater Noise from Impact Piling in the Harbour Area

The review of existing underwater noise levels reveals the waters surrounding Toondah Harbour are exposed to a wide range of noise levels. The ambient noise level is influenced by both anthropogenic and natural sources. Since there is an existing ferry terminal, the noise from boats will be significant in the harbour and Fison Channel. Measurements of underwater noise near Redcliffe during construction of the Hornibrook Bridge duplication indicates the ambient noise levels were between 94 to 104 (dB re 1 μPa^2.s). The modelling indicates that the noise generated by pile driving may lead to underwater noise levels in excess of the ambient noise experienced near Toondah Harbour. The highest underwater noise levels are likely during impact pile driving of circular piles associated with the ferry terminal development. The pile driving in the marina will be carried out prior to its connection to Moreton Bay and no offsite impacts are expected. Underwater noise from sheet piling is only likely when sheet piling occurs in water (i.e. when sheet piling is undertaken during or close to high tide periods). Given the sheet piling is taking place only within the intertidal region, underwater noise may be generated for approximately 3.25 hours either side of high tide.

The impacts of construction noise on marine fauna are addressed in Chapter 16 of the Draft EIS. Levels fall below the NOAA behavioural criteria of 160 dB re 1 μPa for impact pile driving and SPL 120 dB re 1 μPa for vibration pile driving within 1 km of the Project footprint.

12.4.3 Operational Noise Levels

Future uses of the reclaimed land are predominantly residential. These are not typically significant noise sources and are likely to comply with long-term noise level goals. The current Toondah Harbour uses remain in a similar location and hence a change in their environmental noise levels is unlikely.

Ongoing use will result in similar noise levels around the harbour and park areas. Although there may be additional traffic accessing the site, a doubling of traffic flows will only cause a 3dB(A) increase and this is not detectable by humans.

The future residential uses are expected to be subjected to high noise levels from construction due to the proximity to the construction works. Accordingly, noise control will be incorporated into the building envelope to ensure the internal noise level goals are met.

12.5. Adaptive Management and Monitoring Measures

While impacts are not anticipated to be significant, options available to mitigate construction noise are limited since the works are in an exposed location and close to sensitive receptors.

High noise generating activities are an unavoidable part of construction, however the duration of noisy works can be reduced through concurrent programming of higher intensity works, with longer periods of respite. For instance, rather than only deploy one vibration sheet piling unit to vibrate the sheet piles in place, multiple units could be operated concurrently to reduce the total number of construction days. Multiple units would result in a slightly higher noise level but allow the duration of noise impact to be significantly reduced.

Increased intensity works would also be programmed to avoid ecologically important times and locations. For example, sheet piling using multiple units would be carried out in winter months to avoid migratory bird non-breeding season when more shorebirds are present in Moreton Bay. Real time monitoring of shorebirds and noise levels would be carried out at Cassim Island and Nandeebie Claypan so that the intensity of works can be reduced in response to observed disturbances.

Where possible, low-noise plant will be selected for the site and be fitted with high-performance mufflers and other specific noise control for the engine and drive train to substantially reduce noise from equipment that is predominantly engine noise (i.e., from graders, excavators, rollers etc).

Acoustic screens may be deployed close to any activity or sensitive receptor. Suitable locations for acoustic screens include:

- Laydown areas;
- Fixed plant;
- Pug mill (if adopted) and unloading dock;
- Dewatering pumps; and
- Generators.

Where an activity is anticipated to impact on ambient and underwater noise and vibration levels, mitigation measures to reduce severity of impacts and measures for detection and management of potential impacts are proposed in Table 12-11. Management measures address mitigation and monitoring of noise sources only. Measures specific to terrestrial fauna, marine fauna and migratory shorebirds are addressed in Chapters 15, 16 and 17 respectively.

Table 12-11: Ambient and Underwater Noise Management Measures

Potential Impacts	Mitigation Measure	Desired outcomes and effectiveness
Ambient and underwater noise generation from installation of sheet piling and rock revetments for reclamation perimeter walls	▪ Ensure all equipment used is maintained in good working condition and fitted with high performance mufflers. ▪ Increase intensity of high noise activities (i.e., multiple piling units) when low risk to environmental receptors (i.e., migratory bird breeding season). ▪ Where the high noise level works are projected to occur for several hours, provide a two-hour respite period every four hours. ▪ Ensure the crew is trained and suitably qualified to carry out piling works. ▪ Use low noise piling methods, such as vibro-driving, instead of impact piling methods where possible. ▪ Acoustic screens to be deployed close to any high noise activity or sensitive receptor as required ▪ Carry out monitoring and management measures for marine fauna (Chapter 16) and migratory shorebirds (Chapter 17). This will include ongoing monitoring for fauna and ecologically sensitive locations and modifying works in real time to minimise disturbance.	▪ No long-term disturbance to marine or terrestrial fauna as a result of high noise generating activities. ▪ Noise modelling has shown that high noise generating activities will occur for short periods throughout construction. Impacts to ecologically sensitive receptors can be managed by careful programming of noisy works and ongoing monitoring and adaptive management of the works program is required. ▪ Management measures are expected to be highly effective in minimising disturbance to ecologically sensitive receptors.
Ambient and underwater noise generation from installation of vertical piles within the harbour area	▪ Ensure all equipment used is maintained in good working condition and fitted with high performance mufflers. ▪ Increase intensity of high noise activities (i.e., multiple piling units) when low risk to environmental receptors (i.e., migratory bird breeding season when most of the shorebirds are away from Moreton Bay). ▪ Where the high noise level works are projected to occur for several hours, provide a two-hour respite period every four hours. ▪ Ensure the crew is trained and suitably qualified to carry out piling works. ▪ Use low noise piling methods, such as vibro-driving, instead of impact piling methods where possible. ▪ Acoustic screens to be deployed close to any high noise activity or sensitive receptor as required. ▪ Carry out monitoring and management measures for marine fauna (Chapter 16) and migratory shorebirds (Chapter 17). This will include ongoing monitoring for fauna and ecologically sensitive locations and modifying works in real time to minimise disturbance.	▪ No long-term disturbance to marine or terrestrial fauna as a result of high noise generating activities. ▪ Noise modelling has shown that high noise generating activities will occur for short periods throughout construction. Impacts to ecologically sensitive receptors can be managed by careful programming of noisy works and ongoing monitoring and adaptive management of the works program is required. ▪ Management measures are expected to be highly effective in minimising disturbance to ecologically sensitive receptors.

Potential Impacts	Mitigation Measure	Desired outcomes and effectiveness
Ambient noise generation from dredging activities at night	▪ Ensure all equipment used is maintained in good working condition and fitted with high performance mufflers. ▪ Ensure the crew is trained and suitably qualified. ▪ Acoustic screens to be deployed around unloading dock. ▪ Carry out monitoring and management measures for marine fauna (Chapter 16) and migratory shorebirds (Chapter 17). This will include ongoing monitoring for fauna and ecologically sensitive locations and modifying works in real time to minimise disturbance.	▪ No long-term disturbance to marine or terrestrial fauna as a result of high noise generating activities. ▪ Management measures are expected to be highly effective in minimising disturbance to ecologically sensitive receptors.
Ambient noise generation from reclamation and construction of revetments for the marina and internal channels	▪ Ensure all equipment used is maintained in good working condition and fitted with high performance mufflers. ▪ Increase intensity of high noise activities (i.e., multiple piling units) when low risk to environmental receptors (i.e., during migratory bird breeding season). ▪ Where the high noise level works are projected to occur for several hours, provide a two-hour respite period every four hours. ▪ Ensure the crew is trained and suitably qualified to carry out piling works. ▪ Use low noise piling methods, such as vibro-driving, instead of impact piling methods where possible. ▪ Acoustic screens to be deployed close to any high noise activity or sensitive receptor as required. ▪ Carry out monitoring and management measures for marine fauna (Chapter 16) and migratory shorebirds (Chapter 17). This will include ongoing monitoring for fauna and ecologically sensitive locations and modifying works in real time to minimise disturbance.	▪ No long-term disturbance to marine or terrestrial fauna as a result of high noise generating activities. ▪ Noise modelling has shown that high noise generating activities will occur for short periods throughout construction. Impacts to ecologically sensitive receptors can be managed by careful programming of noisy works and ongoing monitoring and adaptive management of the works program is required. ▪ Management measures are expected to be highly effective in minimising disturbance to ecologically sensitive receptors.
Disturbance of human receptors through all stages of construction	▪ Develop and implement a comprehensive construction noise and vibration management plan. ▪ Ensure all affected or potentially adversely affected residences are notified of the works program. ▪ Ensure all equipment used is maintained in good working condition and fitted with high performance mufflers. ▪ Avoid unnecessary revving of engines and switch off equipment when not required. ▪ Provide broad band reversing audible alarms (rather than beepers) for mobile plant.	▪ Minimise human disturbance during high noise generating activities. ▪ Management measures are expected to be effective in minimising human disturbance, although some short-term impacts are likely.

Potential Impacts	Mitigation Measure	Desired outcomes and effectiveness
	▪ Where the high noise level works are projected to occur for several hours, provide a two-hour respite period every four hours. ▪ Where possible, ensure that construction vehicles (especially heavy vehicles) waiting for access to the site do not congregate adjacent to existing and future noise sensitive receptors. ▪ Provide a contact person and phone number for the community to contact regarding any issues that may arise during construction. ▪ Develop and implement a response plan for noise complaints.	

12.6. Residual Risk of Impact

The risk of significant residual impacts to the noise environment has been assessed following the methodology outlined in Chapter 6 of the EIS. The risk of significant residual impacts to environmental values, such as terrestrial and marine flora and fauna and migratory shorebirds, has been addressed in Chapters 15, 16 and 17 respectively. If managed appropriately, risk of impacts from noise to ecological sensors is considered low (Table 12-12).

Table 12-12: Ambient and Underwater Noise and Vibration Risk Assessment of Key Activities.

Activity	**Initial risk assessment**					**Mitigated risk assessment**				
	Scale	**Duration**	**Impact**	**Likelihood**	**Risk**	**Scale**	**Duration**	**Impact**	**Likelihood**	**Residual risk**
Ambient and underwater noise generation from installation of sheet piling and rock revetments for reclamation perimeter walls	Local	Short	Low	Possible	**Low**	Local	Short	Low	Not Likely	**Low**
Ambient and underwater noise generation from installation of vertical piles within the harbour area	Local	Short	Low	Possible	**Low**	Local	Short	Low	Not Likely	**Low**
Ambient noise generation from dredging activities at night	Local	Short	Low	Possible	**Low**	Local	Short	Low	Not Likely	**Low**
Ambient noise generation from landforming and construction of revetments for the marina and internal channels	Local	Short	Low	Possible	**Low**	Local	Short	Low	Not Likely	**Low**
Disturbance of human receptors through all stages of construction	Local	Short	Low	Likely	**Medium**	Local	Short	Low	Likely	**Medium**