

ARMADALE CITY CENTRE ACTIVITY CENTRE PLAN

ROAD AND RAIL NOISE AND GROUND VIBRATION MANAGEMENT

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NOISE AND GROUND VIBRATION MANAGEMENT
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EXECUTIVE SUMMARY

Herring Storer Acoustics was commissioned to provide acoustical advice with regards to the Activity Centre Plan for the Armadale City Centre. The advice was to provide a framework for the acoustic requirements for development to be undertaken within the project area. For information, a plan of the project area is shown below.



Armadale Activity Centre Boundary

The acoustic requirements include :

- Noise ingress, as would be required under State Planning Policy 5.4 *“Road and Rail Transport Noise and Freight Considerations In Land Use Planning”*. This applies to noise received at residences and other noise sensitive premises located adjacent or near major roads (Armadale Road and South Western Highway) and the railway line.
- Provide appropriate parameters and criteria relating to ground vibration from the passenger trains.
- Provide guidance on the acoustical requirements relating to the requirements of the Environmental Protection (Noise) Regulations 1997. The Regulations are applicable to the noise received at one premises from another.

At this stage of the projects’ development, there are 2 concept plans being considered. The acoustical requirements are applicable to both plans.

The acoustic requirements for the development area are summarised below.

NOISE INGRESS – STATE PLANNING POLICY 5.4

Noise received at residences and other noise sensitive premises, located adjacent or near a major road or railway need to comply with the requirements of State Planning Policy 5.4 (SPP 5.4).

With regards to major road, the project area is bounded on 2 side by major roads, these being Armadale Road and South Western Highway. The current traffic volumes obtained from the MRWA Traffic Map are approximately :

Armadale Road	-	26000 vpd; and
South Western Highway	-	19500 vpd.

At this stage of the project, it is recommended that assessments in accordance with SPP 5.4 be required to be undertaken for any noise sensitive premises located within 200 metres of either Armadale Road and / or the South Western Highway; and within 100 metres of the passenger train line.

For the assessment of noise received from trains, given the variation between the noise received from a single train pass, compared to the noise level averaged over the 16 hours of the day period (as per SPP 5.4 criterion), the noise emission from a single train pass should be used for the basis of assessment with regards to State Planning Policy 5.4.

A Noise Management Plan is attached in Appendix C. Along with other acoustic requirements, this plan outlines the acoustic criteria and key management strategies for achieving compliance with State Planning Policy 5.4.

Notes :

- 1 With the possibility of the passenger train line being extended to Byford, assessment should also be undertaken for those noise sensitive premises located south of the Armadale Station.
- 2 Under State Planning Policy, additional to residences, it includes other noise sensitive uses, including schools, child care centres, hospitals, aged care facilities etc.

GROUND VIBRATION - TRAINS

The acceptable criteria for ground vibration from passing passenger trains for residential premises is 1.4x base curve 4(a) as defined in AS 2670.2-1990 *“Evaluation of human exposure to whole-body vibration; Part 2: Continuous and shock-induced vibration in buildings (1 to 80 Hz)”*.

Based on the measurements undertaken, it is recommended that ground vibration measurement and assessment be undertaken for all developments within 50 metres from the edge of the closest track to the development. If the results of these measurements show an exceedance of the criteria, then appropriate mitigation need to be implemented.

With regards to trains, it is noted that the Australind also uses this train line. However, as there are only 2 trains per day (during the day period) and that the assessment of noise and vibration from trains is recommended to be based on discreet train movements, it is recommended that the Australind be excluded from the assessment. However, if it is felt necessary to include ground vibration from the Australind, then a slight relaxation of the criteria to 2x base curve is recommended.

With the possibility of the passenger train line being extended to Byford, assessment should also be undertaken for those noise sensitive premises located south of the Armadale Station. Thus, for these premises, measurements of the Australind should be used for assessment purposes.

ENVIRONMENTAL NOISE

To provide a vibrant and active city centre to allow cafes, restaurants and bars to operate without the need to impose excessive restrictions, we believe that some leniency to the requirements of the Environmental Protection (Noise) Regulations 1997 is required. Such a way would be to provide a commercial zoning for the development area. By doing this, the Influencing Factor for a residence within the development area would generally be around +11 dB compared to around 4 or 5 dB as would currently be the case.

Based on an Influencing Factor of +11 dB, the assigned noise levels at residences would be as listed in Table 3.5.

TABLE 3.5 - ASSIGNED OUTDOOR NOISE LEVEL – INFLUENCING FACTOR OF 11 dB

Premises Receiving Noise	Time of Day	Assigned Level (dB)		
		L _A 10	L _A 1	L _A max
Noise sensitive premises	0700 - 1900 hours Monday to Saturday	56	66	76
	0900 - 1900 hours Sunday and Public Holidays	51	61	76
	1900 - 2200 hours all days	51	61	66
	2200 hours on any day to 0700 hours Monday to Saturday and 0900 hours Sunday and Public Holidays	46	56	66

Note: L_{A10} is the noise level exceeded for 10% of the time.
L_{A1} is the noise level exceeded for 1% of the time.
L_{Amax} is the maximum noise level.

Note : To the best of our knowledge, the above proposal to zone the development area as commercial has not been previously implemented. However, we believe that it provides the balanced solution to a difficult and complex problem.

1. INTRODUCTION

Hassell commissioned Herring Storer Acoustics to provide acoustical advice with regards to the Activity Centre Plan for the Armadale City Centre. The advice was to provide a framework for the acoustic requirements for development to be undertaken within the project area.

The acoustical requirements include :

- Noise ingress, as would be required under State Planning Policy 5.4 *“Road and Rail Transport Noise and Freight Considerations In Land Use Planning”*. This applies to noise received at residences and other noise sensitive premises located adjacent or near major roads (Armadale Road and South Western Highway) and the railway line.
- Provide appropriate parameters and criteria relating to ground vibration from the passenger trains.
- Provide guidance on the acoustical requirements relating to the requirements of the *Environmental Protection (Noise) Regulations 1997*.

At this stage of the projects development, there are 2 concept plans being considered. The acoustical requirements are applicable to both plans.

For information, the concepts plans are attached in Appendix A.

2. ACOUSTIC CRITERIA

The following criteria have been in place in Western Australia for a number years and they are the accepted criteria used for such developments.

We believe that the first use of noise ingress and the setting of ground vibration criteria for trains was associated with the South Beach Development, followed by the Port Coogee development. We believe that both these developments have been successful from an acoustic perspective.

The assessment and implementation of noise mitigation for noise received at noise sensitive premises for roads and railways, based on State Planning Policy 5.4, is well established and is standard practice. Experience has shown that the criteria stated in the Policy for both external and internal noise provides the correct balance between protecting the occupants and still allowing development.

2.1 STATE PLANNING POLICY 5.4

The Western Australian Planning Commission (WAPC) released on 22 September 2009 State Planning Policy 5.4 *“Road and Rail Transport Noise and Freight Considerations In Land Use Planning”*. This policy provides acoustic criteria and requirements for noise received at noise sensitive premises from both road and rail infrastructure.

Section 5.3 – Noise Criteria, which outlines the acoustic criteria, states:

“5.3 - NOISE CRITERIA

Table 1 sets out the outdoor noise criteria that apply to proposals for new noise-sensitive development or new major roads and railways assessed under this policy.

These criteria do not apply to –

- *proposals for redevelopment of existing major roads or railways, which are dealt with by a separate approach as described in section 5.4.1; and*
- *proposals for new freight handling facilities, for which a separate approach is described in section 5.4.2.*

The outdoor noise criteria set out in Table 1 apply to the emission of road and rail transport noise as received at a noise-sensitive land use. These noise levels apply at the following locations—

- *for new road or rail infrastructure proposals, at 1 m from the most exposed, habitable façade of the building receiving the noise, at ground floor level only; and*
- *for new noise-sensitive development proposals, at 1 m from the most exposed, habitable façade of the proposed building, at each floor level, and within at least one outdoor living area on each residential lot.*

Further information is provided in the guidelines.

Table 1 - Outdoor Noise Criteria

Time of day	Noise Target	Noise Limit
Day (6 am–10 pm)	$L_{Aeq(Day)} = 55 \text{ dB(A)}$	$L_{Aeq(Day)} = 60 \text{ dB(A)}$
Night (10 pm–6 am)	$L_{Aeq(Night)} = 50 \text{ dB(A)}$	$L_{Aeq(Night)} = 55 \text{ dB(A)}$

The 5 dB difference between the outdoor noise target and the outdoor noise limit, as prescribed in Table 1, represents an acceptable margin for compliance. 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. In relation to greenfield sites, however, there is an expectation that the design of the proposal will be consistent with the target ultimately being achieved.

Because the range of noise amelioration measures available for implementation is dependent upon the type of proposal being considered, the application of the noise criteria will vary slightly for each different type. Policy interpretation of the criteria for each type of proposal is outlined in sections 5.3.1 and 5.3.2.

The noise criteria were developed after consideration of road and rail transport noise criteria in Australia and overseas, and after a series of case studies to assess whether the levels were practicable. The noise criteria take into account the considerable body of research into the effects of noise on humans, particularly community annoyance, sleep disturbance, long-term effects on cardiovascular health, effects on children's learning performance, and impacts on vulnerable groups such as children and the elderly. Reference is made to the World Health Organization (WHO) recommendations for noise policies in their publications on community noise and the Night Noise Guidelines for Europe. See the policy guidelines for suggested further reading.

5.3.1 Interpretation and application for noise-sensitive development proposals

In the application of these outdoor noise criteria to new noise-sensitive developments, the objective of this policy is to achieve –

- acceptable indoor noise levels in noise-sensitive areas (for example, bedrooms and living rooms of houses, and school classrooms); and*
- a reasonable degree of acoustic amenity in at least one outdoor living area on each residential lot¹.*

If a noise-sensitive development takes place in an area where outdoor noise levels will meet the noise target, no further measures are required under this policy.

In areas where the noise target is likely to be exceeded, but noise levels are likely to be within the 5dB margin, mitigation measures should be implemented by the developer with a view to achieving the target levels in a least one outdoor living area on each residential lot¹. Where indoor spaces are planned to be facing any outdoor area in the margin, noise mitigation measures should be implemented to achieve acceptable indoor noise levels in those spaces. In this case, compliance with this policy can be achieved for residential buildings through implementation of the deemed-to-comply measures detailed in the guidelines.

In areas where the outdoor noise limit is likely to be exceeded (i.e. above $L_{Aeq(Day)}$ of 60 dB(A) or $L_{Aeq(Night)}$ of 55 dB(A)), a detailed noise assessment in accordance with the guidelines should be undertaken by the developer. Customised noise mitigation measures should be implemented with a view to achieving the noise target in at least one outdoor living or recreation area on each noise-sensitive lot or, if this is not practicable, within the margin. Where indoor spaces will face outdoor areas that are above the noise limit, mitigation measures should be implemented to achieve acceptable indoor noise levels in those spaces, as specified in the following paragraphs.

For residential buildings, acceptable indoor noise levels are $L_{Aeq(Day)}$ of 40 dB(A) in living and work areas and $L_{Aeq(Night)}$ of 35 dB(A) in bedrooms². For all other noise-sensitive buildings, acceptable indoor noise levels under this policy comprise noise levels that meet the recommended design sound levels in Table 1 of Australian Standard AS 2107:2000 Acoustics—Recommended design sound levels and reverberation times for building interiors.

These requirements also apply in the case of new noise-sensitive developments in the vicinity of a major transport corridor where there is no existing railway or major road (bearing in mind the policy's 15-20 year planning horizon). In these instances, the developer should engage in dialogue with the relevant infrastructure provider to develop a noise management plan to ascertain individual responsibilities, cost sharing arrangements and construction time frame.

If the policy objectives for noise-sensitive developments are not achievable, best practicable measures should be implemented, having regard to section 5.8 and the guidelines."

1 For non residential noise-sensitive developments, (e.g. schools and child care centres) consideration should be given to providing a suitable outdoor area that achieves the noise target, where this is appropriate to the type of use.

2 For residential buildings, indoor noise levels are not set for utility spaces such as bathrooms. This policy encourages effective "quiet house" design, which positions these non-sensitive spaces to shield the more sensitive spaces from transport noise (see guidelines for further information).

The Policy, under Section 5.7, also provides information regarding “Notifications on Titles”.

2.2 GROUND VIBRATION

For ground vibration received within a building AS 2670.2-2001 “*Evaluation of human exposure to whole-body vibration; Part 2: Continuous and shock-induced vibration in buildings (1 to 80 Hz)*” has been used to assess compliance with the appropriate criteria. This Australian Standard provides various criteria with regards to human perception in various building uses. The criteria is provided as multiplies of a base curve.

AS 2670.2-2001 “*Evaluation of human exposure to whole-body vibration; Part 2: Continuous and shock-induced vibration in buildings (1 to 80 Hz)*” and uses acceleration with units of m/s^2 .

As a building may be used for many different human activities, for example standing, sitting, lying or a combination of all three, vertical vibration of the building may enter the body as either z-axis, x-axis or y-axis vibration, as shown in Figure 1.

Figure 1 – Axis of Vibration

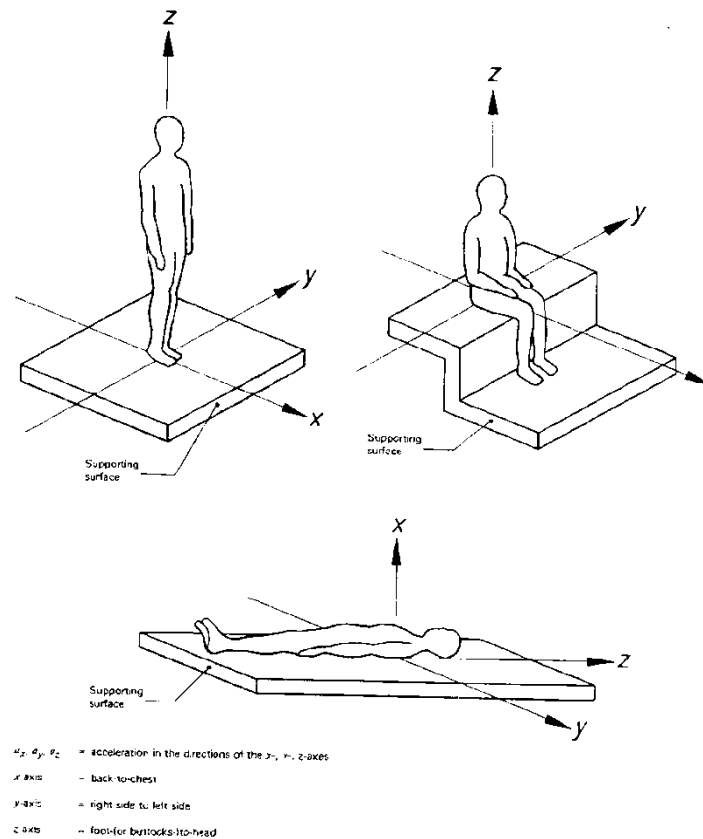


Figure 1 – Directions of basic coordinate systems for mechanical vibrations influencing humans

(Extract from AS2670.2-2001)

2.2.1 As it is not clear which direction vibration would enter the body, a combination curve of the base curves is used. The combination curve combines the worst-case combination of the z-axis, x-axis and y-axis curves.

In this case where the axis of the occupants varies or is not known Curve 4(a) is used as the bases of assessment. From AS2670.2 the base Curve for curve 4(a) is shown in Figure

2. This base curve represents magnitudes of approximately equal human response with respect to human annoyance and/or complaints about interference with activities. The satisfactory vibration magnitudes in rooms and building are specified as multiples of this base curve.

Figure 2 – Combined Direction Base Curve

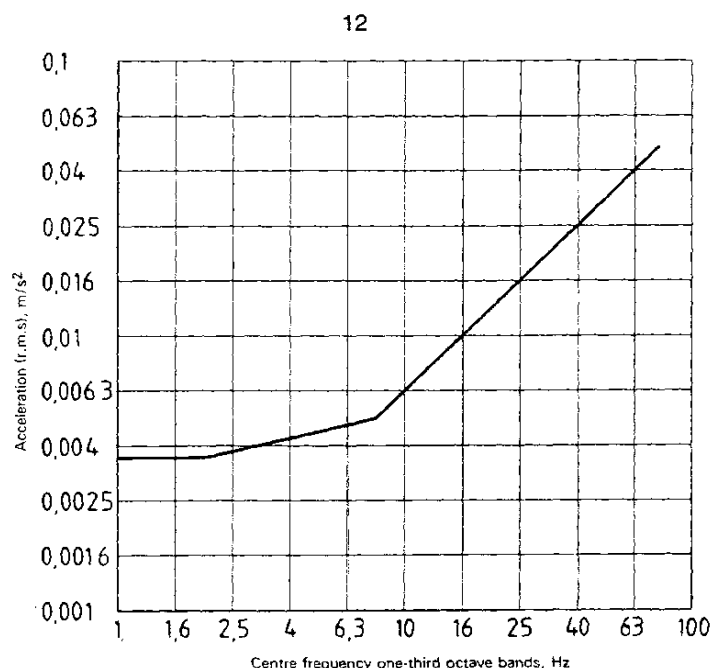


Figure 4a – Building vibration combined direction (x-, y-, z-axis) acceleration base curve (this curve shall be used when the direction of the human occupants varies or is unknown with respect to the most interfering or annoying vibration. See 4.2.3)

The multiplying factors used within the AS2670.2, specify satisfactory magnitudes of building vibration within residential buildings with respect to human response and are listed in Table of Annex A of the standard. The residential section of Table 2 of Annex A is summarised in Table 2.1 below.

TABLE 2.1 – SUMMARY OF MULTIPLYING FACTORS WITHIN RESIDENTIAL BUILDINGS

Place	Time	Continuous or Intermittent Vibration	Transient Vibration Excitation With Several Occurrences
Residential	Day	2 to 4	30 to 90
	Night	1.4	1.4 to 20
Office	Day	4	60 to 128
	Night		
Workshop	Day	8	90 to 128
	Night		

Table 3.1 in Appendix A of the standard lists the acceptable criteria. In this situation the passing trains would be considered as transient vibration. As such the recommended range of multiplying factors range from 1.4 to 4.0 times the base curve. However, AS2670.2 states 1.4x the base curve as the night period criteria. Hence, this has been used as the criteria for this project. We understand that the Department of Environment Regulation (DER) has expressed a preference that the 1.4 x the base curve be used as the criteria.

The above is only applicable to the passenger railway line.

2.3 ENVIRONMENTAL PROTECTION (NOISE) REGULATIONS 1997

The *Environmental Protection (Noise) Regulations 1997* prescribe the allowable noise level emissions from one premises that can be received at another.

Under the Regulations, the allowable noise levels, when received at a premise are outlined in Regulations 7 and 8.

2.3.1 Regulation 7

Regulation 7 stipulate the allowable noise levels at any noise sensitive premises from other premises. For residential premises, this noise level is determined by the calculation of an influencing factor, which is then added to the base levels shown below. The influencing factor is calculated for the usage of land within two circles, having radii of 100m and 450m from the premises of concern. For commercial premises, the assigned noise levels are fixed. The base noise levels for residential premises and the assigned noise levels for commercial premises are listed in Table 3.1.

TABLE 3.1 – ASSIGNED NOISE LEVELS

Premises Receiving Noise	Time of Day	Assigned Level (dB)		
		L _{A 10}	L _{A 1}	L _{A max}
Noise sensitive premises within 15 metres of a dwelling (Highly Sensitive Areas)	0700 - 1900 hours Monday to Saturday	45 + IF	55 + IF	65 + IF
	0900 - 1900 hours Sunday and Public Holidays	40 + IF	50 + IF	65 + IF
	1900 - 2200 hours all days	40 + IF	50 + IF	55 + IF
	2200 hours on any day to 0700 hours Monday to Saturday and 0900 hours Sunday and Public Holidays	35 + IF	45 + IF	55 + IF
Commercial Premises	All hours	60	75	80

Note: The L_{A10} noise level is the noise that is exceeded for 10% of the time.
The L_{A1} noise level is the noise that is exceeded for 1% of the time.
The L_{Amax} noise level is the maximum noise level recorded.

It is a requirement that noise emissions be free of annoying characteristics (tonality, modulation and impulsiveness) at other premises, defined below as per Regulation 9.

“impulsiveness” means a variation in the emission of a noise where the difference between L_{Apeak} and L_{Amax Slow} is more than 15dB when determined for a single representative event;

“modulation” means a variation in the emission of noise that –

- (a) is more than 3dB L_{A Fast} or is more than 3dB L_{A Fast} in any one-third octave band;
- (b) is present for more at least 10% of the representative assessment period; and
- (c) is regular, cyclic and audible;

“tonality” means the presence in the noise emission of tonal characteristics where the difference between –

- (a) the A-weighted sound pressure level in any one-third octave band; and
- (b) the arithmetic average of the A-weighted sound pressure levels in the 2 adjacent one-third octave bands,

is greater than 3 dB when the sound pressure levels are determined as $L_{Aeq,T}$ levels where the time period T is greater than 10% of the representative assessment period, or greater than 8 dB at any time when the sound pressure levels are determined as $L_{A\text{ Slow}}$ levels.

Where the noise emission is not music, if the above characteristics exist and cannot be practicably removed, then any measured level is adjusted according to Table 3.2 below.

TABLE 3.2 - ADJUSTMENTS TO MEASURED LEVELS

Where tonality is present	Where modulation is present	Where impulsiveness is present
+5 dB(A)	+5 dB(A)	+10 dB(A)

Note: These adjustments are cumulative to a maximum of 15 dB.

Where the noise emission is music, then any measured level is adjusted according to Table 3.3 below.

TABLE 3.3 – ADJUSTMENTS TO MEASURED MUSIC NOISE LEVELS

Where impulsiveness is not present	Where impulsiveness is present
+10 dB(A)	+15 dB(A)

3. GROUND VIBRATION MEASUREMENTS

To assess the ground vibration emanating from passing passenger trains, ground vibration measurements were carried out of trains passing at the locations as shown on Figures 3.1 and 3.2.



FIGURE 3.1 – NOISE AND VIBRATION MEASUREMENT LOCATION 1



FIGURE 3.2 – NOISE AND VIBRATION MEASUREMENT LOCATION 2

As shown in Figures 3.1 and 3.2, ground vibration measurements were recorded at the following locations :

- Location 1 - 15m and 30 metres from the edge of the closest railway track.
- Location 2 - 16m and 26 metres from the edge of the closest railway track.

Vibration measurements were carried out in the 3 directional axis, parallel, perpendicular and vertically to the railway line. Ground vibration measurements were undertaken on Tuesday 1st August 2017 of six train passes in each direction. Ground vibration representative of the measurements recorded are attached in Appendix B. A summary of the measurements results are listed in Tables 3.1 and 3.2.

TABLE 3.1 – SUMMARY OF GROUND VIBRATION RESULTS – LOCATION 1

Position	Direction of Train Movement	Maximum Vibration level
15m from track	Perth Bound	2x base curve
	Armadale Bound	Greater than 2x base curve
30m from track	Perth Bound	2x base curve
	Armadale Bound	Base curve

TABLE 3.2 – SUMMARY OF GROUND VIBRATION RESULTS – LOCATION 2

Position	Direction of Train Movement	Vibration level
16m from track	Perth Bound	Greater than 2x base curve
	Armadale Bound	1.4x base curve
26m from track	Perth Bound	Less than base curve
	Armadale Bound	Less than base curve

The results of the ground vibration monitoring show that ground vibration could on occasions exceed the 2x base curve criteria at a distance of 30 metres from the edge of the nearest track.

4. DISCUSSION

4.1 ROAD TRAFFIC

The project area is bounded on 2 sides by major roads, these being Armadale Road and South Western Highway.

The current traffic volumes obtained from the MRWA Traffic Map are approximately :

Armadale Road	-	26000 vpd; and
South Western Highway	-	19500 vpd.

Under the Implementation Guidelines for State Planning Policy 5.4, a noise traffic study in compliance with State Planning Policy 5.4 is required for all noise sensitive premises located within 300 metres of these roads. However, it is noted that the buildings located near these roads provide a barrier to those residences located behind. For these plans, there is mainly parkland to the south of Armadale Road and thus, any residence located within this distance could be exposed to noise from vehicles travelling along Armadale Road. By contrast the majority of noise sensitive premises / uses are located within 300 metres of the South Western Highway and even though some shielding could occur, an assessment would be required.

To provide a better understanding of the likely noise propagation from these roads, preliminary noise modelling was undertaken using SoundPlan.

The results of preliminary modelling undertaken indicated that noise emissions from Armadale Road and the South Western Highway would comply with the day period noise "Target" at a distance of approximately 150m. On this basis and as the building heights and layout have not been finalised it is recommended that assessments be required to be undertaken for all noise sensitive premises located within 200 metres of either Armadale Road and / or the South Western Highway.

It also needs to be noted that State Planning Policy covers not only residential premises, but all noise sensitive uses, such as schools, child care centres, hospitals, aged care facilities etc.,.

Under the Western Australian Planning Commission (WAPC) Planning Policy 5.4 *"Road and Rail Transport Noise and Freight Considerations in Land Use Planning"* the following external criteria are listed:

"Noise Limits"

$L_{Aeq(Day)}$ of 60 dB(A); and
 $L_{Aeq(Night)}$ of 55 dB(A).

As external noise levels exceed the "Noise Target" noise levels, then the residential premises should be designed to comply with the following internal noise levels:

INTERNAL

$L_{Aeq(Day)}$ of 40 dB(A) in living and work areas; and
 $L_{Aeq(Night)}$ of 35 dB(A) in bedrooms.

We also note that under the SPP5.4, noise mitigation measures should be implemented with a view to achieve, in at least one outdoor area, the L_{Aeq} of 50 dB(A) noise level for the night period.

4.2 PASSENGER TRAINS

Preliminary noise modelling of noise received within the development area from a passing passenger train was also undertaken. Noise modelling was based on the $L_{Aeq(Day)}$ determined from the measured noise levels recorded for a single train pass, as listed in Table 3.2.

We note that noise received within the development site from passenger trains is basically a number of discreet events of around 20 seconds duration. Based on the current time table for the Armadale line the number of train movements during the day and night periods would be around 260 and 30 respectively. Based on this differential in train movements, the difference between the day and night period noise levels is approximately 9 dB(A). Therefore, if compliance is achieved with the day period acoustic criteria, compliance with the night period acoustic criteria would also be achieved. Thus, the day period is the critical period with regards to achieving compliance. We also note that due to the discreet nature of the train noise, the $L_{Aeq(Day)}$ would be around 13 dB(A) below the L_{Aeq} of a single train passing by. Thus, the $L_{Aeq(Day)}$ period noise due to passing passenger trains complies with the "Target" noise levels as listed under SPP 5.4.

Given the variation between the noise received from a single train pass, compared to the noise level averaged over the 16 hours of the day period, it is recommended that the noise emissions from a single train pass be used to form the basis of assessment with regards to noise ingress for this project.

The results of preliminary modelling, based on a single train pass, indicated that noise emissions from the Armadale passenger railway line would comply with the day period noise "Target" at a distance of approximately 75m. On this basis and as the building heights and layout have not been finalised it is recommended that assessments be required to be undertaken within 100 metres of the railway line.

Under the Western Australian Planning Commission (WAPC) Planning Policy 5.4 *"Road and Rail Transport Noise and Freight Considerations in Land Use Planning"* the following external criteria are listed:

"Noise Limits"

$L_{Aeq(Day)}$ of 60 dB(A); and
 $L_{Aeq(Night)}$ of 55 dB(A).

As external noise levels exceed the "Noise Target" noise levels, then the residential premises should be designed to comply with the following internal noise levels:

INTERNAL

$L_{Aeq(Day)}$ of 40 dB(A) in living and work areas; and
 $L_{Aeq(Night)}$ of 35 dB(A) in bedrooms.

We also note that under the SPP5.4, noise mitigation measures should be implemented with a view to achieve, in at least one outdoor area, the L_{Aeq} of 50 dB(A) noise level for the night period.

The above criteria would be applicable to all development located adjacent or near the railway line. This includes the train lines south of the Armadale train station, which is used currently by the Australind. However, an extension of the passenger service to Byford also needs to be included in the assessment.

We also note that the Australind train also uses this line and there are 2 train movements per day (i.e. one to Bunbury and another returning to Perth). However, these movements are in the day period and would have a negligible impact on the day period (L_{Aeq}) noise level. Therefore, even though noise emissions from the Australind may exceed that of the normal passenger train, given the frequency of the number of passenger train movements, it is recommended that noise emissions from the Australind train not be included in the assessment and acoustic requirements be based on the Perth to Armadale passenger trains.

4.3 GROUND VIBRATION

The results of the ground vibration measurements show that at a distance of 30 metres from the edge of the closest track, ground vibration could exceed the stated criteria, being 1.4x the base curve. On this basis, it is recommended that ground vibration measurement be undertaken for all developments within 50 metres from the edge of the closest track to the development. If the results of these measurements show an exceedance of the criteria, then appropriate mitigation can be implemented.

With regards to train vibration associated with the Australind, given the number of movements compared to the Perth to Armadale service and that the Australind is a day time service, it is recommended, as for noise, that as the vibration from discrete train movements are being assessed, the ground vibration from the Australind be excluded from the assessment. If it is felt necessary to include ground vibration from the Australind, then a slight relaxation of the criteria to 2x base curve is recommended.

4.4 ENVIRONMENTAL NOISE

To provide an opportunity for a vibrant mix of activities, including bars, restaurants and cafes, it is desirable to maintain a balance between the noise levels allowable under the Requirements of the *Environmental Protection (Noise) Regulations 1997* and the noise received at residential premises. The best opportunity to achieve this is to maintain the zoning as either mixed usage or commercial. By doing this the area with the Armadale City Centre achieves a reasonable influencing factor and hence, assigned noise levels.

We believe that for a city centre, such that is being proposed here, the difficulty within the *Environmental Protection (Noise) Regulation 1997* is in regards to entertainment areas, or even café strips, due to the penalties that apply (music etc.) and the low assigned noise level once a noise sensitive premise is more than 100 metre from a major road. For example, at a residence located at say 95 metres from either Armadale Road or the South Western Highway the Road Influencing Factor would be +6 dB, however, move this residence 6 metres further away from these roads and the Road Influencing Factor drops to +2 dB. However, this can be partly compensated for by maintaining a commercial zoning. In this case, the Influencing Factor for a residence located within 100 metres of the South Western Highway or a residence located near the centre of the development area would both be around +11 dB.

Note : If only the internal area, which is currently zoned commercial, is considered, then the influencing factors would be around +8 dB for residence located within 100 metre of the South Western Highway or a residence located near the centre of the development area. However, for some locations near the edge of the commercial zoning, the Influencing Factor could be as low as +4 or +5 dB.

Based on an Influencing Factor of +11 dB, the assigned noise levels at residences would be as listed in Table 3.5.

TABLE 3.5 - ASSIGNED OUTDOOR NOISE LEVEL – INFLUENCING FACTOR OF 11 dB

Premises Receiving Noise	Time of Day	Assigned Level (dB)		
		L _A 10	L _A 1	L _A max
Noise sensitive premises	0700 - 1900 hours Monday to Saturday	56	66	76
	0900 - 1900 hours Sunday and Public Holidays	51	61	76
	1900 - 2200 hours all days	51	61	66
	2200 hours on any day to 0700 hours Monday to Saturday and 0900 hours Sunday and Public Holidays	46	56	66

Note : To the best of our knowledge, the above proposal to zone the development area as commercial has not been previously implemented. However, we believe that it provides a balanced solution to a difficult and complex problem.

APPENDIX A

Site Layout – Master Plan
(Options 1 and 2)

ARMADALE CITY CENTRE ACTIVITY CENTRE PLAN_

OPTION ONE CONCEPT PLAN

PREFERRED PLAN

This preferred plan has formed the basis of the Activity Centre Structure Plan.

- _ Rail tunnelled between Armadale Road and Church Avenue with the dive structures extending north and south of the centre
- _ Limited built form over the rail tunnels within the centre core only
- _ Central focus provided by way of a grand civic plaza integrating with a new station entrance structure
- _ The civic plaza connects directly with Jull Street Mall
- _ The preferred plan requires closure to part of Commercial Avenue

1. Armadale underground train station.
2. Train line dive cutting.
3. Public open space / tunnel ventilation.
4. Neerigen Brook reintroduced as a living stream.
5. Jull Street Mall.
6. New civic plaza anchoring Jull Street Mall.
7. Retail and mixed use core focussed around Jull Street and new shared streets - car parking provided in basements, decked structures or on rooftop.
8. Education / mixed use.
9. Performing arts centre / mixed use.
10. Activated buildings address Memorial Park.
11. Commercial office core and mixed use including desirable mid block link.
12. Mixed use development.
13. Landscaped plaza surrounds the heritage listed jarrah tree.
14. Landmark building.
15. Landscaped mid block pedestrian links.
16. Desirable shared streets as a mid block link.
17. New Justice Precinct.
18. High density residential development.
19. Desirable pedestrian link / open space.
20. William Street public transit boulevard.
21. New principal shared path.
22. New development addresses Neerigen Brook.
23. Improved landscaping and pathway systems along Neerigen Brook.
24. Landmark Short stay or mixed use development site.
25. Boulevard planting to Armadale Road.
26. Former Post Office activates Jull Street Mall.
27. District Hall upgrade to facility.
28. Streich Avenue to Commerce Avenue bridge investigation.
29. Mixed use development activating the civic plaza.



ARMADALE CITY CENTRE ACTIVITY CENTRE PLAN_

OPTION TWO CONCEPT PLAN

SCENARIO 2: RAIL VIADUCT

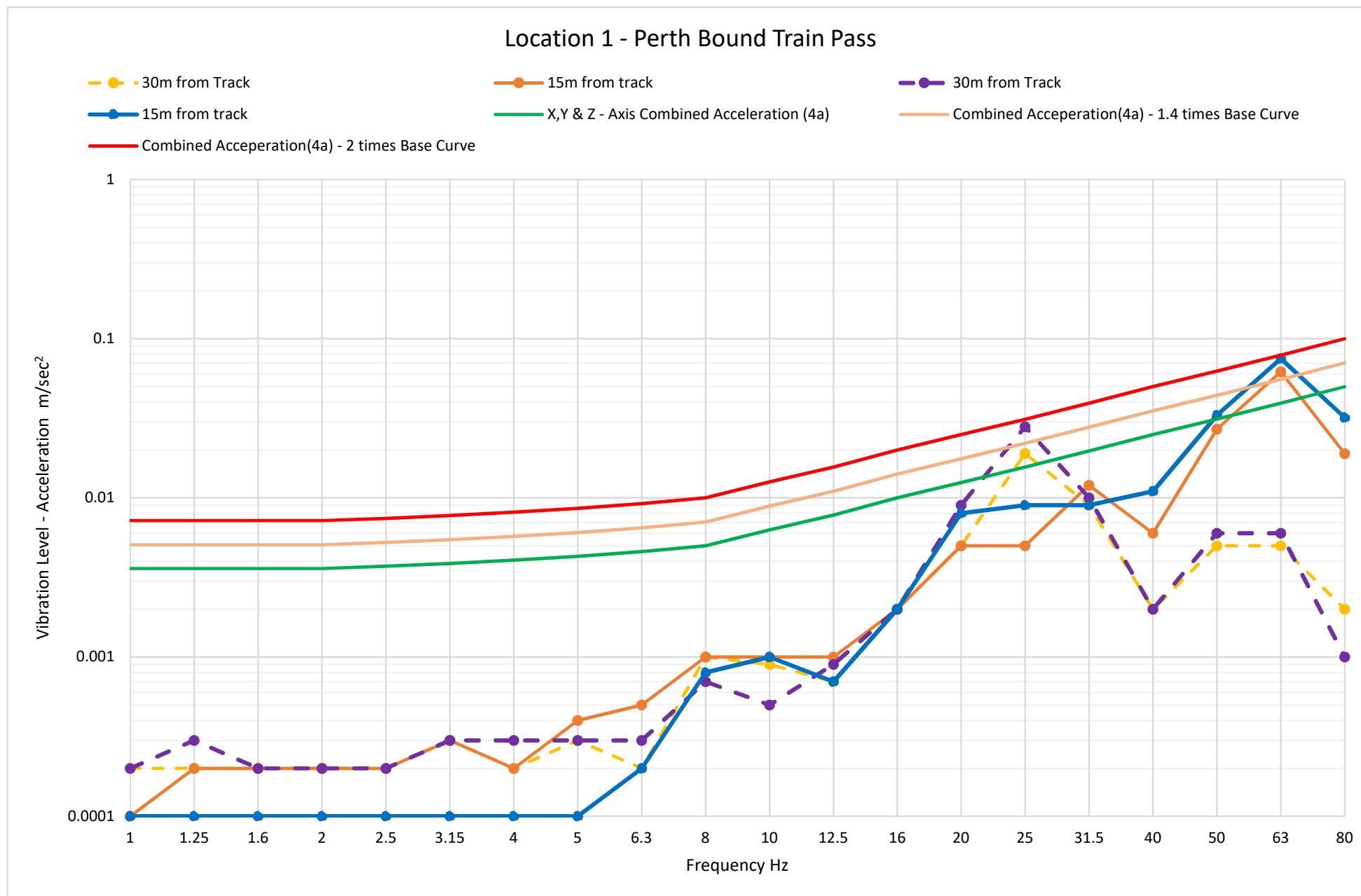
- _Rail in elevated viaduct with open space and (limited) development under viaduct;
- _Elevated train station.
- _Road connections across the rail corridor at Armadale Road, Forrest Road, William Street – Fifth Road and Church Avenue.

1. Armadale elevated train station.
2. Elevated rail viaduct.
3. Public rail plaza and transport interchange (On street bus stops).
4. Public open space below rail.
5. New street connections below rail viaduct.
6. Jull Street Mall.
7. Retail and mixed use core focussed around existing shopping precinct. Car parking provided as basement or on rooftops.
8. University-education and mixed use development. (Including interpretation of existing local heritage fabric)
9. District Hall upgrade to facility.
10. Activated building edges address Memorial Park.
11. Commercial office core.
12. Mixed use development.
13. Landscaped plaza surrounds the heritage listed jarrah tree.
14. Landscaped mid-block pedestrian links.
15. Shared street.
16. New Justice Precinct.
17. High density residential development.
18. Desirable pedestrian link / open space.
19. Public transit bus interchange.
20. New principal shared path.
21. New development addresses the existing drainage corridor.
22. Improved landscaping and pathway systems along Neerigen Brook.
23. Landmark Short stay development site.
24. Boulevard planting to Armadale Road.

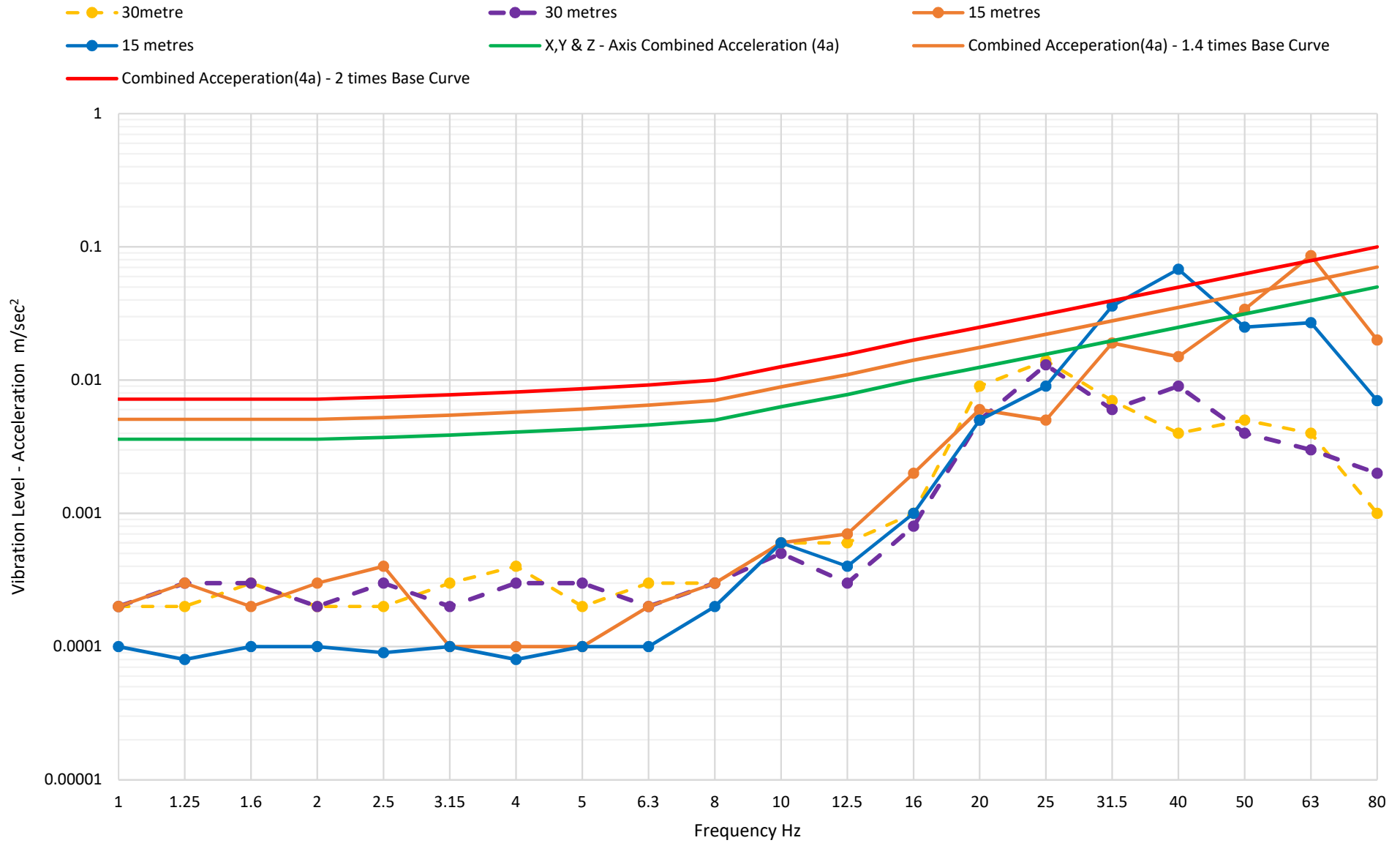


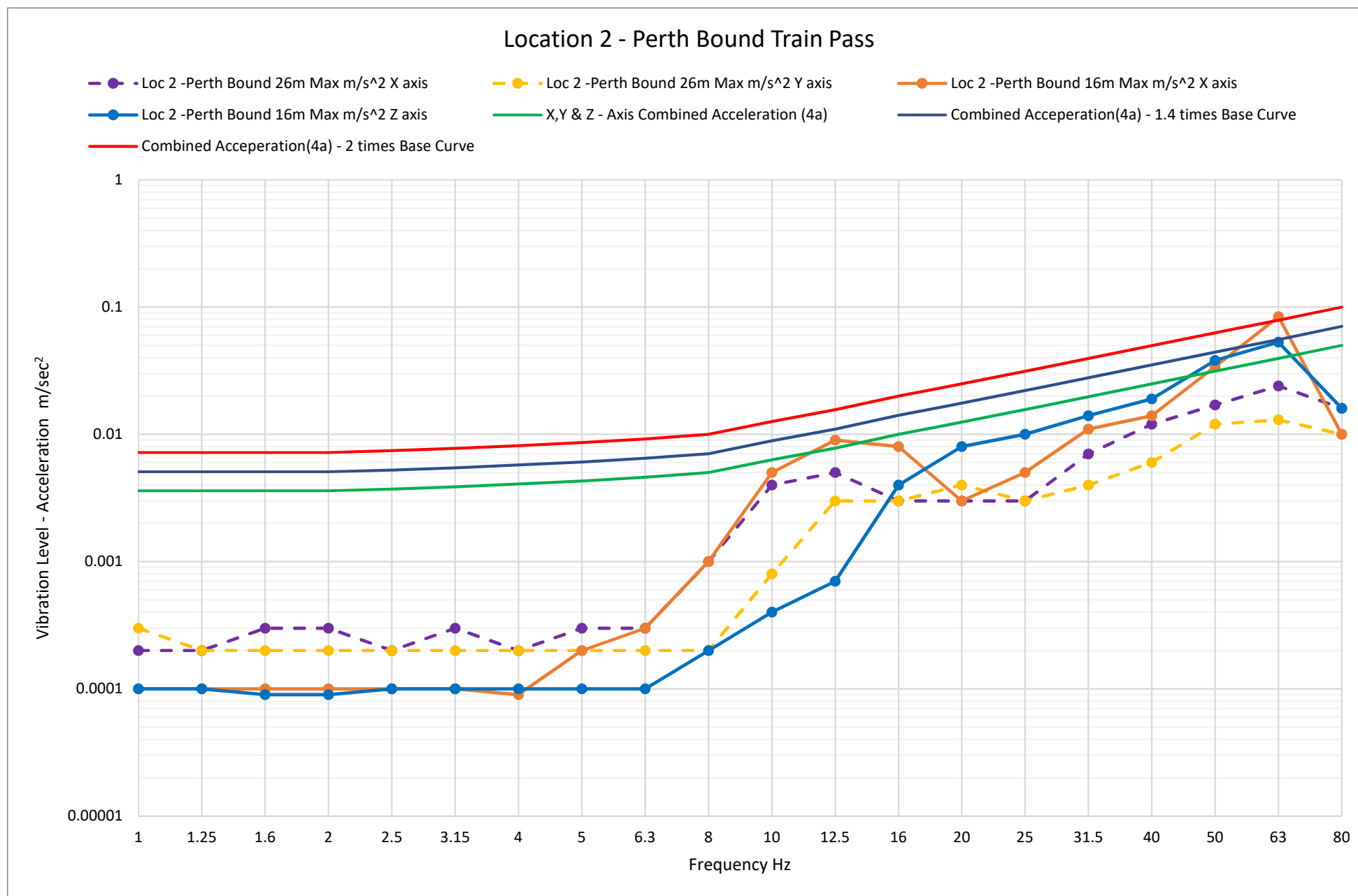
APPENDIX B

Ground Vibration Measurements

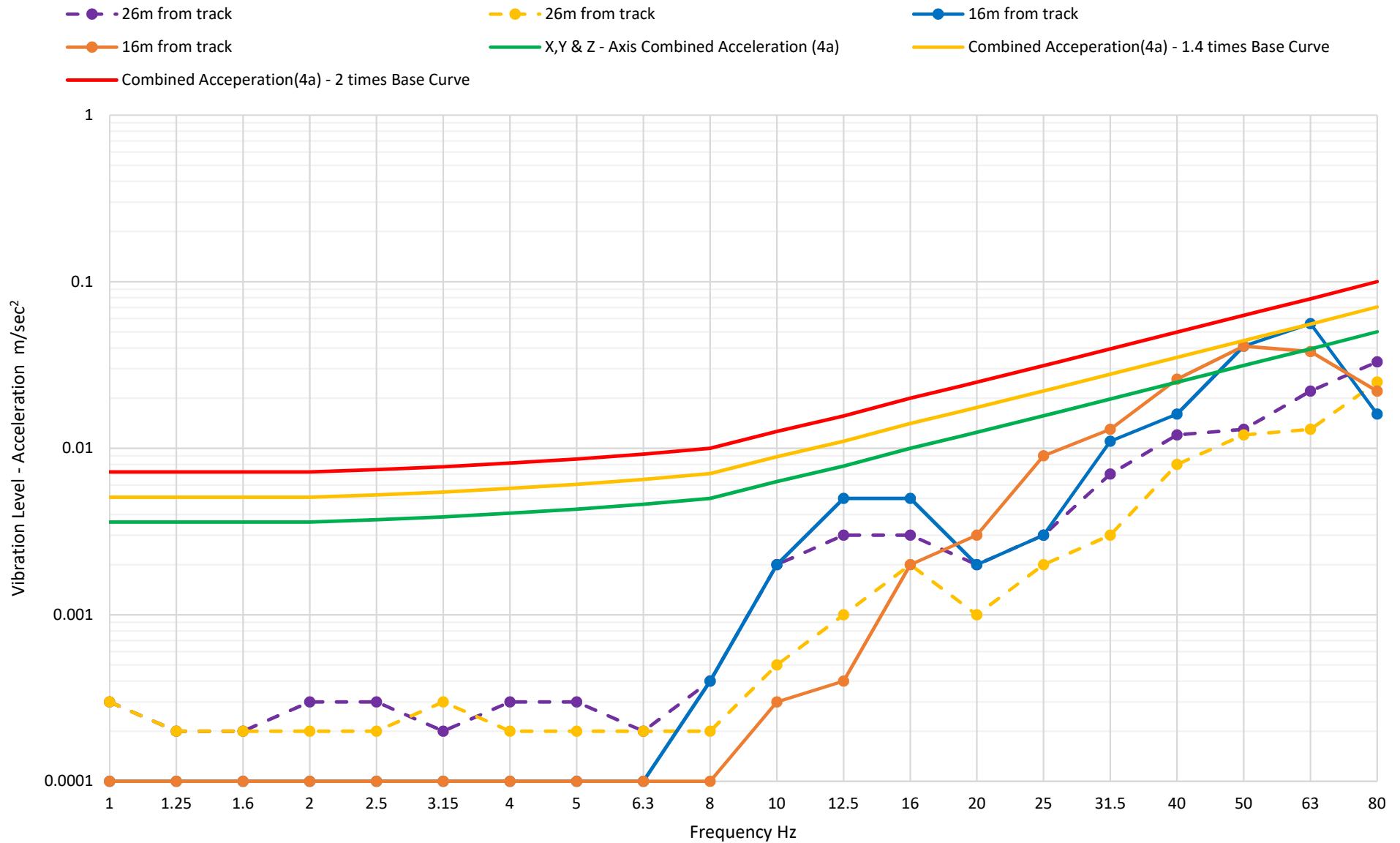


Location 1 - Armadale Bound Train Pass





Location 2 - Armadale Bound Train Pass



APPENDIX C

Noise and Vibration Management Plan

ARMADALE CITY CENTRE

Noise and Vibration Design Guidelines

Within and neighbouring Armadale City Centre Development Area there are the follow existing or proposed major transport routes :

- Armadale passenger railway line;
- Armadale Road; and
- South Western Highway.

For noise received within the development from the above, the acoustic criteria used was as outlined in the WAPC State Planning Policy 5.4 *“Road and Rail Transportation Noise and Freight Consideration in Land Use Planning”*.

With regards to ground vibration from train movements on the freight railway line, the criteria was based on AS 2670.2-1990 *“Evaluation of human exposure to whole-body vibration; Part 2: Continuous and shock-induced vibration in buildings (1 to 80 Hz)”*.

CRITERIA

NOISE

Under the Western Australian Planning Commission (WAPC) Planning Policy 5.4 *“Road and Rail Transport Noise and Freight Considerations in Land Use Planning”* (SPP5.4), the criteria for assessment are the “Noise Limits”, as listed below :

EXTERNAL

$L_{Aeq(Day)}$ of 60 dB(A); and
 $L_{Aeq(Night)}$ of 55 dB(A).

INTERNAL

$L_{Aeq(Day)}$ of 40 dB(A) in living and work areas; and
 $L_{Aeq(Night)}$ of 35 dB(A) in bedrooms.

It should also be practicable at a residence outdoor living area to achieve compliance with the above external criteria. For a multi-residential development this may involve the inclusion of a common outdoor area in the developments design that is protected from the major road and rail transport infrastructure.

VIBRIATION

It is noted that State Planning Policy 5.4, does not include vibration, however, some information is contained within the Implementation Guidelines. Under Appendix 4 of the Implementation Guidelines, it states that :

Curves 1.4 and 2 are often used as assessment benchmarks for residential buildings. Curve 1.4 is generally considered to be the level of vibration at which attenuation measures could be considered were practicable. Curve 2 is generally used as the limit at which vibration isolation measures should be considered.”

This approach is basically being followed for this project, for where ground vibration exceeds the following, mitigation measures are required:

Perth to Armadale Passenger Train	–	1.4x Base Curve;
Australind	-	2x Base Curve.

ASSESSMENT AT DEVELOPMENT APPLICATION STAGE

The following assessments are to be submitted to the City of Armadale with the Development Application.

ROAD NOISE

A preliminary assessment with regards to the requirements of State Planning Policy 5.4 is to be undertaken for all noise sensitive premises located within 200 metres of Armadale Road and / or the South Western Highway.

RAIL NOISE

An assessment with regards to the requirements of State Planning Policy 5.4 is to be undertaken for all noise sensitive premises located within 100 metres of the edge of the closest railway track.

PRELIMINARY NOISE ASSESSMENT REPORT TO CONTAIN

The assessment report is to include :

- Results of noise monitoring for the site.
- Results of noise modelling for the noise to be received at each façade of the development.
- Preliminary advice indicating the “Quiet House” design requirements to achieve compliance with SPP 5.4

Note : State Planning Policy covers all noise sensitive uses, not only residences, but also includes school, child care centres, hospitals, aged care facilities etc.,.

RAIL VIBRATION

For the railway line, a ground vibration assessment and report is to be provided for all development located with 50 metres of the centre of the rail reserve.

The vibration criteria is :

Perth to Armadale Passenger Line	-	1.4x base curve.
Australind	-	2x base curve.

PRELIMINARY GROUND VIBRATION ASSESSMENT REPORT TO CONTAIN

The assessment report is to include :

- Results of site measurements.
- Where measurements show that ground vibration exceed the stated criteria, preliminary information as to the mitigation method(s).

ASSESSMENT REPORTS REQUIRED WITH BUILDING PERMIT SUBMISSION

Where the monitoring / measurements indicate that noise would exceed the following “Target” noise levels, as outlined in State Planning Policy 5.4, then the requirement for a full acoustic report outlining the “Quiet House” design requirements based on the drawings submitted for building permit will be a Conditioned by the City of Armadale.

SPP 5.4 TARGET NOISE LEVELS

$L_{Aeq(Day)}$ of 55 dB(A); and

$L_{Aeq(Night)}$ of 50 dB(A).

Where the monitoring / measurements indicate that ground vibration would exceed the above criteria, then the requirement for a full acoustic report outlining the “Quiet House” design requirements based on the drawings submitted for building permit will be a Conditioned by the City of Armadale.

NOTIFICATIONS ON TITLES

Under the Planning Policy, notification on Titles are required for residence with exposure to noise the ‘Target’ noise levels. Extending this to include ground vibration and the more stringent acoustic requirements for train noise, Notifications should be placed on Titles, where the following is exceeded:

ROAD NOISE

$L_{Aeq(Day)}$ of 55 dB(A); and

$L_{Aeq(Night)}$ of 50 dB(A).

RAIL NOISE

L_{Aeq} of 55 dB(A) for single train pass.

GROUND VIBRATION FROM TRAIN MOVEMENTS

1.4 x Base Curve

Environmental Protection (Noise) Regulations 1997

Noise emissions from all premises are required to comply with the requirements of the Environmental Protection (Noise) Regulations 1997.