ENVIRONMENTAL NOISE IMPACT ASSESSMENT
URBAN PERSPECTIVES
PROPOSED SUPERYACHT MARINA
ROZELLE BAY, NSW

Prepared for: Urban Perspectives

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1. INTRODUCTION

Benbow Environmental (BE) were commissioned by Urban Perspectives to undertake a noise impact assessment for the proposed operations associated with the Rozelle Bay Super Yacht Marina (the 'Marina').

The primary objective of this study was to assess potential noise impacts during the construction and operational phase of the proposed Marina at the nearest identified receivers and to make recommendations regarding any necessary noise mitigation measures and management techniques where required.

This report has predicted potential noise impacts from the proposed Marina at each of the closest residential receivers and assesses compliance against guidelines provided within the NSW DECCW's Industrial Noise Policy (INP) and the Interim Construction Noise Guideline (the 'Guideline').

The facility is proposed to be in operation 24 hours a day, 7 days per week.

The proposed Marina is located within an existing industrial / urban area.

The nearest residents are located 250 metres distant to the south of the site and Glebe Point, 400 metres to the north west at Lilyfield Road, Rozelle, and 600 metres distant to the east of the site at Pyrmont. Based on the locations of the nearest potentially affected receivers, there exists potential for impacts associated with noise emissions from the development.

Monitoring of existing ambient noise levels has been conducted in 2007 at the potentially worst affected residences. The background noise levels from this previous 2007 noise survey has been used in establishing the project-specific noise criteria in accordance with the NSW INP. Noise emission levels from the proposed operations have been calculated at these residential locations and compared with the established noise criteria in order to assess for any potential operational and construction noise impacts offsite.

It is expected that with the implementation of the recommended noise control measures, off-site noise impacts would be minimal and therefore would comply with the INP project-specific noise criteria.

Assumptions have been made for modelling purposes and may not directly correspond with the actual operations of the proposed development. Therefore, a post-construction noise assessment is recommended in order to validate the noise levels predicted during the operational phase of the development against the actual operational noise levels. Noise monitoring is also recommended at the commencement of the construction phase in order to maintain an acceptable noise level at the receiver locations.

1.1 SCOPE

The scope of works for this study was to prepare a noise impact assessment for the proposed development in accordance with the DECCW's Industrial Noise Policy and the Interim Construction Noise Guideline.

This commissioning included the consideration of the following:

- provide a description of the site and the proposed development;
- a review of the appropriate noise criteria and guidelines for the development;
- assessment of previously measured ambient noise levels in the areas surrounding the site;
- establishment / justification of project-specific noise limits for the development;
- assessment of potential noise sources and prediction of potential noise impacts from the development;
- determination of appropriate noise controls and noise management practices to minimise noise (where required); and
- provide a statement of potential noise impact.

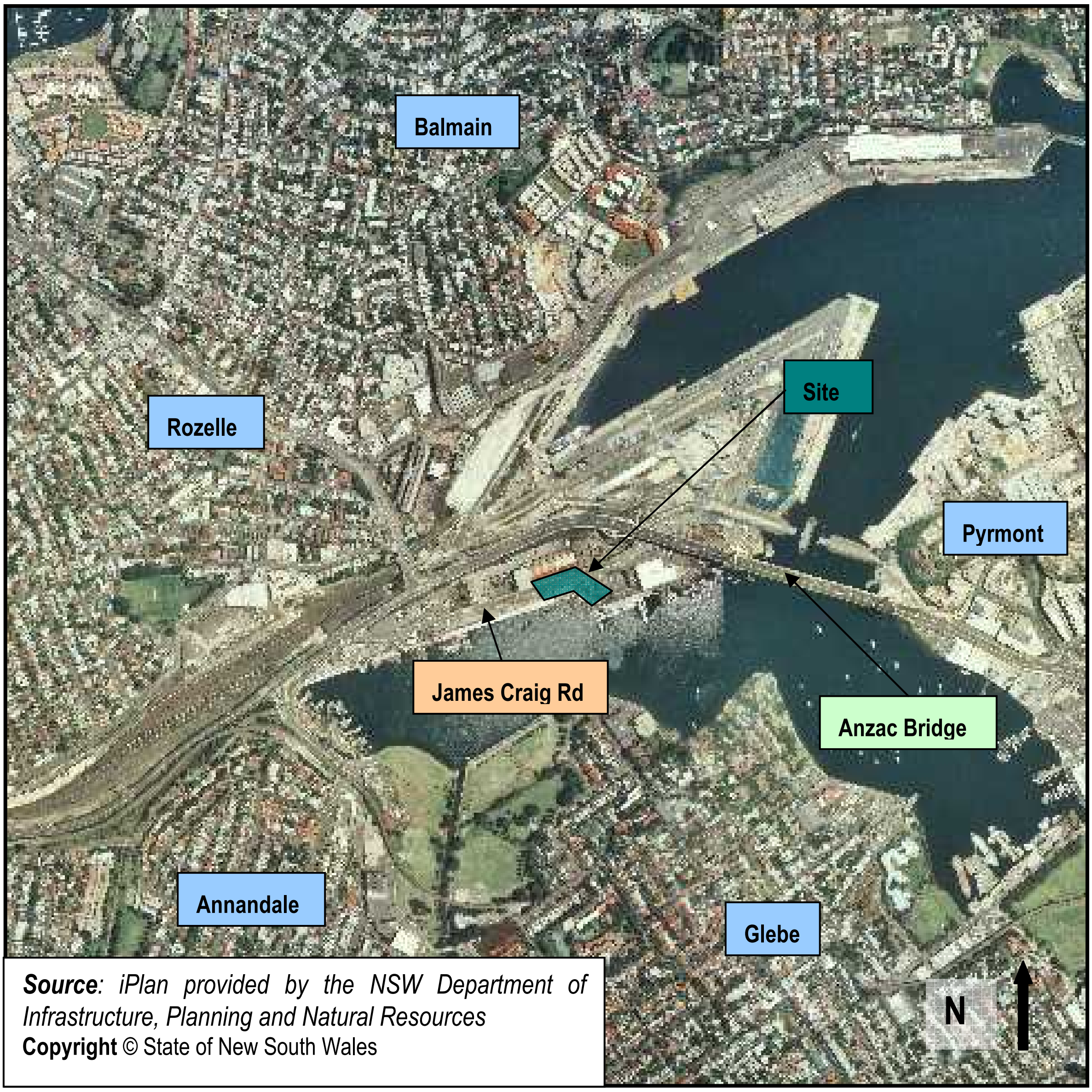
2. PROJECT INFORMATION

A brief description of the subject site and proposed operations have been provided below.

2.1 Site Locality

A site locality plan has been provided as Figure 2-1 with the nearest identified receiver locations presented in Figure 2-2 below.

Figure 2-1: Site Aerial and Locality



Source*: iPlan provided by the NSW Department of Infrastructure, Planning and Natural Resources*
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Figure 2-2: Nearest Potentially Affected Receivers

***Source**: Google Earth Pro 2010*

2.2 SURROUNDING LAND USE

The subject site is bordered by existing allotments consistent with the land use and zoning for the region.

Inspection determined that the site is immediately surrounded by marine and industrial uses in the nearby vicinity. In the far field are the residential areas of Rozelle, Glebe Point and Pyrmont. Accordingly, the surrounding land uses were found to predominantly comprise an 'urban and industrial' setting.

The subject site and its surrounding landscapes are subject to minor variations in topographical grade (based on the 1:10,000 topographic map for the region, Leichhardt U0945).

Nine (9) potentially affected residential receivers have been specifically considered at locations marked R1 to R9, as outlined in Table 2-1 below.

Table 2-1: Adjacent Receiver Locations Considered

Receiver	Location	Approx. Separation Distance †	Bearing	Indicative Noise Amenity Area
R1*	Mansfield Street	550 m	N	Urban
R2*	Crescent Street	550 m	NW	Urban
R3*	Hornsey Street	500 m	NW	Urban
R4*	Bayview Crescent	650 m	SW	Urban
R5	Federal Road	250 m	S	Urban
R6*	Oxley Street	370 m	SSE	Urban
R7	Bank Street	650 m	E	Urban
R8*	Refinery Road	800 m	ENE	Urban
R9*	Bowman Street	1100 m	ENE	Urban

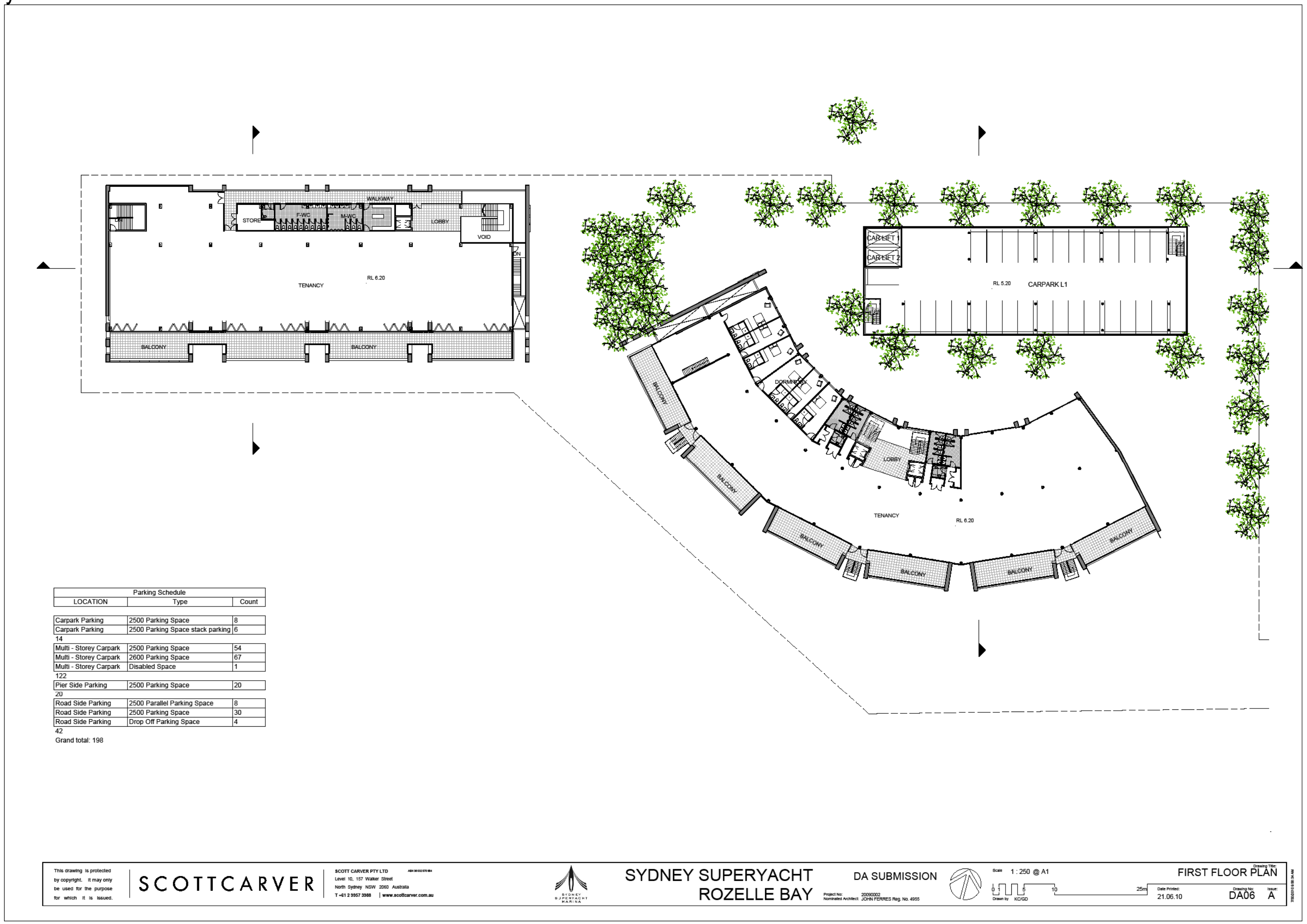
† assessed from proposed site
* noise monitoring previously undertaken at nominated locations (reference Section 4 for further details)

2.3 PROJECT DESCRIPTION

The proposed development has been assumed to operate 24 hours a day, 7 days a week as a super yacht marina (and its associated operational areas). The following areas are proposed to be developed as shown in Figure 2-3:

- Commercial/retail premises; and
- Car park.

Figure 2-3: Site Layout Plan



2.3.1 Operations Overview

The primary noise sources associated with the proposed Marina include :

- Car park operations; and
- Commercial/retail premises.

Noise modelling scenarios have been established based on all of these operations occurring simultaneously in order to assess under a suitably worst-case scenario.

3. NOISE MONITORING RESULTS

For the purposes of this assessment, background noise measurements previously undertaken for the study area have been referenced.

It is not anticipated that the local ambient noise environment has undergone significant variation. The data set is considered as being suitable for the purposes of this environmental noise impact assessment.

3.1 LOCAL AMBIENT NOISE ENVIRONMENT

Existing noise sources have previously been measured and assessed by an independent acoustic consultancy (Renzo Tonin & Associates 2003) for the White Bay and Glebe Island dock area:

- Constant noise emissions from sources such as vessel engines, fans and generators; and
- Intermittent noise emissions from cranes, forklifts, trucks etc (generally associated with cargo unloading).

Previous site investigations undertaken by BE during the day noted that the local ambient noise environment was readily characterised as typically urban. Industrial noise sources and traffic were noted as being predominant.

The Anzac Bridge passes over and is near to the proposed development site. Therefore the existing road traffic noise would be an important component of the ambient noise.

The noise measurements adopted in the completion of this assessment are presented in the following section.

3.2 RESULTS OF AMBIENT NOISE MEASUREMENTS

3.2.1 Measurement Locations

Noise monitoring was undertaken at R1, R2, R3, R4, R6, R8 and R9 (Table 3-1and Figure 2-2). The noise measurement locations can be summarised as follows:

- R1 – 39 Mansfield Street, Rozelle;
- R2 – 47 Crescent Street, Rozelle;
- R3 – 13 Hornsey Street, Rozelle;
- R4 – 15 Bayview Crescent, Annandale;
- R6 – 14 Oxley Street, Glebe Point;
- R8 – 202 Refinery Drive, Pyrmont; and
- R9 – 114 Bowman Street, Pyrmont.

3.2.2 Measured Noise Levels

The background noise levels as reported by Renzo Tonin & Associates (2003) are presented in the following table.

Table 3-1: Measured L_{A90} and L_{Aeq} Noise Levels – Unattended Noise Monitoring (August, September 2003) (values expressed as dB(A))

Receiver		L_{A90} Background noise levels (RBL)			L_{Aeq} Ambient noise levels		
		Day 7:00 – 18:00	Evening 18:00 – 22:00	Night 22:00 – 7:00	Day 7:00 – 18:00	Evening 18:00 – 22:00	Night 22:00 – 7:00
R1	39 Mansfield Street	42	41	36	56	53	49
R2	47 Crescent Street	52	50	41	58	55	53
R3	13 Hornsey Street	49	47	40	54	51	48
R4	15 Bayview Crescent	51	50	43	54	53	50
R6	14 Oxley Street	53	52	45	58	59	53
R8	202 Refinery Drive	50	48	46	54	52	51
R9	114 Bowman Street	48	46	47	56	52	51

4. CURRENT LEGISLATION AND GUIDELINES

4.1 NSW INDUSTRIAL NOISE POLICY

The NSW Industrial Noise Policy was developed by the NSW EPA primarily for the assessment of noise emissions from industrial sites regulated by the NSW EPA. However, the policy can also be used by Planning NSW and local government to assist in their assessment of potential noise issues.

An important point to note in the policy is presented in Section 1.4.1. This section states:

> *"The industrial noise source criteria set down in Section 2 are best regarded as planning tools. They are not mandatory, and an application for a noise-producing development is not determined purely on the basis of compliance or otherwise with the noise criteria. Numerous other factors need to be taken into account in the determination. These factors include economic consequences, other environmental effects and the social worth of the development."*

The policy sets out two criteria that are used to assess potential site related noise impacts. The first criterion aims at controlling intrusive noise impacts in the short-term for residences. This criterion is therefore called the intrusive criterion.

The second criterion aims at maintaining a suitable amenity for particular land uses including residences in the long-term. This criterion is called the amenity criterion.

4.1.1 Intrusive Criterion

The intrusive criterion can be summarised as:

$$L_{Aeq,(15minute)} \leq \text{rating background level} + 5 \text{ dB(A)}$$

Where the $L_{Aeq,(15minute)}$ is the predicted or measured L_{Aeq} from the site over a fifteen minute interval at the receiver. The rating background level is the existing background noise level at the receiver and has been determined for this project in Table 3-1. From this, the project-specific intrusiveness criteria has been set and presented in Table 5-1.

4.1.2 Amenity Criterion

The amenity criterion is determined using the guidelines presented in Section 2.2 of the INP. Table 4-1 and Table 4-2 below summarise the key information.

Table 4-1: NSW EPA Amenity Criteria
Recommended L_{Aeq} Noise Levels from Industrial Noise Sources

Type of Receiver	Indicative noise amenity area	Time of Day	Recommended L_{Aeq} noise level (dB(A))	
			Acceptable	Recommended Maximum
Residential	Urban	Day	**60**	65
		Evening	**50**	55
		Night	**45**	50
	Urban Industrial Interface - existing situations only -	Day	65	70
		Evening	55	60
		Night	50	55
Commercial Premises	All	When in use	**65**	70
Industrial Premises	All	When In use	**70**	75

Source: Table 2.1 NSW EPA INP
* The values in bold have been used to establish INP project-specific criteria.

According to the NSW INP, the 'Urban Industrial Interface' category only applies to 'existing situations'. Since the Sydney Super Yacht Marina is a proposed development, the more conservative amenity criteria under the 'Urban' category has been considered.

Table 4-2: Modification to Acceptable Noise Level (ANL[1]) to Account for Exist. Level of Stationary Noise (values expressed as dB(A))

Total existing L_{Aeq} noise level from industrial sources	Maximum L_{Aeq} noise level for noise from new sources alone
≥ ANL + 2	If existing noise level is likely to decrease in future: ANL – 10 If existing noise level is unlikely to decrease in the future: Existing level – 10
ANL + 1	ANL – 8
ANL	ANL – 8
ANL – 1	ANL – 6
ANL – 2	ANL – 4
ANL – 3	ANL – 3
ANL – 4	ANL – 2
ANL – 5	ANL – 2
ANL – 6	ANL –1
< ANL - 6	ANL

Source: Table 2.2 NSW EPA INP
1. ANL is the recommended acceptable L_{Aeq} noise level for the specific receiver, area and time of day from Table 4-1 above.

Measured noise levels for the area have been presented in Section 3.2.2 of this report.

The INP also allows for corrections for 'modifying factors' if the characteristics' of the noise source/s include:

- annoying tonal components;
- impulsiveness;
- intermittency;
- irregularity; or
- prevailing low frequency.

Table 4.1 in Chapter 4 of the INP specifies the adjustments allowed for each modifying factor, however the maximum allowable correction is 10 dB(A), where two or more modifying factors are present.

Noise emissions from this operation are in general not determined to be tonal, impulsive or intermittent in character.

4.2 SLEEP DISTURBANCE CRITERIA

The emission of peak noise levels for an instant or very short time period between 10pm and 7am may cause sleep disturbance to residents. Chapter 19 of the NSW EPA Environmental Noise Control Manual states:

> *"Noise control should be applied with the general intent to protect people from sleep arousal. To achieve this, the L_1 level of any specific noise source should not exceed the background noise level (L_{90}) by more than 15 dB(A) when measured outside the bedroom window."*

Also the Application Notes for the NSW INP (DEC), accepts that the sleep disturbance criterion of an L_{A1} (1minute) not exceeding the L_{A90} (15 minute) by more than 15 dB(A), whilst not ideal, will suffice until more scientific research is completed to identify what should replace it.

4.3 DECCW Construction Noise Criteria

The NSW DECCW's Environmental Noise Control Manual (ENCM) has been superseded at large by the department's Interim Construction Noise Guideline (the 'Guideline'). Therefore management levels specified in the Guideline have been provided in lieu thereof the previous construction noise criteria specified in the ENCM.

The Guideline recommends assessing noise at residences using a quantitative method under the management level of RBL (Rating Background Level) + 10 dB which may attract 'some community response to noise at this level. At the highly noise affected management level of 75 dB(A), higher levels of community response may be expected when compared to RBL+10 dB.

It is important to note that the recommended criteria are planning goals only. Numerous other factors need to be considered when assessing potential noise impacts from construction works.

However, in undertaking the assessment of potential noise intrusion associated with the proposed construction activities, the DECCW's Guideline has been specifically referenced in assessing the potential airborne construction noise during 'standard construction hours'.

According to the Guideline, the recommended standard hours for 'normal' construction work are between:

- Monday to Friday 7am to 6pm;
- Saturday 8am to 1pm; and
- No work on Sundays or public holidays.

The relevant management levels have been tabulated below.

Table 4-3: NSW DECCW Guideline – Noise at residences using quantitative assessment

Time of day	Management level, $L_{Aeq(15min)}$*
Recommended standard hours	Noise affected RBL + 10 dB
	Highly noise affected 75 dB(A)

* Noise levels apply at the property boundary that is most exposed to construction noise and at a height of 1.5m above ground level.

4.4 NSW EPA ENVIRONMENTAL CRITERIA FOR ROAD TRAFFIC NOISE

Road noise traffic criteria were adopted from the NSW DECCW's "Environmental Criteria for Road Traffic Noise" (1999). In adopting suitable criteria, it was considered that James Craig Road could be defined as a "local road" based on the NSW EPA's definition as 'a road that handles local traffic'. This road is used solely as local access roads.

The potential increase of traffic noise should be assessed for James Craig Road. Following the road realignment, James Craig Road has been pushed north from its current position parallel to the Crescent (arterial road) and Victoria Road (arterial road), which has resulted in an increased distance from the residences located in Glebe Point.

This road is not passing by any residences and the traffic noise generated on this road would be minimal compared to the existing traffic noise generated by vehicles travelling on the Anzac Bridge.

As an example the following table presents a comparison between the number of vehicles travelling on Anzac Bridge and the number of vehicles that would access the site during peak hour period. The peak hour period represent the worst-case scenario where the maximum number of vehicles would access the site.

A detailed description of the vehicle movements on site has been provided in Section 6.1 of this report.

The following Table 4-4 presents the peak hour traffic volume of James Craig Road compared to that of Anzac Bridge.

Table 4-4: Peak Hour Traffic Volume

Location	Anzac Bridge	James Craig Road (Accessing the Site)
Number of Vehicles per hour	5000	54*

Sources: RTA AADT Traffic Volume Study for the Anzac Bridge
Note: * this number represents the worst-case scenario within a one-hour period combining cars and trucks.

The maximum number of vehicles that will access the site within an hour is 54, which represent s 1% of the peak hour traffic on the Anzac Bridge. Therefore, it is expected that the traffic noise generated by the proposed development will not contribute to the overall traffic noise in the area.

As a result, the traffic noise assessment has been conducted (based on comparison of volumes) and based on the preliminary findings, no further assessment is required.

5. SITE-SPECIFIC NOISE LIMITS

Noise limits for the development can now be established based on the guidelines provided in Section 4 of this report and the measured background noise levels (Section 3.2.2).

In measuring existing ambient and background noise levels at the residential locations, and including amenity limits, any potential cumulative impacts would be accounted for.

The measured noise levels and the observations made demonstrate the local industrial noise sources are not influencing the existing ambient noise environment for those receivers with a direct line of sight to the proposed operational areas.

5.1 INTRUSIVENESS AND AMENITY CRITERIA

Project-specific noise limits can now be set based on the results of the background noise monitoring at the nearest residents to the site and the requirements outlined by the NSW DECCW. The selected criteria and calculated limits are presented in Table 5-1 below.

Table 5-1: Residential Noise Limits (values expressed as dB(A))

Receiver	Indicative Noise Amenity Area	Period	Measured L_{A90} (RBL)	Measured L_{Aeq} (logarithmic average)	Amenity Limit (L_{Aeq})	Intrusive Limit ($L_{Aeq,15minute}$)	Sleep Arousal (L_{A1})
R1 Mansfield Street, Rozelle	Urban	Day	42	56	60	**47**	-
		Evening	41	53	50	**46**	-
		Night	36	49	45	**41**	51
R2 Crescent Street, Rozelle	Urban	Day	52	58	60	**57**	-
		Evening	50	55	**50**	55	-
		Night	41	53	**45**	46	56
R3 Hornsey Street, Rozelle	Urban	Day	49	54	60	**54**	-
		Evening	47	51	**50**	52	-
		Night	40	48	**45**	**45**	55
R4 Bayview Crescent, Annandale	Urban	Day	51	54	60	**56**	-
		Evening	50	53	**50**	55	-
		Night	43	50	**45**	48	58

Table 5-1: Residential Noise Limits (values expressed as dB(A))							
Receiver	Indicative Noise Amenity Area	Period	Measured L_{A90} (RBL)	Measured L_{Aeq} (logarithmic average)	Amenity Limit (L_{Aeq})	Intrusive Limit ($L_{Aeq,15minute}$)	Sleep Arousal (L_{A1})
R5 Federal Road, Glebe	Urban	Day	-	-	60	**58**	-
		Evening	-	-	**50**	57	-
		Night	-	-	**45**	50	60
R6 Oxley Street, Glebe Point	Urban	Day	53	58	60	**58**	-
		Evening	52	59	**50**	57	-
		Night	45	53	**45**	50	60
R7 Bank Street, Pyrmont	Urban	Day	-	-	60	**53**	-
		Evening	-	-	**50**	51	-
		Night	-	-	**45**	52	62
R8 Refinery Drive, Pyrmont	Urban	Day	50	54	60	**55**	-
		Evening	48	52	**50**	53	-
		Night	46	51	**45**	51	61
R9 Bowman Street, Pyrmont	Urban	Day	48	56	60	**53**	-
		Evening	46	52	**50**	51	-
		Night	47	51	**45**	52	62

1. Criteria for R5 and R7 were adopted from measured levels at R6 and R9 respectively, as they share the local ambient noise environment and therefore are representative of the relevant areas.
2. The values in bold are the lower limiting values as per the INP and has been set as the project-specific noise criteria.
3. All nine (9) receivers presented in the table above have been considered in the modelling for prediction of noise emission levels.

5.2 PROJECT-SPECIFIC NOISE LEVELS

By comparing the intrusiveness with the amenity criteria, and selecting the most stringent criteria for day, evening and night time periods, the project-specific noise levels for the proposed operations are outlined below.

Table 5-2: Project-Specific Noise Levels – Proposed Operations

R1: 39 Mansfield St, Rozelle		Period
$L_{Aeq, 15min}$	**47 dB(A)**	Day
$L_{Aeq, Evening}$	**46 dB(A)**	Evening
$L_{Aeq, Night}$	**41 dB(A)**	Night
R2: 47 Crescent St, Rozelle		**Period**
$L_{Aeq, Day}$	**57 dB(A)**	Day
$L_{Aeq, Evening}$	**50 dB(A)**	Evening
$L_{Aeq, Night}$	**45 dB(A)**	Night
R3: 13 Hornsey St, Rozelle		**Period**
$L_{Aeq, 15min}$	**54 dB(A)**	Day
$L_{Aeq, Evening}$	**50 dB(A)**	Evening
$L_{Aeq, Night}$	**45 dB(A)**	Night
R4: 15 Bayview Cr, Annandale		**Period**
$L_{Aeq, 15min}$	**56 dB(A)**	Day
$L_{Aeq, Evening}$	**50 dB(A)**	Evening
$L_{Aeq, Night}$	**45 dB(A)**	Night
R5: Federal Rd, Glebe.		**Period**
$L_{Aeq, 15min}$	**58 dB(A)**	Day
$L_{Aeq, Evening}$	**50 dB(A)**	Evening
$L_{Aeq, Night}$	**45 dB(A)**	Night
R6: Oxley St, Glebe Point		**Period**
$L_{Aeq, 15min}$	**58 dB(A)**	Day
$L_{Aeq, Evening}$	**50 dB(A)**	Evening
$L_{Aeq, Night}$	**45 dB(A)**	Night
R7: Bank St, Pyrmont.		**Period**
$L_{Aeq, 15min}$	**53 dB(A)**	Day
$L_{Aeq, Evening}$	**50 dB(A)**	Evening
$L_{Aeq, Night}$	**45 dB(A)**	Night

Table 5-2: Project-Specific Noise Levels – Proposed Operations		
R8: 202 Refinery Dr, Pyrmont		**Period**
$L_{Aeq,\ 15min}$	**55 dB(A)**	Day
$L_{Aeq,\ Evening}$	**50 dB(A)**	Evening
$L_{Aeq,\ Night}$	**45 dB(A)**	Night
R9: 114 Bowman St, Pyrmont.		**Period**
$L_{Aeq,\ 15min}$	**53 dB(A)**	Day
$L_{Aeq,\ Evening}$	**50 dB(A)**	Evening
$L_{Aeq,\ Night}$	**45 dB(A)**	Night

Note: Similar project-specific noise levels have been applied to R5, R6 and R7, R8 respectively because the receivers are located within a similar existing ambient noise environment.

According to the DECCW's Guideline, the 'noise affected' management level of RBL + 10 dB has been applied to the construction phase of the proposed development.

Table 5-3: Project-Specific Noise Levels – Proposed Construction Phase	
Time of day	**Management level, $L_{Aeq(15min)}$**
Recommended standard hours	RBL + 10 dB

6. PREDICTED NOISE IMPACTS

6.1 NOISE SOURCES ASSOCIATED WITH PROPOSED SITE ACTIVITIES

The noise sources associated with the proposed development have been investigated through discussions with the proponent.

The construction activity schedule will heavily depend on the subcontractor assigned to complete the works. Therefore, assumptions of activities and equipment (pertinent to this stage of the application) have been made for each construction phase of the project.

The primary noise sources assumed for the construction phase of the proposed development are listed in the table below. The typical L_{Aeq} sound power levels for the anticipated construction plant are also presented.

Table 6-1: Summary of Sound Power Levels used – Construction Plant

Plant Item	Overall L_{Aeq} Sound Power Level, dB(A)
Dump truck (approx. 50 tonne)	**108**
Excavator	**105**
Scraper	**108**
Dozer	**114**
Concrete saw	**110**
Front end loader	**111**
Semi-trailer	**102**
Pile driving	**118**

The anticipated noise sources during the operational phase of the development are tabulated below.

Table 6-2: Summary of Sound Power Levels used – Operational Phase

Plant Item	Overall L_{Aeq} Sound Power Level, dB(A)
Live band (amplified music)	**105**
Group of 20 people conversing	**83**
Light vehicle manoeuvring within car park	**75**
Plant room ventilation fan	**80**

The L_{Aeq} sound power levels applied to this project have been sourced from BE's inhouse noise source database of previous measurements undertaken during similar construction activities. The instrument sets used to carry out the measurements comply with AS 1259.1 for Type 1 sound level meters.
All internal QA/QC procedures were adhered to during the noise source measurement program.

It is recommended that post-commissioning compliance monitoring be undertaken so as to validate all assumptions made within this section of the document. Additional variables, such as annoying characteristics, can also be assessed in detail at this stage and ensure that such characteristics are not present.

The data presented in the table above are overall levels (single value).

For accuracy in the calculations of the predicted noise levels, octave band spectrums have been used to run the environmental noise model.

6.2 MODELLING METHODOLOGY

6.2.1 Noise Model SoundPlan 7.0

In order to quantify the potential construction noise levels from the proposed works, the anticipated noise sources have been modelled in the DECCW-recognised SoundPLAN software program to predict the $L_{Aeq(15min)}$ noise levels at the nearest potentially affected receivers.

SoundPLAN has been extensively utilised by Benbow Environmental for assessing airborne noise emissions from similar proposed developments, and is recognised by regulator authorities throughout Australia. The model allows for prediction of the total noise from the site (at the specified receptor) by calculating the contribution of each noise source.

The noise sources (given in Table 6-1 and Table 6-2) as well as the topographical features of the area, receiver locations, were all input into the noise model to determine the noise emissions of the proposed development at the nearest potentially most affected residence/s.

Noise levels were calculated at the nearest affected residential locations considering the 'worst case' scenario, which has taken into account all site equipment and vehicles in operation simultaneously.

The model can predict L_{Amax} noise levels but not the L_{A1} noise levels. The L_{Amax} level, although higher than the L_{A1} level, has been used in the modelling and therefore the modelled results are based on the precautionary approach.

The modelling scenario has been carried out using two different descriptors (L_{Amax} and L_{Aeq}). Using these descriptors, noise emission levels were predicted at the receiver locations to determine the noise impact against the relevant noise criteria. The L_{Amax} was used to assess against the project-specific sleep disturbance criteria and the L_{Aeq} against the DECCW's INP. The relevant criteria are presented in Section 4.

The noise modelling included noise-enhancing meteorological factors such as wind effects. It can be expected that the residences would experience higher levels of noise emanating from the site when wind blows from the site directly to the residences. Therefore, a meteorological factor of light winds of 3m/s (source to receiver) was taken into consideration for the prediction of noise levels when assessing under the 'worst case' scenario.

In undertaking the predictive noise modelling, point-to-point calculations were undertaken for nine (9) nearest potentially affected residential receiver locations.

The predicted noise levels at different receiver locations are presented in Section 6.3 of this report.

6.2.2 Assumptions Made for Noise Modelling

The following assumptions were made to assess the noise impact of the site for the operational scenarios throughout the day.

- In the model, the operations have been assumed as a constant source throughout the day for a worst case assessment, which would be the case for 24-hour activities;
- 4 (four) ventilation fans placed on the roofs of the proposed building;
- 9 (nine) outdoor live music bands, 1 (one) at each 'balcony' area;
- Groups of 20 people conversing, evenly distributed along the 'tenancy' areas to total 100 people conversing;
- A multi-deck car park with 4 (four) levels including the ground floor; and
- 9 vehicle movements per hour per parking lot based on the Parking Schedule (Ref: Drawing No. DA06, Scott Carver).

Under the construction scenario of the proposed Marina, the following modelling construction activities were assumed for modelling purposes. As discussed above, the actual construction activities may vary upon commissioning the works and therefore monitoring during the construction phase is recommended in order to validate the assumed construction plant.

- The purpose of the proposed construction works is to construct onsite commercial/retail premises and the multi-deck car park;
- The worst-case scenario during the construction phase has been modeled, i.e. site clearing and bulk earthworks to represent the most noise-intensive plant; and
- Construction works have been assumed to occur during 'standard hours' only, i.e. daytime.

Although it is clear that several general assumptions were required in the establishment of the site-specific noise prediction model, the limitations are recognised by the regulatory authorities. As such the SoundPlan package is used by many environment regulators throughout Australia.

6.2.3 Modelling Techniques and Scenarios

Noise modelling scenarios were developed based on what was considered to be maximum single-point operating conditions during each assessment period. In achieving compliance with the design objectives, no annoyance to the local community would be apparent.

Model scenarios were configured that provided a detailed assessment of potential site-related noise emissions. In establishing each model run, all pre-defined sources were conservatively positioned within the designated work areas.

6.2.4 Meteorological Factors

The DECCW's INP has been referenced in relation to assessing meteorological conditions in potential noise impacts. The Policy states:

> *"Wind effects need to be assessed where wind is a feature of the area. Wind is considered to be a feature where source-to-receiver wind speeds (at a 10m height) of 3m/s or below occur for 30 percent of the time or more in any assessment period (day, evening, night) in any season."*

Compliance under the noise enhancing meteorological conditions is required.

Analysis of regional weather conditions has been carried out with careful consideration of wind effects in our previous noise study (2005) of which relevant sections have been included in Attachments. This previous wind study of the local area concluded that noise enhancing meteorological conditions (wind) require no further consideration.

Notwithstanding, a noise enhancing meteorological condition of 3m/s source to receiver was included in the predictive noise model to account for the time lapse since the study and also to present the results under a precautionary approach.

6.3 PREDICTED NOISE LEVELS

The following meteorological conditions were applied to each modelling scenario:

Condition A: Calm, isothermal conditions; and
Condition B: Equivalent to 3m/s wind from source to receiver.

6.3.1 Proposed Operations

Noise levels have been predicted for the nearest potentially affected receivers during an operational scenario including nine (9) music bands on the balcony of each operational premises and groups of 20 patrons conversing and distributed near the premises to total 100 patrons conversing. Three (3) plant room ventilation fans have also been included. This represents the maximum operational scenario, i.e. Scenario 1.

Table 6-3: Predicted noise levels during proposed operations - **L_{Aeq}**, dB(A) NO NOISE CONTROLS (Condition A)

Scenario 1	**Receiver Location**								
	R1	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**
Project Specific Noise Levels									
Daytime	*47*	*57*	*54*	*56*	*58*	*58*	*53*	*55*	*53*
Evening	*46*	*50*	*50*	*50*	*50*	*50*	*50*	*50*	*50*
Night time	*41*	*45*	*45*	*45*	*45*	*45*	*45*	*45*	*45*
Operational Noise Levels (L_{Aeq})									
Daytime	35	29	37	44	56	49	40	44	41
Evening Time	35	29	37	44	**56**	49	40	44	41
Night Time	35	29	37	44	**56**	**49**	40	44	41

Notes: The results shown in bold font indicate potential exceedance.

Table 6-4: Predicted noise levels during proposed operations - **L_{Amax}**, dB(A) NO NOISE CONTROLS (Condition A)

Scenario 1 – Sleep Disturbance	**Receiver Location**								
	R1	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**
Sleep Disturbance Criteria									
Night time	*51*	*56*	*55*	*58*	*60*	*60*	*62*	*61*	*62*
Operational Noise Levels (L_{Amax})									
Night Time	32	24	34	37	50	43	35	40	36

Notes: The above noise levels are based on predictions of a typical 'worst case' operational scenario proposed onsite

Comments

From our foregoing analysis, the proposed operations at the subject site are not expected to be audible at R1 during the day, evening, and night time.

Operational noise is predicted to be audible at R5 during the evening and night-time periods with an exceedance of 6 dB(A) predicted during the evening period and a potential exceedance of 11 dB(A) during the night-time period.

At R6, an exceedance of 4 dB(A) is expected during the night time period.

These exceedances are mainly due to the live band activities.

Compliance is expected to be achieved at the remaining receiver locations.

Under the sleep disturbance scenario, compliance is expected at all receiver locations.

During the noise enhancing meteorological condition of 3m/s wind to receiver, the following operational noise levels are predicted at the receiver locations.

Table 6-5: Predicted noise levels during proposed operations - **L_{Aeq},** dB(A) NO NOISE CONTROLS (Condition B)

Scenario 1	**Receiver Location**								
	R1	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**
Project Specific Noise Levels									
Daytime	*47*	*57*	*54*	*56*	*58*	*58*	*53*	*55*	*53*
Evening	*46*	*50*	*50*	*50*	*50*	*50*	*50*	*50*	*50*
Night time	*41*	*45*	*45*	*45*	*45*	*45*	*45*	*45*	*45*
Operational Noise Levels (L_{Aeq})									
Daytime	41	33	41	47	57	51	44	48	45
Evening Time	41	33	41	47	**57**	**51**	44	48	45
Night Time	41	33	41	**47**	**57**	**51**	44	**48**	45

Notes: The results shown in bold font indicate potential exceedance.

Table 6-6: Predicted noise levels during proposed operations - **L_{Amax}**, dB(A) NO NOISE CONTROLS (Condition B)

Scenario 1 – Sleep Disturbance	**Receiver Location**								
	R1	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**
Sleep Disturbance Criteria									
Night time	*51*	*56*	*55*	*58*	*60*	*60*	*62*	*61*	*62*
Operational Noise Levels (L_{Amax})									
Night Time	38	29	39	41	51	46	39	44	40

Comments

The predictive results of under Condition B suggest that amplified music in the outdoor areas should be minimised especially during the evening and night-time periods.

At R4, a minor exceedance of 2 dB(A) is predicted during the night-time period.

During the evening and night-time periods at R5, an exceedance of 7 dB(A) and 12 dB(A) are expected.

At R6, a minor exceedance of 1 dB(A) is predicted during the evening with a predicted exceedance of 6 dB(A) during the night-time period.

The amplified music is expected to be slightly audible above traffic crossing the Anzac Bridge at R8 during the night time period with a predicted exceedance of 3 dB(A), considering the measured noise levels at this location would comprise mainly of road traffic noise. The predicted exceedance at R8 during Condition B is due to the raised local topography at the receiver's location, i.e. 20m above the subject site. This places the receiver at a more direct line of sight to the subject noise sources.

Figure 6-1 is a Noise Contour Map showing the propagation of onsite noise under calm, isothermal weather conditions.

Figure 6-2 shows the noise isopleths of onsite noise propagation under enhanced meteorological conditions, i.e. 3m/s wind source to receiver. During this noise enhancing meteorological condition, it can be seen that the path of noise is directed across the water body towards the receiver locations. It also shows 'quiet zones' due to the proposed buildings at the subject site as well as the local topography providing effective acoustic shielding to the north-west.

Both figures include site-specific noise sources such as the multi-deck car park operations, nine (9) live music bands (one at each proposed balcony area), roof mounted mechanical plant, and patrons engaged in loud conversations.

Figure 6-1: Noise Contour Map - Neutral Weather

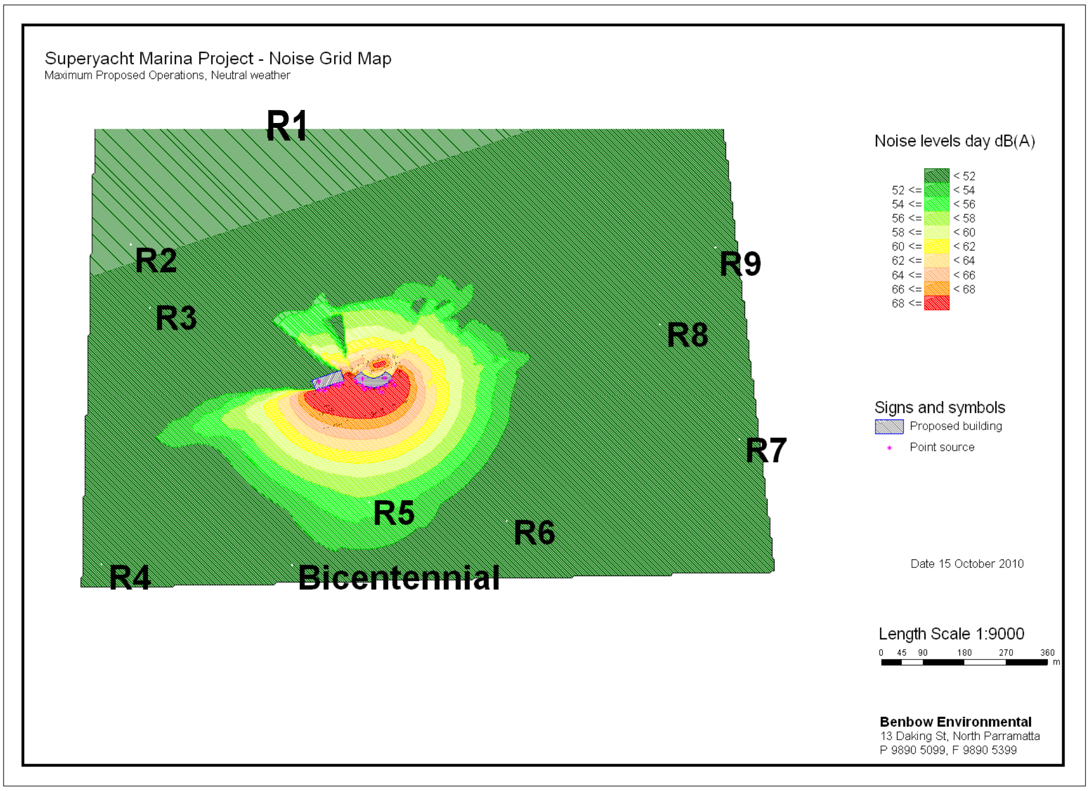
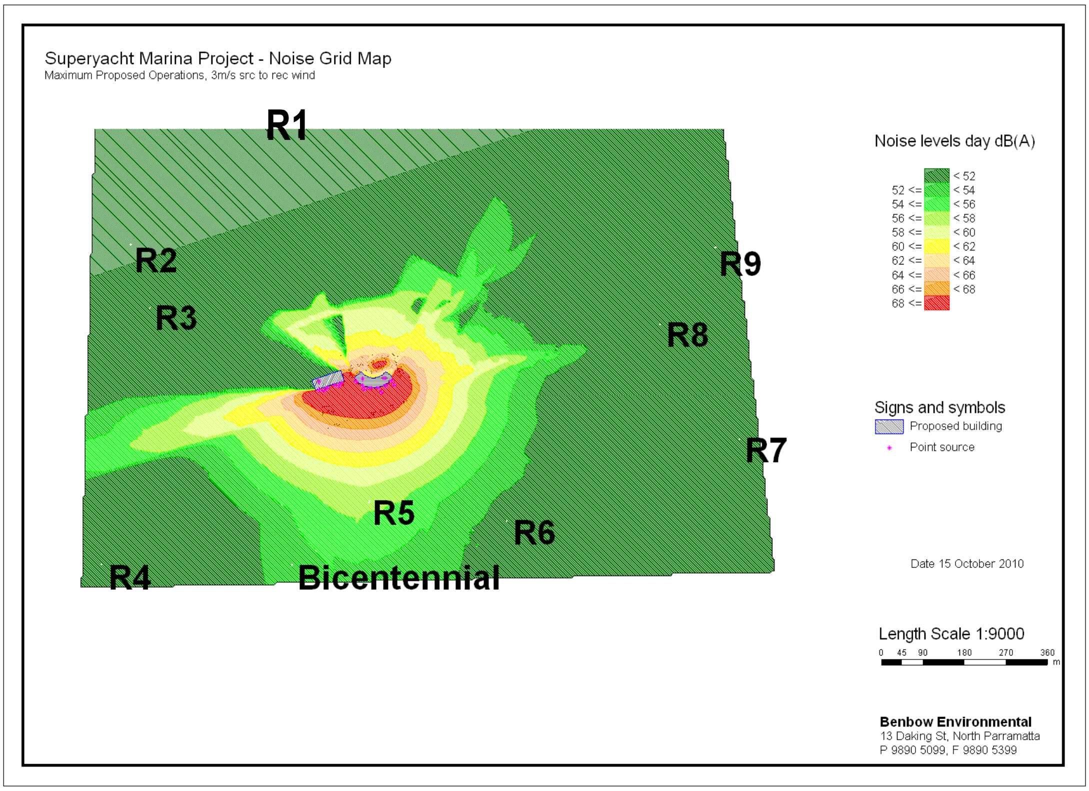


Figure 6-2: 3m/s Source to Receiver Wind



Under Section 6.4 of this report, general safeguards have been provided in an effort to minimise the potential offsite impacts.

Compliance is predicted under the sleep disturbance criteria at all receiver locations.

6.3.2 Construction Noise Impact Assessment

Construction noise limits have been outlined in the criteria section based on the requirements of the NSW DECCW's Guideline.

Construction noise impacts were calculated based on an assumed schedule of construction activities.

The construction activities pertinent to this project development application will consist of site preparation (including concrete removal) and earthworks as well as the construction of the buildings and the multi-deck car park. The noisiest activities during construction occur typically during the site preparation and bulk earthworks stage and therefore predictive modelling results correspond to this phase of the construction.

Equipment generating high noise levels, e.g. bulldozer or heavy track excavators will be used onsite at the designated areas.

Construction noise impacts at the residential receivers were calculated based on the assumption that construction activities will only take place during the daytime as per the Guideline. The results are outlined in the following Table 6-7.

Table 6-7: Predicted Construction Noise Levels at Residential Receivers, dB(A) (Condition A)

Residential Receivers	R1	R2	R3	R4	R5	R6	R7	R8	R9
Construction Noise Criteria, L_{Aeq} (RBL+10dB)	52	62	59	61	63	63	58	60	58
Construction noise impacts									
Predicted Construction Noise Levels	37	29	41	46	58	53	45	49	46

Notes:

- The results in bold exceed the criteria.

The results show that compliance is expected at all of the identified receiver locations during the 'worst-case' construction phase of the proposed development (Condition A). Notwithstanding, safeguards as detailed within Section 6.5 of this report are recommended in order to maintain acceptable noise levels at the identified receivers.

Under the noise enhancing meteorological condition of 3m/s wind source to receiver, the predicted construction noise levels are shown in the table below.

Table 6-8: Predicted Construction Noise Levels at Residential Receivers, dB(A) (Condition B)									
Residential Receivers	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**
Construction Noise Criteria, L_{Aeq} (RBL+10dB)	52	62	59	61	63	63	58	60	58
Construction noise impacts									
Predicted Construction Noise Levels	43	34	46	50	62	57	50	53	51

Notes:

- The results shown in bold font indicate potential exceedance.

A construction noise management plan is recommended to be prepared prior to the commencement of the construction phase in order to minimise such potential impacts at the nearby receiver locations.

Furthermore, noise compliance monitoring is recommended to be undertaken during the construction phase to ensure that the actual construction noise levels are contained within the specific management noise levels.

6.3.3 Traffic noise impacts

As James Craig Road is an industrial access road there are no residential receivers that would be directly affected by noise from increased traffic flows.

The nearest receivers to James Craig Road are located across Rozelle Bay in Glebe and Annandale. The separation distance between James Craig Road and the nearest receivers are over 300m.

Considering that James Craig Road would be adjacent to The Crescent and Victoria Road, both of which experience high traffic flows, increases in traffic flows along James Craig Road as associated with the proposed development are not expected to cause a perceivable increase of the traffic noise level experienced by the nearest residences located in Rozelle Bay. As such, no further consideration of traffic noise impacts is warranted.

6.4 RECOMMENDATIONS

The proposed site activities onsite will generally comply with the DECCW's INP criteria at most of the potentially affected residences. This is assuming that there will be amplified music or live music bands in the outdoor balcony areas. In the absence thereof, compliance with the design criteria is predicted to be achieved at all receiver locations under the maximum operational scenario as shown in the subsequent modelling results below.

6.4.1 General Noise Mitigation Measures

When considering reasonable noise mitigation measures, a noise barrier is not the most cost-effective option and may also affect the visual amenity of the local area. In stating this, a reduced number of bands have been included in the subsequent predictive model in order to reduce the potential noise impacts at the nearby residences before excluding the bands altogether from the model to show the expected compliance.

6.4.2 Noise Levels with Controls

Noise levels have been predicted for the nearest potentially affected receivers – with the implementation of the noise controls presented in 6.4.1.

The following predicted noise levels are calculated based on two (2) music bands in operation simultaneously along the outdoor balconies at the proposed site. In this case, compliance is predicted at all receiver locations under all periods of the day with the exception of R5. At R5, a marginal exceedance of 1 dB(A) is expected during the night-time period.

Table 6-9: Predicted noise levels during proposed operations - **L_{Aeq}**, dB(A) REDUCED NUMBER OF BANDS (Condition A)

Scenario	**Receiver Location**								
2	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**
Project Specific Noise Levels									
Daytime	*47*	*57*	*54*	*56*	*58*	*58*	*53*	*55*	*53*
Evening	*46*	*50*	*50*	*50*	*50*	*50*	*50*	*50*	*50*
Night time	*41*	*45*	*45*	*45*	*45*	*45*	*45*	*45*	*45*
Predicted Operational Noise Levels (L_{Aeq})									
Daytime	25	20	28	34	46	39	31	36	31
Evening Time	25	20	28	34	46	39	31	36	31
Night Time	25	20	28	34	**46**	39	31	36	31

Notes:

- The results shown in bold font indicate potential exceedance.

Compliance is expected to be achieved at all receiver locations under the sleep disturbance scenario as shown in the following table.

Table 6-10: Predicted noise levels during proposed operations - $\mathbf{L_{Amax}}$, dB(A) REDUCED NUMBER OF BANDS (Condition A)

Scenario 2 – Sleep Disturbance	**Receiver Location**								
	R1	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**
Sleep Disturbance Criteria									
Night time	*51*	*56*	*55*	*58*	*60*	*60*	*62*	*61*	*62*
Operational Noise Levels (L_{Amax})									
Night Time	25	20	29	38	49	43	34	39	35

Under Scenario 2, (Condition B) the following noise levels are predicted.

Table 6-11: Predicted noise levels during proposed operations - $\mathbf{L_{Aeq}}$, dB(A) REDUCED NUMBER OF BANDS (Condition B)

Scenario 2	**Receiver Location**								
	R1	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**
Project Specific Noise Levels									
Daytime	*47*	*57*	*54*	*56*	*58*	*58*	*53*	*55*	*53*
Evening	*46*	*50*	*50*	*50*	*50*	*50*	*50*	*50*	*50*
Night time	*41*	*45*	*45*	*45*	*45*	*45*	*45*	*45*	*45*
Predicted Operational Noise Levels (L_{Aeq})									
Daytime	29	24	32	39	48	42	36	40	36
Evening Time	29	24	32	39	48	42	36	40	36
Night Time	29	24	32	39	**48**	42	36	40	36

Notes:

- The results shown in bold font indicate potential exceedance.

Under light winds of 3m/s source to receiver, an exceedance of 3 dB(A) is predicted at R5 during the night time period with 2 (two) outdoor bands. From this, a subsequent predictive model was run to predict the offsite noise impacts with no outdoor amplified music activities.

Assuming that there will be no live bands or amplified music at the outdoor balcony areas, the following operational noise levels can be expected at the receiver locations.

Table 6-12: Predicted noise levels during proposed operations - **L_{Aeq}**, dB(A) NO BANDS (Condition A)									
Scenario	**Receiver Location**								
3	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**
Project Specific Noise Levels									
Daytime	*47*	*57*	*54*	*56*	*58*	*58*	*53*	*55*	*53*
Evening	*46*	*50*	*50*	*50*	*50*	*50*	*50*	*50*	*50*
Night time	*41*	*45*	*45*	*45*	*45*	*45*	*45*	*45*	*45*
Predicted Operational Noise Levels (L_{Aeq})									
Daytime	23	16	24	25	34	31	22	26	22
Evening Time	23	16	24	25	34	31	22	26	22
Night Time	23	16	24	25	34	31	22	26	22

In the absence of outdoor bands, compliance is readily achieved at all receiver locations as shown by the predictive noise levels.

Under the same Scenario 3 with light winds of 3m/s source to receiver, the following offsite noise levels are predicted.

Table 6-13: Predicted noise levels during proposed operations - **L_{Aeq}**, dB(A) NO BANDS (Condition B)									
Scenario	**Receiver Location**								
3	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**
Project Specific Noise Levels									
Daytime	*47*	*57*	*54*	*56*	*58*	*58*	*53*	*55*	*53*
Evening	*46*	*50*	*50*	*50*	*50*	*50*	*50*	*50*	*50*
Night time	*41*	*45*	*45*	*45*	*45*	*45*	*45*	*45*	*45*
Predicted Operational Noise Levels (L_{Aeq})									
Daytime	24	17	25	26	36	32	24	27	22
Evening Time	24	17	25	26	36	32	24	27	22
Night Time	24	17	25	26	36	32	24	27	22

Compliance is predicted at all receiver locations under Scenario B (Condition B) during all periods of the day.

With the management of the number and frequency of outdoor amplified music, the predicted noise levels show that the proposed site operations would comply with the DECCW's INP criteria at any period during the day and at any receiver locations.

6.5 STATEMENT OF POTENTIAL NOISE IMPACT

Careful considerations of potential noise sources under the maximum operational and construction stages have been made.

The inclusion of live bands or amplified music in each of the outdoor balcony areas represents the worst-case scenario. Under this scenario, the proposed site operations are predicted to be audible at receiver locations R4, R5, R6, R8 as discussed above.

By minimising the amplified music or the number of bands to 2 (two) within these outdoor areas, compliance is predicted at all receiver locations with the exception of R5 during the night time. The assumption that there will be bands playing at these outdoor areas is based on a precautionary approach and the actual operations of the proposed Marina may not require such outdoor activities. Therefore, the final maximum operations modelled exclude the outdoor bands to show the predicted noise levels in the absence thereof, and in the latter case, compliance is expected at all receiver locations.

Should the proposed operations of the Marina require outdoor live bands, it should be noted that the actual noise levels of the live bands may exceed the noise levels applied for the purposes of this assessment and therefore post-commissioning monitoring would be required to validate the actual operational levels.
The post-construction noise monitoring would also address any enhanced noise levels at the receiver locations due to the existing water bodies that surround the proposed site. Water is generally known to be an effective conduit of noise and therefore variations in offsite noise impacts may be apparent.

The methodologies and guiding principles of the DECCW's Industrial Noise Policy would be adhered to under the proposed site operations. Several factors increase the conservativeness of the study significantly and include:

- Adopting worst case source-specific sound power levels; and
- Configuring predictive noise impact scenarios that are based on maximum operating conditions and a noise enhancing weather condition.

Whilst the site operations have minimal potential for impact upon the local ambient noise environment, there are several simple measures that can be applied by management which would further reduce the potential for significant noise issues during the proposed operations:

1. Ensuring all 'noisy' construction and operational activities occur during the daytime period.
2. Awareness training of staff/contractors in environmental noise issues.
3. Completion of a noise compliance assessment during the construction phases.
4. Completion of a 3 months post commissioning noise compliance study, then a yearly compliance monitoring program during normal operations are recommended. The study will enable comparison to the background noise levels reported as part of this assessment; thereby ensuring industrial noise related 'creep' effects from the site are not apparent.
5. Establish a *Community Liaison Committee* and maintain a suitable complaint *Register* (in accordance with the site EMP). Any complaints received in relation to noise impacts will need to be recorded,

verified and followed up. Suitable noise minimisation measures and noise management techniques can then be implemented where necessary.

6.6 CONCLUSIONS

A detailed noise impact assessment was conducted for the proposed construction and operation of the Sydney Super Yacht Marina development located at Rozelle Bay.

Noise impacts for the proposed operations were modelled based on current NSW DECCW guidelines using conservative factors throughout. Noise design objectives were set in accordance with the criteria set out in the DECCW's Industrial Noise Policy and the Interim Construction Noise Guideline.

This assessment has shown that the set noise criteria (DECCW's INP) Project Specific Noise Levels (PSNL) will be achieved throughout with the management of outdoor amplified music activities during the operational phase. Under the predictive model scenario where there are 2 (two) outdoor live bands, a minor exceedance of 3 dB(A) is predicted at R5 during the night time period under noise enhancing meteorological conditions of 3 m/s source to receiver.

It should be noted that a noise level change of up to 3 dB(A) generally cannot be detected by the human auditory system and is therefore deemed insignificant. For predicted exceedances above this detectable threshold, staggered outdoor activities are recommended in order to maintain an acceptable acoustic environment at the receiver locations.

The predictive noise model has demonstrated that compliance is expected during the construction phase at all receiver locations. Noise mitigation and safeguards have been outlined in Section 6.3.2 of this report.

Even though no assessment can be considered as being thorough enough to preclude all potential environmental impacts, having given regard to the above listed conclusions, it is the finding of this assessment that the development application should not be refused on the grounds of excessive noise generation.

This concludes the report.

Brandon Burrell	R T Benbow
Acoustical Engineer	Principal Consultant

7. LIMITATIONS

Our services for this project are carried out in accordance with our current professional standards for site assessment investigations. No guarantees are either expressed or implied.

This report has been prepared solely for the use by Urban Perspectives, as per our agreement for providing environmental assessment services. Although all due care has been taken in the preparation of this study, no warranty is given, nor liability accepted (except that required by law) in relation to the information contained within this document.

Urban Perspectives are entitled to rely upon the findings in the report within the scope of work described in this report. No responsibility is accepted for the use of any part of the report in any other context or for any other purpose.

Opinions and judgements expressed herein, which are based on our understanding and interpretation of current regulatory standards, should not be construed as legal opinions.

ATTACHMENTS

Attachment 1: Glossary of Environmental Noise Terminology

Glossary of Noise Terminology

Acceptable Noise Level: The acceptable L_{Aeq} noise level from industrial sources, recommended by the NSW EPA (Table 2.1, INP). Note that this noise level refers to all industrial sources at the receiver location, and not only noise due to a specific project under consideration.

Acoustic Barrier*:* Solid walls or partitions, solid fences, earth mounds, earth berms, buildings, etc used to reduce noise, without eliminating it.

Adverse Weather: Weather conditions that affect noise (wind and temperature inversions) that occur at a particular site for a significant period of time. The previous conditions are for wind occurring more than 30% of the time in any assessment period in any season and/or for temperature inversions occurring more than 30% of the nights in winter.

Ambient Noise: The all-encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far.

Assessment Period: The period in a day over which assessments are made.

Assessment Point A: position at which noise measurements are undertaken or estimated.

Background Noise: Background noise is the term used to describe the underlying level of noise present in the ambient noise, measured in the absence of the noise under investigation, when extraneous noise is removed. It is described as the average of the minimum noise levels measured on a sound level meter and is measured statistically as the A-weighted noise level exceeded for ninety percent of a sample period. This is represented as the $\mathbf{L_{A90}}$ noise level.

Decibel [dB] : The units of sound pressure level.

dB(A): A-weighted decibels. Noise measured using the A filter.

Free field: An environment in which there are no acoustic reflective surfaces. Free field noise measurements are carried out outdoors at least 3.5m from any acoustic reflecting structures other than the ground.

Frequency: Frequency is synonymous to pitch. Frequency or pitch can be measured on a scale in units of Hertz (Hz).

Impulsive noise: Noise having a high peak of short duration or a sequence of such peaks. A sequence of impulses in rapid succession is termed repetitive impulsive noise.

Intermittent noise: Level that drops to the background noise level several times during the period of observation.

$\mathbf{L_{Amax}}$ The maximum sound pressure level measured over a period.

$\mathbf{L_{Amin}}$ The minimum sound pressure level measured over a period.

$\mathbf{L_{A1}}$ The sound pressure level that is exceeded for 1% of the time for which the sound is measured.

$\mathbf{L_{A10}}$ The sound pressure level that is exceeded for 10% of the time for which the sound is measured.

L_{A90} The level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L_{A90} noise level expressed in units of dB(A).

L_{Aeq} The "equivalent noise level" is the summation of noise events and integrated over a selected period of time.

Reflection: Sound wave changed in direction of propagation due to a solid object meeting on its path.

R-w: The Sound Insulation Rating R-w is a measure of the noise reduction performance of the partition.

SEL: Sound Exposure Level is the constant sound level which, if maintained for a period of 1 second, would have the same acoustic energy as the measured noise event. SEL noise measurements are useful as they can be converted to obtain L_{Aeq} sound levels over any period of time and can be used for predicting noise at various locations.

Sound Absorption: The ability of a material to absorb sound energy through its conversion into thermal energy.

Sound Level Meter: An instrument consisting of a microphone, amplifier and indicating device, having a declared performance and designed to measure sound pressure levels.

Sound Pressure Level: The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone.

Sound Power Level: Ten times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power.

Tonal noise: Containing a prominent frequency and characterised by a definite pitch.

Attachment 2: Meteorological Considerations

METEOROLOGICAL CONSIDERATIONS

The following meteorological study has been sourced from Benbow Environmental's previous noise study (Report 16080_rep rev 4) and has been provided for information purposes.

Meteorological Factors

The DEC's INP has been referenced in relation to assessing meteorological conditions in potential noise impacts. The Policy states:

> *"Wind effects need to be assessed where wind is a feature of the area. Wind is considered to be a feature where source-to-receiver wind speeds (at a 10m height) of 3m/s or below occur for 30 percent of the time or more in any assessment period (day, evening, night) in any season."*

Compliance under the noise enhancing meteorological conditions is required. (If appropriate – based on assessment of region-specific conditions).

Analysis of regional weather conditions has been carried out, special attention has been made to the wind. The results of this analysis are presented below.

A site-representative meteorological data file was created from data obtained from the Bureau of Meteorology (BoM). Wind speed, wind direction, and sigma theta data were measured at the BoM's Fort Denison monitoring station. Temperature data is not measured at the Fort Denison station and so was obtained from the BoM's stations at Observatory Hill. The years considered were from 1999 to 2005, inclusive. Mixing height and stability class values were calculated according to section 4.3.3 and 4.4.2, respectively, of the NSW EPA AMMAAP.

The Fort Denison and Observatory Hill monitoring stations were considered to be the most appropriate to reference, there being no other stations closer to the site. The stations are approximately 4 kilometres and 2 kilometres from the subject site, respectively. In addition, there are no significant terrain features between the stations and subject site that would greatly alter weather conditions for the two locations. Thus both the site and the monitoring station would be subject to similar weather conditions.

Wind

Seasonal wind rose plots have been included in the following section as Table 0-1 and Table 0-2. These tables show wind rose plots created from BoM measurements made over a period of 6 years along with wind rose plots for the year 2005, which was the year considered in this assessment.

Inspection of the two tables shows that wind rose plots for 2005 are similar to those for the longer time period, thus demonstrating that weather patterns in 2005 were not unusual and so the data for 2005 is acceptable for use as representative meteorological data for the region.

It can be seen in Table 0-1 (“All Seasons” wind rose plot) and Table 0-2 that winds, often moderate to strong throughout the year, originating from the west are the most common throughout the year with a frequency of 31%. Winds from northeast through south were had similar occurrences with frequencies ranging from 11% to 14% of the time.

In summer (considering only Table 0-1) winds tend to originate mainly from the east (23%) and north-east (21%), followed by contributions from the south-east and south each accounting for approximately 16% of winds. The 2005 data differs slightly from the longer period data here, with the 2005 data showing a smaller contribution from the northeast and a minor increase on winds from the southeast and west.

Wind patterns in autumn show a very dominant contribution from the west, accounting for approximately 34% of all winds for the season. Winds from the northeast through south were similar in occurrence, ranging in frequency from approximately 10% to 13%. After the dominant westerlies, the 2005 data shows the next most common directions of origins to be south and southeast, each with frequencies just above 14%.

In winter (considering only Table 0-2.) it is seen that again westerly winds dominate, though on a much larger scale, accounting for nearly 60% of winds for the season. Northwesterly winds were the next most common with a frequency of occurrence of approximately 12%. Winds from other directions were minor. The wind pattern for the 2005 data is essentially the same as for the longer period data.

Wind patterns in spring are more varied like those seen for summer. Winds from the west dominate the season, with a frequency of approximately 24%, followed by easterly winds (17%) and north-easterlies (17%). Smaller contributions come from the south (12%) and southeast (11%).

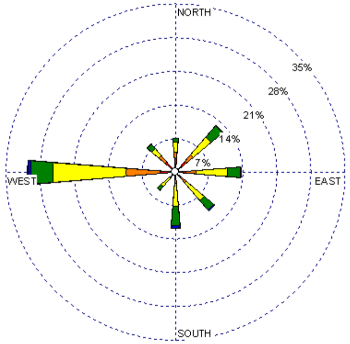
Average seasonal wind speed were noted to be similarly high throughout the year, ranging from 4.06m.s^{-1} (autumn) to 4.51 m.s^{-1} (summer), based on the long period data.

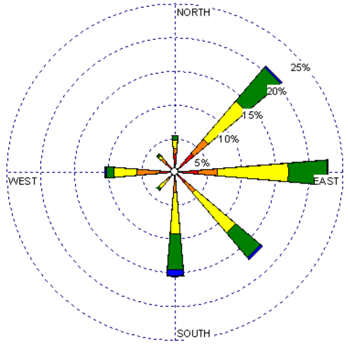
Wind Rose Plots

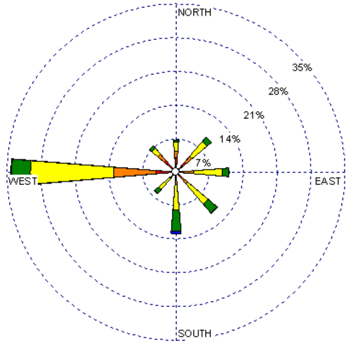
Wind rose plots show the direction from which the wind is coming with triangles known as “petals”. The petals of the plots in the figure summarise wind direction data into 8 compass directions ie. north, northeast, east, etc.

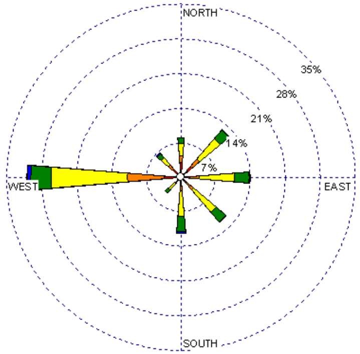
The length of the triangles, or “petals”, indicates the frequency that the wind blows from the direction presented. Longer petals for a given direction indicate a higher frequency of wind from that direction. Each petal is divided into segments, with each segment representing one of the six wind speed classes. Thus, the segments of a petal show what proportion of wind for a given direction falls into each class. The proportion of time for which wind speed is less than speeds in the first class (i.e. 0.5 m.s^{-1}), when speed is negligible, is referred to as calm hours or “calms”. Calms are not shown on a wind rose as they have no direction, but the proportion of time that they make up for the period under consideration is noted under each wind rose.

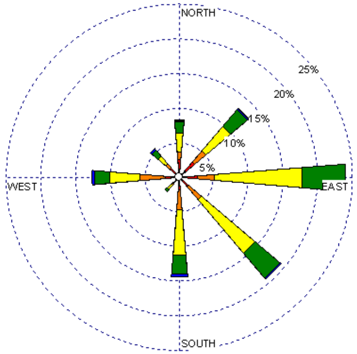
The concentric circles in each wind rose are the axis which denote frequencies. In comparing the plots it should be noted that the axis varies between wind roses, although all wind roses are the same size. The frequencies denoted on the axis of each wind rose are indicated beneath the wind rose.

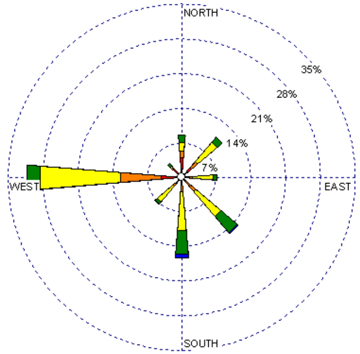
<table>
<tr><td colspan="5">Table 0-1: Comparison of Sydney Wind Rose Plots for 2005 With Wind Rose Plots for Longer Time Spans (All Seasons, Summer, and Autumn)</td></tr>
<tr><th>Year</th><th>All Seasons</th><th>Summer (December-February)</th><th>Autumn (March-May)</th><th>Legend</th></tr>
<tr><td>1999 – 2005</td>
<td>

Ave. wind speed: 4.34 m.s^{-1}
Calms: 0.51%
Axis Frequencies: 7%, 14%, 21%, 28%, 35%</td>
<td>

Ave. wind speed: 4.51 m.s^{-1}
Calms: 0.62%
Axis Frequencies: 5%, 10%, 15%, 20%, 25%</td>
<td>

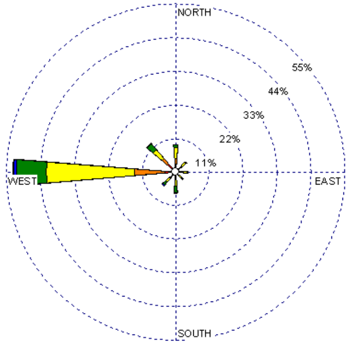
Ave. wind speed: 4.06 m.s^{-1}
Calms: 0.91%
Axis Frequencies: 7%, 14%, 21%, 28%, 35%</td>
<td rowspan="2">WIND SPEED (m/s)
>= 11.1
8.8 - 11.1
5.7 - 8.8
3.6 - 5.7
2.1 - 3.6
0.5 - 2.1</td></tr>
<tr><td>2005</td>
<td>

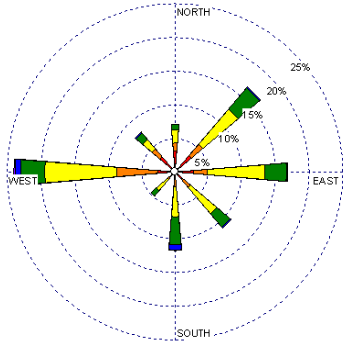
Ave. wind speed: 4.35 m.s^{-1}
Calms: 0.03%
Axis Frequencies: 7%, 14%, 21%, 28%, 35%</td>
<td>

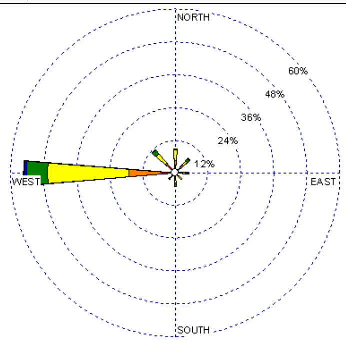
Ave. wind speed: 4.50 m.s^{-1}
Calms: 0.05%
Axis Frequencies: 5%, 10%, 15%, 20%, 25%</td>
<td>

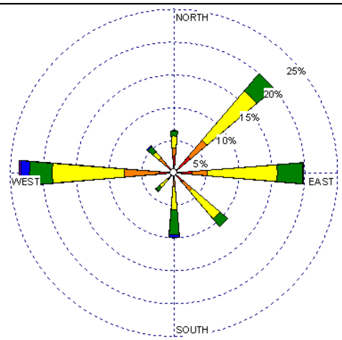
Ave. wind speed: 4.20 m.s^{-1}
Calms: 0.00%
Axis Frequencies: 7%, 14%, 21%, 28%, 35%</td></tr>
</table>

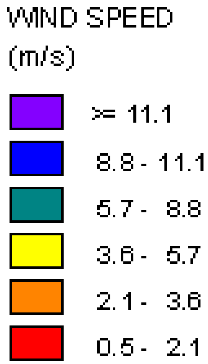
Table 0-2: Comparison of Sydney Wind Rose Plots for 2005 With Wind Rose Plots for Longer Time Spans (Winter and Spring)











Year	**Winter (June-August)**	**Spring (September-November)**	**Legend**
1999 – 2005	Ave. wind speed: 4.36 m.s^{-1} Calms: 0.21% Axis Frequencies: 11%, 22%, 33%, 44%, 55%	Ave. wind speed: 4.43 m.s^{-1} Calms: 0.31% Axis Frequencies: 5%, 10%, 15%, 20%, 25%	
2005	Ave. wind speed: 4.24 m.s^{-1} Calms: 0.09% Axis Frequencies: 12%, 24%, 36%, 48%, 60%	Ave. wind speed: 4.45 m.s^{-1} Calms: 0.00% Axis Frequencies: 5%, 10%, 15%, 20%, 25%	

Review of the data indicates noise enhancing meteorological conditions require no further consideration