Great Keppel Island Resort

Central Queensland

Noise and Vibration Assessment

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Prepared for

Great Keppel Island Resort Pty Ltd

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Executive Summary

GKI Resort Pty Ltd proposes to revitalise the Great Keppel Island resort including providing new accommodation, marina, retail outlets, restaurants, golf course and support facilities. Great Keppel Island is located approximately 12km east of Yeppoon on the Central Queensland coast and is within the Great Barrier Reef World Heritage Area.

The principle noise and vibration aspects of the development relate to aircraft movements, construction, equipment within the industrial compound, resort activities (e.g. retail & restaurants), and underwater activities (e.g. sea vessels, marina construction).

Existing residences on the Island are generally located by the beach, and thus the existing noise environment at these locations is typical of most beachside locations, in that noise environment is dominated by waves on the beach, wind rustling leaves in the trees and animals, including insects, usually a seasonal effect which is strongest in warmer months, and birds. The noise environment is also affected by the operation of a number of diesel powered generators at the various dwellings and backpacker accommodation. Further from the beach the noise environment was found to be quieter.

A number of underwater noise measurements were conducted off Fishermans Beach and around the Island. The measurements indicated that the underwater acoustic environment was dominated by snapping shrimps. Measurements were also conducted of various sea vessels including recreational craft and the ferry.

A review of Department of Environment and Resource Management noise criteria was conducted. The review considers noise criteria contained within the Act, Environmental Protection (Noise) Policy and EcoAccess Guidelines. To achieve compliance with the nominated noise and vibration criteria will require implementation of noise and vibration mitigation and management measures.

Aircraft noise has been assessed using a combination of noise measurements and modelling. The existing runway has been modelled using light aircraft whilst the proposed relocated runway has been modelled using the proposed mid-sized aircraft (Dash8 & ERJ190). For the proposed runway, aircraft noise has been modelled using the overpass noise levels from AS2021, and also using ground based noise levels. Based on this modelling there is a predicted net reduction in noise levels of 5 to 10 dB(A) at existing residences and accommodation due to the relocation of the runway to the north-east.

The predicted aircraft noise levels at the proposed resort accommodation are generally 70 to 90 dB(A) $L_{max,S}$. For an aerodrome with low flight numbers, the acceptable noise levels for aircraft are up to 85 dB(A) $L_{max,S}$ and therefore some apartments may require acoustic upgrades. Based on the current design, the impacted apartments are those located in the marina, in line with the end of the runway, and those adjacent the runway (Airstrip Villas). The acoustic upgrades would likely result in the requirement for upgraded roof/ceiling construction, blockwork walls (or lightweight walls with multiple layers of plasterboard) and double-glazing.

The industrial compound is an area likely to include elevated noise levels due to the location of the emergency generators, wastewater treatment facility, and solid waste management. The compound is removed from existing residences (700m) and proposed guest accommodation (250m), but is adjacent the proposed staff accommodation. Whilst some allowance for elevated noise levels could be expected for the staff accommodation, there will be noise constraints on the activities within the compound.

Modelling has indicated that the generators are likely to require enclosure and acoustic treatment, the extent of which will depend on their design, selection and location within the compound. A similar result is indicated for the wastewater treatment facility, where compliance is expected for existing residences and the guest accommodation, but mitigation measures may be required to address the adjoining staff accommodation. The solid waste management component of the compound is likely to require screening with bunding or intervening buildings to achieve compliant noise levels at the proposed guest accommodation due to noise from heavy vehicles and composting fans. In all instances, consideration will need to be given to the relative proximity of the staff accommodation.

Noise data for golf course maintenance equipment has been provided and demonstrates that relatively high noise levels can be emitted. Maintenance equipment is therefore restricted to daytime hours to minimise noise impacts on proposed guest accommodation. Due to the significant separation distance, there are no significant day time noise impacts expected at existing residences.

The marina will include a number of activities with the potential to create noise. A noise management plan will need to be developed for the marina in the course of its design to ensure an appropriate noise amenity for the apartments in this complex. The management of noise issues in the marina itself will generally result in minimal noise emissions to the existing residences which are located some 250m away (backpacker accommodation) or 400m away (detached dwellings).

Noise from vehicles driving around the Island has been assessed in terms of the impact on existing dwellings. Recommended buffer distances are proposed for various vehicles and whether the road is regularly accessed in the day or night. Buffer distances range from several metres for a driveway only used in the daytime, to 30m for a carpark used in the day and night, to over 200m for a heavy vehicle carpark used in the day and night.

Construction activity is likely to be the most significant noise impact on existing residences due to the duration of the works (2012 to 2023) and the proximity of parts of the resort. Within the Environmental Protection Act construction activity is restricted to daytime unless inaudibility is achieved outside these hours. Within this report it is recommended that long term noise limits be the target for daytime construction activities where possible. The intent of this is to encourage good practice through the location of some construction activities away from residences. A detailed construction noise management plan should be prepared as part of the detailed design process. It should make reference to Australian Standard AS2436-2010 "Guide to noise and vibration control on construction, demolition and maintenance sites". This standard provides details on strategies to minimise construction noise.

The noise impact on marine life has been assessed and an animal safety zone has been recommended for marina piling operations, as follows:

- The marine animal safety zone is 500m.
- Piling should not commence or continue if dolphins, dugongs or turtles are within the marine animal safety zone.
- A pre-piling observation time of 30 minutes is proposed.
- Piling should commence with a soft start-up to scare animals away before piling starts.
- If a marine animal is spotted during piling, then piling is to cease until the animal has left the safety zone, or until it has not been observed for at least 10 minutes.

To assess the risk posed to the noise and vibration environment by activities undertaken as part of the proposed project a risk assessment has been undertaken. This risk assessment addresses the potential impacts for each phase of the project and their consequences described in the above sections along with proposed mitigation measures to address each identified risk. The risk assessment matrix and potential impacts and mitigation strategies are included in Appendix G.

1 Introduction

GKI Resort Pty Ltd proposes to revitalise the Great Keppel Island resort including providing new accommodation, a marina, retail outlets, restaurants, golf course and support facilities. Great Keppel Island is located approximately 12km east of Yeppoon on the Central Queensland coast within the Great Barrier Reef World Heritage Area.

ASK Consulting Engineers Pty Ltd (ASK) was commissioned by GKI Resort Pty Ltd to provide a noise and vibration assessment for the proposed resort development. This report is to form part of the Environmental Impact Statement (EIS) for the project.

The principal noise and vibration aspects of the development relate to aircraft movements, construction, the industrial compound, resort activities (e.g. retail & restaurants), and underwater activities (e.g. sea vessels, marina construction).

The purpose of this report is as follows:

- Outline the relevant project noise and vibration criteria.
- Present the results of noise monitoring.
- Predict and assess the noise and vibration emissions from the development.
- Predict and assess the noise and vibration impacts onto the development.
- Recommend mitigation and management requirements.

To aid in the understanding of the terms in this report a glossary is included in Appendix A.

2 Study Area Description

The proposed development is to be located Great Keppel Island, which is located 12km east of Yeppoon on the Central Queensland coast. The site location is shown in Figure 2.1 (source: Google Earth Pro).

A plan showing the names of the beaches around the Island, and the proposed resort plan, is included in Appendix B.

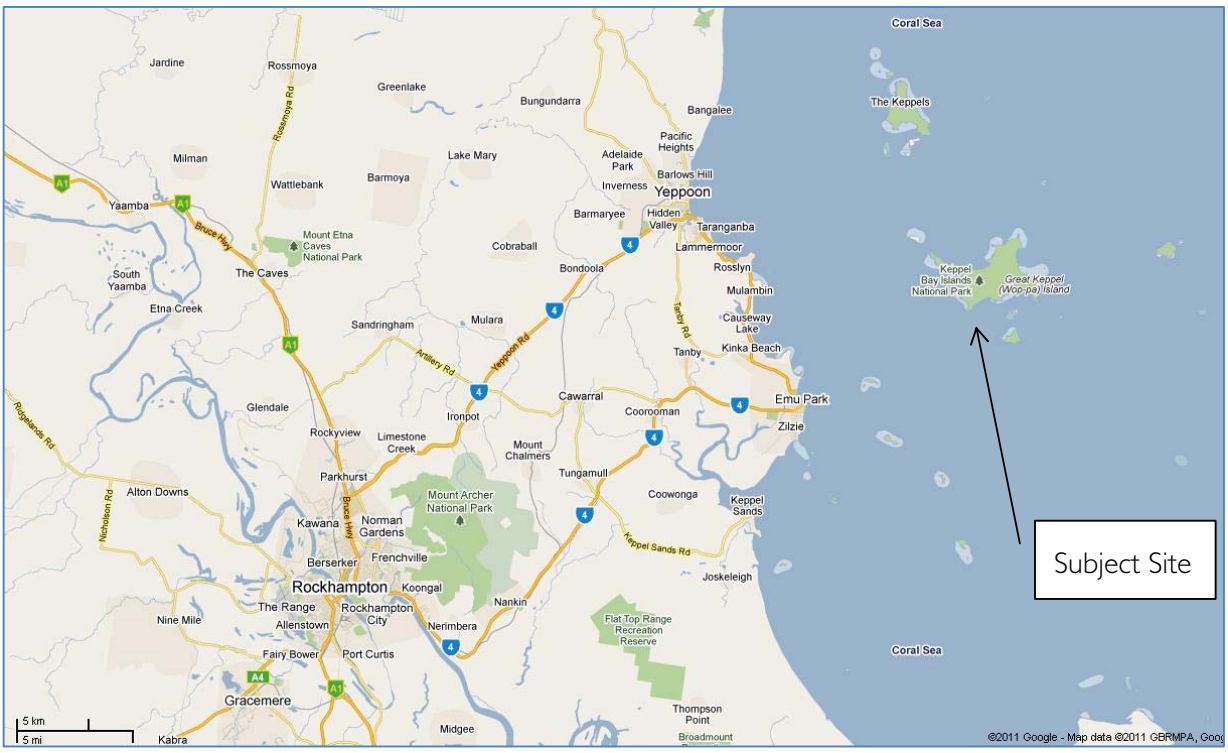

Figure 2.1 Location of Great Keppel Island (North to Top of Page)

Great Keppel Island currently includes a number of existing uses, which are shown on Figure 2.2 and listed as follows:

- Approximately 20 private detached dwellings, including private generators for power.
- Holiday Village, including backpacker facilities.
- Runway for light aircraft.
- Non-operational 'old' Great Keppel resort.
- Svendsens Beach Retreat.

Figure 2.2 Aerial Photo Showing Existing Uses on Island

The majority of existing dwellings are located around Fishermans Beach (refer **Figure 2.2**), on the western side of the Island. Aerial photos of these residences are shown in **Figures 2.3**, **2.4** and **2.5**. A photo of the Holiday Village backpacker accommodation is shown in **Figure 2.6**. A photo of the Svendsens Beach Restreat is shown in **Figure 2.7**.

A photo of the old resort staff accommodation and adjoining services area is shown in **Figure 2.8**.

Figure 2.3 Photo of Fishermans Beach Looking East

Figure 2.4 Photo of Northern End of Fishermans Beach and Putney Beach Looking North

Figure 2.5 Photo of Southern End of Fishermans Beach Looking North-East

Figure 2.6 Holiday Village Backpacker Accommodation Looking South

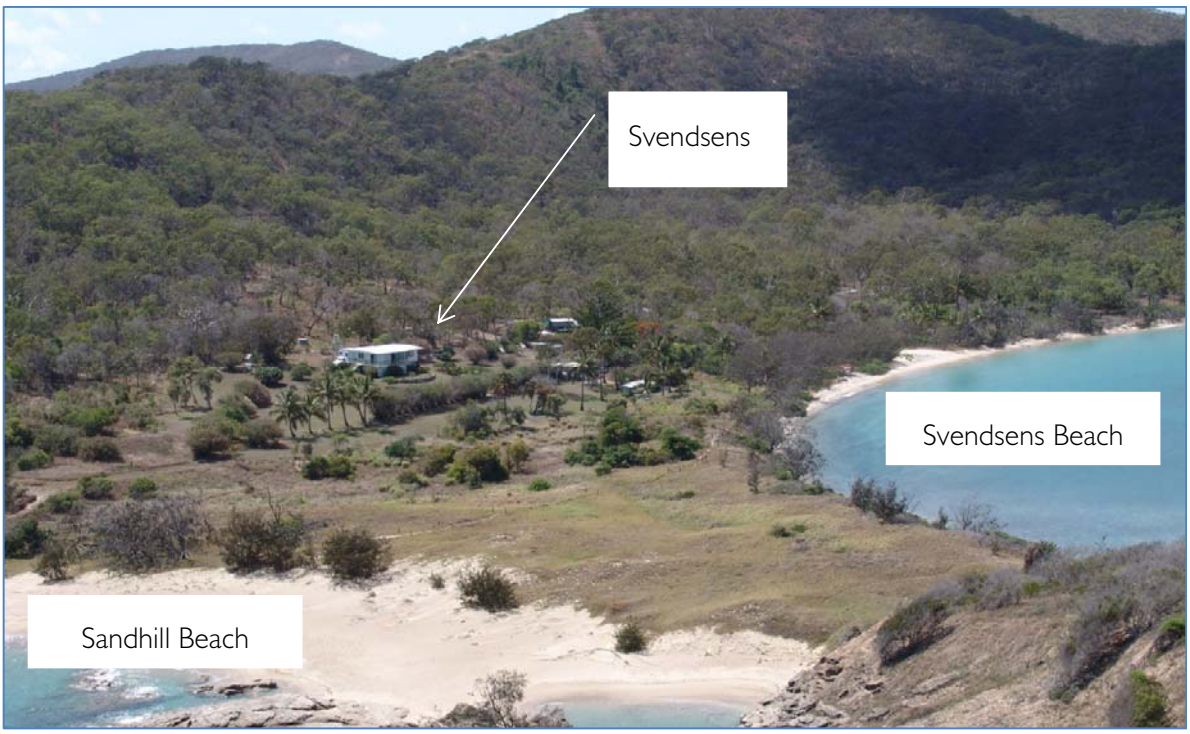

Figure 2.7 Svendsens Beach Retreat Looking East

Figure 2.8 Old Resort Staff Accommodation and Services Area Looking East

3 Proposed Development

3.1 Overview

The proposed development is located in areas of Great Keppel Island that are leased by the proponent, including Lot 21 SP 192569, which covers a total area of 875 hectares out of an overall Island area of 1478 hectares.

The major components of the action are expected to include:

- 750 eco-tourism villas.
- 300 eco-tourism apartments.
- A 250 suite hotel facility at Fisherman's Beach (Including day spa and swimming pools).
- New marina at Putney Beach comprising 250 berths. emergency services facilities, ferry terminal yacht club, and dry dock storage, including associated dredging activities.
- Retail area with a mix of cafes, restaurants and clothing shops around the marina.
- An 18 hole golf course and golf club (Including golf pro shop cafe, restaurant swimming pool, convenience store, day spa tennis courts and gymnasium facility).
- Sporting oval/park.
- New relocated runway.
- Associated service facilities and utilities (waste collection area fire-fighting and emergency services hub, fuel solar, wastewater treatment plant).
- Wastewater treatment plant and constructed wetlands.
- Scientific research centre.
- Installation of sub-marine connection of power, water telecommunications and possibly wastewater and gas between the Island and mainland.
- Restoration work to the historic Leeke's homestead.
- Creation of 545 hectares of environmental protection areas including marked walking tracks, compost toilets and picnic facilities.

The resort will be powered by a combination of solar energy and electricity supplied from the mainland via a proposed sea-cable. Water supply will be provided by rainwater tanks at all villas and throughout the resort, and supplemented by a mainland water connection. Transportation between the resort precincts is proposed to be undertaken via pedestrian access bicycles and electric carts/buggies. Other transport between the various resort precincts will be provided by regulated resort mini-bus services.

The proposed development plan is included in Appendix B.

The construction is proposed to commence in 2012 subject to all necessary approvals. The construction period is expected to take between 10 and 15 years. Construction will be staged with Stage 1 expected to comprise decommissioning of existing infrastructure, construction of the new hotel at Fishermans Beach, the marina, refurbishment of the historical Leeke's Homestead, creation of environment protection areas and associated infrastructure.

3.2 Noise Emissions

The proposed development has the potential to create noise and vibration impacts on existing and future nearby residences and/or marine life due to the following sources:

- Aircraft (flight overpasses, terminal activities) – noise impact on residents, guests and staff.
- Industrial compound, including generators, wastewater treatment facility, and waste management – noise impact on residents, guests and staff.
- Golf course (maintenance activities, clubhouse operation) – noise impact on residents, guests and staff.
- Marina operation (maintenance activities, ferries, retail and restaurant) – noise impact on residents, marine life, guests and staff.
- Marina construction (dredge, pile driving, general activities) – noise and vibration impact on residents, marine life, guests and staff.
- Overall resort demolition and construction (demolition, earthmoving equipment, haulage routes, general activities) – noise and vibration impact on residents and overall environment.

The nearest affected sensitive receivers are described as follows (refer **Figure 2.2**):

- Approximately 20 existing private detached dwellings (refer **Figures 2.3**, **2.4** and **2.5**).
- Holiday Village, including backpacker accommodation (Refer **Figure 2.6**).
- Svendsens Beach Retreat (Refer **Figure 2.7**).

If predicted noise and vibration emission levels are compliant with nominated noise criteria at the receivers listed above, and impacts on marine life are acceptably managed then it is considered that all noise and vibration emission levels are compliant.

4 Noise and Vibration Criteria

4.1 Overview

Noise and vibration criteria for the project will need to address a number of potential noise impacts on existing and future residential receivers.

The assessment will be undertaken in accordance with relevant legislation and criteria including:

- The Queensland State Government Coordinator General Terms of Reference for the Environmental Impact Statement, dated April 2011.
- Department of Sustainability, Environment, Water, Population & Communities (SEWPAC) guidelines for the EIS, dated 21/02/11. These guidelines have been partly developed by Great Barrier Reef Marine Park Authority (GBRMPA), and acknowledge that the Island is located within Great Barrier Reef World Heritage Area, the Great Barrier Reef National Heritage place, and the Great Barrier Reef Marine Park.
- Department of Environment and Resource Management (DERM)
    - Environmental Protection Policy (Noise) 2008.
    - Environmental Protection Act 1994.
    - EcoAccess Guideline "Planning For Noise Control".
    - EcoAccess Guideline "Assessment of Low Frequency Noise".
    - EcoAccess Guideline "Noise & Vibration from Blasting".

4.2 Terms of Reference

The Queensland State Government Coordinator General Terms of Reference for the Environmental Impact Statement includes the following section on noise and vibration:

"3.8 Noise and vibration

3.8.1 Description of environmental values

This section should describe the existing noise and vibration environment that may be affected by the project in the context of environmental values as defined by the Environmental Protection (Noise) Policy 2008. The DERM's Noise Measurement Manual should be considered and references should be made to the EPA Guideline Noise and Vibration from Blasting.

Sensitive noise receptors adjacent to all project components should be identified and typical background noise and vibration levels estimated based on surveys at representative sites. The potential sensitivity of such receptors should be discussed and performance indicators and standards nominated.

3.8.2 Potential impacts and mitigation measures

The EIS should describe the impacts of noise and vibration generated during the construction and operational phases of the project. An analysis of noise and vibration impacts should include:

- *the levels of noise and vibration generated, including noise contours, assessed against current typical background levels, using modelling where appropriate, at the identified sensitive receptors*
- *impact of noise, including low frequency noise (noise with components below 200Hz) and vibration at all potentially sensitive receivers compared with the performance indicators and standards nominated above*

- *impact on terrestrial and aquatic fauna*
- *proposals to minimise or eliminate these effects, including details of any screening, lining, enclosing or bunding of facilities, or timing schedules for construction and operations that would minimise environmental harm and environmental nuisance from noise and vibration.*
- *options for sensitive receivers that are otherwise unable to achieve a satisfactory internal noise level for the preservation of health and well-being identified within the Environmental Protection (Noise) Policy 2008 .*

3.8.3 Aircraft noise

In addition to expressing noise impact in terms of average measures, the EIS must include information and discussion about peak noise levels, frequency of overflights and the times and day overflights could occur, compare maximum aircraft noise levels to existing ambient noise levels and characteristics without noise impacts resulting from the proposed airstrip upgrade, and discuss the impacts of changes in noise exposure.

Fully assess the potential disturbance to everyday activities of the project created by aircraft noise with reference to current research. This must include, but not necessarily limited to:

- *discussion of the impact of changes to the noise environment on interruptions to everyday activities (in particular, sleep disturbance resulting from any proposed night time operations), level of annoyance and impacts on the physical and psychological health of the affected population and groups of people who may be especially vulnerable to such impacts*
- *discussion of the implications of increased aircraft noise on sensitive times of the day (e.g. late evening and early morning) and any proposed noise mitigation strategies*
- *discussion of aircraft noise impacts on existing or proposed recreational, conservation, residential, heritage or wilderness areas, including impacts on amenity and the wildlife using those areas.*

The assessment of potential impacts from aircraft noise should be discussed in the context of Australian Standard 2021: Acoustics – Aircraft Noise Intrusion and Building Siting and Construction (2000)."

4.3 Australian Government SEWPAC Guidelines for the EIS

The Department of Sustainability, Environment, Water, Population & Communities has finalised the guidelines for the EIS in a document dated 21/02/11 (reference: 2010/5521). In the guidelines it is noted that they have been revised since a draft was released for public comment on 4 October 2010, and that the revisions take account of comments from GKI Resort Pty Ltd, the public, Great Barrier Reef Marine Park Authority, and relevant areas of the department including subsequent discussions by assessment officers.

In terms of noise, in Section 5.9.5 of the guidelines it is stated that the assessment must address the *"Impacts of the proposal on noise levels and vibration impacts, including impacts associated with construction activities (e.g. marina), increased aircraft, and increased vessel movement from the proposed marina and development operations."*

The guidelines also refer to addressing the impact on cetaceans (i.e. whales and dolphins), dugongs, turtles and other marine animals, however, there is no specific mention of noise impacts. However, it is proposed to address the underwater noise impacts on marine life in this report.

4.4 Environmental Protection Act

In Queensland, the environment is protected under the *Environmental Protection Act 1994*. The object of the Act is 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 (ecologically sustainable development).

This legislation refers to noise as including *"vibration of any frequency, whether emitted through air or another medium"* and thus includes underwater noise.

The Act states a person must not carry out any activity that causes, or is likely to cause, environmental harm unless the person takes all reasonable and practicable measures to prevent or minimise the harm. This is termed the 'general environmental duty'. Environmental harm is defined as any adverse effect, or potential adverse effect (whether temporary or permanent and of whatever magnitude, duration or frequency) on an environmental value, and includes environmental nuisance. Environmental nuisance is unreasonable interference or likely interference with an environmental value caused by noise or vibration.

The Act describes a number of offences relating to noise standards, including building work, regulated devices (e.g. power tools), pumps, air-conditioning equipment, refrigeration equipment, indoor venues, outdoor events, amplifier devices other than at indoor venue or open-air event, power boat sports in waterway, operating power boat engine at premises, blasting, and outdoor shooting ranges. The standards are included in Appendix C.

The following noise sources are excluded from the Act – audible traffic signals, warning signals for railway crossings, safety signals from reversing vehicle, operating a ship, aircraft, public and state controlled roads, busway, light rail, rail, and non-domestic animals.

This Act refers to the Environmental Protection Policies as being subordinate legislation to the Act.

4.5 Environmental Protection (Noise) Policy

4.5.1 Overview

In respect of the acoustic environment, the object of the Act is achieved by the Environmental Protection (Noise) Policy 2008 (EPP (Noise)). This policy identifies environmental values to be enhanced or protected, states acoustic quality objectives, and provides a framework for making decisions about the acoustic environment.

4.5.2 Background Creep

The EPP(Noise) contains noise criteria for controlling background creep, which are to be applied "for an activity involving noise". The criteria are as follows:

To the extent that it is reasonable to do so, noise from an activity must not be—

a) for noise that is continuous noise measured by $L_{A90,T}$—more than nil dB(A) greater than the existing acoustic environment measured by $L_{A90,T}$; or

b) for noise that varies over time measured by $L_{Aeq,adj,T}$—more than 5dB(A) greater than the existing acoustic environment measured by $L_{A90,T}$.

The EPP(Noise) does not define "continuous noise", but by definition, the "continuous noise" would be required to occur for at least 90% of a measurement period (typically 15 minutes or 60 minutes). Thus this criterion could apply for equipment such as mechanical plant.

The criterion for "noise that varies over time" is appropriate for noise sources operating for less than 90% of a measurement period, and could apply to intermittent events (e.g. vehicles) or mechanical plant that does not run continuously (e.g. air-conditioning).

4.5.3 Acoustic Quality Objectives

The EPP(Noise) contains a range of acoustic quality objectives for a range of receptors. The objectives are in the form of noise levels, and are defined for various periods of the day, and use a number of acoustic parameters.

Schedule 1 of the EPP(Noise) includes the following acoustic quality objectives to be met at residential dwellings:

- Outdoors
  - Daytime and Evening: 50 dB(A) $L_{Aeq,adj,1hr}$, 55 dB(A) $L_{A10,adj,1hr}$ and 65 dB(A) $L_{A1,adj,1hr}$
- Indoors
  - Daytime and Evening: 35 dB(A) $L_{Aeq,adj,1hr}$, 40 dB(A) $L_{A10,adj,1hr}$ and 45 dB(A) $L_{A1,adj,1hr}$
  - Night: 30 dB(A) $L_{Aeq,adj,1hr}$, 35 dB(A) $L_{A10,adj,1hr}$ and 40 dB(A) $L_{A1,adj,1hr}$

In the DERM EcoAccess Guideline "Planning For Noise Control" documentation it is proposed that the noise reduction provided by a typical residential building façade is 5 to 10 dB(A) assuming open windows. That is, with an external noise source, a 5 to 10 dB(A) reduction in noise levels from outside a house to inside a house is expected when windows are fully open. Thus the indoor noise objectives noted above could be considered as the following external objectives (with windows open):

- Daytime and Evening: 40 to 45 dB(A) $L_{Aeq,adj,1hr}$, 45 to 50 dB(A) $L_{A10,adj,1hr}$ and 50 to 55 dB(A) $L_{A1,adj,1hr}$
- Night: 35 to 40 dB(A) $L_{Aeq,adj,1hr}$, 40 to 45 dB(A) $L_{A10,adj,1hr}$ and 45 to 50 dB(A) $L_{A1,adj,1hr}$

A sensitive receptor is defined as *"an area or place where noise is measured"*.

The EPP(Noise) states that the objectives are intended to be progressively achieved over the long term. However, as this project involves the introduction of new noise sources it would seem reasonable that the acoustic quality objectives are achieved upon commencement of operation of the project, and this may be the intent of the policy. Therefore, consideration to achieving these acoustic quality objectives will be included in the design noise limits for the project.

The acoustic quality objectives do not take into consideration the existing noise environment and therefore it is considered that they do not necessarily protect or enhance the acoustic amenity of the area surrounding the site as required by the EPP(Noise). Therefore, it is considered that the objectives should not be used as the sole noise limits for a development, and reference should also be made to noise limits which are determined with consideration for the existing noise environment.

4.6 EcoAccess Guidelines

DERM has a number of EcoAccess guidelines relevant to the assessment of noise and vibration. These are summarised as follows.

4.6.1 EcoAccess – Planning for Noise Control

DERM EcoAccess Guideline "Planning For Noise Control" contains procedures and methods that are applicable for setting conditions relating to noise emitted from industrial premises for planning purposes. The guideline is applicable to noise from all sources, individually and in combination, which contribute to the total noise from a site.

4.6.1.1 Control and Prevention of Background Creep

The procedure takes into account three factors: firstly, the control and prevention of background noise creep in the case of a steady noise level from equipment such as caused by ventilation fans and other continuously operating machinery; secondly, the containment of variable noise levels and short-term noise events such as those caused by forklifts and isolated hand tools to an acceptable level above the background noise level; thirdly, the setting of noise limits that should not be exceeded to avoid sleep disturbance. The calculation of suitable background creep limits is described in Appendix D.

4.6.1.2 Sleep Disturbance Criteria

The World Health Organization (WHO) issued its "Guidelines for Community Noise" in April 1999. The WHO guideline states the following in regard to sleep disturbance from continuous noise from activities such as mining operations:

> *"Where noise is continuous, the equivalent sound pressure level should not exceed 30 dB(A) indoors, if negative effects on sleep are to be avoided. When noise is composed of a large proportion of low-frequency sounds a still lower guideline value is recommended, because low-frequency noise (eg from a ventilation system) can disturb rest and sleep even at low sound pressure levels."*

The EcoAccess Guideline "Planning for Noise Control", in referring to the World Health Organisation guidelines, makes the following general recommendation regarding short term transient noise events:

> *"As a rule in planning for short-term or transient noise events, for good sleep over eight hours, the indoor sound pressure level measured as a maximum instantaneous value should not exceed approximately 45 dB(A) maxL_{pA} more than 10 to 15 times per night."*

For less regular night events, the allowable internal noise level is higher, as follows:

- Approximately 3 events per night: 50 dB(A) L_{max}.
- Approximately 1 event per night: 65 dB(A) L_{max}.

Note: For the purpose of this assessment the maxL_{pA} level is defined using the L_{max} descriptor.

The WHO guideline states the following in regard to annoyance response to community noise:

> *"Annoyance to community noise varies with the type of activity producing the noise. During the daytime few people are seriously annoyed by activities with LAeq levels below 55 dB(A); or moderately annoyed by L_{Aeq} levels below 50 dB(A). Sound pressure levels during the evening and night should be 5 – 10 dB(A) lower than during the day. Noise with low frequency components requires even lower levels."*

As noted previously, DERM propose that the noise reduction provided by a typical residential building façade is 5 to 10 dB(A) assuming open windows. Thus the indoor noise objectives noted above could be considered external objectives (with windows open) with the appropriate correction.

The criteria are summarised in Table 4.1.

Table 4.1 Summary of WHO Sleep Disturbance and Annoyance Criteria

Descriptor	Number of Noise Events	Indoor Criterion in dB(A)	Outdoor Criterion, dB(A)
Sleep Disturbance (Short Duration Events)	10 – 15	L_{max} 45	L_{max} 50 to 55
	3	L_{max} 50	L_{max} 55 to 60
	1	L_{max} 55	L_{max} 60 to 65
Sleep Disturbance (Continuous Noise)	Continuous	L_{eq} 30	L_{eq} 35 to 40
Annoyance (Night Time)	Continuous	L_{eq} 35	L_{eq} 40 to 45

Note: The outdoor criteria are based on a DERM EcoAccess nominated outdoor-to-indoor noise reduction of 5 to 10 dB(A) for open windows.

4.6.2 EcoAccess – Assessment of Low Frequency Noise

DERM EcoAccess Guideline "Assessment of Low Frequency Noise" contains methods and procedures that are applicable to low frequency noise emitted from industrial premises and mining operations for planning purposes. Items such as boilers, pumps, transformers, cooling fans, compressors, oil and gas burners, foundries, wind farms, electrical installations, diesel engines, ventilation and air-conditioning equipment, wind turbulence and large chimney resonance may comprise sources of high level noise having frequency content less than 200 Hz.

These sources may exhibit a spectrum that characteristically shows a general increase in sound pressure level with decrease in frequency. Annoyance due to low frequency noise can be high even though the dB(A) level measured is relatively low. Typically, annoyance is experienced in the otherwise quiet environments of residences, offices and factories adjacent to or near low frequency noise sources. Generally, low level/low frequency noises become annoying when the masking effect of higher frequencies is absent. This loss of high frequency components may occur as a result of transmission through the fabric of a building, or in propagation over long distances.

Where a noise immission occurs exhibiting an unbalanced frequency spectrum, the overall sound pressure level inside residences should not exceed 50 dB(Linear) to avoid complaints of low frequency noise annoyance. A spectrum is considered unbalanced when the un-weighted overall noise level is more than 15 dB higher than the A-weighted overall noise level.

4.6.3 EcoAccess – Noise & Vibration from Blasting

DERM EcoAccess Guideline "Noise and vibration from blasting" contains criteria and procedures that are applicable to noise and vibration emitted from blasting. It applies to activities such as mining, quarries, construction and other operations which involve the use of explosives for fragmenting rock.

The criteria address human comfort and are below typical limits for prevention of structural damage. The criteria apply at residential and commercial receivers. The criteria are presented in Table 4.2.

Table 4.2 Blasting Vibration and Airblast Criteria

Issue	Criteria
Airblast	Air blast overpressure of 115 dB (linear peak) for nine (9) out of ten (10) consecutive blasts initiated and not greater than 120 dB (linear peak) at any time.
Vibration	5 mm/s peak particle velocity for nine (9) out of ten (10) consecutive blasts and not greater than 10 mm/s peak particle velocity at any time.

5 Noise Measurements & Limits

5.1 Monitoring Sites

Acoustic measurements consisted of noise logging at four sites (A to D), brief attended noise measurements at five sites (A to E), and attended underwater measurements using a hydrophone at 14 sites in the water around the Island (B1 to B14). Location E was used to monitor to aircraft overpass.

An aerial photo showing the noise measurement site locations is shown in Figure 5.1.

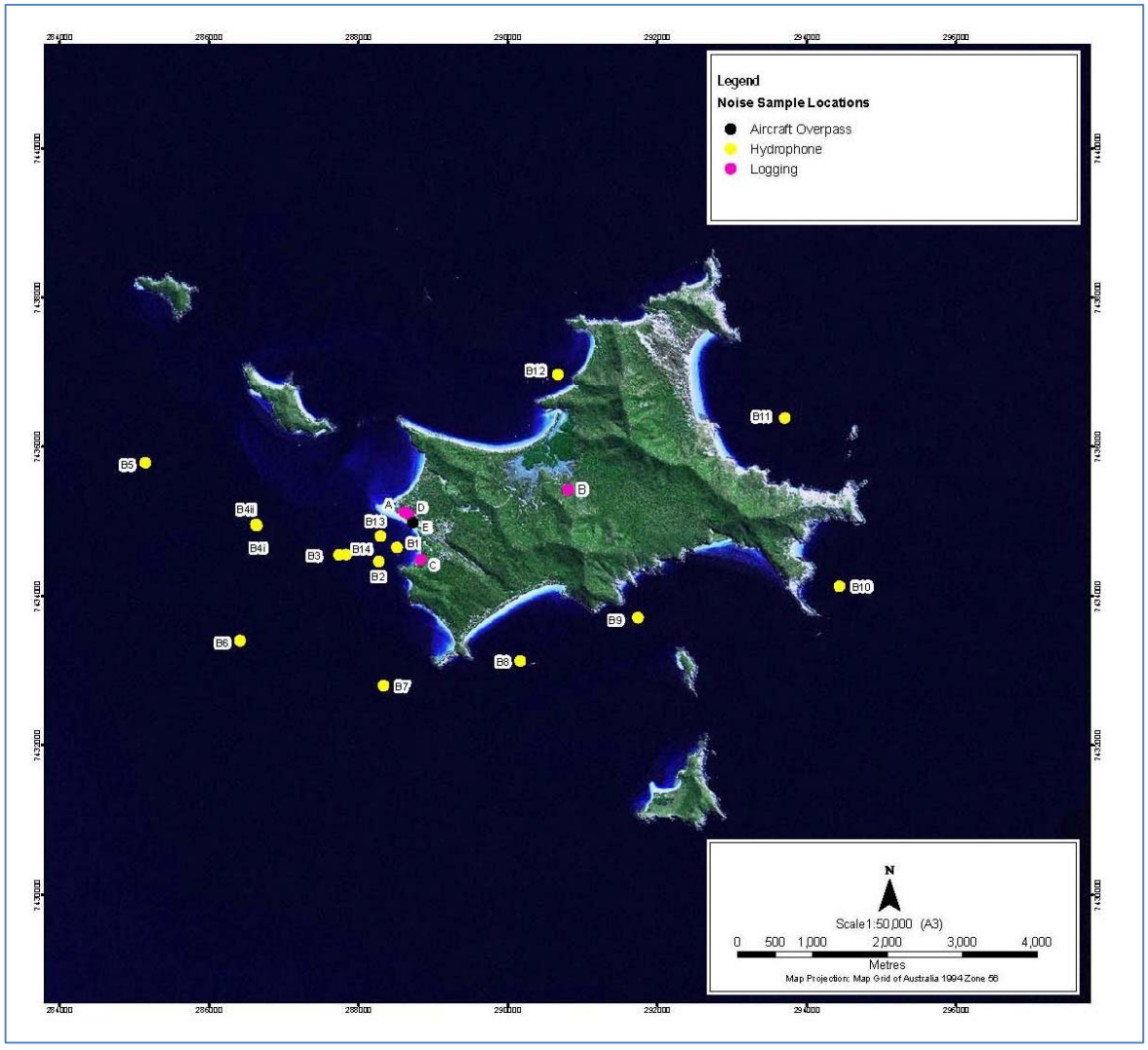

Figure 5.1 Location of Noise Monitoring Sites (A to E and B1 to B14)

The locations of the sites are described in Table 5.1. Photos of the four noise logging sites on the Island are included in Appendix E.

Table 5.1 Monitoring Site Locations

Location		GPS Coordinates		Location Description
		Southing	Easting	
Land	A	23.179364	150.934947	In front (south-western side) of a two-storey detached dwelling at the northern end of the main Fishermans Beach. The house was signposted as "For Sale". The logger was located outside the fenced courtyard in the garden area, and was in the free-field. The RP is Lot 26 LN1658.
	B	23.176939	150.956314	On roof of the unused generator shed near to the old homestead in the centre of the Island.
	C	23.185133	150.936942	In front (south-western side) of a single-storey detached dwelling towards the southern end of the main Fishermans Beach. The logger was located in the free-field. The RP is Lot 13 LN1428.
	D	23.179667	150.935464	In front (south-western side) of a two-storey detached dwelling, known as the "Beach House" towards the northern end of the main Fishermans Beach. The logger was located on the front deck on the upper floor, and was 1m from the facade. The RP is Lot 20 LN1658.
	E	23.180658	150.935964	Beside the narrow road behind the main Fishermans Beach, opposite the Keppel Lodge, beside a monument.
Underwater*	B1	23.172936	150.901124	Off Fishermans Beach.
	B2	23.194629	150.913169	Off Fishermans Beach, further offshore than B1.
	B3	23.200304	150.931852	Off Fishermans Beach, further offshore than B2.
	B4i	23.197550	150.949772	Off Fishermans Beach, further offshore than B3. The two GPS locations represent the start and end of the drift of the boat during the measurement period.
	B4ii	23.192543	150.965219	
	B5	23.189071	150.991631	Off Fishermans Beach, further offshore than B4.
	B6	23.168629	150.984788	Off Monkey Beach.
	B7	23.162997	150.955216	Off Monkey Beach, closer inshore than B6.
	B8	23.182238	150.931741	Off Long Beach, at Little Monkey Point end.
	B9	23.184389	150.927191	Off Wyndham Cove.
	B10	23.179225	150.934827	Off Red Beach.
	B11	23.177063	150.956533	In Wreck Bay, off Wreck Beach.
	B12	23.184619	150.936997	Off Svendsens Beach.
	B13	23.179701	150.935627	Off Fishermans Beach.

Location	GPS Coordinates		Location Description
	Southing	Easting	
B14	23.180657	150.935965	Off Fishermans Beach.

Note: * The GPS coordinates for underwater measurements represent the start location of the measurement before the boat drifted, except as noted for Locations B4i and B4ii.

The purpose of the noise monitoring is to understand the existing noise environment. The noise environment is expected to be similar at beachside locations around the island due to the similar noise levels created by waves and wind in trees. The beachside noise environment is represented by Locations A, B and C.

Inland areas would be subject to similar noise levels, and are typically quieter than beachside locations due to the lack of wave noise and often lower wind speeds. The inland noise environment is represented by Location D.

The underwater noise measurements were undertaken to determine existing ambient noise levels around the island, and also near to existing underwater noise sources, being sea vessels.

5.2 Attended Noise Measurements

The attended noise measurements on the Island were undertaken on 15/12/10 and 16/12/10 over 15 minute periods using a field and laboratory calibrated Rion NA27 sound level meter. The microphone height was approximately 1.3m above ground level.

During the measurements the weather was fine, warm at night and hot during the day, light to moderate breezes and some cloud cover.

The measured noise levels are summarised in Table 5.2. The parameters noted in Table 5.2 are described in the glossary in Appendix A.

Table 5.2 Attended Noise Measurement Results on Island

Location	Date and Time	Period	Results and Notes
A	9:25pm 15/12/10	15 minutes	Noise environment was dominated by wind blowing palms, generator to the west, insects and curlews. Noise from insects varies between 30 & 45 dBA, and dominant around 4 to 5 kHz Noise from curlews varies between 30 & 60 dBA, and dominant around 1.25 to 2 kHz Noise from generator to the west, around 36 dBA at 80 Hz. Statistical noise levels: L_{10} 46 dBA, L_{eq} 44 dBA, L_{90} 42 dBA

Location	Date and Time	Period	Results and Notes
B	1:24pm 16/12/10	15 minutes	Noise environment was dominated by insects and wind blowing trees. Noise from insects varies between 47 & 54 dBA, and dominant around 4 kHz Statistical noise levels: L_{10} 53 dBA, L_{eq} 50 dBA, L_{90} 48 dBA
C	9:53pm 15/12/10	15 minutes	Noise environment was dominated by waves on beach, wind blowing trees, insects and possums. Noise from waves varies between 45 & 50 dBA. Noise from insects dominant around 4 to 5 kHz Statistical noise levels: L_{10} 49 dBA, L_{eq} 48 dBA, L_{90} 47 dBA
D	10:32pm 15/12/10	15 minutes	Noise environment was dominated by wind blowing palms, insects and geckos. Noise from wind in palm trees between 40 & 45 dBA. Noise from insects dominant around 5 kHz. Noise from geckos dominant around 1 to 2 kHz Statistical noise levels: L_{10} 47 dBA, L_{eq} 44 dBA, L_{90} 39 dBA
E	1:52pm 17/12/10	25 seconds	Noise measurement of light aircraft coming into landing from the west. Maximum noise level of 74 dBA when aircraft overhead.

From these attended noise measurements it is apparent that the ambient noise level is dominated by wind in the trees, waves on the beach (excluding inland Location D), insects and other animals (curlews, geckos and possums).

Wind conditions will change throughout the day and year, and ambient noise levels would generally be lower in calm conditions. It is not possible to determine the degree to which noise levels would be reduced in calm conditions, except to review the minimum background noise levels, which would be representative of the lowest wind speed conditions during the measurement.

Noise from insects tends to be seasonal, and insect noise levels during winter would be expected to be significantly lower. Insect noise can effectively be removed from the data by subtracting the affected frequency bands from the overall noise level, and thus the resulting noise levels could be considered to represent lower ambient noise levels typical of winter.

The impact of wind and insects on the measured noise levels will be considered in the review of noise logging data in the following section.

5.3 Noise Logging

5.3.1 Equipment and Dates

Noise logging was undertaken at the four sites as shown on Figure 5.1. Logging was undertaken from 15/12/10 to 27/12/10 using field and laboratory calibrated Larson Davis LD831 environmental noise loggers. The monitoring periods were as follows:

- Logger A: 15/12/10 to 27/12/10
- Logger B: 16/12/10 to 26/12/10
- Logger C: 15/12/10 to 17/12/10
- Logger D: 15/12/10 to 18/12/10

5.3.2 Weather Data

Weather data for the monitoring period was obtained from the following sites:

- Pumpkin Island – A small Island located on the southern side of North Keppel Island, approximately 9km north of Great Keppel Island. The data includes wind speed and direction. The temperature and humidity data is incorrect due to malfunction of the respective sensors.
- Rundle Island – A small Island located on the eastern side of Curtis Island, approximately 50km south-east of Great Keppel Island. The data does not included rainfall.
- Yeppoon – The coastside town approximately 20km west of Great Keppel Island.

The daily rainfall data has been extracted from these sources and is summarised in Table 5.3.

Table 5.3 Daily Rainfall Data

Site	Daily Rainfall (mm) by Date (December 2010)												
	15	16	17	18	19	20	21	22	23	24	25	26	27
Pumpkin	0	0	0	8	7	1	0	13	0	3	37	64	-
Yeppoon	0	0	0	0	6	17	0	2	4	0	17	103	4

Note: Shaded cells indicate rainfall

From Table 5.3 it can be seen that there are 4 days without recorded rainfall at both sites. Given the proximity of the Pumpkin Island weather station to Great Keppel Island, it is considered more likely that it better represents the rainfall conditions at Great Keppel Island.

From the hourly Pumpkin Island weather data it is noted that in a 12 day period there are 53 hours (i.e. 2.2 days) of recorded rainfall in the period from 15th to 26th December. Thus there are sufficient periods without rainfall that the data at Locations A and B can be considered long term monitoring periods, requiring a minimum 7 days of monitoring. The logging at Locations C and D occurred in periods where no rainfall was recorded.

The average hourly wind speed data from Pumpkin Island has been analysed and is summarised in Table 5.4 in terms of the daily maximum, average and minimum values, in addition to the lowest 10th percentile value. It is noted that there will be periods of higher and lower instantaneous wind speed, as these results are based on hourly average wind speeds rather than wind gusts.

Table 5.4 Daily Wind Speed Data

Parameter	Wind Speed (m/s) by Date (December 2010)											
	15	16	17	18	19	20	21	22	23	24	25	26
Maximum	7	12	11	12	8	8	8	9	9	8	8	9
Average	4	6	6	6	5	3	6	8	6	7	7	6
Lowest 10%	2	2	4	2	3	1	3	8	5	6	6	3
Minimum	0	0	3	0	2	0	1	7	4	6	6	2

From Table 5.4 it can be seen that wind speeds are, on average, consistently moderate to high for the entire monitoring period. However, there are periods of lower wind speeds, and it is likely that these low wind speed periods are at night, when low background noise levels are generally experienced.

A review of yearly data indicates that these moderate wind speeds are relatively consistent throughout the year. According to an analysis of 2 years of weather data at Rundle Island, the wind speed is greater than 5.0 m/s for approximately 80% of the time, and greater than 2.5 m/s for approximately 98% of the year. Thus the wind speeds during the monitoring period, are expected to be typical of the Island.

The average hourly night-time wind speed data from Pumpkin Island has been analysed and is summarised in Table 5.5 in terms of the night maximum, average and minimum values.

Table 5.5 Night Wind Speed Data

Parameter	Night-Time Wind Speed (m/s) by Date (December 2010)												
	15	16	17	18	19	20	21	22	23	24	25	26	27
Maximum	7	6	7	9	5	5	8	9	9	8	8	9	-
Average	3	3	6	4	4	4	5	9	6	7	7	7	-
Minimum	0	1	4	0	2	2	1	8	4	6	6	3	-

From Table 5.5 it can be seen that there are low-moderate wind speed conditions (i.e. less than 5 m/s) on most nights, but they increase during the latter half of the overall measurement period.

Overall, from a review of the rainfall and wind speed data it is apparent that there are significant periods of rainfall and high average wind speed, however, the majority of the measurement period is free of rainfall, and there are a number of periods, including at night, when wind speeds are acceptably low. Therefore the noise monitoring data is considered appropriate for further analysis.

5.3.3 Results

Graphs of the measured noise levels are shown in Figures F.1 to F.4 in Appendix F. The parameters graphed in Appendix F are described in the glossary in Appendix A.

From the noise logging the statistical results have been summarised in Tables F.1 to F.4 in Appendix F. The calculated lowest 10th percentile background noise levels (minL_{A90}) are summarised in Table 5.6.

Table 5.6 Background Noise Levels from Noise Logging

Location	Background Noise Levels, minL_{A90} dB(A)		
	Day	Evening	Night
A	44	45	45
B	46	46	45
C	46	52	48
D	44	40	40

From the results in Appendix F and the observations noted from attended measurements in Section 5.1 the following comments are made regarding the levels in Table 5.6:

- The background noise levels at Location A are affected by a generator hence the relatively constant noise level during the day, evening and night. The levels for Location A are therefore representative of noise levels at residential properties which are in the proximity of diesel generators.
- All locations are affected by moderate to high levels of insect noise. When the insect noise is removed from the background noise level data by removing all noise contribution above the 1 kHz octave band, the recalculated background noise levels are as shown in Table 5.7.

Table 5.7 Background Noise Levels (With Insect Noise Removed) from Noise Logging

Location	Background Noise Levels, minL_{A90} dB(A)		
	Day	Evening	Night
A	40	42	40
B	29	30	26
C	35	47	39
D	35	33	31

From the results in Table 5.7 the following comments are made:

- The background noise levels at Location A still include the generator noise. An estimate of the background noise level in the absence of the generator can be determined by removing the influence of the generator in the 63Hz octave band. In this instance the background noise levels are reduced from 40, 42 and 40 down to 35, 37 and 37 dB(A) minL_{A90} for day, evening and night periods respectively.
- The background noise levels are lowest at Location B as it is located well away from noise from residential dwellings and waves on the beach. The background noise at this location would likely be dominated by wind rustling leaves in the trees.
- Location C was closer to the beach than Location D, and this could explain the elevated background noise levels at Location C in the night. It is considered that the evening background noise level was particularly affected by domestic activities in and around the dwelling.

5.4 Noise Limits

5.4.1 Overview

The potential noise limits that could be applied to the development can be calculated using the criteria in Section 4 and the noise level measurement results in Section 5.

5.4.2 EPP (Noise) Background Creep

The calculation of EPP(Noise) background creep limits is described in Section 4.4.2. Criteria are applied to continuous noise and variable noise.

Based on the background levels in Table 5.7 the resulting EPP(Noise) background creep limits can be calculated. The resulting limits are summarized in Table 5.8.

Table 5.8 EPP(Noise) Background Creep Limits

Location	Background Creep Limits for Continuous Noise, $L_{A90,T}$ dB(A)			Background Creep Limits for Variable Noise, $L_{Aeq,adj,T}$ dB(A)		
	Day	Evening	Night	Day	Evening	Night
A	40	42	40	45	47	45
B	29	30	26	34	35	31
C	35	47	39	40	52	44
D	35	33	31	40	38	36

From **Table 5.8** it can be seen that the limits are lowest at Location B, which is the inland measurement location.

5.4.3 EcoAccess Background Creep

The calculation of EcoAccess background creep limits is described in **Appendix D**. The calculation requires data on the receiver land dominant use, and the description of neighbourhood for each location as described in **Table 5.9**.

Table 5.9 Data Used for EcoAccess Background Creep Limit Calculations

Location	EcoAccess Background Creep Calculation Data			
	Receiver Land Use	Receiver Area Dominant Land Use	Noise Area Category	Description of Neighborhood
A, C and D	Purely residential	Rural residential, church, hospital	z1	Very rural, purely residential, Less than 40 vehicles per hour
B	Purely residential	Very rural	z1	Very rural, purely residential, Less than 40 vehicles per hour

From **Table 5.9** it can be seen that the same classifications have been used except Location B – The Old Homestead is considered very rural. It is understood that this dwelling is not used for residential purposes, and therefore the limits at this location are currently provided for information purposes only.

Based on the background levels in **Table 5.7** and the data in **Table 5.9** the resulting EcoAccess background creep limits can be calculated. The calculation process is included in **Tables D.5 to D.8** in **Appendix D** and the resulting limits are summarized in **Table 5.10**.

Table 5.10 EcoAccess Background Creep Limits

Location	Background Creep Limits, $L_{Aeq,1hour}$ dB(A)		
	Day	Evening	Night
A	33	28	28
B	37	28	28
C	41	28	28
D	40	33	28

From **Table 5.10** it can be seen that the limits at the four locations are similar in the day and evening, and the same at night. The EcoAcces background creep calculation method often results in lower noise limits in areas subject to higher noise levels as the methodology aims to minimise background creep above a target noise level. This methodology results in daytime limits at Locations C and D which are higher than Location A.

This method of calculation can be considered counter-intuitive in some respects and it can result in unusual limits. It is not proposed to use these limits in this project, as preference is given to the limits developed from the DERM EPP(Noise) Policy.

5.4.4 Summary of Airborne Noise Limits

The noise limits from **Section 4** and **Section 5.4.3** are summarised in **Table 5.11**. The appropriate noise criteria are selected for each noise source in each situation, i.e. not all noise criteria are applicable in each instance.

Table 5.11 Summary of Airborne Noise Limits at Residential Receivers

Criteria and Measurement Location	Parameter	Location	Noise Limits dB(A)*		
			Day	Evening	Night
DERM EPP(Noise), Background Creep, Continuous Noise, Outdoors	$L_{A90,T}$	A	40	42	40
		B	29	30	26
		C	35	47	39
		D	35	33	31
DERM EPP(Noise), Background Creep, Variable Noise, Outdoors	$L_{Aeq,adj,T}$	A	45	47	45
		B	34	35	31
		C	40	52	44
		D	40	38	36
DERM EPP(Noise) Acoustic Quality Objectives, Indoors	$L_{Aeq,adj,T}$	All	35	35	30
	$L_{A10,adj,T}$	All	40	40	35
	$L_{A1,adj,T}$	All	45	45	40
DERM EPP(Noise) Acoustic Quality Objectives, Outdoors	$L_{Aeq,adj,T}$	All	50	50	N/A
	$L_{A10,adj,T}$	All	55	55	N/A

Criteria and Measurement Location	Parameter	Location	Noise Limits dB(A)*		
			Day	Evening	Night
	$L_{A1,adj,T}$	All	65	65	N/A
DERM EPP(Noise) Acoustic Quality Objectives, Outdoors (At façade, assuming open windows)	$L_{Aeq,adj,T}$	All	40-45	40-45	35-40
	$L_{A10,adj,T}$	All	45-50	45-50	40-45
	$L_{A1,adj,T}$	All	50-55	50-55	45-50
DERM EcoAccess Sleep Disturbance, Indoors	$L_{Amax,T}$	All	N/A	N/A	45
	$L_{Aeq,T}$	All	N/A	N/A	30
DERM EcoAccess Sleep Annoyance, Indoors	$L_{Aeq,T}$	All	N/A	N/A	35
DERM EcoAccess Sleep Disturbance, Outdoors	$L_{Amax,T}$	All	N/A	N/A	50-55
	$L_{Aeq,T}$	All	N/A	N/A	35-40
DERM EcoAccess Sleep Annoyance, Outdoors	$L_{Aeq,T}$	All	N/A	N/A	40-45
DERM EcoAccess Low Frequency Noise, Indoors	$L_{Amax,T}$	All	50 dB(Lin)		

Note: * Limits are applied as A-weighted levels, i.e. dB(A), unless mentioned otherwise.

5.5 Underwater Monitoring

Underwater noise measurements were conducted to provide quantitative data on the baseline ambient noise levels around the Island to assist in the assessment of noise sources expected to affect underwater noise levels.

The attended underwater noise measurements were undertaken on 17/12/10 over 5 minute periods using the following equipment:

- Sinus Soundbook Sound Level Analyser. This calibrated laptop based analyser was setup to record one-third octave band sound levels in 0.12 second intervals over a period of 5 minutes. The time period was extended if there was a noise source of interest in the vicinity (e.g. ferry, boat). The measurement frequency range was 2 Hz to 20 kHz.
- HTI-96-MIN hydrophone. This hydrophone was a hire unit, and was provided with a calibration report. The equipment data sheet indicates a hydrophone sensitivity with preamp of -165 dB re: 1 V/µPa and a frequency response range of 2 Hz to 30 kHz.
- Binoculars with range finding capability to determine distances to objects within 400m.
- 'Sealegs' boat, buoy, weight, rope, depth sounder and other accessories.

The hydrophone cable was wrapped in string to minimise vortex shedding which results from water flow across the hydrophone cable and can potentially create pressure fluctuations and introduce unnecessary noise into the recordings (refer Figure 5.2).

Figure 5.2 Hydrophone Cable and Coiled String

The hydrophone was located 2.5m below the water surface and was attached to a free floating buoyed system approximately 20m from the boat. The system consisted of the hydrophone cable zip tied to a nylon rope that was connected to a floating buoy which ran down to a metal weight on the seabed. The depth of 2.5m for the hydrophone is approximately the mid-water depth in the water off Fishermans Beach where the majority of current boating activities occur. The water depth was measured as between 4.2m and 15.0m, based on the display of the depth sounder on the boat. The depth of each measurement is included in Table 5.12.

A photo of the testing arrangement is shown in Figure 5.3.

Figure 5.3 Hydrophone Cable Running to Yellow Buoy Off Rear of Boat

The weather during the measurements of underwater noise was fine with light to moderate breezes ranging in wind speed from 5 to 7 knots based on weather data from nearby Pumpkin Island. The engine of the monitoring boat was off when measurements were undertaken.

The underwater measurements are described in Table 5.12. The measurements included audio samples so that the recording could be listened to during analysis. The audio samples indicated that the main noise sources, aside from passing boats, resulted from the biological noise of snapping shrimp.

Table 5.12 Underwater Noise Measurements

Location	Time	Depth (m)	Distance from Boat to Buoy (m)	Statistic	Description
B1	6:13 AM	4.2	10	lowest 25%	Background noise sample
B2	6:23 AM	6.0		lowest 25%	Background noise sample
B3	6:36 AM	6.0		lowest 25%	Background noise sample
B4	6:57 AM	11.0		lowest 25%	Background noise sample
B5	7:09 AM	10.0		lowest 25%	Background noise sample
B6	7:23 AM	12.0		lowest 25%	Background noise sample
B6	7:32 AM	12.0	20	lowest 25%	Background noise sample
B7	7:46 AM	15.0		lowest 25%	Background noise of sample which included a nearby fishing boat passing
				highest 5%	160m from 10m motor boat
B8	8:03 AM	10.0		lowest 25%	Background noise sample
B9	8:15 AM	15.0		lowest 25%	Background noise sample
B10	8:38 AM	14.0		lowest 25%	Background noise sample
B11	8:56 AM	14.0		lowest 25%	Background noise sample
B12	9:21 AM	4.3		lowest 25%	Background noise sample
B13	9:37 AM	4.2		lowest 25%	Background noise of sample which included ferry approaching beach, and boats nearby
				maximum	324m from ferry approaching beach
				maximum	120m from small powerboat
B14	9:47 AM	4.6		lowest 25%	Background noise of sample which included ferry departing beach
				highest 5%	250m from ferry departing beach

From Table 5.12 it can be seen that the majority of the measurements were ambient noise samples in which there was no observed man made noise source in the vicinity of the hydrophone (i.e. measurements at Locations B1 to B6 and B8 to B12). In those instances the ambient noise level is calculated as the lowest 25th percentile of the 0.12 second data samples. This statistical analysis is undertaken to avoid data samples which are affected by the presence of the boat such as noise of water lapping onto the boat. It is considered that the lowest 25th percentile excludes the lapping noise.

The measurement at Location B7 includes a 10m motor boat passing by at a distance of 160m, and thus the highest 5th percentile level has been calculated to understand the typical average maximum level of the event.

The measurement at Location B13 includes a ferry approaching the beach at a distance of 324m, and a small powerboat passing at 120m. The maximum one-third octave band levels of these two events are calculated.

The measurement at Location B14 includes a ferry departing the beach at a distance of 250m. The highest 5th percentile of this event is calculated.

The noise spectral levels of the background noise samples (i.e. measurements at Locations B1 to B6 and B8 to B12) are shown in Figure 5.4. Noise spectral levels are the one-third octave band levels corrected for the bandwidth of the one-third octave band, giving a noise level per hertz (Hz). The data below the 40 Hz one-third octave band has not been included in Figure 5.4 as it is considered to include high noise levels due to measurements in shallow waters.

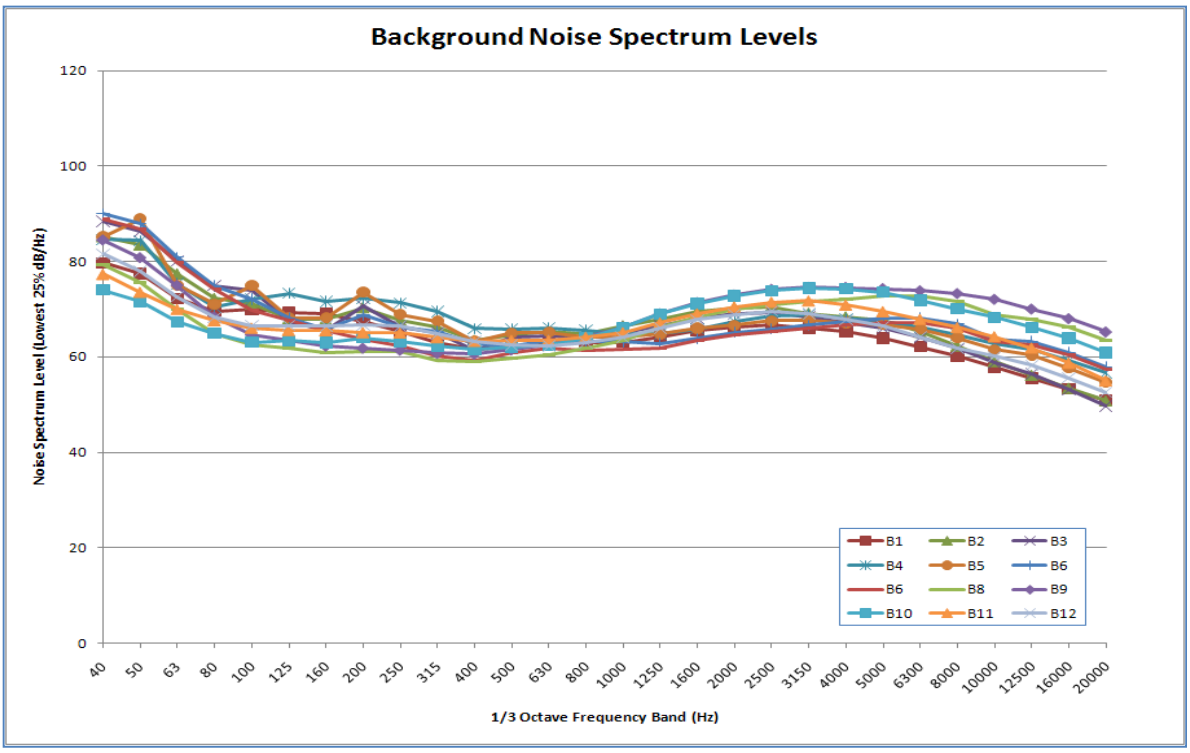

Figure 5.4 Background Underwater Noise Spectral Level Results

The shape of the noise spectrum in Figure 5.4 is affected by several issues. Generally ambient noise levels are composed of (a) sea-surface or wind dependent noise, (b) biological noise, and (c) traffic noise (consisting of distant shipping noise, not individual boats). The low frequency rise in noise is likely due to the shallow depth of the water, the low to mid frequency region is affected by the wind, and the high frequency region is affected by snapping shrimps. It is noted that the background noise levels show a similar magnitude and spectral shape in all 12 samples across 11 locations.

The noise spectral levels of the samples which included boat noise are shown in Figure 5.5. This figure also includes the average background level, being the arithmetic average of the samples shown in Figure 5.4. It can be seen that the presence of a boat within several hundred metres of the hydrophone results in a significant increase in noise levels at all frequencies, particularly in the low to mid frequency region.

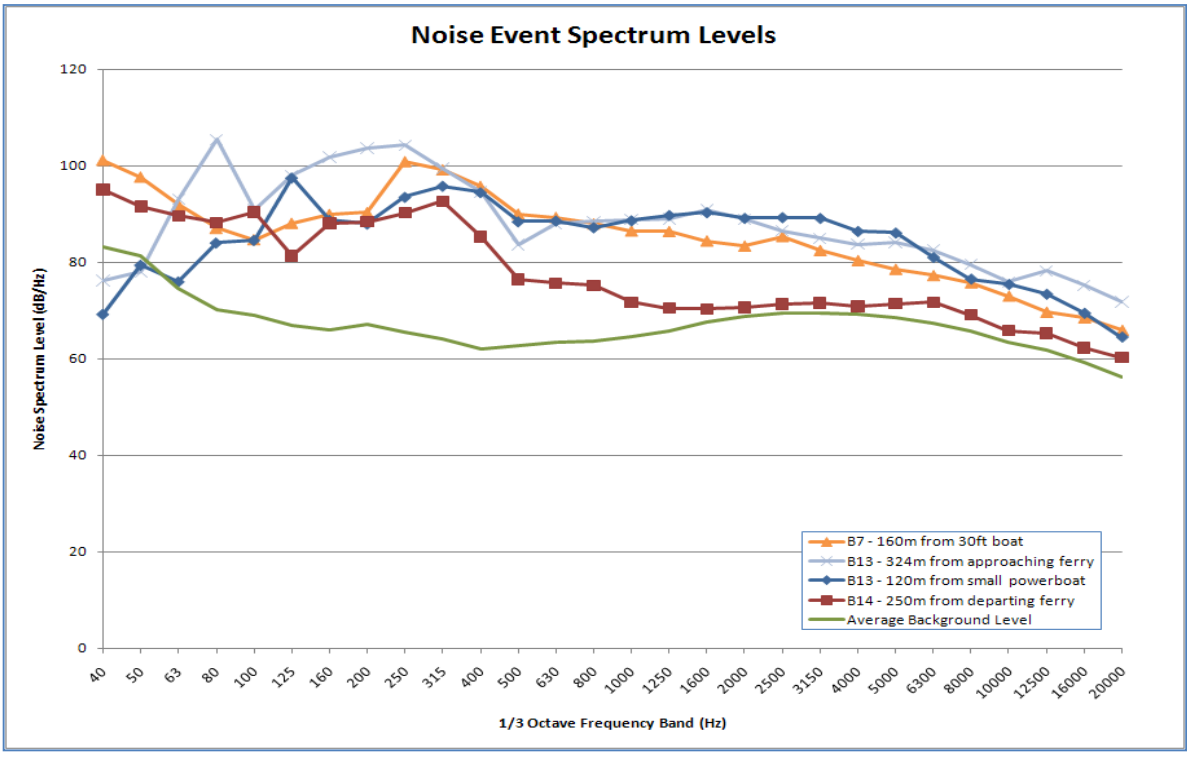

Figure 5.5 Underwater Noise Spectral Level Results of Boat Passby Events and Average Background Level

6 Existing Airborne Noise and Vibration Environment

6.1 Overview

As discussed in Section 5.2, the ambient noise level on the Island is dominated by wind in the trees, waves on the beach, insects and other animals (curlews, geckos and possums). However, there are a number of other localised noise sources present on the Island including mechanical plant (e.g. generators, air-conditioning and refrigeration units), traffic (e.g. private cars, buggies, aircraft and boats). At times there is noise from social activities at accommodation facilities (e.g. restaurant, bars, music), recreation facilities (e.g. people on the beach), and domestic activities (e.g. television sets, radios, people talking).

The ambient noise monitoring on the Island presented in the previous section is most useful in providing a quantitative review of the natural environment. Generally it is intended that noise loggers are located in areas which are not subject to highly localised noise sources, such as mechanical plant, however, in this instance the noise levels at Location A are affected by a nearby generator.

This section of the report will provide a review of major noise sources currently affecting the area near proposed resort activities.

6.2 Aircraft

There is an existing runway on the Island and this is used on a daily basis by light aircraft arriving from, and departing to, the mainland. There are existing noise impacts from the aircraft using the runway, and this will require assessment so that the noise impact of the proposed relocated runway can be assessed. A photo of the existing runway is included in Figure 6.1.

Due to the low frequency of flights to/from the Island, only a single aircraft noise measurement was conducted whilst on Great Keppel Island. A noise measurement has been conducted at Location E, near Fishermans Beach, when a light aircraft was approaching the runway to land from the west. The noise level at the measurement location was up to a maximum of 74 dB(A). The noise level at this location from an aircraft taking off to the west would be expected to be noticeably louder as the aircraft engine is under maximum load at take off. Noise levels of the order of 10 dB(A) higher could be expected at this location during takeoff.

To determine the overall noise impact of the existing runway, reference is made to the aircraft noise level data in Australian Standard AS2021-2000 "Acoustics - Aircraft noise intrusion - Building siting and construction". The noise level data in AS2021 excludes locations near to the runway, which in the case of Great Keppel Island, is where a number of existing residences are located, and hence additional noise measurements of light aircraft have been conducted at Brisbane's Archerfield Airport.

Figure 6.1 Photo of Existing Runway Looking South-East

Figure 6.2 shows an aerial photo of the Island with maximum noise level ($L_{max,S}$) contours, developed from AS2021 for light aircraft. The $L_{max,S}$ levels are the maximum noise levels measured using a slow time weighting. The noise level contours represent the maximum of predicted noise levels for take-off and landing. The outer contour represents a noise level of 60 dB(A) $L_{max,S}$, and the contours increase in 5 dB(A) steps up to a maximum contour of 85 dB(A) $L_{max,S}$.

The area bounded by the blue box in Figure 6.2 represents where AS2021 does not predict any noise levels. It should be noted that the noise levels do not account for the shielding effects of the local terrain.

Noise level markers shown on Figure 6.2 are at locations relative to the Great Keppel Island runway, similar to actual noise level measurement locations relative to the runway at Archerfield Airport. That is, the location of the noise measurement relative to the aircraft take-off or landing has been translated to the equivalent location at Great Keppel Island.

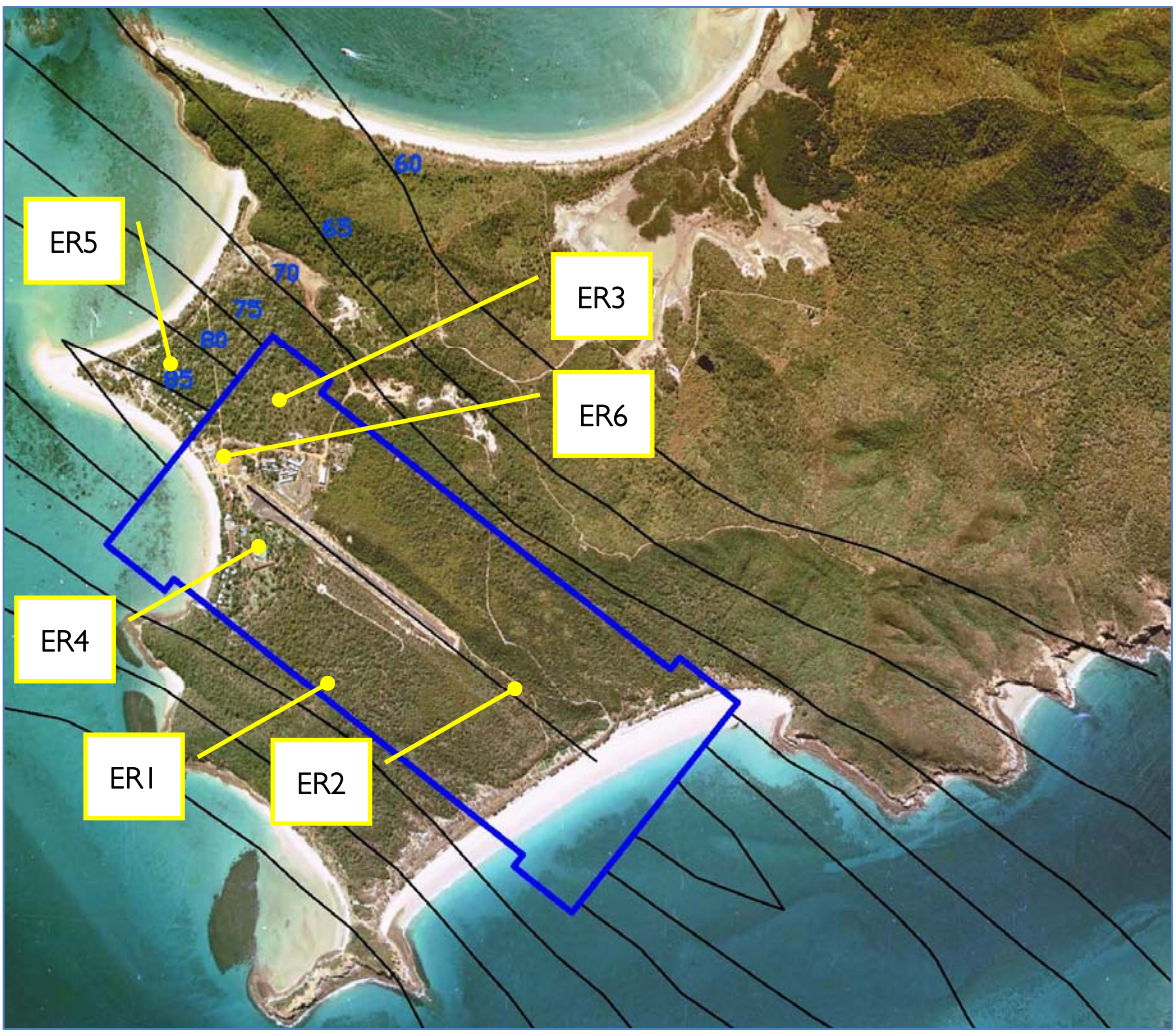

Figure 6.2 Existing Light Aircraft Noise Level L_{max} Contours Derived from AS2021

The measured noise levels corresponding to the markers on **Figure 6.2** are summarised in **Table 6.1**. These measurements were conducted by ASK on 7/06/11 using a calibrated Rion NA27 Type 1 sound level meter.

Table 6.1 Measured Aircraft Noise Levels

Marker Location (Refer Figure 6.2)	Aircraft Maximum Noise Level $L_{max,S}$ dB(A)	Aircraft Taking Off or Landing
ER1	67 to 73	Takeoff
ER2	69 to 70	Landing
ER3	69 to 75	Takeoff
ER4	84	Takeoff
ER5	71 to 78	Takeoff
ER6	84	Takeoff

From **Table 6.1** and **Figure 6.2**, the following comments are made regarding existing noise levels at Great Keppel Island:

- Noise levels measured at locations ER4 to ER6 are considered representative of the take-off noise levels at existing residences and the old resort. Thus these premises are subject to noise levels of 71 to 84 dB(A) L_{max}.
- An attended noise measurement conducted whilst ASK was onsite, indicated an aircraft landing noise level of 74 dB(A) L_{max} at a position approximately midway between ER5 and ER6. Measurements in **Table 6.1** indicate that the noise level during takeoff could be approximately 84 dB(A) L_{max} at this position.

From Table D1 in Australian Standard AS2021, with a maximum noise level of 84 dB(A) L_{max} and less than 20 flights per day, the sites would be considered 'Conditionally Acceptable' for a house, home, unit, flat or caravan park, and 'Acceptable' for a hotel, motel or hostel. 'Conditionally Acceptable' would indicate that new dwellings should consider acoustic design in their construction. Given the very low number of existing flights, understood to average approximately 1 flight per day, and that these are limited to daytime hours (7am to 6pm), the existing noise impact would be expected to be minimal.

From Australian Standard AS2021, the recommended maximum noise level in a residential dwelling in a bedroom or dedicated lounge is 50 dB(A) L_{max}, and 55 dB(A) L_{max} in other habitable spaces. In hotels, motels and hostels the recommended internal noise levels are 55 dB(A) L_{max} in sleeping and relaxing areas, and 70 dB(A) L_{max} where social activities are occurring.

It is unlikely the sleeping and relaxing criteria would be achieved at existing residences based on predicted noise levels of up to 84 dB(A) and the lightweight construction of the dwellings. However, as noted above, due to the low flight numbers and restriction to daytime hours this is unlikely to be of concern to most residents.

6.3 Generators

As there is no power supply to the Island, the existing residences and old resort complex are generally setup with individual generators. It is understood that some residences also use solar however they have not been considered in this noise assessment.

The generators used by the old resort are located in a steel shed and include the following items:

- Generator #1 - Partner 700KVA, 85 dB(A) @ 1 metre.
- Generator #2 - Stamford 650KVA, 82 dB(A) @ 1 metre.
- Generator #3 - Stamford 1150KVA, 90 dB(A) @ 1 metre.
- Generator #4 - Partner/Virtus 1000KVA, 86 dB(A) @ 1 metre.

The combined sound power level of all these generators is approximately 110 dB(A).

The steel shed in which the plant is located could be expected to provide some level of noise reduction. Similarly, it is unlikely that all generators will be simultaneously running at 100% load, and thus the overall sound power level is reduced. Taking these two factors into account, the estimated overall external sound power level of the generator shed is 100 dB(A). The expected noise level at various setback distances from the equipment is as follows:

- At 25m from centre of shed: 64 dB(A).
- At 50m from centre of shed: 57 dB(A).
- At 100m from centre of shed: 50 dB(A).

The above generators have been sold and removed from the Island.

There are a number of generators associated with the private residences and also likely the commercial operators (e.g. Holiday Village). Indeed the noise measurements at Location A included a noise level of approximately 35 to 40 dB(A) from a nearby generator, and this was predominantly a low frequency noise.

Overall, it is reasonable to expect that there will be a number of areas around existing residences and commercial operators where the noise of generators will be readily audible.

6.4 Wastewater Treatment Facility

In the Opus report "GKI Wastewater Infrastructure" dated 29/06/11, the old resort wastewater treatment facility is described as follows:

> *From late 2004 until the closure of the Great Keppel Island Resort (GKI Resort) in 2007-2008, wastewater from the resort was collected by gravity reticulation and pumped to a central treatment facility. The wastewater treatment process consisted of the following: Inflows of raw effluent through a static screen where gross solids are collected in an adjacent bunded area. The screened liquid was then transferred to an old oxidation ditch that served as a balancing tank and was utilized for pH correction. From there, the wastewater was pumped to two parallel treatment trains consisting of aeration, clarification and sludge aging. The nitrification/denitrification process was conducted in the aeration phase then the wastewater was transferred to the two clarifiers.*

Alum dosing was conducted in the clarifiers to precipitate phosphorus. The settled sludge in the clarifiers was transferred to a sludge stabilization tank; whereas, the clarified wastewater was then pumped to a Dyna Sand filter. The filtered water was then dosed with chlorine and stored in a 250kL treated effluent holding tank. Backwash from the sand filter was returned to the balance tank for retreatment.

The treated effluent within the 250kL holding tank was then metered and pumped to the Golf Course for irrigating purposes with a portion being pumped to a 50kL holding tank above the Hillside Villas for irrigation of landscaped areas. The timing of irrigation was such that exposure of guests to effluent water was minimized.

There is no noise data associated with the old facility, however, its noise impact on residential areas was minimized by having a buffer distance of over 500m.

It is proposed to completely rebuild and expand the wastewater treatment infrastructure and thus the associated noise environment will change.

6.5 Vibration

There are currently no significant sources of ground borne vibration on the Island. There will be localised areas of increased vibration associated with mechanical plant (e.g. generators).

Overall, the existing vibration levels on the Island are negligible except for small localised sources of ground borne vibration.

7 Future Airborne Noise Environment

7.1 Overview

The proposed development has the potential to create noise and vibration impacts on existing and future nearby residences and/or marine life. However, there is also the potential to reduce the noise from existing noisy equipment (e.g. generators) should they exceed nominated noise limits.

The following future noise sources are to be addressed:

- Aircraft movements – takeoff, landing and taxiing.
- Industrial compound
    - Diesel generators.
    - Waste water treatment plant.
    - Waste management (e.g. vehicles & equipment)
- Golf course activities and maintenance.
- Marina operation.
    - Retail and restaurants.
    - Emergency services facilities.
    - Ferry terminal.
- Transport of goods to/from the resort.
- Construction activities (land based and marine based).
    - Piling and dredging.
    - Mobile crushing plant.
    - Mobile concrete batching plant.
    - Vehicle movements.
    - General construction.

This section of the report will provide a review of these potential future noise sources.

7.2 Aircraft

7.2.1 Overview

It is proposed to relocate the runway on the Island to accommodate larger aircraft, expected to be travelling from Brisbane and Rockhampton. The existing runway cannot accommodate flights from Brisbane as it is too short for landing of the required aircraft.

It is expected that the frequency of flights will increase to service the new resort, but they will still be limited to daytime hours (7am to 6pm). The frequency of flights would initially be expected to be one per day and increase to 2 or 3 flights per day as the later resort stages are completed.

7.2.2 Noise Levels from Aircraft Overpasses

To determine the noise impact aircraft overpasses associated with the proposed runway, reference is made to the aircraft noise level data in Australian Standard AS2021-2000 "Acoustics - Aircraft noise intrusion - Building siting and construction".

It is expected that Dash 8 and Embraer ERJ190 aircraft will access the Island as direct flights to/from Brisbane, and light aircraft will continue to use the new runway. AS2021 does not contain noise levels for ERJ190 aircraft, and therefore a review was conducted to determine which of the aircraft noise level tables included in AS2021 is most representative of the Dash 8 and ERJ190 aircraft.

A review was conducted of the relative difference in aircraft noise levels using the data in Airservices Australia – Noise and Flight Path Monitoring Systems reports for Gold Coast, Cairns and Brisbane. The review indicated the following results:

- The ERJ190 is typically louder than a Dash 8 or light aircraft and hence should be the aircraft included in modelling.
- The ERJ190 is approximately 5 dB(A) noisier than light aircraft.
- The ERJ190 resulted in similar takeoff and landing noise levels as an Airbus A320, an aircraft type which is included in AS2021 noise levels tables.

Based on this review it was determined that the AS2021 noise level tables for the Airbus A320 should be used for modelling purposes. **Figure 7.1** shows an aerial photo of the Island with maximum noise level ($L_{max,S}$) contours, developed from AS2021 for Airbus A320 type aircraft. The noise level contours represent the maximum of predicted noise levels for take-off and landing. The outer contour represents a noise level of 65 dB(A) $L_{max,S}$, and the contours increase in 5 dB(A) steps up to a maximum contour of 90 dB(A) $L_{max,S}$. It should be noted that the noise levels do not account for the shielding effects of the local terrain.

The area bounded by the blue box in **Figure 7.1** represents where AS2021 does not contain any noise data.

The noise level data in AS2021 excludes locations near to the runway, which in the case of Great Keppel Island, is where a number of existing residences are located, and hence additional noise measurements of medium sized aircraft have been conducted at Brisbane Airport.

The noise level marker 'FR1' shown on **Figure 7.1** is a location relative to the Great Keppel Island runway, similar to actual noise level measurement locations relative to the runway at Brisbane Airport. That is, the location of the noise measurement relative to the aircraft take-off or landing has been translated to the equivalent location at Great Keppel Island.

The measured noise levels corresponding to the marker 'FR1' on **Figure 7.1** are summarised in **Table 7.1**. These measurements were conducted by ASK on 1/07/11 using a calibrated Rion NA27 Type 1 sound level meter.

It is noted that the measured noise levels in **Table 7.1** (70 to 82 dB(A) $L_{max,S}$) are similar to the AS2021 predicted average noise level for FR1 on **Figure 7.1** of approximately 74 dB(A) $L_{max,S}$.

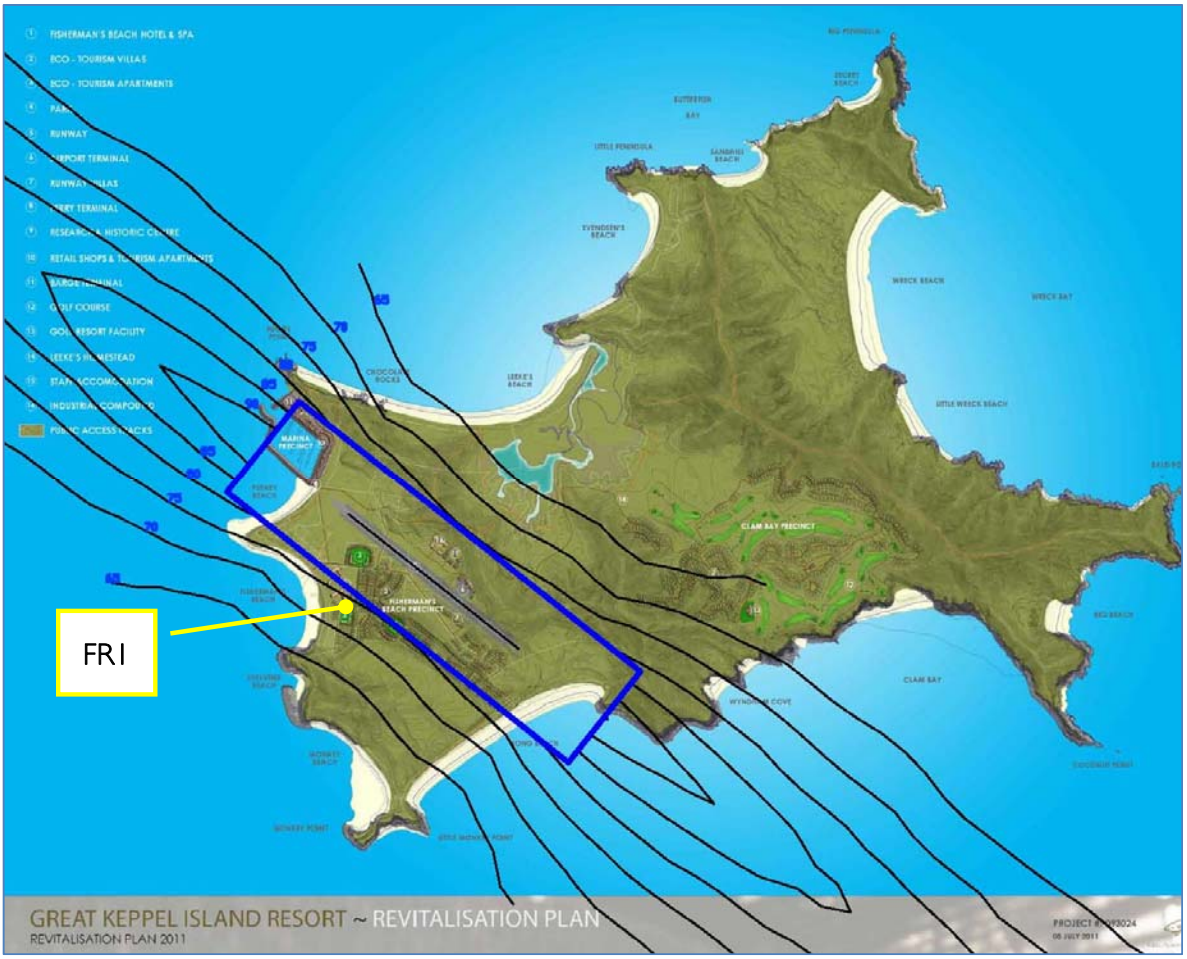

Figure 7.1 Future Aircraft Noise Level $L_{max,S}$ Contours Derived from AS2021

Table 7.1 Measured Aircraft Noise Levels During Takeoff and Landing

Marker Location (Refer Figure 7.1)	Aircraft	Aircraft Maximum Noise Level $L_{max,S}$ dB(A)	Aircraft Taking Off, Landing, Taxiing or Waiting for Access
FR1	Dash 8	70 to 71	Takeoff
FR1	Dash 8	70 to 72, with one louder/abrupt landing at 80	Landing
FR1	ERJ190	79 to 82	Takeoff
FR1	ERJ190	77 to 78	Landing

7.2.3 Noise Levels from Aircraft Movements on Runway

Noise levels measured at Brisbane Airport have been used to determine approximate sound power level for aircraft on the runway, including taxiing, landing and takeoff. The noise levels relate the aircraft on the ground or just above the ground. The measured noise levels include those listed in **Table 7.1** and the additional taxiing noise measurement results in **Table 7.2**. These measurements were conducted by ASK on 1/07/11 using a calibrated Rion NA27 Type 1 sound level meter.

Table 7.2 Measured Aircraft Noise Levels during Taxiing

Marker Location (Refer Figure 7.1)	Aircraft	Aircraft Maximum Noise Level $L_{max,S}$ dB(A)	Aircraft Taking Off, Landing, Taxiing or Waiting for Access
At 350m distance	Dash 8	72	Taxiing
At 450m distance	Dash 8	65 to 67	Waiting for Runway Access
At 150m distance	ERJ190	73	Taxiing

A computer model has been setup for the aircraft movements on the runway, taking off within 500m of each end of the runway, and taxiing adjacent the terminal. The model includes the Island terrain incorporating the proposed relocated runway. The model includes an average ERJ190 taxiing in front of the terminal and aircraft during takeoff or landing on the runway. The average ERJ190 is 5 to 10 dB(A) louder than a Dash8 or typical light aircraft.

Noise levels have been predicted for the western portion of the Island including the existing residences and proposed resort accommodation as shown in **Figure 7.2**. The predicted noise levels are the highest noise levels generated by the taxiing, takeoff or landing point sources. The outer 'blue' contour represents a noise level of 65 dB(A) $L_{max,S}$, and the contours increase in 5 dB(A) steps up to a maximum 'orange' contour of 90 dB(A) $L_{max,S}$.

The predicted noise levels do not account for shielding provided by the buildings, and thus aircraft noise levels within residential areas will be lower than that shown in **Figure 7.2**.

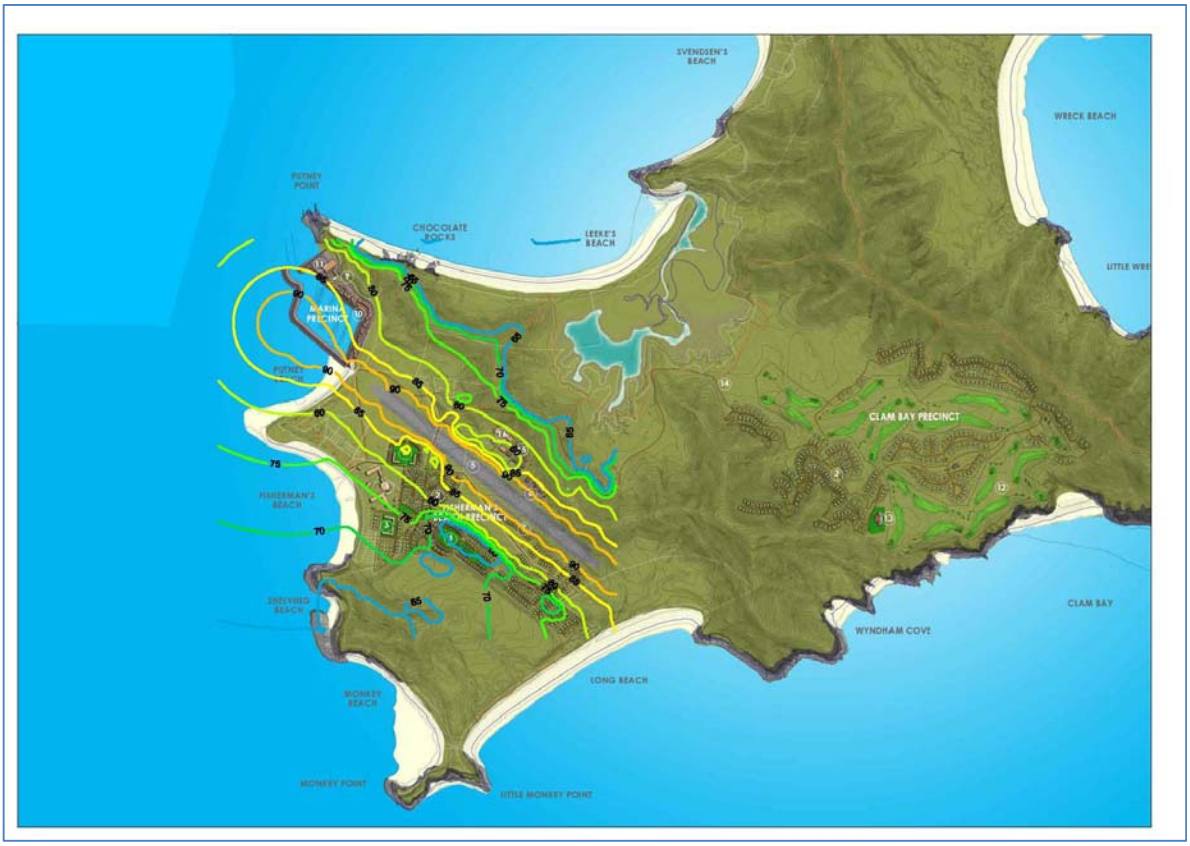

Figure 7.2 Future Aircraft Noise Level $L_{max,S}$ Contours Near to Runway and Terminal

From Figure 7.2 it can be seen that the predicted noise levels in various parts of the resort are generally 70 to 90 dB(A) $L_{max,S}$.

7.2.4 Assessment

A summary of existing and future aircraft noise levels, with reference to **Figure 6.2**, **Table 7.1** and **Table 7.2**, **Figure 7.1** and **Figure 7.2**, is presented in **Table 7.3**.

Table 7.3 Summary of Aircraft Noise Levels for Existing and Future Scenarios

Location	Existing Aircraft Noise Levels $L_{max,S}$ (Figure 7.2)	Future Aircraft Noise Levels $L_{max,S}$	
		Airborne Noise (Figure 7.1)	Groundborne/ Airborne Noise (Figure 7.2)
Existing dwellings along Fishermans Beach – northern section	85	75 to 80	75 to 80
Existing dwellings along Fishermans Beach – southern section	Approximately 80 to 85	65 to 75	70 to 75
Existing backpacker accommodation	80 to 85	75 to 80	75 to 80
Marina apartment	N/A	Not Identified	80 to 90
Accommodation on the southern side of the runway	N/A	Not Identified	90
Apartment in the valley location of the current runway	N/A	Not Identified	65 to 75
Staff accommodation	N/A	Not Identified	80
Central part of the Fishermans Beach precinct	N/A	70 plus	70 to 85
Clam Bay precinct	N/A	Up to 70	Not Identified

The following comments are made regarding aircraft noise levels at Great Keppel Island:

- Aircraft noise levels are predicted to reduce by 5 to 10 dB(A) from existing noise levels at existing dwellings and accommodation units.
- The marina apartments are the most exposed to noise due to the location being inline with the new runway.

Predicted noise levels are up to 90 dB(A) $L_{max,S}$ at the new resort, with most apartments exposed to noise levels above 70 dB(A) $L_{max,S}$.

Appendix D in AS2021 presents methods to determine the acceptability of building sites based on aircraft noise levels at light general aviation aerodromes without ANEF charts. Table D1 in Appendix D presents acceptable noise levels for various building site uses for either (i) 20 or less flights per day; or (ii) greater than 20 flights per day. Currently the Island airport only accepts light aircraft, but the future airport will also include mid-sized aircraft. However, as the flight numbers would still be less than 20 flights per day, the acceptability assessment method in Appendix D is still considered valid.

From Table D1, the acceptability is assessed as follows for hotels, motels and hostels:

- Acceptable: Up to 85 dB(A) $L_{max,S}$.
- Conditionally acceptable: 85 to 95 dB(A) $L_{max,S}$.
- Unacceptable: Greater than 95 dB(A) $L_{max,S}$.

From Table 7.3, all the existing residences and the majority of the site would be classified as acceptable. According to AS2021, *"If from Table D1 the building site is classified as 'acceptable', there is usually no need for the building construction to provide protection specifically against aircraft noise."*

The accommodation near the runway and in the marina would be classified as conditionally acceptable. According to AS2021," *If from Table D1 the building site is classified as 'conditionally acceptable', the required noise reduction should be determined in accordance with Clause 3.2, and the aircraft noise attenuation to be expected from the proposed construction should be determined in accordance with Clause 3.3."*

The calculation of aircraft noise attenuation requires consideration of the external aircraft noise level (up to 90 dB(A) as indicated in Table 7.3), design internal noise level (from AS2021 this is 55 dB(A) $L_{max,S}$ inside sleeping and relaxing areas), and the building design. At the current time the building design is unknown, although it could readily be assumed that units will have relatively large glazing areas.

To achieve an aircraft noise reduction (ANR) of 35 dB(A) (i.e. 90 – 55) would be expected to require construction as follows:

- Walls and roof/ceiling: Acoustic rating of approximately Rw 50, which is satisfied by masonry or concrete construction, or lightweight constructions with cavity insulation and multiple layers of plasterboard sheeting.
- Glazed areas: Acoustic rating of approximately Rw 35 to Rw 40, which will require either thick glazing (e.g. 10 to 12mm laminates) or double-glazed units.

To achieve the nominated internal noise level would require windows and doors to be closed to the accommodation. In this situation, alternative ventilation would be recommended in accordance with the Building Code of Australia. Air-conditioning is usually considered a satisfactory method of ventilation.

The actual acoustic performance required for the units would be determined during more detailed design.

7.3 Industrial Compound

7.3.1 Diesel Generators

It is proposed to access power supply from the mainland and thus the proposed new generators will only be accessed during initial construction (i.e. until mainland power is connected), emergency operations or for approximately 1 hour per month for testing. The testing would normally be programmed to occur in daytime hours.

Although the generators are not used regularly, they are still required to comply with reasonable environmental noise limits such that their occasional use does not present a significant noise impact.

The generators are proposed to be located in the industrial compound on the northern side of the runway. This compound is over 700m from the nearest existing residences, 250m from the nearest proposed accommodation on the opposite side of the runway, and is adjacent the proposed staff accommodation area (Refer Figure B.1). Depending on the generator locations in the compound, they may be located up to 125m from the staff accommodation area.

There is no noise data available for the generators at this stage, and therefore this assessment is limited to nominating appropriate noise limits. The generators should be located, selected and attenuated to achieve the nominated noise limits. The closer the generators are to the staff accommodation area, the more extensive the noise attenuation measures, and could include generator enclosure, upgraded mufflers and/or acoustic ventilation louvers.

It is recommended that the noise emissions comply with stricter noise limits at existing residences and proposed unit accommodation, however, less strict noise limits could be applied to the staff accommodation facilities. The stricter noise limits aim to minimise background creep, and effectively maintain the existing noise environment. The less strict noise limits allow an increase in the ambient noise levels, but to a level which is still considered acceptable.

If a more pleasant acoustic environment is sought for the staff accommodation, the stricter noise limits could be applied to all residential receivers including the staff accommodation.

Given the nearest receivers are inland from the beach, the background noise levels measured at Location B are considered most appropriate to determine noise limits. From Table 5.11, the appropriate criteria are considered to be as follows:

- Stricter criteria are taken from DERM EPP(Noise), Background Creep, Continuous Noise (Refer Table 5.11), and are applicable to existing residences and proposed unit accommodation:
  - Daytime: 29 dB(A) $L_{A90,T}$
  - Evening: 30 dB(A) $L_{A90,T}$
  - Night: 26 dB(A) $L_{A90,T}$
- Less strict criteria are taken from DERM EPP(Noise), Acoustic Quality Objectives, Outdoors (At façade, assuming open windows) (Refer Table 5.11), and are applicable to staff accommodation:
  - Daytime: 40 to 45 dB(A) $L_{eq,adj,T}$
  - Evening: 40 to 45 dB(A) $L_{eq,adj,T}$
  - Night: 35 to 40 dB(A) $L_{eq,adj,T}$

Given the distance of 250m from the generators to the nearest proposed accommodation, the lowest noise limit of 26 dB(A) should be readily achieved with an enclosed generator, with perhaps minimal acoustic upgrades.

In terms of the staff accommodation criteria, the night limit of 35 to 40 dB(A) may require a buffer distance of approximately 100m from an enclosed generator in the absence of intervening buildings or acoustic upgrades. Given the compound is located adjacent the staff accommodation, care should be taken in the location, design and selection of the generators.

7.3.2 Wastewater Treatment Facility

The wastewater treatment facility is proposed to be located within the industrial compound. There is no detail on the proposed system, but we understand it will be a modern fully enclosed package unit design.

The noise sources within the proposed wastewater treatment plant would likely be limited to pumps, motors and blowers. Based on ASK's noise data from a small regional wastewater treatment plant the noise emission levels are estimated at 30 dB(A) L_{eq} at 300m from the plant. This corresponds to a sound power level of approximately 88 dB(A) L_{eq}. This is similar to the sound power level of an idling vehicle.

Given the continuous nature of the noise from this facility, it is recommended to apply the stricter criteria from Section 7.3.1, as follows:

- Criteria are taken from DERM EPP(Noise), Background Creep, Continuous Noise (Refer Table 5.11), and are applicable to existing residences, proposed unit accommodation, and staff accommodation:
    - Daytime: 29 dB(A) $L_{A90,T}$
    - Evening: 30 dB(A) $L_{A90,T}$
    - Night: 26 dB(A) $L_{A90,T}$

Based on the estimated equipment sound power level of 85 dB(A) L_{eq} the noise limits would be readily achieved at existing residences, may be marginal at proposed accommodation, and is not predicted to be met at the staff accommodation in the absence of intervening buildings or acoustic upgrades.

It is recommended that a review of noise levels is undertaken during the detailed design process of the wastewater treatment facility. At that point, consideration of less strict noise criteria could be considered for the proposed accommodation and staff accommodation.

7.3.3 Solid Waste Management

7.3.3.1 Overview and Equipment Data

The management of solid waste could potentially include a number of activities in the industrial compound, including:

- Delivery of waste to the compound via truck from around the Island.
- Composting organic waste streams including, food waste, cardboard, sewage sludge using a bagged compost system. The waste is placed into a hopper and rammed into plastic tubes for composting. After several months, the compost is removed, loaded into trucks and used around the Island as required.
- Compacting waste using a small stationary refuse compactor, bin press or similar. Resulting waste to be loaded into containers, trucks to the ferry terminal and transported back to the mainland.
- Unloading wheelie bins into industrial bins for weekly or twice weekly transport to the ferry terminal.

Based on ASK's library of data we would expect the following indicative sound power levels for the listed activities:

- Truck and loader movements: 110 dB(A) $L_{max,T}$
- Composting bag fans: 80 dB(A) L_{eq} each, or 90 dB(A) L_{eq} for 10 of
- Loading hopper and compaction: 100 dB(A) $L_{max,T}$

7.3.3.2 Assessment

As noted previously, this compound is over 700m from the nearest existing residences, 250m from the nearest proposed accommodation on the opposite side of the runway, and is adjacent the proposed staff accommodation area (Refer Figure B.1).

With respect to the vehicle related activities and compaction, it could be expected that the short-term L_{max} noise events will occur for approximately 10% of daytime hours. That is, whilst the vehicles may be continually operational, the loudest periods of their activity, e.g. engine startup, revving to lift material, would occur for approximately 10% of the operational period.

An appropriate noise limit for residences is considered to be the DERM EPP(Noise) Acoustic Quality Objective of $L_{A10,adj,T}$ of 45 to 50 dB(A) during the daytime. At this noise level the operation would be expected to be audible. In the absence of any screening, this noise limit will be achieved at distances of greater than 400m. With an intervening barrier/mound, the noise limit will be achieved at distances of greater than 200m. Given the proposed residences are as close as 250m it is likely that the compound will be required to be screened from residences using an earth mound of several metres height.

The staff accommodation is located adjacent to the compound and thus would be subject to higher noise levels than the nominated criteria. Therefore, either the noise criteria are relaxed for the staff accommodation or the activities are substantially shielded or enclosed.

In terms of the continuous noise generated by fans associated with composting equipment, an appropriate criterion would be the same as that used for the generators and wastewater treatment, as follows:

- Criteria are taken from DERM EPP(Noise), Background Creep, Continuous Noise (Refer Table 5.11), and are applicable to existing residences, proposed unit accommodation, and staff accommodation:
  - Daytime: 29 dB(A) $L_{A90,T}$
  - Evening: 30 dB(A) $L_{A90,T}$
  - Night: 26 dB(A) $L_{A90,T}$

The day/evening criteria would be achieved with a separation distance of approximately 400m. This would be reduced to approximately 100m to 200m with the afore-mentioned screening around the compound. At night, we understand that the aeration fans can be setup to operate at lower speed, thus reducing noise emission levels by approximately 10 dB(A), and the buffer distance to 200m. Therefore the fans are predicted to achieve compliance at the nearest proposed accommodation and existing residences.

To achieve these criteria at the proposed staff accommodation will require additional attenuation measures, such as enclosures and localised screening.

7.4 Golf Course

The proposed golf course is located in an area known as the Clam Bay Precinct as shown in Appendix B. The golf course is over 2 km from the nearest existing residences to the north (Svendsen) and west (Fisherman's Beach), and therefore would be expected to cause negligible noise impacts on existing residences.

Around the golf course will be a number of dwellings. There is the potential for noise impacts on the proposed dwellings due to the equipment typically used to maintain a golf course.

The typical equipment and associated noise levels that could be expected at a quality golf course are listed in Table 7.4. This noise data was measured by ASK at Queensland Golf Course.

Table 7.4 Sound Power Levels of Golf Course Equipment

#	Equipment	Sound Power Level, $L_{w,max}$ dB(A)
1	Toro 3150P Greenmaster (greens)	92 to 99
2	Toro 3100D Reelmaster	88 to 96
3	John Deere F1145 (rough)	84 to 108
4	Toro Reelmaster 6500D (fairway)	89 to 101
5	John Deere 1200A (bunker raker)	97
6	Tractor FORD 3910 (spraying)	99 to 109
7	Yanmar Diesel YM186D (blow leaves off fairway)	112
8	Leafblower STIHL BG45	105

#	Equipment	Sound Power Level, $L_{w,max}$ dB(A)
9	Leafblower STIHL BR420	111
10	Whipper snipper STIHL FS85R	107
11	Chainsaw	106

During the daytime, there is usually little noise impact from golf course maintenance equipment as it is highly mobile and resort guests may be utilising the course or other activities. It is not proposed to use the equipment in the night (10pm to 7am) and hence sleep disturbance is not an issue.

There may be other facilities at the golf course with the potential to create noise, e.g. patrons and/or entertainment at a club house facility. This would cause negligible impact on existing residences due to the large buffer distance involved. In terms of the proposed dwellings on and adjacent to the golf course, it is reasonable to expect that these noise sources will need to be appropriately managed.

Overall, the golf course is not expected to cause a noise impact on existing residences, and its impact on proposed dwellings can be managed through appropriate management of activities.

7.5 Marina

7.5.1 Overview

The proposed marina precinct will be located at the northern end of Putney Beach. The marina precinct includes the following uses:

- Barge terminal
- Minor maintenance activities (daytime only).
- Ferry terminal.
- Retail shops.
- Restaurants.
- Apartments.
- Marina.

The marina will be located approximately 230m from the nearest existing accommodation to the south (Holiday Village Backpacker Accommodation) and 400m from the nearest existing private dwelling to the south. The barge terminal hardstand and service component located at the northern end of the marina is approximately 750m from the nearest existing accommodation to the south.

7.5.2 Barge Terminal and Servicing Area

A buffer distance of 750m from the barge terminal to existing accommodation would sufficiently attenuate typical noise events associated with a barge terminal, e.g. vehicle movements, movement of goods and waste bins, and barge engine motors.

Similarly noise from occasional service activities (e.g. power tools) would also be satisfactory attenuated. It is expected that any service activity involving power tools, hammering or similar, will need to occur indoors given the proposal for apartments around the marina, which could be as close as 100m to the service area.

The current preliminary design shows a hardstand area on the northern side of a service shed, with the proposed apartments to the south. Thus activities on the hardstand will be shielded from the apartments.

During detailed design of the marina, a management plan will need to be devised for the barge terminal, servicing and associated activities. It is reasonable to expect that activities will be limited to daytime hours, and noisy activities would be required to be conducted indoors.

7.5.3 Retail and Restaurants

The marina will be a hub for retail and restaurant activities and thus there will be associated noise with patrons and mechanical plant (e.g. air-conditioning and refrigeration plant). These activities will need to be managed to achieve reasonable noise levels within the marina apartment complex. By managing the noise levels within the marina complex, the resulting emissions to external accommodation, some 250m to 750m south of the marina, would be satisfactorily controlled.

7.5.4 Ferry Terminal

Current barges and ferries access the Island by landing on Fishermans Beach, immediately in front of the residential area. The beach edge is approximately 150m from the nearest residential dwellings.

The proposed marina ferry terminal is 250m from the nearest accommodation, and the ferry will be shielded by the marina break wall to the south. Therefore it is expected that the ferry noise impact will result in lower noise emission levels than the current arrangement.

7.5.5 Noise Criteria

The nearest existing accommodation and residential dwellings are near to the beach, and therefore noise limits are to be based on measured noise levels at a beachside locations with minimal extraneous noise (i.e. Location D). The proposed criteria for existing accommodation and residential dwellings are as follows:

- Steady noise sources (e.g. mechanical plant): Criteria are taken from DERM EPP(Noise), Background Creep, Continuous Noise (Refer **Table 5.11**):
  - Daytime: 40 dB(A) $L_{A90,T}$
  - Evening: 38 dB(A) $L_{A90,T}$
  - Night: 36 dB(A) $L_{A90,T}$

- Intermittent noise sources (e.g. patrons, boat maintenance, vehicle movements) DERM EPP(Noise), Acoustic Quality Objectives, Outdoors (At façade, assuming open windows) (Refer Table 5.11), and are applicable to staff accommodation:
    - Daytime and Evening: 40 to 45 dB(A) $L_{eq,adj,T}$, 45 to 50 dB(A) $L_{10,adj,T}$ & 50 to 55 dB(A) $L_{1,adj,T}$.
    - Night: 35 to 40 dB(A) $L_{eq,adj,T}$, 40 to 45 dB(A) $L_{10,adj,T}$ & 45 to 50 dB(A) $L_{1,adj,T}$.

Whilst the above noise criteria are considered appropriate for existing sensitive receivers, more relaxed criteria may be nominated for proposed accommodation and this could be considered in the detailed design phase. More relaxed criteria could be justified on the basis that marina apartments would be designed to accommodate high aircraft noise levels. The detailed design should aim to minimise potential noise conflicts and provide reasonable buffers and shielding of noise from maintenance areas onto apartments.

7.6 Transport

Transport related to the operation of the resort will include:

- Air – Aircraft.
- Sea – Ferries and barges.
- Land – Small buggies for guests & trucks for waste and construction materials/waste.

Aircraft, ferries and barges are addressed in other sections, as are construction related vehicle movements. This section relate to buggies and truck movement on local roads.

There are existing vehicles on the Island, including buggies and cars. The number of these vehicles is limited, however, and significantly less than the vehicle numbers expected of a resort operation. Therefore whilst minor driveways/roads in the development are unlikely to be of significant concern, the collector roads could contain more regular traffic movements.

The proposed criteria for existing accommodation and residential dwellings are as follows (Refer Table 5.11):

- Daytime and Evening – DERM EPP(Noise), Acoustic Quality Objectives, Outdoors: 65 dB(A) $L_{1,adj,T}$.
- Night – DERM EcoAccess Sleep Disturbance, Outdoors: 50 to 55 dB(A) $L_{max,T}$.

For the purpose of this analysis the following assumptions are made:

- Buggies have similar noise emission levels as typical road cars. The actual sound level will depend on the choice of buggy, and thus revised noise calculations may be conducted once vehicle selection is completed.
- The maximum noise ($L_{max,T}$) from vehicle movements occurs for 1% of a typical measurement period ($L_{1,adj,T}$) and are neither tonal nor impulsive in nature (i.e. the 'adj' component of the $L_{1,adj,T}$ level is equal to zero.

The typical noise levels of vehicles are as follows:

- Vehicle moving slowly (flat or downhill): Lw 81.5 dB(A)
- Vehicle moving slowly (accelerating or uphill): Lw 91 dB(A)
- Car door slam or engine startup: Lw 92.5 dB(A)
- Medium or large rigid truck (flat or downhill): Lw 105 dB(A)
- Medium or large rigid truck (starting, accelerating or uphill): Lw 110 dB(A)

To achieve the nominated noise limits, the separation distance between vehicle and residences have been calculated and are shown in Table 7.5.

Table 7.5 Recommended Buffer Distances for Vehicle Activities Near Existing Residences

Vehicle Activity	Buffer Distance, metres	
	Daytime & Evening	Night
Vehicle moving slowly (flat or downhill)	3	8
Vehicle moving slowly (accelerating or uphill)	8	25
Car door slam or engine startup	9	30
Medium or large rigid truck (flat or downhill)	40	126
Medium or large rigid truck (starting, accelerating or uphill)	71	224

From Table 7.5 the following recommendations are made for roads subject to regular vehicle movements:

- If trucks are to use the roads at night (10pm to 7am), the roads should be located at least 126m to 224m (depending on road terrain) from existing residents. During the day and evening the separation distance can be reduced down to 40m to 71m.
- Roads used by cars (i.e. including buggies) should be 25m from existing residents, if there is an uphill or starting component, or 8m if the road is continuous and level.
- Noise barriers or extensive vegetation (e.g. greater than 50m deep) could be used to reduce the buffer distances in Table 7.5.
- Vehicle carparks and road intersections should be at least 30m from existing residents, and truck parking areas should be at least 71m from existing residents assuming daytime use only, or 224m if used at night.

As proposed previously, the above noise criteria are considered appropriate for existing sensitive receivers, but more relaxed criteria may be nominated for proposed accommodation and this could be considered in the detailed design phase. The detailed design should aim to minimise potential noise conflicts and provide reasonable buffers and shielding of noise from regularly used roads onto apartments.

7.7 Construction Activities

7.7.1 Noise Criteria

There are no specific construction noise criteria in the Environmental Protection Act 1994 or other state legislation. The Environmental Protection Act 1994 notes that noise limits are not applied to building work between 6:30am and 6:30pm on a business day (typically Monday to Friday) or Saturday. Outside these times, the Act notes that building work must be inaudible.

The GKI Construction report (refer Opus report dated 25/07/11) currently nominates construction times of 6am to 6pm Monday to Friday, 6am to 2pm on Saturday, and no work on Sunday and public holidays. If work is to occur between 6am and 6:30am, then it must remain inaudible, which would limit work to quiet activities or locations distant from existing residences.

The relaxation of noise limits during daytime construction is generally considered appropriate. The reasons for the relaxation of limits include (i) construction activities are not a long-term noise source, and (ii) operational noise can be controlled within enclosures or buildings, whereas these buildings are not completed during the construction phase.

Although noise limits may be relaxed for construction activities during the daytime, it is required that noise emissions are minimised where practicable, especially where construction will occur for long periods. In this instance, the proposed construction period is from 2012 to 2023 and will initially include approximately 350 construction workers, reducing to 150 workers over latter years.

Given the duration of the construction period, long-term noise criteria associated with non-construction activities are to be targeted where practicably possible. Example of which activities may practicably achieve long term noise criteria are as follows:

- Generators used for powering equipment – this equipment can readily achieve long term noise criteria through equipment location, selection and attenuation.
- Grading a road near to existing houses – this activity would not be able to achieve long term noise criteria, but should only occur for a relatively short period at any one location, and hence would normally be considered acceptable. The activity should therefore occur only in daytime hours, and well maintained and appropriately muffled equipment should be used.
- Concrete batching plan – this plant should be located well away from existing residences and accommodation, in latter stages, and long term noise criteria should be achievable with appropriate buffer distances.

7.7.2 Noise Levels

7.7.2.1 General Equipment

Noise from construction of the project is expected to include steady or quasi-steady noise sources (e.g. motors, pumps etc) and intermittent noise sources (e.g. earthmoving equipment, site vehicles etc).

Typical noise emission levels from the anticipated construction equipment are included in Table 7.6. The sound power levels of the equipment in Table 7.6 are between 105 dB(A) and 111 dB(A), except for the concrete saw which is 118 dB(A). This sound power level range is similar to the previously nominated levels for medium and rigid trucks of 105 dB(A) and 110 dB(A) (Section 7.6), depending on the road slope and vehicle action.

The previously nominated long term noise criteria for occasional truck movements was the DERM EPP(Noise), Acoustic Quality Objectives (Outdoors) of 65 dB(A) $L_{1,adj,T}$. For construction activity that results in more regular noise events (i.e. maximum sound levels are experienced for approximately 10% of a time period rather than the 1% proposed for occasional truck movements on local roads), a target noise limit would be 55 dB(A) $L_{10,adj,T}$. Buffer zone distances required to achieve these noise limits are included in Table 7.7.

Table 7.6 Typical Noise Levels From Anticipated Construction Equipment

Construction Plant	Noise Level at 7m, dB(A)*	Sound Power Level, dB(A)*
Scraper	86	111
Bulldozer	85	110
Grader	84	109
Front-end loader	86	111
Vibrating roller	82	107
Backhoe	83	108
Excavator	80	105
Compressor	75	100
Concrete vibrator	87	112
Concrete pump	84	109
Dump truck	83	108
Water tanker	84	109
Compactor	85	110
Concrete saw	93	118

* Source RTA Environmental Noise Measurement Manual 2001

Table 7.7 Target Buffer Distances For Anticipated Construction Equipment

Construction Plant	Target Buffer Distance, metres	
	Equipment Operating Occasionally (i.e. maximum noise levels occurring approximately 1% of time period)	Equipment Operating Continuously (i.e. maximum noise levels occurring approximately 10% of time period)
Scraper	79	248
Bulldozer	70	221
Grader	62	197
Front-end loader	79	248

Construction Plant	Target Buffer Distance, metres	
	Equipment Operating Occasionally (i.e. maximum noise levels occurring approximately 1% of time period)	Equipment Operating Continuously (i.e. maximum noise levels occurring approximately 10% of time period)
Vibrating roller	50	157
Backhoe	56	176
Excavator	39	124
Compressor	22	70
Concrete vibrator	88	279
Concrete pump	62	197
Haul truck	56	176
Water tanker	62	197
Compactor	70	221
Concrete saw	176	556

Given the scale of the development and the scarcity of residences on the Island, the buffer distances listed in Table 7.7 would be readily achieved for most of the construction process. Portions of Stage 1 to 3 of the construction work will be within the target buffer distances, and in these instances noise and vibration emissions should be minimised in accordance with Australian Standard AS2436-2010 "Guide to noise and vibration control on construction, demolition and maintenance sites".

7.7.2.2 Haulage Trucks

The proposed construction access road (refer: Appendix B of Opus Construction Management Plan report) runs between the existing and proposed relocated runway, up towards the southern corner of the marina, around the marina barge terminal. A second road runs from the western end of the proposed relocated runway across to the proposed golf course precinct.

The road is closest to existing residences at the southern corner of the proposed marina. At this point the road is approximately 200m from the backpacker accommodation to the south, and approximately 400m from the detached dwellings on Fishermans Beach. It can be seen from Table 7.7 that the recommended buffer distances of 56 to 176m for a haul truck have been achieved with the proposed haul road location.

At the proposed road location, the noise from the haul trucks would expect to be readily audible, but compliant with the EPP Acoustic Quality Objective levels.

7.7.2.3 Demolition

Initial construction works will require the demolition of the existing resort, hotel, villas and units to make room for the proposed development at Fishermans Beach. This site is adjacent to existing residences, and thus there is little opportunity for buffer zones.

To minimise noise emissions, the following steps will be undertaken:

- Limit hours to daytime, as per proposed construction hours.
- Utilise quiet equipment and demolition techniques where practical.
- Store waste away from from residential areas.
- Loading of waste into containers for removal from the Island should be conducted away from residential areas.

General recommendations for minimising construction noise are included in Section 7.7.3.

7.7.2.4 Mobile Concrete Batching Plant

A concrete batching plant will be required during the construction process. The size and use of the plant is not confirmed at the current time, but it could be expected to be a significant noise source during operational periods and hence should not be located near to residences. It is expected that the batching plant would be relocated to be near to each stage of the construction process.

A recent assessment of a regional commercial concrete batching plant indicated that with a 200m buffer distance between the plant and residences the noise emissions were generally acceptable with the construction of a noise barrier/mound and good management of activities in the early morning period (5am to 7am).

Given the batching plant will include heavy vehicles as major noise sources, the buffer distances determined in Section 7.7.2.2 would be expected to be similar to that required for a concrete batching plant.

With a buffer distance of approximately 200m it is expected that noise emissions would be compliant with the DERM EPP(Noise), Acoustic Quality Objectives (Outdoors) during the daytime (7am to 6pm).

The following general noise minimisation techniques (refer Victorian EPA) are recommended:

- Use of self cleaning weigh hoppers.
- Enclosing compressors and pumps.
- Fitting silencing devices to all pressure operated equipment.
- Lining hoppers with a sound absorbing material, such as rubber.
- Fitting efficient muffling devices to all engines.
- Using visual alarms in preference to audible alarms.
- Using a personal paging service instead of hooters to gain attention of staff.
- Relocation sirens to face away from residences.
- Weighing fine aggregates before coarse aggregates.

7.7.2.5 Mobile Crushing Plant

A crushing plant may be used to recycle material from existing foundations and/or from the existing runway. The plant may be mobile if required.

Previous noise measurements have indicated sound power levels of approximately 120 dB(A) L_{10} from rock crushing plant.

The previously nominated long term noise criterion was the DERM EPP(Noise), Acoustic Quality Objectives (Outdoors) of 55 dB(A) $L_{10,adj,T}$.

Assuming negligible shielding, intervening forest or other significant ground attenuation the required buffer distance from residences would be 700m. If the crushing plant is shielded by intervening topography, earth mounding to the height of the crusher, or forest, this buffer distance may be reduced to approximately 250m.

7.7.2.6 Blasting

The Construction Management Plan indicates that *"there is no proposed blasting in any stages of the GKI Resort project. However, it may be necessary if unexpected hard rock is encountered subject to assessment by qualified geotechnical consultant."*

If blasting is required as part of the bulk earthworks it is required to comply with the DERM EcoAccess Guideline "Noise and vibration from blasting" criteria:

- Air blast overpressure of 115 dB (linear peak) for nine (9) out of ten (10) consecutive blasts initiated and not greater than 120 dB (linear peak) at any time.
- 5 mm/s peak particle velocity for nine (9) out of ten (10) consecutive blasts and not greater than 10 mm/s peak particle velocity at any time.

The DERM criteria are likely to be achieved at distances of several hundred metres from a blast, depending on the blast and ground parameters.

7.7.3 General Recommendations

Noise and vibration from typical expected construction activities have been assessed. Generally noise and vibration from construction are to be managed through hours of operation and, where practical, use of appropriate buffer distances.

The noise and vibration management plan should make reference to Australian Standard AS2436-2010 "Guide to noise and vibration control on construction, demolition and maintenance sites". This standard provides details on strategies to minimise construction noise, such as the following:

Plant and Equipment:

- Employing quieter techniques for all high noise activities such as rockbreaking, concrete sawing, power and pneumatic tools.
- Choosing quieter plant and equipment based on the optimal power and size to most efficiently perform the required tasks.
- Operating plant and equipment in the quietest and most efficient manner.
- Where possible modify equipment to reduce noise levels, however only after consultation with the manufacturer. For example, providing mufflers to existing equipment.
- Regularly inspecting and maintaining plant and equipment to minimise noise and vibration level increases to ensure that all noise and vibration reduction devices are operating effectively. Maintenance should be carried out by trained persons.
- Excessive noise caused by resonance of body panels and cover plates can be reduced by stiffening with additional ribs or by increasing the damping with a surface coating of

resonance-damping material. Rattling noises can be controlled by tightening loose parts and fixing resilient material between the surfaces in contact.

- For stationary plant where limited access is required, the noise source should be enclosed.
- Plant that is used intermittently, e.g. cranes, dozers, graders, back hoes, bobcats and loaders, should be shut down in the intervening periods between work or throttled down to a minimum.
- In demolition work alongside occupied premises there should, if possible, be a break in solid connections, e.g. concrete paving, between the working areas and the adjoining buildings. This will reduce the transmission of vibration and structure-borne noise. Care should be taken that any such break is of no structural significance in relation to the planned system of demolition. The break should result in premature collapse due to lack of continuity of restraint.
- Vibration from machinery with rotating parts can be reduced by attention to proper balancing. Frictional noise from the cutting action of tools and saws may be reduced if the tools are kept sharp. Other noises caused by frictional in machines, conveyor rollers and trolleys can be reduced by proper lubrication.

On-site Noise Mitigation

- Maximising the distance between noise activities and noise sensitive land uses.
- Undertaking noise fabrication work off site where possible.
- Adopting alternatives to reversing alarms.
- Maintaining any pre-existing barriers or walls on a demolition or excavation site as long as possible to provide optimum sound propagation control.
- Constructing barriers that are part of the project design early in the project to afford mitigation against site noise.
- Using temporary site building and material stockpiles as noise barriers. These can often be created using site earthworks and may be included as a part of final landscape design.
- Installing purpose built noise barriers, acoustic sheds and enclosures.

General

- Regular reinforcement (such as toolbox talks) of the need to minimize noise and vibration.
- Regular identification of noisy activities and adoption of improvement techniques.
- When dropping materials into for example trucks, the surfaces on to which the materials are being moved should be covered by some resilient material. Particular care should be taken during the loading and unloading of scaffolding. Where material can not be lowered into skips or by other means, it is recommended that properly constructed and damped chutes be used.
- Avoiding the use of portable radios, public address systems or other methods of site communication that may unnecessarily impact upon nearby residents.
- Developing routes for the delivery of materials and parking of vehicles to minimise noise.
- Where possible avoiding the use of equipment which generates impulsive noise.
- Minimising the need for vehicle reversing for example by arranging for one way site traffic routes.

- Minimise the movement of materials, equipment and unnecessary metal-on-metal contact.
- Minimising truck movements.
- Scheduling respite periods.

7.8 Vibration

Potential significant vibration impacts occurring during construction include rock blasting (refer Section 7.7.2.5) and marina piling works (refer Section 8.6.2). Otherwise, vibration impacts during operation are expected to be limited to localised impacts, e.g. near to construction and demolition activities.

7.9 Impacts on Fauna

The proposed resort will create a range of noise sources from transient (e.g. aircraft overpasses, passing vehicles) to continuous (e.g. air-conditioning plant, water treatment plant). In most instances the noise sources are already occurring on the Island or have done so in the past. However, the noise sources are likely to increase in frequency and number due to the increased scale of the resort compared with the old resort. The proposed resort would thus cause increased noise impacts on fauna on the Island.

There are a number of birds and small mammals that have been sighted on the Island, and these maybe subject to increased noise levels due to construction and resort operation. In most instances the noise impacts on fauna would be expected to be insignificant as the resort would be designed to achieve the relatively low noise criteria required of residents.

8 Marine Noise Assessment

8.1 Overview

Great Keppel Island is within the Great Barrier Reef Marine Park, in the Mackay / Capricorn Management Area. The areas bounding the Island are Conservation Park, Marine National Park, Habitat Protection and General Uses areas. There are no Preservation or Species Conservation areas in the immediate vicinity of the Island.

In terms of the use of the marine areas immediately around the Island, the majority of activity would occur in the marina precinct, on the western side of the Island beside Putney Beach (refer Appendix B). There will be piling and dredging activities associated with the construction of the marina, and boat movements during its general operation. It is understood that there are no other significant marine activities around the Island.

There are a number of marine creatures[1] that may appear in the vicinity of the marina development, and these are likely to include dolphins (Cetaceans), dugongs, marine turtles and fish. These marine animals were identified in the SEWPAC/GBRMPA document "Guidelines for an Environmental Impact Statement for the Great Keppel Island Tourism and Marina Development, Queensland" (ref: EPBC 2010/5521/GBRMPA G33652.1, February 2011).

The results of ambient marine noise monitoring at the Island were presented in Section 5.5. During the monitoring the significant existing marine noise sources included boats and snapping shrimps.

8.2 Marine Species

8.2.1 Dolphins

The EPBC Act Protected Matter Report indicates the following dolphins may be present around the Island:

- Irrawaddy Dolphin (*Orcaella brevirostris*).
- Indo-Pacific Humpback Dolphin (*Sousa chinensis*).
- Common Dophin, Short-beaked Common Dolphin (*Delphinus delphis*).
- Risso's Dolphin, Grampus (*Grampus griseus*).
- Spotted Dolphin, Pantropical Spotted Dolphin (*Stenella attenuate*).
- Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin (*Tursiops aduncus*).
- Bottlenose Dolphin (*Tursiops truncatus s. str.).*

[1] frc environmental, 2010, Great Keppel Island Resort: Marine Ecology Technical Paper, ref: 100206

The Queensland Nature Conservation (Whales and Dolphins) Conservation Plan 1997 has a section which includes comments on noise as follows:

Protection of whales and dolphins

(1) A person must not, without reasonable excuse, do any of the following to a whale or dolphin in the wild—

a) deposit rubbish near the whale or dolphin;
b) make a noise that is likely to disturb the whale or dolphin;
c) make a noise that is likely to attract the whale or dolphin;
d) intentionally feed the whale or dolphin;
e) touch the whale or dolphin.

Although the legislation noted above generally refers to the impact of people temporarily in the vicinity of dolphins, it could be considered to also relate to the construction and operation of a marina.

Dolphins are generally considered a mid-frequency cetacean (Southall et al, 2007)[2] with an estimated auditory bandwidth of 150 Hz to 160 kHz (c.v. human range of 20 Hz to 20 kHz), although this will vary between species. The frequency of best hearing (Au & Hastings, 2010)[3] is typically between 3 kHz and 110 kHz.

In terms of sound generation, social communication generally includes sound in the frequency range of 5 kHz to 15 kHz. Sound generation for the purpose of echolocation is generally in the range of 30 kHz to 130 kHz (Au & Hastings, 2010).

8.2.2 Dugongs

The EPBC Act Protected Matter Report indicates that dugongs (*dugong dugon*) may be present around the Island.

Based on an anatomical study by Iwashina, 2008[4], the estimated auditory bandwidth of dugongs is 24-34 Hz to 24-27 kHz.

In terms of sound generation, dugongs produce sound in the range of 500 Hz to 18 kHz (Anderson & Barclay, 1995)[5]. This range consists of barks (500Hz to 2.2 kHz), trills (3 kHz to 18 kHz) and chirp-squeaks (3 kHz to 18 kHz).

[2] Southall et al, 2007, Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations, Aquatic Mammals Volume 33 Number 4

[3] Au W. & Hastings M., 2010, Principles of Marine Bioacoustics

[4] Iwashina, Y., 2008, A Preliminary Study of the Basic Ear Anatomy of the Dugongs, School of Earth and Environmental Science, James Cook University, Queensland

[5] Anderson & Barclay, 1995, Acoustic Signals of Solitary Dugongs: Physical Characteristics and Behavioural Correlates, Journal of Mammalogy, Volume 76 Number 4 pp 1226-1237

8.2.3 Turtles

The auditory bandwidth of turtles is significantly smaller than that of dolphins and dugongs. An estimated range of 250 Hz to 1 kHz (URS 2009)[6] has been reported for marine turtles.

8.2.4 Fish

In terms of hearing, fish are split into two categories – hearing specialists and hearing generalists. Hearing specialists have more sensitive and/or broader bandwidth hearing capability because of specialised anatomy (Au & Hastings, 2010).

The estimated auditory bandwidth of hearing specialists is below 100 Hz to 2 kHz. Hearing generalists are limited to approximately 1 kHz (Au & Hastings, 2010).

In terms of sound generation, the subject is difficult due to the many species of fish and limited research. Fish can produce sound as individual entities or in a chorus. A fish chorus could extend over a bandwidth of 50 Hz to over 5 kHz (Au & Hastings, 2010).

8.2.5 Snapping Shrimp

One of the most significant causes of ambient underwater noise in shallow coastal waters (i.e. depth less than 60m) is snapping shrimps. Snapping shrimp can produce sound from 1 kHz to many 10s of kHz.

8.3 Marine Ambient Noise Levels

The ambient noise level in a marine environment is affected by sea surface, biological and traffic noise, as follows:

- Sea surface – wind and rain.
- Biological – fish choruses, snapping shrimps and individual marine animals (e.g. whales etc).
- Traffic noise – ships.

The following graph, Figure 8.1, shows the influence of these factors on typical ambient sea noise levels in Australian Waters (Cato, 1995)[7]. From Figure 8.1 it can be seen that the wind speed (shown in knots) significantly affects the ambient sea noise level).

[6] URS Australia, 2009, Ichthys Gas Field Development Project: Review of Literature on Sound in the Ocean and Effects of Noise on Marine Fauna. Report prepared for the INPEX Browse, Ltd by URS Australia Pty Ltd, Perth, Western Australia, Report No. R1387

[7] Cato, 1995, Updated version of graph contained in: Cato , D. H., "Ambient sea noise in waters near Australia ", J. Acoustical Society of America, 60 (2), pp 320-328, August 1976

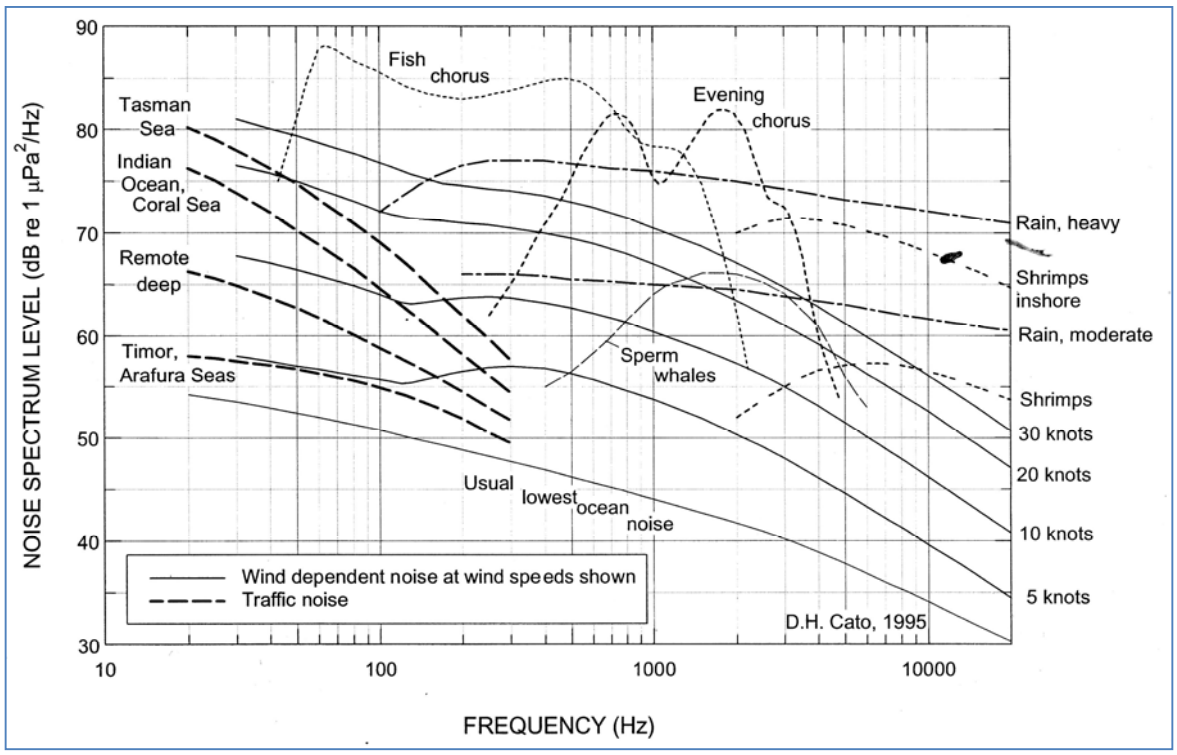

Figure 8.1 Ambient Sea Noise Prediction Curves – Australian Waters

8.4 Noise Exposure Criteria

8.4.1 Dolphins

Noise exposure criteria for dolphins have been based on the study by Southall et al, 2007, which was a comprehensive review on marine mammal hearing and responses by a group of experts in the relevant fields.

Noise exposure criteria have been developed for injury and behavioural response, which are described as follows:

- The minimum exposure criterion for injury is the level at which a single exposure is estimated to cause onset of permanent hearing loss, i.e. permanent threshold shift (PTS).
- The minimum exposure criterion for significant behavioural disturbance is the level at which a single exposure has a measurable transient effect on hearing, i.e. temporary threshold shift (TTS).

These criteria have been based on the following sound types:

- Single pulse (e.g. one pile strike in a 24 hour period).
- Multiple pulse (e.g. repeated pile striking).
- Nonpulses (e.g. sea vessel passby).

The proposed criteria for injury and behavioural responses are listed in Table 8.1. The critieria are presented in terms of the un-weighted peak level, and the M_{mf}-weighted level. The M_{mf}-weighting is the generalized frequency weighting for the mid-frequency cetaceans (most odontocetes) group of marine mammals.

Table 8.1 Noise Exposure Criteria for Dolphins

Criteria Type	Sound Type	Noise Exposure Criteria for Mid-Frequency Cetaceans	
		Sound Pressure Level dB re: 1 µPa (peak) (flat)	Sound Exposure Level dB re: 1 μPa^2-s (M_{mf})
Injury	Single pulse	230	198
	Multiple pulse	230	198
	Nonpulses	230	215
Behavioural Response	Single pulse	224	183
	Multiple pulse	224*	183*
	Nonpulses	224*	195*

Note: * These criteria have been based on the temporary threshold shift or TTS levels due to the limited number of behavioural observations.

8.4.2 Dugongs, Turtles and Fish

It is our understanding that there are no exposure criteria specifically developed for dugongs, and there is also limited information on noise exposure criteria for turtles and fish.

In this instance it is proposed to refer to work by Broner & Huber, 2010[8], where they proposed criteria for dugongs, turtles and fish based on work by others, including Southall et al, as reported in Section 8.4.1. The proposed criteria are listed in Table 8.2.

[8] Broner, N & Huber, M, 2010, Establishing a safety zone for marine animals due to underwater blasting, Second International Conference, The Effects of Noise on Aquatic Life, Cork, Ireland, 15-102 August 2010

Table 8.2 Noise Exposure Criteria for Dugongs, Turtles and Fish

Animal	Criteria Type	Sound Type	Noise Exposure Criteria for Mid-Frequency Cetaceans	
			Sound Pressure Level dB re: 1 µPa (peak) (flat)	Sound Exposure Level dB re: 1 μPa^2-s (M_{mf})
Dugongs	Injury	Single pulse	230	198
		Multiple pulse	230	198
		Nonpulses	230	215
	Behavioural Response	Single pulse	224	183
		Multiple pulse	224	183
		Nonpulses	224	195
Turtles	Injury	All	224	198
	Behavioural Response		224	183
Fish (0.1 kg)	Injury	All	-	195
Fish (1.0 kg)			-	200

8.5 Review of Existing Noise Levels

The results of underwater noise monitoring were presented in **Section 5.5**. The results included ambient noise levels with and without the presence of boats and subsequent boat noise. These noise sources did not include significant peak events, and therefore peak sound pressure levels have not been reported.

The measured sound exposure levels produced by the boats and in the absence of boats are reported in **Table 8.3**.

Table 8.3 Measured Sound Exposure Level of Sea Vessels and Ambient

Vessel	Distance from Vessel	Sound Exposure Level dB re: 1 μPa^2-s (M_{mf})	
		Maximum (1 second)	Passby
10m boat	160m	124	< 169
Ferry (arriving at Island)	324m	127	< 159
Small powerboat	120m	126	< 159
Ferry (departing Island)	250m	115	< 166
Ambient – No Vessel	N/A	108	157* (24 hours)

Note: * This is a calculated level assuming the ambient level (determined as the average of the lowest 25% of the measured ambient levels) occurs over a 24 hour period. This level excludes the effect of local sea vessels, fish choruses, etc.

A comparison of the results in Table 8.3 and the sound exposure level criteria in Tables 8.1 and 8.2 indicates that the measured passby events of 169 dB(M_{mf}) are well below the criteria of 183 to 215 dB(M_{mf}). The boats would have to be within several metres of an animal for several minutes whilst the engine is under load, for the criteria to be exceeded, and this is unlikely to occur.

8.6 Review of Future Noise Levels

Marine animals may be subject to increased noise levels due to the construction of the marina and the additional boats associated with the operation of the marina. The construction process will include piling and dredging.

8.6.1 Dredging

Details on dredging have been drawn from the Coastal Environment Technical Report by Water Technology. The relevant detail are summarised as follows:

- *During construction, dredging will be required to create the marine facility basin, approach channel and to provide material for reclamation and breakwater construction. The volume of material to be dredged including an allowance for over-dredging has been determined as approximately 300,000m^3".*
- Preliminary work has indicated that bedrock occurs at least 10m below the seabed and that the sediment above the bedrock is 95% sand.
- The dredging will be staged as follows:
    - Marine Facility Stage 1 - Western Breakwater Construction and Basin Dredging
        - It is expected that a small cutter suction dredge (CSD) will be able to achieve a dredging rate of 120m^3/hr.
        - it is estimated that the western breakwater core construction can be completed in 12 weeks.
    - Marine Facility Stage 2 – Marina Basin Revetment and Basin Dredging
        - A small CSD will be used as per Stage 1.
        - A total 12 weeks is expected to be required to construct the marina revetments.
    - Marine Facility Stage 3 – Northern Reclamation
        - The total remaining volume of material to be dredged in Stage 3 has been determined as approximately 185,000m^3.
        - It expected that a medium sized cutter dredge, achieving a dredge rate of approximately 500m^3/hr and operating 8 hours a day, 7 days a week could complete the dredging within 8 weeks.
    - Marine Facility Stage 4 – Placement of Breakwater Armour and Marina Basin Rip Rap
        - Armour rock will be placed over the breakwaters and marina revetments from a barge mounted excavator, with the armour rock barged from sources on the mainland.
        - The placement of the armour rock is not expected to constitute a significant source of turbidity in relation to the dredging stages of construction.

- A cutter suction dredge (CSD) is usually mounted on a barge and consists of a rotating cutter head with adjacent vacuum pump and pipeline which transports the dredge material as a slurry to the disposal site.

Typical noise source data for dredging is as follows:

- Transfer dredge in Beaufort Sea (9 to 18m hydrophone depth): 133 to 142 dB at 200m, 125 to 135 dB at 1km (Richardson et al, 1995)[9].
- Hopper dredge in Beaufort Sea (9 to 18m hydrophone depth): 150 dB at 200m, 143 dB at 1km (Richardson et al, 1995).
- 'Brisbane' suction hopper dredge lifting sandy material in 11m water depth: 142 dB(M_{mf}) (1 second SEL) at 45m (Savery & Associates, 2010)[10].
- 'Brisbane' suction hopper dredge lifting rocky material in 11m water depth: 158 dB(M_{mf}) (1 second SEL) and 173 dB(M_{mf}) (2 minute SEL) at 45m (Savery & Associates, 2010).
- 'Amity' cutter-suction dredge in sandy material in 14m water depth: 142 dB(M_{mf}) (1 second SEL) at 45m (Savery & Associates, 2010).
- Trailer suction hopper dredge in Port of Melbourne: 143 dB to 154 dB at 100m (L Huson & Associates, 2009)[11].

The spectral noise data for the dredges in the Beaufort Sea indicated maximum noise levels around 100 Hz to 500 Hz, where the M_{mf}-weighting is 0 to -10 dB, and thus the M_{mf}-weighted equivalent noise levels may be 0 to 10 dB lower than the linear levels reported for the Beaufort Sea dredges and the Port of Melbourne dredge. Thus the comparison of the above linear noise levels against M_{mf}-weighted criteria produces a conservative result.

The noise levels above are taken as 1 second or 2 minute measurements, and therefore to determine the sound exposure level the exposure duration is required to be added to the noise levels.

Summarising the above noise levels results in an approximate range of noise levels of 142 dB(M_{mf}) to 158 dB(M_{mf}) at 45m. Using the highest reported dredging noise level and the most stringent sound exposure level criterion of 183 dB(M_{mf}) (refer Tables 8.1 and 8.2), exceedances would occur after 6 minutes at this location. This duration is not considered to be of concern given the likelihood that the noise would elicit responses in the marine animal in which they orient themselves away from the noise source.

The dolphin and dugong behavioural response sound exposure level criterion of 195 dB(M_{mf}) for nonpulse noise events, such as dredging, would be exceeded in approximately 2 hours. It would be considered unlikely that a dolphin or dugong would remain within 45m of a dredge for 2 hours.

A general recommendation is that dredge equipment include physical turtle deflectors installed to minimise the likelihood of turtle injury.

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[9] Richardson W. et al, 1995, Marine Mammals and Noise

[10] Savery & Associates 2010, Australia Pacific LNG Transmission Gas Pipeline – Noise and Vibration Impact Study, S851.3, Revision 1, 27 January 2010.

[11] L Huson & Associates 2009, Gladstone LNG Project – Underwater Noise Impact Assessment, LHA256, May 2009.

8.6.2 Piling

As part of the marina construction it is expected that piling will occur to anchor the marina walkways.

Piles are generally impact driven or vibratory. The latter method produces lower noise levels but is only suitable for relatively soft sea beds and requires a longer duration of piling.

Typical noise source data for piling is as follows:

- Impact driven pile at Gellibrand Wharf (8.5m depth over silt and sand): 170 dB SEL at 45m, 167 dB at 120m (Duncan) [12].
- Impact driven pile at South Channel (13m depth over course sand): 170 dB SEL at 80m, 165 dB at 170m (Duncan).
- Impact drive pile at Alameda, CA, USA: 175 to 180 dB SEL at 10m, 170 dB SEL at 10m with air bubble curtain (Duncan).
- Impact piling at Darwin Harbour: approximately 180 dB SEL at 50m, 170 dB SEL at 200m and 160 dB SEL at 500m (URS 2009).
- Impact piling at various projects: 152 to 180 dB SEL at 10m, and 165 to 192 dB msp at 10m (McCauley and Kent, 2008) [13].
- Impact piling at various projects: 152 to 180 dB SEL at 10m (McCauley and Kent, 2008).

Potential mitigation measures include (Duncan):

- Stop, or don't start, piling if a marine animal is too close.
- Using lower level sounds or soft start-up to scare animals away before piling starts.
- Use vibratory rather than impact piling.
- Placing cushion blocks between impact hammer and pile.
- Attenuate the noise with isolation casing and bubble curtains.

A review of other recent projects including piling operations was conducted and the following project recommendations were noted:

- A marine animal safety zone of 350m was used for piling operations at Swanson Dock (L Huson & Associates, 2009).
- Marine animal safety zones of 150m (water depth <3m) and 350m (water depth >3m) were proposed for the Gladstone LNG project (L Huson & Associates, 2009).
- Marine animal safety zone of 500m in Darwin harbour, with pre-piling observation time of 30 minutes to ensure no animals were in the safety zone (URS 2009).
- Piling should not commence or continue when marine mammals are within 100m of piling in 18m water depth (McCauley and Kent, 2008).

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[12] Duncan A., Underwater noise from pile-driving: Measurement, modelling and mitigation, Powerpoint Presentation, Centre for Marine Science and Technology, Curtin University

[13] McCauley R. D. and Kent C. P. Salgado, 2008, Pile Driving Underwater Noise Assessment, Proposed Bell Bay Pulp Mill Wharf Development, Curtin University, Prepared for Gunns Limited.

At the current time, there is little information on the proposed piling operations, i.e. piling type, number of piles, and number of expected strikes. In the absence of such data it is proposed to utilise a recommended animal safety zone of 500m. This also matches the animal safety zone noted in the Great Keppel Island Resort – Marine Ecology Technical Paper (frc Environmental, 2010). At a distance of 500m, the noise from piling would be expected to be approximately 155 to 160 dB SEL.

Using the most stringent sound exposure level criterion of 183 dB(M_{mf}) (refer Tables 8.1 and 8.2), exceedances could occur after approximately 200 piling strikes. This number of strikes is not considered to be of concern given the likelihood that the marine animal would not be expected to stay for a long time in the piling area and could readily move to a nearby quieter location.

The dolphin and dugong behavioural response sound exposure level criterion of 198 dB(M_{mf}) for multi-pulse noise events, such as piling, would be exceeded in approximately 6000 piling strikes. A dolphin or dugong would not be expected to remain within 500m of piling operations for this many strikes.

The recommendations for piling are:

- The marine animal safety zone is 500m.
- Piling should not commence or continue if dolphins, dugongs or turtles are within the marine animal safety zone.
- A pre-piling observation time of 30 minutes is proposed.
- Piling should commence with a soft start-up to scare animals away before piling starts.
- If a marine animal is spotted during piling, then piling is to cease until the animal has left the safety zone, or until it has not been observed for at least 10 minutes.

8.6.3 Boating

Once the marina is operational there will be additional boat movements in its vicinity. This could include ferries and recreational boats heading to/from the mainland and recreational boats travelling along the coast.

Ferries and larger boats could be expected to produce noise levels of approximately 160 dB(M_{mf}) at 50m from a vessel passby. With the most stringent sound exposure level criterion being 183 dB(M_{mf}) (refer Tables 8.1 and 8.2), exceedances would not be expected to occur at any distance. Thus noise impacts from the marina operation are considered negligible in terms of significant behavioural response or injury, but will rather be limited to minor behavioural responses.

9 Conclusion

A noise and vibration assessment has been conducted for the proposed resort revitalisation at Great Keppel Island. The report has addressed both airborne and seaborne noise and sources.

Existing residences on the Island are generally located by the beach, and thus the existing noise environment at these locations is typical of most beachside locations, in that noise environment is dominated by waves on the beach and wind rustling leaves in the trees. There is also the influence of insects, usually a seasonal effect which is strongest in warmer months, and birds. The noise environment is also affected by the operation of a number of diesel powered generators at the various dwellings and backpacker accommodation. Noise monitoring conducted inland, away from the beach, resulted in lower noise levels.

A number of underwater noise measurements were conducted off Fishermans Beach and around the Island. The measurements indicated that the underwater acoustic environment was dominated by snapping shrimps. Measurements were also conducted of various sea vessels including recreational craft and the ferry.

To establish suitable noise limits for the project a review of Department of Environment and Resource Management noise criteria was conducted. The review considers noise criteria contained within the Act, Environmental Protection (Noise) Policy and EcoAccess Guidelines.

To achieve compliance with the nominated noise and vibration criteria will require implementation of noise and vibration mitigation and management measures.

Aircraft noise has been assessed using a combination of noise measurements and modelling. The existing runway has been modelled using light aircraft whilst the proposed relocated runway has been modelled using the proposed mid-sized aircraft (Dash8 & ERJ190). For the proposed runway, aircraft noise has been modelled using the overpass noise levels from AS2021, and also using ground based noise levels measured by ASK. Based on these modelling, it has been determined that there is a predicted net reduction in noise levels of 5 to 10 dB(A) at existing residences and accommodation due to the relocation of the runway.

The predicted aircraft noise levels at the proposed resort accommodation are generally 70 to 90 dB(A) $L_{max,S}$. For an aerodrome with low flight numbers, the acceptable noise levels for aircraft are up to 85 dB(A) $L_{max,S}$ and therefore some apartments may require acoustic upgrades. Based on the current design, the impacted apartments are those located in the marina, in line with the end of the runway, and those adjacent the runway (Airstrip Villas). The acoustic upgrades would likely result in the requirement for upgraded roof/ceiling construction, blockwork walls (or lightweight walls with multiple layers of plasterboard) and double-glazing.

The industrial compound is an area likely to include elevated noise levels due to the location of the emergency generators, wastewater treatment facility, and solid waste management. The compound is removed from existing residences (700m) and proposed guest accommodation (250m), but is adjacent the proposed staff accommodation. Whilst some allowance for elevated noise levels could be expected for the staff accommodation, there will be noise constraints on the activities within the compound.

Modelling has indicated that the generators are likely to require enclosure and acoustic treatment, the extent of which will depend on their design, selection and location within the compound. A similar result is indicated for the wastewater treatment facility, where compliance is expected for existing residences and the guest accommodation, but mitigation measures may be required to address the adjoining staff accommodation. The solid waste management component of the compound is likely to require screening with bunding or intervening buildings to achieve compliant noise levels at the proposed guest accommodation due to noise from heavy vehicles and composting fans. In all instances, consideration will need to be given to the relative proximity of the staff accommodation.

Noise data for golf course maintenance equipment has been provided and demonstrates that relatively high noise levels can be emitted. Maintenance equipment is therefore to be restricted to daytime hours to minimise noise impacts on proposed guest accommodation. Due to the significant separation distance, there are no significant day time noise impacts expected at existing residences.

The marina will include a number of activities with the potential to create noise. A noise management plan will need to be developed for the marina in the course of its design to ensure an appropriate noise amenity for the apartments in this complex. The management of noise issues in the marina itself will generally result in minimal noise emissions to the existing residences which are located some 250m away (backpacker accommodation) or 400m away (detached dwellings).

Noise from vehicles driving around the Island has been assessed in terms of the impact on existing dwellings. Recommended buffer distances are proposed for various vehicles and whether the road is regularly accessed in the day or night. Buffer distances range from several metres for a driveway only used in the daytime, to 30m for a carpark used in the day and night, to over 200m for a heavy vehicle carpark used in the day and night.

Construction activity is likely to be the most significant noise impact on existing residences due to the duration of the works (2012 to 2023) and the proximity of parts of the resort. Within the Environmental Protection Act construction activity is restricted to daytime unless inaudibility is achieved outside these hours. Within this report it is recommended that long term noise limits be the target for daytime construction activities where possible. The intent of this is to encourage good practice through the location of some construction activities away from residences. A detailed construction noise management plan should be prepared as part of the detailed design process. It should make reference to Australian Standard AS2436-2010 "Guide to noise and vibration control on construction, demolition and maintenance sites". This standard provides details on strategies to minimise construction noise.

The noise impact on marine life has been assessed and an animal safety zone has been recommended for marina piling operations, as follows:

- The marine animal safety zone is 500m.
- Piling should not commence or continue if dolphins, dugongs or turtles are within the marine animal safety zone.
- A pre-piling observation time of 30 minutes is proposed.
- Piling should commence with a soft start-up to scare animals away before piling starts.
- If a marine animal is spotted during piling, then piling is to cease until the animal has left the safety zone, or until it has not been observed for at least 10 minutes.

To assess the risk posed to the noise and vibration environment by activities undertaken as part of the proposed project a risk assessment has been undertaken. This risk assessment addresses the potential impacts for each phase of the project and their consequences described in the above sections along with proposed mitigation measures to address each identified risk. The risk assessment matrix and potential impacts and mitigation strategies are included in Appendix G.

Please contact the undersigned with any queries on 07 3255 3355.

Yours faithfully

ASK Consulting Engineers

Stephen Pugh

Director

Appendix A – Glossary

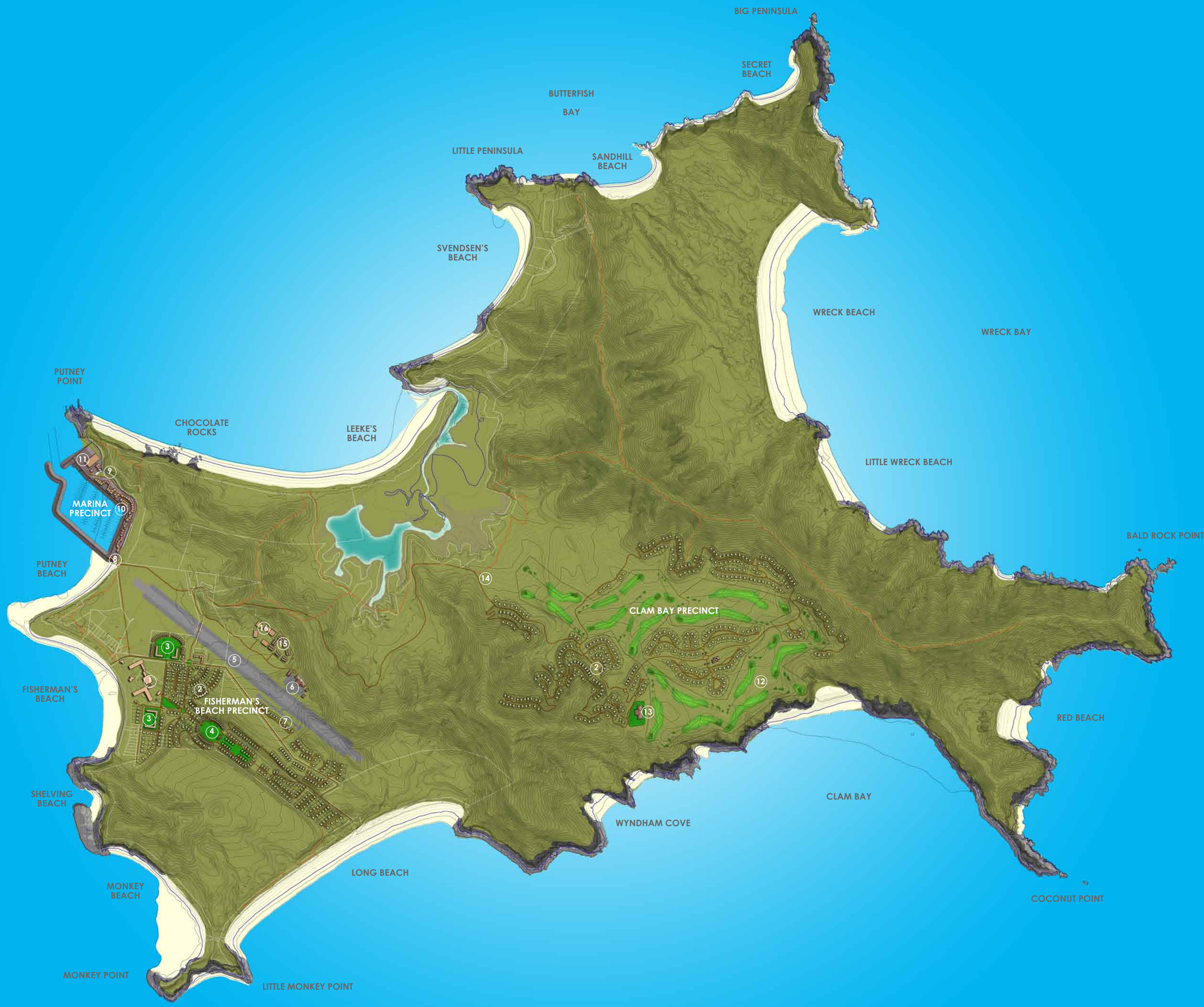
Parameter or Term	Description
Frequency	The number of vibrations, or complete cycles, that take place in one second. Measured in hertz (Hz), where one Hz equals one cycle per second. A young person with normal hearing will be able to perceive frequencies between approximately 20 and 20,000 Hz. With increasing age, the upper frequency limit tends to decrease.
dB	The decibel (dB) is the unit measure of sound. Most noises occur in a range of 20 dB (quiet rural area at night) to 120 dB (nightclub dance floor or concert).
dB(A)	Noise levels are most commonly expressed in terms of the 'A' weighted decibel scale, dB(A). This scale closely approximates the response of the human ear, thus providing a measure of the subjective loudness of noise and enabling the intensity of noises with different frequency characteristics (e.g. pitch and tone) to be compared.
dB(lin), dB(linear) OR dB(Z)	Noise levels are sometimes expressed in terms of the linear, Z or un-weighted decibel scale – they all take the same meaning. The value has no weighting applied to it and is the same as the dB level.
dB(C)	Noise levels are sometimes expressed in terms of the 'C' weighted decibel scale, dB(C). This scale is very similar to the dB, dB(lin), dB(linear), dB(Z) un-weighted scale. The difference being that some negative weighting is applied below 250Hz and above 1kHz. The magnitude of the weighting is significantly less than the dB(A) scale.
Octave band	Ranges of frequencies where the highest frequency of the band is double the lowest frequency of the band. The band is usually specified by the centre frequency, i.e., 31.5, 63, 125, 250, 500 Hz, etc.
Day	The period between 7am and 6pm.
Evening	The period between 6pm and 10pm.
Night	The period between 10pm and 7am.
Free-field	The description of a noise receiver or source location which is away from any significantly reflective objects (e.g. buildings, walls).
Reverberant field	The description of a noise receiver or source location which is in a room or near significant reflective objects (e.g. surrounded by walls).
Noise sensitive receiver OR Noise sensitive receptor	The definition can vary depending on the project type or location, but generally defines a building or land area which is sensitive to noise. Generally it includes residential dwellings (e.g. houses, units, caravans, marina), medical buildings (e.g. hospitals, health clinics, medical centres), educational facilities (e.g. schools, universities, colleges),
L_p	The instantaneous noise level, which is noted during a noise event.
L_{pA}	As for Lp except the frequency weighting is defined as being the 'A' weighted decibel scale. Often the 'A' is not included in the subscript if the level is reported as being dB(A).
L_1	The noise level exceeded for 1% of the measurement period.

Parameter or Term	Description
L_{10}	The noise level exceeded for 10% of the measurement period. It is sometimes referred to as the average maximum noise level.
L_{90}	The noise level exceeded for 90% of the measurement period. This is commonly referred to as the background noise level.
minL_{90}	The background noise levels calculated using the 'lowest 10th percentile' of the L_{90} levels in each period of the day. This 'lowest 10th percentile' method is defined in the Queensland Department of Environment and Resource Management (DERM) guidelines.
min$L_{90,1hour}$	As for minL_{90} except the measurement intervals are defined as 1 hour duration.
L_{eq}	The equivalent continuous sound level, which is the constant sound level over a given time period, which is equivalent in total sound energy to the time-varying sound level, measured over the same time period.
$L_{eq,1hour}$	As for L_{eq} except the measurement intervals are defined as 1 hour duration.
L_{Amax} OR maxL_{pA}	Maximum A-weighted sound pressure level.
$L_{Amax,T}$	Average maximum A-weighted sound pressure level.
$L_{Amax,adj,T}$	Adjusted average maximum A-weighted sound pressure level.
L_{eq}(24 hour)	The average L_{eq} noise level over the 24-hour period from midnight to midnight.
LAr,Tr	The rating noise level, as used by the Queensland Department of Environment and Resource Management (DERM) EcoAccess "Planning for Noise Control" guideline document.
LAr,1hr	The 1 hour noise level which is based on the LAeq,1hr noise level but only includes the noise contribution of the source under investigation (e.g. a mine) and the background noise, but excludes other noises which may influence the ambient measured level (e.g. birds, insects).
PNL	The planning noise level, as used by the Queensland Department of Environment and Resource Management (DERM) EcoAccess "Planning for Noise Control" guideline document.

Appendix B – Development Information

1. FISHERMAN'S BEACH HOTEL & SPA
2. ECO - TOURISM VILLAS
3. ECO - TOURISM APARTMENTS
4. PARK
5. RUNWAY
6. AIRPORT TERMINAL
7. RUNWAY VILLAS
8. FERRY TERMINAL
9. RESEARCH & HISTORIC CENTRE
10. RETAIL SHOPS & TOURISM APARTMENTS
11. BARGE TERMINAL
12. GOLF COURSE
13. GOLF RESORT FACILITY
14. LEEKE'S HOMESTEAD
15. STAFF ACCOMODATION
16. INDUSTRIAL COMPOUND

PUBLIC ACCESS TRACKS



GRAPHIC SCALE 1:8000 M

GREAT KEPPEL ISLAND RESORT ~ REVITALISATION PLAN

REVITALISATION PLAN 2011

PROJECT #: 093024
08 JULY 2011

GREG NORMAN GOLF COURSE DESIGN

WATG

Appendix C – Environmental Protection Act Noise Standards

The following noise standards are included in the Act.

440R Building work

(1) A person must not carry out building work in a way thatmakes an audible noise—

(a) on a business day or Saturday, before 6.30a.m. or after 6.30p.m; or

(b) on any other day, at any time.

(2) The reference in subsection (1) to a person carrying out building work—

(a) includes a person carrying out building work under an owner-builder permit; and

(b) otherwise does not include a person carrying out building work at premises used by the person only for residential purposes.

440S Regulated devices

(1) This section applies to—

(a) a person carrying out an activity other than building work; and

(b) a person carrying out building work, at premises used by the person only for residential purposes, other than under an owner-builder permit.

(2) A person must not operate a regulated device in a way that makes an audible noise—

(a) on a business day or Saturday, before 7.00a.m. or after 7.00p.m; or

(b) on any other day, before 8.00a.m. or after 7.00p.m.

(3) Subsection (2) does not apply to a person operating a grass-cutter or leaf-blower at a place that is a State-controlled road or a railway under an authority from the occupier of the place.

(4) Subsection (2)(a) does not apply to a person operating a regulated device at a manual arts facility at an educational institution between 7.00p.m. and 10.00p.m.

(5) In this section—

grass-cutter means an electrical or mechanical device a function of which is to cut grass.

Examples—

brush cutter, edge cutter, lawnmower, ride-on mower, string trimmer

leaf-blower means an electrical or mechanical device a function of which is to blow leaves.

regulated device means any of the following—

(a) a compressor;

(b) a ducted vacuuming system;

(c) a generator;

(d) a grass-cutter;

(e) an impacting tool;

(f) a leaf-blower;

(g) a mulcher;

(h) an oxyacetylene burner;

(i) an electrical, mechanical or pneumatic power tool.

Examples of a power tool—

chainsaw, drill, electric grinder or sander, electric welder, nail gun

440T Pumps

(1) This section applies to premises at or for which there is a pump.

(2) An occupier of the premises must not use, or permit the use of, the pump on any day—

(a) before 7a.m, if it makes an audible noise; or

(b) from 7a.m. to 7p.m, if it makes a noise of more than 5dB(A) above the background level; or

(c) from 7p.m. to 10p.m, if it makes a noise of more than 3dB(A) above the background level; or

(d) after 10p.m, if it makes an audible noise.

(3) Subsection (2)(a), (c) and (d) do not apply to a noise made at an educational institution, that is not more than 5dB(A) above the background level.

(4) In this section—

pump—

(a) means an electrical, mechanical or pneumatic pump; and

Examples—

liquid pump, air pump, heat pump

(b) includes a swimming pool pump and a spa blower.

440U Air-conditioning equipment

(1) This section applies to premises at or for which there is air-conditioning equipment.

(2) An occupier of the premises must not use, or permit the use of, the equipment on any day—

(a) before 7a.m, if it makes a noise of more than 3dB(A) above the background level; or

(b) from 7a.m. to 10p.m, if it makes a noise of more than 5dB(A) above the background level; or

(c) after 10p.m, if it makes a noise of more than 3dB(A) above the background level.

440V Refrigeration equipment

(1) This section applies to a person who is—

(a) an occupier of premises at or for which there is plant or equipment for refrigeration (***refrigeration equipment***); or

(b) an owner of refrigeration equipment that is on or in a vehicle, other than a vehicle used or to be used on a railway.

(2) The person must not use, or permit the use of, the refrigeration equipment on any day—

(a) before 7a.m, if it makes a noise of more than 3dB(A) above the background level; or

(b) from 7a.m. to 10p.m, if it makes a noise of more than 5dB(A) above the background level; or

(c) after 10p.m, if it makes a noise of more than 3dB(A) above the background level.

(3) In this section—

vehicle includes a trailer.

440W Indoor venues

(1) An occupier of a building must not use, or permit the use of, the building as an indoor venue on any day—

(a) before 7a.m, if the use makes an audible noise; or

(b) from 7a.m. to 10p.m, if the use makes a noise of more than 5dB(A) above the background level; or

(c) from 10p.m. to midnight, if the use makes a noise of more than 3dB(A) above the background level.

(2) However, subsection (1)(b) does not apply if—

(a) the building is, or is part of, an educational institution; and

(b) the use of the building as an indoor venue is organized by or for the educational institution for non-commercial purposes of the institution.

440X Open-air events

(1) An occupier of premises must not use, or permit the use of, the premises for an open-air event on any day—

(a) before 7a.m, if the use causes audible noise; or

(b) from 7a.m. to 10p.m, if the use causes noise of more than 70dB(A); or

(c) from 10p.m. to midnight, if the use causes noise of more than the lesser of the following—

(i) 50dB(A);

(ii) 10dB(A) above the background level.

(2) However, subsection (1) does not apply to licensed premises.

(3) Also, subsection (1)(b) does not apply if—

(a) the premises is, or is part of, an educational institution; and

(b) the use of the premises for an open-air event is organised by or for the educational institution for non-commercial purposes of the institution.

440Y Amplifier devices other than at indoor venue or open-air event

(1) This section applies to a person who operates an amplifier device other than at an indoor venue or open-air event.

(2) The person must not operate the device in a way that makes audible noise—

(a) on a business day, before 7a.m. or after 10p.m; or

(b) on any other day, before 8a.m. or after 6p.m.

(3) At a time when the person may operate the device under subsection (2), the person must not operate the device in a way that makes noise of more than 10dB(A) above the background level.

(4) However, subsection (3) does not apply if the person is operating the device at an educational institution.

(5) In this section—

amplifier device means any of the following—

(a) a loudhailer;

(b) a megaphone;

(c) a public address system, other than for a railway;

(d) a remote telephone bell;

(e) a telephone repeater bell.

440ZA Operating power boat engine at premises

(1) A person must not operate, or permit the operation of, a power boat engine at premises in a way that makes audible noise—

(a) on a business day or Saturday, before 7a.m. or after 7p.m; or

(b) on any other day, before 8a.m. or after 6.30p.m.

(2) In this section—

operate, a power boat engine, includes flushing the engine.

440ZB Blasting

A person must not conduct blasting if—

(a) the airblast overpressure is more than 115dB Z Peak for 4 out of any 5 consecutive blasts; or

(b) the airblast overpressure is more than 120dB Z Peak for any blast; or

(c) the ground vibration is—

(i) for vibrations of more than 35Hz—more than 25mm a second ground vibration, peak particle

velocity; or

(ii) for vibrations of no more than 35Hz—more than 10mm a second ground vibration, peak particle velocity.

Appendix D – Detailed Discussion of EcoAccess "Planning for Noise Control"

To prevent background noise levels from progressively creeping higher and higher over time with the establishment of new developments in an area, it is recommended than the min$L_{A90,1hour}$ outdoor background noise planning levels given in Table D.1 not be exceeded.

Table D.1 Recommended Outdoor background noise planning levels

Receiver Land Use	Receiver Area Dominant Land Use (description of neighborhood) *Note 1*	Background noise level, min$L_{90,1hour}$ dB(A) *Note 2*		
		Time Period		
		Day	Evening	Night
Purely residential	Very rural	35	30	25
	Rural residential, church, hospital	40	35	30
	Shop or commercial office	45	40	35
	Light industry	50	45	40
Residential area on a busy road or near an industrial area or commercial area	Residential, church, hospital, school	45	40	35
	Shop or commercial office	50	45	40
	Light industry	55	50	45
Industrial areas	Residential, church, hospital school	50	45	40
	Shop or commercial office	55	50	45
	Factory office or factory	60	60	60
Passive recreation area	Picnic grounds, public beaches, bush walks, public gardens, etc.	35	35	35

Note 1: The dominant land use is defined by a radius of 200 m from the receiver location under consideration.

Note 2: minL_{A90} is defined as the rating background noise level

The next step is to measure the existing minL_{A90} and compare this with the recommended background noise level. If the measured minL_{A90} varies from the recommended minL_{A90}, then the guideline recommends a planning minL_{A90}. Table D.2 shows the planning minL_{A90}.

Table D.2 Recommended Noise Immission Planning Levels (L_{A90}, 1 hour) for Developments

Existing background noise level at the most sensitive point in an affected residential area	Recommended $L_{A90,\ 1\ hour}$ maximum noise level contribution for planning approval purposes, at that point as a result of a proposed new source
Background noise level is above relevant recommended level (Table 4.1)	Preferably, set maximum planning level 10 dB(A) or more below relevant recommended level (Table 4.1). At least set maximum planning level 10 dB(A) below the existing background level.
Background noise level is equal to recommended level	Set maximum planning level relevant recommended level (Table 4.1)
Background noise level is below recommended level by: 1 dB(A) 2 dB(A) 3 dB(A) 4 dB(A) 5 dB(A) 6 dB(A)	Set maximum planning level: 9 dB(A) below recommended level 5 dB(A) below recommended level 3 dB(A) below recommended level 2 dB(A) below recommended level 2 dB(A) below recommended level 5 dB(A) above background level

Note: It may not be possible to maintain background noise levels in very rural areas below 25 dB(A) as developments occur. In such cases a threshold background noise level of 25 dB(A) is to be used.

The Guideline recommends that the L_{eq} noise descriptor be used to define the long-term noise criteria. For this purpose it is termed the 'rating level' of the noise source under consideration and designated L_{Ar}, Tr. The estimated maximum hourly values of planning noise levels (PNL) for different areas containing residences are given in Table D.3. Table D.3 is used as a guideline.

Table D.3 Estimated Maximum Values of Planning Noise Levels (PNL) for Proposed Noise Sources for Different Areas Containing Residences

Noise Area Category	Description of Neighborhood	Maximum hourly sound Pressure Level, $L_{Aeq,1hour}$ (PNL)		
		Monday to Saturday Sunday/Public Holidays		
		Day	Evening	Night
Z1	Very rural, purely residential, Less than 40 vehicles per hour	40	35	30
Z2	Negligible transportation. Less than 80 vehicles per hour	50	45	40
Z3	Low-density transportation. Less than 200 vehicles per hour	55	50	45
Z4	Medium-density transportation. Less than 600 vehicles per hour	60	55	50
Z5	Dense transportation. Less than 1400 vehicles per hour or some commerce or industry	65	60	55
Z6	Very dense transportation. Less than 3000 vehicles per hour or in commercial or bordering industry districts	70	65	60
Z7	Extremely dense transportation. Less than 3000 vehicles per hour or in commercial or bordering industry districts	75	70	65

Notes:

1. Some industrial and commercial sites are not predominantly sources of high ambient noise levels;
2. Where transportation noise is present, the minimum of the hourly L_{Aeq} values for transportation noise in the appropriate time period is taken or the corresponding value from Table D.3, whichever is the greater.
3. The criteria should not be exceeded in any hour of the appropriate time period.
4. Planning noise levels (PNL) apply at a location 4.0 m from the façade of a building
5. Time periods are as follows:
    - Daytime 7am to 6pm
    - Evening 6pm to 10pm
    - Night-time 10pm to 7am

Where the existing noise level from specific noise sources is close to the maximum planning noise level (PNL) the noise level from any new source(s) must be controlled to preserve the amenity of an area. If the total noise level from specific noise sources already exceeds the maximum planning level for the area in question, the L_{Aeq}, 1 hour noise level from any new source should not be greater than:

- 10 dB(A) below the maximum planning level (Table D.3) if there is a possibility that the existing levels will be reduced in the future;
- 10 dB(A) below the existing noise level if there is no such possibility that the existing levels will fall and no significant changes to the land use are expected.

Table D.4 sets out the implications of this requirement for noise from new sources. The specific noise level or component noise level criteria for a new development is:

- L_{Aeq}, 1 hour = minL_{A90}, 1 hour + 3

Table D.4: Modification to Recommended Maximum Planning Noise Level (PNL) to Account for Existing Level of Specific Noise

Total existing noise level from specific sources, L_{Aeq} dB(A)	Maximum Planning noise level for noise from new sources alone L_{Aeq} dB(A)
>= PNL+2	If existing noise level is likely to decrease in the future PNL – 10 If existing noise level is unlikely to decrease in the future Existing Level - 10
PNL + 1	PNL - 9
PNL	PNL - 8
PNL - 1	PNL - 6
PNL - 2	PNL - 4
PNL - 3	PNL - 3
PNL - 4	PNL - 2
PNL - 5	PNL - 2
PNL - 6	PNL - 1
< PNL - 6	PNL

The EcoAccess noise guideline levels at the nearby residential receivers have been determined in Table D.5 (D, E and N represent Day, Evening and Night respectively).

Table D.5 Calculation of Noise Guideline Levels for Residential Receivers near Location A

Description	Location A Noise Levels, dB(A)		
	Day	Evening	Night
Measured Rating Background Noise Levels (RBL), from Logging Data (lowest 10th %)	40	42	40
Acceptable Rating Background Noise Levels (RBL), from Logging Data (lowest 10th %) - Minimum 25 dB(A)	40	42	40
Recommended Background Noise Planning Levels, Table 1	40	35	30
Differences	0	-7	-10
Adjustment to Background Noise Planning Level (Table 2)	-10	-10	-10
Recommended Maximum Planning Level, L_{90}	30	25	25
1. Specific Noise Limit (Equation 1), I.e. Maximum L_{90} + 3, L_{eq}, dB(A)	33	28	28
Existing Residual Noise Levels, from Logging Data, $L_{eq,1hr}$ dB(A)	50	51	49
Noise Area Category	z1		
Recommended Maximum Planning Noise Level (PNL), $L_{eq,1hr,}$ dB(A)	40	35	30
Differences	-10	-16	-19
Existing Noise Level Likely to Decrease in Future ? (y/n)	n		
Adjustment to Maximum PNL (Table 4)	-10	-10	-10
2. Recommended Maximum PNL, L_{eq}	40	41	39
Lowest Criteria (1 or 2)	33	28	28

Table D.6 Calculation of Noise Guideline Levels for Residential Receivers near Location B

Description	Location B Noise Levels, dB(A)		
	Day	Evening	Night
Measured Rating Background Noise Levels (RBL), from Logging Data (lowest 10th %)	29	30	26
Acceptable Rating Background Noise Levels (RBL), from Logging Data (lowest 10th %) - Minimum 25 dB(A)	29	30	26
Recommended Background Noise Planning Levels, Table 1	35	30	25
Differences	6	0	-1
Adjustment to Background Noise Planning Level (Table 2)	5	-10	-10
Recommended Maximum Planning Level, L_{90}	34	25	25
1. Specific Noise Limit (Equation 1), I.e. Maximum L_{90} + 3, L_{eq}, dB(A)	37	28	28
Existing Residual Noise Levels, from Logging Data, $L_{eq,1hr}$ dB(A)	51	51	50
Noise Area Category	z1		
Recommended Maximum Planning Noise Level (PNL), $L_{eq,1hr}$, dB(A)	40	35	30
Differences	-11	-16	-20
Existing Noise Level Likely to Decrease in Future ? (y/n)	n		
Adjustment to Maximum PNL (Table 4)	-10	-10	-10
2. Recommended Maximum PNL, L_{eq}	41	41	40
Lowest Criteria (1 or 2)	37	28	28

Table D.7 Calculation of Noise Guideline Levels for Residential Receivers near Location C

Description	Location C Noise Levels, dB(A)		
	Day	Evening	Night
Measured Rating Background Noise Levels (RBL), from Logging Data (lowest 10th %)	35	47	39
Acceptable Rating Background Noise Levels (RBL), from Logging Data (lowest 10th %) - Minimum 25 dB(A)	35	47	39
Recommended Background Noise Planning Levels, Table 1	40	35	30
Differences	5	-12	-9
Adjustment to Background Noise Planning Level (Table 2)	-2	-10	-10
Recommended Maximum Planning Level, L_{90}	38	25	25
1. Specific Noise Limit (Equation 1), I.e. Maximum L_{90} + 3, L_{eq}, dB(A)	41	28	28
Existing Residual Noise Levels, from Logging Data, Leq,1hr dB(A)	51	52	50
Noise Area Category	z1		
Recommended Maximum Planning Noise Level (PNL), $L_{eq,1hr}$, dB(A)	40	35	30
Differences	-11	-17	-20
Existing Noise Level Likely to Decrease in Future ? (y/n)	n		
Adjustment to Maximum PNL (Table 4)	-10	-10	-10
2. Recommended Maximum PNL, L_{eq}	41	42	40
Lowest Criteria (1 or 2)	41	28	28

Table D.8 Calculation of Noise Guideline Levels for Residential Receivers near Location D

Description	Location D Noise Levels, dB(A)		
	Day	Evening	Night
Measured Rating Background Noise Levels (RBL), from Logging Data (lowest 10th %)	35	33	31
Acceptable Rating Background Noise Levels (RBL), from Logging Data (lowest 10th %) - Minimum 25 dB(A)	35	33	31
Recommended Background Noise Planning Levels, Table 1	40	35	30
Differences	5	2	-1
Adjustment to Background Noise Planning Level (Table 2)	-2	-5	-10
Recommended Maximum Planning Level, L_{90}	38	30	25
1. Specific Noise Limit (Equation 1), I.e. Maximum L_{90} + 3, Leq, dB(A)	41	33	28
Existing Residual Noise Levels, from Logging Data, $L_{eq,1hr}$ dB(A)	50	45	49
Noise Area Category	z1		
Recommended Maximum Planning Noise Level (PNL), $L_{eq,1hr}$, dB(A)	40	35	30
Differences	-10	-10	-19
Existing Noise Level Likely to Decrease in Future ? (y/n)	n		
Adjustment to Maximum PNL (Table 4)	-10	-10	-10
2. Recommended Maximum PNL, L_{eq}	40	35	39
Lowest Criteria (1 or 2)	40	33	28

Appendix E – Photos of Monitoring Sites on Island

Figure E.1 Logger Location A – Far Northern End of Main Beach

Figure E.2 Logger Location B – Old Homestead in Centre of Island

Figure E.3 Logger Location C – Southern End of Main Beach

Figure E.4 Logger Location D – Northern End of Main Beach

Appendix F – Graphs of Noise Logging Results

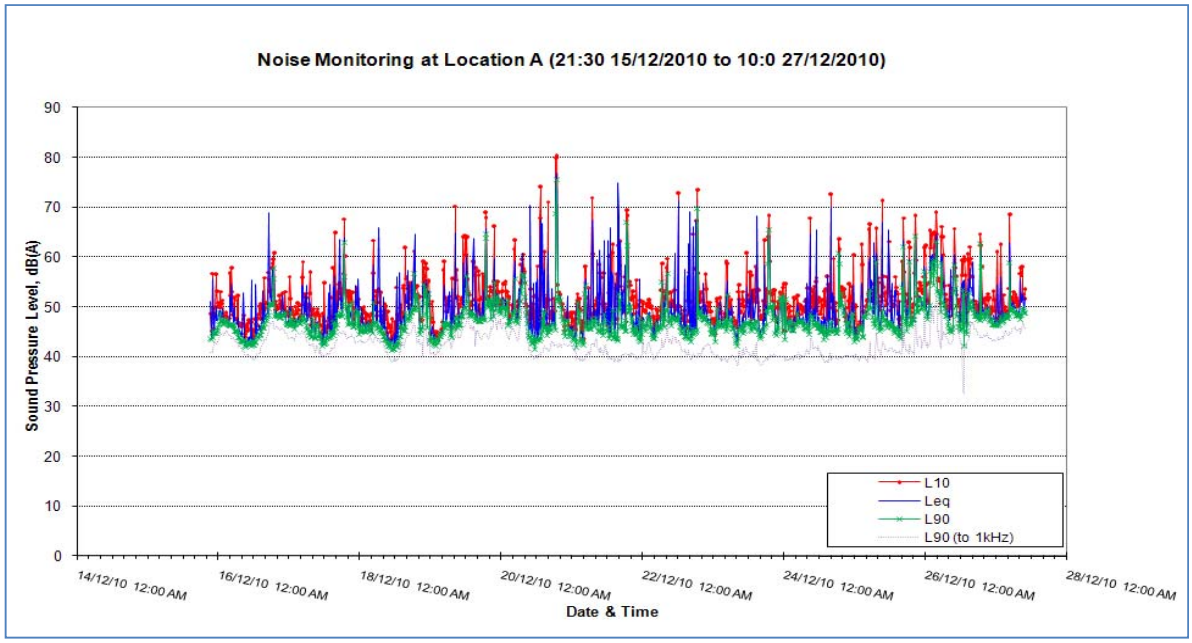


Figure F.1: Noise Logging at Location A

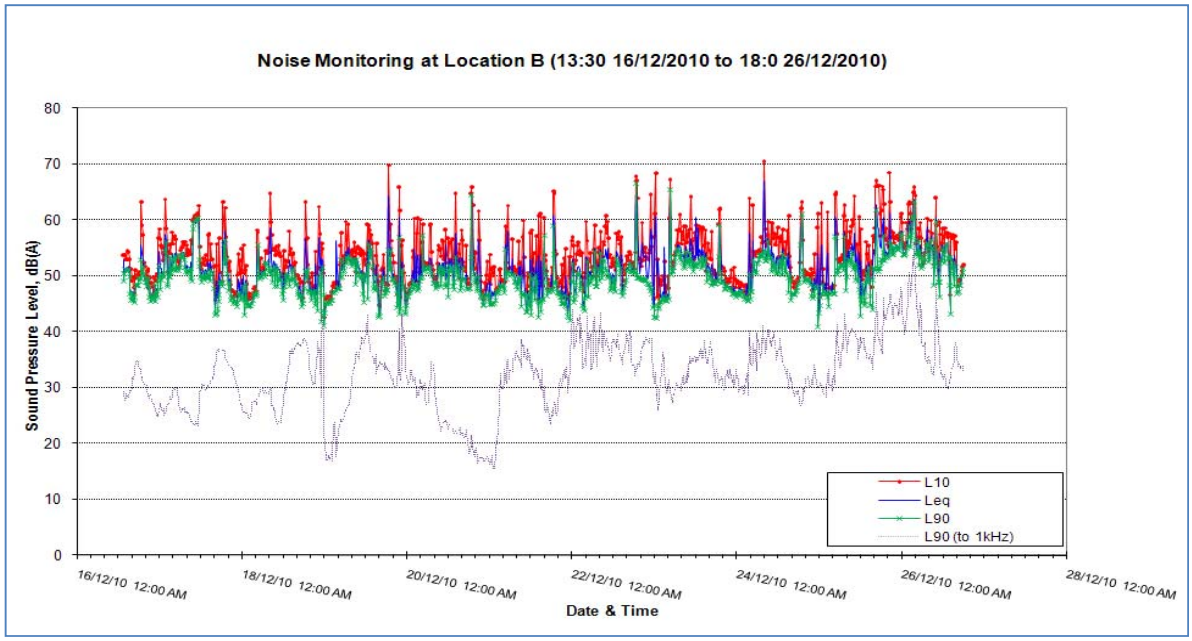


Figure F.2: Noise Logging at Location B

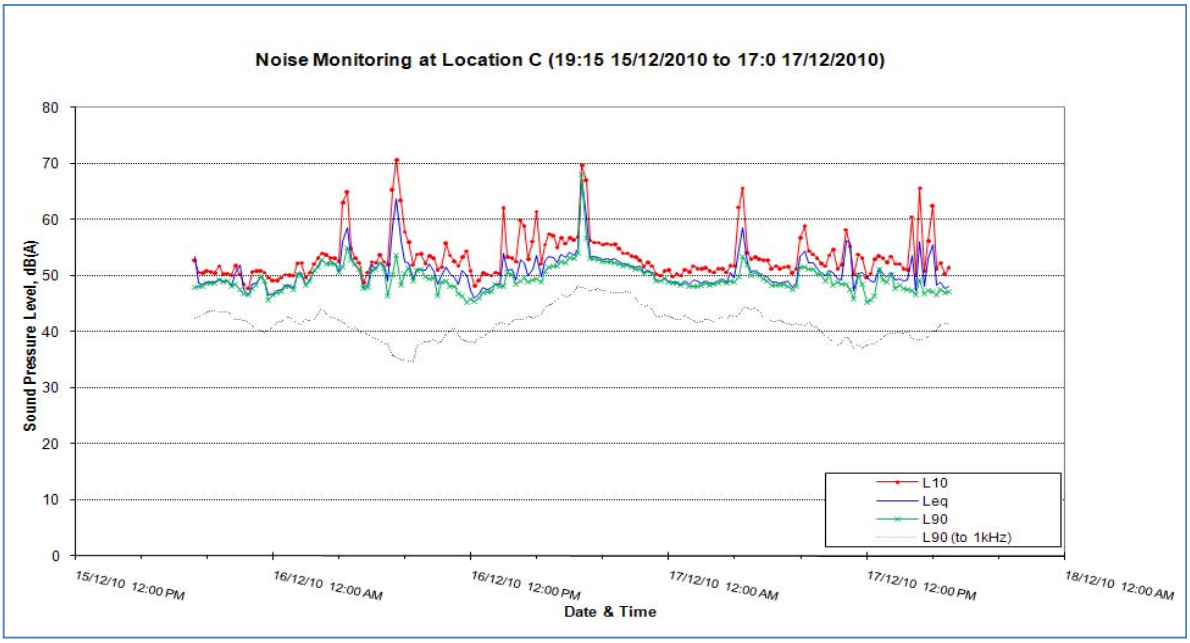


Figure F.3: Noise Logging at Location C

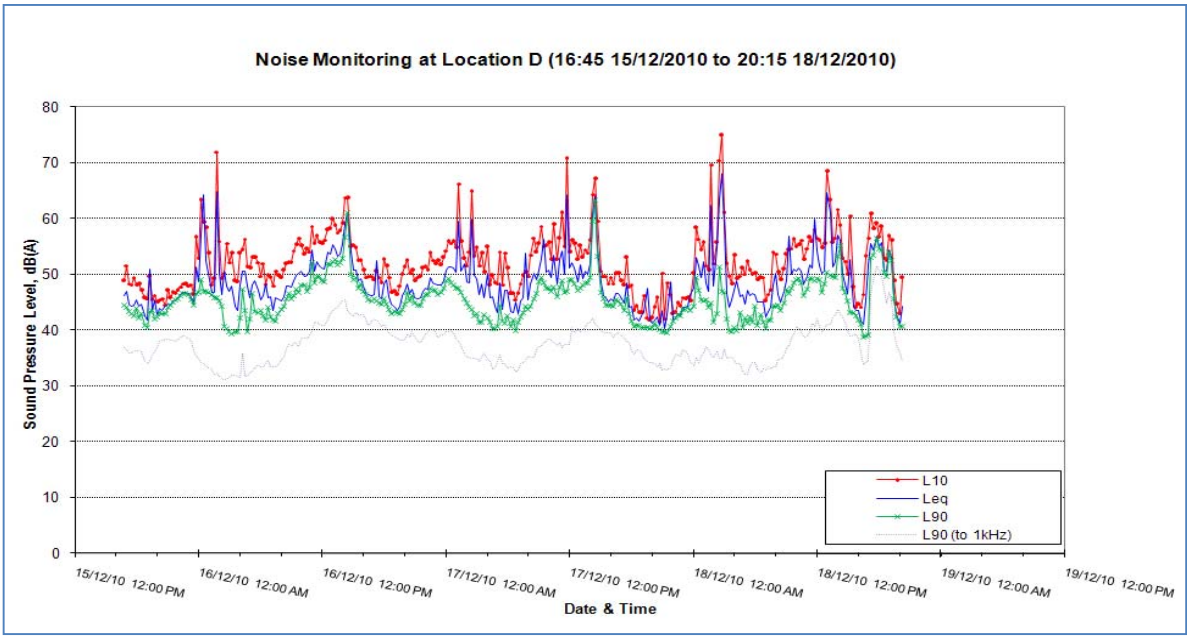


Figure F.4: Noise Logging at Location D

Table F.1 Statistical Noise Levels at Location A

Descriptor	L_{10}, dB(A)			L_{90}, dB(A)			L_{eq}, dB(A)		
Period	Day	Evening	Night	Day	Evening	Night	Day	Evening	Night
Maximum	74	80	69	62	76	63	75	77	66
Minimum	44	45	43	41	43	42	42	44	42
Average	52	54	51	46	50	47	50	51	49

Table F.2 Statistical Noise Levels at Location B

Descriptor	L_{10}, dB(A)			L_{90}, dB(A)			L_{eq}, dB(A)		
Period	Day	Evening	Night	Day	Evening	Night	Day	Evening	Night
Maximum	71	70	68	62	67	66	67	66	64
Minimum	45	46	43	43	44	41	43	45	41
Average	54	54	52	50	50	49	51	51	50

Table F.3 Statistical Noise Levels at Location C

Descriptor	L_{10}, dB(A)			L_{90}, dB(A)			L_{eq}, dB(A)		
Period	Day	Evening	Night	Day	Evening	Night	Day	Evening	Night
Maximum	71	70	66	54	68	55	64	67	59
Minimum	48	50	48	45	48	46	46	48	46
Average	54	55	52	49	52	50	51	52	50

Table F.4 Statistical Noise Levels at Location D

Descriptor	L_{10}, dB(A)			L_{90}, dB(A)			L_{eq}, dB(A)		
Period	Day	Evening	Night	Day	Evening	Night	Day	Evening	Night
Maximum	71	59	75	63	55	51	65	56	68
Minimum	44	42	43	39	40	39	41	40	42
Average	54	48	52	47	44	44	50	45	49

Appendix G – Risk Matrix

Table G.1 Risk Assessment Matrix

Probability	Consequence				
	5 Catastrophic Irreversible Permanent	4 Major Long Term	3 Moderate Medium Term	2 Minor Short Term Manageable	1 Insignificant Manageable
5-Almost Certain	25-Extreme	20-Extreme	15-High	10-Medium	5-Medium
4-Likely	20-Extreme	16-High	10- High	8- Medium	4-Low
3-Possible	15-High	12-High	9-Medium	6- Medium	3-Low
2-Unlikely	10-Medium	8-Medium	6- Medium	4-Low	2-Low
1-Rare	5-Medium	4-Low	3-Low	2-Low	1-Low

Table G.2 Risk Assessment

Activity Description	Potential Impacts and Their Consequences	Preliminary Risk Assessment (C,L) Score	Additional Control Strategy	Residual Risk with Control Strategies Adopted (C,L) Score
Aircraft	Night-time aircraft noise causing sleep awakening at existing residences and accommodation.	(3,4) High	Aircraft operations to be restricted to daytime hours (except emergency flights).	(2,2) Low
Aircraft	Excessive aircraft noise at proposed resort.	(3,3) Medium	Acoustic building construction for units predicted to be subject to noise levels in excess of 85 dB(A) $L_{max,S}$	(1,3) Low
Industrial compound – generators	Excessive noise from generators at existing residences	(2,2) Low	None required.	(2,2) Low
Industrial compound – generators	Excessive noise from generators at proposed guest and staff accommodation	(3,3) Medium	Careful design, selection and acoustic treatment of generators to achieve noise criteria.	(1,2) Low
Industrial compound – wastewater treatment	Excessive noise from wastewater treatment plant at existing residences	(2,2) Low	None required.	(2,2) Low
Industrial compound – wastewater treatment	Excessive noise from wastewater treatment plant at proposed guest and staff accommodation	(3,3) Medium	Acoustic treatment of wastewater treatment to achieve noise criteria.	(1,2) Low
Industrial compound – solid waste management	Excessive noise from onsite activities at existing residences	(2,2) Low	None required.	(2,2) Low

Activity Description	Potential Impacts and Their Consequences	Preliminary Risk Assessment (C,L) Score	Additional Control Strategy	Residual Risk with Control Strategies Adopted (C,L) Score
Industrial compound – solid waste management	Excessive noise from onsite activities at proposed guest and staff accommodation	(3,3) Medium	Daytime vehicle movements only. Acoustic screening/bunding, and treatment to composting fans	(2,2) Low
Golf course maintenance	Excessive noise from onsite activities at proposed guest accommodation	(3,3) Medium	Restrict to daytime hours	(2,2) Low
Marina – Barge Terminal	Excessive noise from barge and maintenance activities at proposed guest accommodation	(3,3) Medium	Restrict to daytime hours. Noisy activities to be conducted indoors. Management of other noise sources as required.	(2,2) Low
Marina – Retail and restaurants	Excessive noise from onsite activities at proposed guest accommodation	(3,3) Medium	Restrict hours of restaurants in the night.	(2,2) Low
Marina – Ferry terminal	Excessive noise from ferry activities at proposed guest accommodation	(2,2) Low	Restrict to daytime hours	(2,2) Low
Road transport	Excessive noise at residences and accommodation, and wakening at night	(3,3) Medium	Design road system with consideration to recommended buffer distances.	(2,2) Low
Construction noise	Excessive noise from construction at existing residences	(3,4) High	Restrict to daytime hours. Maintain buffer distances from major plant items where possible. Haul roads to adhere to recommended buffer distance. Management in accordance with AS2436-2010.	(2,2) Low

Activity Description	Potential Impacts and Their Consequences	Preliminary Risk Assessment (C,L) Score	Additional Control Strategy	Residual Risk with Control Strategies Adopted (C,L) Score
Construction vibration	Excessive vibration from blasting and construction equipment at residences	(3,4) High	Maintain buffer distances and achieve criteria for blasting. Minimise vibration activities near residences and accommodation.	(2,2) Low
Marine noise and vibration	Noise from piling impacting on marine animals	(3,4) High	Implement a safety zone and observation.	(2,2) Low

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