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Prospect Highway Upgrade

Detailed Design Acoustic Assessment

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Detailed Design Acoustic Assessment

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1 INTRODUCTION

1.1 Background

The Prospect Highway Upgrade received project approval in September 2014. The 3.6 km upgrade, located around 30 km west of Sydney's Central Business District (CBD), aims to upgrade the Prospect Highway between Reservoir Road at Prospect and St Martins Crescent at Blacktown.

The project provides additional lanes on Prospect Highway which would be achieved primarily through road widening within the existing road corridor.

1.2 Scope of this Report

Development of the Detailed Design of the project is being delivered by SMEC on behalf of Roads and Maritime Services (Roads and Maritime or RMS). SLR Consulting Pty Ltd (SLR) has been commissioned by SMEC to provide an acoustic review of the Detailed Design of the project in accordance with project's Detail Design Brief documentation.

A Review of Environmental Factors (REF) was completed for the project in June 2014. As part of the REF, a noise and vibration technical paper was produced by SKM which assessed the likely operational and construction noise impacts from the project.

The operational noise assessment of the REF noise and vibration technical paper identified 231 sensitive receivers as being eligible for consideration of additional noise mitigation. The recommended mitigation option included four potential noise barriers combined with at-property architectural treatment of the residual noise impacts.

1.3 Relevant Guidelines

Noise from the operation of the project is required to be assessed in accordance with guidelines provided in the NSW *Road Noise Policy* (RNP) (DECCW, 2011). Roads and Maritime provide additional guidance for assessing operational road noise impacts in the *Environmental Noise Management Manual* (ENMM) (RTA, 2001) and in the recently released *Noise Criteria Guideline* (NCG) (RMS, 2015).

The NCG supersedes Practice Note (i) of the ENMM and provides a consistent approach to identifying road noise criteria for Roads and Maritime projects and meets the intention of the RNP.

Guidance for additional noise mitigation is taken from the Roads and Maritime *Noise Mitigation Guideline* (NMG) (RMS, 2015). The NMG supersedes Practice Note (iv), (iv-a) and (iv-c) of the ENMM.

Roads and Maritime have confirmed that the current NCG and NMG are to be used for assessing the Detailed Design of this project. This ensures consistency with the recently assessed M4 Motorway Smart Motorway project, which is to the south of Prospect Highway. It is noted that the project's REF was undertaken prior to the release of the NCG and NMG and was therefore completed with reference to the ENMM.

1.4 Terminology

The assessment has used specific acoustic terminology, and an explanation of common terms is included as **Appendix A**.

2 PROJECT DESCRIPTION

Prospect Highway functions as a principal arterial road linking major residential, commercial and industrial areas to the M4 Western Motorway, M7 Motorway and M2 Hills Motorway.

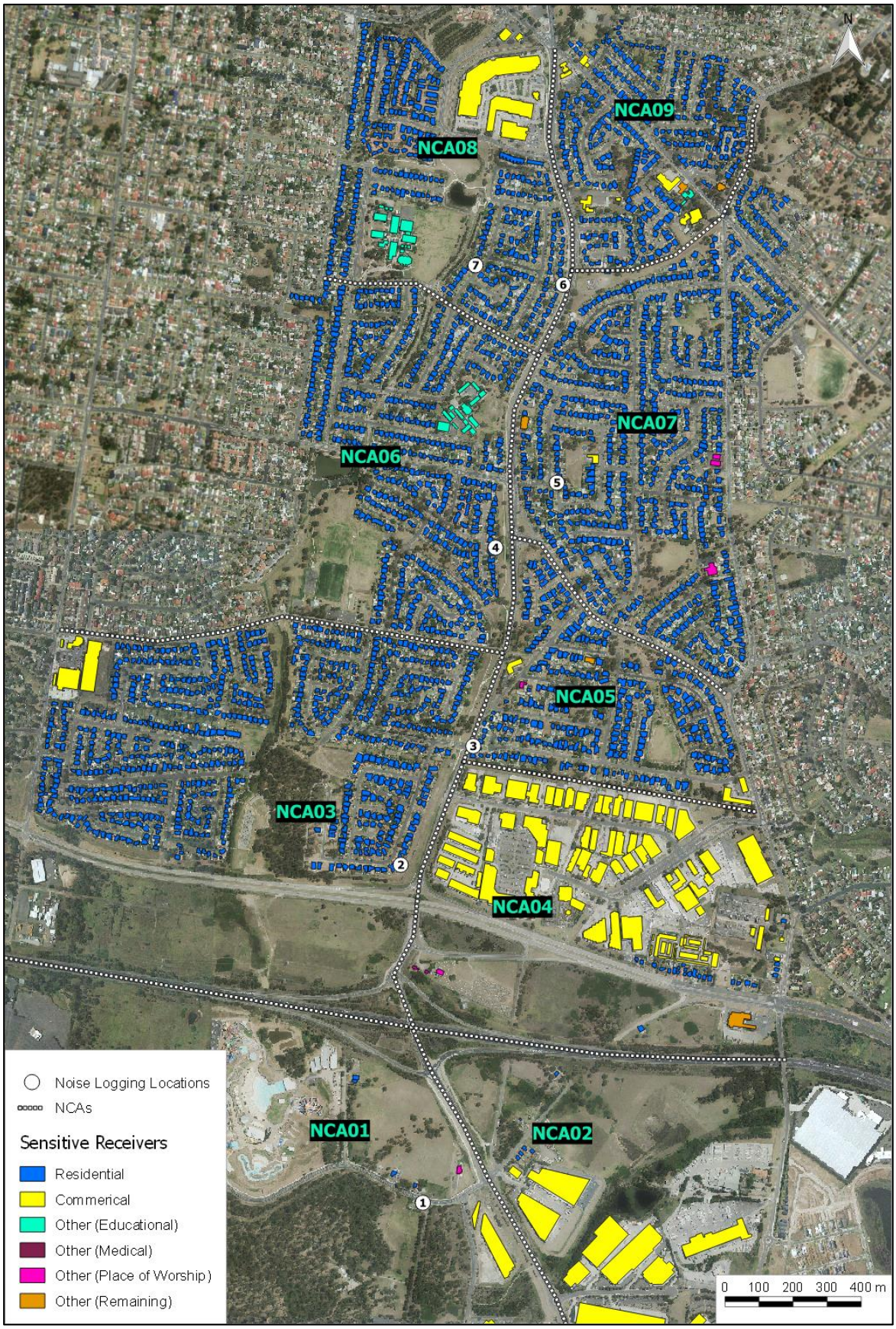
The project aims to provide a (generally) four-lane divided road between Reservoir Road at Prospect and St Martins Crescent at Blacktown, with the section north of Lancelot Street to be upgraded as a six-lane divided road. The additional lanes would be constructed primarily within the existing road corridor.

The main features of the proposal are:

- A new two way link road between the Great Western Highway and Prospect Highway including two new signalised intersections at the Great Western Highway and Prospect Highway.
- Upgrading of seven intersections on Prospect Highway.
- Upgrading and altering the intersections to left in and left out (no right turns).
- Widening to provide additional traffic lanes on Prospect Highway at the following location:
  - Four lanes between Reservoir Road / Reconciliation Road and Blacktown Road.
  - Six lanes between Lancelot Street and 200 m north of St Martins Crescent.
- A central median of variable width.
- New bridges over the M4 Western Motorway and Great Western Highway for northbound traffic.
- Upgrade of the Old Church Lane to Keyne Street pedestrian underpass linking Old Church Lane and Keyne Street, Prospect.
- Upgrade of the existing road pavement and cross drainage systems.
- Utilities relocation and adjustment where required.
- Upgrade of street lighting within the proposal area.
- Provision of three retaining walls.
- Relocation of five bus stops and provision of two new bus stops.
- Upgrading and realignment of the shared paths.
- Provision of new signalised pedestrian crossings.

The project area runs from south of the M4 Motorway to Leabons Lane as shown in **Figure 1**.

Figure 1 Site Plan



3 DESCRIPTION OF THE EXISTING ENVIRONMENT

3.1 Ambient Noise Surveys and Monitoring Locations

In order to characterise the existing ambient noise environment across the project area, environmental noise monitoring was performed by SKM as part of the project's REF at seven representative locations during October 2013. These locations are indicated in **Figure 1** and on the site plan in **Appendix B**.

3.2 Unattended Noise Monitoring Results

The results of the unattended ambient noise surveys are presented in **Table 1** and **Table 2**.

Representative Rating Background Levels (RBLs) and L_{Aeq} (energy averaged) noise levels during the standard Industrial Noise Policy (INP) defined daytime, evening and night-time hours are shown in **Table 2**, together with the RNP defined daytime $L_{Aeq(15hour)}$ and night-time $L_{Aeq(9hour)}$ noise indices, as detailed in the REF.

Table 1 Unattended Noise Monitoring Locations – REF

ID	Address	Distance from Nearest Major Road	Noise Sources
1	544 Reservoir Road	200 m from Prospect Highway, 15 m Reservoir Road.	Local road traffic noise from Reservoir Road. Distant road noise from the M4 Motorway and Great Western Highway.
2	31 Hampton Crescent	67 m from Prospect Highway.	Road traffic noise from Prospect Highway dominant, distant Great Western Highway in background. Occasional bird noises and traffic movements on local road.
3	83 Aldgate Street	12 m from Prospect Highway.	Road traffic noise from Prospect Highway is the dominant noise source. Occasional lulls in traffic.
4	10 Fife Street	46 m from Prospect Highway.	Road traffic noise from Prospect Highway is the dominant noise source. Some bird noise and other domestic noise sources audible.
5	3 Ozark Street	125 m from Prospect Highway.	Local road traffic noise from Ozark Street. Road noise from Prospect Highway clearly audible.
6	170 Blacktown Road	30 m from Blacktown Road.	Local road traffic noise from Blacktown Road.
7	24 Cavendish Avenue	250 m from Prospect Highway.	Local road traffic noise from Cavendish Road. Distant road noise from the Prospect Highway.

Note: All details are taken from the REF for the project.

Table 2 Summary of Noise Monitoring Results – REF

ID	Measured Noise Level (dBA)							
	INP Periods						RNP Periods	
	Daytime		Evening		Night-time		Daytime	Night-time
	LAeq	RBL	LAeq	RBL	LAeq	RBL	LAeq(15hr)	LAeq(9hr)
1	61	45	55	45	56	42	-	-
2	55	45	53	46	49	39	55	49
3	68	50	66	49	61	39	68	61
4	58	47	56	45	54	36	58	54
5	55	42	50	42	48	37	53	48
6	63	54	60	50	59	37	62	59
7	52	38	47	36	45	30	-	-

Note: All results are taken from the REF for the project.

3.3 Identification of Noise and Vibration Sensitive Receivers

The sensitivity of receivers to noise and vibration is dependent upon the occupancy type and the nature of the activities performed within the affected premises. Sensitivity to noise is a subjective response varying for different individuals and can depend on the existing noise environment.

For the purpose of this assessment, receivers potentially sensitive to noise and vibration have been categorised as:

- Residential.
- Other – Education institutions.
- Other – Child-care centres.
- Other – Medical (hospital wards or other uses including medical centres).
- Other – Aged care facilities (including nursing homes).
- Other – Places of worship.

Other receivers sensitive to noise and vibration (other than residential dwellings or commercial premises) identified in the study area are detailed in **Table 3**.

The NCAs in this assessment have been simplified from those defined in the REF, which is required to consider both operational and construction noise impacts. This has been done to allow a more straightforward summary to be presented for this Detailed Design operational noise assessment.

Table 3 Other Noise and Vibration Sensitive Receivers

NCA	Description	Address (approx. within 50 m)[1]	Type
NCA01	St Mark Coptic Catholic Church	533 Reservoir Road, Prospect	Place of Worship
NCA04	Ponds Road Graveyard	Ponds Road, Prospect	Place of Worship
NCA05	Cannon Street Pre-School and Child Care Centre	16 Cannon Street, Prospect	Child Care
NCA05	Blacktown Church of Christ	6 Broad Street, Prospect	Place of Worship
NCA06	Shelley Public School	Hadrian Avenue, Blacktown	Educational
NCA07	Blacktown Road Children's Centre	217 Blacktown Road, Seven Hills	Child Care
NCA07	Grace Baptist Church	54 Ellam Drive, Seven Hills	Place of Worship
NCA07	Jehovah's Witnesses Kingdom Halls	102A Ellam Drive, Seven Hills	Place of Worship
NCA08	Mitchell High School	Keyworth Drive, Blacktown	Educational
NCA09	Leabons Lane Child Care Centre	9 Leabons Lane, Seven Hills	Child Care
NCA09	Aftercare Associate of NSW	2/8 Leabons Lane, Seven Hills	Educational

Note 1: Address has been generated from a NSW Land and Property Information (LPI) database.

4 ASSESSMENT METHODOLOGY

4.1 Detailed Design Review

This assessment has progressed through predicting and assessing sensitive receiver noise levels using the Detailed Design of the project against the relative guidelines and comparing this to the assessment outcomes as contained in the REF.

It is noted that as the project has moved through the Detailed Design phase, a number of alignment and design changes have occurred. A description of all major changes made since the concept design are provided in **Section 5.4**.

4.2 Assessment Scenarios

RNP Assessment Scenarios

The following four scenarios have been modelled for this assessment:

- **2018 No Build**
  Base 'do minimum' – the forecast road traffic volumes without the project.
- **2018 Build**
  Prospect Highway Upgrade – the forecast 'at opening' road traffic volumes including the project.
- **2028 No Build**
  Future 'do minimum' – the forecast road traffic volumes 10 years after the opening year due to general traffic growth that would have occurred without the project.
- **2028 Build**
  Prospect Highway Upgrade – the forecast '10 year after opening' road traffic volumes including the project.

The comparison (Build minus No Build) for 2018 will indicate the potential for any noise issues at the commencement of the project, such as community reaction to significant changes in noise levels. The comparison for 2028 will indicate the potential for noise impacts in the longer term once the project is well established and the surrounding road network has stabilised.

4.3 Road Noise Prediction Algorithms

Noise modelling of the project area was carried out using the *Calculation of Road Traffic Noise* (CORTN) (UK Department of Transport, 1988) algorithms incorporated in SoundPLAN V7.1. The modelling allows for traffic volume and mix, type of road surface, vehicle speed, road gradient, reflections off building surfaces, ground absorption and shielding from ground topography and physical noise barriers.

The algorithm output of CORTN (designed as an L_{A10} predictor) has been modified to calculate the relevant daytime $L_{Aeq(15hour)}$ and night-time $L_{Aeq(9hour)}$ road traffic noise emission levels at noise sensitive receivers, as required by the RNP.

The CoRTN traffic source line as modelled in SoundPLAN has also been modified to incorporate four effective noise sources (and associated heights) for each carriageway. This is because the three distinct noise sources of heavy vehicles (representing the tyres, engine and the exhaust, with different noise emission levels and different heights) are important in determining the noise propagation where barriers are present. The four effective noise sources comprise a *'CAR*' source with height of 0.5 m above pavement and three *'TRUCK*' sources at three separate heights representing the noise emission from truck tyres (0.5 m), truck engines (1.5 m) and truck exhausts (3.6 m).

The SoundPLAN noise models were set up to calculate noise levels at receiver points for all facades and all floors of each noise sensitive receiver identified within the project area.

4.4 Modelling of the Road Alignment

Input Data

The noise model was constructed from a combination of survey data within the road corridor, aerial photography and LIDAR information. All design information (altered road corridor, carriageway levels, modified ramps, etc) in areas where upgrade works are proposed within the project area was supplied by the project team.

No Build Scenarios

The predictions for the No Build scenarios make use of the existing road alignment geometry of Prospect Highway and the surrounding road network. Existing features within the road corridor are included in the No Build noise modelling scenarios.

Build Scenarios

The Build scenarios make use of the proposed design of the project which includes proposed modifications to the various roads, widening works and changes to existing cuttings / embankments, etc.

This assessment has been undertaken on the basis of the 80% design provided by the project team.

4.5 Modelling of Pavement Surfaces

No Build Scenario

The existing road network pavement surface is Dense Grade Asphalt (DGA).

Build Scenario

Where works are proposed, a re-sheet with DGA is proposed. As detailed in the REF, low noise pavements are not considered feasible or reasonable for this project due to speeds below 60 km/h.

4.6 Modelling of Traffic Data

Traffic data for the RNP Build and No Build assessment scenarios for both project opening and the future design year was provided by the project team and is presented in **Appendix C**.

4.7 Modelling of Noise Barriers

Existing Noise Barriers

There are no existing noise barriers in the project area.

Project Noise Barriers

Indicative noise barriers were detailed in the REF noise assessment. A summary of the REF barriers is provided in **Section 5.2**.

The process for determining the Detailed Design noise barriers is provided in **Section 8.2**.

4.8 Summary of Noise Modelling Parameters

A summary of the modelling parameters is provided in **Table 4**.

Table 4 Summary of Noise Model Inputs and Parameters

Input Parameter	Source of Data	
Ground topography	Combination of surveyed road corridor data and LIDAR point cloud survey	
Proportion of absorbing ground	0.5 (CORTN)	
Receiver Locations	Aerial photography and LIDAR point cloud	
Vehicle Speed (2018 and 2028 Build and No Build)	Prospect Highway Surrounding roads and access ramps M4 Motorway carriageway	70 km/h 60 km/h 90 km/h
Source Heights and Source Correction (dB)	Car exhaust Truck tyres Truck engines Truck exhausts	0.5 m (0.0 dB) 0.5 m (-5.4 dB) 1.5 m (-2.4 dB) 3.6 m (-8.5 dB)
Road Surface Corrections	DGA OGA	0 dB -2 dB[1]
Receiver Location (@ 1m from Facade)	Ground floor[2] First floor[2]	1.5m 4.3m
Facade Correction	+2.5 dB	
ARRB	-1.7 dB for facade conditions -0.7 dB for free-field conditions	
L_{A10} to L_{Aeq}	-3 dB	
$L_{Aeq(period)}$ to $L_{Aeq(1hour)}$ correction	$L_{Aeq(15hour)}$ to $L_{Aeq(1hour)}$ +5.0 dB $L_{Aeq(9hour)}$ to $L_{Aeq(1hour)}$ +6.0 dB	

Note 1: This is the standard correction for OGA.

Note 2: These are typical heights above ground level, the height of some receivers were adjusted according to site survey information.

4.9 Noise Model Validation

4.9.1 Overview

The noise modelling procedures and algorithms used in this assessment have been shown to give reliable results which are within normal accepted tolerances.

Comparison of measured and predicted levels has been performed by undertaking single point receiver calculations at noise model locations coinciding with the REF ambient monitoring locations. These locations have been limited to those with a direct line of sight or those near to major sources of road traffic noise with minimal complex screening in order to provide reliable prediction results.

4.9.2 Validation Traffic Data

Traffic counting was undertaken concurrently with the REF ambient noise monitoring survey. The traffic data used in the validation of the noise model is presented in **Table 5**.

Table 5 REF Traffic Survey Data – Existing Situation

Location	Direction	Daytime		Night-time	
		Light	Heavy	Light	Heavy
Prospect Highway (north of GWH)	NB	14498	1762	2458	292
	SB	13600	1893	2723	405
Blacktown Road (north of Lancelot Street)	NB	12729	1533	2123	255
	SB	12208	1441	2317	252
Blacktown Road (south of Lancelot Street)	NB	3469	213	518	29
	SB	4634	321	460	40

Note: All data taken from the REF for the project.

The traffic counts are used for the purpose of validating the noise model and relate only to the period over which the noise logging was undertaken. Consequently, these are of limited use in providing long-term traffic volumes and speeds and should not necessarily be regarded as representative of existing volumes.

4.9.3 Validation

The comparison of the noise level predictions for the 2014 Validation Scenario is shown in **Table 6**. Only noise logging locations that are immediately adjacent to major roads, where traffic counting data is available, have been included in the comparison.

Table 6 Comparison of Measured and Predicted Noise Data

ID	Address	Noise Level (dBA)					
		Measured[1]		Predicted		Difference	
		$L_{Aeq(15hr)}$	$L_{Aeq(9hr)}$	$L_{Aeq(15hr)}$	$L_{Aeq(9hr)}$	$L_{Aeq(15hr)}$	$L_{Aeq(9hr)}$
3	83 Aldgate Street	68	61	66	61	-2	0
4	10 Fife Street	58	54	60	56	2	2
6	170 Blacktown Road	62	59	64	60	2	1
					Median Difference	**2**	**1**

Note 1: Measured noise data is taken from the REF for the project.

The ENMM notes that “it should be recognised that noise prediction modelling has some accuracy limitations and will commonly produce acceptable errors of around 2 dBA”.

As per RMS guidance, as the validation of the noise model is within ± 2 dB, no further corrections are required and the model is considered validated.

On the basis of the comparison of noise model predictions with baseline measurement results, it is also concluded that the noise model provides results which enable a reliable assessment of the project.

5 REF PROPOSED NOISE MITIGATION

The operational noise assessment of the REF identified 231 sensitive receivers as being eligible for consideration of additional noise mitigation. These locations are illustrated in **Figure 2**.

The preferred noise mitigation option detailed in the REF was the combined use of noise barriers (where possible) with at-property architectural treatment. The indicative Concept Design noise mitigation package detailed in the REF is discussed in the following sections.

5.1 Road Pavement Surfaces

The REF concluded that low noise pavements would not provide any significant noise benefit to noise impacted residences where vehicle speeds of 60 km/h are apparent. This noise mitigation option was therefore not considered feasible or reasonable for the project, and is not discussed any further in this assessment.

5.2 Noise Barriers

The REF concluded that noise barriers were not a feasible mitigation option for many areas of the project due many receivers having vehicle and pedestrian access from the front of the property via Prospect Highway or Blacktown Road.

Four potential noise barrier locations were however detailed in the areas detailed in **Table 7** and illustrated in **Figure 2**.

Table 7 REF Potential Noise Barrier Locations

No.	Location Description	Length (m)
1	Northern side of Great Western Highway two-way link road.	310
2	Eastern side of Prospect Highway south of Harrod Street to Edgeware Road.	175
3	Eastern side of Prospect Highway from pedestrian underpass at Old Church Lane to the intersection of Prospect Highway and Blacktown Road.	305
4	On the eastern side of Prospect Highway north of Keyworth Drive to north of Topaz Crescent.	160

The REF did not determine specific heights for the above noise barriers. The report only noted that the above noise barriers would be about 3 m in height, depending on the final design location within the corridor.

5.3 Residual At-Property Treatment

The REF concluded that where residual impacts remain after the use of noise barriers, the preferred option for mitigating noise sensitive receivers locations would be at-property architectural treatments.

Figure 2 Proposed REF Noise Mitigation

5.4 Changes since Concept Design

The various changes in the project road alignment documented in this report from that proposed in the Concept Design REF are detailed in the Addendum REF. Reference should be made to that document for a full description of the changes.

One change which has been made since completion of the Concept Design REF that has potential acoustical impacts is he increasing the vehicle speed from 60 km/h to 70 km/h for the full length of Prospect Highway. It is however noted that in reality, Prospect Highway north of Blacktown Road will be posted at 60 km/h, however the noise modelling assumed 70 km/h to ensure a conservative noise assessment.

6 OPERATIONAL NOISE GOALS AND NOISE MITIGATION GUIDANCE

6.1 Operational Noise Metrics

The noise metrics applied in the modelling and assessment of airborne noise from road traffic are:

$L_{Aeq(15hour)}$ the 'energy average noise level' evaluated over the daytime period (7.00 am to 10.00 pm). The L_{Aeq} can be likened to the average of all the noise events occurring in the relevant time period.

$L_{Aeq(9hour)}$ the 'energy average noise level' evaluated over the night-time period (10.00 am to 7.00 am).

$L_{Aeq(1hour)}$ the 'energy average noise level' evaluated for a specific one-hour period.

L_{Amax} The maximum noise level from road traffic noise occurring at a particular location.

The subscript 'A' indicates that the noise levels are filtered to match normal human hearing characteristics (ie A-weighted).

6.2 Noise Criteria – Roads and Maritime Noise Criteria Guideline

This assessment is required to be undertaken with guidance from the NCG. The NCG documents Roads and Maritime's interpretation of the RNP. The NCG provides a consistent approach to identifying road noise criteria for Roads and Maritime projects.

Although it is not mandatory to achieve the noise assessment criteria in the NCG, project proponents need to provide justification if it is not considered feasible or reasonable to achieve them.

The guideline recognises that there are generally more opportunities to minimise noise impacts from new roads and road corridors, especially those in greenfield locations, through judicious road design and land use planning. The scope to reduce noise impacts from existing roads and corridors is typically more limited. The NCG criteria are applicable both at the time of project opening and also in a future design year, typically taken to be ten years after project completion.

The NCG sets out four key principles aimed to guide the assessment. These are:

- Criteria are based on the road development type a residence is affected by due to the road project.
- Adjacent and nearby residences should not have significantly different criteria for the same road.
- Criteria for the surrounding road network are assessed where a road project generates an increase in traffic noise greater than 2 dB on the surrounding road network.
- Protect existing quiet areas from excessive changes in amenity due to traffic noise.

6.3 Noise Assessment Criteria

Noise criteria are assigned to sensitive receivers using the NCG. The NCG provides guidance on how to assign the RNP. The assessment timeframe for the criteria are in the year of opening (2018) and 10 years after opening (2028).

Residences may be assigned new, redeveloped, transition zone or relative increase criteria depending on how the project will influence noise levels. For each facade of the residence the most stringent applicable criteria is to be used in the assessment.

Criteria are based on the road development type a residence is affected by due to the road project.

In some instances residences may be exposed to noise from both new and redeveloped roads. In this instance the proportion of noise from each road is used to establish transition zone criteria.

A further check is made to prevent large increases in noise level using the relative increase criteria.

6.3.1 Criteria by Road Type

The Prospect Highway Upgrade is regarded as a redevelopment of an existing road. The criteria for residences affected by redevelopment projects are summarised in **Table 8**. These criteria for residences are applicable to aged care facilities.

Table 8 NCG Criteria – Residential

Road Category	Type of Project/Land Use	Assessment Criteria (dB)	
		Daytime (7 am - 10 pm)	**Night-time (10 pm - 7 am)**
Freeway/ arterial/ sub-arterial roads	Existing residences affected by noise from redevelopment of existing freeway/arterial/sub-arterial roads Existing residences affected by additional traffic on existing freeways/arterial/sub-arterial roads generated by land use developments	$L_{Aeq(15hour)}$ 60 (external)	$L_{Aeq(9hour)}$ 55 (external)
	Existing residences affected by increases in traffic noise of 12dBA or more from new freeway/arterial/sub-arterial roads[2]	Between $L_{Aeq(15hour)}$ 42-55 (external)	Between $L_{Aeq(9hour)}$ 42-50 (external)
	Existing residences affected by increases in traffic noise of 12dBA or more from redevelopment of existing freeway/arterial/sub-arterial roads[1]	Between $L_{Aeq(15hour)}$ 42-60 (external)	Between $L_{Aeq(9hour)}$ 42-55 (external)

Note 1: The criteria at each facade are determined from the existing traffic noise level plus 12dBA.

The criteria for other sensitive receivers are summarised in **Table 9**.

Table 9 NCG Criteria – Other Sensitive Land Uses

Existing Sensitive Land Use	Assessment Criteria (dB)		Additional Considerations
	Daytime (7.00 am – 10.00 pm)	Night-time (10.00 pm – 7.00 am)	
School Classrooms	$L_{Aeq(1hour)}$ 40 (internal)	-	In the case of buildings used for education or health care, noise level criteria for spaces other than classrooms and wards may be obtained by interpolation from the 'maximum' levels shown in Australian Standard 2107:2000 (Standards Australia 2000).
Hospital Wards	$L_{Aeq(1hour)}$ 35 (internal)	$L_{Aeq(1hour)}$ 35 (internal)	
Places of Worship	$L_{Aeq(1hour)}$ 40 (internal)	$L_{Aeq(1hour)}$ 40 (internal)	The criteria are internal, ie the inside of a church. Areas outside the place of worship, such as a churchyard or cemetery, may also be a place of worship. Therefore, in determining appropriate criteria for such external areas, it should be established which activities in these areas may be affected by road traffic noise.
Open Space (Active Use)	$L_{Aeq(15hour)}$ 60 (external) when in use	-	Active recreation is characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion.
Open Space (Passive Use)	$L_{Aeq(15hour)}$ 55 (external) when in use	-	Passive recreation is characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, eg playing chess, reading.
Childcare facilities	Sleeping rooms $L_{Aeq(1hour)}$ 35 (internal) Indoor play areas $L_{Aeq(1hour)}$ 40 (internal) Outdoor play areas $L_{Aeq(1hour)}$ 55 (external)	-	Multi-purpose spaces, e.g. shared indoor play/sleeping rooms should meet the lower of the respective criteria. Measurements for sleeping rooms should be taken during designated sleeping times for the facility, or if these are not known, during the highest hourly traffic noise level during the opening hours of the facility.
Aged care facilities	-	-	Residential land use noise assessment criteria should be applied to these facilities, see **Table 8**

For sensitive receivers such as schools, places of worship and childcare facilities, the NCG criteria presented in **Table 9** are based on internal noise levels.

Internal NCG noise criteria have been converted to external noise criteria for the purposes of assessment with external noise level predictions. Where detailed information relating to building construction is not available, the EPA recommends a 10 dB factor to convert internal to external noise levels on the basis that facades with windows open typically provide approximately 10 dB attenuation from inside to outside (refer to guidance contained in the ICNG and INP). For non-residential receivers this assumption may be overly conservative as the facade area to window ratios are often larger when compared to residential receivers.

The noise models predict noise levels for $L_{Aeq(15hour)}$ and $L_{Aeq(9hour)}$ intervals (day and night). Where receivers have 1-hour criteria, the model outputs have been converted accordingly.

6.4 Receivers Included for Assessment

In accordance with Roads and Maritime guidance, receiver noise levels are not required to be assessed where the project related roads are not predicted to contribute significantly to the total road traffic noise. This means that in certain locations where secondary roads are seen to be dominant, and the noise level contribution from the project is not significant, the receiver should be excluded from the assessment.

Notwithstanding the above, in assessment areas adjacent to secondary roads, noise levels are assessed where the project generates an increase in total road traffic noise (ie from No Build to Build) of greater than 2 dB, or where the noise levels due to the project road results in 'acute' noise levels.

6.5 Noise Mitigation Guideline (NMG)

The NMG provides guidance in managing and controlling road traffic generated noise and describes the principles to be applied when reviewing noise mitigation. The NMG recognises that the criteria recommended by the NCG are not always practicable and that it is not always feasible or reasonable to expect that they should be achieved.

The NMG notes that the most effective way of minimising noise from vehicles and traffic is to control vehicle noise at the source. Where source measures are not practical, or do not provide sufficient noise reduction, additional methods are required to reduce levels to within acceptable margins. Such additional methods may include the use of noise barriers and/or consideration for at-property architectural treatment of residences.

Further detail on the process of applying the NMG is presented in the following sections.

6.6 Guidance for Consideration of Reasonable Additional Noise Mitigation

The NMG provides three triggers where a receiver may qualify for consideration of noise mitigation (beyond the adoption of road design and traffic management measures). These are:

Trigger 1

- The predicted Build noise level exceeds the NCG controlling criterion and the noise level increase due to the project (ie the noise predictions for the Build minus the No Build) is greater than 2 dB.

Trigger 2

- The predicted Build noise level is 5 dB or more above the criteria (exceeds the cumulative limit) and the receiver is significantly influenced by project road noise, regardless of the incremental impact of the project.

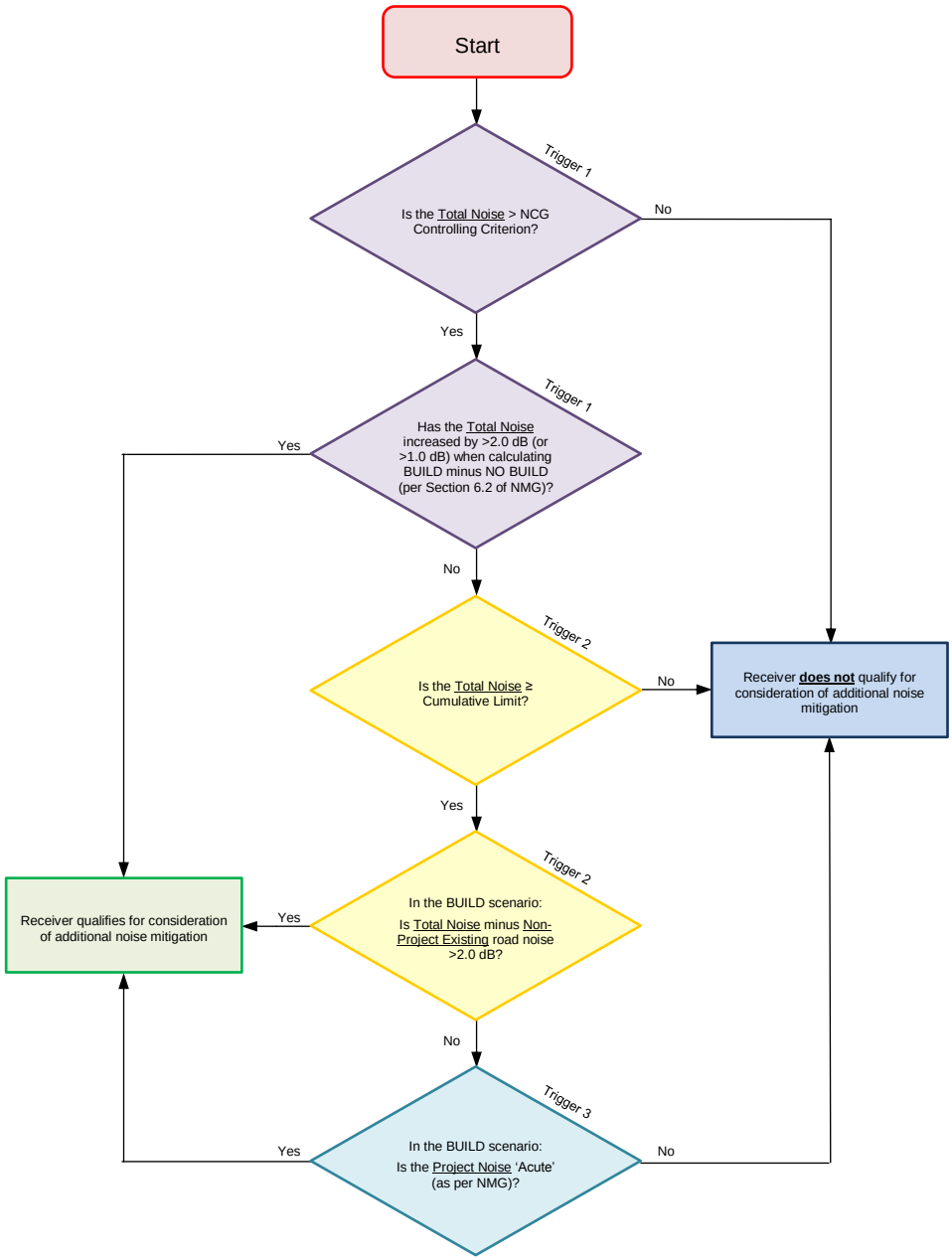
Trigger 3

- The noise level contribution from the road project is acute (daytime $L_{Aeq(15hour)}$ 65 dBA or higher, or night-time $L_{Aeq(9hour)}$ 60 dBA or higher) then it qualifies for consideration of noise mitigation even if noise levels are dominated by another road.

The eligibility of receivers for consideration of additional noise mitigation is determined before the benefit of additional noise mitigation (low noise pavement and noise barriers) is included. The requirement for the project is to provide feasible and reasonable additional mitigation for these eligible receivers to meet the NCG controlling criterion. If the NCG criterion cannot be satisfied with low noise pavement and noise barriers, then the receiver is eligible for consideration of at-property treatment.

The NMG process is summarised in the flowchart in **Figure 3**.

Figure 3 Flowchart – Feasible and Reasonable Noise Mitigation (NMG)



6.7 Procedure Overview

As highlighted in the NMG, once noise has been minimised by feasible and reasonable methods during the corridor planning and road design stages, receivers with residual exceedances of the NCG controlling criteria shall be assessed to determine if they qualify for noise mitigation.

For receivers that qualify for consideration of additional noise mitigation measures, the potential noise mitigation measures are identified in the order of preference from the list below:

1. Quieter pavement surfaces
2. Noise mounds
3. Noise barriers
4. At-property treatments.

The redevelopment of existing road corridors offers a limited range of noise control measures because of the inherent limitations to using corridor route adjustment, the proximity of existing residents to the road and limited road redesign options.

The priority of mitigation measures recognises that noise control at the source is preferable over noise path control and noise mitigation at the receiver. The NMG notes that noise mitigation measures should be both feasible and reasonable.

Selecting reasonable measures from those that are feasible involves judging whether the overall noise benefits outweigh the overall adverse social, economic and environmental effects, including the cost of the abatement measure. To make such a judgement, consideration may be given to noise impacts, noise mitigation benefits, the cost effectiveness of noise mitigation and community views.

6.8 Definition of Feasible and Reasonable

Where the noise goals in the Build scenarios are found to be exceeded as a result of a project, the project is required to adopt all feasible and reasonable mitigation measures to meet the targets.

The NMG defines what feasible and reasonable factors may be considered when investigating noise mitigation measures.

'Feasibility' relates to engineering considerations (what can be practically built) and may include:

- The inherent limitations of different techniques to reduce noise emissions from road traffic noise sources.
- Safety issues, such as restrictions on road vision.
- Road corridor site constraints such as space limitations.
- Floodway and stormwater flow obstruction.
- Access requirements.
- Maintenance requirements.

'Reasonableness' relates to the application of wider judgements. The factors to be considered are:

- The noise reduction provided and the number of people protected.
- The cost of mitigation, including the total cost and cost variations with different benefits provided.
- Community views and wishes.
- Visual impacts.
- Existing and future noise levels, including changes in noise levels.
- The benefits arising from the proposed road or road development.

7 OPERATIONAL ROAD TRAFFIC NOISE IMPACT ASSESSMENT OVERVIEW

The following sections present an overview of the considerations and procedures involved in the operational road traffic noise impact assessment. It is intended that this section is read in conjunction with the assessment outcomes presented in **Section 8**.

7.1 Operational Noise Impact without Mitigation

The 'without mitigation' noise predictions identify receivers which qualify for consideration of additional noise mitigation. These receivers remain triggered (ie qualify for consideration of at-property treatment) unless the predicted noise level meets the NCG controlling criterion with low noise pavement and/or noise barriers, where feasible and reasonable.

The predicted noise levels at receivers which are above the NCG controlling criteria do not necessarily qualify for additional noise mitigation. As per the discussion in **Section 5.4**, consideration of reasonableness is used to decide which of those receivers are eligible for additional noise mitigation measures.

7.2 Road Design and Traffic Management

There are limited opportunities to acoustically optimise the design of the project given that the works are within or close to the existing road corridor and surrounded in most places by existing communities.

Traffic management strategies aimed at reducing noise are not considered to be a feasible option for the project given the high daily volumes of traffic that use the motorway in both the existing and future scenarios.

The early design planning of the project during concept design considered noise impacts as far as reasonably practicable.

7.3 Additional Noise Mitigation – Noise Barriers

In sensitive receiver locations where exceedances of the operational noise criteria are predicted, new or increased height noise barriers have been considered where four or more eligible properties are found to be closely spaced. Where the number of exceeding receivers is found to be three or less, the specification of noise barriers is not considered to be a reasonable or cost-effective approach and at-property architectural treatment of these receivers should be considered. This approach is consistent with the NMG.

7.3.1 NMG Requirements

The underlying principle in the NMG document is to give preference to at-road noise mitigation measures over at-property measures.

The NMG approach identifies the number of receivers (noting that a two storey residence is counted as two receivers) that receive at-property treatment versus barrier height to establish an initial design height and then conducts a weighted analysis to find the optimal mix of barrier height and at-property treatments. This prioritises at-road mitigation and minimises the use of at-property treatments, as per the intent of the RNP.

This approach first identifies the maximum barrier height (up to 8 m) where no receivers require at-property treatment. The initial design height is then established by identifying the height where, of the receivers that benefit from the noise barrier, two thirds no longer require at-property treatment. A value of two thirds is defined in the NMG as the point at which further increases in barrier height have been shown to have diminishing benefits with respect to increasing barrier heights.

Weightings are then applied which consider cost and the overall noise benefits the barrier provides to the wider community. The total points weighting at each barrier height is the sum of the weightings for barrier area, number of at-property treatments and exceedances of 50 dBA $L_{Aeq(15hour)}$ daytime or 45 dBA $L_{Aeq(9hour)}$ night-time noise levels (based on the World Health Organisation (WHO) criteria).

A low point in the weighting curve between the initial design height and the maximum barrier height corresponds to the most reasonable barrier height in terms of community benefit and weighted cost. The feasibleness and reasonableness of the design and maximum barrier heights are then reviewed.

As a guide, noise barriers are considered to be a reasonable noise mitigation option where they are capable of providing an insertion loss of:

- 5 dB at representative receivers for barrier heights of up to 5 m.
- 10 dB at representative receivers for barrier heights above 5 m high and up to 8 m high.

In certain situations the requirements for the barrier cannot always be met. In this case further feasible and reasonable considerations are undertaken with guidance from Roads and Maritime.

Where an existing barrier is relocated as part of the works, the top of noise wall height of the replacement section of the noise barrier should be consistent with the existing height unless the optimised barrier height is greater.

7.4 Receivers Considered for At-Property Architectural Treatments

For individual residential receivers, Roads and Maritime does not consider it reasonable to consider noise mitigation above the ground and first floor. It is generally not feasible and reasonable to provide at-receiver noise mitigation to multi-level residential receivers.

7.5 At-Property Architectural Treatments

At locations where residual impacts remain after all feasible and reasonable approaches have been exhausted, noise mitigation in the form of acoustic treatment of existing individual dwellings is to be considered.

At-property architectural acoustic treatments should aim to achieve internal noise levels in habitable rooms 10 dB below the external noise level criteria. In some cases this will be limited by the existing construction and condition of the residence.

Building element treatments are more effective when they are applied to masonry structures than lightly clad timber frame structures. Caution should be exercised before providing treatments for buildings in a poor state of repair, as they will be less effective and may not provide any appreciable noise reduction benefit. Heritage advice should be sought if the treatments have the potential to impact the heritage significance of a property. In extreme cases this could result in a decision not to proceed with a treatment on the grounds that it was not considered to be feasible or reasonable mitigation option.

The at-property treatments provided by Roads and Maritime are typically limited to:

- Fresh air ventilation systems that meet the Building Code of Australia requirements with the windows and doors closed.
- Upgraded windows and glazing and solid core doors on the exposed facades of the substantial structures only (eg masonry or insulated weather board cladding with sealed underfloor). These techniques would be unlikely to produce any noticeable benefit for light frame structures with no acoustic insulation in the walls.
- Upgrading window or door seals and appropriately treating sub-floor ventilation.
- The sealing of wall vents.
- The sealing of the underfloor below the bearers.
- The sealing of eaves.

The recommended residual noise impact mitigation package for all habitable rooms of eligible locations is as follows:

At-Property Architectural Treatment of Dwellings ≤10 dB over NCG Target

- Where external noise levels are less than 10 dB above the NCG criteria, acceptable internal noise levels may be achieved with appropriately sealed windows closed on exposed facades.
- A light framed building with single glazed (closed and adequately sealed) windows with sealed wall vents will typically provide an external to internal noise reduction of 20 dB. Where the NCG internal criteria in habitable rooms can only be achieved with windows and vents closed, then mechanical ventilation should be provided (subject to individual consultation with dwelling owners) to ensure sufficient airflow inside the dwelling, so as to meet the requirements of the Building Code of Australia.

At-Property Architectural Treatment of Exceeding Dwellings >10 dB over NCG Target

- Where the external levels are more than 10 dB greater than the NCG criteria, then upgraded windows, doors and/or seals (depending on individual assessment and generally only suitable for masonry type buildings) is necessary, in addition to the above.

8 DETAILED DESIGN – ROAD TRAFFIC NOISE IMPACT ASSESSMENT

8.1 Operational Noise Impacts without Mitigation

Noise levels for the Detailed Design of the project have been predated at all receivers in the study area. The results for all assessed scenarios are shown in **Appendix D** and **Appendix E** for the No Build and Build (without mitigation) scenarios respectively.

The 'without mitigation' noise predictions identify receivers which qualify for consideration of additional noise mitigation.

8.1.1 Change in Noise Levels without Mitigation

Noise predictions throughout the study area indicate that receivers adjacent to the project are subject to significant existing noise impacts from existing road traffic and in many cases exceed the NCG controlling criterion due to noise from existing road traffic, as shown in the No Build scenarios in **Table 10**.

Table 10 Receivers over the NCG Controlling Criteria without Mitigation

NCA	Receiver Type	Floor	2018 No Build		2018 Build		2028 No Build		2028 Build	
			Day	Night	Day	Night	Day	Night	Day	Night
NCA01	All	All	3	5	5	5	5	5	5	5
NCA02	All	All	5	6	6	6	6	6	6	6
NCA03	All	All	66	71	68	76	71	81	77	82
NCA04	All	All	30	34	30	34	34	34	34	34
NCA05	All	All	83	83	86	86	87	88	90	93
NCA06	All	All	77	56	76	58	77	57	80	59
NCA07	All	All	89	82	91	84	92	85	95	86
NCA08	All	All	48	33	55	35	55	35	62	39
NCA09	All	All	31	30	35	30	35	30	36	33
All	**All**	**All**	**432**	**400**	**452**	**414**	**462**	**421**	**485**	**437**

Note: Predicted noise levels at receivers which are above the NCG controlling criteria do not necessarily qualify for additional noise mitigation. As per the discussion in **Section 6**, further criteria are used to determine which of those receivers are eligible for additional noise mitigation measures.

8.1.2 Receivers Considered for Additional Noise Mitigation

Maps showing the location of receivers identified for consideration of additional noise mitigation (all assessment scenarios) are presented in **Appendix F**. Further discussion of the project noise impacts (without mitigation) is presented in **Table 11**.

A total of 238 receivers/floors (199 buildings) are considered for additional noise mitigation.

Table 11 Receivers Considered for Additional Noise Mitigation by NCA

NCA	Receiver Type	Receiver Floors (Receiver Lots)	Comments
NCA01	Residential	0 (0)	Triggered receivers are adjacent to the widened section of Prospect Highway.
	Other	2 (1)	
NCA02	Residential	1 (1)	Triggered receiver is adjacent to the widened section of Prospect Highway.
	Other	0 (0)	
NCA03	Residential	35 (29)	Triggered receivers are adjacent to the widened section of Prospect Highway and also the widened access ramp to/from Great Western Highway.
	Other	0 (0)	
NCA04	Residential	0 (0)	Triggered receivers are adjacent to the widened section of Prospect Highway.
	Other	5 (4)	
NCA05	Residential	32 (24)	Triggered receivers are adjacent to the widened section of Prospect Highway.
	Other	2 (2)	
NCA06	Residential	46 (34)	Triggered receivers are adjacent to the widened section of Prospect Highway.
	Other	18 (13)	
NCA07	Residential	39 (35)	Triggered receivers are adjacent to the widened section of Prospect Highway.
	Other	2 (1)	
NCA08	Residential	29 (28)	Triggered receivers are adjacent to the widened section of Prospect Highway.
	Other	1 (1)	
NCA09	Residential	25 (25)	Triggered receivers are adjacent to the widened section of Prospect Highway.
	Other	1 (1)	
ALL	**Residential**	**207 (176)**	**-**
	Other	**31 (23)**	**-**
	TOTAL	**238 (199)**	**-**

8.2 Additional Noise Mitigation – Noise Barriers

The noise barrier optimisation process is based on guidance in the NMG as discussed in **Section 7.2**. The optimisation results are detailed in **Appendix G** with the assessed barriers identified in **Figure 4** and recommendations summarised in **Table 12**.

Table 12 Detailed Design Noise Barriers

No.	Barrier Reference	Barrier Identified in REF?	Noise Barrier Height (m)		Comments
			NMG Optimised	RMS Final	
1	NW_NB01	Yes	3.5	3.5	Barrier length and position consistent with REF.
2	NW_NB02a	-	-	-	Noise barrier deleted based on community preference.
	NW_NB02b		3.0	3.0	New barrier identified in Detailed Design.
3	NW_NB03a	-	-	-	Noise barrier deleted based on community preference.
	NW_NB03b		2.5	2.5	New barrier identified in Detailed Design.
4	NW_NB04a	-	6.0	3.5[1]	New barrier identified in Detailed Design. Access provided to existing footpath in middle of barrier.
	NW_NB04b		6.0	3.5[1]	
5	NW_SB01	Yes	4.0	4.0	Barrier length and position consistent with REF.
6	NW_SB02a	Yes	4.0	3.5[1]	Barrier length consistent with REF. Southern section of barrier at roadside, northern section at property boundary.
	NW_SB02b		7.0	3.5[1]	
7	NW_SB03a	Yes	4.5	4.5	Barrier length and position consistent with REF. Access provided to existing footpath in middle of barrier.
	NW_SB03b		4.5	4.5	

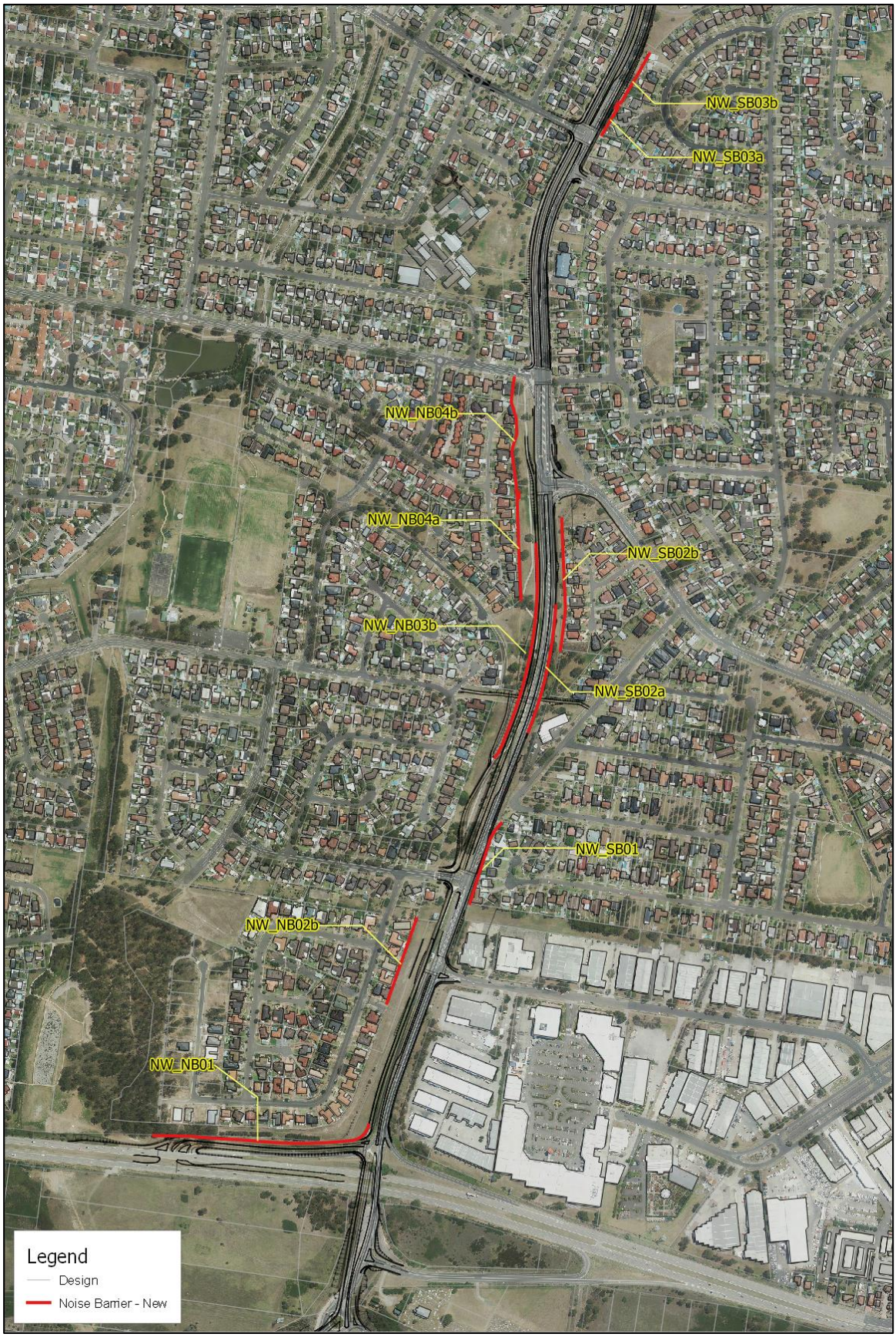
Note 1: The final heights of the larger optimised barrier heights were reduced at the direction of RMS due to concerns regarding their construction. Large barriers have potential issues with urban design, overshadowing, visual appearance, etc.

The analysis identifies a total of seven noise barriers that are considered reasonable under the NMG. Three additional noise barriers are required over those indicated in the REF assessment (NW_NB02, NW_NB03 and NW_NB04). These additional noise barriers are all located on the western side of the alignment, adjacent to the widening works of Prospect Highway.

It is noted that noise barrier NW_NB02a and NW_NB03a were removed from the assessment at the request of the effected community behind these barriers. Concerns were raised during community consultation regarding the size and location of the barriers.

Installation of the proposed noise barriers is predicted to reduce noise such that 44 receivers (total floors) are no longer eligible for consideration of further additional noise mitigation (at-property treatment) which is discussed further in **Section 8.3.3**.

Figure 4 Detailed Design Noise Barriers



8.3 Operational Noise Impacts with Mitigation

Predicted noise level maps showing noise levels at all residential receiver buildings for the Build (with mitigation) scenarios are provided in **Appendix H**. The 'with mitigation' scenarios include the noise barrier as detailed in **Section 8.2**.

The 'with mitigation' noise predictions are used to identify receivers which qualify for consideration of at-property treatment.

8.3.1 Change in Noise Levels with Mitigation

The number of receivers predicted to remain over the NCG criteria in the Build (with mitigation) scenario are summarised in **Table 13**.

Table 13 Receivers over the NCG Controlling Criteria with Mitigation

NCA	Receiver Type	Floor	2018 No Build		2028 Build		2018 No Build		2028 Build	
			Day	Night	Day	Night	Day	Night	Day	Night
NCA01	All	All	3	5	5	5	5	5	5	5
NCA02	All	All	5	6	6	6	6	6	6	6
NCA03	All	All	66	71	43	50	71	81	54	59
NCA04	All	All	30	34	30	34	34	34	34	34
NCA05	All	All	83	83	63	62	87	88	66	67
NCA06	All	All	77	56	49	28	77	57	50	31
NCA07	All	All	89	82	86	78	92	85	89	81
NCA08	All	All	48	33	55	35	55	35	62	39
NCA09	All	All	31	30	35	30	35	30	36	33
All	**All**	**All**	**432**	**400**	**372**	**328**	**462**	**421**	**402**	**355**

Note: Predicted noise levels at receivers which are above the NCG controlling criteria do not necessarily qualify for at-property treatment. As per the discussion in **Section 6**, further criteria are used to determine which of those receivers are eligible for consideration of at-property treatment.

With reference to **Table 10**, the information presented in **Table 13** indicates that the proposed additional noise mitigation (noise barriers) is predicted to reduce the overall number of receivers with an exceedance of the NCG criteria. This reduction equates to 83 and 82 receivers in the 2028 day and night-time period respectively, when compared to the Build (without mitigation) scenario detailed in **Table 10**.

8.3.2 Receivers Considered for At-Property Treatment

With reference to the criteria for additional mitigation (refer to **Section 6.6**), the number of receivers which have been identified as eligible for consideration of property treatment after additional noise mitigation (noise barriers) are shown in **Table 14**.

Table 14 Receivers Considered Eligible for At-Property Treatment

NCA	Receiver Type	2018 Final Build			2028 Final Build			TOTAL	
		Day	Night	Combined	Day	Night	Combined	By Floor	By Lot
NCA01	Residential	-	-	-	-	-	-	-	-
	Other	2	2	2	2	2	2	2	1
NCA02	Residential	-	-	-	-	1	1	1	1
	Other	-	-	-	-	-	-	-	-
NCA03	Residential	17	19	19	23	26	26	26	21
	Other	-	-	-	-	-	-	-	-
NCA04	Residential	-	-	-	-	-	-	-	-
	Other	5	5	5	5	5	5	5	4
NCA05	Residential	15	16	17	18	19	19	19	14
	Other	2	1	2	2	1	2	2	2
NCA06	Residential	26	26	26	27	28	28	28	22
	Other	15	-	15	18	-	18	18	13
NCA07	Residential	32	34	34	34	35	35	35	31
	Other	2	-	2	2	-	2	2	1
NCA08	Residential	29	29	29	29	29	29	29	28
	Other	-	-	-	1	-	1	1	1
NCA09	Residential	25	25	25	25	25	25	25	25
	Other	1	-	1	1	-	1	1	1
ALL	**Residential**	**144**	**149**	**150**	**156**	**163**	**163**	**163**	**142**
	Other	**27**	**8**	**27**	**31**	**8**	**31**	**31**	**23**
	Total	**171**	**157**	**177**	**187**	**171**	**194**	**194**	**165**

The full NCG assessment table for all receivers eligible for consideration of at-property treatment is provided in **Appendix I**.

The locations of the receivers eligible for consideration of at-property treatment are shown in the maps in **Appendix J**. These receivers correspond to those eligible for consideration of additional noise mitigation where the feasible and reasonable mitigation does not reduce the noise levels to meet the NCG controlling criterion.

8.3.3 Discussion of At-Property Treatments

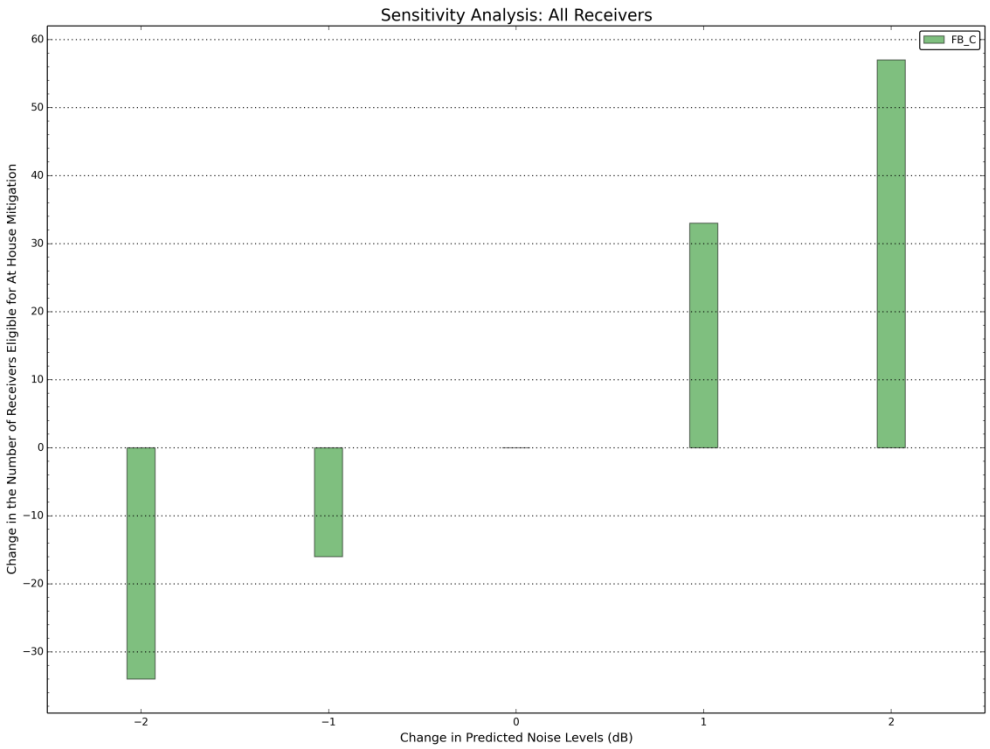
As shown in **Table 14**, a total of 194 receivers (floors) are predicted to be eligible for consideration of at-property treatment as part of this project. This number comprises:

- 163 residential receivers on a ground or first floor (142 individual lots)
- 31 other sensitive receivers on a ground or first floor (23 individual lots)

8.4 Sensitivity Analysis

The sensitivity of the total number of at-property treatments to changes in the noise level predictions is shown in **Figure 5** below.

Figure 5 Assessment Sensitivity Analysis



The information contained in **Figure 5** indicates that an additional 33 receivers would be eligible for consideration of at-property treatment if a +1 dB correction were to be added to the noise model predictions. A reduction of 16 receivers would be apparent if 1 dB was subtracted from the noise model predictions.

9 CONCLUSION

Noise levels have been predicted and assessed for the Detailed Design of the Prospect Highway Upgrade.

The Detailed Design noise predictions have been compared against the applicable criteria and to the acoustic assessment of the concept design contained in the REF for the project.

Additional noise mitigation measures aimed at reducing the potential noise impacts of the final Detailed Design have been investigated. The final noise mitigation package includes noise barriers on both the western and eastern side of the alignment, combined with at-property architectural treatment of the residual noise impacts.