SouthmetroConnect

Acoustic assessment report

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Appendix U

Acoustic assessment report

Roe Highway Extension
South Metro Connect
6 May 2011
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Acoustic Assessment Report

Roe Highway Extension

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Roe Highway Extension

Prepared for

South Metro Connect

Prepared by

AECOM Australia Pty Ltd
3 Forrest Place, Perth WA 6000, GPO Box B59, Perth WA 6849, Australia
T +61 8 6430 2000 F +61 8 6430 2999 www.aecom.com
ABN 20 093 846 925

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Executive Summary

As part of the South Metro Connect alliance, AECOM has carried out an acoustic assessment study of the concept design for the Roe Highway Extension project. This report documents the assessment procedure and its outcomes.

Ambient noise measurements were taken at ten sites within the project area. The locations were chosen to represent all major and several minor roads in the vicinity of the project corridor. These comprise Roe Highway, Kwinana Freeway, North Lake Road, Stock Road, Farrington Road, Forrest Road and Bibra Drive. The measurements were supplemented by Roe Highway Stage 7 Post Compliance measurements carried out in 2006 by Lloyd George Acoustics (LGA).

Noise measurement results were used to calibrate the existing road traffic noise model and predict existing noise emissions within the project area. The calibrated noise model was used to predict the future noise environment for build and no-build scenarios in the opening year (2016) and in the design year (2031).

The predictions were used to assess noise impacts associated with the proposed upgrade, and the results of assessment are summarised in the table below for the cases with no noise control measures implemented at site:

Modelled Scenario	Number of Receivers				Predicted Daytime Statistics $L_{Aeq,16hr}$ (dB(A))	
	Total	> 55 dB(A)	> 60 dB(A)	> 65 dB(A)	Average	Maximum
2016, No-build	1,472	100	0	0	47.1	59.8
2016, Build	1,472	245	5	0	51.8	63.8
2031, No-build	1,472	205	21	0	49.0	63.3
2031, Build	1,472	494	79	0	53.9	64.3

Predicted noise impacts have been assessed against the outdoor noise criteria at the ground floor of noise sensitive receivers, both in terms of noise targets and noise limits, as required by the WA State Planning Policy 5.4 (SPP 5.4). Mitigation was generally required along the new section of the project. Realignment of Stock Road significantly increased noise levels at some noise-sensitive receivers south of the proposed interchange. Reasonable and practicable noise mitigation measures have been considered to meet the noise limits at these receivers.

Noise impacts have also been assessed at parks and recreational areas within the project area against noise criteria which have been developed for the project on the basis of SPP 5.4 outdoor noise criteria.

Noise barrier designs have been developed to meet both the noise target and noise limit criteria. A concept of reasonable and practicable noise mitigation measures was then developed that best balances noise benefit, cost, feasibility, amenity impacts as well as safety and security. It should be noted that concept noise mitigation is based on the concept-phase road design and is subject to change during the detailed design phase. A summary of all three barrier configurations investigated as part of this study are presented in the table below.

Barrier Configuration	Total Barrier Length	Average Barrier Height	Maximum Barrier Height	Total Barrier Area
Barrier to meet noise limits	1,962 m	2.4 m	3.6 m	4,611 m^2
Barrier to meet noise targets	8,045 m	3.8 m	6.2 m	30,460 m^2
Proposed concept noise barrier design	8,270 m	3.2 m	5 m	26,331 m^2

Preliminary mitigation designs have been developed which incorporate some community preferences where these mitigation treatments do not conflict with other planning and transport policies. Noise barriers located on residential boundaries have been limited to 4.4m in height and those within the road reserve to 5m, providing a balance between noise benefit, cost and visual amenity.

The table below shows the reduction in noise impacts due to the proposed mitigation, showing future build scenario result summaries with and without the proposed mitigation.

Scenario	Total number of receivers	>55 dB(A)		> 60 dB(A)		Max exceedance of 60 dB(A) noise limit criterion	
		Without Barrier	With Barrier	Without Barrier	With Barrier	Without Barrier	With Barrier
2016 Build	1472	245	61	5	0	3.8	0.0
2031 Build	1472	494	170	79	5	4.3	1.6

It shows that the proposed barriers reduce the number of noise sensitive receivers within the project area exceeding the noise limit of 60 dB(A) from 79 to just five. The proposed barriers also decrease the number of noise sensitive receivers exceeding the noise target of 55 dB(A) from 494 to 170.

Summary of results comparing "build" scenarios with proposed mitigation to the corresponding "no-build" scenarios is presented in the following table.

Modelled Scenario	Number of Receivers				Daytime $L_{Aeq,16hr}$ (dB(A))	
	Total	> 55 dB(A)	> 60 dB(A)	> 65 dB(A)	Average	Maximum
2016 No-build	1,472	100	0	0	47.1	59.8
2016 Mitigation	1,472	61	0	0	50.5	59.8
2031 No-build	1,472	205	21	0	49.0	63.3
2031 Mitigation	1,472	170	5	0	52.6	61.6

The comparison shows that although the average noise exposure across all receivers increases due to the project, the number of receivers exceeding both the target and the limit criteria decreases. The number of receivers exceeding the noise target in 2031 decreases from 205 to 170 due to the project. Similarly, the number of receivers exceeding the noise limit decreases from 21 to five. All five receivers exceeding the noise limit are located adjacent to existing roads and either out of the scope of the proposed upgrade, or the noise levels are predicted to decrease due to the proposed upgrade.

Only 29 of the 170 receivers exceeding the noise target are adjacent to the new road (i.e. those previously not exposed to significant noise from road traffic). Of these, seven exceed the target by 2 dB(A) and 22 by 1 dB(A). The remaining 141 receivers exceeding the target but not the limit are adjacent to existing roads, where the net result of the proposed project is a decrease in the number of receivers exceeding the noise target from 205 to 141.

We note that the above assessment is based on noise levels predicted at the ground floor of noise sensitive receivers, in accordance with SPP 5.4 assessment methodology. The noise levels at upper storeys of double storey residences are expected to be up to 3 to 6 dB(A) greater than those on the ground floor. Although many first floor receivers will exceed the noise target, based on the above, they are generally expected to comply with the noise limit criterion adjacent to the new road. Noise exposure at first storey residences adjacent to existing roads may exceed the noise limit, however it is noted that many locations will experience a decrease in noise levels as a result of the proposed works, and where the levels do increase, the increase will be marginal.

The assessment does not take into account noise shielding from visual screening barriers. Where installed, visual screening barriers will provide additional noise reduction and will be assessed separately. Assessment of noise mitigation from visual screening barriers will be incorporated into the detailed design phase of this project, and proposed noise barriers revised accordingly. The results of all noise modelling scenarios are presented in Appendix D and E.

Construction noise and vibration criteria applicable to the project have been developed. The potential for construction noise and vibration impacts has been identified along the majority of the proposed project due to its close proximity to noise and vibration sensitive receivers. A construction noise and vibration impact management plan will be prepared in collaboration with the construction team, and submitted to DEC and / or Local government for approval of any out-of-hours works prior to commencement of construction.

1.0 Introduction

1.1 Background

In August 2009, Main Roads Western Australia and industry partners, AECOM Australia, formed the South Metro Connect alliance (SMC). The team was created for the development phase of the Roe Highway Extension project. Its primary objective is to work collaboratively with specialist consultants, stakeholders, and regulatory authorities to develop an environmentally, socially and economically acceptable project design in order to obtain relevant statutory approvals.

As part of the alliance, AECOM has carried out an acoustic assessment of the proposed extension of Roe Highway from Kwinana Freeway to Stock Road.

The purpose of this report is to document the noise assessment study, comprising:

1.) Measurement and modelling of the existing noise environment within the study area.

2.) Predictions of future noise emissions within the study area and assessment against noise criteria to determine impacts associated with the project.

3.) Design of noise mitigation to manage impacts and achieve compliance with applicable noise criteria.

The acoustic terminology used in this report is explained in Appendix A.

1.2 Project Description

Main Roads Western Australia (MRWA) propose to extend Roe Highway from Kwinana Freeway to Stock Road. The proposal comprises a four lane, two carriageway main highway, with full interchanges at Kwinana Freeway, Murdoch Drive, North Lake Road and Stock Road. These roads would also be modified as part of the project to accommodate the interchanges as follows:

- Stock Road would be widened by one lane in each direction (to three lanes per direction), extending approximately 750 m on either side of the interchange. The extents of the widened section of Stock Road are yet to be finalised.
- North Lake Road would be widened by one lane in the southbound direction, extending approximately 450 m on either side of the interchange. It would revert to the existing 5 lane, two carriageway configuration outside of this area.
- Murdoch Drive would be extended from Farrington Road to the proposed Roe Highway alignment.
- Kwinana Freeway south of the interchange and Roe Highway west of Karel Avenue would also be widened to accommodate the modified interchange design

Several local roads, including Coolbellup Avenue, Sudlow Road, Bibra Drive and Progress Drive are also proposed to be realigned in the vicinity of the proposed Roe Highway alignment as part of the works. The noise assessment study area comprises all noise sensitive receivers located within 200 m of the proposed works. The extent of the study area is shown in Figure 1.

1.3 Project Study Area

The residences in the study area are predominantly single storey. They are situated adjacent to the road corridor on the northern, southern and eastern sides of the proposed works. Other noise sensitive receivers within the project area include the Blue Gum Montesorri School and Hamilton Senior High School. The remaining area at the eastern central section of the project is predominantly wetland or natural vegetation ranging between 1 and 5 m in height. An aerial photograph of the site is presented in Figure 1.

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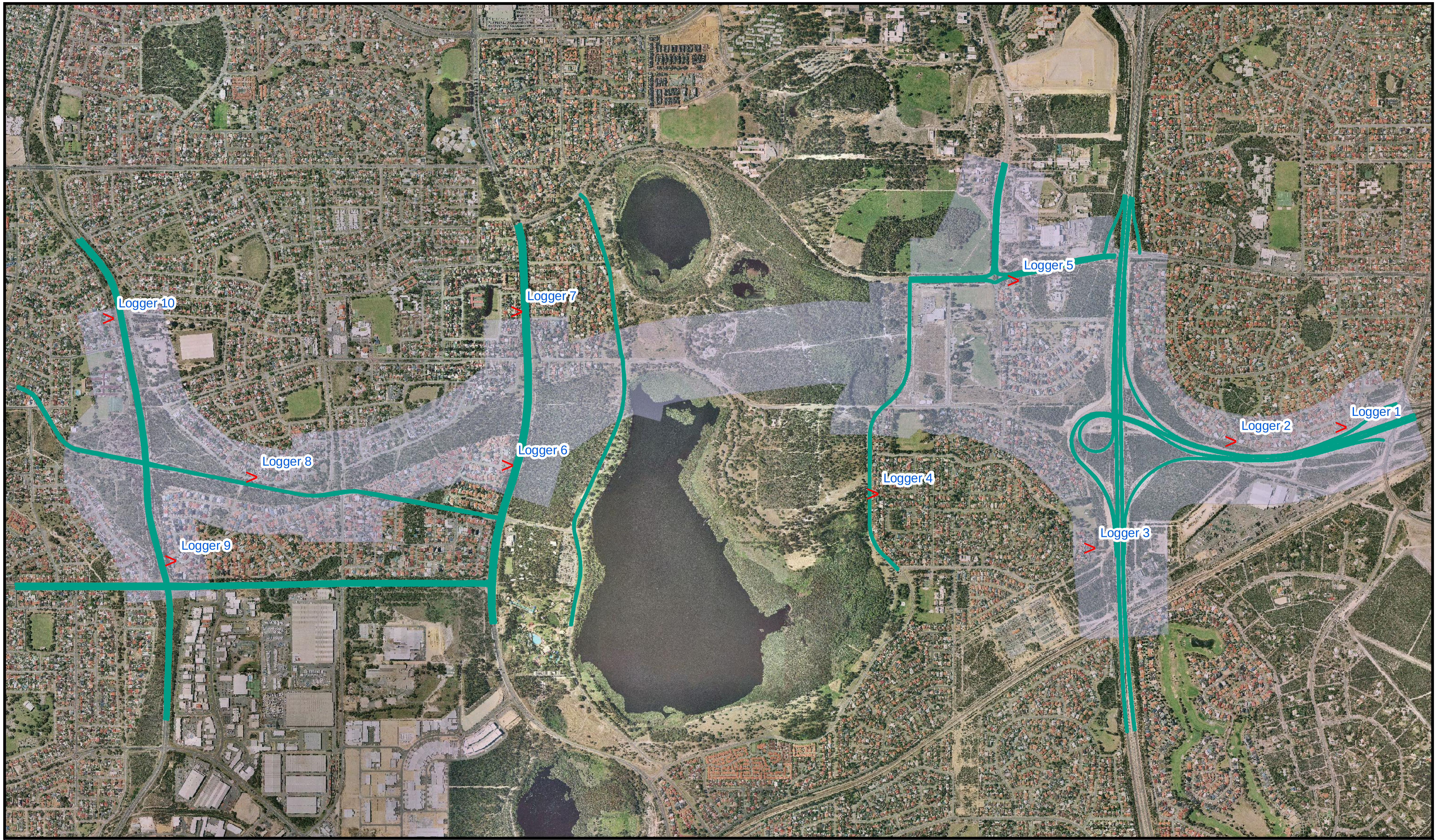

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metres

Legend

Study Area

> Noise Measurement Location

Roads considered in Existing noise environment study

South Metro Connect - Roe Highway Extension
Project Area and Existing Noise Monitoring Locations

PROJECT ID 60100953

CREATED BY BS

LAST MODIFIED NB 30 NOVEMBER 2010

Figure 1

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2.0 Noise and Vibration Criteria

2.1 Operational Noise Criteria

The criteria applicable to noise emissions from new roads or redevelopments of existing major roads are outlined in the *State Planning Policy 5.4: Road and Rail Transport Noise and Freight Considerations in Land Use Planning* (SPP 5.4).

The noise criteria apply to the emission of road transport noise as received at a noise-sensitive land use such as residential dwellings or non-residential noise sensitive receivers such as schools and child care centres. The criteria are applicable at 1 m from the most exposed, habitable façade of the building receiving the noise, at ground floor level only.

2.1.1 Criteria for New Roads

Outdoor noise criteria for sensitive receivers affected by emissions from new major road proposals are outlined in Table 1 below. The criteria are not applicable to major redevelopment of existing transport infrastructure, which are discussed in Section 2.1.2.

Table 1 SPP 5.4 Outdoor noise criteria for new major road proposals

Time of day	Noise Target	Noise Limit
Day (6 am–10 pm) - $L_{Aeq,16hr}$	55dB(A)	60dB(A)
Night (10 pm–6 am) – $L_{Aeq,8hr}$	50dB(A)	55dB(A)

The 5 dB(A) difference between the outdoor noise target and the outdoor noise limit, as prescribed in Table 1, represents an acceptable margin for compliance. The policy states that "*In most situations in which either the noise-sensitive land use or the major road or railway already exists, it should be practicable to achieve outdoor noise levels within this acceptable margin*".

Policy guidelines for interpretation and application for new infrastructure proposals state that:

"*If a transport infrastructure project will emit transport noise levels that meet the noise target, no further measures are required under this policy. Otherwise, transport infrastructure providers should design mitigation measures to achieve the noise limit of LAeq(Day) 60dB(A) and LAeq(Night) 55dB(A), when assessed at one metre from the façade at ground floor level. Transport infrastructure providers are also required to consider design measures to meet the noise target of LAeq(Day) 55dB(A) and LAeq(Night) 50dB(A), and to implement these measures where reasonable and practicable.*"

The policy also recognises that in some cases it may not be practicable to achieve the outdoor noise criteria. Where outdoor noise limits cannot be achieved with reasonable and practicable mitigation measures, treatment of individual properties should be considered to achieve acceptable indoor noise levels.

2.1.2 Criteria for Redevelopment of Existing Roads

With regard to redevelopment of existing major road infrastructure, SPP 5.4 states that reasonable and practicable noise management and mitigation measures should be considered having regard to:

- the existing transport noise levels
- the likely changes in noise emissions resulting from the proposal; and
- the nature and scale of the works and the potential for noise amelioration.

Guidelines for reasonable and practicable measures are provided within Section 5.8 of the policy, which is reproduced in full below:

5.8 Reasonable and practicable measures

This policy applies a performance-based approach to the management and mitigation of transport noise.

It is recognised that in a number of instances it may not be reasonable and practicable to meet the noise target criteria. Where transport noise is above the target level, measures are expected to be implemented that best balance reasonable and practicable considerations, such as noise benefit, cost, feasibility, community preferences, amenity impacts, safety, security and conflict with other planning and transport policies. In these cases the community should also be consulted to assist in identifying best overall solutions. The guidelines assist in outlining ways in which some reasonable and practicable limitations can be addressed in a manner that also minimises transport noise.

It is further acknowledged that there may also be situations in which the noise limit cannot practicably be achieved, especially in the case of major redevelopment of existing transport infrastructure. Similarly, it may not be practicable to achieve acceptable indoor noise levels if the new development is located very close to the transport corridor. In these situations the primary focus should be on achieving the lowest level of noise, with other reasonable and practicable considerations being secondary to this objective.

In cases where the noise limit or indoor noise criteria cannot practicably be met, longer term strategies for land use planning, transport policy and vehicle emissions should be considered to minimise transport noise impact over time.

2.1.3 Noise Criteria within Parks and Recreational Areas

While SPP 5.4 does not discuss noise criteria for parks and recreational areas, it provides criteria for outdoor residential and noise sensitive areas, which are presented in Table 1.

Main Roads WA will consider reasonable and practicable noise management and mitigation measures to satisfy the noise criteria at parks and recreational areas, giving regard to:

- the size of the park / recreational area and the proportion of area exceeding the criteria, and
- the location of fixed recreational infrastructure (e.g. playgrounds, picnic tables, barbecue facilities etc) and the noise levels predicted at these locations.
- the availability of alternative recreational areas within reasonable distance of affected areas

2.2 Construction Noise and Vibration Criteria

2.2.1 Construction Noise Criteria

Western Australian Environmental Protection (Noise) Regulations 1997 (WAEPNR) regulate noise emissions from construction sites, including those of road and rail infrastructure. Noise emission from construction sites is regulated by noise criteria developed under Regulation 7, as applied within the framework specified by Regulation 13.

Regulation 7 of WAEPNR provides maximum allowable noise levels termed the “assigned noise level” and require that:

“. . . noise emitted from any premises or public place when received at other premises must not cause, or significantly contribute to, a level of noise which exceeds the assigned level in respect of noise received at premises of that kind”

A noise emission is taken to ‘significantly contribute to’ a level of noise if the noise emission exceeds a level which is 5 dB below the assigned level at the point of reception. The table of assigned noise levels from the Regulations is reproduced in Table 2.

Table 2 WA Environmental Protection (Noise) Regulations 1997 Assigned noise levels

Type of premise receiving noise	Time of Day	Assigned Level (dB)		
		L_{A10}	L_{A1}	L_{Amax}
Noise sensitive premises at locations within 15m of a building directly associated with a noise sensitive use	0700 to 1900 hours Monday to Saturday	45 + influencing factor	55 + influencing factor	65 + influencing factor
	0900 to 1900 hours Sundays and public holidays	40 + influencing factor	50 + influencing factor	65 + influencing factor
	1900 to 2200 hours all days	40 + influencing factor	50 + influencing factor	55 + influencing factor
	2200 hours on any day to 0700 hours Monday to Saturday and 0900 hours Sunday and public holidays	35 + influencing factor	45 + influencing factor	55 + influencing factor
Noise sensitive premises at locations further than 15m of a building directly associated with a noise sensitive use	All hours	60	75	80
Commercial premises	All hours	60	75	80
Industrial and Utility premises	All hours	65	80	90

The Assigned Level for a noise sensitive receiver is dependent on the location of the existing noise sensitive receiver, the noise character of the locality with respect to traffic corridors and commercial or industrial use, the time of day that the noise is present and the character of the noise. These characteristics are taken into account by the "influencing factor".

The influencing factor is determined by considering the land use and presence of road transport infrastructure in the vicinity of the noise sensitive premises of concern. The influencing factor at controlling noise sensitive receivers within the project area ranges from 0 to 7 depending on their location, and is as follows:

- 0 at locations more than 450 m away from commercial or industrial areas and existing transport routes.
- 2 at receivers within 450 m but more than 100m of existing major transport routes,
- 3 at receivers within 450 m but less than 100 m of existing major transport routes and within 450 m of industrial / commercial areas
- 6 at receivers within 100 m of existing major transport routes, and
- 7 at premises which are within 100m of existing major transport routes as well as within 450 m of industrial / commercial areas.

A summary of the applicable range of noise criteria, depending on receiver location, is shown in Table 3.

For example, a receiver with an influencing factor of 2 and a criterion range (as presented in Table 3) of 40 – 47 dB(A) would have a noise criterion of 42 dB(A).

Table 3 Environmental noise emission criteria summary

Type of premise receiving noise	Time of Day	Environmental Noise Criteria Range dB(A)		
		L_{A10}	L_{A1}	L_{Amax}
Noise sensitive premises at locations within 15m of a building directly associated with a noise sensitive use	0700 to 1900 hours Monday to Saturday	40 – 47	50 – 57	60 – 67
	0900 to 1900 hours Sundays and public holidays	35 – 42	45 – 52	60 – 67
	1900 to 2200 hours all days	35 – 42	45 – 52	50 – 57
	2200 hours on any day to 0700 hours Monday to Saturday and 0900 hours Sunday and public holidays	30 – 37	40 – 47	50 – 57
Noise sensitive premises at locations further than 15m of a building directly associated with a noise sensitive use	All hours	55	70	75
Commercial premises	All hours	55	70	75
Industrial and Utility premises	All hours	60	75	85

Penalties apply to noise sources with characteristics which are likely to cause further annoyance to the population. A 5 dB(A) penalty applies to noise sources characterised by “modulation” or “tonality” and a 10 dB(A) penalty to sources characterised as “impulsive”.

Exceptions to noise criteria developed under Regulation 7, which are applicable to construction noise are outlined in Regulation 13 (Section 2 and 3), and are reproduced in full below:

(2) Regulation 7 does not apply to noise emitted from a construction site as a result of construction work carried out between 0700 hours and 1900 hours on any day which is not a Sunday or public holiday if the occupier of the premises or public place, shows that —

(a) the construction work was carried out in accordance with control of environmental noise practices set out in section 6 of AS 2436-1981 Guide to Noise Control on Construction, Maintenance and Demolition Sites;

(b) the equipment used on the premises was the quietest reasonably available; and

(c) if the occupier was required to prepare a noise management plan under subregulation (4) in respect of the construction site —

(i) the noise management plan was prepared and given in accordance with the requirement, and approved by the Chief Executive Officer; and

(ii) the construction work was carried out in accordance with the management plan.

(3) Regulation 7 does not apply to noise emitted from a construction site as a result of construction work carried out other than between the hours specified in subregulation (2) if the occupier of the construction site shows that —

(a) the construction work was carried out in accordance with control of environmental noise practices set out in section 6 of AS 2436-1981 Guide to Noise Control on Construction, Maintenance and Demolition Sites;

(b) the equipment used on the premises was the quietest reasonably available;

(c) the construction work was carried out in accordance with a noise management plan in respect of the construction site —

(i) *prepared and given to the Chief Executive Officer not later than 7 days before the construction work commenced; and*

(ii) *approved by the Chief Executive Officer;*

(d) *at least 24 hours before the construction work commenced, the occupier of the construction site gave written notice of the proposed construction work to the occupiers of all premises at which noise emissions received were likely to fail to comply with the standard prescribed under regulation 7; and*

(e) *it was reasonably necessary for the construction work to be carried out at that time.*

Daytime construction activities are generally exempt from Regulation 7 noise criteria provided that best practice construction methods are employed during construction using the quietest reasonably available equipment.

Furthermore, construction activities during the evening or night time may also be allowed to exceed the noise criteria (subject to necessary approvals) provided that it is necessary for construction work to be carried out at that time, and potentially affected residents are given prior written notice of the event(s). A construction noise management plan must be approved by DEC or relevant local government authority for any out-of-hours construction work.

2.2.2 Construction Vibration Assessment Guidelines

The effects of ground vibration on buildings resulting from construction activities may be segregated into the following three categories:

- human exposure - disturbance to building occupants: vibration in which the occupants or users of the building are inconvenienced or possibly disturbed
- effects on building contents - vibration where the building contents may be affected
- effects on building structures - vibration in which the integrity of the building or structure itself may be prejudiced.

EPA Draft Guidance for the Assessment of Environmental Factors No. 8 – Environmental Noise (Draft EPA Guidance 8) recommends that construction vibration be assessed against vibration criteria for human comfort, as outlined in Annex A of *Australian Standard 2670.2-1990 "Evaluation of human exposure to whole-body vibration - Part 2: Continuous and shock induced vibration in buildings (1 to 80 Hz)"* (AS 2670).

In general, vibration criteria for human disturbance are more stringent than vibration criteria for effects on building contents and building structural damage. Compliance with the more stringent limits dictated by human exposure will therefore ensure that compliance is also achieved for the other two categories.

2.2.3 Human Comfort – AS2670

In general the human response to floor motion is found to be a complex phenomenon. There are wide variations in vibration tolerance of humans and accordingly acceptance criteria for human comfort are hard to define and quantify. Acceptable values of human exposure to vibration are primarily dependent on the activity taking place in the occupied space (e.g. workshop, office, or residence) and the character of vibration (e.g. continuous or intermittent). In addition, specific values are dependent upon social and cultural factors, psychological attitudes, expected interference with privacy, and ultimately the individual's perceptibility.

The Australian Standard AS 2670 offers guidance on how to assess human response to building vibration. All discussions in this section relate to vibrations and vibration levels in the controlling (most stringent) *vertical* direction.

The recommendations on maximum vibration levels given in Annex A of AS 2670, Part 2:

- are frequency dependent;
- distinguish between continuous and transient vibration; and
- differ for day and night time in residential areas.

AS 2670 specifies maximum allowable vibration levels in terms of multiples of a “baseline curve”. Baseline curves specify maximum allowable vibrations in critical working areas such as hospital operating theatres or precision laboratories. Recommended multipliers for different occupation types are listed in Table 4. Baseline curves for acceleration and velocity are shown in black in Figure 2 and Figure 3 respectively. The red and blue curves represent criteria for human comfort in residential buildings during the daytime and night-time periods.

Table 4 Ranges of multiplying factors used in several countries to specify satisfactory magnitudes of building vibration with respect to human response.

Place	Time	Continuous or inter-mittent vibration	Transient vibration excitation with several occurrences per day
Critical working areas (some hospital operating-theatres, some precision laboratories, etc.)	Day Night	1	1
Residential	Day	2 to 4	30 to 90
	Night	1.4	1.4 to 20
Office	Day Night	4	60 to 128
Workshop	Day Night	8	90 to 128

Figure 2 AS 2670.2 Vibration criteria for human comfort - Acceleration criterion

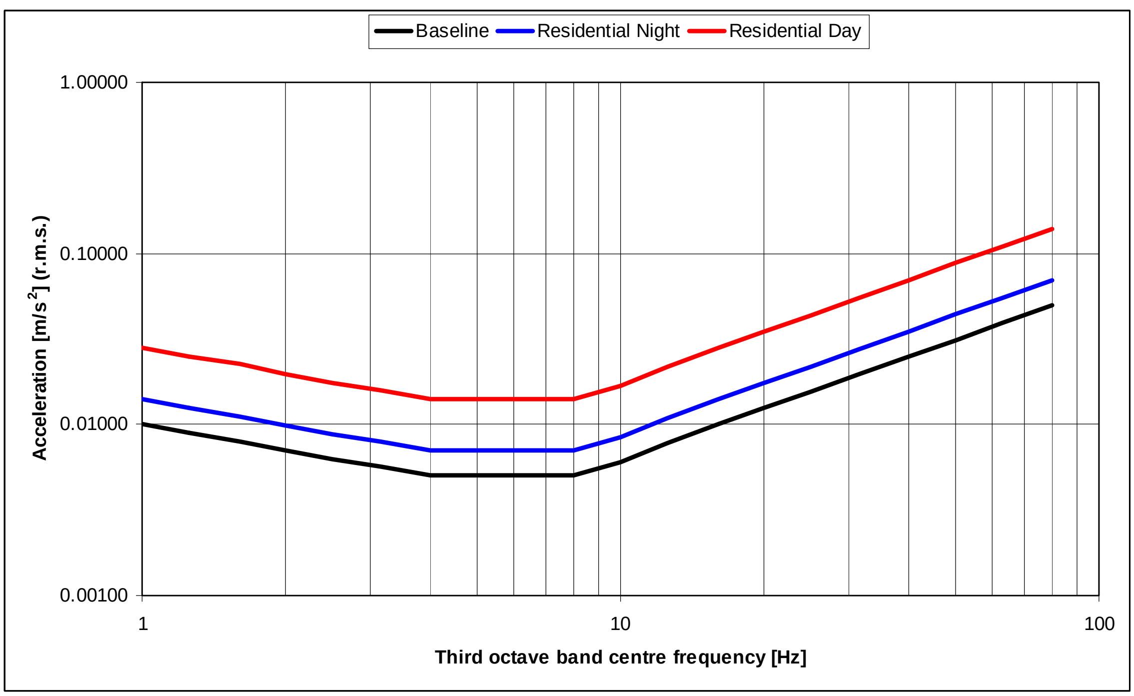
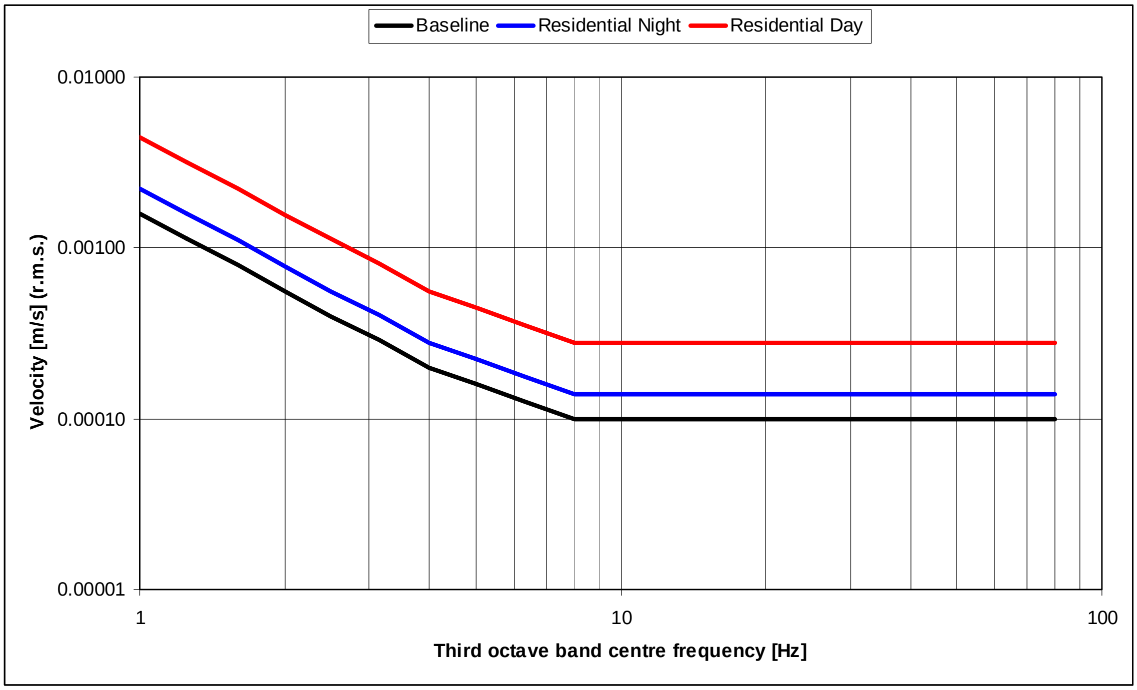


Figure 3 AS 2670.2 Vibration criteria for human comfort - Velocity criterion



It is noted that adjustments to the above criteria may be warranted in some circumstances where restriction on vibration levels may prolong operations and result in greater annoyance. If, as a result of community consultation, adjustments to the above vibration criteria are warranted, vibration levels should not exceed the criteria for structural damage in buildings.

2.2.4 Structural Damage

There are two widely used standards which provide guidelines for assessing structural damage due to construction vibration. These are

- *German Standard DIN 4150 "Structural Vibration Part 3: Effects of Vibration on Structures Guidelines"*, 1999.
- *British Standard BS 7385 Part 2 "Evaluation and measurement for vibration in buildings – Guide to damage levels from ground-borne vibration",1993*; and

DIN 4150 guidelines are based on vibration levels at which no damage due to vibration effects has been observed, while BS 7385 is based on the principle of "*minimal risk of building damage".*

The guideline limits in DIN 4150 are therefore slightly lower than those of the BS 7385, and are generally considered to be somewhat conservative. It is recommended that DIN 4150 vibration criteria be adopted as the structural damage vibration target on this project.

DIN 4150 defines structural damage as "*any permanent effect of vibration that reduces the serviceability of a structure or of one of its components."*

In addition,

Serviceability is considered to have been reduced if:

- *Cracks form in plastered surfaces of walls;*
- *Existing cracks in the building are enlarged;*

- *Partitions become detached from load-bearing walls or floors.*

These effects are deemed minor damage.

DIN 4150 distinguishes between short term and long term exposure duration. Short term vibration is vibration which does not occur often enough to cause structural fatigue and which does not produce resonance in the structure being evaluated. Long term vibration, in turn, covers all type of vibration which is not covered by the definition of short term vibration.

Guideline vibration levels to assess short term and long term vibration on structures are listed in Table 5 and Table 6.

Table 5 DIN4150 Guideline values for vibration velocity to be used when evaluating the effects of short-term vibration on structures

Type of structure	Guideline values for Peak Particle Velocity (PPV) in mm/s			
	Vibration at the foundation at a frequency of			Vibration at horizontal plane of highest floor at all frequencies
	1 Hz to 10 Hz	10 Hz to 50Hz	50 Hz to 100Hz	
Dwellings and buildings of similar design and/or occupancy	5 mm/s	5 mm/s at 10 Hz to 15 mm/s at 50 Hz	15 mm/s at 50 Hz to 20 mm/s at 100 Hz	15 mm/s
Buildings used for commercial purposes, industrial buildings, and buildings of similar design	20 mm/s	20 mm/s at 10 Hz to 40 mm/s at 50 Hz	40 mm/s at 50 Hz to 50 mm/s at 100 Hz	40 mm/s
Structures that, because of their particular sensitivity to vibration, cannot be classified under lines 1 and 2 and are of great intrinsic value (e.g. listed buildings under preservation order)	3 mm/s	3 mm/s at 10 Hz to 8 mm/s at 50 Hz	8 mm/s at 50 Hz to 10 mm/s at 100 Hz	8 mm/s

Table 6 DIN4150 Guideline values for vibration velocity to be used when evaluating the effects of long-term vibration on structures

Type of structure	Guideline values for Peak Particle Velocity (PPV) in mm/s in horizontal plane of highest floor at all frequencies
Dwellings and buildings of similar design and/or occupancy	5
Buildings used for commercial purposes, industrial buildings, and buildings of similar design	10
Structures that, because of their particular sensitivity to vibration, cannot be classified under lines 1 and 2 and are of great intrinsic value (e.g. listed buildings under preservation order)	2.5

DIN 4150 also states that:

'Experience has shown that if these values are complied with, damage that reduces the serviceability of the building will not occur. If damage nevertheless occurs, it is to be assumed that other causes are responsible'.

It is important to note that exceeding the values above does not necessarily lead to building damage.

3.0 Traffic Noise Monitoring

3.1 Noise Monitoring Sites

Noise monitoring has been carried out to quantify the existing noise environment along the project area. Noise monitoring locations have been selected on the basis of major and minor roads within the project area and their potential impact on the existing noise environment within it.

Two noise monitoring locations were selected along each of the major roads in the project area comprising Stock Road, North Lake Road and Roe Highway. In addition, one location was selected at each of the following roads: Bibra Drive, Farrington Road, Forest Road and Kwinana Freeway. Noise logging locations are shown in Figure 1.

The selected locations cover all major and several minor roads within the project area. The monitoring locations are representative of most affected dwellings adjacent to each of the roads. Noise monitoring locations and details of monitoring are listed in Table 7, and shown in Figure 1.

Table 7 Noise monitoring location and deployment summary

Location No.	Address	Instrument Serial No.	Deployment Period	
			Date deployed	Date retrieved
1	50 Sylvan Cres, Leeming	00187446	3/05/2010	13/05/2010
2	25 Brandwood Gdns, Leeming	00765701	3/05/2010	13/05/2010
3	12 Dowell Pl, Bibra Lake	00187446	24/03/2010	6/04/2010
4	20 Bibra Dr, Bibra Lake	00865768	23/03/2010	6/04/2010
5	16 Cheshunt Gdns, North Lake	00265112	23/03/2010	6/04/2010
6	32 Marshwood Rtt, Bibra Lake	00354110	3/05/2010	13/05/2010
7	13 Gregory Way, Coolbellup	00765701	3/05/2010	13/05/2010
8	58 Sebastian Cres, Coolbellup	00865768	3/05/2010	13/05/2010
9	94 Forillion Ave, Bibra Lake	00354110	23/03/2010	6/04/2010
10	65 Curven Rd, Hamilton Hill	00354110	23/03/2010	13/05/2010

3.2 Instrumentation, Calibration and Deployment

All noise monitoring was carried out using Type 2 Rion NL-21 automated noise loggers programmed to record various statistical noise descriptors in 1 hour intervals throughout the monitoring period. All noise loggers were laboratory calibrated within the 24 months preceding the measurements.

The loggers were deployed in two batches, the first between Friday the 23rd of March 2010 and Friday the 6th of April 2010, and second between Monday the 3rd of May 2010 and Thursday the 13th of May 2010. Each logger was field calibrated during deployment and again prior to collection. One logger ran out of charge prior to collection and could therefore not be calibrated on site. In this instance, post measurement calibration was carried out after batteries were recharged. Calibration of each logger was found to be within acceptable limits. Details of the noise monitoring program, including pre and post deployment calibration results, are presented in Appendix C.

All noise loggers were located 1 m from the dwelling façade nearest to the dominant road and 1.5 m above ground floor level, in accordance with MRWA traffic noise monitoring specification. Where possible, noise loggers were placed at a minimum distance of 1.5 m from building corners and openable windows and doors. At locations where loggers were placed at less than 1.5 m away from an openable window, residents have been asked to keep windows closed for the duration of the monitoring period, and monitoring results were checked for any discrepancies.

3.3 Meteorological Conditions

Noise measurement results were filtered to exclude data from adverse meteorological conditions. These meteorological conditions included periods of rainfall exceeding 2 mm per hour and average wind speeds exceeding 19 km/h, or 11 km/h in case of 'continuous positive wind' (i.e. wind blowing from the road to the receiver throughout the day) .

Meteorological conditions during the monitoring periods were obtained from the nearest Bureau of Meteorology (BOM) weather station, which is located at Jandakot airport, approximately 5 km southeast of the project area. The BOM reported wind speeds were generally greater than the maximum MRWA accepted wind conditions for at least several hours per day, on most days during the monitoring period. It is noted however that BOM reported wind speeds were not necessarily the same as at the study area.

The wind speed at a particular location depends on observation height and on the type of terrain over which the wind approaches that location. The terrain surrounding the BOM weather station comprises mostly open terrain with few, well-scattered buildings. The terrain surrounding the noise monitoring locations on the other hand has numerous closely-spaced buildings generally between 3 m and 5 m in height, which act as wind obstructions. Furthermore, horizontal wind speed generally increases with height above ground. Noise monitoring was conducted at a microphone height of 1.5 m, while wind speed at the BOM weather station is measured at a height of 10 m. The BOM reported wind speed was therefore adjusted to reflect the actual wind speed at the measurement locations in accordance with the procedure outlined in Proceedings of Acoustics 2004 journal "*Converting Bureau of Meteorology wind speed data to local wind speeds at 1.5 m above ground level*" by Gowen et al. (2004).

Gowen et al. (2004) provide a method to adjust the wind speed for height and terrain. This procedure was used to determine the wind speed at the microphone at the time of noise monitoring. More specifically the BOM weather station was situated in 'Category 1' terrain at a height of 10m, while noise monitoring locations were located in 'Category 2' terrain at a height of less than 3 m. Based on the Gowen et al procedure, a wind speed multiplier of 0.68 was applied to all BOM measured wind speeds. The revised wind speeds appeared consistent with Beaufort scale observations made at the microphone locations during logger deployment and retrieval.

All noise measurements were examined following the adjustment procedure, and any data that appeared to be affected by adverse wind conditions was excluded from further assessment, even if adjusted wind speeds complied with the meteorological criteria.

3.4 Traffic Noise Monitoring Results

Ambient noise monitoring was carried out at 10 representative locations along the project corridor. All noise loggers were deployed on site for a minimum of one week in order to obtain valid noise data for at least 5 week days. Due to premature battery failure, only three days of valid data were available at Location 3.

Full five weekdays of valid noise monitoring data were available for all other monitoring locations. Summaries of daily $L_{A10,18hr}$, $L_{Aeq,16hr}$, $L_{Aeq,8hr}$ and $L_{Aeq,24hr}$ noise indicators for each location are presented in Table 8.

Detailed results including the processed data, as well as descriptions and photographs of monitoring locations are presented in Appendix C. Where graphs show L_{Aeq} or L_{A10} data to be affected by extraneous noise, the original values are adjusted, in accordance with MRWA procedures. The value was adjusted to the average of the corresponding indicators in the preceding and the following (unaffected) hour. All adjusted values are highlighted in the graphs and tabulated results. The adjusted values were used to calculate the daily $L_{A10,18hr}$, $L_{Aeq,16hr}$, $L_{Aeq,8hr}$ and $L_{Aeq,24hr}$ statistical indicators presented in Table 8.

Table 8 Environmental noise emission summary

Location Reference		Existing Noise Exposure Levels – dB(A)				Difference between $L_{Aeq,16hr}$ and $L_{Aeq,8hr}$
Location	Date	$L_{A10,18h}$	$L_{Aeq,24h}$	$L_{Aeq,16hr}$	$L_{Aeq,8hr}$	
Location 1: 50 Sylvan Cres, Leeming	4-May-10	60.1	57.5	58.4	52.9	5.7
	5-May-10	59.8	57.0	58.0	52.6	
	6-May-10	60.2	57.4	58.2	53.3	
	7-May-10	60.2	57.4	58.3	53.4	
	10-May-10	60.0	57.3	58.5	50.9	
	Period Average	60.1	57.3	58.3	52.6	
Location 2: 25 Brandwood Gdns, Leeming	4-May-10	59.4	56.7	57.8	53.0	4.4
	5-May-10	58.9	56.4	57.3	53.6	
	6-May-10	59.6	56.8	57.8	53.7	
	7-May-10	59.2	56.5	57.4	54.0	
	10-May-10	59.7	56.8	58.0	51.9	
	Period Average	59.4	56.6	57.7	53.2	
Location 3: 12 Dowell Pl, Bibra Lake	26-Mar-10	58.4	58.5	59.6	55.2	4.6
	29-Mar-10	59.4	58.4	59.4	54.8	
	1-Apr-10	59.8	59.0	60.1	55.5	
	Period Average	59.2	58.6	59.7	55.1	
Location 4: 20 Bibra Dr, Bibra Lake	24-Mar-10	63.7	59.6	61.1	51.9	9.6
	25-Mar-10	64.0	59.7	61.2	51.3	
	29-Mar-10	63.1	59.2	60.7	50.8	
	30-Mar-10	63.5	59.5	61.0	51.7	
	31-Mar-10	64.4	60.1	61.7	52.2	
	Period Average	63.8	59.6	61.1	51.6	
Location 5: 16 Cheshunt Gdns, North Lake	24-Mar-10	55.5	53.0	54.2	45.7	7.7
	25-Mar-10	55.7	53.2	54.4	46.6	
	26-Mar-10	56.2	54.0	55.2	48.4	
	29-Mar-10	55.7	53.2	54.4	47.1	
	31-Mar-10	56.2	53.9	55.1	47.3	
	Period Average	55.9	53.5	54.7	47.0	
Location 6: 32 Marshwood Rtt, Bibra Lake	4-May-10	53.6	50.5	51.9	44.5	6.7
	5-May-10	53.4	50.4	51.7	44.8	
	6-May-10	53.6	50.5	51.8	45.2	
	7-May-10	53.9	50.6	51.7	46.8	
	10-May-10	53.5	50.4	51.8	44.1	
	Period Average	53.6	50.5	51.8	45.1	

Location Reference		Existing Noise Exposure Levels – dB(A)				Difference between $L_{Aeq,16hr}$ and $L_{Aeq,8hr}$
Location	Date	$L_{A10,18h}$	$L_{Aeq,24h}$	$L_{Aeq,16hr}$	$L_{Aeq,8hr}$	
Location7: 13 Gregory Way, Coolbellup	4-May-10	57.1	54.5	56.0	47.5	8.2
	6-May-10	57.2	54.3	55.7	48.7	
	7-May-10	57.5	54.5	55.7	49.5	
	10-May-10	56.8	54.1	55.6	46.3	
	11-May-10	58.6	55.7	57.2	47.4	
	Period Average	57.4	54.6	56.0	47.9	
Location 8: 58 Sebastian Cres, Coolbellup	4-May-10	60.2	56.7	58.1	51.1	7.2
	5-May-10	60.7	57.5	58.9	50.9	
	6-May-10	60.4	57.3	58.7	51.3	
	7-May-10	60.9	57.0	58.3	51.7	
	10-May-10	59.7	56.2	57.6	50.3	
	Period Average	60.4	57.0	58.3	51.1	
Location 9: 94 Forillion Ave, Bibra Lake	24-Mar-10	58.9	55.5	56.9	46.9	10.1
	25-Mar-10	58.2	55.0	56.4	47.1	
	26-Mar-10	57.3	53.9	55.2	47.0	
	29-Mar-10	57.9	54.5	56.0	44.5	
	30-Mar-10	58.4	54.9	56.4	44.9	
	Period Average	58.1	54.8	56.2	46.1	
Location 10: 65 Curven Rd, Hamilton Hill	5-May-10	56.8	54.0	55.4	47.2	9.0
	6-May-10	56.5	53.7	55.2	46.4	
	10-May-10	56.5	53.7	55.3	45.1	
	11-May-10	57.6	55.0	56.5	47.3	
	12-May-10	56.8	53.9	55.4	47.0	
	Period Average	56.8	54.1	55.5	46.6	

4.0 Model Calibration and Existing Noise Modelling

4.1 Noise Modelling Methodology

Noise modelling of the proposed upgrade was carried out using the UK Department of Transport, "Calculation of Road Traffic Noise" (CoRTN 1988) algorithms as implemented by SoundPLAN 6.5 noise modelling software suite. The modelling suite allows for traffic volume and mix, type of road surface, vehicle speed, road gradient, ground absorption, and shielding from ground topography and intervening structures such as noise barriers and existing dwellings to be taken into account.

Receiver locations, ground topography, current road alignment and other cadastral data (e.g. property boundaries) were derived from aerial photographs and electronic information supplied by SMC.

4.2 Modelling Parameters

The CoRTN calculation predicts noise levels based on the $L_{A10,18hr}$ statistical noise descriptor. Operational road traffic noise criteria are based on the energy averaged $L_{Aeq,16hr}$ noise descriptor. The following conversion factors have therefore been incorporated into the model.

4.2.1 L_{A10} to L_{Aeq} Conversion Factor

Existing noise measurement results have been used to calculate the average difference of 1.6 dB(A) between the $L_{A10,18hr}$ and $L_{Aeq,16hr}$ noise descriptors. This difference has been applied to the $L_{A10,18hr}$ CoRTN output to convert it to the $L_{Aeq,16hr}$ noise descriptor relevant to road traffic noise assessment procedure in WA.

4.2.2 Low Volume Correction Factor

The CoRTN calculation algorithm implements a correction for roads with low traffic volumes (i.e. below 200 vehicles/hour) in order to account for the effect that intermittent traffic has on the $L_{A10,18h}$ statistical descriptor. This correction factor is not applicable to energy based L_{Aeq} descriptor calculations. Traffic volumes in this project have therefore been adjusted to ensure the low volume correction factor is not triggered within the model. CoRTN output is balanced accordingly by applying an additional correction factor to all traffic strings with adjusted traffic volumes. This approach has been successfully used on Kwinana Freeway 3rd Lane Extension project in WA and satisfactorily accounts for the L_{Aeq} prediction from both low and high-volume traffic flows.

4.2.3 Modified Source Height Noise Modelling

The CoRTN calculation algorithm assumes road traffic noise emission height of 0.5 m above road surface for all vehicle classes. This assumption can overestimate the effect of noise barriers, particularly on heavy vehicle routes, as heavy vehicle noise sources (namely engine and exhaust) have a significantly higher noise emission height. In order to account for the elevated height of heavy vehicle noise sources, traffic volumes were separated into light and heavy vehicles (Austroads Class 1 and 2, and 3-12 respectively). Light vehicle traffic strings were unmodified, while heavy vehicle traffic was modelled at a height of 1.5 m for heavy vehicle engines and 3.6 m for heavy vehicle exhausts in accordance with the implementation guidelines for State Planning Policy 5.4: Corrections to the outputs of the modified heavy vehicle traffic strings of -0.8 dB(A) for engine and -8.0 dB(A) for exhaust were applied in accordance with the implementation guidelines.

4.2.4 Multiple Lane Road Traffic Noise Modelling

On roads where multiple road lanes were present, each lane was modelled as a separate noise emission string. Traffic volumes were divided equally between multiple road traffic lanes.

4.3 Design Inputs and Modelling Assumptions

4.3.1 Topography

A Light Detection and Ranging (LIDAR) survey extending approximately 100m outside of the project area was supplied by SMC for the purpose of this study. The survey contained topographical data in 0.25 m intervals, as well as the locations of existing noise barriers and residential fences (provided as a barrier footprint string). The surveyed topographical data was supplemented by Department of Land Information (DLI) topographical data in 1 m intervals outside of the LIDAR surveyed area. This was also supplied by SMC.

The two data sets were combined into one set of elevation contours used to generate the Digital Ground Model (DGM) used in the *SoundPLAN* model for the noise assessment of the existing and 'no-build' scenarios.

The existing elevation contour data was cropped and combined with the three dimensional concept design of the proposed road, interchanges and associated earthworks. A new DGM was built from the combination of the two topographical datasets and used for noise assessment of the 'build' scenarios.

4.3.2 Existing Noise Barriers and Fences

Noise barrier and fence footprint location were derived from the LIDAR survey supplied by SMC. This information was supplemented by a field survey to confirm barrier / fence heights and condition assumed in the model. The height of all residential fences was found to generally vary between 1.8 m and 2 m, with the lowest being 1.5 m and highest being 2.4 m. For the purpose of this study, all residential fences that were found to be in good condition were conservatively assumed to be 1.8 m in height. Similarly, all existing roadside noise barriers on Kwinana Freeway and Roe Highway were assumed to be at a height of 2.4 m. In addition, a 1.1 m concrete crash barrier was assumed along the inner boundaries of Kwinana Freeway carriageways.

4.3.3 Dwellings

Dwelling eave outlines were digitised from aerial photography supplied by SMC. Dwellings were assigned names in accordance with corresponding Digital Cadastral Database (DCDB) addresses supplied by SMC. Where multiple dwellings were located on a single allotment, street numbers were alphabetically post-scripted, so that each dwelling is assigned a unique identifier. They do not necessarily reflect actual sub-allotment addresses.

For the purpose of this study, all dwellings were assumed to be single storey, and have a height of 3.5 m. Noise receivers were placed at 1.5 m above ground level and 1 m away from dwelling façades at all building facades greater than 3 m in length, in order to capture the loudest façade at each dwelling. Noise assessments are based on the noise level predicted at the loudest façade of each dwelling.

4.3.4 Ground Attenuation

Reflective (hard) ground was assumed for all road surfaces, with soft (absorptive) ground assumed elsewhere in the project area.

4.3.5 Multiple Lane Road Traffic Noise Modelling Strings

On roads where multiple road lanes were present, each lane was modelled as a separate noise emission string. Existing and future road design outlines were used to construct the noise emission lines at the centreline of each lane. The traffic flows on each road lane were then modelled separately, with traffic volumes divided equally between the lanes.

4.3.6 Traffic Data

Existing traffic data including travel direction, day and night traffic volumes and corresponding percentage of heavy vehicles have been derived from AAWT traffic count information supplied by SMC for the purpose of the study. Where traffic counts for year 2010 were not available, the latest available counts were adjusted to year 2010 by factoring in a traffic growth factor of 2.5% p.a. Daytime18 hour traffic volumes (between 6am and midnight) were assumed to be 94% of Annual Average Weekday Traffic (AAWT) volumes. The road traffic data has been segmented into sections of constant traffic volumes, as shown in Figure 2. The corresponding 2010 AAWT traffic volumes are presented in Table 9. Assumed / observed road pavement surfaces and traffic speeds are listed in Table 9, and the relative noise relationships between different types of road pavement surfaces are presented in Table 10

Note that measurements of traffic volume flows were not conducted simultaneously with the measured traffic noise levels. As such any estimate of actual traffic flow volumes which are correlated with the measured noise levels may introduce a degree of error in the modelling process. By way of example, a 10% overestimate of traffic volumes results in a 0.4 dB(A) overprediction in the predicted noise levels.

Table 9 Existing scenario road traffic data

Road Name	Section	Direction	2010 AAWT[1]	Heavy Vehicle Percentage[2]	Speed (km/h)	Pavement Surface
Bibra Dr	1	NB	12666	2.8	60	Dense Graded Asphalt
Bibra Dr	1	SB	12666	2.8	60	Dense Graded Asphalt
Farrington Rd	3	EB	26418	6.8	70	Dense Graded Asphalt
Farrington Rd	3	WB	26418	6.8	70	Dense Graded Asphalt
Farrington Rd	4	EB	25984	5.2	70	Dense Graded Asphalt
Farrington Rd	4	WB	25984	5.2	70	Dense Graded Asphalt
Forrest Rd	1	EB	7642	5.6	70	Dense Graded Asphalt
Forrest Rd	1	WB	7642	5.6	70	Dense Graded Asphalt
Forrest Rd	2	EB	9191	5.6	70	Dense Graded Asphalt
Forrest Rd	2	WB	9191	5.6	70	Dense Graded Asphalt
Forrest Rd	3	EB	10089	5.6	70	Dense Graded Asphalt
Forrest Rd	3	WB	10089	5.6	70	Dense Graded Asphalt
Kwinana Fwy	0	NB	52894	10.0	100	Open Graded Asphalt
Kwinana Fwy	0	SB	41382	10.0	100	Open Graded Asphalt
Kwinana Fwy	1	NB	32063	13.6	100	Open Graded Asphalt
Kwinana Fwy	1	SB	32137	9.4	100	Open Graded Asphalt
Kwinana Fwy	2	NB	42051	13.6	100	Open Graded Asphalt
Kwinana Fwy	2	SB	40050	9.4	100	Open Graded Asphalt
Murdoch Dr	0	NB	10364	2.8	70	Dense Graded Asphalt
Murdoch Dr	0	SB	10364	2.8	70	Dense Graded Asphalt
North Lake Rd	A	NB	23372	5.9	70	Dense Graded Asphalt
North Lake Rd	A	SB	23372	5.9	70	Dense Graded Asphalt
North Lake Rd	B	NB	31163	5.9	70	Dense Graded Asphalt
North Lake Rd	B	SB	31163	5.9	70	Dense Graded Asphalt
North Lake Rd	C	NB	31433	5.9	70	Dense Graded Asphalt
North Lake Rd	C	SB	31433	5.9	70	Dense Graded Asphalt
Phoenix Rd	1	EB	17221	7.6	70	Dense Graded Asphalt
Phoenix Rd	1	WB	17221	7.6	70	Dense Graded Asphalt
Phoenix Rd	2	EB	19605	7.6	70	Dense Graded Asphalt
Phoenix Rd	2	WB	19605	7.6	70	Dense Graded Asphalt
Progress Dr	1	NB	4701	2.0	50	Dense Graded Asphalt
Progress Dr	1	SB	4701	2.0	50	Dense Graded Asphalt
Roe Hwy	B	EB	29196	17.5	100	Open Graded Asphalt

Road Name	Section	Direction	2010 AAWT[1]	Heavy Vehicle Percentage[2]	Speed (km/h)	Pavement Surface
Roe Hwy	B	WB	28988	17.5	80	Open Graded Asphalt
Roe Hwy	C	EB	26044	22.1	100	Open Graded Asphalt
Roe Hwy	C	WB	24785	22.1	100	Open Graded Asphalt
Roe Offramp – Karel Ave	C	EB	3152	5.0	60	Dense Graded Asphalt
Roe Onramp – Karel Ave	C	WB	4203	5.0	60	Dense Graded Asphalt
Stock Rd	A	NB	27929	10.2	80	Dense Graded Asphalt
Stock Rd	A	SB	27929	10.2	80	Dense Graded Asphalt
Stock Rd	B	NB	28709	10.2	80	Dense Graded Asphalt
Stock Rd	B	SB	28709	10.2	80	Dense Graded Asphalt
Stock Rd	C	NB	26933	10.2	80	Dense Graded Asphalt
Stock Rd	C	SB	26933	10.2	80	Dense Graded Asphalt
Stock Rd	D	NB	29519	10.2	80	Dense Graded Asphalt
Stock Rd	D	SB	29519	10.2	80	Dense Graded Asphalt
Kwinana Onramp - Farrington Rd	5	NB	6649	13.6	70	Dense Graded Asphalt
Kwinana Offramp - Farrington Rd	5	SB	7211	9.4	70	Dense Graded Asphalt
Kwinana Offramp - Roe Hwy	A	NB	19419	16.4	70	Dense Graded Asphalt
Kwinana Onramp - Roe Hwy	A	NB	9097	16.3	60	Dense Graded Asphalt
Kwinana Offramp - Roe Hwy	A	SB	7913	19.0	70	Dense Graded Asphalt
Kwinana Onramp - Roe Hwy	A	SB	18460	17.6	70	Dense Graded Asphalt

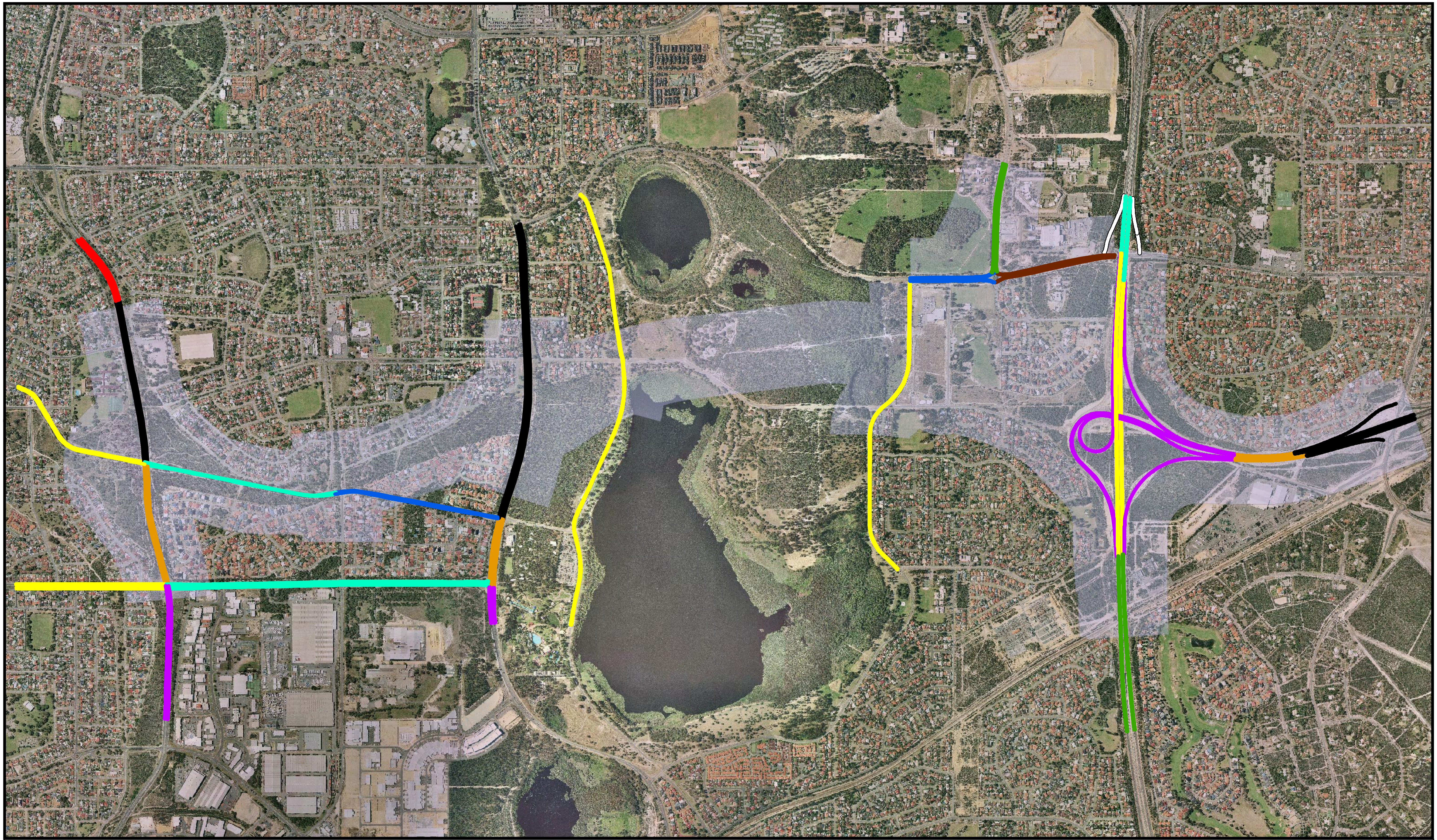
Notes:

1.) 2010 AAWT represents the supplied Annual Average Weekday Traffic volumes adjusted to 2010 equivalent volumes.

2.) Heavy Vehicle percentage represents the percentage of heavy vehicles (Class 3-12) making up the AAWT traffic volume

Table 10 Noise emissions from different road pavement surfaces relative to Dense Graded Asphalt.

Chip Seal			Asphalt		
14mm	10mm	5mm	Dense Graded (DGA)	Stone Mastic (SMA)	Open Graded (OGA)
+3.5 dB(A)	+2.5 dB(A)	+1.5 dB(A)	0 dB(A)	-1.5 dB(A)	-2.5 dB(A)



South Metro Connect - Roe Highway Extension
Existing Scenario (2009)
Traffic Volume Road Section Reference Map

PROJECT ID 60100953
CREATED BY BS
LAST MODIFIED NB 30 NOVEMBER 2010

Figure 4

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4.4 Assessment methodology

The SPP 5.4 noise criteria applicable to the daytime period is 5 dB(A) greater than the criteria applicable in the night-time period. This means that all locations where daytime noise levels exceed the corresponding night-time levels by 5 dB(A) or more will be controlled by daytime noise emissions. Conversely, where the difference between daytime and night-time levels is less than 5 dB(A), the mitigation requirements to meet criteria will be controlled by night-time emissions.

4.4.1 Diurnal Analysis – Existing Noise Environment

Noise monitoring results presented in Section 3.4 show that the difference between daytime ($L_{Aeq,day}$) and night-time ($L_{Aeq,night}$) noise emissions is greater than 5dB(A) at most, but not all locations adjacent to the project area (refer Table 8) The locations where the difference is less than 5 dB(A) are situated in the vicinity of Roe Highway.

In order to better establish the diurnal noise patterns on Roe Highway, AECOM has carried out a review of the 2006 post-construction noise monitoring results on Roe Highway Stage 7 carried out by Lloyd George Acoustics (Reported in “Roe Highway Stage 7 Post-Construction Noise Monitoring” Reference 609616-01). A summary of LGA’s noise monitoring results is presented in Table 11.

Table 11 Roe Highway Stage 7 – Summary of Roe Highway Stage 7 - Post construction noise monitoring results (2006)

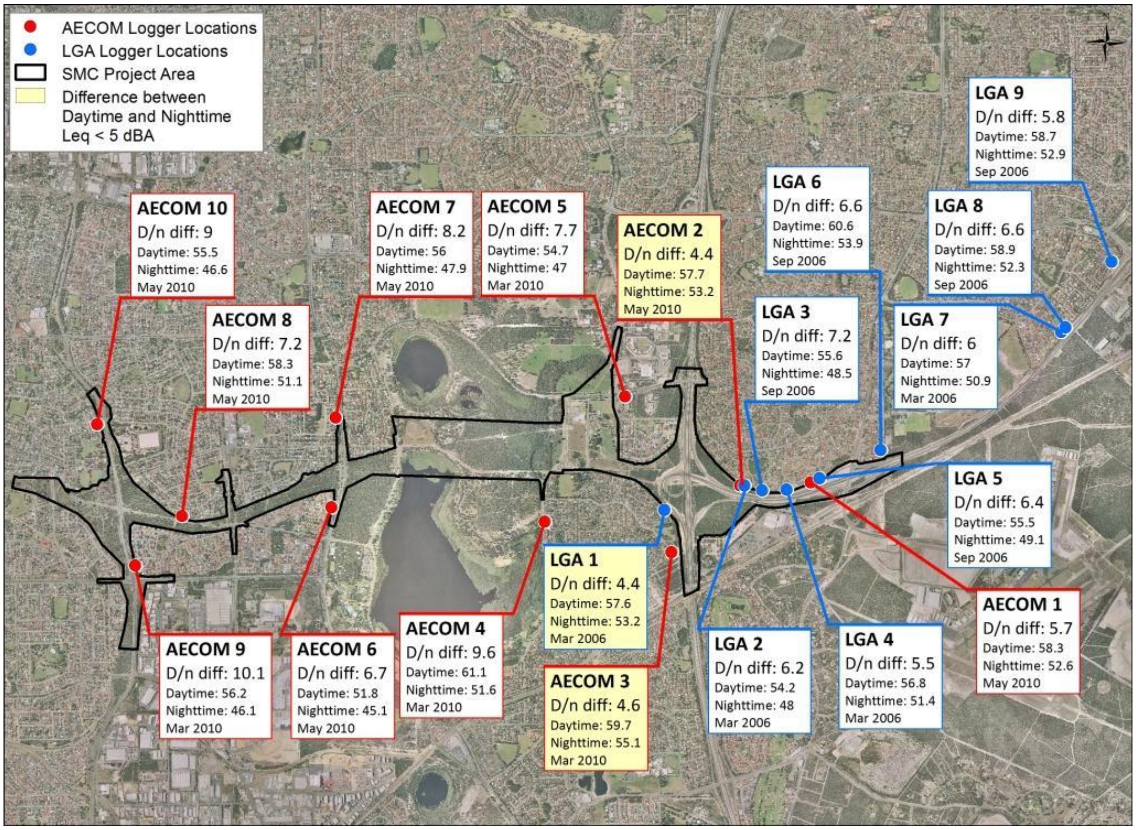
Location Reference		2006 Measured Noise Levels – dB(A)				Difference between $L_{Aeq,16hr}$ and $L_{Aeq,8hr}$
Location	Date	$L_{A10,18h}$	$L_{Aeq,24h}$	$L_{Aeq,16hr}$	$L_{Aeq,8hr}$	
Location 1: 25 Tetlow Place, Bibra Lake	24 March 2006	58.0	55.8	56.9	52.1	4.4
	27 March 2006	57.5	55.8	56.8	52.5	
	28 March 2006	57.5	56.1	56.8	54.2	
	29 March 2006	61.0	58.8	60.0	54.0	
	Period Average	58.5	56.6	57.6	53.2	
Location 2: 10 Evergreen Court, Leeming	24 March 2006	55.6	53.7	55.0	48.7	6.2
	27 March 2006	54.2	51.8	53.1	45.7	
	28 March 2006	56.0	53.9	55.1	49.1	
	29 March 2006	55.3	52.5	53.7	48.4	
	Period Average	55.3	53.0	54.2	48.0	
Location 3: 29 Greencroft Gardens, Leeming	4 September 2006	57.8	54.9	56.4	47.4	7.2
	5 September 2006	57.3	54.9	56.4	48.3	
	6 September 2006	56.8	54.1	55.4	49.6	
	7 September 2006	57.4	53.9	55.1	49.2	
	13 September 2006	56.1	53.5	54.9	47.8	
	Period Average	57.1	54.3	55.6	48.5	

Location Reference		2006 Measured Noise Levels – dB(A)				Difference between $L_{Aeq,16hr}$ and $L_{Aeq,8hr}$
Location	**Date**	$L_{A10,18h}$	$L_{Aeq,24h}$	$L_{Aeq,16hr}$	$L_{Aeq,8hr}$	
Location 4: 6 Briar Court, Leeming	24 March 2006	58.7	56.7	57.7	53.6	5.5
	27 March 2006	56.9	54.5	55.7	50.3	
	28 March 2006	58.8	55.8	57.1	49.8	
	29 March 2006	58.0	55.5	56.7	51.7	
	Period Average	58.1	55.6	56.8	51.4	
Location 5: 42[1] Sylvan Court, Leeming	4 September 2006	57.9	55.0	56.6	47.1	6.4
	5 September 2006	57.5	54.4	55.7	48.9	
	6 September 2006	57.8	54.5	55.9	48.6	
	7 September 2006	57.8	54.4	55.2	52.5	
	13 September 2006	56.2	52.9	54.1	48.6	
	Period Average	57.4	54.2	55.5	49.1	
Location 6: 21 Fern Leaf Court, Leeming	4 September 2006	62.5	59.6	61.0	53.7	6.6
	5 September 2006	63.0	59.7	61.0	54.3	
	6 September 2006	62.8	59.5	60.9	53.2	
	7 September 2006	62.8	59.7	61.1	54.3	
	13 September 2006	61.0	57.7	58.8	54.2	
	Period Average	62.4	59.2	60.6	53.9	
Location7: 9 Capill Corner, Leeming	24 March 2006	57.8	56.1	57.1	52.7	6.0
	27 March 2006	57.5	54.9	56.2	49.6	
	28 March 2006	57.4	55.3	56.5	51.0	
	29 March 2006	58.5	56.6	58.0	50.4	
	Period Average	57.8	55.7	57.0	50.9	
Location 8: 25 Hollingsworth Way, Leeming	4 September 2006	59.9	57.3	58.8	50.8	6.6
	5 September 2006	60.1	57.3	58.7	50.8	
	6 September 2006	61.8	58.7	59.9	54.1	
	7 September 2006	61.7	58.0	59.0	54.6	
	13 September 2006	59.3	56.6	57.9	51.0	
	Period Average	60.6	57.6	58.9	52.3	
Location 9: 33 Merrifield Circle, Leeming	4 September 2006	58.9	56.1	57.3	52.1	5.8
	5 September 2006	60.1	57.8	59.1	52.3	
	6 September 2006	60.7	58.5	59.8	53.1	
	7 September 2006	61.0	58.6	59.9	53.0	
	13 September 2006	58.3	56.6	57.5	53.9	
	Period Average	59.8	57.5	58.7	52.9	

Notes: 1.) Location 5 is reported as 52 Sylvan Court, Leeming in the LGA report. Site photos indicate that the measurements were carried out at 42 Sylvan Crescent - this address was confirmed by Daniel Lloyd of Lloyd George Acoustics.

The measured daytime and night-time L_{Aeq} noise levels and the corresponding day/night differences summarised in Table 8 and Table 11 are shown graphically in Figure 5. The locations controlled by night-time noise emissions (i.e. where the difference between measured daytime and night-time noise levels is less than 5 dB(A)) are highlighted in yellow – all other locations are controlled by daytime noise emissions.

Figure 5 Summary of daytime and night-time L_{Aeq} noise levels on the project



The results show that the daytime criterion is the controlling criterion at all but three locations (indicated in yellow text boxes), with the exceptions occurring in the vicinity of the Roe Highway / Kwinana Freeway interchange.

Given that night-time noise emission is the controlling criterion around Roe Highway / Kwinana Freeway interchange, it is reasonable to assume the same will be true for the future Roe Highway / Stock Road interchange. The results show that at these locations, the night-time criterion is up to 0.6 dB(A) more stringent than the daytime criterion.

4.4.2 Diurnal Traffic Analysis

In addition to the diurnal noise analysis, a traffic planning study has also been carried out in order to better understand the future diurnal traffic patterns on Roe Highway and their effect on the corresponding night-time noise levels.

The hourly traffic profile on Roe Highway Extension (RHE) is expected to be similar to that of Roe Highway. Traffic data was acquired from Main Roads Asset & Network Information Branch to determine the existing (2008) total traffic and heavy vehicle (Austroads Classes 3-12) hourly profiles for a normal day on Roe Highway at the bridge under Karel Avenue. The adjusted forecast 2031 daily total traffic and heavy vehicle traffic for RHE and Roe Highway were determined from the Main Roads Regional Operations Model (ROM), West of Stock Road (WoS) project case. The forecast 2031 daily total traffic and heavy vehicle traffic for Roe Highway (at Karel Avenue) are 107,200 and 10,900 respectively. The corresponding traffic figures from the 2008 data are 41,700 and 9,300. This represents a growth in daily total traffic of 157% and a low growth in daily heavy vehicle traffic of 17%. This low growth in daily heavy vehicle traffic is not considered to be realistic.

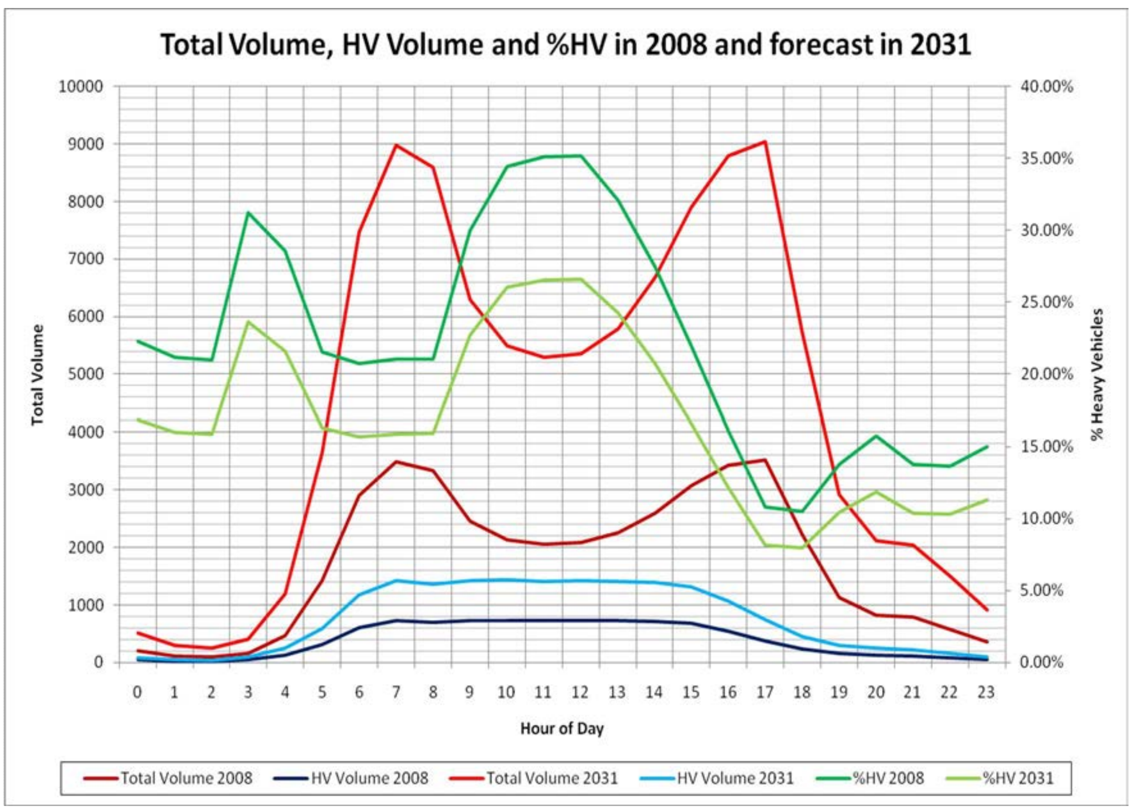
According to the Perth Urban Corridor Strategy 2007 (PUCS 2007[1]), "road freight will continue to increase by between three and four per cent a year to 2018, tailing off to between two and three per cent to 2025". If this forecast is used, along with the assumption that 2.5% growth will apply from 2025 to 2031, then the growth in heavy vehicle traffic from 2008 to 2031 would be 94%.

From the above, it is suggested that the forecast hourly total traffic and heavy vehicle traffic profiles be determined as follows:

- 2031 Total Traffic Profile = 2008 Total Traffic Profile × 2031 ROM Daily Total / 2008 Data Daily Total
- 2031 Heavy Vehicle Profile = 2008 Heavy Vehicle Profile × PUCS 2007 Heavy Vehicle Growth

The total traffic, heavy vehicle traffic and heavy vehicle percentage profiles for 2031, based on the above, are shown in Figure 6 in light red, light blue and light green respectively. From these 2031 profiles for Roe Highway (at Karel Avenue), the heavy vehicle percentage profile is proposed for use in the noise assessment for RHE. Since Fremantle Ports already operates 24 hours a day, seven days a week, no further adjustments to the heavy vehicle percentage profile are deemed necessary.

Figure 6 Total Traffic, Heavy Vehicle and Heavy Vehicle Percentage Profiles



The graph shows that currently, heavy vehicle proportion on Roe Highway hovers just above 20% for most of the night-time period, with an increase to 30% at 3am and 28% at 4am. The percentage of heavy vehicles returns to its night-time median (of just above 20%) after 4am as the number of light vehicles on the road increases.

[1]PUCS 2007 available from:
http://www.infrastructure.gov.au/transport/publications/files/Perth_Urban_Corridor_Strategy.pdf

Diurnal noise analysis shows that with current light / heavy vehicle distribution, daytime noise emission is the controlling criterion at all locations adjacent to Roe Highway except in the vicinity of the Roe / Kwinana interchange. This may be due to a change in driver behaviour on approach to / departure from the interchange (e.g. acceleration / engine braking), however the reasons are not clear.

The heavy vehicle percentage distribution curves for 2008 and 2031 (dark green and light green respectively) show that the proportion of heavy vehicles is likely to decrease on Roe Highway as a percentage of total traffic by 3 to 6%. On this basis, it is expected that daytime noise emission will continue to be the controlling criterion on Roe Highway everywhere except for major interchanges at Kwinana Freeway and Stock Road.

Noise assessment based on daytime noise emissions has therefore been implemented on this project, with a 0.6 dB(A) night-time penalty applied to receivers adjacent to Roe Highway which are within 500 m of interchanges at Stock Road and Kwinana Freeway.

4.4.3 Noise Assessment Height

In accordance with SPP 5.4 assessment methodology, noise criteria are applicable at 1m from the most exposed, habitable façade at ground floor level of the building receiving the noise. Noise assessments are therefore based on the noise level predicted at the loudest façade on the ground floor of each dwelling.

Noise levels at upper storeys of multiple storey dwellings have not been assessed in this study. It is noted however that noise levels predicted at the ground floor may not be representative of upper floor noise exposure, particularly if the ground floor is shielded from the road (i.e. by ground topography, a residential boundary fence or other intervening buildings). Where this is the case, the noise exposure at upper levels will be greater than that predicted at the ground floor.

By way of example, the ground floor of Hamilton Senior High School is shielded from Stock Road by an embankment that is between 2 and 4 m high. The noise levels at the first floor of Hamilton Senior High School are 3 dB(A) to 5 dB(A) greater than at ground level due to the shielding provided by the embankment. When a 1.8 m high noise barrier is added to the top of the embankment, the noise level difference increases to between 3 dB(A) and 6 dB(A). This is considered to be representative of typical worst case differences between ground and first floor noise levels expected on this project. Negligible differences are expected in noise levels between ground and first floors where the ground floor is directly exposed to the road (i.e. with no acoustic shielding between the road and ground floor).

4.5 Model Calibration

A computer noise model of the existing (2010) scenario was constructed based on the existing traffic volumes, posted speed limits, ground topography and existing noise barrier and residential fence locations. A -1.7 dB(A) correction for Australian conditions was applied to the existing noise model. Uncalibrated existing scenario modelling results were then compared against corresponding roadside noise measurements and calibration factors derived to match measured noise levels.

A comparison of the calibrated noise model calculations versus those measured at representative locations are presented in Table 12. Details of the calibration procedure are summarised in Appendix F

Table 12 Comparison of Predicted versus Measured Noise Levels at Noise Logging Locations

Loc no.	Address	Adjacent Road	Measured Noise levels (2010)	Calibrated Noise Model Calculation	Prediction Difference
			$L_{Aeq,16hour}$	$L_{Aeq,16hour}$	dB(A)
1	50 Sylvan Cres, Leeming	Roe Hwy	58.3	57.5	-0.8
2	25 Brandwood Gdns, Leeming	Roe Hwy	57.7	58.6	0.9
3	12 Dowell Pl, Bibra Lake	Kwinana Fwy	59.7	57.7	-2
4	20 Bibra Dr, Bibra Lake	Bibra Dr	61.1	61.1	0
5	16 Cheshunt Gdns, North Lake	Farrington Rd	54.7	54.7	0
6	32 Marshwood Rtt, Bibra Lake	North Lake Rd	51.8	51.8	0
7	13 Gregory Way, Coolbellup	North Lake Rd	56	56	0
8	58 Sebastian Cres, Coolbellup	Forrest Rd	58.3	58.3	0
9	94 Forillion Ave, Bibra Lake	Stock Rd	56.2	54.4	-1.8
10	65 Curven Rd, Hamilton Hill	Stock Rd	55.5	57.3	1.8

4.5.1 Accuracy of Noise Modelling and Sensitivity Analysis

The calibrated noise model shows good correlation between measured and modelled results, with all modelled receivers being within ± 2 dB(A) of measured results. Due to the small number of logger locations adjacent to each of the existing roads, AECOM is unable to determine the extent of statistical variation in the predicted noise levels. It is therefore recommended that additional noise measurements be undertaken adjacent to existing roads during the detailed design phase of this project to quantify this uncertainty.

The above noise monitoring results were supplemented with findings of AECOM's previous road traffic noise studies in order to calibrate the noise emissions from Kwinana Freeway and Roe Highway.

AECOM has carried out a noise assessment of Kwinana Freeway between Roe Highway and Leach Highway (report reference 60100953.BS001.REP). The model calibration factors developed for that study have been used on this project. The calibration procedure was based on 11 reference locations directly adjacent to the freeway. The prediction difference of the calibrated model had a standard deviation of 1.4 dB(A).

A significant portion of Roe Highway considered in this study is a new road. It is therefore not be possible to compare calculated existing noise levels against corresponding roadside measurements to calibrate noise emissions from Roe Highway. Instead, AECOM has surveyed its road traffic noise modelling projects nationally and adopted a calibration factor which is based on the calibration results of five comparable projects. In order to add a degree of conservativeness, the adopted Roe Highway calibration factor was based on the average of "calibration factor minus one standard deviation" for the five comparable studies. This shifts the mean of the model prediction difference such that it overpredicts noise levels by an average of one standard deviation. The calibration procedure is discussed in Appendix F. Outputs of the calibrated model have been compared against noise measurements carried out on Roe Highway east of Kwinana Freeway.

With the availability of additional measurements (documented in LGA's *"Roe Highway Stage 7 Post-Construction Noise Monitoring"* report), additional receivers have been modelled and compared against measurements to further verify the adopted calibration factor.

Analysis of MRWA June 2006 AAWT traffic counts shows a total volume of of 33,149 v.p.d. on Roe Highway east of Kwinana Freeway. The corresponding 2010 AAWT traffic volume which has been used in the model is 58,184 v.p.d. An adjustment factor of -2.4 dB(A) has therefore been applied to 2010 predicted noise levels at LGA measured locations (i.e. an adjustment of 10log[33,149/58,184]).

A summary of calibrated noise model calculations versus those measured at representative locations on Roe Highway east of Kwinana Freeway is presented in Table 13.

Table 13 Summary of daytime L_{Aeq} noise levels and corresponding calibration factors

Monitoring Location	Measurement date	Existing Noise Exposure Levels – dB(A)				Measured Minus Modelled dB(A)
		Measured 2006	Modelled 2006	Measured 2010	Modelled 2010	
AECOM						
Logger 1	3-13 May 2010	-	-	58.3	57.5	0.8
Logger 2	3-13 May 2010	-	-	57.7	58.6	-0.9
Roe Highway 7 Post opening compliance noise monitoring (LGA)						
LGA 1	24-29 Mar 2006	57.6	57.1	-	59.5	0.5
LGA 2	24-29 Mar 2006	54.2	55.2	-	57.6	-1.0
LGA 3	4-13 Sep 2006	55.6	54.4	-	56.8	1.2
LGA 4	24-29 Mar 2006	56.8	55.6	-	58.0	1.2
LGA 5	4-13 Sep 2006	55.5	54.9		57.3	0.6

The above results show that the predicted noise levels based on the calibration factor developed for Roe Highway are within ± 1.2 dB(A) of all available measurements, showing good correlation between modelled and measured results.

4.6 Existing Noise Modelling Results

A summary of the existing noise environment at the ground floor of noise-sensitive receivers within the study area is presented in Table 14 below.

Table 14 Calculated Existing Daytime ($L_{Aeq,16hr}$) Noise Levels

Number of Noise-Sensitive Receivers					Daytime $L_{Aeq,16hr}$ Noise Level	
Total modelled	<55 dB(A)	>55 dB(A)	>60 dB(A)	>65 dB(A)	Average	Maximum
1472	1317	145	10	0	49 dB(A)	65 dB(A)

The results show that the majority of noise sensitive receivers within the study area are currently exposed to 55 dB(A) or less at the ground floor, with an average noise exposure of 49 dB(A). Only 10 percent of the receivers are exposed to $L_{Aeq,16hr}$ noise levels above 55 dB(A) at the ground floor. Less than one percent of the receivers are above 60 dB(A) and these receivers are situated adjacent to existing transport corridors of Roe Highway, Forrest Road and Stock Road.

Existing $L_{Aeq,16hr}$ noise contour maps are presented in Appendix D. Noise levels outside the shown contours are generally below 48 dB(A). Dwelling footprints at all dwellings have been colour coded according to predicted noise exposure. The graphical results are based on the noise level predicted at the loudest façade at each dwelling, as discussed in Section 4.3.3.

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5.0 Future Road Traffic Noise Predictions

5.1 Modelled Scenarios

In accordance with SPP 5.4, four future scenarios were modelled in order to assess noise impacts associated with the proposed development. These comprise a build scenario and a no-build scenario at the year of assumed project opening (2016) and a build and a no-build scenario in the design year, 15 years after project opening (2031). The four scenarios do not consider additional noise mitigation due to any future proposed noise walls. That is, models of the following:

- Opening year, no-build scenario (no mitigation)
- Opening year, build scenario (no mitigation)
- Design year, no-build scenario (no mitigation)
- Design year, build scenario (no mitigation)

These scenarios are considered in order to determine the impact of the project on the noise environment relative to the noise environment if the project did not proceed, and to assess reasonable and practicable noise management and mitigation measures adjacent to existing road transport corridors.

The difference between noise criteria applicable to new roads between daytime and night-time periods is 5 dB(A) (as discussed in Section 2.1).

Diurnal noise/traffic analysis shows that the daytime noise criterion will be the controlling criterion at all locations except in the vicinity of Roe Highway interchanges with Kwinana Freeway and Stock Road. Noise assessment is therefore based on daytime noise emissions, with a 0.6 dB(A) night-time penalty applied to receivers adjacent to Roe Highway which are within 500 m of interchanges at Stock Road and Kwinana Freeway (refer Section 4.4).

This penalty has been applied at the noise barrier design phase of the project to achieve a noise level that is 0.6 dB(A) below the criterion at these receivers. Noise emissions from all scenarios are predicted at the ground floor only, in accordance with the assessment methodology discussed in Section 4.4.3.

5.2 Traffic Volumes

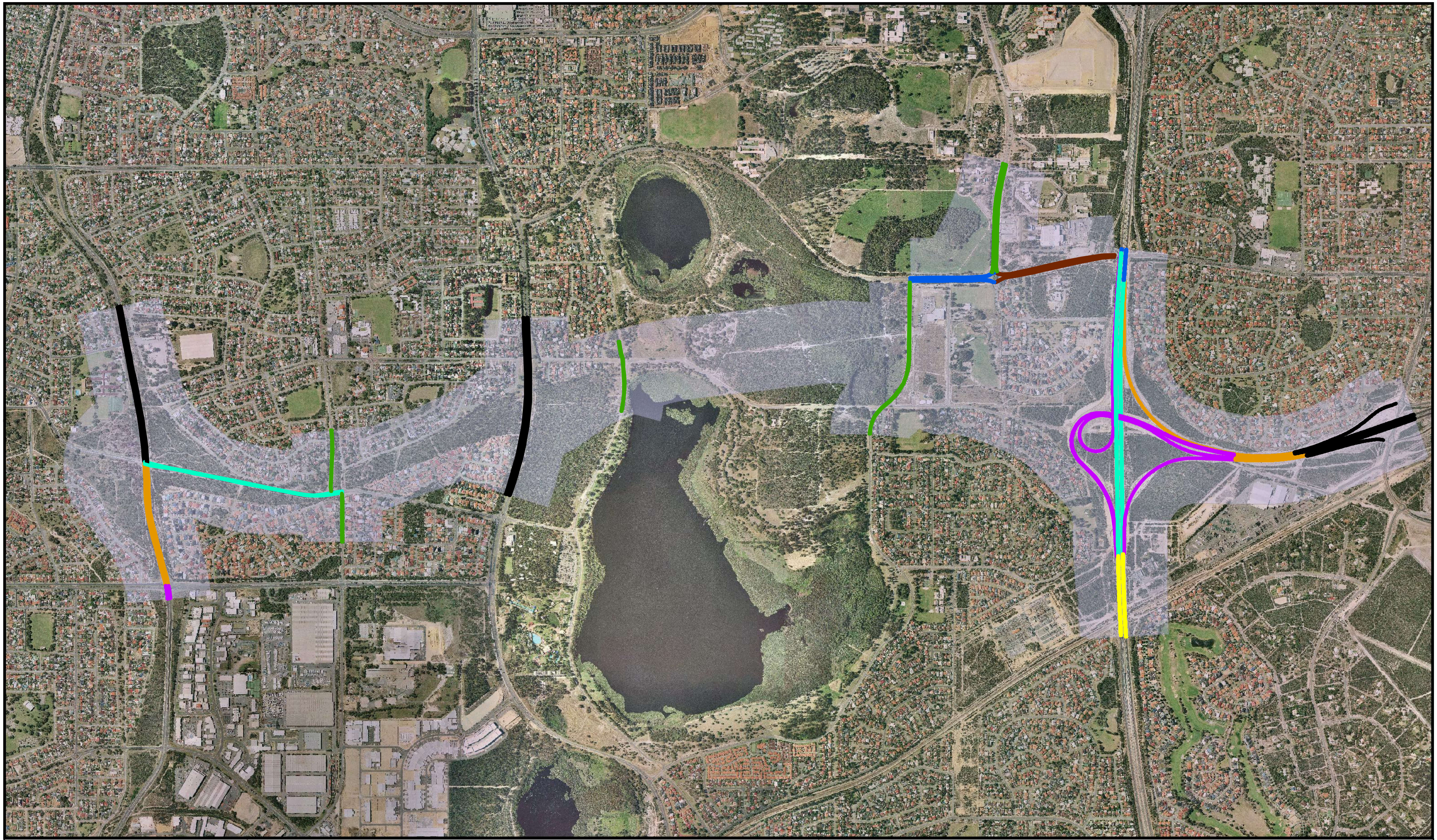
Future road traffic volume predictions including travel direction and corresponding percentage of heavy vehicles are based on suggested Annual Average Weekday Traffic (AAWT) traffic figures supplied by AECOM and confirmed by SMC for the purpose of this study. The 16 hour daytime volumes (between 6am and 10pm) were assumed to be 94% of AAWT volumes.

5.2.1 No-build Scenarios

The daytime traffic volumes and heavy vehicle percentages used in the modelling of Opening year and Design year no-build scenarios are presented in Table 15. The road traffic data presented below has been segmented into sections of road with constant traffic volumes and posted speed limits. The corresponding road sections have been referenced in Figure 7.

Table 15 Traffic forecasts used for modelling of no-build scenarios

Road Name	Section	Direction	2016 AAWT	2016 HV%	2031 AAWT	2031 HV%	Speed (km/h)
Bibra Dr	S0	NB	3883	13%	5383	7%	60
Bibra Dr	S0	SB	4720	17%	7720	9%	60
Coolbellup Av	S0	NB	2300	4%	3800	3%	50
Coolbellup Av	S0	SB	2400	4%	4100	2%	50
Farrington Rd	S3	EB	10221	8%	15421	5%	70
Farrington Rd	S3	WB	10894	10%	20094	5%	70
Farrington Rd	S4	EB	10643	8%	12443	5%	70
Farrington Rd	S4	WB	10008	12%	13608	7%	70
Forrest Rd	S2	EB	3159	16%	8559	8%	70
Forrest Rd	S2	WB	4335	7%	14035	6%	70
Kwinana Fwy	S1	NB	49386	11%	76986	9%	100
Kwinana Fwy	S1	SB	49386	11%	76986	9%	100
Kwinana Fwy	S2	NB	29176	10%	49537	9%	100
Kwinana Fwy	S2	SB	30479	10%	49537	9%	100
Kwinana Fwy	S3	NB	39437	9%	49537	9%	100
Kwinana Fwy	S3	SB	39437	9%	49537	9%	100
Murdoch Dr	S0	NB	8947	1%	17047	1%	70
Murdoch Dr	S0	SB	9634	1%	11134	1%	70
North Lake Rd	Sc	NB	18244	7%	16244	7%	70
North Lake Rd	Sc	SB	13900	6%	16700	5%	70
Progress Dr	S0	NB	1700	0%	1400	0%	50
Progress Dr	S0	SB	2200	0%	1900	5%	50
Kwinana Offramp - Roe Hwy	Sa	NB	23611	10%	27413	10%	70
Kwinana Onramp - Roe Hwy	Sa	NB	10261	10%	11913	10%	60
Kwinana Offramp - Roe Hwy	Sa	SB	8958	10%	10400	10%	70
Kwinana Onramp - Roe Hwy	Sa	SB	22076	10%	25630	10%	70
Roe Hwy	Sb	EB	32569	10%	37812	10%	100
Roe Hwy	Sb	WB	32337	10%	37543	10%	80
Roe Hwy	Sc	EB	29269	10%	32812	10%	100
Roe Hwy	Sc	WB	31437	10%	36143	10%	100
Roe Offramp - Karel Hwy	Sc	EB	3300	5%	5000	7%	60
Roe Onramp - Karel Hwy	Sc	WB	900	5%	1400	7%	60
Stock Rd	Sa	NB	11165	14%	34203	8%	80
Stock Rd	Sa	SB	10240	16%	30159	9%	80
Stock Rd	Sb	NB	15403	7%	34203	8%	80
Stock Rd	Sb	SB	12959	9%	30159	9%	80
Stock Rd	Sc	NB	14192	8%	34592	8%	80
Stock Rd	Sc	SB	13747	11%	30747	9%	80
Sudlow Rd	S0	NB	900	11%	3600	6%	60
Sudlow Rd	S0	SB	1300	8%	3100	3%	60



Legend

- Section 0
- Section 1
- Section 2
- Section 3
- Section 4
- Section A
- Section B
- Section C
- Study Area

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metres

South Metro Connect - Roe Highway Extension
No Build Scenarios
Traffic Volume Road Section Reference Map

PROJECT ID 60100953
CREATED BY BS
LAST MODIFIED NB 30 NOVEMBER 2010

Figure
7

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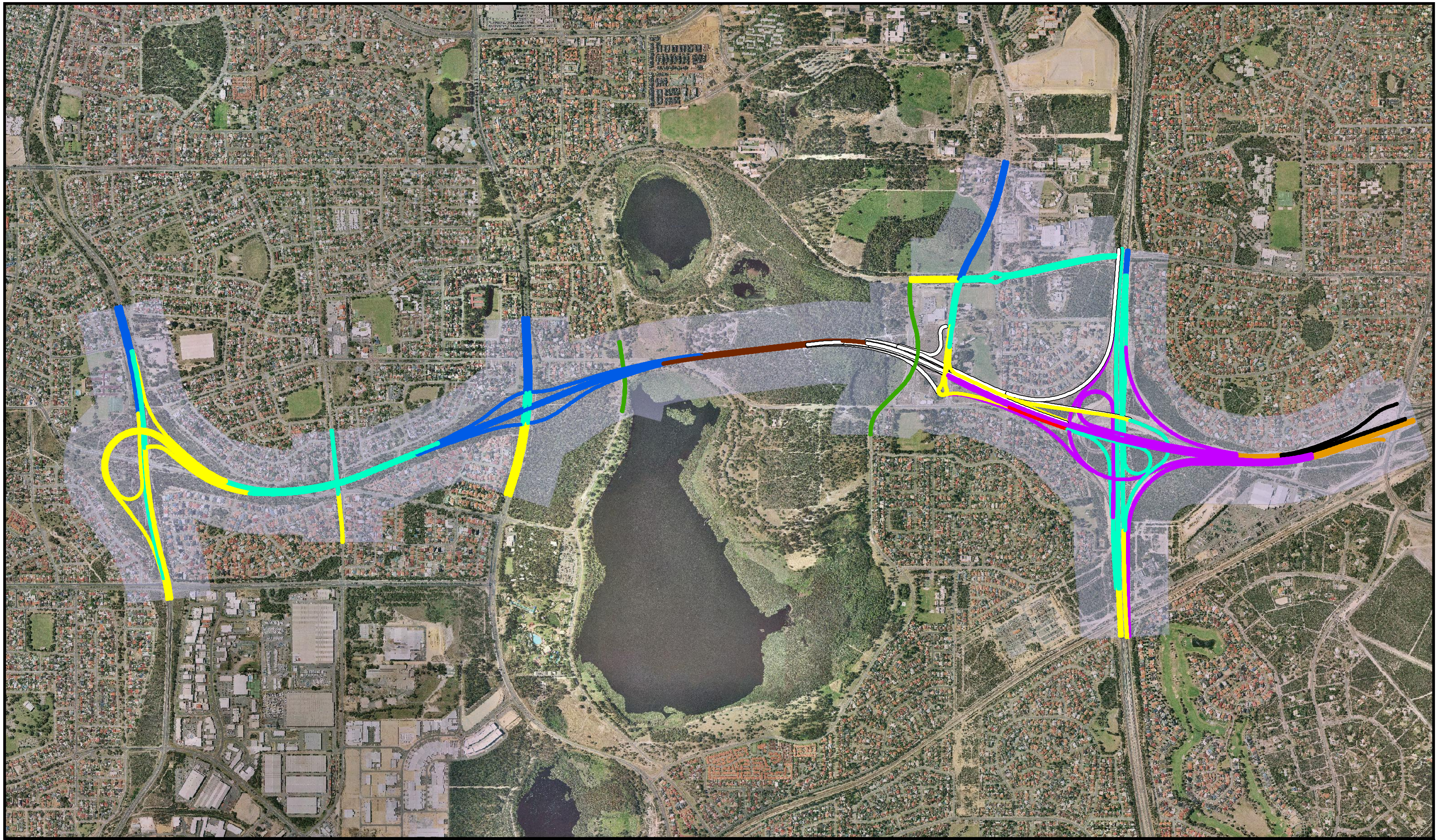
5.2.2 Build Scenarios

The daytime traffic volumes and heavy vehicle percentages used in the modelling of build scenarios are presented in Table 16 below. Build scenario road traffic data has been segmented into sections of constant traffic volume referenced in Figure 8.

Table 16 Traffic forecasts used for modelling of build scenarios

Road Name	Section	Direction	2016 AAWT	2016 HV%	2031 AAWT	2031 HV%	Speed (km/h)
Bibra Dr	S0	NB	5700	2.5%	5300	2.0%	50
Bibra Dr	S0	SB	5700	2.5%	6000	2.0%	50
Coolbellup / Sudlow Av	S1	NB	3200	3.1%	3100	3.2%	50
Coolbellup / Sudlow Av	S1	SB	3400	2.9%	3600	2.8%	50
Coolbellup / Sudlow Av	S2	NB	4000	2.5%	4100	2.4%	50
Coolbellup / Sudlow Av	S2	SB	4900	2.0%	5100	2.0%	50
Farrington Rd	S1	EB	6421	1.6%	7621	1.3%	70
Farrington Rd	S1	WB	6094	1.6%	8294	2.4%	70
Farrington Rd	S2	EB	7643	3.9%	10443	7.7%	70
Farrington Rd	S2	WB	9608	8.3%	9508	8.4%	70
Kwinana Fwy	S1	NB	51300	10%	71100	9%	100
Kwinana Fwy	S1	SB	32600	10%	50800	10%	100
Kwinana Offramp to Roe EB, WB & Murdoch Dr	S2	NB	24900	10%	35200	10%	60
Kwinana Offramp to Roe EB, WB & Murdoch Dr	S2	SB	12500	10%	15800	10%	80
Kwinana Offramp to Roe WB & Murdoch Dr	S2	SB	3500	10%	4800	10%	60
Kwinana Offramp to Roe WB & Murdoch Dr	S2	NB	4400	10%	6400	10%	60
Kwinana Onramp from Roe EB & Murdoch Dr	S2	SB	4400	10%	8300	10%	60
Kwinana Fwy	S2	NB	26400	10%	34200	10%	100
Kwinana Fwy	S2	SB	28200	10%	42500	10%	100
Kwinana Fwy	S3	SB	40700	11%	50800	11%	100
Murdoch Dr Offramp to Kwinana SB	S1	SB	1300	3%	4000	3%	60
Murdoch Dr Offramp to Roe EB	S1	SB	1300	3%	2000	3%	60
Murdoch Dr Offramp to Roe EB and Kwinana SB	S1	SB	2600	3%	6000	3%	60
Murdoch Dr Onramp from Kwinana SB & NB	S1	NB	3300	3%	4000	3%	60
Murdoch Dr	S1	NB	3300	3%	5400	3%	60
Murdoch Dr	S1	SB	7100	3%	9400	3%	60
Murdoch Dr	S2	NB	7400	3%	13700	3%	60
Murdoch Dr	S2	SB	9700	3%	15400	3%	60
Murdoch Dr	S3	NB	10347	1.9%	17147	1.2%	70
Murdoch Dr	S3	SB	9434	2.1%	11334	0.9%	70
North Lake Rd	S1	NB	16000	12%	15600	9%	70
North Lake Rd	S1	SB	10000	12%	15000	9%	70
North Lake Rd	S2	NB	17500	10%	20000	8%	70
North Lake Rd	S2	SB	7500	6%	13500	6%	70
North Lake Rd	S3	NB	14200	6%	12600	5%	70
North Lake Rd	S3	SB	10000	6%	11300	5%	70
Progress Dr	S0	NB	300	0%	200	0%	50
Progress Dr	S0	SB	400	0%	300	0%	50
Roe Hwy Offramp to Stock Rd NB	S1	WB	3800	12%	7700	12%	50

Road Name	Section	Direction	2016 AAWT	2016 HV%	2031 AAWT	2031 HV%	Speed (km/h)
Roe Hwy Offramp to Stock Rd SB	S1	WB	13600	12%	23800	12%	60
Roe Hwy Onramp from Stock Rd NB	S1	EB	4000	12%	13200	12%	80
Roe Hwy Onramp from Stock Rd SB	S1	EB	10700	12%	20100	12%	60
Roe Hwy	S2	EB	14700	12%	33300	12%	100
Roe Hwy	S2	WB	17400	12%	31500	12%	100
Roe Hwy Offramp to North Lake	S3	EB	4000	6%	10500	6%	80
Roe Hwy Offramp to North Lake	S3	WB	12000	12%	10600	8%	80
Roe Hwy Onramp from North Lake	S3	EB	14100	10%	11400	9%	80
Roe Hwy Onramp from North Lake	S3	WB	3000	6%	6700	6%	80
Roe Hwy	S3	EB	10700	11%	26800	11%	100
Roe Hwy	S3	WB	14400	11%	27400	11%	100
Roe Hwy	S4	EB	24800	11%	38200	11%	100
Roe Hwy	S4	WB	26400	11%	38000	11%	100
Roe Hwy Offramp to Kwinana NB	S5	EB	5300	10%	5500	10%	60
Roe Hwy Offramp to Kwinana NB & Kwinana SB	S5	EB	9700	10%	13800	10%	60
Roe Hwy Offramp to Kwinana SB	S5	EB	3100	10%	8300	10%	60
Roe Hwy Offramp to Murdoch	S5	EB	4100	3%	8300	3%	60
Roe Hwy Offramp to Murdoch & Kwinana NB, SB	S5	EB	13800	11%	22100	11%	60
Roe Hwy Onramp from Murdoch	S5	WB	7600	4%	10400	4%	60
Roe Hwy	S5	EB	11000	11%	16100	11%	80
Roe Hwy	S5	WB	19300	11%	27600	11%	80
Roe Hwy Offramp to Kwinana NB	S6	WB	10760	10%	11300	10%	60
Roe Hwy Offramp to Kwinana NB & Murdoch Dr	S6	WB	11760	10%	13300	10%	60
Roe Hwy Offramp to Kwinana SB	S6	WB	23300	10%	23300	10%	60
Roe Hwy Offramp to Kwinana SB, NB & Murdoch Dr	S6	WB	35060	10%	36600	10%	60
Roe Hwy Offramp to Murdoch	S6	WB	1000	5%	2000	5%	60
Roe Hwy Onramp from Kwinana NB	S6	EB	9000	10%	11000	10%	60
Roe Hwy Onramp from Kwinana SB	S6	EB	20500	10%	28800	10%	60
Roe Hwy Onramp from Kwinana SB & Kwinana NB	S6	WB	4600	10%	8800	10%	60
Roe Hwy	S6	EB	12300	10%	18100	10%	80
Roe Hwy	S6	WB	14700	10%	21200	10%	80
Roe Hwy Onramp from Karel Ave	S7	EB	1600	12%	5100	6%	60
Roe Hwy	S7	EB	41800	10%	57900	10%	80
Roe Hwy	S7	WB	48160	10%	52700	10%	80
Roe Hwy Offramp to Karel Ave	S8	EB	1300	8%	3400	6%	60
Roe Hwy	S8	EB	40500	10%	54500	10%	80
Stock Rd	S1	NB	21400	9%	42500	11%	90
Stock Rd	S1	SB	30400	9%	40600	11%	90
Stock Rd	S2	NB	12100	8%	22400	9%	90
Stock Rd	S2	SB	17100	8%	16900	9%	90
Stock Rd	S3	NB	15900	8%	28900	9%	90
Stock Rd	S3	SB	21100	8%	30100	9%	90
Slip road from Kwinana to Roe WB & Murdoch Dr	-	EB	7900	10%	12000	10%	60



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- Section 0
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- Section 4
- Section 5
- Section 6
- Section 7
- Section 8
- Slip road
- Study Area

South Metro Connect - Roe Highway Extension
Build Scenarios
Traffic Volume Road Section Reference Map

PROJECT ID 60100953
CREATED BY BS
LAST MODIFIED NB 30 NOVEMBER 2010

Figure
8

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5.3 Additional Modelling Parameters

5.3.1 Future Noise Barriers

Future noise predictions were modelled on the basis that existing noise barriers and residential fences are acoustically solid and will remain maintained and effective until the design year. That is, the modelling assumes that surveyed noise barriers and residential fences will remain in good order and perform as effective noise barriers in year 2031. Should the effectiveness of these barriers degrade over time through lack of maintenance or other means, road traffic noise levels at affected residences may exceed those predicted by this study.

5.3.2 Proposed Roe Highway Pavement Surface

The modelling of all “build” scenarios assumes that main carriageways on Roe Highway Extension will be paved with Open Graded Asphalt, and all exit ramps with Dense Graded Asphalt.

5.3.3 Parallel Barrier Degradation

The CoRTN calculation algorithm which is utilised on the SMC project considers the shielding provided by noise barriers and other intervening structures, such as dwellings and / or ground topography; however, it does not allow for a build-up of sound between two parallel barriers, or other reflective surfaces.

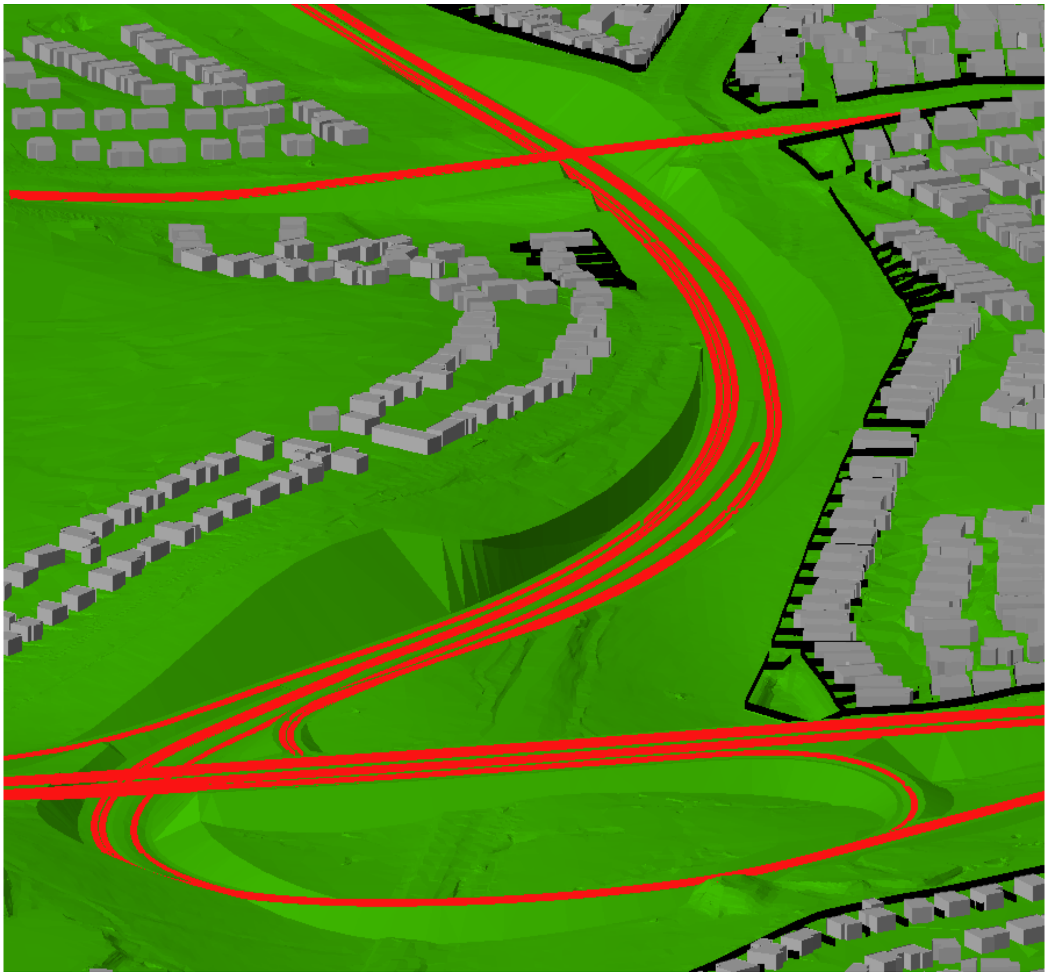
The phenomenon of parallel barrier degradation (PBD) is well documented and has been the subject of numerous studies. A literature survey has been carried out to determine if PBD is likely to occur on the SMC project, and if so, to develop appropriate modelling methodology to account for its effects. A summary of the literature survey is provided in Appendix G. The studies generally conclude that the significance of PBD is related to the following factors:

- The ratio of the width of road section and the height of the parallel barriers (i.e. the distance between the two reflecting surfaces and the height of the smaller reflecting surface) (W:H ratio)
- The “reflectiveness” of the barriers
- The location of the noise sensitive receivers and height of the source in relation to the road

The literature survey shows that PBD effect can be measured for W:H ratios of less than 20:1 (Fleming and Rickley, 1992), and can be significant for W:H ratios of less than 10:1 (Fleming and Rickley, 1992; Hendriks, 1993). Absorptive or inclined barriers are shown to reduce the effect of PBD because of the reduction in reflections of sound between non parallel / absorptive surfaces (Fleming and Rickley 1992; Marsella, 1991 and Bowlby et al 1987). Studies indicate that reflective barriers or retaining walls that are inclined by 10 degrees or more have a performance that is approximately equivalent to fully absorptive barriers (Slutsky and Bertoni,1988; Lee et al, 1988 and Watts, 1996).

AECOM has examined the potential areas of concern where the project traverses in deep cutting or where large parallel barriers are considered on the project. The main area of concern is generally between Stock Road and Sudlow / Coolbellup overpass, where the proposed alignment is in a deep cut. The W:H ratio for the majority of the proposed road in this section is in the 6:1 to 10:1 range, indicating the parallel barrier degradation effect may be significant. A vertical retaining wall is proposed for the northern section of this cutting, while a batter is proposed on the southern section of the cutting, see Figure 9.

Figure 9 Proposed vertical road alignment – Stock Rd Interchange to Sudlow / Coolbellup Overpass (easterly view)



The multiple reflection assessment included in the CoRTN emission calculation for SoundPLAN has been implemented for the sections of the highway between Stock Road and Sudlow / Coolbellup overpass. A correction of between 0.4 dB(A) and 0.7 dB(A) has been applied to the base Level Mean Emission (LME) for this region, which is over and above the standard CoRTN calculation. This has been included in the model to account for a build up of sound that may occur within the cutting.

Furthermore SoundPLAN does not take into account the reflections from ground topography, where the ground is not between the source and receiver. The northern retaining wall has therefore been modelled as a reflective barrier, resulting in an increase in predicted noise levels at receivers located opposite the cutting of up to 1.5 dB(A). This accounts for the increased noise levels on the southern side of the alignment due to the reflection from the vertical retaining wall.

A similar modelling approach has been successfully implemented on the EastLink Freeway project in Victoria, with post-opening compliance measurements showing good correlation with predicted noise levels.

6.0 Noise Impact Assessment

6.1 Summary

Summaries of the predicted noise levels for each of the four future modelling scenarios are presented in Table 17. Detailed noise modelling results are presented graphically in Appendix D and tabulated in Appendix E. Both the tabulated and graphical results are based on the noise level predicted at the loudest façade on the ground floor of each dwelling, as discussed in Section 4.3.3.

Table 17 Summary of predicted daytime (L_{eq}) noise levels for each modelled scenario

Modelled Scenario	Number of Receivers				Daytime $L_{Aeq,16hr}$ (dB(A))	
	Total	> 55 dB(A)	> 60 dB(A)	> 65 dB(A)	Average	Maximum
2016, No-build	1,472	100	0	0	47.1	59.8
2016, Build	1,472	245	5	0	51.8	63.8
2031, No-build	1,472	205	21	0	49.0	63.3
2031, Build	1,472	494	79	0	53.9	64.3

The results show that the highest noise levels associated with the build scenarios occur in the design year (2031). This scenario is therefore the controlling scenario, so compliance with noise criteria in the design year will ensure compliance in the opening year. Detailed results of 2031 build scenario noise modelling are presented graphically in Figure 10 and Figure 11. The figures present façade-corrected noise contour maps and building footprints that have been colour-coded according to noise exposure predicted at each noise-sensitive receiver.

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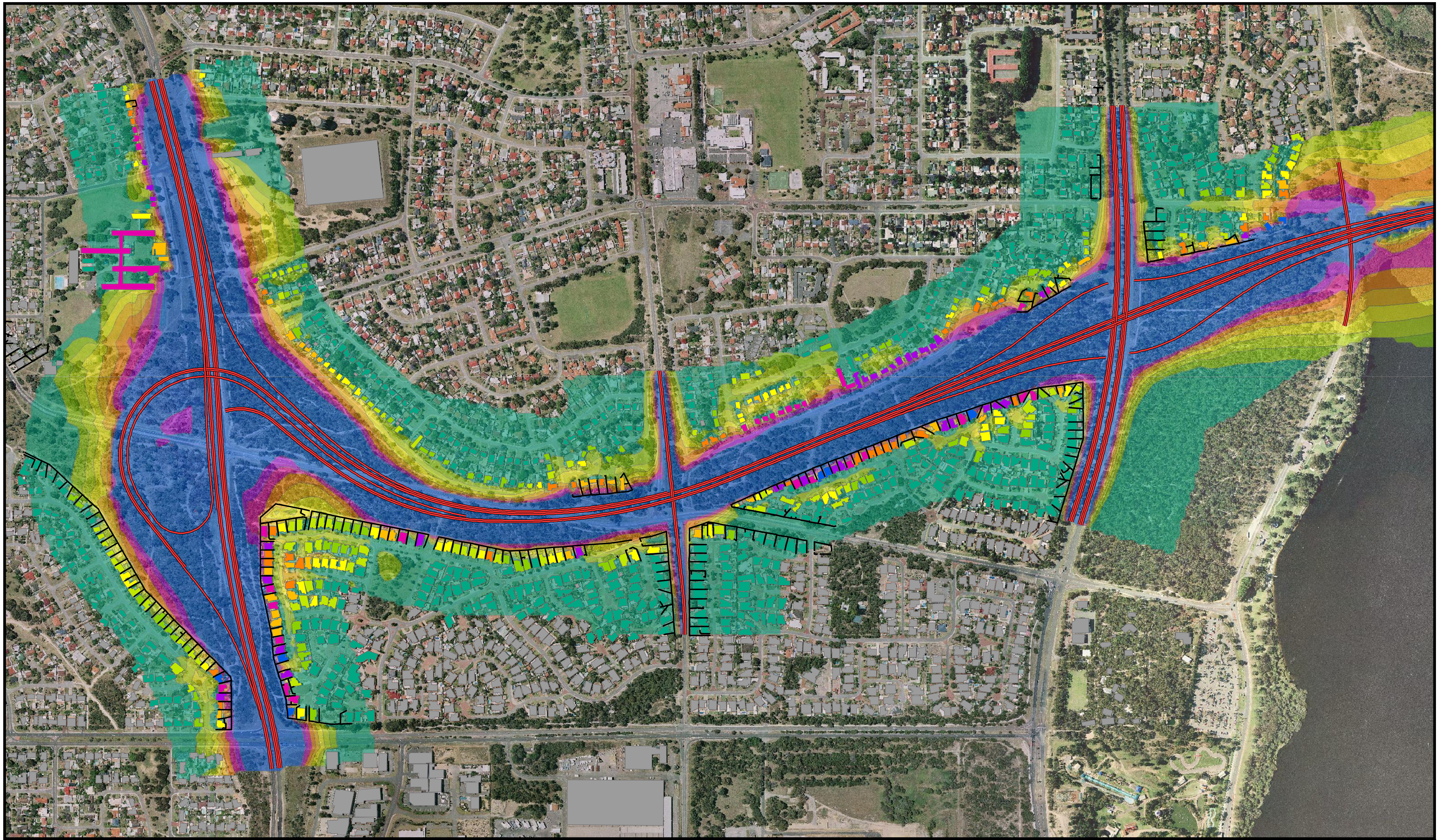

AECOM
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0 120 240 480
metres

Legend - LAeq, 16hr Noise Levels

Not Considered		59		Proposed Roads	
≤ 55		60		Existing Fences	
56		61			
57		62			
58		≥ 63			

Controlling (2031) Build Scenario
Façade Corrected Noise Levels
Stock Road to Progress Drive

PROJECT ID 60100953
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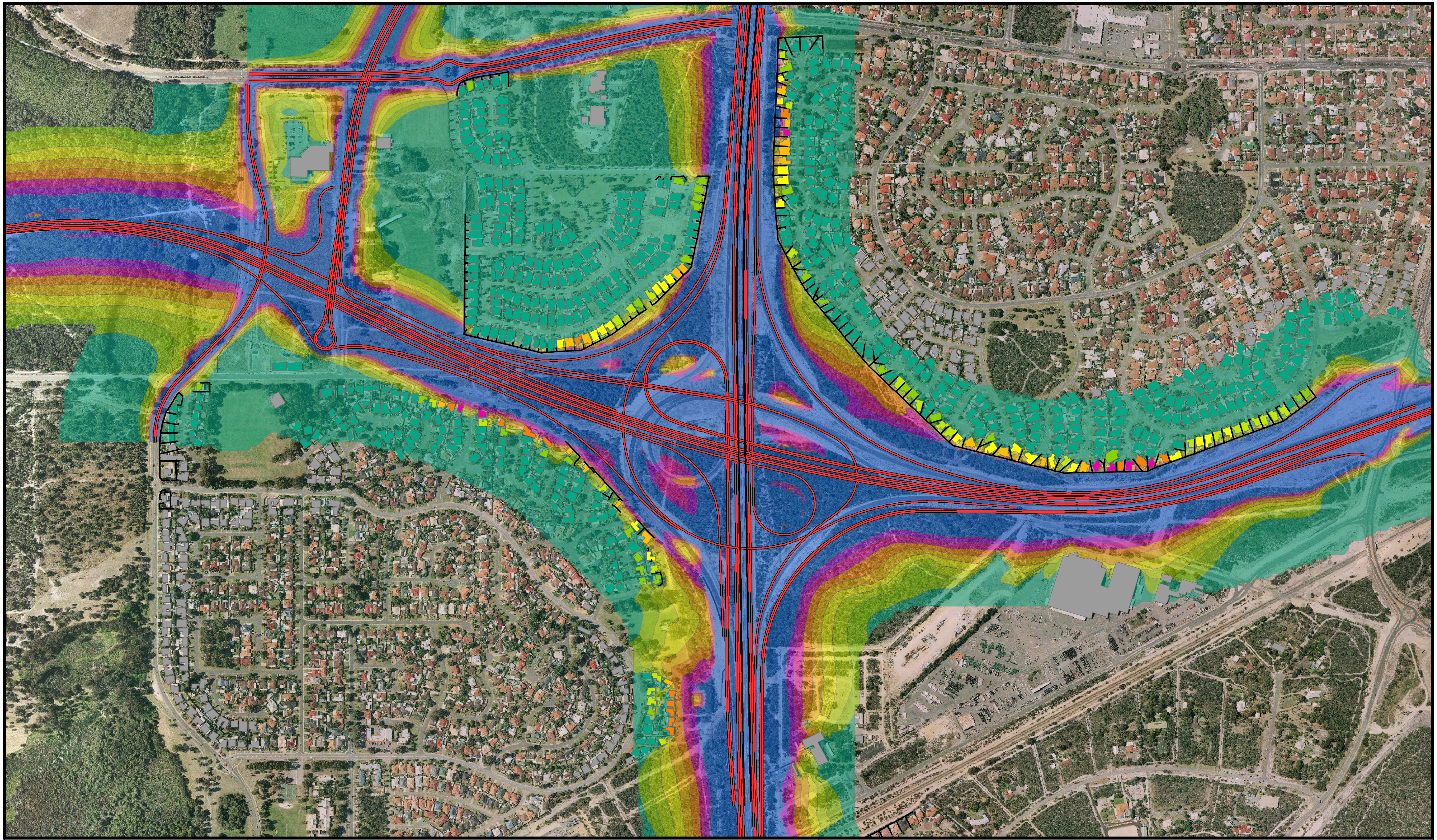
LAST MODIFIED NB 30 NOVEMBER 2010

Figure
10



AECOM

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metres

Legend - LAeq, 16hr Noise Levels

Not Considered
≤ 55
56
57
58
59
60
61
62
≥ 63
Proposed Roads
Existing Fences

Controlling (2031) Build Scenario
Façade Corrected Noise Levels
Bibra Drive to Karel Avenue

PROJECT ID 60100953
CREATED BY NB
LAST MODIFIED NB 30 NOVEMBER 2010

Figure

11

6.2 New Roads

Noise impacts on new roads are assessed against the noise target and noise limit criteria of the SPP 5.4 (as discussed in Section 2.1.1). Build scenario modelling results presented in Table 17 indicate that the controlling 2031 (design year) build scenario will result in 494 out of 1,472 modelled receivers exceeding the noise target of 55 dB(A), with 79 of those receivers also exceeding the noise limit of 60 dB(A).

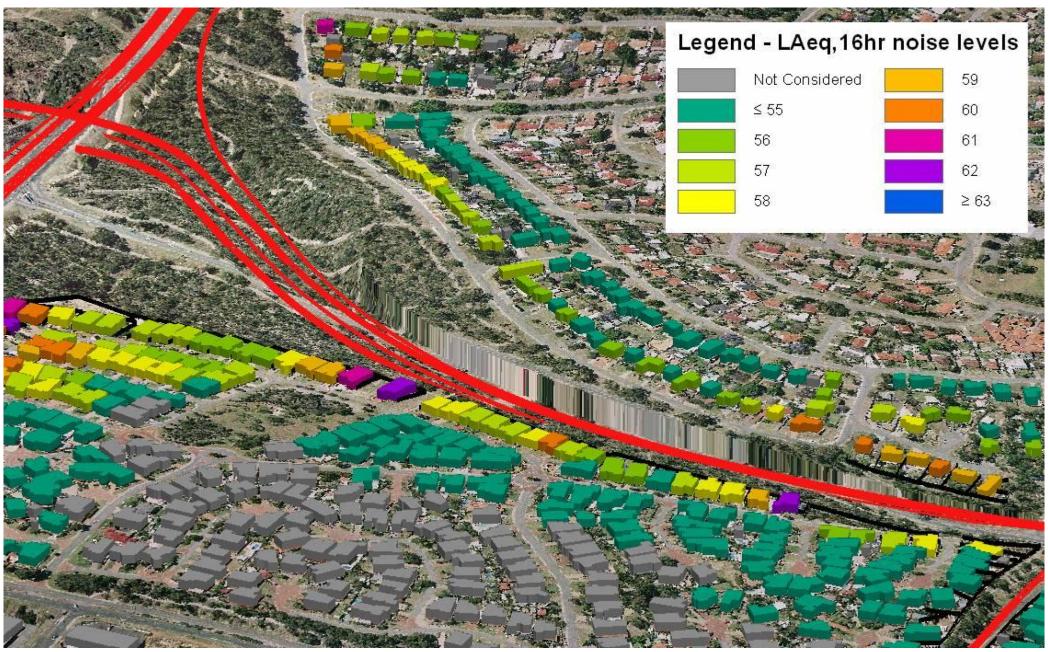
6.2.1 Stock Road to Progress Drive

Noise sensitive receivers south-west of the Roe Highway/Stock Road interchange are generally predicted to exceed the noise target, ranging from below 55 dB(A) to 58 dB(A). Therefore, reasonable and practicable noise mitigation measures have been considered adjacent to the proposed exit ramps, in line with SPP 5.4.

The proposed project between Stock Road and Coolbellup/Sudlow overpass is in a cut, which is up to 10m deep. While the cutting provides a degree of noise shielding to the adjacent sensitive receivers, receivers in this section generally exceed the noise target of 55 dB(A) (Figure 10). Reasonable and practicable noise mitigation measures to meet the noise target have been considered for this part of the proposed project, in accordance with SPP 5.4.

Three-dimensional view of the proposed vertical alignment in this section is shown in Figure 12. The 3-D figures show 2031 build scenario daytime noise levels at the ground floor, against which compliance with criteria is assessed.

Figure 12 Northerly view of Stock to Sudlow Road showing 2031 build noise levels



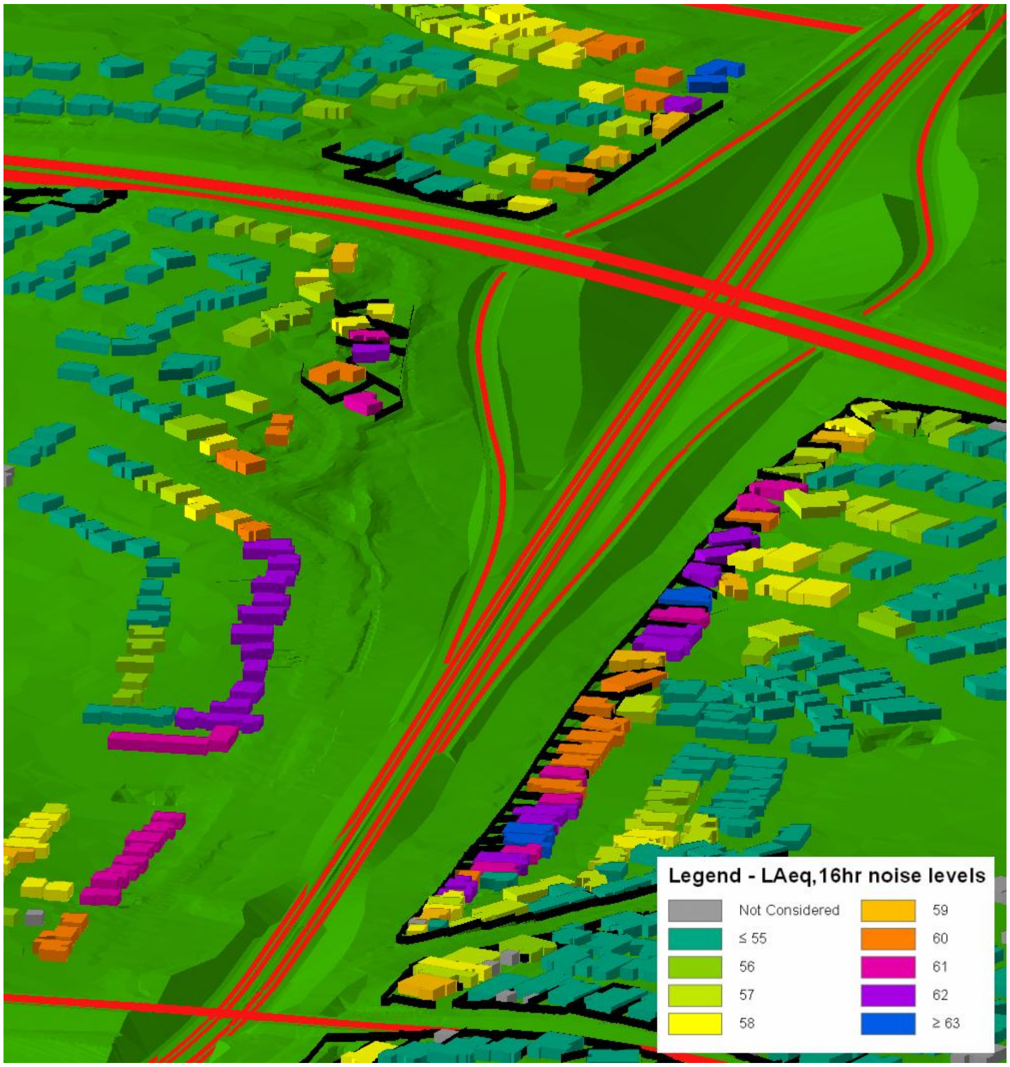
Three receivers in this section are predicted to exceed the noise limit of 60 dB(A). The elevation of these receivers relative to their back fences is such that they overlook the road reserve (i.e. little to no shielding is afforded by the back fence). This can be seen in Figure 13.

Figure 13 Westerly view of Stock and Coolbellup showing 2031 build noise levels

Noise mitigation is required to meet the noise limit, and reasonable and practicable mitigation measures have been considered to achieve the noise target at these receivers.

The proposed project, east of the Coolbellup/Sudlow overpass emerges out of the cutting and runs on fill that is up to 2m above grade. The elevation of the road relative to noise sensitive receivers is shown in Figure 14, with buildings coloured in accordance with 2031 build scenario noise exposure.

Figure 14 Easterly view of Coolbellup/Sudlow overpass to Progress Drive

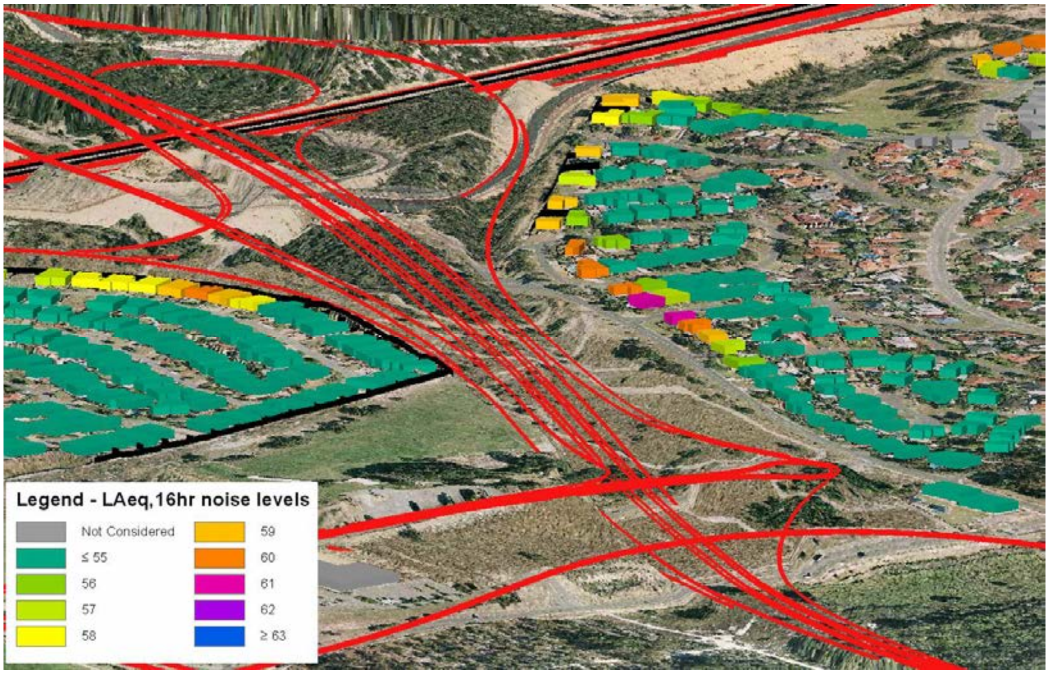


Noise sensitive receivers along this section are generally predicted to exceed the noise limit of 60 dB(A) in 2031 due to the proposed upgrade. The 2031 build scenario predicted noise levels therefore show that noise mitigation is required in this section to achieve the noise limit, and to meet the noise target where reasonable and practicable, in accordance with SPP 5.4.

6.2.2 Bibra Drive to Kwinana Freeway

Figure 11 shows the 2031 build scenario predicted noise levels east of Bibra Drive. The road alignment along this section is in a cutting generally between 4 m and 6 m deep. Dwellings on Hope Road south of the proposed alignment are further shielded by the Murdoch Drive offramp, which projects up to 6 m above grade. The vertical alignment in this section is shown in Figure 15.

Figure 15 Easterly view of Bibra Drive to Kwinana Freeway



Noise sensitive receivers on Hope Road east of Lakeview Drive exceed the noise target of 55 dB(A), and several receivers also exceed the limit of 60 dB(A). Similarly, several receivers north west of the Kwinana Freeway interchange are also predicted to exceed the noise target of 55 dB(A). It is noted that an additional penalty of 0.6 dB(A) is applicable at noise receivers which are within 500 m of the Interchange with Kwinana Freeway. Noise mitigation will therefore be required to meet the noise limit with reasonable and practicable mitigation measures considered to achieve the noise target at these receivers.

Other receivers adjacent to the proposed project are predicted to be below the noise target of 55 dB(A). In accordance with SPP 5.4, no further noise mitigation is necessary at locations adjacent to these receivers.

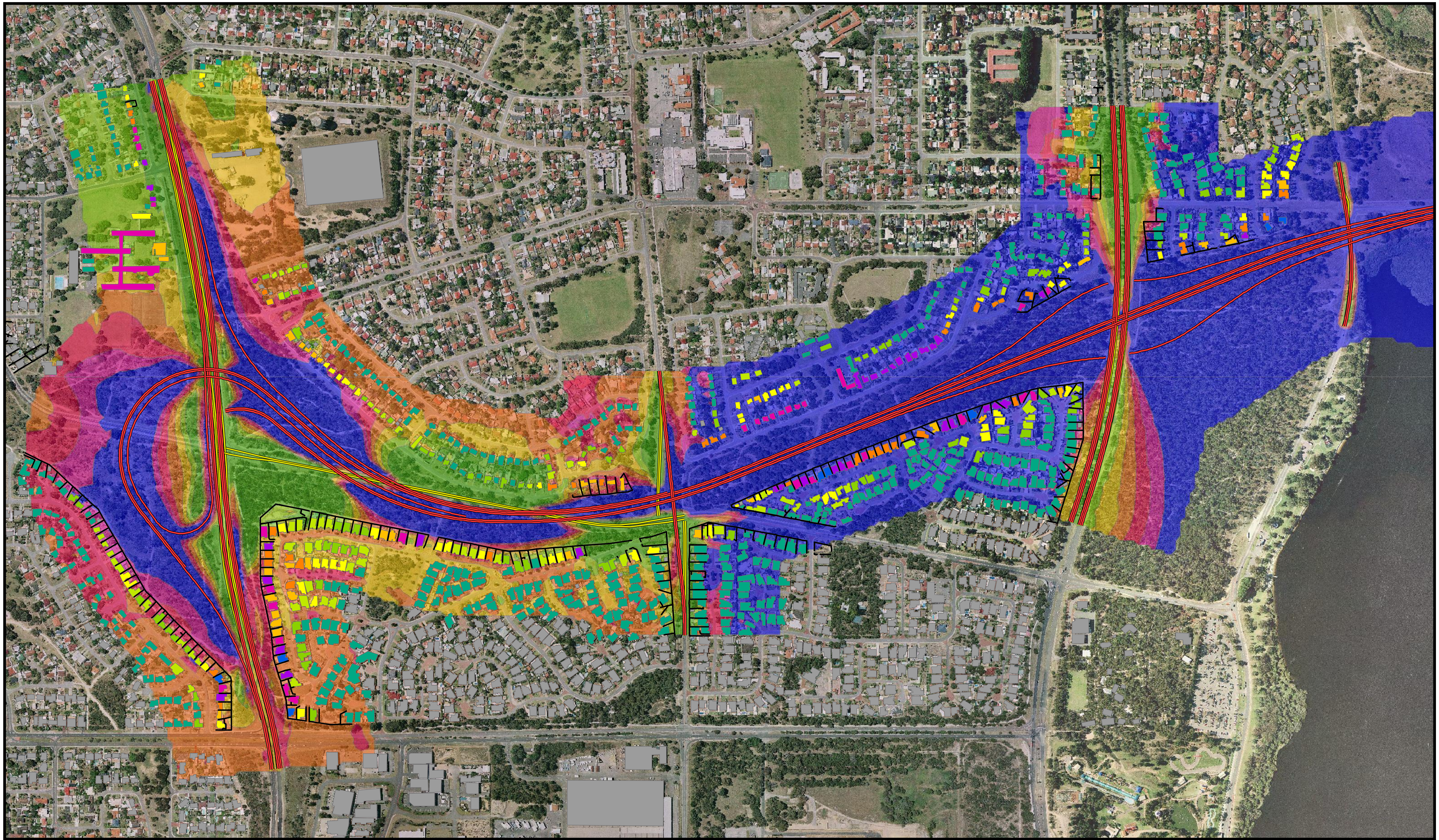
6.3 Redevelopment of Existing Roads

In accordance with SPP 5.4, reasonable and practicable noise management and mitigation measures should be considered at receivers adjacent to major redevelopment of existing roads with regard to:

- existing transport noise levels
- likely changes in noise emissions resulting from the proposal; and
- nature and scale of the works and the potential for noise amelioration.

Noise difference maps (i.e. Build – No-build) for the controlling scenario have been prepared in order to assess predicted changes in noise emissions resulting from the proposed project. These are presented in Figure 16 and Figure 17.

Building footprints have been **colour-coded** to show the controlling(2031 Build scenario) noise exposure, while noise contour lines show the predicted increase in noise levels resulting from the propose project (i.e. 2031 Build Scenario – 2031 No-build Scenario noise level difference).



AECOM
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0 120 240 480
metres

Legend - LAeq, 16hr Noise Levels

- Not Considered
- ≤ 55
- 56
- 57
- 58
- 59
- 60
- 61
- 62
- ≥ 63
- Proposed Roads
- Current Roads
- Existing Fences
- Removed Fences

Noise Level Difference

- < 0
- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- > 5

Controlling (2031) Noise Level Difference Map
Buildings Coloured to Build Scenario
Stock Road to Progress Drive

PROJECT ID 60100953
CREATED BY NB
LAST MODIFIED NB 30 NOVEMBER 2010

Figure
16

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6.3.1 Stock Road

Figure 16 shows that by 2031, noise sensitive receivers adjacent to Stock Road will be exposed to noise levels ranging from 59 dB(A) to 64 dB(A) due to the proposed project. The vertical alignment of Stock Road south of Roe Highway increases by up to 3m due to the proposed project. Noise sensitive receivers adjacent to this section generally exceed the noise limit of 60 dB(A). In addition, the noise levels at these receivers are predicted to increase by between 2 and 4 dB(A). Therefore, reasonable and practicable noise mitigation measures have been considered to meet the noise limit at these receivers.

No significant changes to the vertical alignment of Stock Road are proposed north of Roe Highway. Noise sensitive receivers along this section comprise residential receivers (north of Ralston Street) and Hamilton Senior High School. The receivers are generally predicted to exceed the noise limit of 60 dB(A) by up to 2 dB(A) in 2031 due to the proposal. Noise levels at the school are generally predicted to increase by between 1 and 3 dB(A) due to the proposed upgrade. Reasonable and practicable noise mitigation measures have therefore been considered to meet the noise limit at the ground floor level the school. Noise levels at residential receivers north of Ralston Street are predicted to decrease due to the proposed upgrade. Consequently, noise mitigation has not been considered at these receivers.

6.3.2 North Lake Road

Noise sensitive receivers adjacent to North Lake Road are generally at or below the noise target of 55 dB(A). No further noise mitigation is therefore necessary adjacent to North Lake Road in accordance with SPP 5.4.

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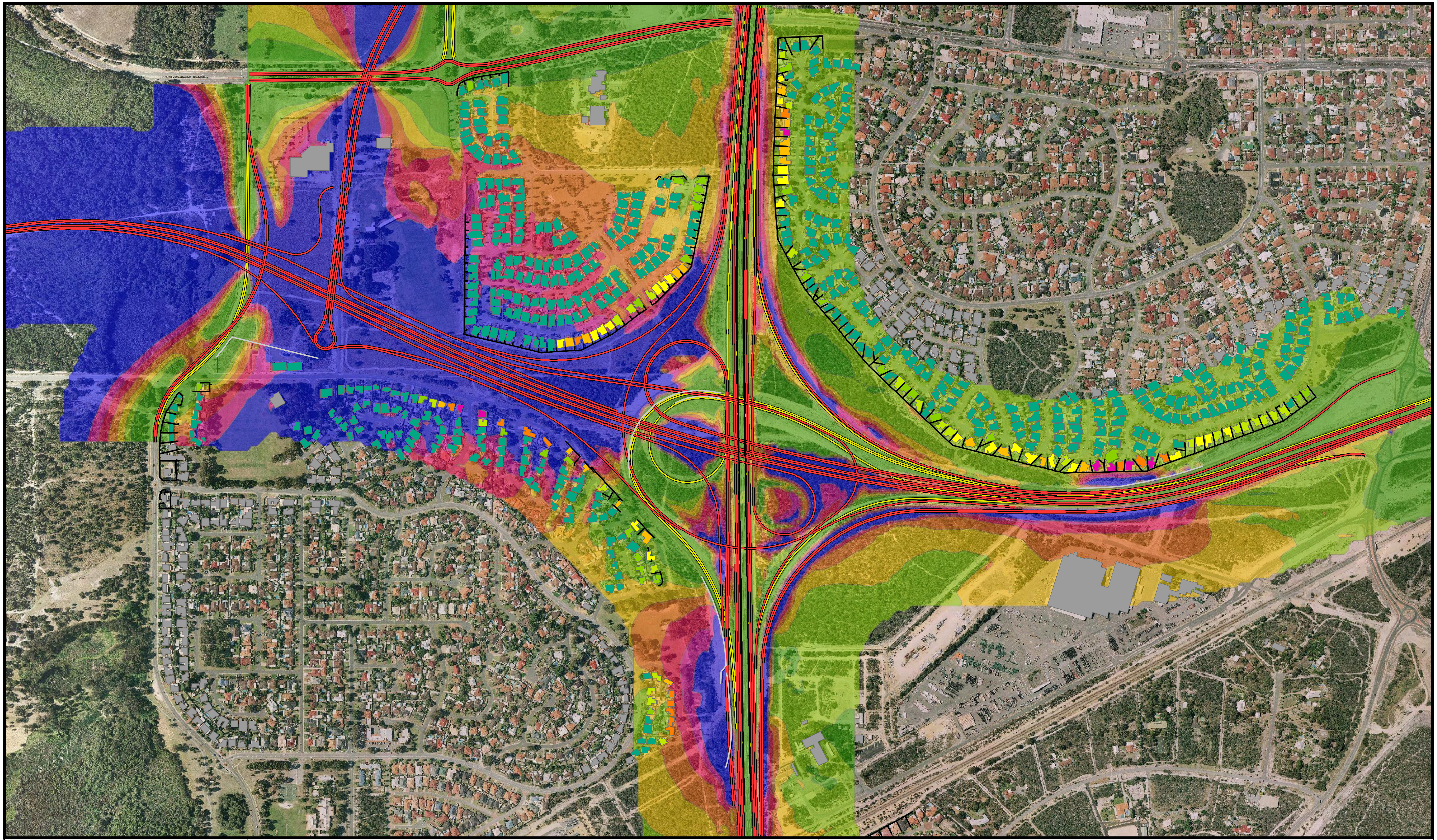

AECOM

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0 120 240 480

metres

Legend - LAeq, 16hr Noise Levels

- Not Considered
- ≤ 55
- 56
- 57
- 58
- 59
- 60
- 61
- 62
- ≥ 63
- Proposed Roads
- Current Roads
- Existing Fences
- Removed Fences

Noise Level Difference

- < 0
- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- > 5

Controlling (2031) Noise Level Difference Map
Buildings Coloured to Build Scenario
Bibra Drive to Karel Avenue

PROJECT ID 60100953

CREATED BY NB

LAST MODIFIED NB 30 NOVEMBER 2010

Figure

17

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6.3.3 Kwinana Freeway

Noise sensitive receivers adjacent to Kwinana Freeway comprise receivers located south-west, north-west, north and north-east of the interchange. Receivers north of the interchange (i.e. those which are located on McKivett Crescent and Woodlea Crescent) are outside the project area, as no changes are proposed to Kwinana Freeway adjacent to these receivers.

Receivers on Peterborough Circle which are adjacent to Kwinana Freeway (i.e. 1 – 19 Peterborough Circle) are exposed to noise levels of up to 56 dB(A) in the controlling 2031 build scenario. Considering they are adjacent to an existing transport corridor and are below the noise limit, noise mitigation has not been considered at these locations.

Similarly, receivers to the north-east will generally be exposed to noise levels of up to 56 dB(A) in the controlling 2031 build scenario. Considering they are adjacent to an existing transport corridor and are below the noise limit, noise mitigation has not been considered at these locations.

South-west of the interchange, the proposal consists of two additional lanes to the west of the existing alignment, making it necessary to remove the existing noise barrier. Build scenario noise models therefore exclude this barrier from noise assessment. With the existing barrier removed, the 2031 build results show that noise levels will comply with the 60 dB(A) limit at the most exposed receivers. Removing the noise barrier however, would result in an increase in noise levels by 3 to 4 dB(A) at the most exposed receivers. A 2.4m high noise barrier of equivalent length is therefore proposed on the outside of the newly constructed lanes.

6.3.4 Roe Highway East of Kwinana Freeway

Noise sensitive receivers adjacent to the proposed project are located on the north side of the highway. The proposed upgrade consists of an additional lane to the north of the existing alignment. Build scenarios assume that this addition will necessitate the removal of the existing noise barrier. Without the existing roadside barrier, the most exposed receivers adjacent to the existing barrier are predicted to marginally exceed the noise limit of 60 dB(A). If the existing noise barrier is removed, other reasonable and practicable noise mitigations will be considered to meet the noise limit of 60 dB(A).

Other noise sensitive receivers in this area are predicted to comply with the noise limit of 60 dB(A) in the controlling (2031 build) scenario. Furthermore, the study predicts a marginal increase in noise levels due to the proposed project of less than 1 dB(A). Considering that the noise receivers are predicted to meet the noise limit, and that the increase in noise levels due to the proposal is considered to be imperceptible by the human ear, no additional mitigation measures have been considered for this section.

6.4 Parks and Recreational Areas

In the absence of noise criteria for parks and recreational areas within the SPP 5.4 noise policy, noise impacts at parks and recreational areas have been assessed against daytime outdoor noise objectives for noise sensitive receivers, with regard to the following:

- size of the park/recreational area and the proportion of area exceeding the noise criteria,
- location of fixed recreational infrastructure (e.g. playgrounds, picnic tables, barbecue facilities etc) and compliance with the outdoor noise criteria at these locations, and
- availability of alternative recreational areas within reasonable distance of areas affected by noise.

The recreational areas potentially affected by the proposed project comprise those surrounding North Lake and Bibra Lake, as well as Matilda Birkett Reserve, Rinaldo Reserve, Basset Reserve, Meller Park, Ramsay Park (formerly Aubin Park), Pioneers Park and James Patterson Park.

Three additional small playgrounds/recreation areas are located within the study area. These comprise:

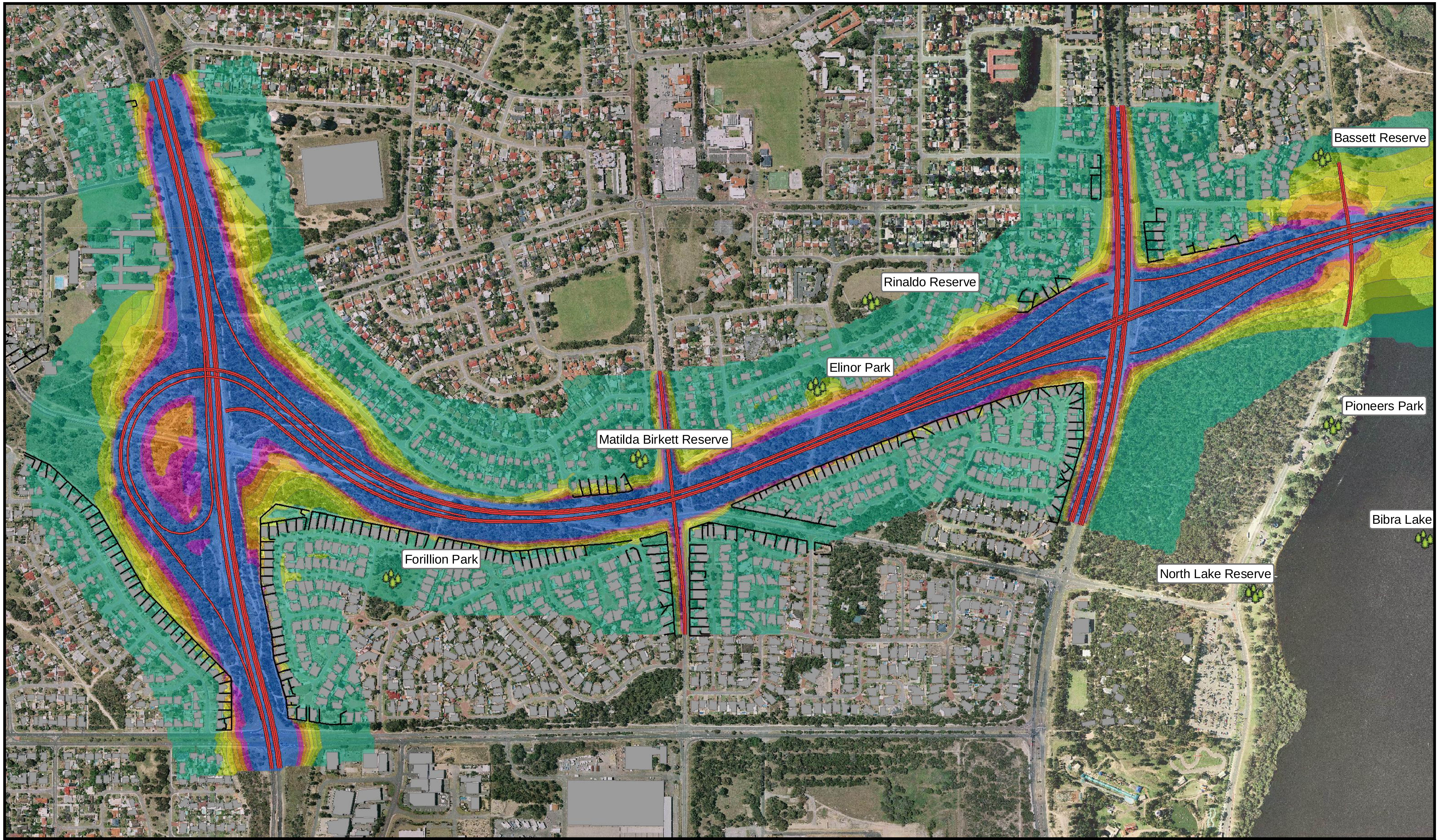
- Recreational area in Coolbellup (Elinor Park[2]) – small park in Coolbellup fronting the MRS road reserve bounded by Elinor Pl, Malvolio Rd and Rinaldo Cres.
- Recreational area in Bibra Lake (Forillion Park[2]) – small recreational area located approximately 100m from the proposed alignment. It is bounded by Forillion Ave, Arches Way, Orlando Ave and Briere Grn.
- Heatherlea Park – a small recreational area / playground in Leeming – small recreational area with playground infrastructure in Leeming. It is bounded by Sylvan Cres, Heatherlea Pkwy, Karel Ave and Roe Highway.

Noise contour maps for assessment of noise impacts in parklands and recreational areas are presented in Figure 18, Figure 19 and Figure 20. As noise receivers within recreational areas are located in free-field conditions (i.e. there are no reflective surfaces such as dwelling façades present at receiver locations), the noise contours presented in these figures do not incorporate a façade correction. Therefore, the noise contour map levels shown in the figures are not applicable to residential receivers, and consequently, building noise exposures are not shown. The predicted worst case (2031 build scenario) noise levels have been assessed against SPP 5.4 outdoor noise criteria.

6.5 Minor Changes to Concept Design Not Included in the Model

We note that the proposed road design has been realigned at the exit ramp from Kwinana Freeway northbound to Roe Highway eastbound since this assessment has been carried out. The realignment has brought the exit ramp closer to the noise sensitive receivers southwest of the Kwinana Freeway / Roe Highway interchange potentially increasing noise levels at these locations. An assessment was conducted to gauge the effect of this change on the predicted noise levels. The assessment indicates that the realignment will increase the overall noise levels at the nearest receivers by less than 1 dB(A). Although this change has not been included in the model, it is estimated to have a marginal effect on the overall noise levels and will be incorporated (and designed for) in the detailed design phase of the project.

[2] Recreational area named after nearest street for reference only. Actual area may not have name, or one which is different from above.



AECOM

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0 120 240 480

metres

Legend - LAeq, 16hr Noise Levels

Not Considered	59
≤ 55	60
56	61
57	62
58	≥ 63

Proposed Roads

Existing Fences

Parklands

Controlling (2031) Build Scenario
Free Field Noise Contour Map
Stock Road to Progress Drive

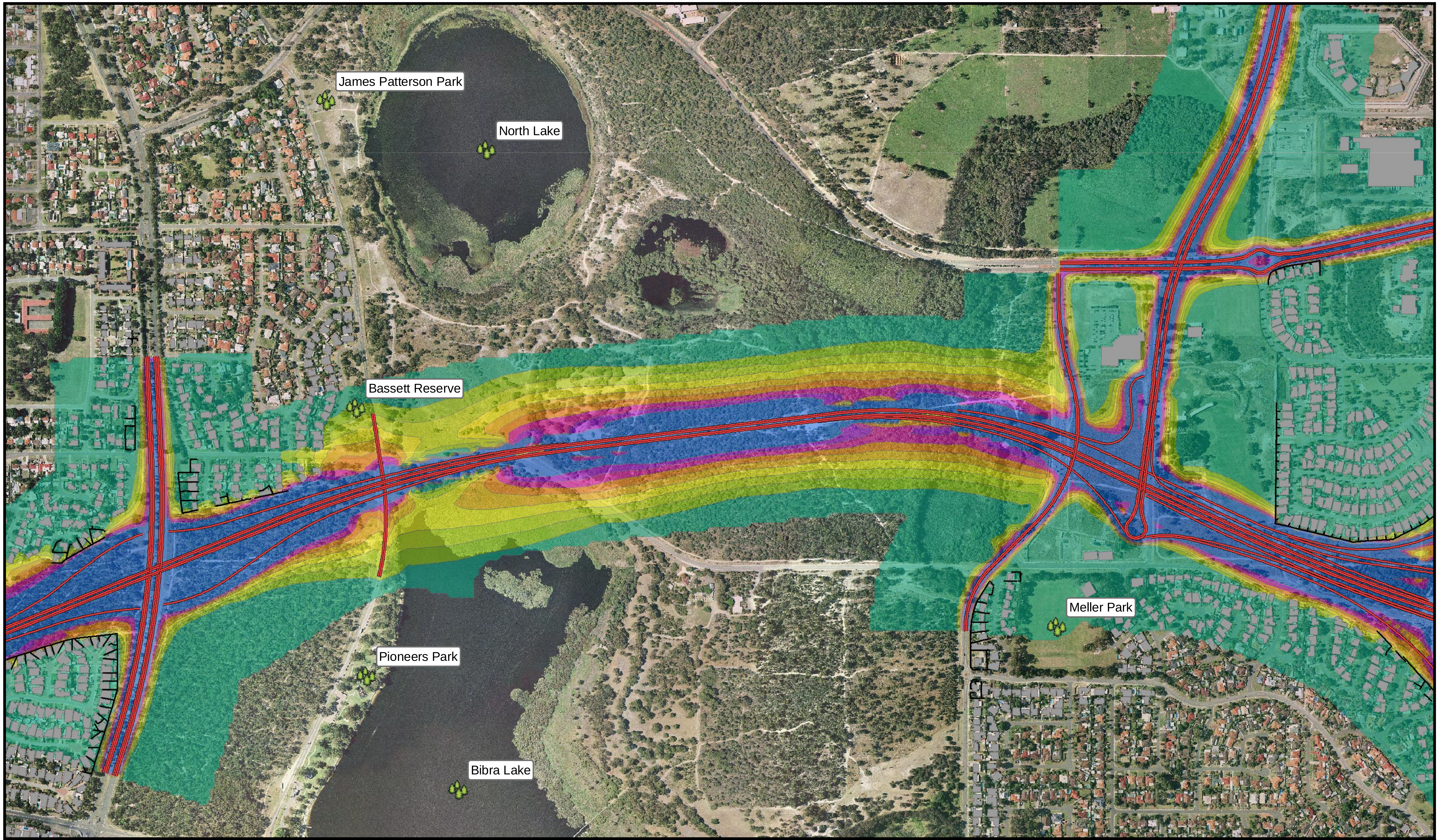
PROJECT ID 60100953

CREATED BY NB

LAST MODIFIED NB 30 NOVEMBER 2010

Figure

18



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metres

Legend - LAeq, 16hr Noise Levels

Not Considered	59	Proposed Roads
≤ 55	60	Existing Fences
56	61	Parklands
57	62	
58	≥ 63	

Controlling (2031) Build Scenario
Free Field Noise Contour Map
Progress Drive to Bibra Drive

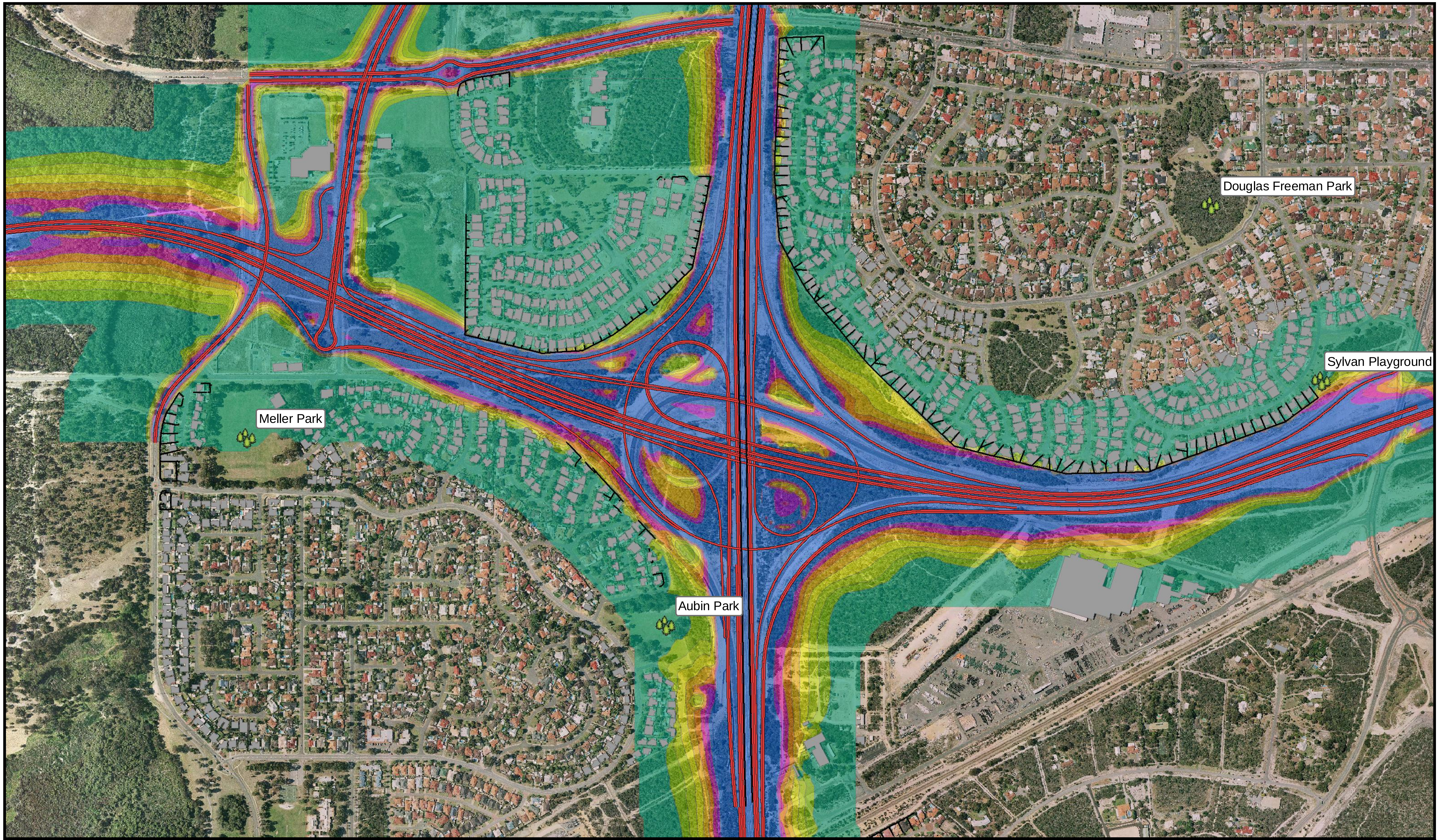
PROJECT ID 60100953

CREATED BY NB

LAST MODIFIED NB 30 NOVEMBER 2010

Figure

19



AECOM

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metres

Legend - LAeq, 16hr Noise Levels

Not Considered	59	Proposed Roads
≤ 55	60	Existing Fences
56	61	Parklands
57	62	
58	≥ 63	

Controlling (2031) Build Scenario
Free Field Noise Contour Map
Bibra Drive to Karel Avenue

PROJECT ID 60100953
CREATED BY NB
LAST MODIFIED NB 30 NOVEMBER 2010

Figure
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6.5.1 Noise Impacts at Parks and Recreational Areas

Summary of noise impacts in parks and recreational areas within the study area is presented in Table 18.

Table 18 Noise Impacts on Parks and Recreational Areas

Park/Recreational Area	Approximate % of park area exceeding noise criteria		Recreational infrastructure exceeding noise criteria?	Nearest alternative recreational area (distance to nearest recreational area)
	Noise Target (55 dB(A)	Noise Limit (60 dB(A))		
Matilda Birkett Reserve	0%	0%	No	N/A
Rinaldo Reserve	0%	0%	No	N/A
Bassett Reserve	50%	0%	Yes	Pioneers Park (500 m)
Meller Park	0%	0%	No	N/A
Ramsay Park	15%	0%	No	Meller Park (>1 Km)
James Patterson Park	0%	0%	No	N/A
Parklands (Bibra Lake)	<5%	<1%	No	N/A
Parklands (North Lake)	35%	15%	No	James Patterson Park (100 m) Bibra Lake Parklands (500 m)
Pioneers Park	10%	0%	No	North Lake Reserve (800 m) James Patterson Park (900 m)
Elinor Park[1]	50%	10%	Yes	Rinaldo Reserve (200 m)
Forillion Park[1]	0%	0%	No	N/A
Heatherlea Park	40%	0%	No[2]	Douglas Freeman Park (400 m)

Notes:

1.) Recreational area named after nearest street for reference only. Actual area may not have name, or one which is different from above.

2.) Heatherlea Park is exposed to noise from existing transport corridors, therefore impacts are assessed against the predicted noise exposure in absence of the proposed development.

Rinaldo Reserve, Meller Park, James Patterson Park, Matilda Birkett Reserve and Forillion Park are predicted to comply with the noise target criterion. Exceedances of the noise target and/or noise limit are predicted at Ramsay Park, Bassett Reserve, North Lake Parklands, Bibra Lake Parklands, Pioneers Park, Elinor Park and Heatherlea Park. The predicted exceedances are further discussed in the following sections.

6.5.2 Ramsay Park (formerly Aubin Park)

A minor exceedance is predicted at Ramsay Park, with 15 percent of the recreational area predicted to exceed the noise target and none to exceed the noise limit. Furthermore, there is no fixed recreational infrastructure that is predicted to exceed the noise criteria. The park area, however, is small and the nearest alternative recreational area is over 1 km away. A new 2.4 m noise barrier is proposed to be built along Kwinana Freeway adjacent to Ramsay Park in order to replace a noise barrier which is being removed as part of the proposed works (refer Section 6.3.3). With the replacement barrier in place, noise levels at Ramsay Park are predicted to comply with the noise target criterion.

6.5.3 Bassett Reserve

Fifty percent of Bassett Reserve is predicted to exceed the noise target, and none to exceed the noise limit. The area has fixed recreational infrastructure (playground) which is predicted to exceed the noise target criterion by between 1 and 2 dB(A). The nearest alternative recreational area is located approximately 500 m away at Pioneers Park, where an equivalent playground is available. In addition, some form of noise mitigation will be required adjacent to the park to reduce noise levels at residences on Rossetti Court. This mitigation will also result in lower noise levels at Bassett Reserve, and is likely to result in compliance with the noise target criterion at the playground area.

6.5.4 Beeliar Wetlands

6.5.4.1 Bibra Lake Parklands

The predicted noise exceedances at Bibra Lake parklands are minor, with no greater than 5 percent exceeding the noise target, and no greater than 1 percent exceeding the noise limit, respectively. In addition, there is no fixed recreational infrastructure within the areas in which noise levels are predicted to exceed the criteria.

6.5.4.2 North Lake Parklands

Approximately 35 percent of the North Lake parklands noise levels are predicted to exceed the noise target criterion, of which approximately 15 percent will exceed the noise limit. The areas exceeding the noise limit are within approximately 80m of the proposed alignment and those exceeding the target within approximately 200m. No fixed recreational infrastructure is located within the areas that are predicted to exceed the noise criteria, and an alternative area of similar recreational value is located around Bibra Lake, approximately 500m south of the affected area.

6.5.5 Pioneers Park

Approximately 10 percent of Pioneers Park is predicted to exceed the noise target but not the noise limit criterion. The park area exceeding the noise criteria does not contain any fixed recreational infrastructure. Furthermore, several formal and informal parks of similar or better recreational value are available within 1km of the noise affected area.

6.5.6 Elinor Place Recreational Area

Fifty percent of the Elinor Place recreational area is predicted to exceed the noise target, of which 10 percent will also exceed the noise limit. The area has fixed recreational infrastructure (playground) which is predicted to exceed the noise target criterion. The nearest alternative recreational area is located approximately 200m away at Rinaldo Reserve, however an equivalent playground is not available within this reserve. In addition, some form of noise mitigation will be required adjacent to the park to reduce noise levels at residences on Malvolio Road. This mitigation will also result in lower noise levels at the Elinor Place recreational area, and is likely to result in compliance with the noise target criterion at the playground area.

6.5.7 Heatherlea Park

Heatherlea Park is predicted to comply with the noise limit criterion, however 40 percent of the area is predicted to exceed the noise target in 2031. The nearest alternative playground area is located approximately 400m away at Douglas Freeman Park. The playground is already exposed to noise from existing transport corridors, and although the playground is predicted to exceed the noise target in 2031, the noise levels are not predicted to increase due to the proposed upgrade. No additional noise impacts are therefore predicted at the park due to the proposed upgrade.

7.0 Noise Mitigation and Management

7.1 Noise Mitigation Design Methodology

Noise barriers were considered at locations that best balance noise benefit, cost, feasibility, amenity impacts, community preferences and safety and security, where these do not conflict with other planning and transport policies.

Where noise sensitive receivers back onto the proposed road reserve, noise barriers were generally designed on property boundaries. This was done in order to avoid creating "trapped corridors" between roadside barriers and residential backyard fences, which can attract anti-social behaviour and reduce safety and security in the area. An exception to the above rule was required on Stock Road, south-west of the Roe Hwy interchange. The ground topography in this area makes residential boundary noise walls ineffective due to a significant height difference between the road and adjacent receivers. Residential boundary noise barriers were therefore supplemented with a roadside noise barrier to achieve the noise criteria.

Similar consideration was also given to barriers adjacent to principal shared paths (PSP). Noise barriers were designed to maximise PSP visibility from the proposed highway and/or other public roads. The objective of design was to maximise security and roadside lighting penetration to the PSP wherever possible. Barriers were generally placed to allow the PSP to run between the noise barrier and the proposed alignment. An exception was made between Stock Road (from Juno Pl) and Coolbellup Avenue, where the proposed project is in a deep cutting, while the PSP runs on top of the retaining wall. Noise barriers were located on top of the retaining wall to maximise barrier performance and provide a safety barrier between the PSP and the cutting.

Roadside noise barriers were used adjacent to residences fronting the road reserve wherever possible, so these can retain outlook to parklands within the road reserve between residences and the road. Outlook to parklands was achieved at the majority of residences fronting the proposed project between Stock Road and North Lake Road.

7.2 Mitigation Design to Meet SPP 5.4 Noise Objectives

In accordance with SPP 5.4, noise mitigation requirements have been designed to meet the SPP 5.4 noise target and noise limit criteria at noise sensitive receivers adjacent to the proposed project. A summary of barrier requirements to meet each of the SPP 5.4 objectives is presented in Table 19.

Table 19 Noise barrier configuration required to meet noise objectives

Theoretical Barrier Configuration	Total Barrier Length (m)	Average Barrier Height (m)	Maximum Barrier Height (m)	Total Barrier Vertical Area (m^2)
Barrier to meet all noise limit	1,962	2.4	3.6	4,611
Barrier to meet all noise target	8,045	3.8	6.2	30,460

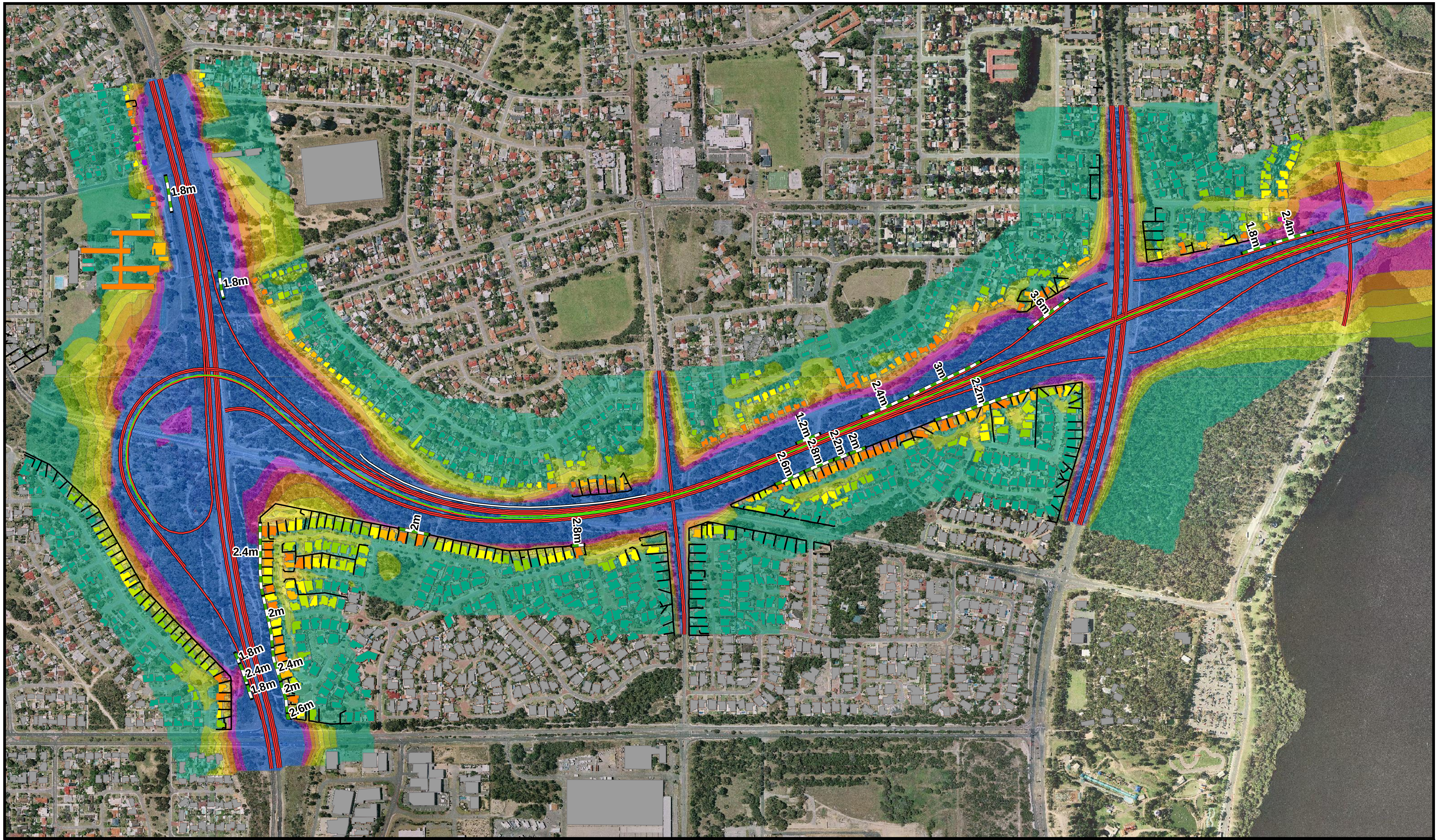
Details of noise barriers required to meet both criteria as well as the resulting noise environment are presented in Appendix D.

7.3 Mitigation to Meet Noise Limit

Noise barriers can be practically applied to meet the noise limit of 60 dB(A) along the majority of the proposed project. An exception to this occurs between Coolbellup / Sudlow overpass and North Lake Road, where the proposed project is vertically aligned at up to 2 m above grade. Noise barriers of between 2 m and 3.6 m in height are required in portions of this section to meet the noise limit. Details of noise barriers that are required to meet the noise limit are presented in Figure 21 and Figure 22.

At upgraded sections of existing roads, only Stock Road requires additional noise barriers to meet the noise limit of 60 dB(A). This is because the vertical alignment of Stock Road south of the interchange is increased by between 1 m and 6 m to accommodate the Roe Highway / Stock Road northbound exit ramps. A 2 m to 2.6 m high noise barrier is required on the property boundary at receivers on the south-east section of Stock Road. The terrain topography on the south-west side is such that receivers are up to 4 m below the level of the adjacent road. This makes noise walls on residential boundaries ineffective due to a significant height difference between the road and adjacent receivers. A 120 m long barrier located adjacent to the road is therefore required to meet the noise limit of 60 dB(A) south west of the interchange.

Provided that existing noise barriers (that may be removed during construction) adjacent to Kwinana Freeway and Roe Highway are replaced, noise limit criteria will be met at all noise sensitive receivers. Alternatively, the existing noise wall adjacent to Roe Highway can be replaced with a 2.2 m wall on the residential boundary, as shown in Figure 26.



AECOM
www.aecom.com

0 95 190 380
metres

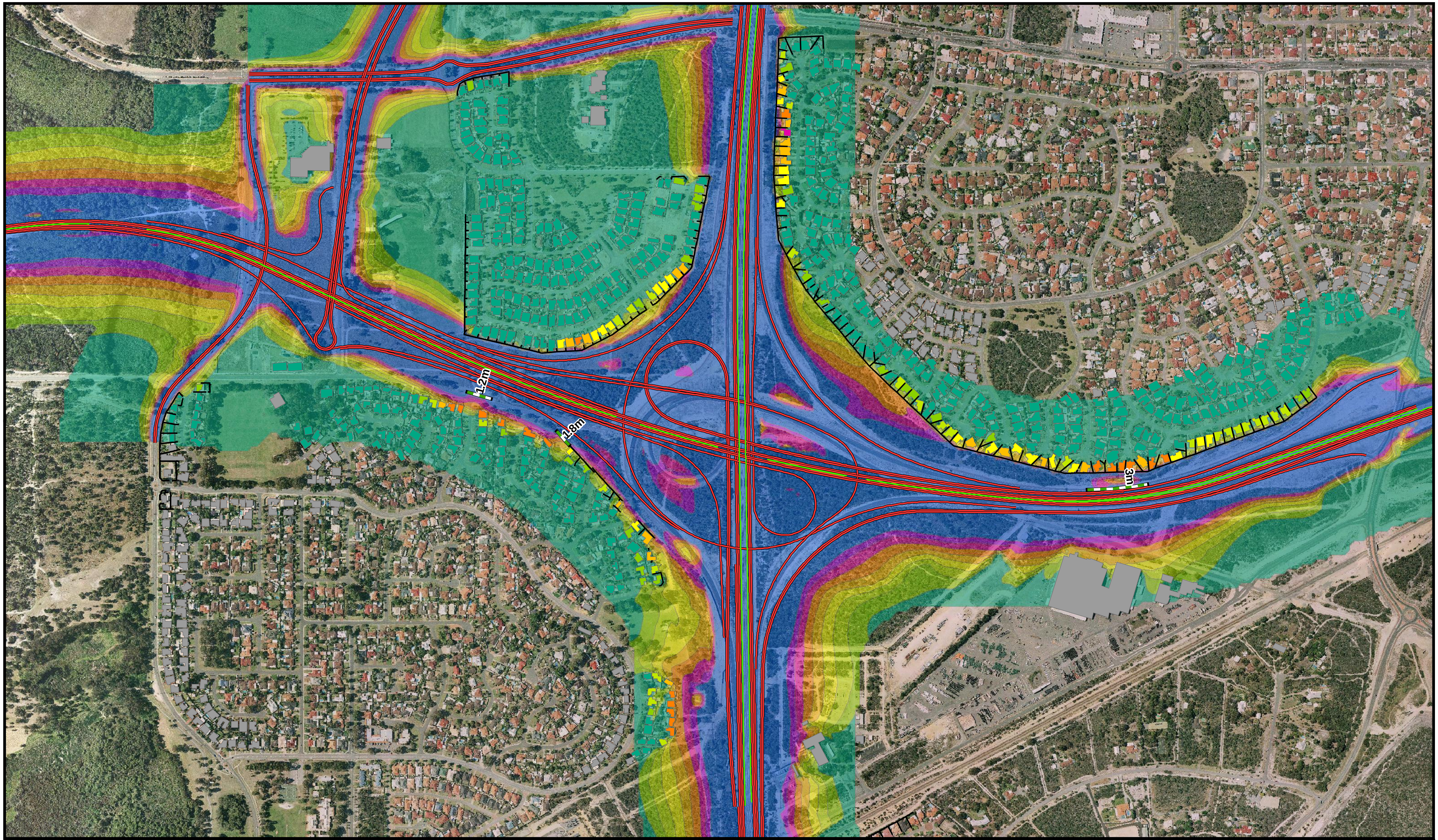
Legend - LAeq, 16hr Noise Levels

- Not Considered
- ≤ 55
- 56
- 57
- 58
- 59
- 60
- 61
- 62
- ≥ 63
- Proposed Roads
- Designed Barrier
- Retaining Wall
- Road Parapet
- Existing Fence

Controlling (2031) Build Scenario with Mitigation to Achieve Noise Limit
Façade Corrected Noise Levels
Stock Road to Progress Drive

PROJECT ID	60100953
CREATED BY	NB
LAST MODIFIED	NB 30 NOVEMBER 2010

Figure
21



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metres

Legend - LAeq, 16hr Noise Levels

- Not Considered
- ≤ 55
- 56
- 57
- 58
- 59
- 60
- 61
- 62
- ≥ 63
- Proposed Roads
- Designed Barrier
- Retaining Wall
- Road Parapet
- Existing Fence

Controlling (2031) Build Scenario with Mitigation to Achieve Noise Limit
Façade Corrected Noise Levels
Bibra Drive to Karel Avenue

PROJECT ID 60100953
CREATED BY NB
LAST MODIFIED NB 30 NOVEMBER 2010

Figure
22

7.4 Mitigation to Meet Noise Target

A total barrier length of 8,045 m at an average height of 3.8 m would be required to meet the noise target criterion along the proposed new road alignment.

The barrier required to meet the noise target would range in height from 1.8 m to 6.2 m. Noise barriers on the residential boundaries south of the proposed alignment would range from 2.4 m up to 5.6 m in height. The barriers required to meet the noise target level are not practical due to visual amenity impacts, cost and / or other design considerations. Details of noise barrier requirements which would be required to meet target levels are shown in Figure 23 and Figure 24.

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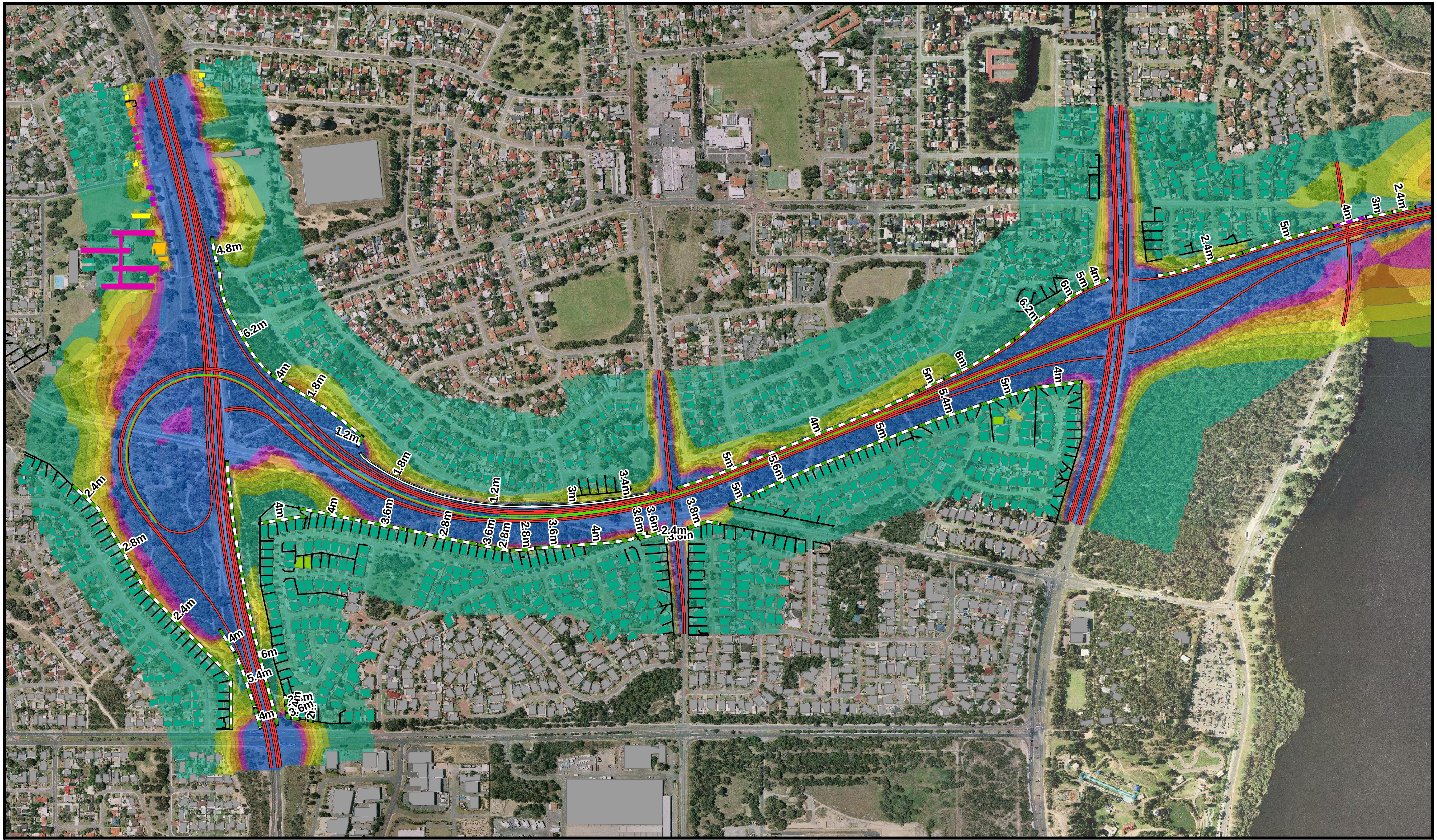


AECOM

www.aecom.com

0 95 190 380
metres

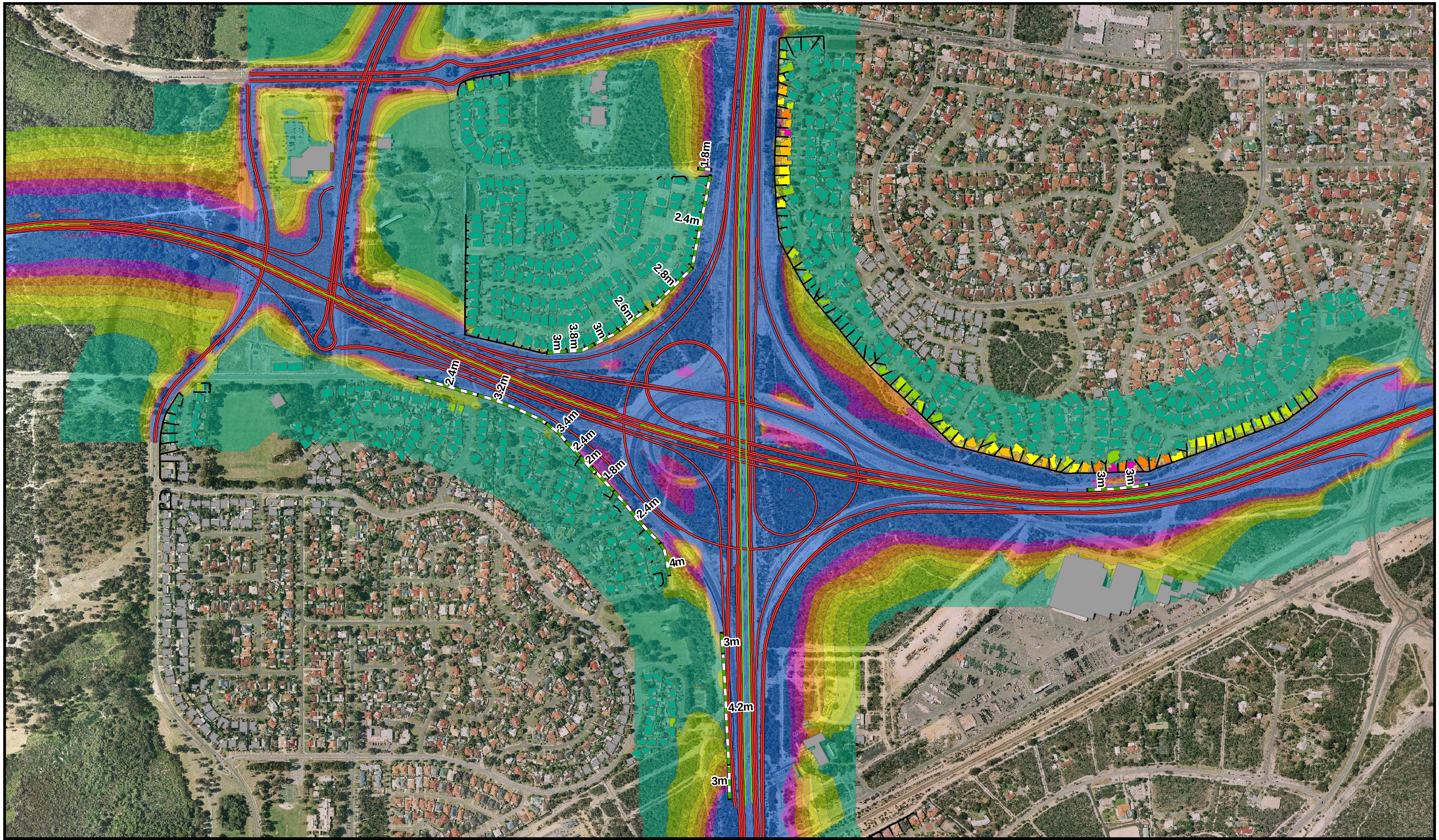
Legend - LAeq, 16hr Noise Levels

Not Considered	59	Proposed Roads	
≤ 55	60	Designed Barrier	
56	61	Bridge Barrier	
57	62	Retaining Wall	
58	≥ 63	Road Parapet	
		Existing Fence	

Controlling (2031) Build Scenario with Mitigation to Achieve Noise Target
Façade Corrected Noise Levels
Stock Road to Progress Drive

PROJECT ID 60100953
CREATED BY NB
LAST MODIFIED NB 30 NOVEMBER 2010

Figure
23



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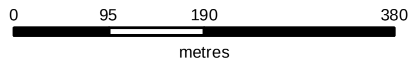

Legend - LAeq, 16hr Noise Levels

- Not Considered
- ≤ 55
- 56
- 57
- 58
- 59
- 60
- 61
- 62
- ≥ 63
- Proposed Roads
- Designed Barrier
- Bridge Barrier
- Retaining Wall
- Road Parapet
- Existing Fence

Controlling (2031) Build Scenario with Mitigation to Achieve Noise Target
Façade Corrected Noise Levels
Bibra Drive to Karel Avenue

PROJECT ID 60100953
CREATED BY NB
LAST MODIFIED NB 30 NOVEMBER 2010

Figure 24

7.5 Proposed Noise Mitigation Design

A concept design of reasonable and practicable noise mitigation measures that best balance noise benefit, cost, feasibility, amenity impacts as well as safety and security is proposed in this section. Preliminary community preferences have been incorporated into the proposed mitigation where they do not conflict with other planning and transport policies.

Noise barriers located on residential boundaries have been limited to 4.4 m in height and those within the road reserve to 5 m, providing a balance between noise benefit, cost and visual amenity.

The proposed barrier design will achieve the noise target at all but 170 receivers, of which only 29 are adjacent to the new road. A summary of the proposed noise barrier is presented in Table 20.

Table 20 Proposed noise barrier summary

Barrier Configuration	Total Barrier Length (m)	Average[1] Barrier Height (m)	Maximum Barrier Height (m)	Total Barrier Area (m^2)
Barrier to meet target	1,962	2.4	3.6	4,611
Barrier to meet limit	8,045	3.8	6.2	30,460
Proposed noise barrier	8,270	3.2	5	26,331

1. Average barrier height has been rounded to the nearest decimal place.

Detailed two-dimensional layouts of the proposed noise barriers and resulting 2031 build noise levels are shown in Figure 25 and Figure 26.

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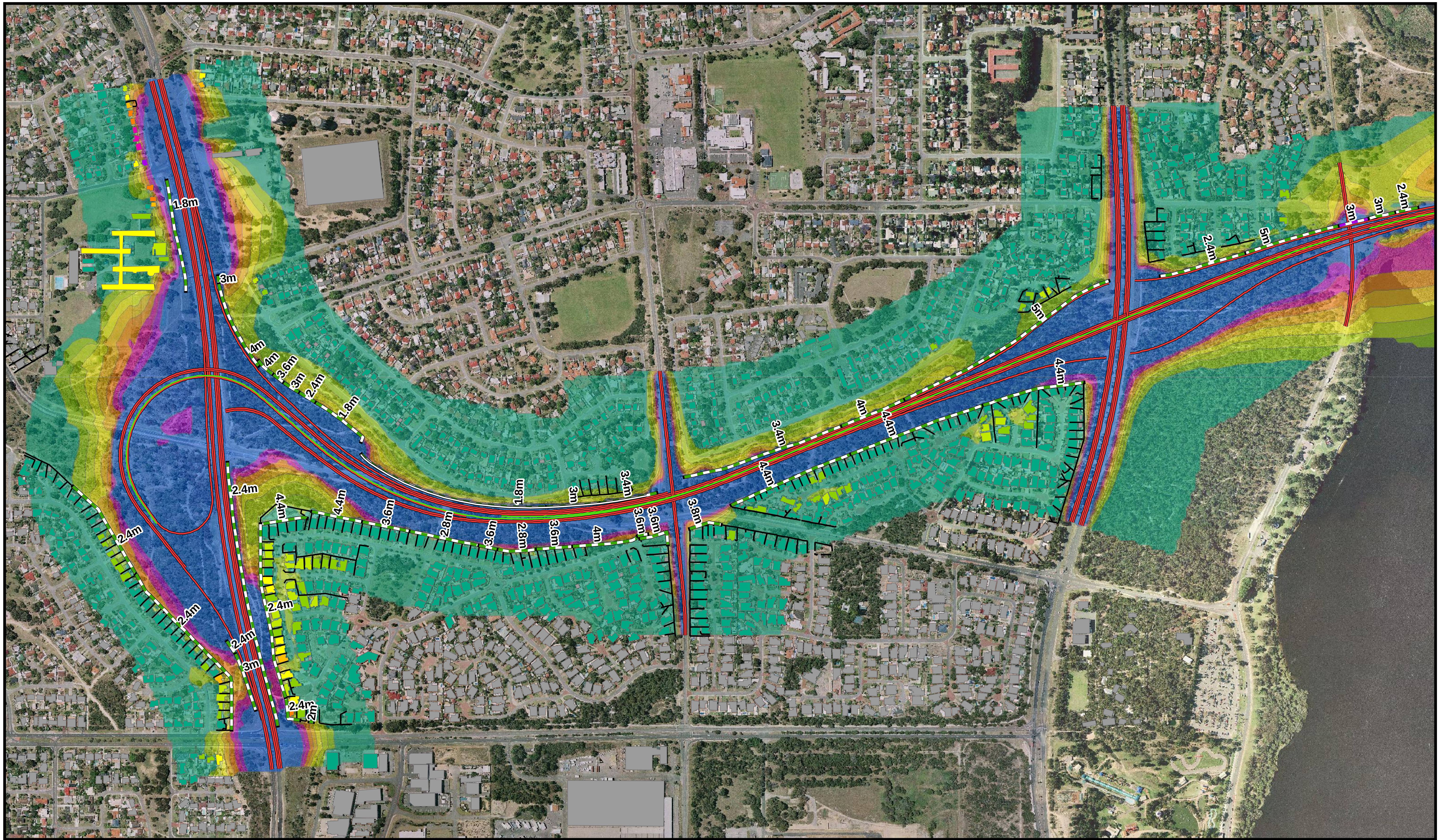


AECOM

www.aecom.com

0 95 190 380
metres

Legend - LAeq, 16hr Noise Levels

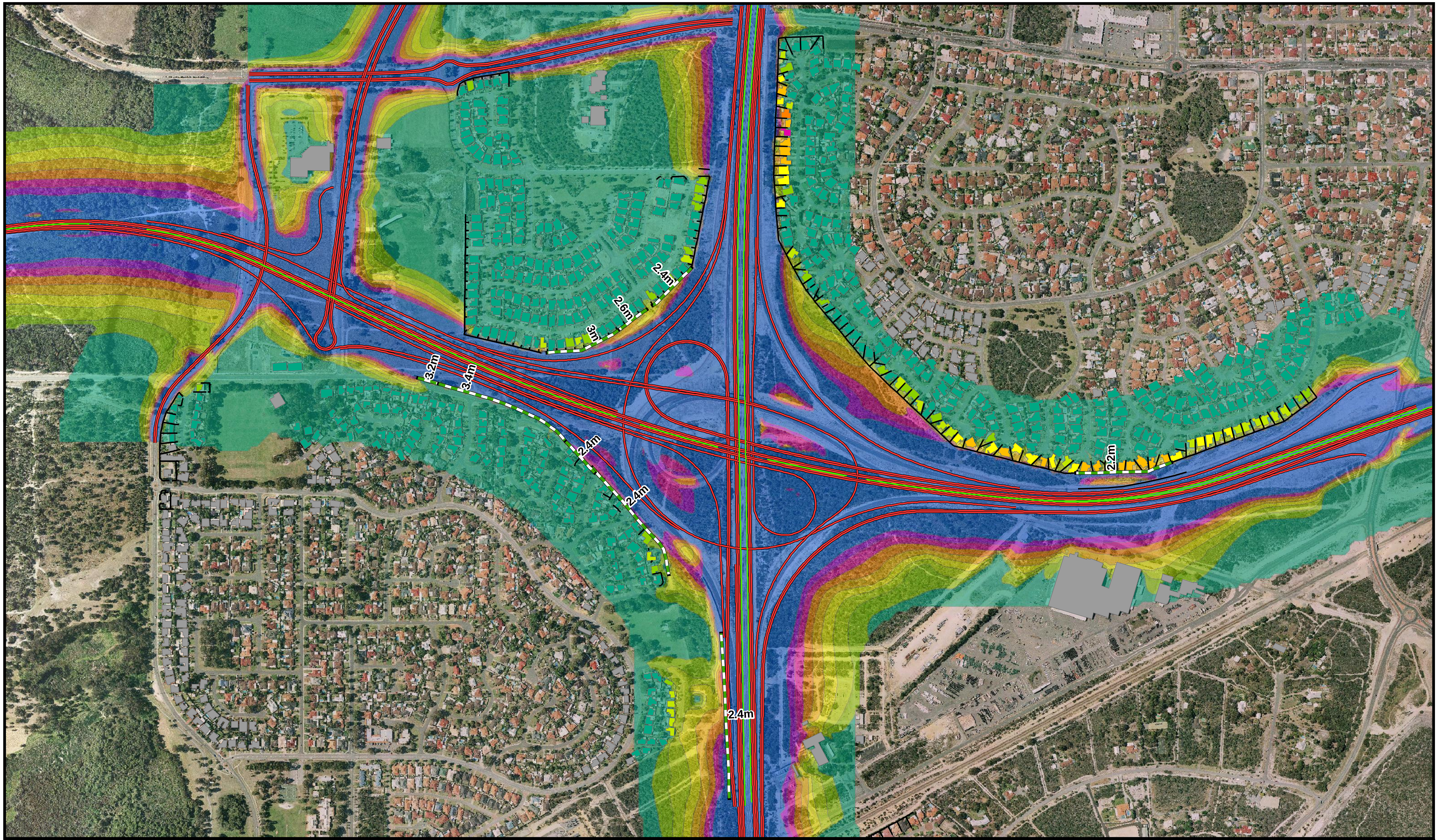
Not Considered	59
≤ 55	60
56	61
57	62
58	≥ 63

- Proposed Roads
- Designed Barrier
- Bridge Barrier
- Retaining Wall
- Road Parapet
- Existing Fence

Controlling (2031) Build Scenario with Proposed Mitigation
Façade Corrected Noise Levels
Stock Road to Progress Drive

PROJECT ID 60100953
CREATED BY NB
LAST MODIFIED NB 30 MARCH 2011

Figure
25



AECOM

www.aecom.com

0 95 190 380

metres

Legend - LAeq, 16hr Noise Levels

Grey	Not Considered
Teal	≤ 55
Green	56
Light green	57
Yellow	58
Amber	59
Orange	60
Magenta	61
Purple	62
Blue	≥ 63

- Proposed Roads
- Designed Barrier
- Bridge Barrier
- Retaining Wall
- Road Parapet
- Existing Fence

Controlling (2031) Build Scenario with Proposed Mitigation
Façade Corrected Noise Levels
Bibra Drive to Karel Avenue

PROJECT ID 60100953
CREATED BY NB
LAST MODIFIED NB 30 MARCH 2011

Figure
26

The configurations of proposed barriers and resulting 2031 build noise levels are also presented three-dimensionally in Figure 27 to Figure 32.

In the following figures, proposed barriers and road parapets are shown in green while existing barriers and fences are shown in black. Road lane centrelines are marked in red, with the vertical retaining walls (between Stock Rd and Sudlow / Coolbellup overpass) shown in grey.

Figure 27 Proposed barrier layout – Stock Road interchange

Figure 28 Proposed barrier layout – Stock Road to Sudlow / Coolbellup overpass

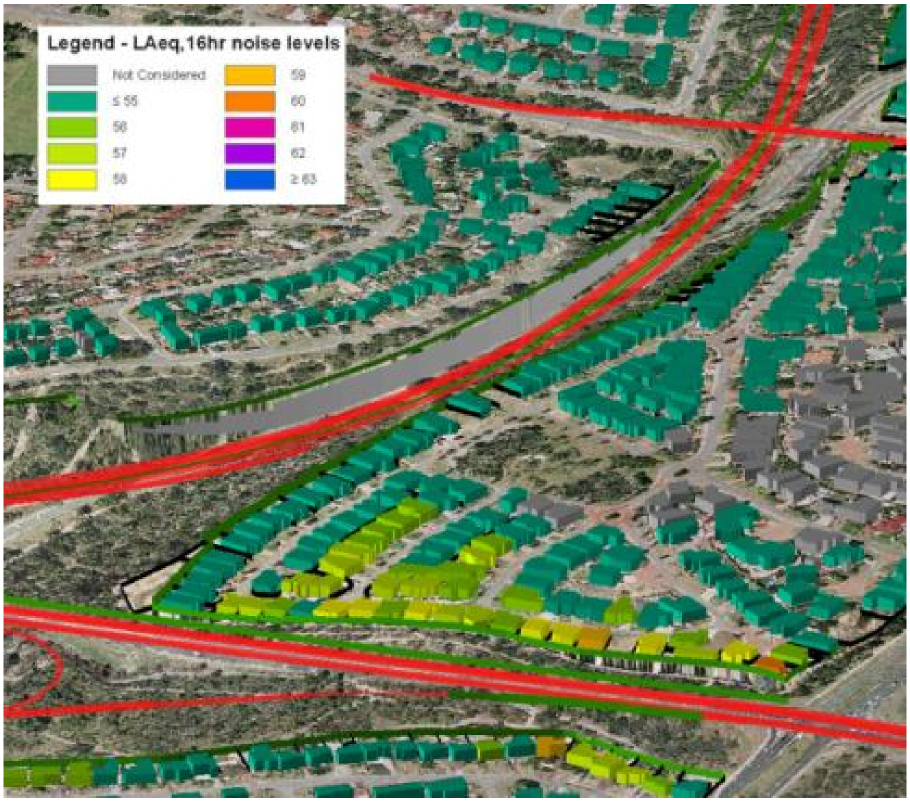


Figure 29 Proposed barrier layout –Sudlow / Coolbellup overpass to Progress Drive

Figure 30 Proposed barrier layout – Bibra Drive to Kwinana Fwy (north-westerly view)

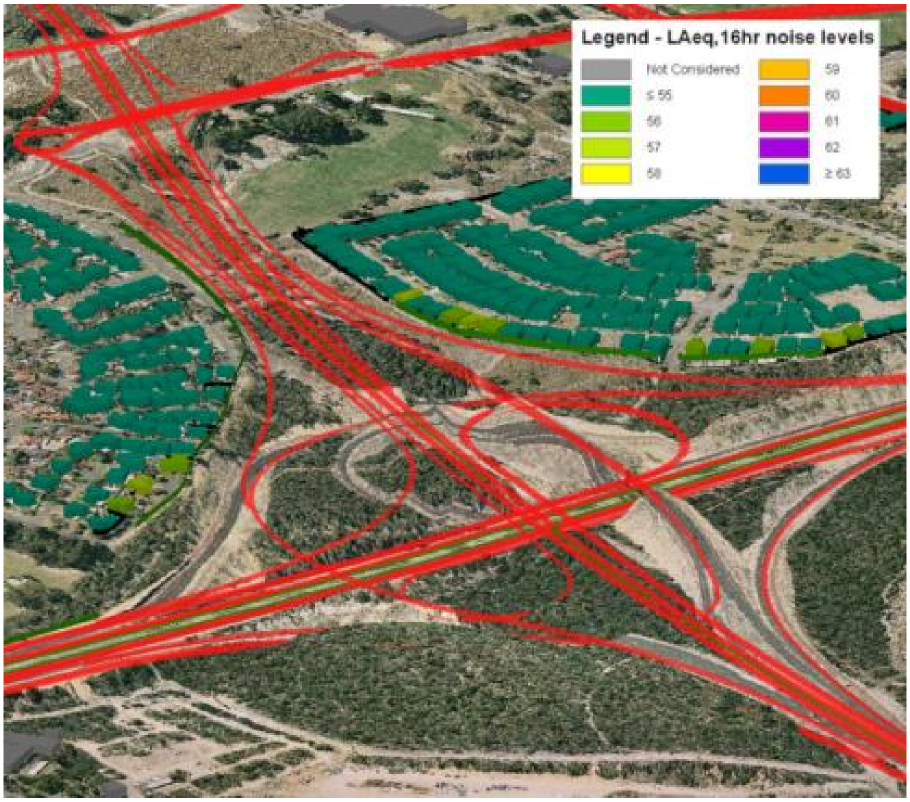


Figure 31 Proposed barrier layout – Kwinana Fwy interchange (north-easterly view)

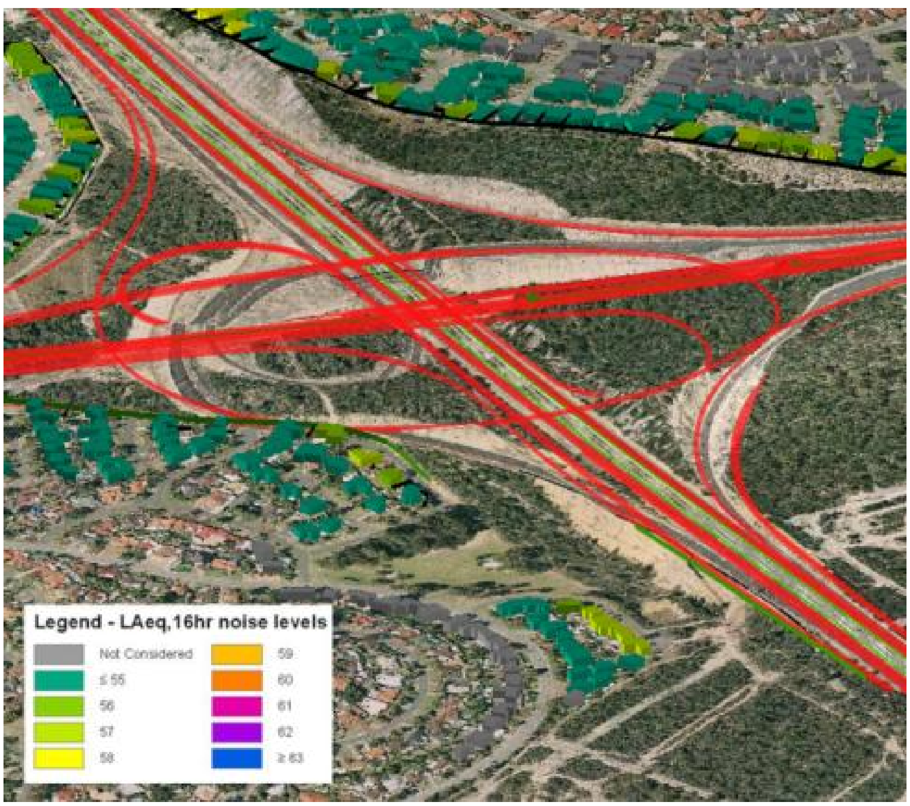


Figure 32 Proposed barrier layout – Roe Hwy east of Kwinana Freeway

Table 21 summarises the reduction in noise impacts due to the proposed noise barriers, showing summaries of predicted impacts in opening and design year “build” scenarios with and without proposed mitigation.

Table 21 Summary of noise impact reductions due to proposed noise barriers

Scenario	Total number of receivers	>55 dB(A)		> 60 dB(A)		Maximum exceedance of 60 dB(A) noise limit criterion	
		Without Barrier	With Barrier	Without Barrier	With Barrier	Without Barrier	With Barrier
2016 Build	1472	245	61	5	0	3.8 dB(A)	0.0 dB(A)
2031 Build	1472	494	170	79	5	4.3 dB(A)	1.6 dB(A)

It shows that the proposed barriers reduce the number of noise sensitive receivers within the project area exceeding the noise limit of 60 dB(A) from 79 to just five. The proposed barriers also increase the number of noise sensitive receivers complying with the noise target of 55 dB(A) by 324, reducing the number of exceedances from 494 to 170.

A summary of results comparing “build” scenarios with proposed mitigation to the corresponding “no-build” scenarios is presented in Table 22.

Table 22 Comparison of Build Scenarios with Proposed Mitigation verses No-build Scenarios

Modelled Scenario	Number of Receivers				Daytime $L_{Aeq,16hr}$ (dB(A))	
	Total	> 55 dB(A)	> 60 dB(A)	> 65 dB(A)	Average	Maximum
2016 No-build	1,472	100	0	0	47.1	59.8
2016 Mitigation	1,472	61	0	0	50.5	59.5
2031 No-build	1,472	205	21	0	49.0	63.3
2031 Mitigation	1,472	170	5	0	52.6	61.6

The comparison shows that although the average noise exposure across all receivers increases due to the project, the number of receivers exceeding both the target and the limit criteria decreases. The number of receivers exceeding the noise target in 2031 decreases from 205 to 170 due to the project. Similarly, the number of receivers exceeding the noise limit decreases from 21 to five. All five receivers exceeding the noise limit are located adjacent to existing roads and either out of the scope of the proposed upgrade, or the noise levels are predicted to decrease due to the proposed upgrade.

Only 29 of the 170 receivers exceeding the noise target are adjacent to the new road (i.e. those previously not exposed to significant noise from road traffic). Of these, seven exceed the target by 2 dB(A) and 22 by 1 dB(A). The remaining 141 receivers exceeding the target but not the limit are adjacent to existing roads, where the net result of the proposed project is a decrease in the number of receivers exceeding the noise target from 205 to 141.

We note that the above assessment is based on noise levels predicted at the ground floor of noise sensitive receivers, in accordance with SPP 5.4 assessment methodology. The noise levels at upper storeys of double storey residences are expected to be between 3 and 6 dB(A) greater than those on the ground floor. Although many first floor receivers will exceed the noise target, based on the above, they are generally expected to comply with the noise limit criterion adjacent to the new road. Noise exposure at first storey residences adjacent to existing roads may exceed the noise limit; however, it is noted that many locations will experience a decrease in noise levels as a result of the proposed works, and where the levels do increase, the increase will be marginal.

The assessment does not take into account noise shielding from visual screening barriers. Where installed, visual screening barriers will provide additional noise reduction and will be assessed separately. Assessment of noise mitigation from visual screening barriers will be incorporated into the detailed design phase of this project, and proposed noise barriers revised accordingly.

The results of all noise modelling scenarios are presented in Appendix D and E.

7.6 Construction Noise and Vibration Impacts

A summary of construction noise and vibration criteria applicable to the project are presented in Section 2.2.

Construction noise and vibration impacts associated with the proposed project cannot be assessed until the road design is finalised, and details of construction methods as well as construction schedules become available. Construction noise and vibration impacts are likely along the majority of the proposed project due to its close proximity to noise and vibration sensitive receivers. The likely impacts and potential ameliorative measures associated with the various phases of construction are summarised in Table 23.

Table 23 Qualitative Construction Noise and Vibration Impacts and potential ameliorative measures

Aspect	Extent	Potential Impacts	Potential Management and Mitigation
Removal of vegetation	Residences adjacent to sites of vegetation removal	Low to medium noise impact for short duration	• Work scheduled during daytime hours when residents least impacted by construction noise.

Aspect	Extent	Potential Impacts	Potential Management and Mitigation
Removal of topsoil	Adjacent to sites of Residences adjacent to sites of topsoil removal	Low to medium noise impact for short duration	• Work scheduled during daytime hours when residents least impacted by construction noise.
Excavation of cut	Stock Road to Kwinana Freeway	Potential medium noise and vibration impacts for finite duration during construction	• Managed through best practice construction methods using quietest reasonably available machinery. • Where possible, work to be scheduled during daytime when residents least impacted by construction noise and vibration. • Where noise barriers are to be built on residential boundaries, consideration given to building prior to other construction work commencing. • Vibration monitoring should be carried out during construction to alert operators of any exceedances of vibration limits. • Conduct dilapidation surveys at most exposed vibration sensitive structures prior to commencement of vibration intensive construction.
Placement of fill / earthworks	Coolbellup/ Sudlow Overpass to Kwinana	Medium noise impact for finite duration during construction Compaction machinery used to take into account location of nearest vibration sensitive structures. Where compaction required in close proximity to sensitive structures, smaller vibratory rollers to be used where possible.	• Managed through best practice construction methods using quietest reasonably available machinery. • Where possible, work to be scheduled during daytime when residents least impacted by construction noise and vibration. • Where noise barriers are to be built on residential boundaries, consideration given to building prior to other construction work commencing. • Vibration monitoring should be carried out during construction to alert operators of any exceedances of vibration limits. • Conduct dilapidation surveys at most exposed vibration sensitive structures prior to commencement of vibration intensive construction.
Pile Driving	Coolbellup/ Sudlow Overpass to Kwinana	Potentially high noise and vibration impact for finite duration during construction, depending on type of piling activities. Screw piling to be used where feasible, as it is quietest / least vibration impacts. Hammer driven piles / sheet piles to be avoided wherever possible.	• Managed through best practice construction methods using quietest reasonably available machinery. • Where possible, work to be scheduled during daytime when residents least impacted by construction noise and vibration. • Where noise barriers are to be built on residential boundaries, consideration given to building prior to other construction work commencing. • Vibration monitoring should be carried out during construction to alert operators of any exceedances of vibration limits. • Conduct building condition surveys at most exposed vibration sensitive structures prior to commencement of vibration intensive construction.

Aspect	Extent	Potential Impacts	Potential Management and Mitigation
Surfacing – asphalt	Length of Project	Medium noise noise impact for short duration	• Managed through best practice construction methods using quietest reasonably available machinery. • Where possible, work to be scheduled during daytime when residents least impacted by construction noise and vibration. • Where noise barriers are to be built on residential boundaries, consideration given to building prior to other construction work commencing.
Surfacing – compaction	Length of Project	Medium noise impact for short duration	• Managed through best practice construction methods using quietest reasonably available machinery. • Where possible, work to be scheduled during daytime when residents least impacted by construction noise and vibration. • Where noise barriers are to be built on residential boundaries, consideration given to building prior to other construction work commencing. • When significant vibration is expected, vibration monitoring should be carried out during construction to alert operators of any exceedances of vibration limits.
Construction of Structures – concrete	Adjacent to concrete structures	Medium to high noise impact for finite duration. Potential for night-time works	• Where possible, work to be scheduled during daytime when residents least impacted by construction noise and vibration. • Where out of hours work required, notifying residents of expected magnitude and duration through letter drops, newspaper announcements etc (Through community consultation). • Where noise barriers are to be built on residential boundaries, consideration given to building prior to other construction work commencing.
Operation of plant and machinery	Length of Project	Low impact for the duration of the project	• Where possible, work to be scheduled during daytime when residents least impacted by construction noise and vibration. • Where noise barriers are to be built on residential boundaries, consideration given to building prior to other construction work commencing. • Vibration monitoring should be carried out during construction to alert operators of any exceedances of vibration limits.
Removal / rehab of existing redundant roads	Adjacent to existing redundant roads	Medium impact for finite duration	• Where possible, work to be scheduled during daytime when residents least impacted by construction noise and vibration. • Where noise barriers are to be built on residential boundaries, consideration given to building prior to other construction work commencing. • Vibration monitoring should be carried out during construction to alert operators of any exceedances of vibration limits.

It is recommended that an assessment of construction noise and vibration impacts be carried out at the detailed design phase of this project, once construction details and schedules become available. This study should quantify the likely noise and vibration impacts in the construction phase of the project, and examine potential mitigation and management measures in accordance with Australian Standard "*AS 2436 – 2010: Guide to noise and vibration control on construction, demolition and maintenance sites"*.

A construction noise and vibration impact management plan will be prepared in collaboration with the construction team, and submitted to DEC and/or local government for approval of any out-of-hours works.

8.0 Conclusion

Noise impacts associated with the proposed upgrade have been predicted and assessed against the outdoor noise criteria, both in terms of noise targets and noise limits, as required by the WA State Planning Policy 5.4.

Mitigation was generally required along the "new road" section of the project. Realignment of Stock Road will significantly increase noise levels at some noise-sensitive receivers south of the proposed interchange. Reasonable and practicable noise mitigation measures have been considered to meet the noise limits at these receivers.

Noise impacts have also been assessed at parks and recreational areas within the project area against noise criteria which have been developed for the project on the basis of SPP 5.4 outdoor noise criteria.

Noise barrier designs have been developed to meet both the noise target and noise limit criteria. A concept of reasonable and practicable noise mitigation measures was then developed that best balances noise benefit, cost, feasibility, amenity impacts as well as safety and security. It is noted that concept noise mitigation is based on the concept road design and is subject to change during the detailed design phase of the project.

Preliminary community preferences have been incorporated into the proposed mitigation where they do not conflict with other planning and transport policies. Noise barriers located on residential boundaries have been limited to 4.4 m in height and those within the road reserve to 5 m, providing a balance between noise benefit, cost and visual amenity.

After the proposed mitigation is implemented, the number of receivers exceeding the noise target in 2031 decreases from 205 to 170 due to the project. Similarly, the number of receivers exceeding the noise limit decreases from 21 to five. All five receivers exceeding the noise limit are located adjacent to existing roads and are either out of the scope of the proposed upgrade, or the noise levels are predicted to decrease due to the proposed upgrade.

Of the 170 receivers exceeding the noise target, only 29 are adjacent to the new road (i.e. those previously not exposed to significant noise from road traffic). Of these, seven exceed the target by 2 dB(A) and 22 by 1 dB(A). The remaining 141 receivers exceeding the target but not the limit are adjacent to existing roads, where the net result of the proposed project is a decrease in the number of receivers exceeding the noise target from 205 to 141.

The proposed mitigation will be subject to refinement following additional consultation and feedback on the proposed noise barriers.

The assessment does not take into account noise shielding from visual screening barriers. Where installed, visual screening barriers will provide additional noise reduction. Assessment of noise mitigation from visual screening barriers will therefore be incorporated into the detailed design phase of this project, and proposed noise barriers revised accordingly.

Construction noise and vibration criteria applicable to the project have been developed in Section 2.2. The potential for construction noise and vibration impacts has been identified along the majority of the proposed project due to its close proximity to noise and vibration sensitive receivers. A construction noise and vibration impact management plan will be prepared in collaboration with the construction team, and submitted to DEC and / or Local government for approval of any out-of-hours works prior to commencement of construction.

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Appendix A

Acoustic Nomenclature

Appendix A Acoustic Nomenclature

The following is a brief description of the acoustic terminology used in this report.

Ambient Sound The totally encompassing sound in a given situation at a given time, usually composed of sound from all sources near and far.

Audible Range The limits of frequency which are audible or heard as sound. The normal ear in young adults detects sound having frequencies in the region 20 Hz to 20 kHz, although it is possible for some people to detect frequencies outside these limits.

Decibel [dB] The level of noise is measured objectively using a Sound Level Meter. The following are examples of the decibel readings of every day sounds;

0dB	The faintest sound we can hear
30dB	A quiet library or in a quiet location in the country
45dB	Typical office space. Ambience in the city at night
60dB	Murray Street Mall at lunch time
70dB	The sound of a car passing on the street
80dB	Loud music played at home
90dB	The sound of a truck passing on the street
100dB	The sound of a rock band
115dB	Limit of sound permitted in industry

dB(A) *A-weighted decibels* The ear is not as effective in hearing low frequency sounds as it is hearing high frequency sounds. That is, low frequency sounds of the same dB level are not heard as loud as high frequency sounds. The sound level meter replicates the human response of the ear by using an electronic filter which is called the "A" filter. A sound level measured with this filter switched on is denoted as dB(A). Practically all noise is measured using the A filter. The sound pressure level in dB(A) gives a close indication of the subjective loudness of the noise.

L_{Amax} The maximum sound pressure level measured over a given period.

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

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

$L_{A10\ (18h)}$ The $L_{A10\ (18h)}$ level is the arithmetic average of 18 hourly L_{10} levels over consecutive hours between 6am and 12 midnight. This indicator is typically used to represent noise exposure from road traffic noise.

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

Appendix B

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Appendix B Bibliography

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Appendix C

Site Details and Noise Monitoring Results

Appendix C Site Details and Noise Monitoring Results

Location No.	Address	Deployment Period	
		From	To
1	50 Sylvan Cres, Leeming	3/05/2010	13/05/2010
2	25 Brandwood Gdns, Leeming	3/05/2010	13/05/2010
3	12 Dowell Pl, Bibra Lake	24/03/2010	6/04/2010
4	20 Bibra Dr, Bibra Lake	23/03/2010	6/04/2010
5	16 Cheshunt Gdns, North Lake	23/03/2010	6/04/2010
6	32 Marshwood Rtt, Bibra Lake	3/05/2010	13/05/2010
7	13 Gregory Way, Coolbellup	3/05/2010	13/05/2010
8	58 Sebastian Cres, Coolbellup	3/05/2010	13/05/2010
9	94 Forillion Ave, Bibra Lake	23/03/2010	6/04/2010
10	65 Curven Rd, Hamilton Hill	23/03/2010	13/05/2010

Noise Monitoring Data Sheet

Roe Hwy Extension
Project No. 60100953

SITE ID. **1**

Dominant Road	Roe Highway	From	03-May-10 11:55 AM	Address	50 Sylvan Cres
Road Surface		To	13-May-10 4:10 PM	Suburb	Leeming
Speed (85%)	80 km/h	Mic. Height	1.5 m	District	Metropolitan
Distance to Road	40 m	Meas. Type	Facade	Longitude	115.8609
		Instrument	00187446	Latitude	-32.0864
		Operator	MB		

LA10(18h) (6am-Midnight)	60.1 dB(A)	**LAeq(8h)** (10pm-6am)	52.6 dB(A)	Pre Calibration	94.0 dB(A)
LAeq(16h) (6am-10pm)	58.3 dB(A)	**LAeq(24h)**	57.3 dB(A)	Post Calibration	93.9 dB(A)

Site Diagram

Site Photo

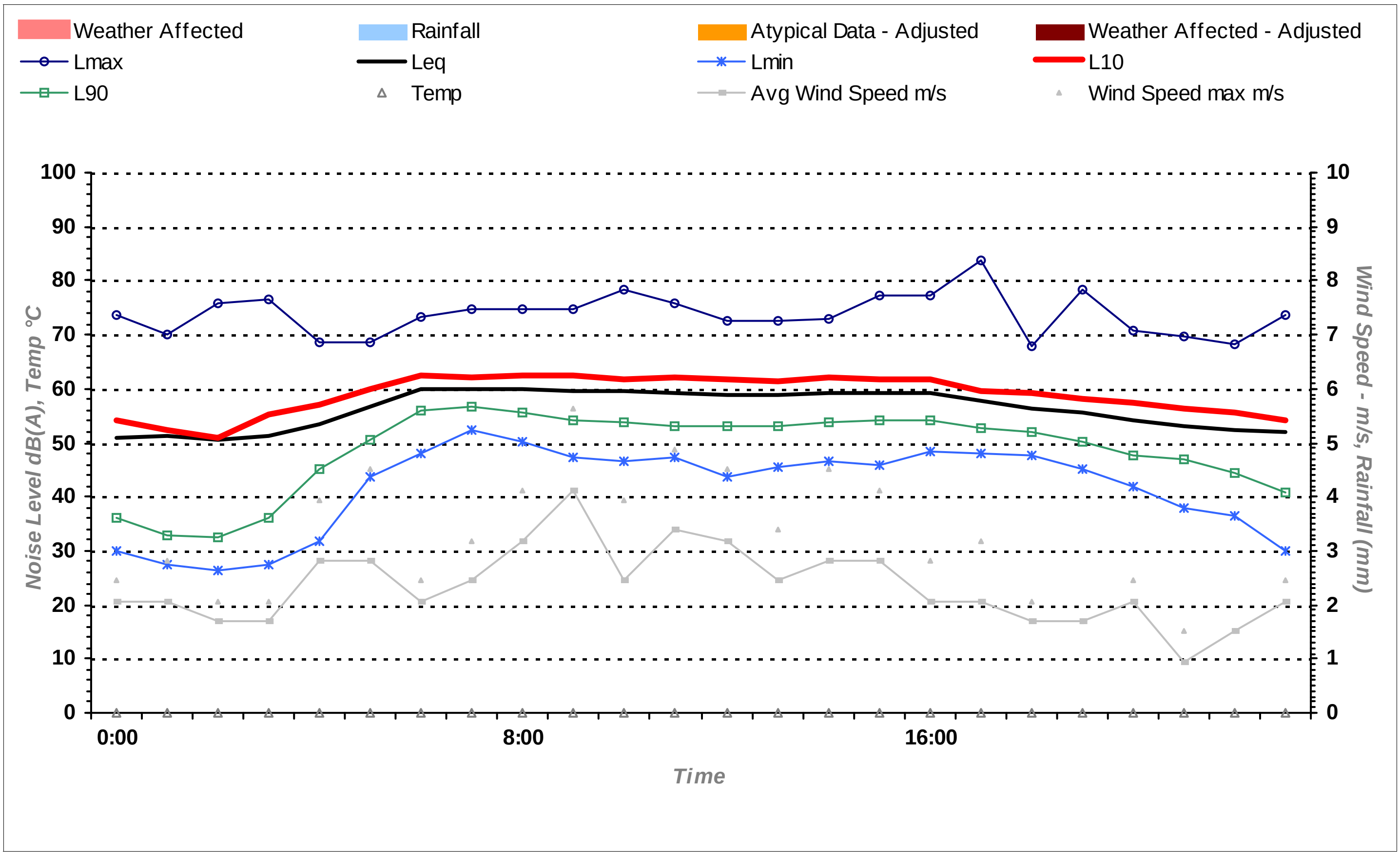
Site Photographs

Site Photo

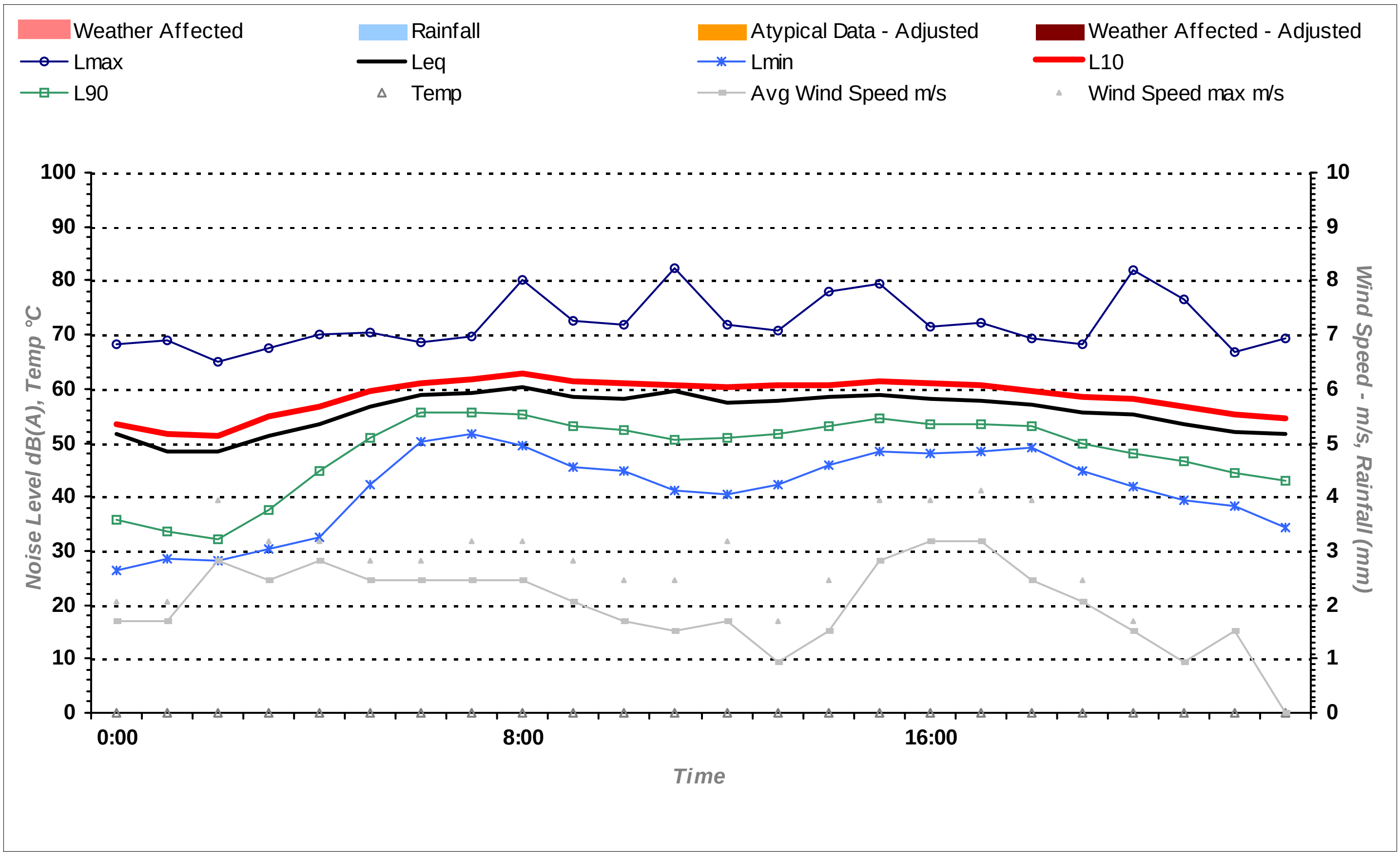
Site Photo

Site Photo

Tuesday, May 04, 2010

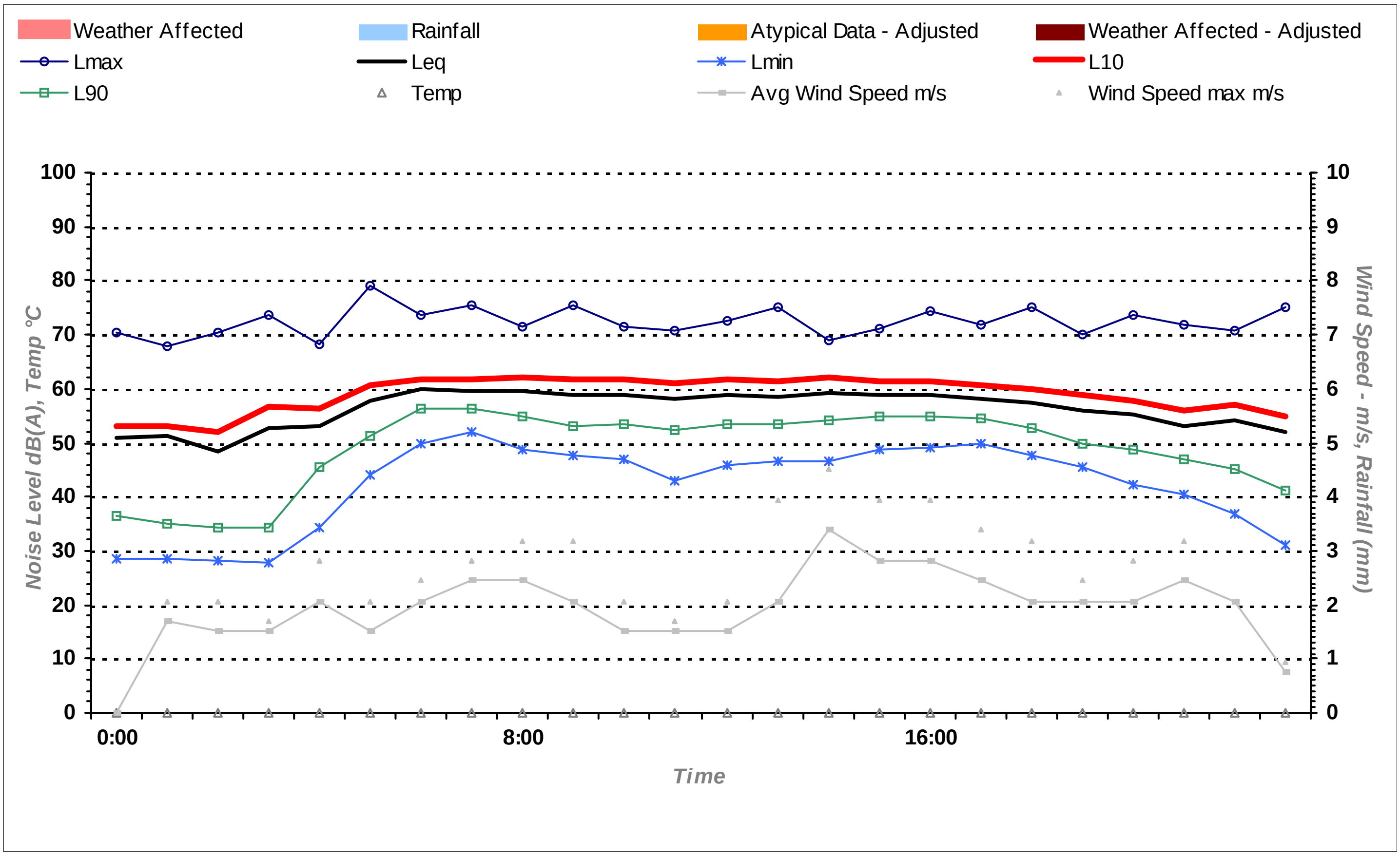


Wednesday, May 05, 2010

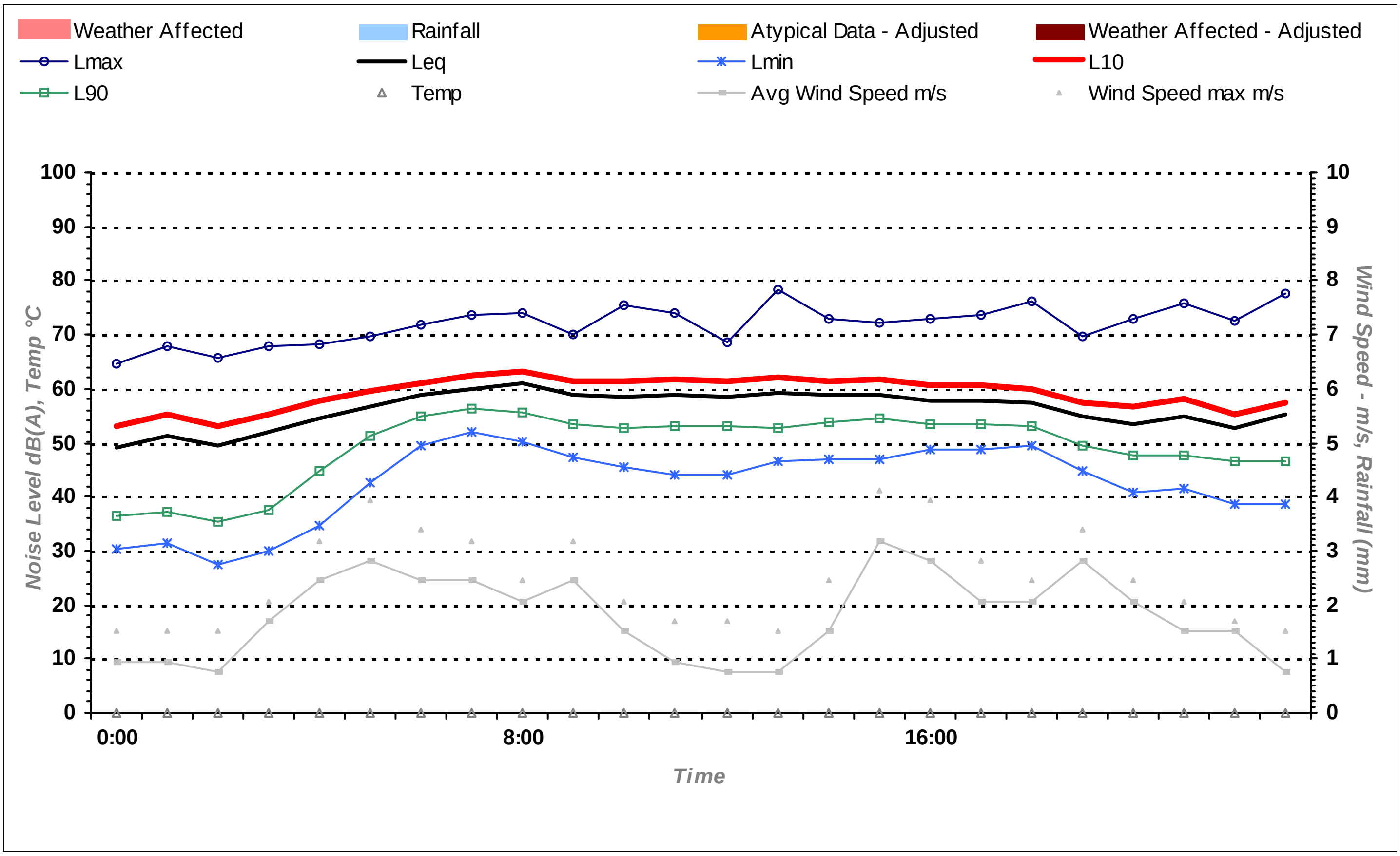


Site Noise and Weather Graphical Analysis

Thursday, May 06, 2010

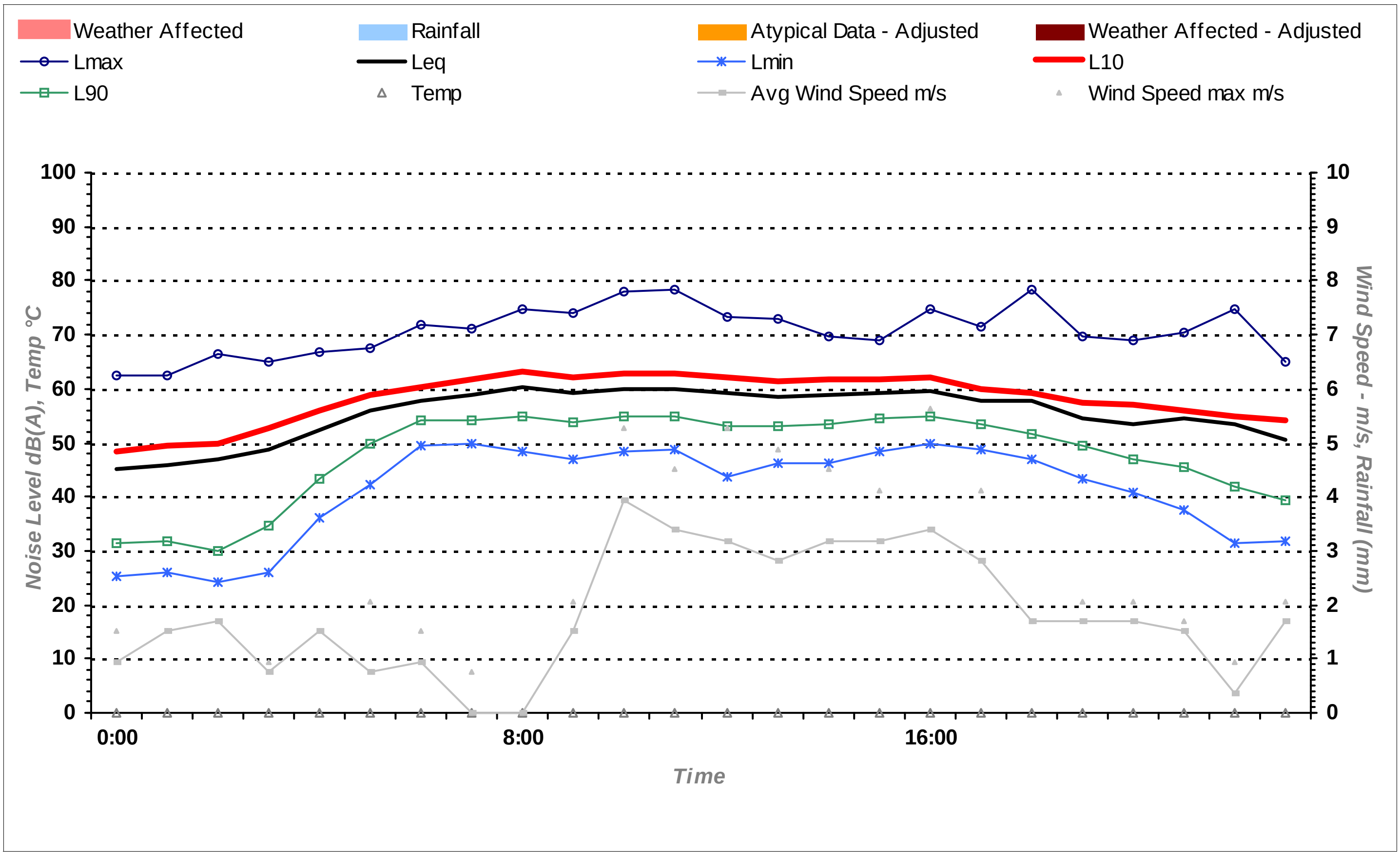


Friday, May 07, 2010



Site Noise and Weather Graphical Analysis

Monday, May 10, 2010



Outline of Descriptors and Terminology

$L_{A10\ (18h)}$ – The $L_{A10\ (18h)}$ noise level is the descriptor used to assess road traffic noise in Western Australia for residential dwellings. The L_{A10} noise level is representative of the level of noise exceeded for 10% of any period (usually 60 minutes). The $L_{A10\ (18h)}$ is the arithmetic average of the 18 hourly $L_{A10\ (1h)}$ noise levels over the consecutive hours between 6am and 12 midnight on a weekday.

Dominant Road – The road which dominates noise measurements at this location

Flow (AADT) – Annual Average Daily Traffic flow on the dominant road

Surface Pavement – Surface Pavement type of Dominant Road. ie, Dense Graded Asphalt (DGA)

Speed – Traffic speed on dominant road

Height – Height of the noise logger microphone at this location

Meas.Type – Type of measurement undertaken at this location, Façade (1m from most exposed façade of building) or Free Field (Location 3.5m or greater from a reflecting surface)

Attended – Measurements that were attended by a person and measured with a sound level meter directly adjacent to the noise logger

Logged – Measurements that were taken by a noise logger at this location

Hourly Logged Noise Data								Hourly Logged Weather Data						
Date	Start Hour	L_{Aeq}	L_{AMax}	L_{A1}	L_{A10}	L_{A90}	L_{Min}	Avg. Wind Speed (m/s)	Max. Wind Speed (m/s)	Wind Dir. (°) North=0°	Temp. (°C)	Humidity (%)	Air Press. (kPa)	Rainfall (mm)
04/05/2010	0	51.0	73.7	62.8	54.1	36.2	30.1	3.1	3.6	180				0.0
04/05/2010	1	51.1	70.0	65.9	52.4	32.8	27.6	3.1	4.2	180				0.0
04/05/2010	2	50.6	75.7	61.4	51.0	32.4	26.2	2.5	3.1	180				0.0
04/05/2010	3	51.4	76.7	61.9	55.1	36.1	27.4	2.5	3.1	170				0.0
04/05/2010	4	53.5	68.5	61.9	57.1	45.1	31.7	4.2	5.8	110				0.0
04/05/2010	5	56.7	68.5	62.9	59.8	50.6	43.8	4.2	6.7	100				0.0
04/05/2010	6	60.0	73.4	65.9	62.4	56.1	48.0	3.1	3.6	90				0.0
04/05/2010	7	59.9	74.6	64.9	62.2	56.5	52.3	3.6	4.7	100				0.0
04/05/2010	8	59.9	74.7	65.7	62.5	55.5	50.2	4.7	6.1	100				0.0
04/05/2010	9	59.6	74.7	66.8	62.4	54.1	47.2	6.1	8.3	110				0.0
04/05/2010	10	59.4	78.3	66.5	61.9	53.9	46.7	3.6	5.8	80				0.0
04/05/2010	11	59.1	75.9	65.9	62.0	53.1	47.4	5.0	7.2	70				0.0
04/05/2010	12	58.7	72.4	65.5	61.6	52.9	43.8	4.7	6.7	90				0.0
04/05/2010	13	58.7	72.6	65.1	61.5	53.2	45.6	3.6	5.0	70				0.0
04/05/2010	14	59.3	73.0	65.8	62.1	53.8	46.4	4.2	6.7	110				0.0
04/05/2010	15	59.2	77.2	65.4	61.8	54.2	45.7	4.2	6.1	110				0.0
04/05/2010	16	59.3	77.2	67.9	61.7	54.0	48.4	3.1	4.2	80				0.0
04/05/2010	17	57.7	83.6	64.5	59.6	52.6	48.1	3.1	4.7	120				0.0
04/05/2010	18	56.4	67.7	63.6	59.1	52.1	47.5	2.5	3.1	140				0.0
04/05/2010	19	55.6	78.5	63.5	58.1	50.1	45.1	2.5	2.5	120				0.0
04/05/2010	20	54.2	70.7	63.5	57.5	47.5	41.8	3.1	3.6	160				0.0
04/05/2010	21	53.2	69.7	61.4	56.2	47.0	37.9	1.4	2.2	120				0.0
04/05/2010	22	52.2	68.1	61.4	55.5	44.5	36.5	2.2	2.2	130				0.0
04/05/2010	23	51.9	73.6	63.1	54.3	40.8	29.9	3.1	3.6	140				0.0
05/05/2010	0	51.7	68.4	65.9	53.4	35.9	26.3	2.5	3.1	150				0.0
05/05/2010	1	48.5	68.8	59.9	51.5	33.7	28.4	2.5	3.1	160				0.0
05/05/2010	2	48.2	65.1	59.8	51.4	32.2	28.1	4.2	5.8	130				0.0
05/05/2010	3	51.4	67.6	62.5	55.0	37.5	30.4	3.6	4.7	130				0.0
05/05/2010	4	53.6	69.9	62.6	56.7	44.7	32.4	4.2	4.7	110				0.0
05/05/2010	5	56.8	70.4	63.3	59.7	50.8	42.4	3.6	4.2	100				0.0
05/05/2010	6	58.9	68.5	63.8	61.1	55.5	50.2	3.6	4.2	100				0.0
05/05/2010	7	59.2	69.6	64.4	61.7	55.7	51.8	3.6	4.7	100				0.0
05/05/2010	8	60.3	80.2	65.5	62.8	55.2	49.4	3.6	4.7	120				0.0
05/05/2010	9	58.6	72.5	66.1	61.4	53.0	45.5	3.1	4.2	120				0.0
05/05/2010	10	58.2	71.8	65.2	61.1	52.2	44.6	2.5	3.6	90				0.0
05/05/2010	11	59.4	82.2	69.3	60.7	50.7	41.3	2.2	3.6	90				0.0
05/05/2010	12	57.5	71.8	64.3	60.3	50.8	40.6	2.5	4.7	30				0.0
05/05/2010	13	57.6	70.9	64.5	60.7	51.5	42.4	1.4	2.5	350				0.0
05/05/2010	14	58.5	77.8	64.8	60.8	53.0	45.7	2.2	3.6	20				0.0
05/05/2010	15	59.0	79.3	65.1	61.4	54.5	48.3	4.2	5.8	240				0.0
05/05/2010	16	58.2	71.5	64.5	61.0	53.6	47.9	4.7	5.8	240				0.0
05/05/2010	17	57.9	72.2	64.9	60.5	53.3	48.3	4.7	6.1	230				0.0
05/05/2010	18	57.0	69.3	63.3	59.6	53.0	49.2	3.6	5.8	210				0.0
05/05/2010	19	55.5	68.3	63.7	58.5	49.9	44.8	3.1	3.6	190				0.0
05/05/2010	20	55.4	82.0	64.5	58.1	47.9	42.0	2.2	2.5	190				0.0
05/05/2010	21	53.5	76.7	61.6	56.5	46.5	39.4	1.4	1.4	170				0.0
05/05/2010	22	52.1	66.8	61.6	55.3	44.5	38.3	2.2	2.2	190				0.0
05/05/2010	23	51.5	69.4	60.8	54.6	43.1	34.2	0.0	0.0	0				0.0
06/05/2010	0	51.0	70.4	63.5	53.1	36.3	28.4	0.0	0.0	0				0.0
06/05/2010	1	51.1	68.0	64.7	52.9	35.1	28.6	2.5	3.1	120				0.0
06/05/2010	2	48.5	70.4	59.3	51.9	34.2	28.0	2.2	3.1	140				0.0
06/05/2010	3	52.7	73.8	63.8	56.6	34.3	27.7	2.2	2.5	110				0.0
06/05/2010	4	53.1	68.3	61.6	56.3	45.4	34.3	3.1	4.2	110				0.0
06/05/2010	5	57.8	79.2	64.9	60.7	51.4	44.1	2.2	3.1	110				0.0
06/05/2010	6	59.8	73.5	65.5	61.9	56.4	50.0	3.1	3.6	120				0.0
06/05/2010	7	59.4	75.5	64.2	61.7	56.4	51.9	3.6	4.2	130				0.0
06/05/2010	8	59.5	71.5	65.2	62.1	54.9	48.8	3.6	4.7	120				0.0
06/05/2010	9	58.8	75.4	65.5	61.6	53.0	47.6	3.1	4.7	110				0.0
06/05/2010	10	59.0	71.6	65.2	61.8	53.5	47.0	2.2	3.1	170				0.0

Hourly Logged Noise Data								Hourly Logged Weather Data						
Date	Start Hour	L_{Aeq}	L_{AMax}	L_{A1}	L_{A10}	L_{A90}	L_{Min}	Avg. Wind Speed (m/s)	Max. Wind Speed (m/s)	Wind Dir. (°) North=0°	Temp. (°C)	Humidity (%)	Air Press. (kPa)	Rainfall (mm)
06/05/2010	11	58.2	70.9	64.5	61.1	52.5	43.1	2.2	2.5	160				0.0
06/05/2010	12	58.8	72.5	65.2	61.8	53.3	45.7	2.2	3.1	160				0.0
06/05/2010	13	58.6	75.1	64.6	61.5	53.6	46.4	3.1	5.8	210				0.0
06/05/2010	14	59.2	68.9	65.3	62.0	54.1	46.6	5.0	6.7	220				0.0
06/05/2010	15	58.9	71.2	64.7	61.4	54.7	48.8	4.2	5.8	210				0.0
06/05/2010	16	59.0	74.2	65.4	61.4	54.8	49.1	4.2	5.8	220				0.0
06/05/2010	17	58.3	72.0	65.2	60.7	54.5	50.0	3.6	5.0	220				0.0
06/05/2010	18	57.4	75.2	65.5	59.8	52.6	47.7	3.1	4.7	210				0.0
06/05/2010	19	55.8	70.1	64.9	58.7	49.9	45.4	3.1	3.6	190				0.0
06/05/2010	20	55.1	73.5	64.1	57.8	48.7	42.4	3.1	4.2	180				0.0
06/05/2010	21	53.2	71.9	61.8	56.0	47.0	40.6	3.6	4.7	180				0.0
06/05/2010	22	54.2	70.6	66.4	57.0	45.0	37.0	3.1	3.1	170				0.0
06/05/2010	23	52.1	75.1	62.9	55.0	41.3	31.0	1.1	1.4	130				0.0
07/05/2010	0	49.2	64.7	59.0	52.9	36.5	30.3	1.4	2.2	130				0.0
07/05/2010	1	51.2	67.7	61.3	55.1	37.2	31.3	1.4	2.2	150				0.0
07/05/2010	2	49.3	65.8	59.9	53.0	35.3	27.5	1.1	2.2	140				0.0
07/05/2010	3	52.1	67.8	63.9	55.2	37.5	29.8	2.5	3.1	110				0.0
07/05/2010	4	54.5	68.3	64.6	57.8	44.6	34.7	3.6	4.7	110				0.0
07/05/2010	5	56.6	69.7	62.8	59.7	51.2	42.7	4.2	5.8	100				0.0
07/05/2010	6	58.7	71.9	63.8	61.0	55.0	49.3	3.6	5.0	110				0.0
07/05/2010	7	60.1	73.7	65.9	62.6	56.2	52.0	3.6	4.7	100				0.0
07/05/2010	8	61.0	74.1	66.3	63.3	55.7	50.1	3.1	3.6	110				0.0
07/05/2010	9	58.7	70.1	65.1	61.5	53.4	47.4	3.6	4.7	100				0.0
07/05/2010	10	58.6	75.3	65.3	61.5	52.6	45.4	2.2	3.1	90				0.0
07/05/2010	11	58.8	74.0	65.1	61.6	53.0	44.2	1.4	2.5	70				0.0
07/05/2010	12	58.5	68.6	64.4	61.4	52.9	44.2	1.1	2.5	90				0.0
07/05/2010	13	59.1	78.3	65.8	62.0	52.8	46.6	1.1	2.2	30				0.0
07/05/2010	14	58.8	72.9	64.9	61.5	53.9	46.8	2.2	3.6	210				0.0
07/05/2010	15	59.0	72.3	65.3	61.8	54.4	47.1	4.7	6.1	240				0.0
07/05/2010	16	57.9	73.1	64.4	60.7	53.5	48.8	4.2	5.8	230				0.0
07/05/2010	17	57.9	73.7	65.4	60.5	53.4	48.8	3.1	4.2	220				0.0
07/05/2010	18	57.5	76.2	65.4	59.9	53.2	49.4	3.1	3.6	190				0.0
07/05/2010	19	54.7	69.8	62.1	57.5	49.6	44.6	4.2	5.0	170				0.0
07/05/2010	20	53.5	73.0	61.1	56.5	47.8	40.8	3.1	3.6	170				0.0
07/05/2010	21	54.7	75.9	62.7	58.3	47.8	41.4	2.2	3.1	160				0.0
07/05/2010	22	52.8	72.6	60.6	55.3	46.6	38.5	2.2	2.5	180				0.0
07/05/2010	23	55.4	77.5	67.2	57.4	46.7	38.6	1.1	2.2	210				0.0
10/05/2010	0	45.0	62.5	56.5	48.3	31.3	25.2	1.4	2.2	200				0.0
10/05/2010	1	45.9	62.3	57.0	49.4	31.6	26.0	2.2	2.2	190				0.0
10/05/2010	2	47.1	66.4	58.8	50.0	29.9	24.2	2.5	2.5	130				0.0
10/05/2010	3	48.9	65.1	59.4	52.6	34.8	26.1	1.1	1.4	160				0.0
10/05/2010	4	52.2	66.7	60.6	55.9	43.2	36.2	2.2	2.2	180				0.0
10/05/2010	5	55.9	67.6	63.0	59.0	49.8	42.2	1.1	3.1	190				0.0
10/05/2010	6	57.9	71.8	62.9	60.2	54.2	49.3	1.4	2.2	170				0.0
10/05/2010	7	58.8	71.1	64.9	61.8	54.3	49.9	0.0	1.1	0				0.0
10/05/2010	8	60.3	74.9	67.5	63.0	54.8	48.4	0.0	0.0	0				0.0
10/05/2010	9	59.1	74.1	65.9	62.0	53.7	47.1	2.2	3.1	150				0.0
10/05/2010	10	60.1	77.9	67.2	62.7	54.7	48.2	5.8	7.8	130				0.0
10/05/2010	11	60.1	78.3	66.7	62.7	54.8	48.8	5.0	6.7	130				0.0
10/05/2010	12	59.1	73.3	66.0	62.0	53.0	43.6	4.7	7.8	90				0.0
10/05/2010	13	58.6	72.8	64.5	61.4	53.0	46.3	4.2	7.2	110				0.0
10/05/2010	14	58.9	69.8	65.0	61.9	53.4	46.3	4.7	6.7	90				0.0
10/05/2010	15	59.1	69.0	64.5	61.7	54.6	48.2	4.7	6.1	120				0.0
10/05/2010	16	59.4	74.8	65.5	62.0	55.0	50.0	5.0	8.3	140				0.0
10/05/2010	17	57.6	71.4	63.6	60.0	53.3	48.7	4.2	6.1	110				0.0
10/05/2010	18	57.7	78.3	65.6	59.3	51.8	47.0	2.5	2.5	110				0.0
10/05/2010	19	54.4	69.5	62.0	57.5	49.3	43.5	2.5	3.1	110				0.0
10/05/2010	20	53.6	69.1	62.0	57.1	47.0	40.8	2.5	3.1	160				0.0
10/05/2010	21	54.4	70.5	67.6	56.1	45.5	37.7	2.2	2.5	160				0.0
10/05/2010	22	53.4	74.7	64.4	55.0	41.7	31.3							

Hourly Logged Noise Data

Date	Start Hour	L_{Aeq}	L_{AMax}	L_{A1}	L_{A10}	L_{A90}	L_{Min}
10/05/2010	23	50.6	65.0	60.9	54.2	39.5	31.8

Hourly Logged Weather Data

Avg. Wind Speed (m/s)	Max. Wind Speed (m/s)	Wind Dir. (°) North=0°	Temp. (°C)	Humidity (%)	Air Press. (kPa)	Rainfall (mm)
0.6	1.4	170				0.0
2.5	3.1	130				0.0

Noise Monitoring Data Sheet

Roe Hwy Extension
Project No. 60100953

SITE ID. **2**

Dominant Road	Roe Highway	From	03-May-10 12:03 PM	Address	25 Brandwood Gdns
Road Surface		To	13-May-10 4:18 PM	Suburb	Leeming
Speed (85%)	100 km/h	Mic. Height	1.5 m	District	Metropolitan
Distance to Road	55 m	Meas. Type	Facade	Longitude	115.8550
		Instrument	00765701	Latitude	-32.0870
		Operator	MB		

LA10(18h) (6am-Midnight)	**59.4 dB(A)**	**LAeq(8h)** (10pm-6am)	**53.2 dB(A)**	Pre Calibration	93.8 dB(A)
LAeq(16h) (6am-10pm)	**57.7 dB(A)**	**LAeq(24h)**	**56.6 dB(A)**	Post Calibration	93.8 dB(A)

Site Diagram

Site Photo

Site Photographs

Site Photo

Site Photo

Site Photo