RSA ACOUSTICS
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Proposed Marina Extension
St George Motor Boat Club, Sans Souci
Noise Impact Assessment

Report 4330R1
Revision 2

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Prepared For
Planning Ingenuity
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TABLE OF CONTENTS

TABLE OF CONTENTS

1 INTRODUCTION

The St George Motor Boat Club (the Club) is located at 2 Wellington Street, Sans Souci, approximately 250 m northwest of the Water Police site and 620 m northwest of the Sans Souci Wharf. The Club marina (the Marina) currently consists of 151 wet berths in a fixed structure, 128 of which have formal approval.

The proposed extension involves the provision of an additional 78 wet berths, 37 of which will be located on a new floating marina arm and 37 located on the southern side of the southernmost existing marina arm. The remaining 4 additional berths will be incorporated within the existing marina structure, following minor reconfiguration. The proposal also seeks formal approval for the existing unauthorised 23 wet berths. The proposal will result in the provision of wet berth accommodation for a total of 229 vessels.

The nearest residences are located to the east of the Marina. The existing wet berth structure is shown in **Figure 1** with the nearest residence located approximately 60 m to the east of the closest berth.

RSA Acoustics (RSA) has been engaged by Planning Ingenuity Pty Ltd to produce a noise impact assessment which is required to form part of the DA Environmental Assessment. Ambient noise and site specific noise levels were collated in order to quantify the noise environment that currently exists at the Marina.

Figure 1 St George Motor Boat Club Marina and Surrounds

Aerial image courtesy of Google Earth

2 EXISTING MARINA FACILITIES AND PROPOSED EXTENSION

2.1 Marina

The existing Marina consists of five floating structures providing 151 wet berths catering for vessels of various sizes. Of these wet berths, 128 have formal approval whilst 23 are unauthorised. The associated Marina office is located on shore at the eastern end of Arm C. Amenities facilities for patrons are located on the lower carpark level, beneath the Club building. The Marina includes a slipway located to the south of the office. Workshop facilities are also available on the site.

The proposed Marina extension comprises the provision of 78 additional wet berths as follows:

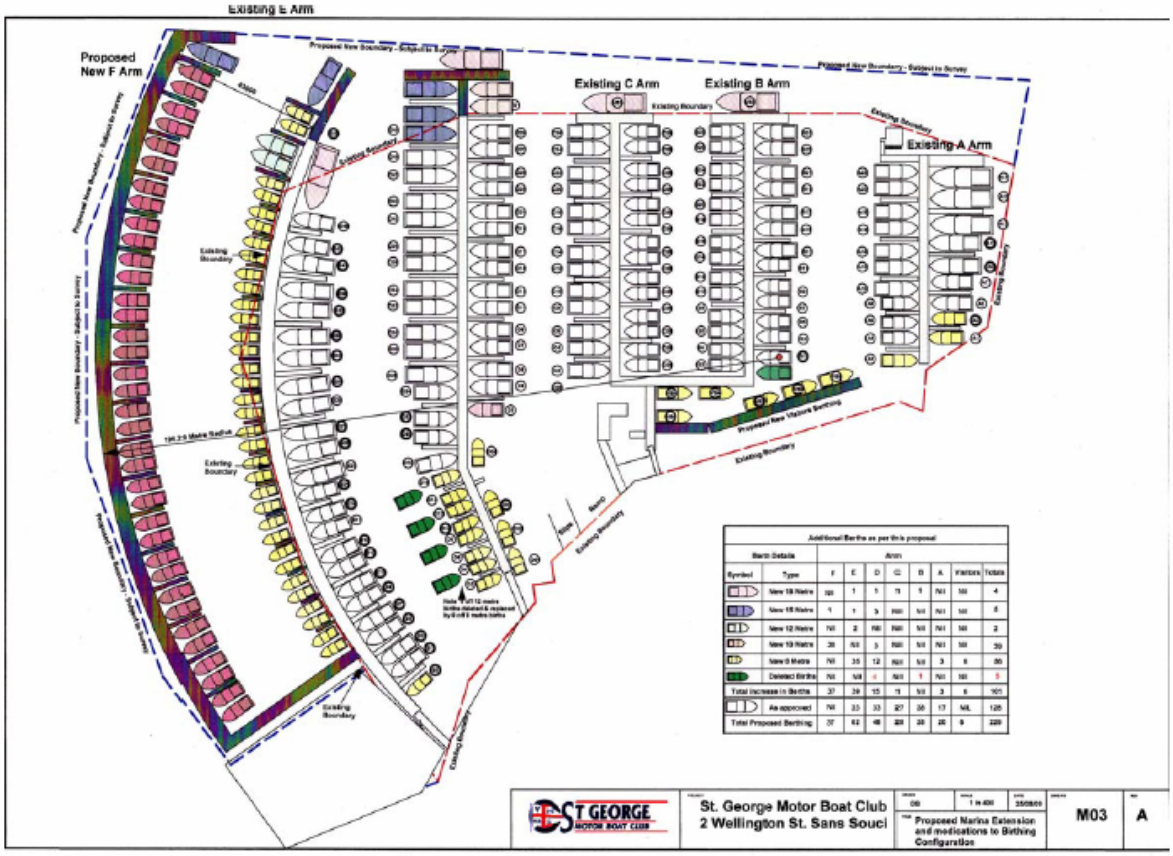
- Provision of 34 off 8 m, 2 off 12 m and 1 off 15 m additional wet berths on the southern side of existing Marina arm E;
- Construction of a new floating structure (Marina arm F) to accommodate 36 off 10 m and 1 off 15 m wet berths on the northern side of the floating arm;
- Reconfiguration of existing berthing layout to include an additional 4 wet berths (giving a total accommodation for 229 vessels);
- Installation of a new access gangway from Marina arm E to the new structure.

The proposed new Marina arm will be located approximately 43 m to the south of the existing arm E.

The normal operating hours for the office are generally 9.00 am to 6.00 pm 7 days during summer and 9.00 am to 5.00 pm 7 days during winter. Marina users have 24 hour access to the moored vessels by way of security gates at the end of each Marina arm. Maintenance activities are generally conducted between 8:00 am and 5:00 pm Monday to Friday with occasional weekend maintenance work as required, to re-launch boats.

The proposed Marina extension is shown in **Figure 2**.

Figure 2 Proposed Marina Extension



Drawing courtesy of the St George Motor Boat Club

2.2 Maintenance Activities

The existing vessel maintenance activities are proposed to continue, comprising general repairs, cleaning and antifouling. No major repairs or refitting are undertaken. There will be no change in the current operations of the slipway. Boats are winched up into the maintenance area by electro-hydraulic winch.

The typical maintenance activities conducted include:

- Antifouling using high pressure water cleaners;
- Hull and stainless steel polishing using electric buffs;
- Stern gear and leg maintenance using small hand tools; and
- Engine service involving small hand tools.

The major power tools used on site with respect to noise emissions consist of:

- air compressor;
- angle grinders; and
- high pressure water cleaner.

The noise that is generated by maintenance activities is non-continuous and loud periods of work are inter-dispersed with quiet periods. The noisiest operation is the use of the high pressure water cleaner. The noise from this cleaner is generated from the machine vibrating on the ground as it operates as well as from the rotary head, as it generates a pulsating water jet, resulting in regenerated noise from the ship's hull.

3 ASSESSMENT CRITERIA FOR NOISE EMISSIONS

3.1 DECCW Industrial Noise Policy (INP)

The NSW government's Industrial Noise Policy, 2000 (INP) is administered by the Department of Environment Climate Change and Water (DECCW) and provides guidelines for the assessment of noise impacts associated with industrial and commercial activities. It aims to balance the need for industrial activity with the desire for quiet within the community. The criteria selected are designed to protect at least 90 per cent of the population living in the vicinity of the industrial and commercial noise sources for at least 90 per cent of the time.

The INP's objectives are:

- To establish noise criteria that would protect the community from excessive noise;
- To preserve the amenity for specific land uses;
- To use the criteria for deriving project specific land uses; and
- To promote uniform methods to estimate and measure noise impacts, including a procedure for evaluating meteorological effects.

Implementation is achieved by ensuring:

- That noise from any single source does not intrude greatly above the prevailing background noise level. This is known as the intrusive noise criteria; and
- The background noise level does not exceed the level appropriate for the particular locality and land use. This is known as the amenity criteria.

In order to satisfy the above two requirements, intrusive noise and amenity noise criteria are recommended.

3.1.1 Assessing Intrusiveness

Given the inherent variable character of environmental noise, noise levels are quantified in terms of various statistical descriptors. A description of these descriptors and common acoustic terminology is contained within **Appendix A** for reference purposes.

In setting the "intrusive" noise goal, the ambient L_{A90} background noise level (in the absence of the noise source to be assessed) needs to be quantified at the nearest sensitive receivers. This is termed the Rating Background Level (RBL). It is a single descriptor (based on ambient noise monitoring) for each INP defined daytime (7 am to 6 pm), evening (6 pm to 10 pm) and night-time (10 pm to 7 am) assessment period, representing the typical minimum background sound level within those periods.

The RBL is obtained by calculating the median value of all day/evening/night Assessment Background Levels (ABLs) for each valid day of an ambient noise survey. The ABL is the background noise level representing each assessment period (daytime, evening and night-time) for each day of the survey. The ABL is determined by calculating the lower 10th percentile level of all the $L_{A90(15minute)}$ samples for each assessment period.

An "RBL plus 5 dBA" criterion is then applied to the 15-minute L_{Aeq} noise emissions of the industrial noise source in question at the receivers of interest (normally at their property boundary). This criterion is consistent with ensuring that industrial noise from any single source does not intrude greatly above the prevailing background noise level.

3.1.2 Assessing Amenity

The amenity noise criteria represent levels for each INP daytime, evening and night-time periods deemed to be acceptable for industrial noise emissions subject to specific land uses and associated activities.

The project specific amenity noise goal places a limit on noise emissions from a subject development based on how existing industrial/commercial-related noise levels relate to the INP recommended acceptable noise levels for various area categories, ie rural, suburban, urban, etc.

The resulting project specific amenity criteria for a facility then depend upon whether the existing industrial/commercial-related $L_{Aeq(period)}$ noise levels are lower or higher than the recommended acceptable amenity levels.

In areas where existing industrial/commercial-related noise levels are already high, the project specific amenity noise goal acts to limit further industrial noise emissions so that the cumulative impact of all industrial/commercial noise emissions does not result in a further exceedance of the acceptable amenity noise level.

Conversely, in areas where there is no existing industrial/commercial noise or planned future activity, the project specific amenity noise goal would be set at a level which allows industrial/commercial noise emissions up to recommended amenity levels for the area.

The DECCW provides recommended acceptable noise levels for residents located in 'Rural', 'Suburban', 'Urban' and 'Urban/Industrial' areas. Consistent with the INP, residences adjacent to the subject site would be considered Suburban. The recommended acceptable levels are shown **Table 1.**

Table 1 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	
			Acceptable	Recommended Maximum
Residence	Suburban	Day	55 dBA	60 dBA
		Evening	45 dBA	50 dBA
		Night	40 dBA	45 dBA

Notes: For Monday to Saturday, Daytime 0700 hours- 1800 hours; Evening 1800 hours - 2200 hours; Night-time 2200 hours - 0700 hours.

On Sundays and Public Holidays, Daytime 0800 hours - 1800 hours; Evening 1800 hours - 2200 hours; Night-time 2200 hours - 0800 hours.

The L_{Aeq} index corresponds to the level of noise equivalent to the energy average of noise levels occurring over a measurement period.

3.2 Sleep Disturbance

The most recent guidance in relation to sleep disturbance are those contained in the DECCW's *'Application Notes - NSW Industrial Noise Policy'* issued 21 February 2008. The pertinent section of the DECCW's Application Notes states the following:

> *"DEC reviewed research on sleep disturbance in the NSW Environmental Criteria for Road Traffic Noise (ECRTN) (EPA, 1999). This review concluded that the range of results is sufficiently diverse that it was not reasonable to issue new noise criteria for sleep disturbance.*
>
> *From the research, DEC recognised that current sleep disturbance criterion of an L_{A1}, (1 minute) not exceeding the L_{A90}, (15 minute) by more than 15 dBA is not ideal. Nevertheless, as there is insufficient evidence to determine what should replace it, DEC will continue to use it as a guide to identify the likelihood of sleep disturbance. This means that where the criterion is met, sleep disturbance is not likely, but where it is not met, a more detailed analysis is required.*
>
> *The detailed analysis should cover the maximum noise level or L_{A1}, (1 minute), that is, the extent to which the maximum noise level exceeds the background level and the number of times this happens during the night-time period. Some guidance on possible impact is contained in the review of research results in the appendices to the ECRTN. Other factors that may be important in assessing the extent of impacts on sleep include:*
>
> - *How often high noise events will occur.*
> - *Time of day (normally between 10pm and 7am).*
> - *Whether there are times of day when there is a clear change in the noise environment (such as during early morning shoulder periods).*
>
> *The LA1, (1 minute) descriptor is meant to represent a maximum noise level measured under 'fast' time response. DEC will accept analysis based on either LA1, (1 minute) or LAmax"*

Based on the DECCW guidance a sleep disturbance screening level of RBL + 15 dBA has been adopted.

3.3 INP Assessment of Prevailing Weather Conditions

Meteorological effects such as wind and temperature inversions need to be considered when these are a feature of the area under consideration. The closest residences to the Marina are typically located between 50 m and 100 m of the facility. At this distance, the impacts of temperature inversions and any potential source to receiver prevailing winds are negligible.

3.4 Construction Noise Control Guidelines

The DECCW issued the "*Interim Construction Noise Guideline"* in July 2009. The main objectives of the guideline are stated in Section 1.3, a portion of which is presented below:

- promote a clear understanding of ways to identify and minimise noise from construction works.
- focus on applying all 'feasible' and 'reasonable' work practices to minimise construction noise impacts.
- encourage construction to be undertaken only during the recommended standard hours unless approval is given for works that cannot be undertaken during these hours.

The guideline sets out Noise Management Levels (NMLs) at residences, and how they are to be applied, as presented in **Table 2**. This approach intends to provide respite for residents exposed to excessive construction noise outside the recommended standard hours whilst allowing construction during the recommended standard hours without undue constraints.

Table 2 Noise at Residences Using Quantitative Assessment

Time of Day	Management Level $L_{Aeq(15minute)}$[1]	How to Apply
Recommended standard hours: Monday to Friday 7.00 am to 6.00 pm Satuday 8.00 am to 1.00 pm No work on Sundays or public holidays	Noise affected RBL + 10 dBA	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured $L_{Aeq(15minute)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to minimise noise. The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details
	Highly noise affected 75 dBA	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the proponent should consider very carefully if there is any other feasible and reasonable way to reduce noise to below this level. If no quieter work method is feasible and reasonable, and the works proceed, the proponent should communicate with the impacted residents by clearly explaining the duration and noise level of the works, and by describing any respite periods that will be provided.
Outside recommended standard hours	Noise affected RBL + 5 dBA	A strong justification would typically be required for works outside the recommended standard hours. The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5 dBA above the noise affected level, the proponent should negotiate with the community.

Note 1: Noise levels apply at the property boundary that is most exposed to construction noise. If the property boundary is more than 30 m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 m of the residence.

4 AMBIENT NOISE SURVEY

An ambient noise survey was carried out via unattended monitoring in close proximity to nearby residential premises. The results of attended noise measurements carried out at the Marina and during previous project work at similar facilities were used to characterise the noise levels typically emitted from operational activities.

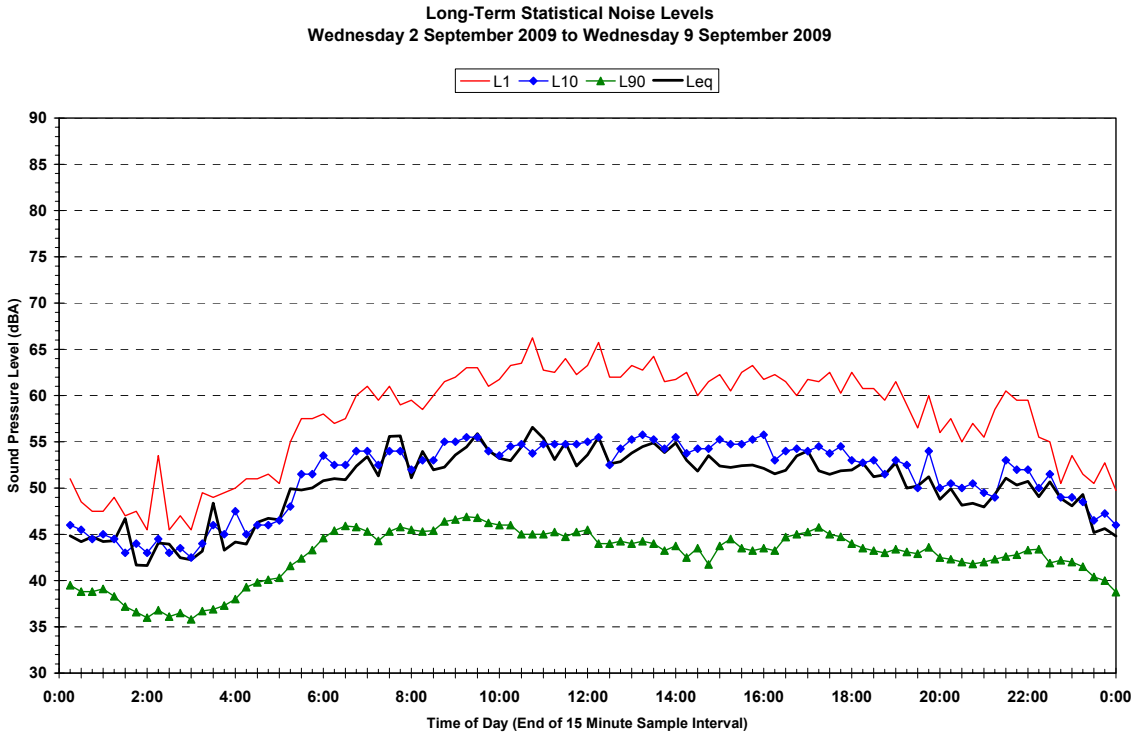
4.1 Unattended Measurements

Unattended noise monitoring was carried out at the south-eastern boundary of the Club site, directly opposite the residential premises located at 50 Plimsoll Street, Sans Souci. This residence is the nearest potentially sensitive receiver to the proposed Marina extension.

Monitoring was carried out from Wednesday 2 September 2009 to Wednesday 9 September 2009. An Acoustic Research Laboratory (ARL) environmental noise logger Type EL 215 was deployed to continuously record the ambient noise levels over the survey period in 15 minute intervals. Calibration of the noise logger was checked prior to and following the measurements and the drift in calibration did not exceed ±0.5 dBA. Data affected by adverse weather conditions during the survey has been excluded from the processed results.

A representative 24 hour period of ambient noise monitoring is shown in **Figure 3**. The data presented incorporates the median values of the L_{A1}, L_{A10} and L_{A90} together with the logarithmic average of the L_{Aeq} levels for the corresponding 15 minute periods of each day.

Figure 3 Ambient Noise Survey – 24 Hour Summary



4.2 Data Analysis

The results of the noise monitoring have been processed in accordance with the procedures contained in the DECCW's INP to establish representative noise levels that occur at surrounding receivers.

The Rating Background Noise Level (RBL) is the background noise level nominated in the INP against which to assess the intrusiveness of noise at the nearest potentially affected residence. It is representative of the typical minimum background sound level during each INP defined daytime, evening and night-time assessment period. The LA90(15minute) RBL and LAeq(15minute) ambient noise levels are summarised in **Table 3**.

Table 3 Measured Ambient Noise Levels

Location	Noise Level - dBA re 20 µPa					
	Daytime 0700 - 1800		Evening 1800 - 2200		Night-time 2200 - 0700	
	RBL [1]	LAeq [2]	RBL [1]	LAeq [2]	RBL [1]	LAeq [2]
Opposite 50 Plimsoll Street	45	53	43	50	38	48

Note 1: The Rated Background Level (RBL) is the single figure level based on ambient noise measurements, for each day, evening and night-time period, representative of the typical minimum background sound level for that period. By definition the RBL is obtained by calculating the median values of day/evening/night Assessment Background Levels (ABL's) of each day of the ambient noise survey. The ABL is the single figure background noise level representing each assessment period (day, evening and night) for each day of the survey. The ABL is determined by calculating the lower 10 percentile level of all LA90(15minute) samples for each assessment period.

Note 2: The LAeq is the logarithmic average of the 15 minute sample in each assessment period.

4.3 Attended Noise Survey

The unattended noise monitoring was supplemented with attended noise measurements for operational emissions of boats entering and leaving the moorings. This was carried out at the existing Marina area.

The attended noise measurements were conducted during the morning of 2 September 2009 using a Bruel & Kjaer 2260 Precision Sound Level Meter. Calibration of the meter was checked before and after the noise measurements. During the survey, there was negligible wind and fine weather with small swell.

The results of the attended measurements are presented in **Table 4** together with the results obtained during previous surveys of boat/operational noise and noise emissions from typical maintenance activities.

Table 4 Marina Operational Noise Levels

Location	$L_{Aeq(15minute)}$ Noise Level in dBA	Distance to source	Comments
St George Motor Boat Club Marina	65	3 m	Mercruiser 6.2l V8 low to high idle
St George Motor Boat Club Marina	63	3 m	Mercruiser 6.2l V8 start and reversing from mooring
St George Motor Boat Club Marina	61	3 m	Mercruiser 6.2l V8 return to wet berth and mooring
St George Motor Boat Club Marina	69	2 m	32 ft Riviera bowthruster
Double Bay Marina Workshop Area	63	3.5 m	Winch lowering a boat back into the water. Measured at 3.5m
Double Bay Marina Workshop Area	62	2.5 m	Winch raising a boat from the water. Measured at 2.5m
Double Bay Marina Workshop Area	54	1 m	Fuel Pump under work area.
Double Bay Marina Wharf Area	68	5 m	60HP outboard passby noise level
Double Bay Marina Wharf Area	56	15 m	60HP outboard tow boat bringing a vessel to mooring
Double Bay Marina Wharf Area	60	Approximately 3 m from vessel hull	Wave boat noise
Double Bay Marina Wharf Area	60	5 m	Boat loading onto slipway
Double Bay Marina Workshop Area	64	5 m	Garden hose on hull of vessel
Double Bay Marina Workshop Area	91	4 m	High pressure cleaner on hull of vessel
Double Bay Marina Workshop Area	84	1 m	2HP 50L Air compressor
Double Bay Marina Workshop Area	86	1 m	125mm Angle Grinder

5 PROJECT SPECIFIC OPERATIONAL AND CONSTRUCTION NOISE GOALS

Based on the NSW DECCW's INP and the Interim Construction Noise Guideline presented in **Section 3**, site specific criteria for operational and construction activities have been determined.

For operational noise, the overall noise criterion for noise emissions from the site is the lower of the intrusive and amenity criteria. Note that the intrusive criterion is assessed over any 15 minute period whereas the amenity level is assessed over the appropriate daytime, evening or night-time period. The controlling criteria are as follows:

Table 5 Operational Noise Criteria

Time Period	$L_{Aeq(15min)}$ Criteria in dBA	Sleep disturbance L_{Amax} criteria in dBA
Day (7.00 am to 6.00 pm)	50	-
Evening (6.00 pm to 10.00 pm)	40	-
Night (10.00 pm to 7.00 am)	38	53

For construction noise a daytime NML of 55 dBA applies to the Marina upgrade.

6 OPERATIONAL NOISE ASSESSMENT

6.1 Noise from Vessels

Operational activities of the Marina will continue in the same manner as currently occurs. Marina users have unrestricted access to their vessels via security gates to each of the Marina arms. Boats may therefore leave and return at any time, although this will usually occur during daylight hours.

The "on water" operation of the Marina is passive, with the primary noise source being boat engines as boats arrive and leave. The proposed expansion of the wet berths involves extending the facility further south with additional berths constructed on the southern side of the existing Marina arm E and the construction of a new Marina arm F. The distance between the location of the closest existing wet berth and the nearest residential receiver at 50 Plimsoll Street is approximately 60 m. The location of the closest proposed wet berth remains in the order of 50 m to 55 m from the residential premises. As such there would likely be little change in the perceived level of boat engine noise received at this residence as a result of the proposed extension.

Based on measurements of a typical cruiser engine leaving and returning to the mooring, and assuming a scenario with constant operation for 5 minutes, the $L_{Aeq(15minute)}$ noise level at the nearest residence is predicted to range between 32 dBA to 34 dBA, which complies with the $L_{Aeq(15minute)}$ daytime, evening and night-time operational goals of 50 dBA, 40 dBA and 38 dBA respectively.

The underlying "long term" ambient noise associated with the Marina consists of wave noise against the boats. The existing southern arm E acts as a breakwater. The proposed new arm will act as the breakwater following construction and calmer conditions are expected at the new vessel locations. As such, wave noise to the nearest residence would essentially remain similar to existing conditions.

6.2 Sleep Disturbance

Noise emissions have been predicted for people talking at raised, loud and shouting voice levels, on board a vessel at the proposed wet berth in closest proximity to the residential receivers. The calculations were based on the data for "normal", "raised", "loud" and "shouting" talkers, presented in the C M Harris text *"Handbook of Acoustical Measurements and Noise Control".* The corresponding sound power levels are 66 dBA, 73 dBA, 83 dBA and 96 dBA for a normal, raised, loud and shouting talker, respectively.

The results of the calculations are summarised as follows:

- The night-time sleep disturbance criterion is complied with for people talking in "raised" and "loud" voices aboard a moored vessel. A marginal 1 dBA exceedance of the criterion is predicted for "shouting".
- The disposal of garbage and bottles into bins located in the lower level carpark area has the potential to exceed the night-time sleep disturbance criterion.
- Based upon the measured level of bowthruster noise, emissions due to the use of bowthrusters comply with the night-time sleep disturbance criterion of 53 dBA.

Where patrons talking (normal, raised, loud and shouting) and other potential sleep disturbing events such as the disposal of bottles exceed the sleep disturbance level, it is recommended that this be addressed in the Marina Noise Management Plan / Code of Conduct.

6.3 Maintenance Activities

Noise from maintenance activities only occurs during daytime hours between 8.00 am to 5.00 pm Monday to Friday and occasionally on weekends as required.

The maintenance activities that are carried out in the hardstand area are cleaning, antifouling, painting and general ship and motor repairs. The slipway hours are the same as the general hours. Typical equipment and associated noise levels with the predicted noise levels at the closest resident are shown in Table 6.

Table 6 Typical Equipment Sound Power Levels and Predicted Noise Levels

Operation/Activity	Calculated A weighted sound power level in dBA re 10^{-12} W	Distance[1]	Loss due to Shielding[2] dBA	Receiver LAeq Noise Level in dBA [3]
Winch Lowering	82	100 m	5	24
Boat loading onto slipway	82	100 m	5	24
Winch pulling ship onto dock	79	100 m	5	21
Garden Hose on hull	86	100 m	5	28
Pressure Cleaner	111	100 m	5	53
50L Air Compressor	92	100 m	5	34
Angle Grinder	94	100 m	5	36

Notes
1. Typical minimum distance from the noise source to the nearest residential façade.
2. Attenuation due to shielding by intervening structures has been conservatively estimated.
3. The receiver noise level includes an adjustment when operation is not continuous for 15 minutes.

For daytime operation the design goal is 50 dBA. Calculations for the operational maintenance activities presented in **Table 6** are summarised as follows:

- Maintenance activities generally comply with the noise level design goal. The operation of the high pressure cleaner may result in a marginal (up to 3 dBA) exceedance of the criterion.

6.4 Road Traffic

A traffic study for the proposed development has been conducted by traffic and transport consultants, Transport and Urban Planning. Traffic counts were undertaken at three locations, Vista Street, Wellington Street and Plimsoll Street, on Sunday 13 September 2009. Plimsoll Street was shown to have the lowest existing traffic volume of the three streets, occurring between 8.00 am and 9.00 am.

According to Transport and Urban Planning, the additional 78 new berths would result in another 28 vehicles arriving and departing on a Sunday (Sunday being the busiest day), with a total of 56 additional vehicle movements over the day.

A worst case projection is that 60% of these vehicles, ie 17 vehicles, arrive in the morning and depart in the afternoon over the same one hour period. The worst case acoustical scenario would occur on Plimsoll Street between 8.00 am and 9.00 am when the existing traffic volume is the lowest and therefore the relative increase in vehicular movements would have the greatest impact.

Traffic counts indicate that approximately 87% of vehicles entering the carpark do so via Plimsoll Street (the remaining 13% entering via Vista Street). Based upon the traffic projections, with 15 additional traffic movements (87% of 17 vehicles) on Plimsoll Street between 8.00 am and 9.00 am, the existing 1 hourly road traffic noise level would increase by less than 2 dBA. This marginal increase would not be discernible to surrounding residents and is acoustically insignificant.

7 CONSTRUCTION NOISE ASSESSMENT

To determine the acoustical impact of the Marina extension in relation to construction noise on the surrounding residences, calculations were performed in order to identify the significant noise sources and scenarios that could potentially affect the nearest residential properties. The nearest residence in Plimsoll Street is located approximately 50 m from the closest new wet berth.

7.1 Construction Overview

The overall construction period of Marina Arm F and the additional berths on Marina Arm E is estimated at between five and six months with the off-site pre-fabrication works taking around two to three months and three months for on-site installation.

There are no dredging works associated with the marina extension and the marina modules will be manufactured off-site, transported by semi-trailer, craned and floated into position. The floating modules will be bolted together and attached to the piles using hand tools. No fabrication work will be conducted on site.

The proposed method for the installation of piles is by boring.

Construction works will be carried out in accordance with the guidelines recommended in the ENCM. Specific phases will be refined by contractors. Most of the construction activity will be over water during the Marina extension.

The sound power levels given in **Table 7** are maximum noise emission levels of plant that may or will be used in this project.

In order to apply the construction noise criteria for the project, it is necessary to convert these levels to equivalent $L_{A10(15minute)}$ noise emissions. The adjustment that has been applied to this project is:

- 4 dBA for equipment characterised by reasonably continuous noise emissions (eg bored piling) ;
- 7 dBA for equipment characterised by intermittent noise emissions (eg trucks, crane, etc).

7.2 Construction Scenarios

The calculated results from construction activities associated with the Marina extension are presented in **Table 7**. The criterion to be complied with is an RBL +10 dBA for works not exceeding 26 weeks.

Table 7 Predicted Construction Noise Levels - dBA re 20 µPa

Plant items	Sound Power Level dBA	Correction Factor dBA	Criteria dBA	Predicted L_{A10} Noise Level at the Nearest Residence	Exceedance
Truck	107	-7	55	60 dBA	5 dBA
Crane	107	-7	55	60 dBA	5 dBA
Bored Piling	108	-4	55	50 – 64 dBA	0-9 dBA

Note 1 The nearest distance from the noise source to the receiver is assumed to be 40 m for truck movements on site, 40 m for crane activity and 40 m to 200 m for piling works.

7.2.1 Assessment of Noise Impacts

For the limiting daytime period, the design goal is 55 dBA for nearby residential receivers. Calculations of the maximum noise emissions associated with construction works are presented in **Table 7** and summarised in the following points:

- The noisiest operation is during piling, with exceedances of the design target of up to 9 dBA when the rig is operating in closest proximity to the residences to the northeast of the construction zone.
- Exceedances of up to 5 dBA may occur at the nearest residential receivers on Plimsoll Street during deliveries of piers and floating modules to the site and operation of the crane.

7.3 Noise Mitigation of Construction Activities

Significant exceedances of the design goals of up to 9 dBA may occur as a result of the bored piling operations and 5 dBA for truck and crane activity on site. Noise mitigation strategies should therefore be implemented wherever possible during these construction works.

7.3.1 Noise Mitigation Strategies

The DECCWs "*Interim Construction Noise Guideline"* and AS 2436-1981 "*Guide to Noise Control on Construction, Maintenance and Demolition Sites*" set out numerous practical recommendations to assist in mitigating construction noise emissions. Examples of strategies that could be implemented on the Marina extension are listed below, including the typical noise reduction achieved, where applicable.

Operational Strategies

- Conduct piling after 8 am, and include respite periods.
- Conduct excavation and off-site disposal of fill during the daytime.
- Regular compliance checks on the noise emissions of all plant and machinery used for the project would indicate whether noise emissions from plant items were higher than normal.
- Ongoing noise monitoring during construction at sensitive receivers during critical periods (ie times when noise emissions are expected to be at their highest - eg piling) will assist in identifying and controlling high risk noise events.

Source Noise Control Strategies

- Engines and exhausts are typically the dominant noise sources on mobile plant such as cranes, trucks, etc. In order to minimise noise emissions, residential grade mufflers should be fitted on all mobile plant utilised on site.
- Regular maintenance of all plant and machinery used for the project will assist in minimising noise emissions.
- Acoustic enclosures of plant items, if required.

Community Consultation

Active community consultation and the maintenance of positive relations with local residents would assist in alleviating concerns and thereby minimising complaint. The community is more likely to be understanding and accepting of noise if the information provided is frank, does not attempt to understate the likely noise level, and if commitments are firmly adhered to.

- To nearby residents provide, reasonably ahead of time, information such as total construction time, what works are expected to be noisy, their duration, what is being done to minimise noise and when respite periods will occur.

- Use a site information board at the front of the site with the name of the organisation responsible for the site and their contact details, hours of operation and regular information updates. This signage should be clearly visible from the outside and include after hours emergency contact details.

8 CONCLUSION

RSA Acoustics Pty Ltd (RSA) has been engaged by Planning Ingenuity to produce a noise impact assessment for the proposed extension of the St George Motor Boat Club marina.

The results of the study are summarised in the following points:

- An ambient noise survey was conducted and operational and construction design criteria developed in accordance with the NSW DECCW's Industrial Noise Policy and Interim Construction Noise Guideline. A daytime operational goal of 50 dBA and construction goal of 55 dBA were set.
- The "on water" operation of the Marina is passive, with the primary noise source boat engine noise as boats arrive and leave. No significant change in operational noise to eastern residences is expected from boats leaving/arriving the Marina as a result of the extension.
- Patrons "shouting" on boats moored in closest proximity to the eastern residence at night have the potential for sleep disturbance, along with the disposal of bottles. It is recommended these issues be addressed in the Marina Noise Management Plan / Code of Conduct.
- For existing maintenance activities the noisiest activity is the pressure cleaner which may at times marginally exceed (by around 3 dBA) the daytime operational criterion. Other activities such as vessel manoeuvring and general cleaning comply with the design goal.
- Additional road traffic generated due to the proposed marina extension is not significant in terms of acoustical impact.
- Predicted noise levels at the nearest residences from construction activities are expected to exceed the daytime period noise design goal. The exceedances range from 5 dBA to 9 dBA for bored piling and crane and truck movements on site. It should be noted that it is common for noise from construction activities to exceed the daytime period noise goal, being a result of the nature of the activities and the often relative close proximity of sensitive receivers. Noise mitigation strategies have the potential to minimise impacts and should therefore be implemented wherever practical during construction works.

ACOUSTIC TERMINOLOGY USED IN THE REPORT

1 Sound Level or Noise Level

The terms "sound" and "noise" are almost interchangeable, except that in common usage "noise" is often used to refer to unwanted sound.

Sound (or noise) consists of minute fluctuations in atmospheric pressure capable of evoking the sense of hearing. The human ear responds to changes in sound pressure over a very wide range. The loudest sound pressure to which the human ear responds is ten million times greater than the softest. The decibel (abbreviated as dB) scale reduces this ratio to a more manageable size by the use of logarithms.

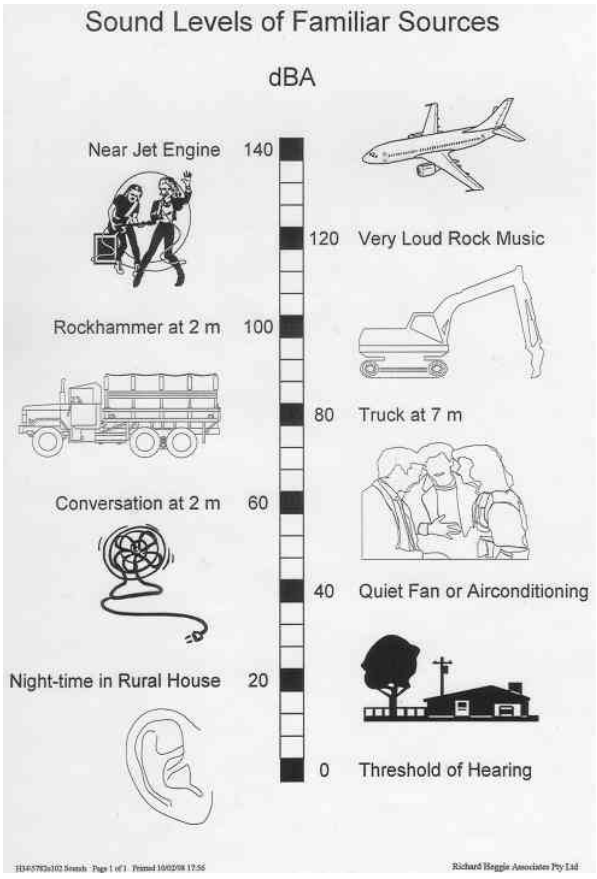
The symbols SPL, L or L_P are commonly used to represent Sound Pressure Level. The symbol L_A represents A-weighted Sound Pressure Level. The standard reference unit for Sound Pressure Levels expressed in decibels is 2×10^{-5} Pa.

2 "A" Weighted Sound Pressure Level

The overall level of a sound is usually expressed in terms of dBA, which is measured using a sound level meter with an "A-weighting" filter. This is an electronic filter having a frequency response corresponding approximately to that of human hearing.

People's hearing is most sensitive to sounds at mid frequencies (500 Hz to 4000 Hz), and less sensitive at lower and higher frequencies. Thus, the level of a sound in dBA is a good measure of the loudness of that sound. Different sources having the same dBA level generally sound about equally loud.

A change of 1 dBA or 2 dBA in the level of a sound is difficult for most people to detect, whilst a 3 dBA to 5 dBA change corresponds to a small but noticeable change in loudness. A 10 dBA change corresponds to an approximate doubling or halving in loudness. The figure below lists examples of typical noise levels



Other weightings (eg B, C and D) are less commonly used than A-weighting. Sound Levels measured without any weighting are referred to as "linear", and the units are expressed as dB(lin) or dB.

3 Sound Power Level

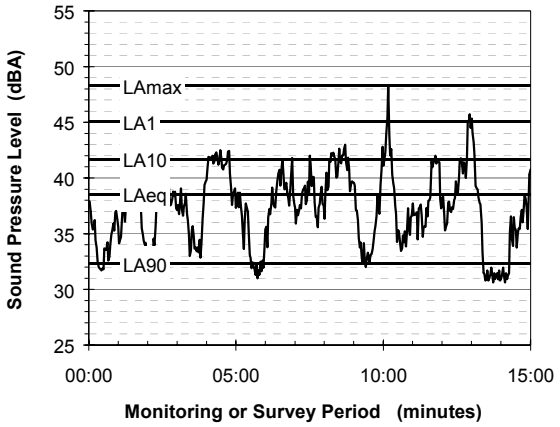
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or L_W, or by the reference unit 10^{-12} W.

The relationship between Sound Power and Sound Pressure may be likened to an electric radiator, which is characterised by a power rating, but has an effect on the surrounding environment that can be measured in terms of a different parameter, temperature.

4 Statistical Noise Levels

Sounds that vary in level over time, such as road traffic noise and most community noise, are commonly described in terms of the statistical exceedance levels L_{AN}, where L_{AN} is the A-weighted sound pressure level exceeded for N% of a given measurement period. For example, the L_{A1} is the noise level exceeded for 1% of the time, L_{A10} the noise exceeded for 10% of the time, and so on.

The following figure presents a hypothetical 15 minute noise survey, illustrating various common statistical indices of interest.



Of particular relevance, are:

L_{Amax} The maximum noise level during the 15 minute interval

L_{A1} The noise level exceeded for 1% of the 15 minute interval.

L_{A10} The noise level exceed for 10% of the 15 minute interval. This is commonly referred to as the average maximum noise level.

L_{A90} The noise level exceeded for 90% of the sample period. This noise level is described as the average minimum background sound level (in the absence of the source under consideration), or simply the background level.

L_{Aeq} The A-weighted equivalent noise level (basically the average noise level). It is defined as the steady sound level that contains the same amount of acoustical energy as the corresponding time-varying sound.

When dealing with numerous days of statistical noise data, it is sometimes necessary to define the typical noise levels at a given monitoring location for a particular time of day. A standardised method is available for determining these representative levels.

ACOUSTIC TERMINOLOGY USED IN THE REPORT

This method produces a level representing the "repeatable minimum" L_{A90} noise level over the daytime and night-time measurement periods, as required by the EPA. In addition the method produces mean or "average" levels representative of the other descriptors (L_{Aeq}, L_{A10}, etc).

5 Tonality

Tonal noise contains one or more prominent tones (ie distinct frequency components), and is normally regarded as more offensive than "broad band" noise.

6 Impulsiveness

An impulsive noise is characterised by one or more short sharp peaks in the time domain, such as occurs during hammering.

7 Frequency Analysis

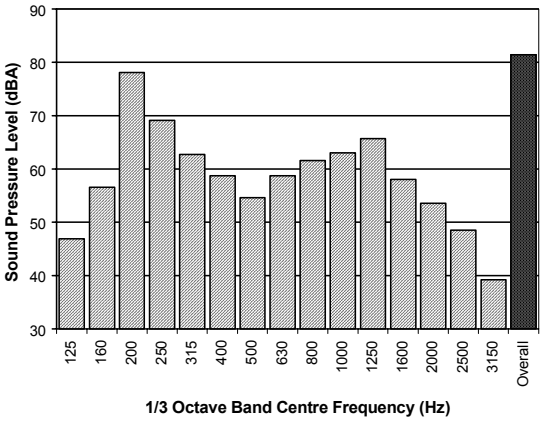
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal. This analysis was traditionally carried out using analogue electronic filters, but is now normally carried out using Fast Fourier Transform (FFT) analysers.

The units for frequency are Hertz (Hz), which represent the number of cycles per second.

Frequency analysis can be in:

- Octave bands (where the centre frequency and width of each band is double the previous band)
- 1/3 octave bands (3 bands in each octave band)
- Narrow band (where the spectrum is divided into 400 or more bands of equal width)

The following figure shows a 1/3 octave band frequency analysis where the noise is dominated by the 200 Hz band. Note that the indicated level of each individual band is less than the overall level, which is the logarithmic sum of the bands.



8 Vibration

Vibration may be defined as cyclic or transient motion. This motion can be measured in terms of its displacement, velocity or acceleration. Most assessments of human response to vibration or the risk of damage to buildings use measurements of vibration velocity. These may be expressed in terms of "peak" velocity or "rms" velocity.

The former is the maximum instantaneous velocity, without any averaging, and is sometimes referred to as "peak particle velocity", or PPV. The latter incorporates "root mean squared" averaging over some defined time period.

Vibration measurements may be carried out in a single axis or alternatively as triaxial measurements. Where triaxial measurements are used, the axes are commonly designated vertical, longitudinal (aligned toward the source) and transverse.

The common units for velocity are millimetres per second (mm/s). As with noise, decibel units can also be used, in which case the reference level should always be stated. A vibration level V, expressed in mm/s can be converted to decibels by the formula 20 log (V/V_o), where V_o is the reference level (10^{-9} m/s). Care is required in this regard, as other reference levels may be used by some organizations.

9 Human Perception of Vibration

People are able to "feel" vibration at levels lower than those required to cause even superficial damage to the most susceptible classes of building (even though they may not be disturbed by the motion). An individual's perception of motion or response to vibration depends very strongly on previous experience and expectations, and on other connotations associated with the perceived source of the vibration. For example, the vibration that a person responds to as "normal" in a car, bus or train is considerably higher than what is perceived as "normal" in a shop, office or dwelling.

10 Over-Pressure

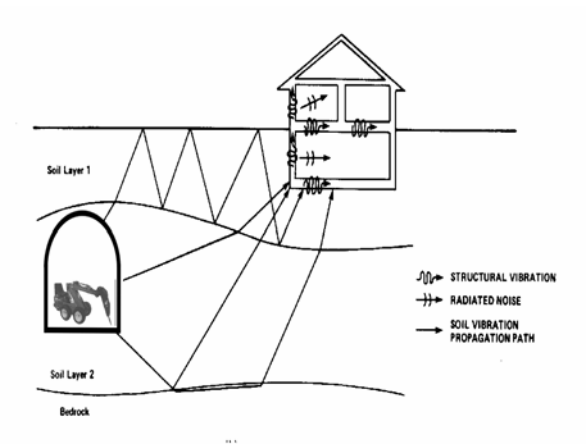
The term "over-pressure" is used to describe the air pressure pulse emitted during blasting or similar events. The peak level of an event is normally measured using a microphone in the same manner as linear noise (ie unweighted), at frequencies both in and below the audible range.

11 Ground-borne Noise, Structure-borne Noise and Regenerated Noise

Noise that propagates through a structure as vibration and is radiated by vibrating wall and floor surfaces is termed "structure-borne noise", "ground-borne noise" or "regenerated noise". This noise originates as vibration and propagates between the source and receiver through the ground and/or building structural elements, rather than through the air.

Typical sources of ground-borne or structure-borne noise include tunnelling works, underground railways, excavation plant (eg rockbreakers), and building services plant (eg fans, compressors and generators).

The following figure presents the various paths by which vibration and ground-borne noise may be transmitted between a source and receiver for construction activities occurring within a tunnel.



The term "regenerated noise" is also used in other instances where energy is converted to noise away from the primary source. One example would be a fan blowing air through a discharge grill. The fan is the energy source and primary noise source. Additional noise may be created by the aerodynamic effect of the discharge grill in the airstream. This secondary noise is referred to as regenerated noise