Brunswick Level Crossing Removal Project

Construction Noise and Vibration Impact Assessment

Level Crossing Removal Project

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SLR Project No.: 640.30625

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Making Sustainability Happen

Basis of Report

This report has been prepared by SLR Consulting Australia (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Level Crossing Removal Project (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

Executive Summary

The Level Crossing Removal Project (LXRP) has engaged SLR Consulting Australia Pty Ltd (SLR) to conduct a Construction Noise and Vibration Impact Assessment (CNVIA) for the proposed Brunswick Level Crossing Removal Project (Brunswick LXRP).

This report outlines the assessment framework for noise and vibration and details the project's requirement relating to General Environmental Duty (GED), and to not emit unreasonable noise under the Environment Protection Act 2017 (EP Act). For construction noise and vibration, objective noise or vibration limits are not provided by the EP Act. Rather, relevant guidelines and standards are used to develop the approach to managing noise and vibration. The approach used on this project aligns with relevant guidelines and standards and broadly involves establishing construction noise and vibration targets, conduct modelling of noise and vibration to the surrounds from construction activity to assist in understanding the potential risks of harm to human health and the environment, and developing measures to manage those risks so far as reasonably practicable. Additionally, as the project is being referred under the Environment Effects Act 1978, this report considers the potential for the project to cause potential adverse environmental effects from construction noise that could be significant in a regional or State context.

To characterise the potential risks from the project's construction noise and vibration emissions, seven indicative construction scenarios were developed to represent the broad phases of the project timeline. A list of typical equipment for each scenario was developed based on prior experience on similar projects and information from the project team. Each scenario was then modelled prior to the implementation of management measures to inform a screening-level assessment of potential noise and vibration impacts. The indicative scenarios developed were site establishment, earthworks and demolition; laydown area; piling, pile breakback and FRP (form reo pour); superstructure construction; asphalting and line-marking; station construction; and rail systems.

As part of the screening-level assessment of potential noise impacts to the surrounding community, a 3D noise model was developed to predict noise levels from each indicative scenario. The assessment of the potential noise impacts involved comparing predicted noise levels with background noise levels for residential receivers, and construction reference levels for non-residential receivers. The background noise levels were obtained from surveys conducted during the operational assessment, while non-residential construction noise reference levels were guided by the NSW Interim Construction Noise Guideline (2009). Given the early stages of project planning, detailed construction program is not available. Therefore, a conservative modelling approach was adopted to understand worst-case impacts from these construction activities. This conservative noise modelling indicated the potential for some level of noise impacts during all modelled scenarios with respite and relocation measures expected to be offered throughout the project timeline.

Prior to the implementation of management measures, screening-level vibration modelling was carried out, focusing exclusively on activities with significant vibration potential, including piling and vibratory rolling. The assessment of these activities was conducted by nominating safe working distances for both cosmetic building damage and amenity. Where safe working distances are predicted to be infringed, this indicates the nominated construction vibration targets have an increased potential to be exceeded. In general, only vibratory rolling is expected to infringe upon cosmetic buildings damage and amenity safe working distances for certain residential and non-residential buildings intermittently. Heritage structures were not assumed to be particularly sensitive to vibration at this stage of the development. Further assessments may be required once the structural integrity of any heritage structures is investigated. The vibration impacts on utilities were considered and a more detailed vibration assessment to utilities will be required during later stages as relevant

details emerge. An indicative assessment of ground-borne noise was also conducted which noted that the management of airborne noise would likely satisfactorily also manage the risks of ground-borne noise.

The management of construction noise and vibration is developed to align with the EPA's suggested approach to General Environmental Duty, employing an evidence and risk-based decision-making approach outlined in EPA publication 1820.1 - *Construction – guide to preventing harm to people and the environment*. The circular approach suggested by the EPA provides a framework for continuous improvement of the management of construction noise and vibration.

Detailed construction noise or vibration impact assessments are expected to be conducted prior to specific work activities commencing where there is a risk of unreasonable noise (or vibration) being generated. The results of these assessments are intended to guide communications, control and mitigation measures and noise monitoring.

Management measures listed in this assessment are based on LXRP's industry best practices and EPA 1834.1: *Civil construction, building and demolition guide*. Management measures identified include scheduling, plant/equipment modifications, siting considerations, noise barrier controls, communications, monitoring, complaints management system and worker behaviour. Specific management controls are also recommended to be developed for special sensitive receivers like the Melbourne Zoo and RMIT uses.

A project specific construction noise and vibration management plan (CNVMP) will be developed that will incorporate the management measures listed in this assessment and LXRP's industry best practices. It is noted that the listed management measures in this assessment are not exhaustive and additional measures shall be considered where appropriate.

The project team will prepare a project-specific respite and relocation subplan based on the most current industry best practice. Various respite options are typically provided to residents, along with relocation offer for extended high-impact night works.

The outlined management measures are generally considered to be LXRP's standard practice and will be implemented so far as reasonably practicable. When these measures are implemented, the noise and vibration impacts to the surrounding community are expected to be adequately managed and comply with the requirements under the EP Act. Project impacts are not expected to cause significant adverse effects in a regional or state context that would require further assessment under the Environment Effects Act 1978. LXRP have delivered numerous level crossing projects with similar construction methodologies prior to this project and have previous experience implementing most of these noise and vibration management measures listed in this report.

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Acronyms and Abbreviations

Abbreviation	Description
CNVIA	Construction Noise and Vibration Impact Assessment
CNVMP	Construction Noise and Vibration Management Plan
CNVS	Construction Noise and Vibration Strategy
CSR	Combined services route
EPA	Environment Protection Authority Victoria
EE Act	Environmental Effects Act 1978
EP Act	Environment Protection Act 2017
ERS	Environmental Reference Standard
FRP	Form reo pour
ICNG	Interim Construction Noise Guideline
GED	General environmental duty
LXRP	Level Crossing Removal Project (the Client)
NCA	Noise Catchment Area
PTN	Permit To Notify
POW	Place of Worship
TfNSW	Transport for NSW
VDV	Vibration dose value

1.0 Introduction

The Level Crossing Removal Project (LXRP) has engaged SLR Consulting Australia Pty Ltd (SLR) to undertake a construction noise and vibration impact assessment (CNVIA) for the proposed Brunswick Level Crossing Removal Project (Brunswick LXRP). This document provides an overview of the project, relevant acoustic requirements, assessment method and outcomes for the project's consideration.

The report focuses on the assessment framework, methodology and outcomes associated with the construction noise and vibration aspects of the project. Assessments relating to operation noise and vibration are not covered in this report.

Acoustic terminology used in this Report is described in **Appendix A**.

2.0 Project Overview

At the time of SLR's engagement the Victorian Government has committed to removing eight level crossings on the Upfield line, from Albion Street, Brunswick to Park Street, Parkville. The level crossings are located north of the Central Business District and west of Sydney Road, Brunswick.

The project is being undertaken in a highly urbanised environment with an existing operating railway line of which the nearby sensitive receivers currently experience impacts (noise, visual, traffic, safety) from rail traffic.

The design solution is a new rail bridge and will include new separated cycling and walking paths from Moreland Road in the north, to Park Street in the south. The Brunswick Level Crossing Removal Project will commence south of Park Street, Parkville and finish at Tinning Street, Brunswick.

Between Royal Park Station and Moreland Station works will provide retained earth walls at either end of a 2.1km elevated rail bridge. The height of the elevated rail bridge will vary but could be between 5-8m above ground level. Also, in this section will be two new train stations (replacing three existing stations) and a new separated cycling and pedestrian paths running the full length of the elevated rail corridor.

The final rail alignment and location of the stations is yet to be determined. The location of the works is shown in **Figure 1**.

The processes, policies, methods, etc. developed on previous LXRP projects will be followed on this project reflecting LXRP's commitment to a 'business as usual' approach. Pertinent to this assessment includes the 'business as usual' management and response to any potential environmental impacts.

Figure 1 Level Crossing Removals as part of the Project

3.0 Sensitive Receivers

Sensitive receivers are buildings which have the potential to be exposed to noise or vibration impacts from the project's construction activities.

There were approximately 7200 sensitive receivers identified within the study area via desktop review, and they consist of the following:

- General residential uses with single dwellings along the alignment. These are generally older buildings within the project area and are more than 95% of the sensitive receivers identified.
- Multistorey residential buildings, including townhouses and apartments facing the rail corridor which form approximately 5% of the receivers identified.
- Places of worship (less than 1% of the total receivers) such as Kingdom Hall of Jehovah's witnesses adjacent to the rail corridor.
- Educational receivers (less than 1% of the total receivers) including the RMIT University Brunswick campus.
- Aged care and accommodation facilities (approximately 1% of the receivers) including the Hope Aged Care Brunswick.
- John Fawkner Private Hospital
- Melbourne Zoo in Parkville

Figure 2 to **Figure 8** presents the sensitive receivers that are in proximity to the construction works. Note that there are more sensitive receivers considered to the west of the rail line relative to the eastern side due to the presence of the project's material laydown area to the west of the construction footprint.

No buildings were confirmed to include vibration sensitive equipment. However, the John Fawkner Private Hospital may potentially include vibration sensitive equipment. Similarly, no buildings housing bio-resources that would be sensitive to noise and/or vibration were identified in the surrounding area of the project site.

Figure 2 Sensitive Receiver Buildings (1 of 7)

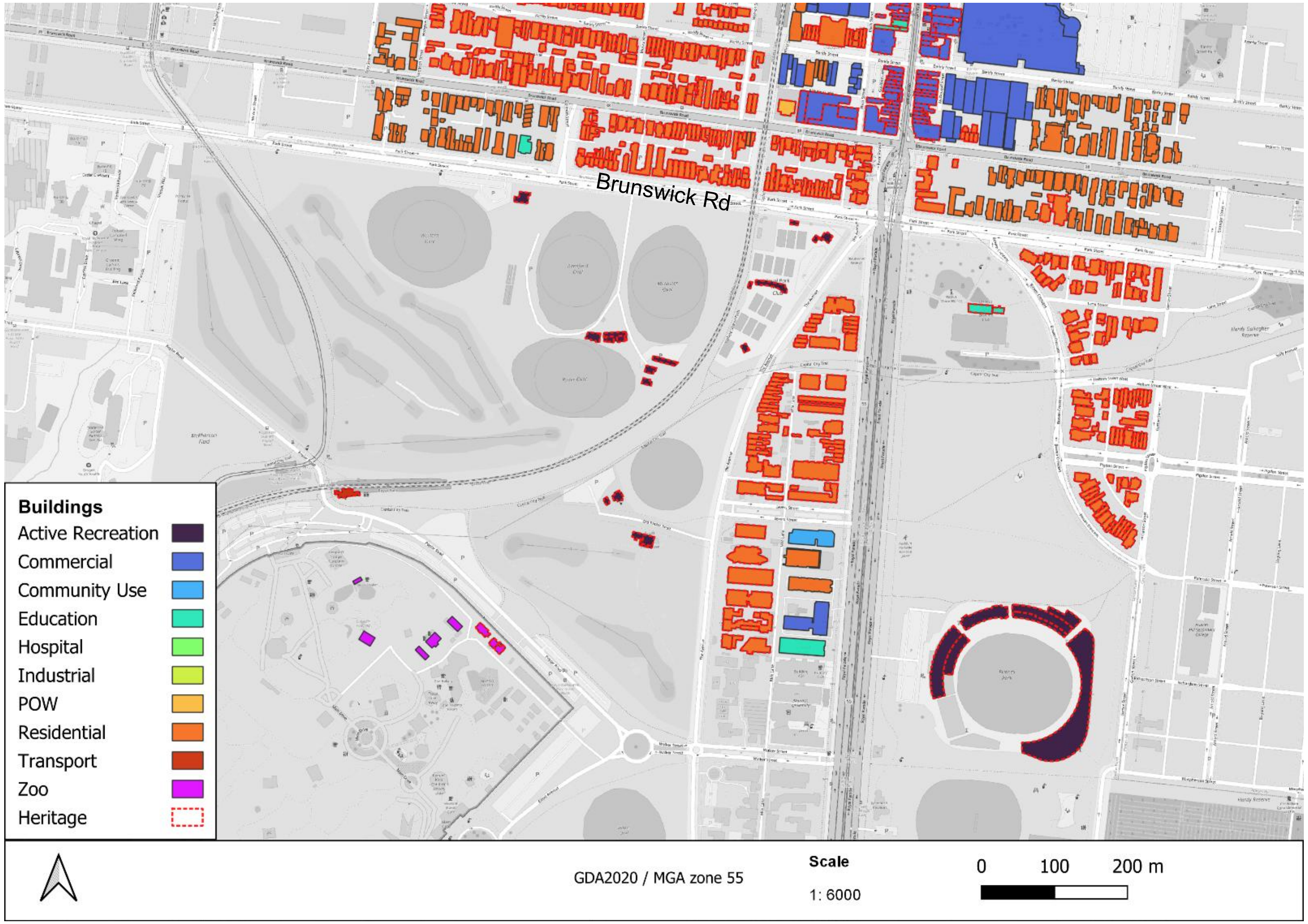


Figure 3 Sensitive Receiver Buildings (2 of 7)

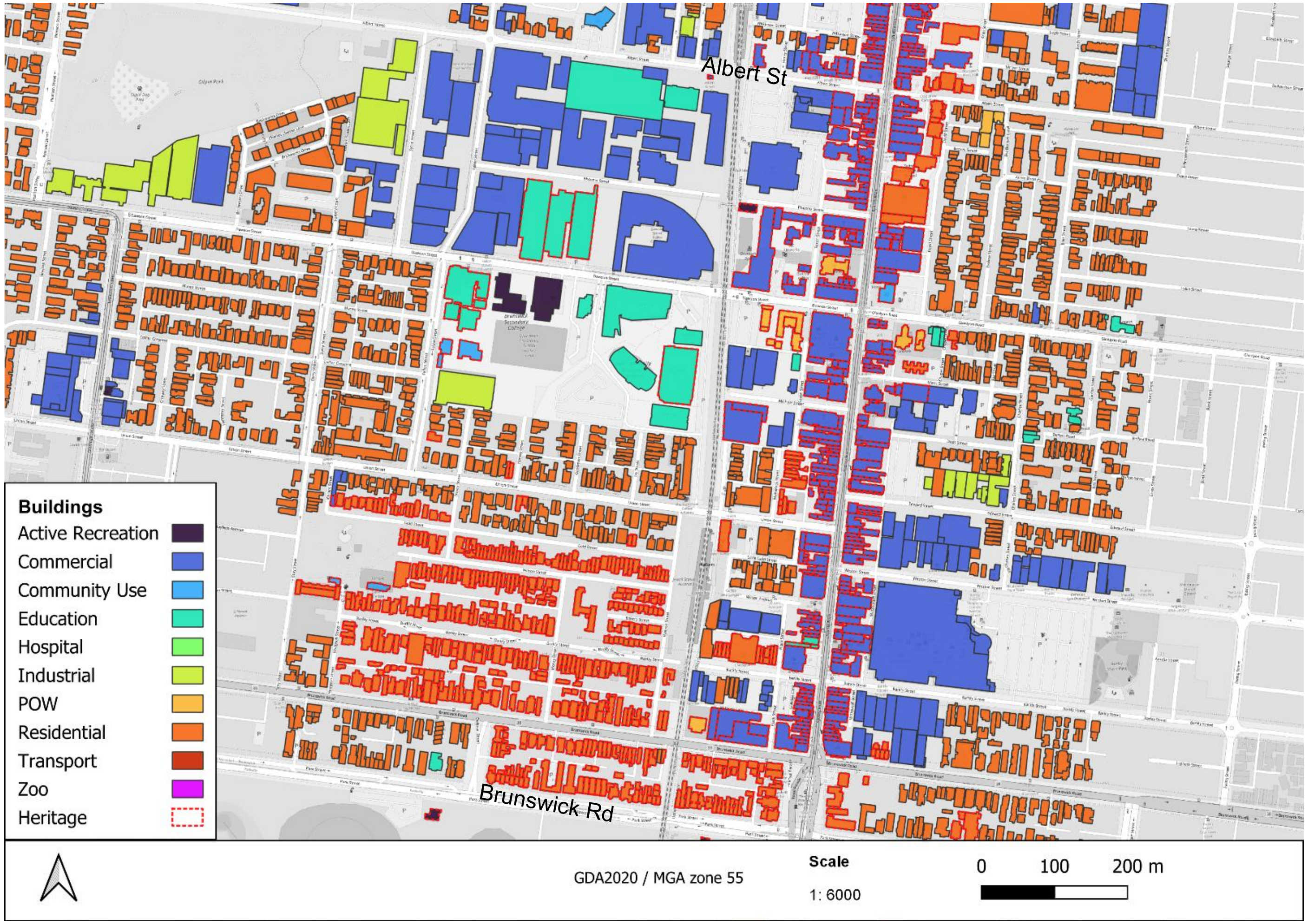


Figure 4 Sensitive Receiver Buildings (3 of 7)

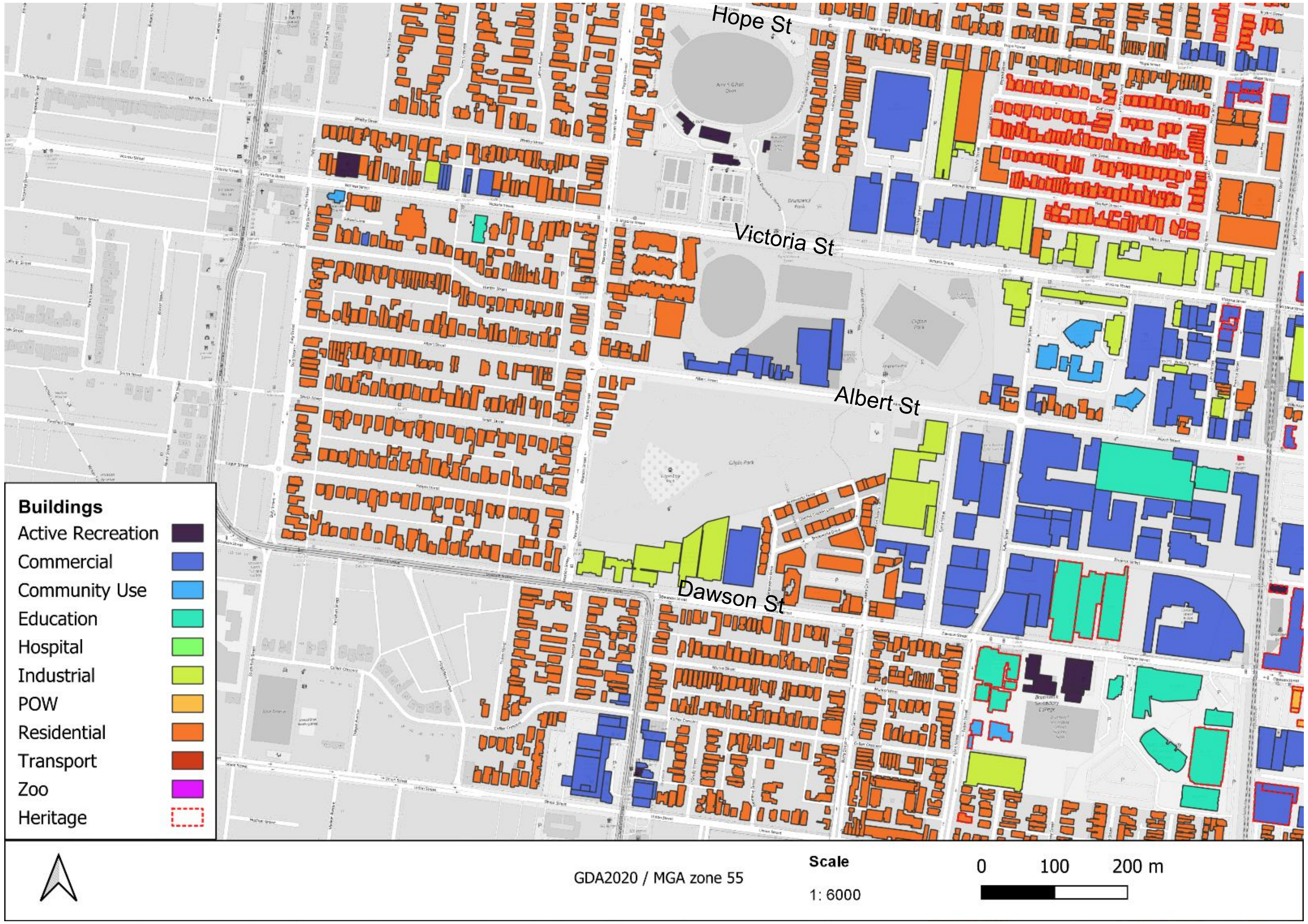


Figure 5 Sensitive Receiver Buildings (4 of 7)

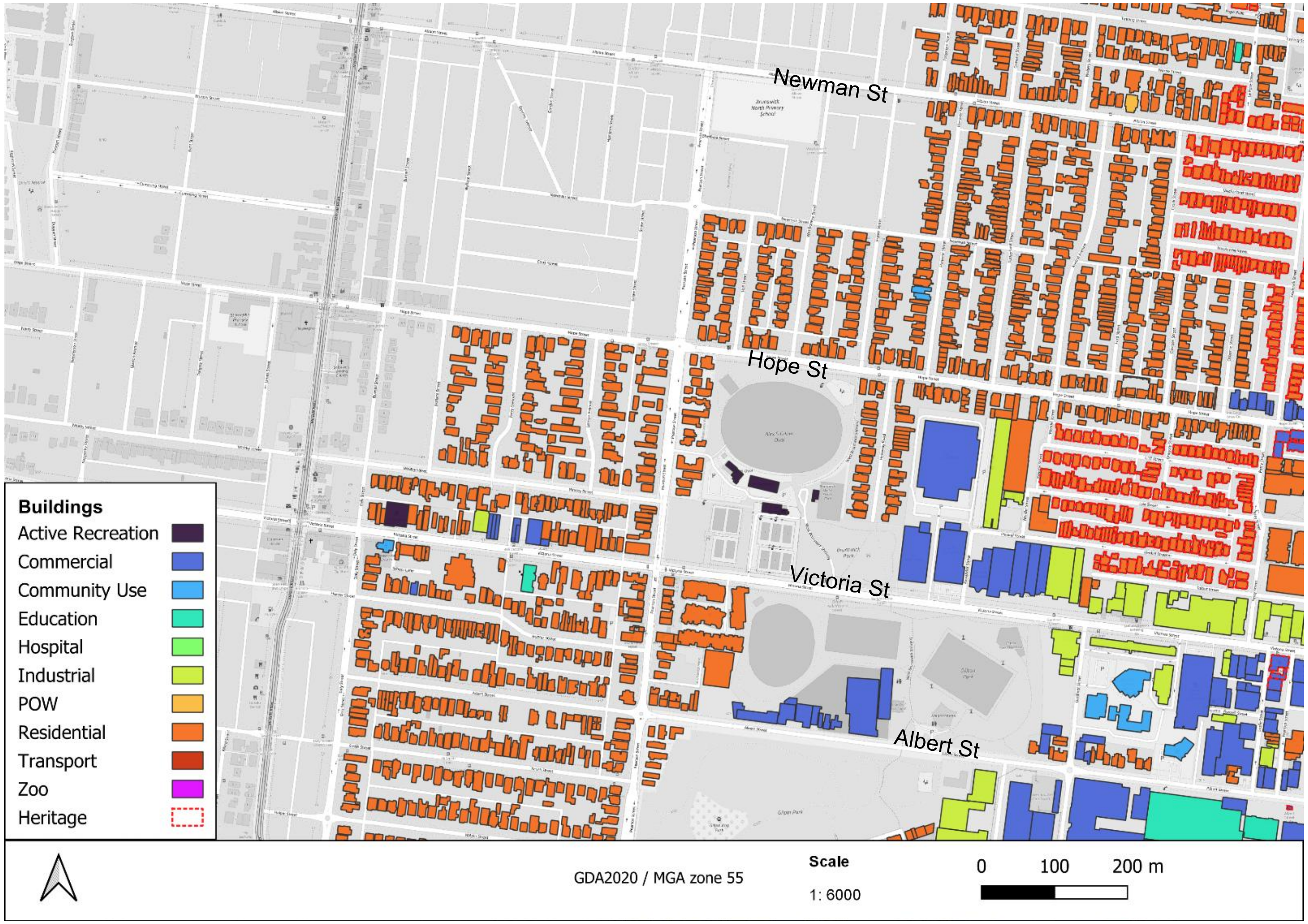


Figure 6 Sensitive Receiver Buildings (5 of 7)

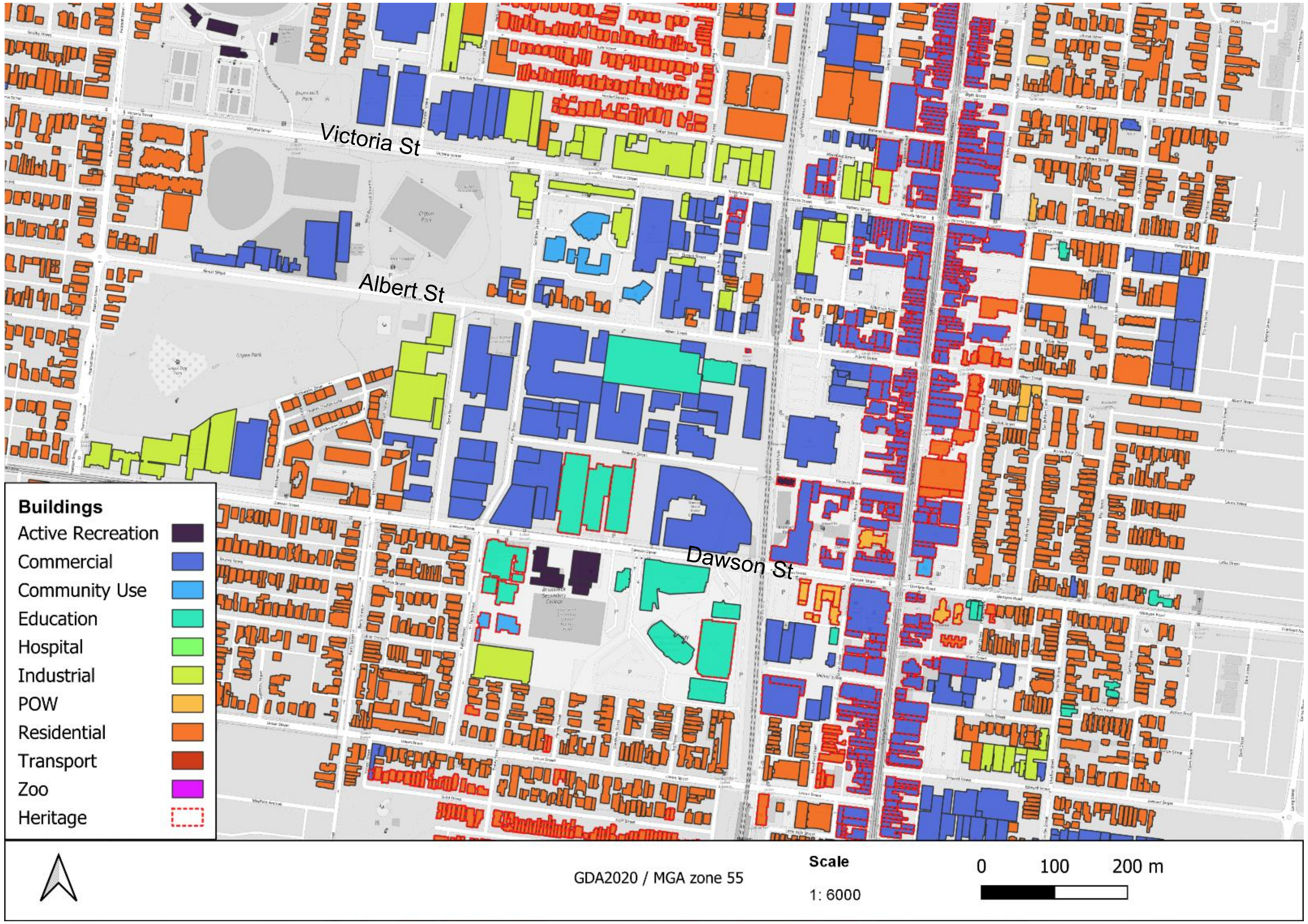


Figure 7 Sensitive Receiver Buildings (6 of 7)

Figure 8 Sensitive Receiver Buildings (7 of 7)

4.0 Existing Acoustic Environment

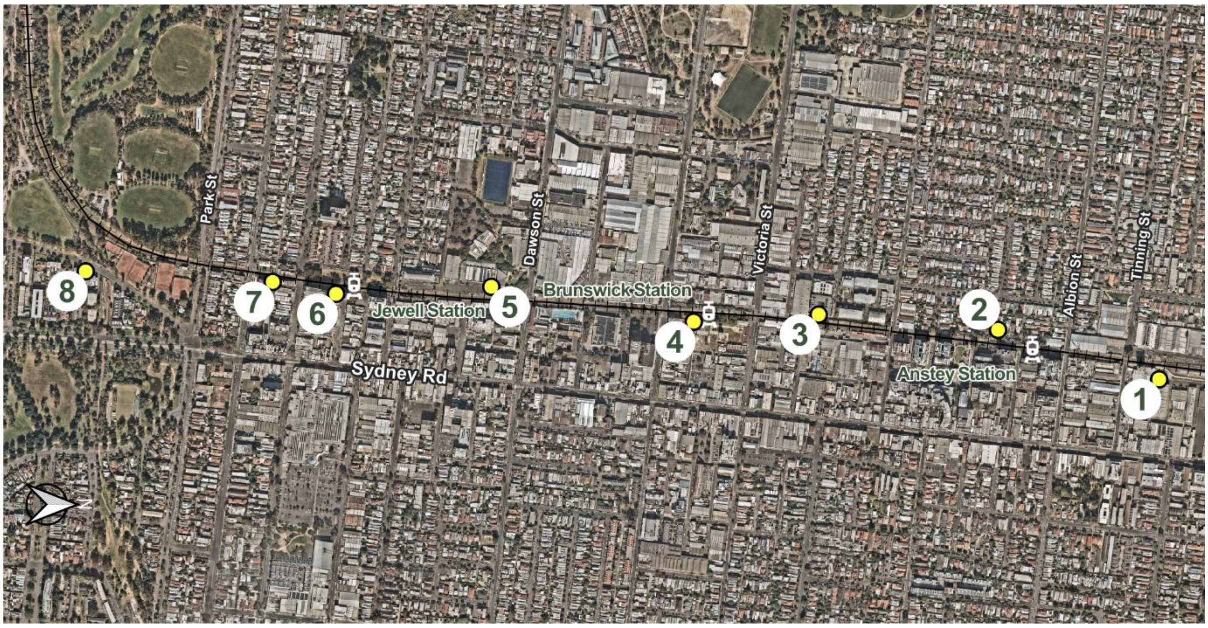
The existing acoustic environment at receivers adjacent to the rail corridor was quantified via unattended noise monitoring at representative locations along the project study area. The noise environment was observed to be typical for a noise environment observed in inner suburban areas and was generally dominated by rail traffic on the Upfield line, road traffic on roads adjacent to the receivers, along with commercial activities within the vicinity.

Considering that there are eight existing level crossings within the project section, along with other pedestrian crossings and three train stations, numerous receivers along the project were observed to currently experience noise effects from level crossing bells and train horns.

Unattended noise monitoring was conducted during February 2023 at eight locations (see **Figure 9**) within the study area of the project. Eight locations were selected to provide representative noise monitoring along the corridor, while accounting for changes in background noise levels due to other background noise sources in the area. The monitoring locations selected are adequate for determining existing noise levels.

The monitoring was conducted over a period of 7-8 days. Details of each location and the noise logger used, along with the data can be found in the operational noise assessment - note that specific addresses and photos of the noise loggers installed on private property have been removed for privacy reasons. All the noise loggers were calibrated with a NATA approved calibrator, and the measurements were undertaken in general accordance with AS 1055: 2018 *Acoustics - Description and measurement of environmental noise*.

Figure 9 Baseline Noise Monitoring Locations (Source: NearMaps) - Overview



All monitoring equipment were generally positioned 1 m from any reflective surfaces (such as building facades or fences).

The monitoring location and existing background L_{A90} noise levels during the day, evening and night are provided in **Table 1**. Analysis of the measured noise levels was conducted in accordance with EPA Publication 1997 *Measuring and analysing industry and music noise.* Noise levels presented in **Table 1** are overall averages for each period. The construction team may need to investigate more specific background levels during the construction phase to address the noise impacts during the 'time of impact'.

Table 1: Baseline Noise Monitoring Locations

Location	Monitoring Location	Day L90, dBA	Evening, L90, dBA	Night L90, dBA
1	Cameron St, Brunswick	42	39	37
2	Orient Grove, Brunswick	40	40	35
3	Lux Way, Brunswick	49	47	43
4	Wilkinson St, Brunswick	44	43	37
5	Dawson Street, Brunswick	49	46	42
6	Wilson Ave, Brunswick	44	44	40
7	Brunswick Road, Brunswick	48	47	42
8	The Avenue, Parkville	43	42	36

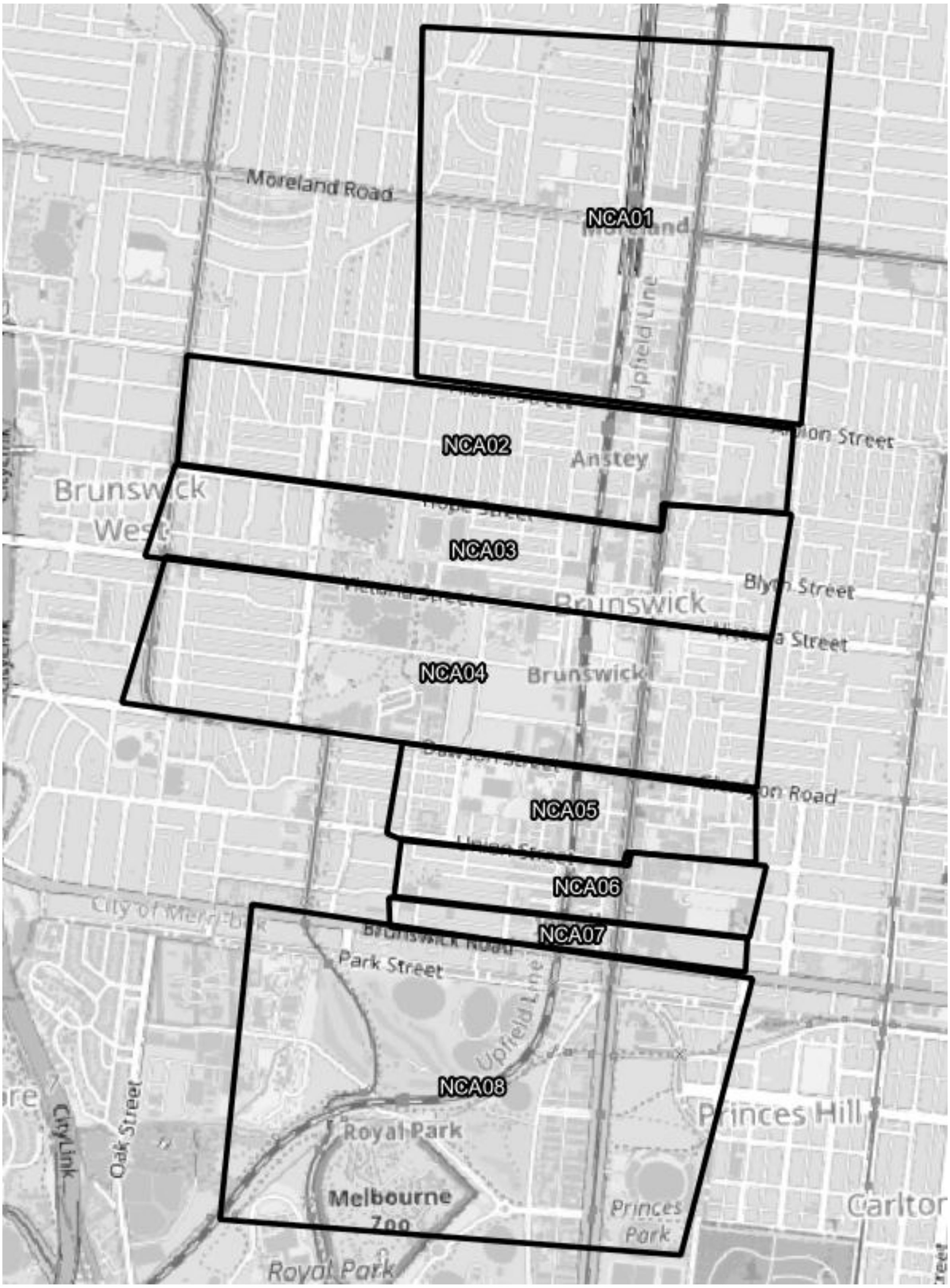
4.1 Noise Catchment Area Determination

Noise catchment areas (NCA) are established to denote areas of similar noise environments. NCA's were determined based on the baseline noise monitoring survey and the surrounding land uses. **Table 2** presents the representative monitoring location along with the respective day, evening and night background LA90 noise levels that each NCA is informed by. **Figure 10** presents the NCAs. The NCAs have additional area to the west of the project in order to assign the background level for receivers near to the laydown area.

Table 2: Background Noise levels per each NCA

Noise Catchment Area	Corresponding Monitoring Location	Day L90, dBA	Evening, L90, dBA	Night L90, dBA
NCA01	1	42	39	37
NCA02	2	40	40	35
NCA03	3	49	47	43
NCA04	4	44	43	37
NCA05	5	49	46	42
NCA06	6	44	44	40
NCA07	7	48	47	42
NCA08	8	43	42	36

Figure 10 NCA Locations



5.0 Assessment Framework

The key legislation, regulations and guidelines that apply to this assessment are summarised in **Table 3**.

Table 3: Legislation and Regulations

Name	Description	Comment
Commonwealth Government		
No requirements relating to noise		
Victorian State		
Title	*Description*	*Comments*
Environment Protection Act 2017 (Vic)	The Environment Protection Act 2017 (EP Act) as amended by the Environment Protection Amendment Act 2018 (Victoria State Government, 2018), took effect on 1 July 2021. The EP Act gives EPA enhanced powers and tools to prevent and minimise the risks of harm to human health and the environment from pollution and waste and includes the general environmental duty (GED). The GED requires everyone, including businesses and individuals, conducting activities that pose a risk to human health or the environment from pollution or waste to understand those risks and take reasonably practicable steps to eliminate or minimise them.	Noise emissions from the Project have the potential to impact human health and the environment. Noise is defined in the EP Act to include both sound and vibration. The EP Act defines unreasonable noise due to factors such as volume, intensity, character, time or if it is prescribed to be unreasonable noise. The project must ensure it does not emit unreasonable noise. GED is relevant to the Project requiring noise emissions that pose a risk to human health or the environment to be minimised as far as reasonably practicable.
Environmental Effects Act 1978 (Vic)	The Environmental Effects Act 1978 (Vic) (EE Act) establishes the framework for assessing proposed works that may have significant effects on the environment. Under the Act, an Environment Effects Statement (EES) may be required to evaluate potential impacts, inform decision-making, and provide opportunities for public input before approval decisions are made.	The Ministerial Guidelines for Assessment of Environmental Effects under the Environment Effects Act 1978 (Vic) sets out individual and combined referral criteria to help determine whether a project's potential impacts warrant referral for an Environment Effects Statement (EES). Proponents are expected to undertake a thorough self-assessment against these criteria to assess the significance of potential environmental effects in a regional or state context. Notably, in the combined referral criteria, the guidelines highlight the "*potential for*

Name	Description	Comment
		significant effects on the amenity of a substantial number of residents, due to extensive or major, long-term changes in visual, noise and traffic conditions." This means that where construction activities may generate substantial or prolonged noise impacts that could significantly affect local communities, this should be considered a factor when determining whether referral is required and how potential impacts will be assessed and managed through the EES process.
Environmental Reference Standard 2021 (Vic)	Under the Environment Protection Act 2017, the Environment Reference Standard (ERS) is to be used to assess and report on environmental conditions in the whole or any part of Victoria. It achieves this by identifying environmental values to be maintained and by setting indicators and objectives for the ambient sound environment. The ERS provides typical ambient (outdoor, free field) noise level objectives for different land use zones. It does not define noise limits nor design criteria.	The ERS sets out ambient noise indicators and objectives for land use categories. Indicators and objectives relevant to the suburban project surrounds (Category III) are: Leq, 8h (10 pm to 6 am) = 40 dBA Leq, 16h (6am to 10pm) = 50 dBA Indicators and objectives relevant to the surrounding areas of unique native habitat are qualitative and relate to a sound quality that is conducive to human tranquillity and enjoyment outdoors, in natural areas, having regard to the ambient natural soundscape.
Civil construction, building and demolition guide, EPA Publication 1834.1 (Victoria EPA, 2023)	This publication supports the civil construction, building and demolition industries to eliminate or reduce the risk of harm to human health and the environment through good environmental practice. Chapter 4 addresses noise and vibration.	Provides recommendations for the management of construction noise, including a definition of Normal Working Hours and specific requirements for works justified to be conducted outside these time periods.
Guide to the Environment Reference Standard, EPA Publication 1992 (Victorian EPA, 2021)	This guide provides information about how the ERS should be applied to support decision making, and how the environmental values, indicators and objectives for each element of the	This guide is primarily for decision makers who need to consider the ERS. Decision makers can include Environment Protection Authority Victoria (EPA) officers, officers from other government authorities and

Name	Description	Comment
	environment should be interpreted.	departments, environmental auditors, and representatives from local government and planning authorities. The guide will also assist applicants of proposals for new developments, infrastructure or sites that may be assessed with reference to the ERS. It will also be of assistance to site owners, environmental managers and consultants.
Construction – guide to preventing harm to people and the environment, EPA Publication 1820.1 (Victorian EPA 2021)	This guide provides information, aimed at construction, to manage environmental risks.	This document highlights the GED obligations as well as linking construction activities to the EP Act and unreasonable noise. Construction noise is not assessed with the Regulations.

5.1 General Environmental Duty

The *Environment Protection Act 2017* (EP Act) is founded on a prevention-based approach to protect human health and the environment from pollution and waste. The EP Act contains environmental duties which apply to all parties who undertake activities that could impact the environment or human health.

General environmental duty (GED) is at the centre of the EP Act and it applies to all Victorians. GED states that a person who is engaging in an activity that may give rise to risks of harm to human health or the environment from pollution or waste must minimise those risks, so far as reasonably practicable.

The concept of minimising risks of harm to human health and the environment, so far as reasonably practicable, requires the person:

- to eliminate risks of harm to human health and the environment so far as reasonably practicable; and
- if it is not reasonably practicable to eliminate risks of harm to human health and the environment, to reduce those risks so far as reasonably practicable.

Under the Act, harm, in relation to human health or the environment, means an adverse effect on human health or the environment (of whatever degree or duration) and includes:

- an adverse effect on the amenity of a place or premises that unreasonably interferes with or is likely to unreasonably interfere with enjoyment of the place or premises; or
- a change to the condition of the environment so as to make it offensive to the senses of human beings; or
- anything prescribed to be harm for the purposes of the Act or the regulations.

Harm may arise as a result of the cumulative effect of harm arising from an activity combined with harm arising from other activities or factors.

To determine what is (or was at a particular time) reasonably practicable in relation to the minimisation of risks of harm to human health and the environment, regard must be had to the following matters:

- the likelihood of those risks eventuating,
- the degree of harm that would result if those risks eventuated
- what the person concerned knows, or ought reasonably to know, about the harm or risks of harm and any ways of eliminating or reducing those risks
- the availability and suitability of ways to eliminate or reduce those risks
- the cost of eliminating or reducing those risks.

In the assessment of noise impacts with reference to GED, consideration must first be given to eliminating risks so far as reasonably practicable, and then to reducing those risks so far as reasonably practicable.

GED imposes a continuing obligation on anyone engaging in an activity that may give rise to a risk to human health and the environment from pollution or waste to take action to eliminate or reduce that risk as far as reasonably practicable. Doing what is reasonably practicable means putting proportionate controls in place to eliminate or reduce the risks of harm. A breach of the GED could lead to criminal or civil penalties.

Table 4 outlines where the statutory environmental duties have been addressed in this document.

Table 4: Environment Protection Act 2017 Duties Compliance Mapping

Duty	Description	Section Reference
General environmental duty (s25-27)	A person who is engaging in an activity that may give rise to risks of harm to human health or the environment from pollution or waste must minimise those risks, so far as reasonably practicable	Section 9.0
Unreasonable noise	A person must not, from a place or premises that are not residential premises emit an unreasonable noise.	Section 9.0
Duty relating to material harm (28)	A person must not engage in conduct that results in material harm to human health or the environment from pollution or waste	Section 9.0

6.0 Reference and Guideline Levels

Construction noise and vibration is to be minimised at all times where practicable on the project.

In Victoria, the EPA does not set construction noise or vibration limits. Instead, target levels or reference levels represent levels at which harm to human health and the environment is more likely to occur. At all times, the contractor must first eliminate risks of harm so far as reasonably practicable, then reduce risks of harm so far as reasonably practicable. If exceedance of reference levels occurs after all reasonably practicable measures have been implemented, then further management actions must be implemented.

6.1 Working Hours

Working hours are as defined by EPA Victoria Publication 1834.1 and are summarised in **Table 5** below.

Table 5: Working Hours According to EPA Publication 1834

Time Period	Applicable
Normal working hours	7am to 6pm Monday to Friday; 7am to 1pm Saturday No work on Sundays or public holidays
Weekend/evening	6pm to 10pm Monday to Friday; 1pm to 10pm Saturday; 7am to 10pm Sundays and public holidays
Night	10 pm to 7 am Monday to Friday

6.2 Airborne Noise

6.2.1 EPA 1834.1

EPA Publication 1834.1 has been adopted as the appropriate guidance document for this assessment as it provides recommended working hours and guideline noise levels relating to construction impacts on residential receivers which are consistent with the performance requirements on this project. Adopting the Publication also provides a consistent approach to assessing and managing construction noise impacts as the Publication has been adopted on various major construction projects across Victoria.

Section 4.1.3 of EPA Publication 1834.1 states:

Complaints about noise and vibration are some of the most common complaints that EPA, councils and businesses involved in civil construction, building and demolition receive.

Noise and vibration can pose a risk of harm to human health and the environment if it is too loud, continues too long, recurs frequently, suddenly increases in level, or includes disturbing sounds such as:

- impulses (banging, hammering)
- tones (squealing, screeching, humming)
- low frequency sound. This can be more intrusive than high frequency sound as it is less attenuated during propagation and when transmitting into buildings. Noise abatement measures are less effective at low frequencies.

For works outside of normal working hours, Table 4.3 of EPA Publication 1834 states the requirements shown in **Table 6** below.

Table 6: EPA Victoria Publication 1834.1 Requirements for Weekend, Evening and Night Works

Time Period	Requirement
Weekend/evening work hours: Monday to Friday – 6:00pm to 10:00pm Saturday – 1:00pm to 10:00pm Sunday – 7:00am to 10:00pm Public holidays – 7:00am to 10:00pm	Noise from non-residential construction at any residential premises not to exceed background noise by: • 10 dB(A) or more for up to 18 months after project commencement • 5 dB(A) or more after 18 months

Time Period	Requirement
Night period: All days – 10:00pm to 7:00am	Noise inaudible* within a habitable room of any residential premises

*The description of inaudible is defined in EPA 1834.1 as follows:

> *Inaudibility is the quality of not being perceptible by ear (i.e., cannot be heard) and cannot be measured in decibels (dB). The requirement for inaudibility relates primarily to adequate scheduling of works.*
>
> *Adequate scheduling would mean, for example, undertaking noisy activities at less sensitive hours, and inherently quiet activities that would be inaudible to people, in the night period.*
>
> *Inaudibility is not meant to be a measurable criterion in dB. It does not only relate to the intensity of the noise, but also to its frequency spectrum, its character and it varies with time.*
>
> *To predict construction noise, a reference level set at the background noise level (LA90 representative of the background at the time of impact) +0 dB could be used as a suitable reference level to assess the risk of audible noise occurring. Where this approach is used, apply adjustments to consider the potential character of the noise that increases its impacts (e.g., tonality, impulsiveness). You should not use this approach for compliance purposes, but only to inform risk assessment regarding the scheduling of works*

The construction noise should be assessed as an L_{Aeq} and compared to the background noise at the time of impact. If the noise presents tonal or impulsive character, apply the following adjustments to the measured or predicted L_{Aeq}:

- +2 dB for a tone just detectable by the observer and +5 dB for a tonal component prominently audible; and
- +2 dB for an impulsiveness just detectable by the observer and +5 dB if it is readily detectable.

An assessment time of 15 minutes is usually considered appropriate.

6.2.1.1 Unavoidable Works

EPA Publication 1834 states the following regarding "unavoidable works":

> *works which pose an unacceptable risk to life or property or a major traffic hazard and can be justified. Includes an activity which has commenced but cannot be stopped. You will need to demonstrate that planned unavoidable works cannot be reasonably moved to normal work hours. This requires additional consideration of potential noise and vibration generating activities and controls to minimise noise and vibration. These can be recorded within the noise and vibration management plan (may be part of a broader environmental management plan).*
>
> *You must contact the relevant authority and seek any necessary approvals for unavoidable works. You should notify affected sensitive receivers of the intended work, its duration and times of occurrence. A noise and vibration management plan may need to be prepared or reviewed by a suitably qualified acoustic consultant or practitioner to address unavoidable works.*

6.2.1.2 Low-Noise or Managed Impact Works

EPA Publication 1834 states the following regarding “low noise impact works” and “managed-impact works”:

> *Low-noise impact works – these are inherently quiet or unobtrusive, for example, manual painting, internal fitouts, and cabling. Low-noise works do not have intrusive characteristics such as impulsive noise or tonal movement alarms. The relevant authority must be contacted, and any necessary approvals sought.*
>
> *Managed-impact works – works where the noise emissions are managed through actions specified in a noise and vibration management plan (may be part of a broader environmental management plan), to minimise impacts on sensitive receivers. Managed-impact works do not have intrusive characteristics such as impulsive noise or tonal movement alarms.*
>
> *You must contact the relevant authority and seek any necessary approvals. A noise and vibration management plan may need to be prepared or reviewed by a suitably qualified acoustic consultant or practitioner.*

6.2.2 Non-residential Noise Sensitive Receivers

Noise from construction activities to non-residential noise sensitive receivers shall be guided by the reference noise levels and considerations detailed in the NSW Interim Construction Noise Guideline (2009) (ICNG) to ensure that the project is meeting it’s obligations in relation to GED.

To determine adverse impacts to non-residential receivers, noise impacts should have regard for the following:

a) The level of construction noise.

b) The duration of construction noise.

c) The presence of any intrusive characteristics as part of the construction noise.

d) The existing ambient noise levels.

e) Consultation with the owner or operator of the noise sensitive receiver.

f) The sensitivity of the receiver to airborne noise that need protection from airborne noise.

g) Any proposed mitigation actions.

h) Is guided by the following constructions reference noise levels in **Table 7**.

Table 7: Construction Noise Reference Levels for Non-residential Receivers

Land Use	Construction Noise Reference Levels, $L_{Aeq,15min}$ (applies when properties are in use)
Classrooms in schools and other education centres including kindergartens	External noise level 55 dB[1]

Land Use	Construction Noise Reference Levels, $L_{Aeq,15min}$ (applies when properties are in use)
Active recreation areas characterised by sporting activities and activities which generate their own noise, making them less sensitive to external noise intrusion	External noise level 65 dB (free-field)
Hospital wards and operating theatres	External noise level 55 dB[1]
Industrial premises	External noise level 75 dB (free-field)
Community Use	External noise level 55 dB[1]
Place of Worship (POW)	External noise level 55 dB[1]
Transport	External noise level 75 dB (free-field)
Commercial	External noise level 70 dB (free-field)
Zoo	NCA background noise levels (See **Section 4.1**)
Note 1: The ICNG nominates indoor construction noise reference levels. A 10 dB difference from indoors to outdoors to allow for passive ventilation through an open window has been applied to the ICNG levels.	

6.2.3 Noise Impact Categories

To assist in the classification of noise impacts, industry standard practice in Victoria is to compare the predicted construction noise levels with the background noise levels for residential receivers and reference levels for non-residential receivers. The background noise levels are determined based on the noise catchment area the residential receiver falls within, see **Section 4.1**; whilst the reference noise levels for non-residential receivers are nominated based on **Table 7.**

Table 8 summarises the noise impact categories These categories are used only for assessing the construction noise impacts during the night when impacts are most intrusive.

Table 8: Noise Impact Categories

Noise Impact Category	Noise Impact Category Detail
Noticeable	Predicted $L_{Aeq,15min}$ construction noise level is 1-10 dB above the background L_{A90} noise level or reference level
Moderate	Predicted $L_{Aeq,15min}$ construction noise level is 11-30 dB above the background L_{A90} noise level or reference level
High	Predicted $L_{Aeq,15min}$ construction noise level is > 30 dB above the background L_{A90} noise level or reference level

Generally the higher the predicted noise impacts, the more substantive management measures are expected to be implemented.

6.3 Ground-Borne Noise

Ground borne noise and vibration is typically not required to be quantitatively assessed for a project of this nature (mostly land-based activities) as direct airborne noise from construction equipment will usually dominate indoor noise levels. Notwithstanding, to minimise the impacts of construction ground borne noise on surrounding residential amenity, management actions shall be considered where:

1. The ground-borne noise reference levels in **Table 9** are predicted or measured to be exceeded during construction; and
2. Airborne noise levels are lower than these ground-borne noise levels in **Table 9**

Table 9: Ground-borne Noise Reference Levels

Time of Day	Ground-borne Noise Reference Levels Internal Noise Level Measured at the Centre of the Most Affected Habitable Room
Evening (6 pm to 10 pm)	$L_{Aeq,15min}$ = 40 dBA
Night (10 pm to 7 am)	$L_{Aeq,15min}$ = 35 dBA

6.4 Construction Vibration

Under the EP Act, any person undertaking an activity that may pose a risk of harm to human health or the environment due to vibration emissions must minimise those risks, so far as is reasonably practicable. As Victoria does not have specific guidance or prescribed limits for managing vibration emissions from construction activities, the 'business as usual' approach is to adopt established standards and guidelines to set target levels for assessing potential impacts. The following sections outline these target levels for the potential onset of cosmetic building damage, impacts on amenity, and the effects on building contents. These levels serve as indicative targets rather than compliance criteria. Where exceedances are predicted or measured, further reasonable management actions should be considered to minimise risks.

6.4.1 Cosmetic Damage to Buildings

British Standard BS7385: Part 2-1993 "Evaluation and measurement for vibration in buildings Part 2" provides criteria against which the likelihood of cosmetic building damage from ground vibration can be assessed. This British Standard is referenced in Australian Standard AS 2187.2-2006.

The standard sets guide values for building vibration based on the lowest vibration levels above which damage has been credibly demonstrated. These levels are judged to result in a minimum risk of vibration-induced damage, where minimal risk for a named effect is usually taken as a 95% probability of no effect.

Sources of vibration that are considered in the standard include demolition, blasting (carried out during mineral extraction or construction excavation), piling, ground treatments (e.g., compaction), construction equipment, tunnelling, road and rail traffic and industrial machinery.

The recommended limits (guide values) for transient vibration to ensure minimal risk of cosmetic damage to residential and industrial buildings are presented numerically in **Table 10** and graphically in **Figure 11.** Minor damage is possible at vibration magnitudes which are greater than twice the values given in **Table 10**, and major damage may occur at four times the magnitude.

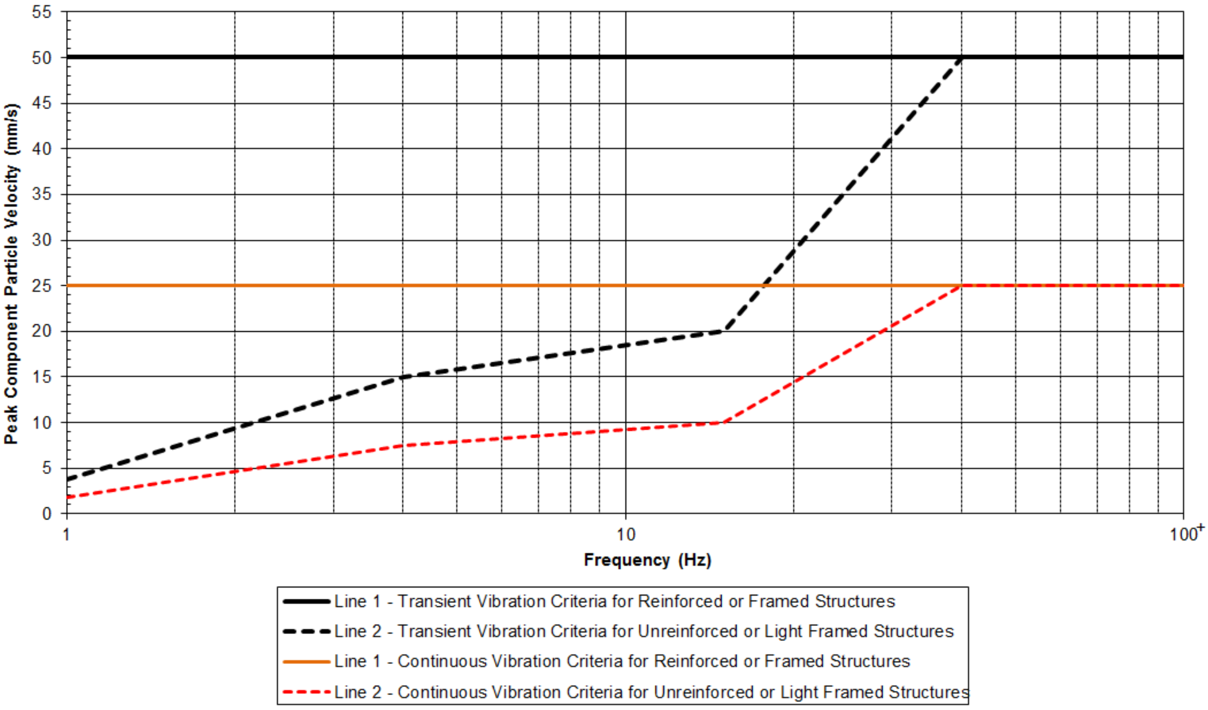
Table 10: Transient Vibration Guide Values – Minimal Risk of Cosmetic Damage

Type of Building	Peak Component Particle Velocity in Frequency Range of Predominant Pulse 4 Hz to 15 Hz
Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above
Unreinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz

The standard states that the guide values in **Table 10** relate predominantly to transient vibration that does not give rise to resonant responses in structures and low-rise buildings.

Where the dynamic loading caused by continuous vibration is such as to give rise to dynamic magnification due to resonance, especially at the lower frequencies where lower guide values apply, then the guide values in **Table 10** may need to be reduced by up to 50%.

Figure 11 Graph of Transient Vibration Guide Values for Cosmetic Damage



For the purposes of this assessment, SLR has assumed that all equipment will trigger the continuous criteria. Based on this assumption, the continuous cosmetic damage criteria shown in **Table 11** would apply.

Table 11: Cosmetic Damage Criteria

Type of Building	Peak Component Particle Velocity Criteria Continuous Criterion
Heavy commercial and industrial buildings	25 mm/s
Residential and light commercial buildings	7.5 mm/s

It is noteworthy that extra to the guide values nominated in **Table 11**, the standard states that:

> *"A building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive."*

6.4.1.1 Heritage Structures in Poor Condition

German standard DIN 4150-3: 2016 provides construction vibration targets in accordance with general industry practice to minimise the risk of structural damage to heritage structures that have a particular sensitivity to vibration. This is interpreted to only be applicable to heritage structure which are in poor condition.

It is recommended that the line 3 criteria are applied to heritage listed structures in poor condition. At this point in time, no such structures have been identified.

6.4.2 Utilities

German standard DIN 4150-3:2016 provides guideline reference levels for buried assets as provided in **Table 12**. Notes are provided for guidance on the application of these levels.

Table 12: Reference Peak Component Particle Velocity for Utility Assets

Type of Building	Peak Component Particle Velocity (mm/s) Criteria Continuous Criterion
Steel (including welded pipes)	100
Clay, concrete, reinforced concrete, prestressed concrete, metal (with or without flange)	80
Masonry, plastic	50

Notes:

a) These reference levels in the table must be reduced by 50% when evaluating the effects of long-term vibration on buried pipework. Long-term vibration relates to events that may result in fatigue of materials or a significant resonant structural response (refer to DIN4150 for guidance on what is considered short-term and long-term).

b) It is assumed pipes have been manufactured and laid using contemporary methods and technology. Where consultation with the asset owner reveals that this is not the case, alternative reference levels shall be established.

c) Representative monitoring of vibration levels during construction is to be undertaken to demonstrate compliance with the relevant reference level.

d) Where a standard, guideline or asset owner's procedures are applied, the measurement locations must reflect those stipulated in the relevant document from which the vibration criteria are adopted.

6.4.3 Amenity

People can sometimes perceive vibration impacts when vibration generating construction works are located close to occupied buildings.

Vibration from construction works tends to be intermittent in nature and the NSW EPA's Assessing Vibration: a technical guideline (2006) provides targets for intermittent vibration based on the Vibration Dose Value (VDV). The 'preferred' and 'maximum' VDVs for human comfort impacts are shown in **Table 13**. The VDV's presented in **Table 13** should be calculated with a Wg-weighting.

Table 13: Vibration Dose Values for Intermittent Vibration

Building Type	Assessment Period	Vibration Dose Value[1] ($m/s^{1.75}$)	
		Preferred	Maximum
Critical Working Areas (eg operating theatres or laboratories)	Day or night-time	0.10	0.20
Residential	Daytime	0.20	0.40
	Night-time	0.13	0.26
Offices, schools, educational institutions and places of worship[2]	Day or night-time	0.40	0.80
Workshops	Day or night-time	0.80	1.60

Note 1: The VDV accumulates vibration energy over the daytime and night-time assessment periods and is dependent on the level of vibration as well as the duration.

6.4.4 Effects on Building Contents

For most receivers, the human comfort vibration targets are the most stringent and it is generally not necessary to set separate criteria for vibration effects on typical building contents.

Exceptions to this can occur when vibration sensitive equipment, such as electron microscopes or medical imaging equipment, are located in buildings near to construction works. No such items of equipment have been confirmed in the surrounding the project area, however it is understood that the John Fawkner Private Hospital includes medical imaging equipment (See **Section 9.3.3**).

7.0 Construction Noise Impact Assessment

This section presents a screening-level construction noise impact assessment prior to controls being implemented for the purposes of informing the project's risks to human health and the environment in relation to construction noise. Broad phases of the project timeline were modelled and do not represent the day-to-day activities during construction. Detailed noise assessments are expected to be developed closer to works commencing as construction methodologies are developed and refined.

7.1 Indicative Construction Scenarios

Based on information provided by the project team and prior experience on similar projects, seven indicative construction scenarios were developed to represent the broad phases of the project timeline shown in **Table 14.** A list of typical equipment for each scenario is detailed in **Section 7.3**.

It is expected that night works will typically be limited to works undertaken during road traffic control or rail occupation whilst working within the rail corridor and therefore classified as 'unavoidable works'. For a project of this nature, it is acknowledged that such unavoidable works would be required for significant night periods. These night work details will be further developed as the project progresses, and a management plan will be developed prior to justifying the works as "unavoidable works".

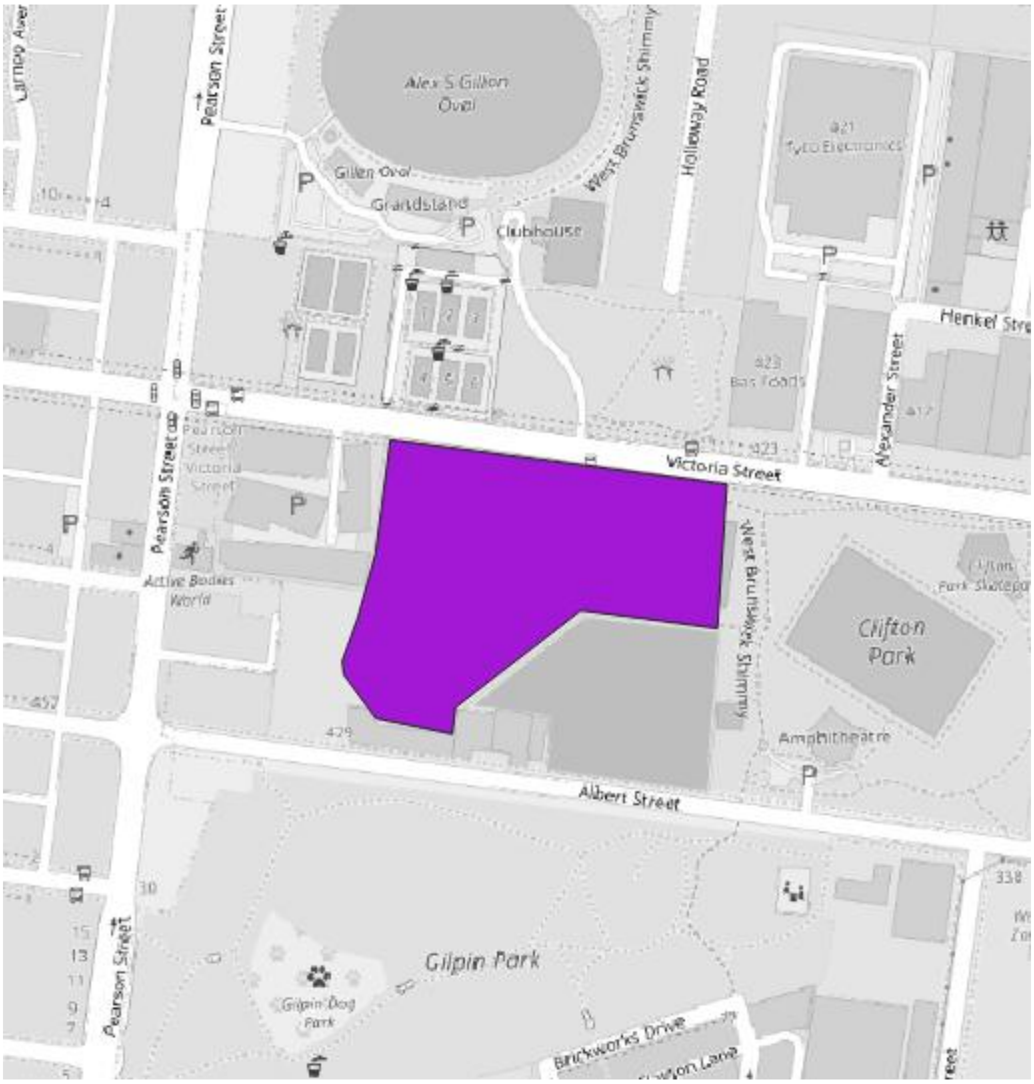
Table 14: Construction Scenario Descriptions

Scenario ID	Scenario Description	Works Period (Typical)	Duration
B.01	Site establishment, earthworks and demolition	Day and night	Multiple weeks over project duration
B.02	Laydown area	Day and night	Multiple weeks over project duration
B.03	Piling, pile breakback and FRP (form reo pour)	Day and night	Multiple weeks over project duration
B.04	Superstructure construction	Day and night	Multiple weeks over project duration
B.05	Asphalting and linemarking	Day and night	Multiple weeks over project duration
B.06	Station Construction	Day and night	Multiple weeks over project duration
B.07	Rail Systems	Day and night	Multiple weeks over project duration

The indicative construction scenarios have been modelled in the assumed works areas shown in **Table 15**. Some scenarios have been further divided up into zones to better represent predicted impacts of large work areas. The highlighted polygons in **Table 15** represent assumed construction work areas for the purpose of characterising noise impacts for this screening-level assessment.

Table 15: Assumed Construction Scenario Works Area

Scenario ID	Assumed Construction Works Area
B.01	

Scenario ID	Assumed Construction Works Area
B.02	

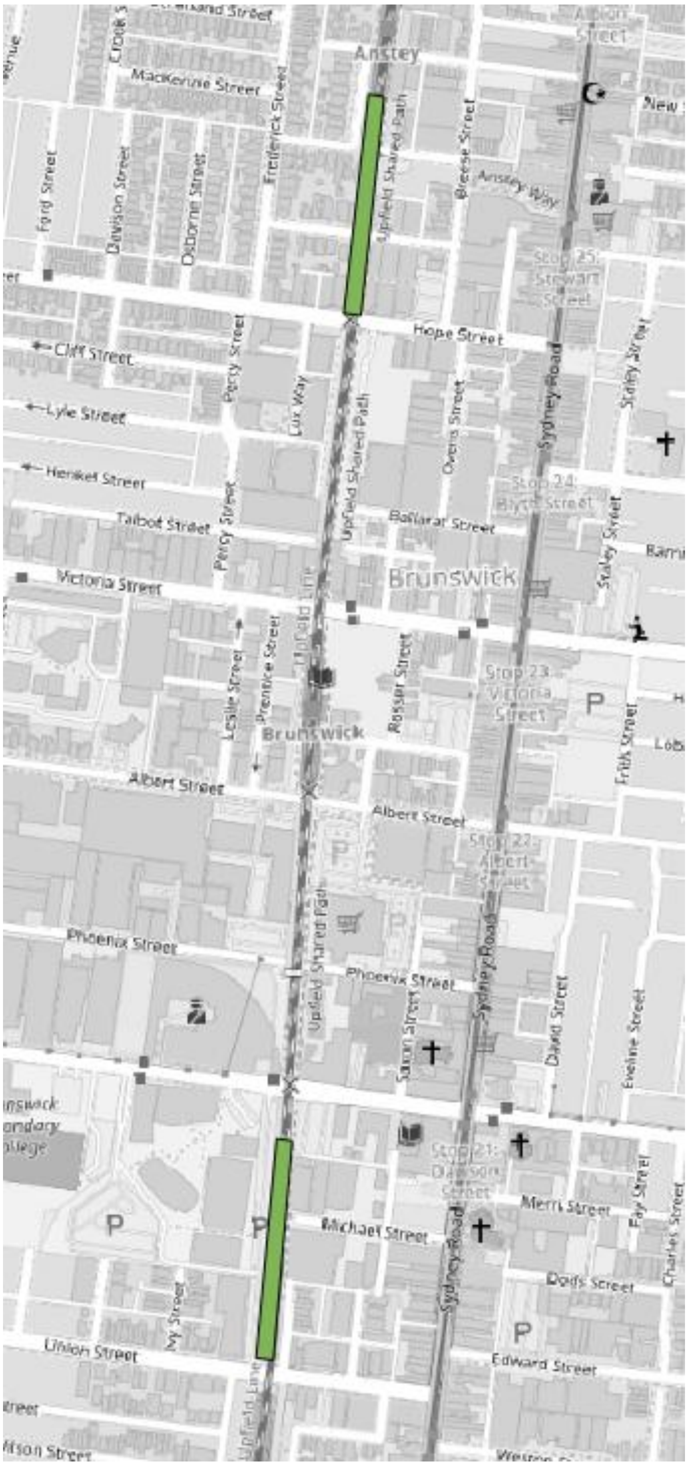
Scenario ID	Assumed Construction Works Area
B.03	

Scenario ID	Assumed Construction Works Area
	

Scenario ID	Assumed Construction Works Area
	

Scenario ID	Assumed Construction Works Area
B.04	

Scenario ID	Assumed Construction Works Area
B.05	

Scenario ID	Assumed Construction Works Area
B.06	

Scenario ID	Assumed Construction Works Area
B.07	

7.2 Noise Modelling Description

A 3D noise model was constructed within the modelling software, SoundPlan 8.2 to predict the noise levels at the nearby receivers for the construction scenarios. The model included elements such as ground topography, ground absorption, buildings, barriers, noise receivers, and noise sources.

The noise levels at the nearby sensitive receivers were calculated using SoundPlan 8.2's implementation of the noise propagation algorithm described in the international standard ISO 9613-2:1996 '*Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation*' (ISO 9613-2).

The following sections outline the modelling assumptions and inputs for the noise model.

7.2.1 General Modelling Assumptions

- The reflection-order off other buildings was set to two, indicating that the noise model allowed for two reflections off facades.
- All source heights were set at 2.0 m above ground level except the rail systems scenario which was set at the height of the proposed rail height.
- All receiver heights were set at 1.5 m above ground level and at subsequent floors above.
- Construction activities were nominally modelled as area sources. Each noise source applies the worst-case modelling assumption that all the construction activity was positioned at the nearest location to each receiver.
- All equipment were assumed to be operating for the entire 15-minute assessment period, unless otherwise stated. It is acknowledged that this assumption is conservative in nature but is deemed appropriate for this assessment in order to estimate worst-case impacts.
- The receivers in the noise model were fixed at 1.0 m from the facades of the buildings (but modelled as free-field).
- The ISO 9613-2 noise propagation algorithm assumes light down-wind conditions which aims to simulate a typical worst-case noise enhancing meteorological situation.
- Noise controls were not considered in the modelling considering the early stages of the planning where detailed construction methodologies are not available.

7.2.2 Ground Absorption

Ground absorption is a measure between 0 and 1, of the amount of noise that is absorbed by the ground during the propagation of noise over a distance. A ground absorption of 0 indicates hard ground which is highly noise reflective whereas a ground absorption of 1 indicates soft ground which is highly absorptive. The noise propagation algorithm uses these ground absorption values to calculate the noise levels at the noise sensitive receivers. Based on a review of the aerial imagery, the overall ground absorption was modelled as 0.3.

7.3 Construction Equipment

Table 16 presents the equipment and associated sound power levels for each indicative construction scenario. Noise levels for each equipment were sourced using a combination of publicly available data such as (DEFRA 2005) and SLR's own noise emission database developed from field measurements of equipment. Noise emission data is based on an average $L_{Aeq\ 15\ minute}$ noise emission for each equipment item operating 100% of the time.

Tonal and impulse corrections are incorporated via a generalised method described in the Noise Protocol EPA 1826.4 and supporting EPA 1997 *Technical guide: Measuring and analysing industry noise and music noise*. Given the dynamic and evolving nature of construction, the equipment listed in **Table 16** represents a indicative, typical worst-case activity during each broad phase of the project.

Table 16: Equipment and Sound Power Levels for Each Construction Scenario

	Equipment	Total Lw (dBA)	Asphalt - Truck and Sprayer	Compactor	Crane - Fixed	Crane Franna (20 tonne)	Elevated Work Platform	Excavator - Tracked (3 tonne)	Excavator - Tracked (20 tonne)	Grader	Generator - attenuated	Grinder	Jackhammer with noise blankets	Lighting - Daymaker	Light Vehicle - 4WD	Line Marking Truck	Loader - skidsteer (1/2 tonne)	Piling Rig - Bored	Roller - Vibratory	Saw - Concrete	Truck - Dump	Truck - Medium Rigid (20 tonne)	Truck - Vacuum (non-destructive digger)	Hand tools (electric)	Concrete agitator truck	Concrete pump truck	Gantry Crane	Modular transporter	Tamper
	Sound Power Level (Lw)		105	106	104	98	97	90	100	111	90	105	110	90	95	93	97	109	109	118	102	95	109	98	104	104	115	107	118
	Estimated utilisation in assessment period (%)		100%	100%	100%	100%	100%	100%	100%	100%	100%	50%	100%	100%	100%	50%	50%	100%	50%	25%	25%	25%	50%	50%	100%	100%	50%	100%	10%
ID	**Construction Scenario**																												
B.01	Site establishment, earthworks and demolition	**117**				1			1	1	1		1		1				1	1		1	1	1					
B.02	Laydown area	**96**												1			1					1							
B.03	Piling, pile breakback and FRP (form reo pour)	**114**				1			1				1					1							1	1			
B.04	Superstructure construction	**114**			1	1	1							1	1							1					1	1	
B.05	Asphalting and linemarking	**112**	1					1	1	1						2					1	1							
B.06	Station Construction	**107**																				1		1	1	1			
B.07	Rail Systems	**110**							1			1												1					1

7.4 Predicted Noise Impacts

Based on the noise modelling described in **Section 7.1**, **Section 7.2** and **Section 7.3**, the $L_{Aeq,15min}$ noise levels have been predicted at nearby noise sensitive receivers for each indicative construction scenario.

Table 17 presents the summary of predicted worst-case noise impacts for night works. The predicted noise impacts are expressed as the number of noise sensitive receivers above the background noise level for residential receivers (see **Section 4.1)** or reference level for non-residential receivers (see **Section 6.2.2**) and categorised as per **Section 6.2.3**. The results are presented as buildings, not properties. This is important as there are a number of buildings around the construction footprint which are apartments and contain many properties within.

The predictions are based on the shortest separation distance to each sensitive receiver. In practice, the distances will vary between equipment and sensitive receivers. This is particularly notable for works that move along the alignment which would reduce noise exposure at each receiver as the works progress past the receiver.

The predicted impacts in **Table 17** will not occur during the entire construction phase. Rather, the predicted impacts are representative only of certain periods where intensive works are in closest to the individual sensitive receiver. It is acknowledged that these predictions are conservative in nature but is deemed appropriate for this assessment in order to estimate typical worst-case impacts.

Table 17: Construction Noise Impact Summary

Noise Category	Number of Buildings Per Scenario																					
	B.01 Zone 1	B.01 Zone 2	B.01 Zone 3	B.01 Zone 4	B.01 Zone 5	B.01 Zone 6	B.02	B.03 Zone 1	B.03 Zone 2	B.03 Zone 3	B.03 Zone 4	B.03 Zone 5	B.03 Zone 6	B.04 Zone 1	B.04 Zone 2	B.04 Zone 3	B.04 Zone 4	B.04 Zone 5	B.04 Zone 6	B.05	B.06	B.07
Assessment Period	Night	Night	Night	Night	Night	Night	Night	Night	Night	Night	Night	Night	Night	Night	Night	Night	Night	Night	Night	Night	Night	Night
Worst-case receiver noise level, dBA	99	113	112	111	116	109	87	89	87	92	92	94	90	96	110	109	108	113	106	109	102	84
Number of buildings above noise target																						
Between 1 dB and 10 dB above background or reference level	582	644	989	1921	1100	828	65	721	1262	1876	2728	1778	1835	568	660	1067	1898	1159	1318	2695	1166	2912
Between 11 dB and 30 dB above background or reference level	473	744	671	1101	1120	1917	11	323	575	324	425	702	446	378	609	362	660	793	1334	1412	338	956
Greater than 30 dB above background or reference level	72	184	33	38	125	62	3	22	64	18	14	76	8	55	132	25	25	102	38	280	27	10

Table 17 shows predicted noise impacts during night works are to be expected throughout the entire construction timeline of the project.

Where high noise impacts are predicted (corresponding to ‘Greater than 30 dB above background or reference level’), these are generally confined to the first two rows of properties interfacing the works, except during Site Establishment works which have high impacts generally confined to approximately 100 m from the works.

These impacts are based on typical worst-case scenarios. In practice whilst it is expected that isolated periods of impacts like those modelled will occur, there will be periods of respite where construction noise impacts are substantially less.

These predicted screening-level noise impacts are generally consistent with previous level crossing removal projects construction noise impacts within suburban areas in Melbourne.

Construction noise predictions are based on typical worst-case scenarios which do not represent the ongoing day-to-day noise impact at noise sensitive receivers for an extended period. Rather, they are representative only of certain periods where intensive works are in proximity to the individual sensitive receiver.

Likewise, the predictions use the shortest separation distance to each sensitive receiver. In practice, the distances will vary between equipment and sensitive receivers. It is acknowledged that these predictions are conservative in nature but is deemed appropriate at this stage in order to estimate worst-case impacts.

Detailed modelling closer to works commencing as described in **Section 9.0** will incorporate modelling inputs that are based on actual proposed equipment and locations allowing for informed consideration of management measures.

When the controls presented in **Section 9.0** are considered and implemented so far as reasonably practicable, it is expected the noise impacts associated with construction will not unreasonably affect the local community and be adequately managed in line with the requirements of the EP Act. It is understood that LXRP have adequately managed this level of impacts with appropriate management controls on past similar projects.

8.0 Construction Vibration Assessment

This section presents a screening-level construction vibration impact assessment prior to controls being implemented for the purposes of informing the project's risks to human health and the environment in relation to vibration. It characterises the potential risks to cosmetic damage to nearby structures, amenity concerns for human comfort, and impacts to vibration sensitive equipment.

This assessment focuses exclusively on piling and vibratory rolling which are considered as the primary vibration generating activities during construction.

8.1 Minimum Safe Working Distances

Preliminary guidance for the protection of cosmetic damage and human comfort is provided in **Table 18** using the "safe working distances" recommended by Transport for New South Wales (TfNSW) Construction Noise and Vibration Guideline (CNVG). They are based on empirical data which suggests that where works are further from receivers than the quoted minimum distances then impacts are not considered likely.

The minimum working distances for human comfort relate to continuous vibration. For most construction activities, vibration emissions are intermittent and for this reason, higher vibration levels occurring over shorter periods are acceptable.

This guidance represents a conservative approach and aids in determining safe working proximity to achieve vibration level values in **Section 6.4**.

Where structures lie within the safe working distance for corresponding works, additional considerations provided in **Section 9.0** should be investigated (where feasible and practicable).

Various sizes of vibratory rollers are provided as specific compaction equipment is yet to be selected.

Table 18 Recommended Minimum Working Distances from Vibration Intensive Equipment

Plant Item	Rating/Description	Minimum Distance		
		Cosmetic Damage		Human Response (NSW EPA Guideline)
		Residential and Light Commercial (BS 7385)	Heavy Commercial and Industrial (BS 7385)[1]	
Vibratory Roller	<50 kN (1–2 tonne)	5 m	2.5 m	15 m to 20 m
	<100 kN (2–4 tonne)	6 m	3 m	20 m
	<200 kN (4–6 tonne)	12 m	6 m	40 m
	<300 kN (7–13 tonne)	15 m	7 m	100 m
	>300 kN (13–18 tonne)	20 m	10 m	100 m
	>300 kN (>18 tonne)	25 m	12 m	100 m

[1] Calculated adjustment from 7.5 mm/s PPV to 25 mm/s PPV based on a generic site coefficient of -1.6 from on AS 2187.2-2006.

Plant Item	Rating/Description	Minimum Distance		
		Cosmetic Damage		Human Response (NSW EPA Guideline)
		Residential and Light Commercial (BS 7385)	Heavy Commercial and Industrial (BS 7385)[1]	
Piling Rig – Bored	≤ 800 mm	2 m (nominal)	2 m (nominal)	4 m
Note 1: Should the bore diameter of the piling rig be greater than 800 mm, the minimum working distances for controlling cosmetic damage and minimising human response would be increased.				

8.2 Screening-Level Assessment of Vibration Impacts

For the purposes of characterising the screening-level potential vibration impacts, the following has been assumed:

- Vibratory rolling could occur anywhere within the areas corresponding to B.01 in **Table 15**
- Piling works could occur in the areas corresponding to B.03 in **Table 15**
- Residential buildings to be triggered if above BS 7385 7.5 mm/s PPV level
- Non-residential buildings to be triggered if above the BS 7385 25 mm/s PPV level
- All heritage structures assumed to not be particularly sensitive to vibration and in good condition.

Table 19 presents the number of buildings predicted to infringe within the safe working distances. Where buildings are predicted to infringe the safe working distances, this represents the nominated construction vibration targets have an increased potential to be exceeded.

Table 19: Summary of Vibration Assessment Results

Plant/Equipment	Receiver Type	Number of Buildings Within Safe Working Distance for Cosmetic Damage	Number of Buildings Within Safe Working Distance for Human Comfort
Vibratory roller <50 kN (1–2 tonne)	Residential	52	100
	Non-residential	32	60
Vibratory roller <100 kN (2–4 tonne)	Residential	56	119
	Non-residential	34	87
Vibratory roller <200 kN (4–6 tonne)	Residential	82	224
	Non-residential	39	140
Vibratory roller <300 kN (7–13 tonne)	Residential	100	574
	Non-residential	41	314
Vibratory roller >300 kN (13–18 tonne)	Residential	119	574
	Non-residential	48	314
Vibratory roller >300 kN (>18 tonne)	Residential	144	574
	Non-residential	52	314

Plant/Equipment	Receiver Type	Number of Buildings Within Safe Working Distance for Cosmetic Damage	Number of Buildings Within Safe Working Distance for Human Comfort
Pile (boring)	Residential	0	1
	Non-residential	0	0

Table 19 shows that piling works are generally low risk based on the number of properties triggered to be within the safe working distance and is likely to be readily managed. **Table 19** further shows that impacts from compaction works are expected due to vibratory rollers likely infringing the safe working distances. Whilst vibratory compaction may generate vibration impacts on this Project, they have been shown on previous level crossing removal projects to be effectively managed through a combination of the measures listed in **Section 9.2**.

It is important to note that a conservative assessment has been conducted. The vibration response of structures is dependent on specific building types, where structures of heavy or reinforced construction are less susceptible to building damage from vibration. Likewise, the minimum safe working distances are meant to be indicative in nature and do not take into consideration local geotechnical information. Further, the minimum safe working distances assume constant vibration levels, however in practice, equipment typically operates intermittently and mobile plant such as compaction rollers operate over an area, not just at the worst-case position. Lastly, it is unlikely that compaction works would occur throughout the entire project area (as has been modelled). Rather the bulk of the compaction works would likely be isolated to the station areas thus substantially reducing the number of properties potentially exposed to vibration impacts.

8.2.1 Utilities

Whilst specific information regarding underground utilities is not yet available, it is known that there exists underground pipework which is not new and has not manufactured and laid in line with contemporary methods. A detailed assessment shall be conducted as details emerge and where high-risk utilities are identified. Based on previous experience on level crossing removal projects in Melbourne that had underground assets in poor condition nearby to construction works, the impacts to underground pipework in poor condition can be successfully managed with close collaboration between the asset owners, the acoustic consultant, and the managing contractor. Advice relating to the management of vibration impacts to underground utilities is provided in **Section 9.2**.

For the purposes of this assessment, the following provides a provisional safe working distance[2] to utilities in good condition.

- Static compaction techniques: Can compact directly over utilities provided engineering loads are calculated and deemed acceptable
- 1-2t Vibratory roller: 2.5 m
- 2-4t Vibratory roller: 3 m
- 4-6t Vibratory roller: 6 m
- 7-13t Vibratory roller: 7 m
- 13-18t Vibratory roller: 10 m

[2] The attenuation with distance has been based on a generic site coefficient of -1.6 based on AS 2187.2-2006.

- > 18t Vibratory roller: 12 m
- < 45t Bored Piling rig: 1 m

8.3 Vibration Sensitive Equipment

The only identified sensitive receiver within the study area which is known to contain vibration sensitive equipment is the John Fawkner Private Hospital, of which is approximately 300 m from the closest point of the construction boundary. From previous experience, offset distances of this magnitude typically protect vibration sensitive equipment (such as X-ray machines, MRIs, etc.) from inaccurate measurements and generally presents a low risk. Notwithstanding, it is expected that the Project will engage with the Hospital to further understand any concerns and potential risk of noise and vibration effects.

8.4 Ground-borne Noise Impacts

For above-ground construction activities near residential land uses, the airborne noise levels transmitting through the building envelope are typically in the range of 15 dB to 25 dB higher than the ground-borne noise levels indoors in the most affected habitable space. Therefore, minimising airborne noise emissions so far as reasonably practicable will generally provide sufficient management of potential ground-borne noise impacts.

One exception to this may occur when a residential building is shielded significantly by a barrier or narrow commercial/industrial building from vibration generating construction works. A review of the aerial imagery and land uses shows that this scenario does not obviously occur within the project study area.

Based on the above assessment, the best-practice management measures presented in **Section 9.0** will effectively manage the likely minimal impacts from ground-borne noise.

8.5 Summary of Vibration Impacts

Prior to controls being implemented modelling of vibration levels to the surrounds shows vibration targets are expected to be exceeded generally only for vibratory rolling. This indicates vibration impacts are possible for cosmetic building damage and amenity during vibratory rolling. It is important to note that a conservative assessment has been conducted. The vibration response of structures is dependent on specific building types, where structures of heavy or reinforced construction are less susceptible to building damage from vibration. Likewise, the minimum safe working distances are meant to be indicative in nature and do not take into consideration local geotechnical information. Further, the minimum safe working distances assume constant vibration levels, however in practice, equipment typically operates intermittently and mobile plant such as compaction rollers operate over an area, not just at the worst-case position. Lastly, it is unlikely that compaction works would occur throughout the entire project area (as has been modelled). Rather the bulk of the compaction works would likely be isolated to the station areas thus substantially reducing the number of properties potentially exposed to vibration impacts (only approximately 20% of the properties may be impacted if compaction is limited to station precincts only).

Nevertheless, provided the controls in **Section 9.0** are appropriately considered and implemented so far as reasonably practicable, construction vibration impacts can be effectively managed to comply with the requirements of the EP Act and are unlikely to result in significant adverse effects for prolonged periods or at a regional or State context.

9.0 Construction Noise and Vibration Management Implementation

9.1 Response to General Environmental Duty

In order to fulfill its duties under GED, the project team must demonstrate that it has identified the potential risks to human health and environment for the delivery of the project. Further, the project team must develop a system for assessing, controlling, and minimising those risks as far as reasonably practicable as required by s25(4) of the Environment Protection Act 2017. Specific actions that the project will take to control the works must then be implemented, documented, and monitored throughout the life of the project.

The framework for GED is illustrated through a wheel diagram as referenced in the EPA publication 1820.1 – Construction Guide to preventing harm to people and the environment, identifying the four principal steps: identify, assess, implement, and check. It is based on a widely adopted approach to evidence and risk- based decision making. This approach has been implemented in the development of this assessment and is stepped out in **Figure 12**.

Figure 12 Wheel Diagram of GED Framework

9.1.1 Identify Hazards

This assessment identifies potential hazards and impacts relating to noise and vibration impacts as presented in **Table 20.**

Table 20: Hazard Identification

Hazard	Impact
Noise from works resulting in impact to residents or businesses	Disturbance to sensitive receivers; potential for complaints; loss of social licence to operate
Vibration from works resulting in impact to residents or businesses	Disturbance to sensitive receivers; project delays; complaints; loss of social licence to operate; damage to infrastructure
Emergency works undertaken outside of Normal Working Hours	Disturbance to sensitive receivers; potential for complaints

Hazard	Impact
Construction traffic noise impacting local amenity	Complaints; community backlash; loss of social licence to operate
Construction vibration impacting utility assets	Project delays; damage to infrastructure; straining relationship with service providers; loss of social licence to operate
Construction vibration impacting vibration-sensitive equipment	Project delays; damage to infrastructure; straining relationship with service equipment owner; loss of social licence to operate
Cumulative impacts of construction noise and noise from other major construction sites impacting the same sensitive receivers	Disturbance to sensitive receivers; project delays (limiting productivity may be required); complaints; construction fatigue

9.1.2 Assess Risk

This report may be used by the project to assess the risk of harm to human health and the environment from noise and vibration impacts prior to controls being applied. Where works in this report are shown to generate noise and vibration risks, targeted noise modelling and detailed vibration assessments shall be undertaken, as detailed in **Section 9.2**.

9.1.3 Implement Controls

The project is responsible for implementing reasonably practicable controls to manage risk that have been identified and assessed. To determine what are reasonably practicable controls, the following factors shall be considered:

1. Eliminate first: Can you eliminate the risk?
2. Likelihood: What's the chance that harm will occur?
3. Degree (consequence): How severe could the harm be on human health or the environment?
4. Your knowledge about the risks: What do you know, or what can you find out, about the risks your activities pose?
5. Availability and suitability: What technology, processes or equipment are available to control the risk? What controls are suitable for use in your circumstances?
6. Cost: How much does the control cost to put in place compared to how effective it would be in reducing the risk?

Noise and vibration management measures to be implemented are listed in **Section 9.2**, noting that this is not an exhaustive list and additional controls may be required to adequately manage the risks. The management controls should be reviewed further in detail as the design progresses.

9.1.4 Check Controls

Controls shall be monitored throughout the project to evaluate their effectiveness and identify any changes that may be required to further reduce the risk of harm to human health and the environment so far as reasonably practicable, in accordance with GED. The development and implementation of the procedure for monitoring controls is the responsibility of the project team.

9.2 General Project Management Measures

Whilst screening-level modelling shows noise and vibration impacts during each construction stage on this Project, these impacts are expected to be effectively managed through a combination of the following measures.

Table 21 presents management measures that shall be considered in each delivery phase of the project so far as reasonably practicable. These measures are based on EPA 1834.1 and industry best practice, and shall be considered in conjunction with:

1. Construction noise and vibration targets outlined in **Section 6.0**, with specific reference to its broad application detailed in **Section 9.1.**
2. Any relevant project specific plans and sub-plans.

The measures listed in **Table 21** are in line with LXRP 'business as usual' practices and do not include any measures beyond what has been adopted on previously delivered projects. It is however noted that the listed management measures are not exhaustive and additional measures shall be considered where appropriate.

Table 21: Potential Construction Noise and Vibration Management Measures

Aspect	Potential Management Measure
Noise and vibration impact on sensitive receivers – Construction Noise and Vibration Management Plan	Prior to commencement of the construction phase, develop a Construction Noise and Vibration Management Plan (CNVMP) that details how noise and vibration impacts will be managed during construction of the project. The CNVMP shall at a minimum include: - Project overview - Identify land uses and sensitive receivers surrounding the Project - Legislation and requirements - Noise and vibration reference and target levels - Management strategy including response to General Environmental Duty, general and specific management measures, approach to detailed noise and vibration modelling, out of hours works approval process and complaints management system - Noise and vibration monitoring, review and continual improvement
Noise and vibration impact on sensitive receivers – Land use survey	Land uses surrounding the Project site identified in this document may change by the time construction commences. Accurate land use and building data information is important for noise and vibration modelling and the associated community engagement. As such, a land use survey may be conducted to update the land use geospatial information utilised in this assessment.
Noise and vibration impact on sensitive receivers – Scheduling	Schedule works to Normal Working Hours so far as reasonably practicable
	Schedule works to less sensitive periods around non-residential noise-sensitive land uses
	Where practical, works will be scheduled so that simultaneous operation of noisy plant can be undertaken to expedite the construction process near sensitive receivers
	Where practical, implement adaptive measures to provide periods of respite for high noise activities, near to sensitive receivers
	Truck and delivery movements to be restricted, where possible, to Normal Working hours.
	Servicing, refuelling and warm-up to be undertaken during Normal Working Hours
Noise and vibration impact on sensitive receivers –	Only plant and equipment specified in the approved Permit to Notify (PTN) for disruptive work is utilised on site and works are only undertaken in specified locations within Permit

Aspect	Potential Management Measure
Plant/equipment	Select the quietest available equipment / process capable of reasonably completing the task
	Noise levels of plant and equipment should be considered in rental decisions
	Where practical and given the geology, utilise equipment with a cutting action, rather than an impact action, such as road header or milling head over a hydraulic hammer
	Implement mufflers/silencers on plant and equipment
	Undertake regular maintenance of plant and equipment, including silencers, to ensure that noise emissions do not increase over time
	Consider plant used intermittently should be shut down or throttled down to a minimum in between use
	Where practical, delivery vehicles should be fitted with straps rather than chains for unloading near residential areas
	Ensure that truck tailgates are cleared and locked at the point of unloading
	Ensure all mobile construction equipment that would be on-site for more than two days have non-tonal reversing alarms
	Ensure all mobile construction equipment that would be on-site for night works have non-tonal reversing alarms
	Vehicle warning devices, such as horns, will not be used as signalling devices
Noise and vibration impact on sensitive receivers – Siting considerations	Plan works so that the offset distance between plant and residences should be maximised so far as reasonably practicable
	Locate plant and equipment to take advantage of barriers provided by existing site features and structures so far as reasonably practicable
	Consider plant emitting noise in a particular direction should be directed away from residences
	Site access points, roads and construction traffic routes should be located as far as possible from residential areas
	Restrict construction traffic speed to 20 km/h across the site, or 40 km/h for haul roads, and signpost the speed limit
	Restrict construction traffic to designated roads, to be managed through stakeholder consultation
Noise and vibration impact on sensitive receivers – Barrier controls	Utilise temporary noise barriers around fixed noise sources so far as reasonably practicable
	Utilise site hoarding to reduce noise levels at neighbouring sensitive receivers so far as reasonably practicable
Noise and vibration impact on sensitive receivers – Communications / respite / relocation / community engagement / document control	Noise and vibration requirements and management measures are documented in subcontractor contracts
	Works outside Normal Working Hours must be either Unavoidable, Managed Impact or Low Noise Impact Works
	Permit to Notify (PTN) for disruptive works is approved prior to works commencing
	Sensitive receivers and appropriate management measures are included in pre-works documentation

Aspect	Potential Management Measure
	Implement notification procedures as per relevant plans.
	Develop and implement respite and relocation procedures in-line with industry best practice.
	Implement acoustic treatment offers if required
	Liaise with Melbourne Zoo to determine any animal-specific noise/vibration targets if applicable.
	Communicate potential noise and vibration impacts to nearby stakeholders (RMIT, Melbourne Zoo etc.) prior to works commencing. Discussions shall include at a minimum: - potential scheduling arrangements around sensitive periods - identifying special receivers at stakeholder's premises that may require targeted consideration of management controls
Noise and vibration impact on sensitive receivers – Worker behaviour	Sensitive receivers, noise and vibration impacts and appropriate management measure are communicated to all workers on-site
	No swearing or unnecessary shouting or loud stereos/radios on-site
	No unnecessary dropping of materials from height, throwing of metal items and slamming of doors
Damage to buildings and structures – Building condition surveys	Building condition surveys shall be undertaken for vibration sensitive receivers identified as potentially exposed to vibration cosmetic damage impacts from construction works, as guided by the safe working distances in **Section 8.0**. Surveys are to take place prior to commencement and on completion of vibration generating works.
Damage to buildings, structures and utilities – Detailed modelling	Consider conducting detailed vibration modelling where buildings, structures and utilities are considered at a high-risk of vibration impact. Where required for such assessments, a structural engineer may be engaged to provide advice on vibration limits.
Damage to buildings and structures – validation testing for improving vibration predictions	Where detailed vibration modelling indicates potential exceedances, validation testing may be considered that includes attended vibration measurements where a statistical relationship between vibration level and distance from the works is established. This is sometimes referred to as "site-law" testing and can be used to update and improve the modelled vibration impacts.
Damage to buildings and structures – vibration monitoring	To minimise the risk construction related cosmetic damage, it is recommended that attended vibration testing be conducted at the commencement of works with the potential to infringe the minimum safe working distances identified in **Section 8.0**; or where detailed modelling closer to the commencement of works indicates impacts are likely. Where the attended monitoring or detailed modelling indicates that structures may still be close to or over the nominated reference levels, then it is recommended that the construction methodology be reviewed and unattended vibration monitors to warn plant operators (via flashing light, audible alarm or SMS) be placed on representative structures to monitor peak vibration levels over the duration of the vibration intensive works. A warning level at 80% of the relevant criteria shall be applied in addition to a threshold level at 100% of the criteria which alerts the project team of potential vibration impacts.

Aspect	Potential Management Measure
	A stop-works procedure shall be prepared in advance and applied when alerts occur at 100% threshold level which should include, at a minimum, the following: • Stop works when alerts are triggered. • Investigate the cause of the trigger. • Investigate any potential damage caused. • Consider altering construction methodology. • Consider any reporting or consultation to be undertaken. • Restart works documenting the details of the exceedance/alert. Given the number of buildings which are predicted to exceed the nominated vibration targets, it is impractical to monitor vibration at each of these buildings. As such, a compromise should be made by selecting vibration monitoring locations using the following considerations: • A representative sample across the entire project. • Bias towards the most affected building or buildings, knowing that buildings further away are likely to have lower impacts. • Bias should be given to heritage buildings. • Bias should be given to more vibration sensitive buildings. • Consideration shall be given to structures which have particular social value and which are community sensitive.
Damage to buildings and structures & vibration related amenity – complaints-based vibration monitoring	Vibration monitoring should be carried out in response to valid vibration complaints.
Damage to buildings and structures – construction methodology for piling and vibratory rolling	Where feasible and practicable, modify the construction methodology near sensitive vibration receivers to reduce the predicted vibration impacts. This could include: • Consider the selection of vibration generation plant with the lowest source vibration levels (e.g. lighter vibratory rollers, static rollers, etc.) to reasonably complete the task. This should be considered on the balance of lower vibration generating plant may increase the duration of the works.
Noise impacts on sensitive receivers – Construction Noise Impact Assessments	Prior to any high impact or out of hours construction works occurring, the construction activity shall be modelled that takes as inputs: • Works area • Works equipment/plant • When the works are occurring • Any temporary noise barriers assumed • General information relating to the works (e.g. description, permit number etc.) The output of the modelling shall be a report that: • Details the inputs • Presents the noise impacts for each impacted receiver and provides guidance to the communications and stakeholder team on which

Aspect	Potential Management Measure
	management measures are required to be considered under the relevant project sub-plan. • Makes clear where tonality and impulse adjustments have been applied
Noise impacts on sensitive receiver – Baseline monitoring	Baseline monitoring was undertaken previously for the Project. Further background noise monitoring can still be undertaken by a suitably trained noise monitoring person, provided no construction activities are occurring.
	Consider conducting additional background noise monitoring at Melbourne Zoo.
Noise impacts on sensitive receiver – Attended or *smart* validation monitoring	Noise monitoring will be undertaken throughout construction works to monitor construction noise levels and validate construction noise predictions. The routine attended noise monitoring program will include: • Identified high noise impact construction activities • At the commencement of new major construction activities on site (such as starting demolition, first night of out of hours works, etc.). • In response to complaints. • Routine periodic monitoring • In response to specific requests for monitoring by key stakeholders. • Where identified attended monitoring is required as part of the permit process approvals. Substantial differences in noise tests and predictions should trigger an update to the source noise levels used for the modelling. When routine attended noise monitoring is conducted, the monitoring methodology will be undertaken in general accordance with AS1055:2018 *Acoustics – Description and measurement of environmental noise using a calibrated sound level meter*. At a minimum the following parameters will be recorded as part of the monitoring process: • Date and time of measurement • Name of person conducting measurements • Sound level meter details: serial number, calibration status, wind sock present, etc. • Measurement location (GPS or equivalent) • Measurement descriptor and frequency weighting • Weather conditions (wind, rain, etc) • Overview of construction activities being monitored • Overview of general ambient environment (i.e. distant traffic noise present) and environment (free field or reflective surface) • Description of nature and character of sound (steady vs. intermittent, low frequency, tonal, etc). The equipment used shall be a Class 1 or Class 2 sound level meter and associated calibrator. The parameter to measured is the $L_{Aeq,15min}$. Alternatively, *smart* continuous monitoring systems that have the ability to detect noise based on directionality, along with audio and visual information recording features to appropriately detect the source of noise can be used to replace attended monitoring.

Aspect	Potential Management Measure
Noise impacts on sensitive receivers – Unattended (24/7 continuous) noise monitoring	Unattended continuous (24/7) noise monitoring is recommended to be used throughout high noise generating works at, or near the most affected noise sensitive receivers, to understand the trend of noise over the course of the works, respond to complaints with data correlation and identify any noise sources if the equipment has visual and audio information capture capabilities linked to noise levels.

9.3 Specific Sensitive Receivers

In addition to the general best-practice controls listed in the previous section, specific management controls may be required for special sensitive receivers such as the Melbourne Zoo and the RMIT campus uses.

9.3.1 Melbourne Zoo

At this preliminary stage of the project, the details of the actual construction equipment and procedures are not available, and engagement with the Zoo is in progress. However, considering the separation distance from the work area and the location of the Zoo with tall walls around its boundary, it is anticipated that the project would be able to adequately manage impacts to the Zoo with specific controls in place.

Melbourne Zoo is understood to have an established noise management strategy to protect occasional noisy events within or around the Zoo affecting their animals. Given this context, the following should be addressed:

- Review Melbourne Zoo’s established noise and vibration management strategy and
    - Comply with their strategy so far as reasonably practicable.
    - Incorporate relevant aspects of their strategy into the Projects CNVMP were appropriate.
- Consult with Melbourne Zoo to understand specific sensitivities within the premises:
    - Certain animals may be more sensitive to noise compared to others.
    - The nature of sound that may impact animal comfort (impulsive vs stead state vs tonal, etc.).
    - Any specific spectral characteristics depending on the animals hearing spectrum.
- Undertake baseline noise monitoring at specific locations within the zoo after consultation.
    - Establish existing exposure of noise to animals from patrons and zoo events (such as exhibits, music, and other events).
- Establish specific criteria based on animal sensitivities and baseline levels.
- Any noise impact assessments of specific works within the vicinity of the Zoo should consider an assessment against the establish specific criteria.
- Based on the assessment outcomes, management plans should be developed and implemented in consultation with the Zoo so far as reasonably practicable.

9.3.2 RMIT Brunswick Campus

It is understood that this RMIT campus focuses courses related to fashion, textiles and industrial design. The campus is not understood to house any bioresources or medical equipment which may be sensitive to vibration or regenerated noise (these are only housed in their City and Bundoora campuses). Nevertheless, consultation with RMIT is ongoing and if any vibration sensitive resources are identified, they should be assessed against relevant criteria using detailed modelling and baseline monitoring. The assessment would typically involve determining the source vibration level, predicting the propagation via the ground, building foundation and floors, and compare against equipment requirements or best-practice vibration threshold levels for the subject equipment use. Typical management of vibration effects, if required, would involve appropriate scheduling of works when sensitive equipment are not used, or additional vibration isolation to the equipment platform if feasible.

RMIT is understood to have active teaching and learning spaces, including research labs, where a suitably quiet ambience may be essential when they are in use. In addition, they are likely to host specific events and exams which may be more sensitive to noise than other typical working days. Consequently, construction activities should be scheduled away from these sensitive periods as far as reasonably practicable to reduce the noise impact to RMIT during these sensitive periods to adequately manage impacts.

9.3.3 John Fawkner Private Hospital

At this preliminary stage, John Fawkner Private Hospital has been identified to be the only likely sensitive receiver which is known to contain vibration sensitive equipment. Considering the large separation distance from the construction compound, the impact assessment notes a low risk of impact to these potential equipment. Nonetheless, consultation with the John Fawkner Private Hospital should be undertaken by LXRP to confirm the existence or otherwise of vibration sensitive equipment, and also any potential concerns from the Hospital. In the unlikely event where impacts are noted by the hospital, a detailed assessment and management by a qualified acoustic consultant can be undertaken to implement any controls so far as reasonably practicable.

9.4 Respite and Relocation

Residents living close to construction sites may be affected by construction noise and vibration. Noise and vibration impacts will vary depending on the location of property and the type and duration of construction activity.

Based on current industry best practice, it is expected that the Project team will develop a respite and relocation plan to effectively manage targeted periods of higher noise and vibration impacts which cannot be practicably and safely be completed during normal business hours.

The respite and relocation plan would typically include proactively managing temporary residential relocation and respite for overnight, out of hours and highly disruptive works, including laydown and site access impacts.

The plan should include:

- assessing likely noise and vibration levels once the works method, time and equipment used are confirmed
- identifying and assessing stakeholders potentially impacted by noise in the early stages of planning
- documenting and maintaining the information for the duration of the Project or activities

- engaging and/or notifying the community before and during construction using email and letterbox notifications, telephone calls and door knocking residents, where possible.
- a dedicated team to manage community impacts, queries and concerns
- implementing and maintaining a process for managing enquiries and complaints, including the Big Build contact centre available 24 hours a day, 7 days a week
- offering alternative accommodation or respite to eligible residents for overnight works over two or more consecutive nights. Relocation must be offered to provide an alternative location for sleep during periods of extended nightworks. The project team should liaise with residents to source suitable accommodation. Relocation accommodation is typically provided locally with kitchen and laundry facilities.

Respite options that should be considered include (but are not limited to):

- cinema vouchers
- restaurant vouchers
- leisure activity vouchers
- white noise machines
- noise cancelling headphones
- ear plugs.

Note that this is ‘business as usual’ practice for LXRP and does not represent measures beyond what has been adopted on previous projects.

9.5 Complaints Management System

A project information line shall be established through which residents can obtain further information or register complaints regarding the carrying out of works, including the effect of construction works on residential amenity.

Residents who were offered respite or alternative accommodation but did not take up the offer prior to construction commencing may contact the project at any time during the carrying out of the relevant works to request respite or alternative accommodation via the project information line. The project team must respond within one calendar day to these requests.

Residents who have not received offers of respite or alternative accommodation but who believe their residential amenity is or will be adversely impacted by construction works may register a request for assessment via the project information line. The project team must respond within one calendar day to these requests.

This is a ‘business as usual’ practice for LXRP and does not represent measures beyond what has been adopted on previous projects.

10.0 Conclusion

A construction noise and vibration assessment has been carried out to quantify potential impacts and compare them to the adopted targets.

Indicative construction scenarios have been developed based on information provided by the project team with indicative equipment associated with each scenario. Each scenario was developed to represent broad phases of the project timeline to assist in quantifying worst-case impacts during construction.

Project specific construction noise and vibration management requirements and guidelines are detailed in **Section 6.0**.

Section 7.0 presents a study of construction noise impacts. **Section 8.0** presents the assessment of construction vibration impacts.

Section 9.0 provides the construction noise and vibration management implementation including the response to GED and the potential management measures for the project. The management measures listed in **Section 9.0** are in line with LXRP 'business as usual' practices, EPA 1834 and industry best practice, and do not include any measures beyond what has been adopted on previously delivered LXRP projects. The listed management measures are not exhaustive and additional measures shall be considered if appropriate.

10.1 Construction Noise Summary of Impacts

A noise model comprising construction noise sources, buildings, terrain etc., has been developed to characterise potential noise impacts from construction activities to nearby noise sensitive receivers, prior to the implementation of controls.

Noise modelling of the construction scenarios found some level of noise intrusion are predicted for all construction activities should they occur during the night. Where high impacts were predicted, these are generally confined to the first two rows of properties interfacing the works, except during Site Establishment works which have high impacts generally confined to approximately 100 m from the works.

These noise impacts are similar to previous level crossing removal projects within suburban areas in Melbourne. Recommended best practice noise management processes, including detailed modelling, monitoring and the implementation of management measures are detailed in **Section 9.0**.

The construction noise predictions were high level in nature and do not represent the ongoing day-to-day noise impact at noise sensitive receivers for an extended period. Rather, they are representative only of certain periods where intensive works would be in proximity to the individual sensitive receiver. Likewise, the predictions use the shortest separation distance to each sensitive receiver. In practice, the distances will vary between equipment and sensitive receivers. It is acknowledged that these predictions are conservative in nature at this stage of the project, and further work is expected to be undertaken to refine predictions and manage potential impacts appropriately.

10.2 Construction Vibration Summary of Impacts

Minimum safe working distances around vibration intensive construction works have been developed to protect cosmetic building damage and amenity (human comfort) of nearby vibration sensitive receivers as outlined in **Section 8.0**.

Where structures are predicted to be within the building cosmetic damage and amenity minimum safe working distances, there is potential for these construction activities to exceed the associated construction vibration management levels. This risk is greatest during vibratory rolling works but may infrequently occur for piling works as well. Recommended best practice vibration management processes, including detailed modelling, monitoring, dilapidation surveys and the implementation of management measures are detailed in **Section 9.0**.

It is important to note that a conservative assessment was conducted. The vibration response of structures is dependent on specific building types, where structures of heavy or reinforced construction are less susceptible to building damage from vibration. Likewise, the minimum safe working distances are meant to be indicative in nature and do not take into consideration local geotechnical information. Further, the minimum safe working distances assume constant vibration levels, however in practice, equipment typically operates intermittently and mobile plant such as compaction rollers operating over an area, not just at the worst-case position as modelled. Therefore, the worst-case impacts predicted may last only for a few days at each receiver across the entire construction program.

Specific information regarding underground utilities is not yet available, however it is noted that there may be underground assets which have not been laid with contemporary methods and be potentially more susceptible to vibration. Setback distances provided in **Section 8.2.1** would typically be sufficient to protect underground assets that are in good condition, but may still require a detailed assessment, particularly if nominated by the asset owner. Where underground assets are identified to be in poor condition, close collaboration with the asset owner, project team and an acoustic consultant is recommended. Active vibration monitoring of intensive works and adapting works methodology as required are expected to ensure appropriate management of potential vibration impacts.

10.3 Overall Project Summary

Based on the results of this assessment, the project is expected to generate some level of construction noise and vibration impacts. The impacts predicted however are based on a conservative assessment to estimate worst-case or maximum possible impacts without management or engineering controls in place. Notwithstanding, the management measures detailed in this report are expected to be adopted to minimise potential risks so far as reasonably practicable, and the impacts are expected to be adequately managed in line with the requirements of the EP Act and not expected to cause significant adverse effects in a regional or State context that would require further assessment under the Environment Effects Act 1978. It is noted that LXRP have delivered numerous level crossing projects with similar construction methodologies prior to this project and have previous experience implementing most of the noise and vibration management measures listed in this report.

Appendix A Terminology

Brunswick Level Crossing Removal Project

Construction Noise and Vibration Impact Assessment

Level Crossing Removal Project

SLR Project No.: 640.30625

19 August 2025

Sound Level or Noise Level

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

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

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

‘A’ Weighted Sound Pressure Level

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

People’s hearing is most sensitive to sounds at mid frequencies (500 Hz to 4,000 Hz), and less sensitive at lower and higher frequencies. Thus, the level of a sound in dBA is a good measure of the loudness of that sound. Different sources having the same dBA level generally sound about equally loud.

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

Table A-1: Typical noise levels

Sound Pressure Level (dBA)	Typical Source	Subjective Evaluation
130	Threshold of pain	Intolerable
120	Heavy rock concert	Extremely noisy
110	Grinding on steel	
100	Loud car horn at 3 m	Very noisy
90	Construction site with pneumatic hammering	
80	Kerbside of busy street	Loud
70	Loud radio or television	
60	Department store	Moderate to quiet
50	General Office	
40	Inside private office	Quiet to very quiet
30	Inside bedroom	
20	Recording studio	Almost silent

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

Sound Power Level

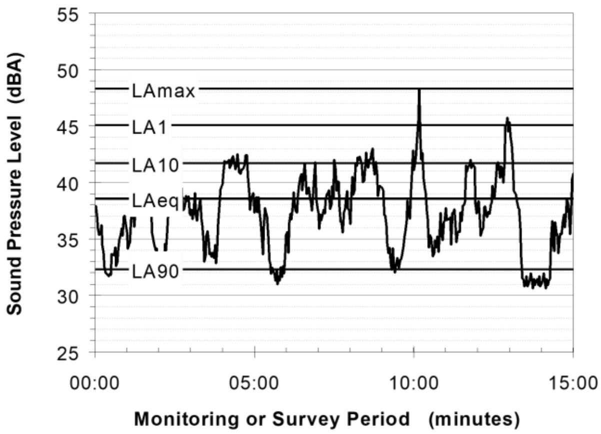
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or LW, or by the reference unit 10-12 W.

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

Statistical Noise Levels

Sounds that vary in level over time, such as road traffic noise and most community noise, are commonly described in terms of the statistical exceedance levels LAN, where LAN is the A-weighted sound pressure level exceeded for N% of a given measurement period. For example, the LA1 is the noise level exceeded for 1% of the time, LA10 the noise exceeded for 10% of the time, and so on.

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



Of particular relevance, are:

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

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

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

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

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

This method produces a level representing the 'repeatable minimum' LA90 noise level over the daytime and night-time measurement periods, as required by the EPA. In addition, the method produces mean or 'average' levels representative of the other descriptors (LAeq, LA10, etc).

Tonality

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

Impulsiveness

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

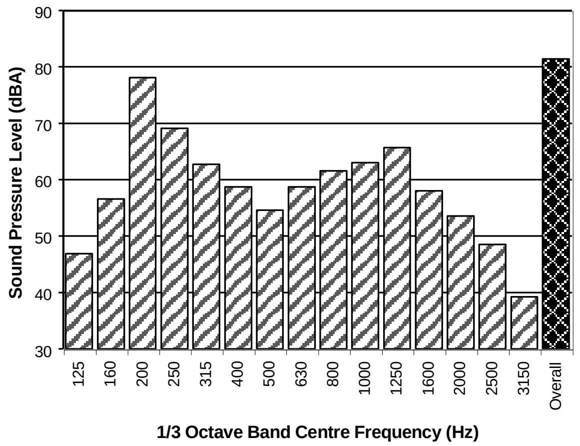
Frequency Analysis

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

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

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

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



Vibration

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

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

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

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

Human Perception of Vibration

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

Over-Pressure

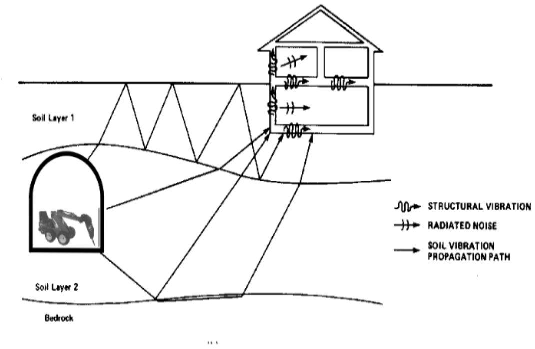
The term 'over-pressure' is used to describe the air pressure pulse emitted during blasting or similar events. The peak level of an event is normally measured using a microphone in the same manner as linear noise (ie unweighted), at frequencies both in and below the audible range.

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

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

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

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



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

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