Transport for NSW

Penrith Station Upgrade

Noise and vibration impact assessment

October 2015

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Glossary

Term	Description
Ambient noise	The all-encompassing noise associated within a given environment. It is the composite of sounds from many sources, both near and far.
Background noise	The underlying level of noise present in the ambient noise, excluding the noise source under investigation, when extraneous noise is removed. This is described using the L_{A90} descriptor.
dB	Decibel is the unit used for expressing the sound pressure level (SPL) or power level (SWL) in acoustics.
dBA	Decibel expressed with the frequency weighting filter used to measure 'A-weighted' sound pressure levels, which conforms approximately to the human ear response, as our hearing is less sensitive at low and high frequencies.
DECC	Department of Environment and Climate Change
DECCW	Department of Environment, Climate Change and Water
EPA	Environment Protection Authority
Groundborne vibration	Groundborne vibration is vibration transmitted from source to receiver via the medium of the ground.
ICNG	*Interim Construction Noise Guideline* (DECC, 2009).
INP	*Industrial Noise Policy* (EPA, 2000).
$L_{A90(period)}$	The A-weighted sound pressure level that is exceeded for 90% of the time over which a given sound is measured. This is considered to represent the background noise e.g. $L_{A90(15\ min)}$.
$L_{Aeq(period)}$	Equivalent sound pressure level: the steady sound level that, over a specified period of time, would produce the same energy equivalence as the fluctuating sound level actually occurring.
$L_{Amax(period)}$	The maximum sound pressure level over a specified period of time.
Mitigation	Reduction in severity.
Noise sensitive receiver	An area or place potentially affected by noise which includes: • a residential dwelling. • an educational institution, library, childcare centre or kindergarten. • a hospital, surgery or other medical institution. • an active (e.g. sports field, golf course) or passive (e.g. national park) recreational area. • commercial or industrial premises. • a place of worship.
Rating Background Level	The overall single-figure background level representing each assessment period (day/evening/night) over the whole monitoring period. This is the level used for assessment purposes.
RNP	*Road Noise Policy* (DECCW, 2011).
Tonality	Noise containing a prominent frequency or frequencies characterised by definite pitch.
V_{rms}	The vibration velocity presented as a root mean square value.
Vibration	The variation of the magnitude of a quantity which is descriptive of the motion or position of a mechanical system, when the magnitude is alternately greater and smaller than some average value or reference. Vibration can be measured in terms of its displacement, velocity or acceleration. The common units for velocity are millimetres per second (mm/s).

1. Introduction

1.1 Overview

The Transport Access Program (TAP) is an initiative of Transport for NSW (TfNSW) to provide a better experience for public transport customers by delivering accessible, modern, secure and integrated transport infrastructure where it is needed most.

As part of the program, TfNSW proposes to undertake works at Penrith Station to improve accessibility (Penrith Station Upgrade, 'the Proposal'). GHD Pty Ltd (GHD) was commissioned by TfNSW to undertake an operational and construction noise and vibration impact assessment for the Proposal.

The noise and vibration impact assessment has been undertaken with consideration to the following guidelines:

- *Assessing Vibration: a Technical Guideline* (DEC, 2006)
- *Construction Noise Strategy* (CNS) (TfNSW, 2012)
- *Industrial Noise Policy* (INP) (EPA, 2000)
- *Interim Construction Noise Guideline* (ICNG*)* (DECC, 2009)
- *Road Noise Policy* (RNP) (DECCW, 2011)
- *Sydney Trains Environmental Management System Guide Noise and Vibration from Rail Facilities* (Sydney Trains, 2013).

1.2 Scope

The following tasks were undertaken as part of this noise and vibration impact assessment:

- Site visit to identify surrounding sensitive receivers potentially impacted by construction and operational noise associated with the Penrith Station Upgrade
- Review of background noise levels from the *Penrith Substation Upgrade Review of Environmental Factors* (TfNSW January 2014) and attended noise monitoring to quantify the level of existing construction noise in the area
- Assessment of potential operational noise impacts in accordance with the INP
- Assessment of potential construction noise impacts in accordance with the ICNG and the CNS
- Assessment of potential construction traffic noise
- Assessment of potential construction vibration
- Providing options for reasonable and feasible noise management measures if required in accordance with the CNS.

2. Existing environment

2.1 Sensitive receivers

Noise and vibration sensitive receivers are defined based on the type of occupancy and the activities performed in the land use. Sensitive noise and vibration receivers could include:

- residences
- educational institutes
- hospitals and medical facilities
- places of worship
- passive and active recreational areas such as parks, sporting fields, golf courses (Note that these recreational areas are only considered sensitive when they are in use or occupied)
- commercial or industrial premises.

The following sensitive receivers and land uses have been identified in close proximity to the Proposal:

- Residences located on The Crescent and Lemon Grove Road over 500 m to the east of Penrith Station
- One residence located along Lawson Street, over 500 m to the south east of Penrith Station
- Residences located along Union Road over 500 m to the south of Penrith Station
- Residential premises in the Urban Growth site to the north of Penrith Station. This site is currently being developed
- Thornton playground, 290 m north-east of Penrith Station
- Nepean TAFE College, 150 m to the south-east of Penrith Station.

The majority of the surrounding area (including the area directly south of Penrith Station) is comprised of commercial and industrial premises.

Additionally, transient receivers (such as commuters and pedestrians) have the potential to be impacted for short periods from construction noise.

Representative sensitive receivers were selected for modelling and assessment purposes and are detailed in Table 2-1 and shown in Figure 1. Commercial and industrial premises have not been individually assessed though noise impacts on these premises are discussed in Section 4.1.2.

Table 2-1 Sensitive receiver locations

Receiver ID	Receiver address	Receiver type
R1	Nepean TAFE College	Educational
R2	55 Lemon Grove Road	Residential
R3	Thornton Playground	Recreational (Active)
R4	78 Lord Sheffield Circuit (Nearest identified residential receiver in the Urban Growth area)	Residential
R5	18 Lawson Street	Residential
R6	109 Station Street	Residential

Legend

- Noise monitoring location (GHD, 2015)
- Noise monitoring location (Aurecon, 2013)
- Sensitive receiver

Paper Size A4

0 85 170 340

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Transport for NSW
Penrith Station Upgrade

Job Number 21-24130
Revision A
Date 25 Sep 2015

Noise monitoring location
and representative sensitive receivers

Figure 1

G:\21\24130\GIS\Maps\Deliverables\21-24130-Z005_SensitiveReceiversPenrith.mxd

Level 15, 133 Castlereagh Street, Sydney NSW 2000 Australia **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com **W** www.ghd.com

Data source: Google Earth Pro, Aerial imagery, 2015; DPI, land zoning, 2015. Created by:Afoddy

2.2 Noise monitoring

2.2.1 Background noise

Background noise monitoring was not undertaken for the project due to existing construction activities at the Urban Growth development site directly north of Penrith Station. However, attended noise monitoring was undertaken to quantify the existing level of construction noise in the area (refer to Section 2.2.2).

Additionally, noise data for the noise assessment were sourced from the *Penrith Substation Noise & Vibration Assessment* (Aurecon, January 2014). This monitoring was attended and undertaken in October and November 2013 by Aurecon. The Aurecon noise monitoring location is shown on Figure 1 and the data is summarised in Table 2-2. It is assumed that the Aurecon data is valid and correct for this assessment- verification of the data has not been undertaken by GHD.

Table 2-2 Aurecon attended noise monitoring summary, dBA

Location	Time	$L_{A90(15min)}$	$L_{Aeq(15min)}$	L_{Amax}
13 Lemon Grove Road, Penrith	Day	43	48	67
	Night	38	41	63

No construction was occurring in the area at the time of the measurements, therefore, the above attended measured noise levels have been considered representative of the background noise levels at residential receivers located away from the Penrith Station and the commercial area. No noise data for the evening time period were provided- hence, the night time Aurecon noise levels have been conservatively assumed as the background for the evening time period.

2.2.2 Attended noise monitoring

Attended noise monitoring was undertaken on 12 November 2014 to quantify the existing level of construction noise. Noise monitoring was undertaken at the eastern end of The Crescent as shown on Figure 1. Noise monitoring was undertaken using a Rion NL-52 sound level meter within calibration for a period of 30 minutes (two 15 minute measurements).

A summary of the attended background and ambient noise levels are summarised in Table 2-3.

The ambient noise levels are typical of an urban area influenced by rail noise. Existing construction noise from the Urban Growth site was audible at the site and generally ranged from 55 dBA to 68 dBA.

Table 2-3 GHD attended noise monitoring summary, dBA

Time	$L_{A90(15min)}$	$L_{Aeq(15min)}$	L_{Amax}	Observations
12:26 pm	49	64	79	General noise sources: Train events on the adjacent railway line, road traffic noise from North Street. A summary of the construction noise levels is as follows: • General construction 55 to 60 dBA • Construction grinding 58 to 60 dBA.
12:42 pm	47	56	74	General noise sources: Train events on the adjacent railway line, road traffic noise from North Street. A summary of the construction noise levels is as follows: • General construction 60 to 68 dBA • Construction grinding 58 to 65 dBA • Material dropping 58 to 68 dBA.

3. Compliance criteria

The noise and vibration compliance criteria during operation and construction of the Proposal are presented in the following section as follows:

- Construction noise criteria (Section 3.1)
- Construction vibration criteria (Section 3.2
- Operational noise criteria (Section 3.3).

3.1 Construction noise criteria

3.1.1 Construction noise management levels

The ICNG outlines standard hours for construction activities as Monday to Friday: 7 am to 6 pm, Saturday: 8 am to 1 pm and no work on Sundays or public holidays. The ICNG acknowledges that the following activities have justification to be undertaken outside the recommended standard construction hours assuming that all reasonable and feasible mitigation measures are implemented to minimise the impacts to the surrounding sensitive land uses:

- the delivery of oversized plant or structures that police or other authorities determine to require special arrangements to transport along public roads
- emergency work to avoid the loss of life or damage to property, or to prevent environmental harm
- works where a proponent demonstrates and justifies a need to operate outside the recommended standard construction hours
- works which maintain noise levels at receivers to below the noise management levels outside of the recommended standard construction hours.

The CNS separates out of hours works (OOHW) into two periods:

- OOHW Period 1: Monday to Friday 6 pm to 10 pm, Saturday 7 am to 8 am and 1 pm to 10 pm and Sunday/Public Holidays 8 am to 6 pm
- OOHW Period 2: Monday to Friday 10 pm to 7 am, Saturday 10 pm to 8 am and Sunday/Public Holidays 6 pm to 7 am.

It is anticipated that some construction activities would be required to be undertaken during OOHW Period 1 and OOHW Period 2. These would be classified as works *where a proponent demonstrates and justifies a need to operate outside the recommended standard construction hours* due to the busy nature of the railway station and the limitations of undertaking various construction activities in a live rail environment (i.e. need to undertake works during possession periods for safety and other operational reasons).

Table 3-1 and Table 3-2 detail the ICNG construction noise management levels at sensitive land uses and residences near the Proposal, respectively, where:

- The noise affected noise management level represents the point above which there may be some community reaction to noise. Where the predicted or measured $L_{Aeq(15min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details

- The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account:
  - times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences)
  - if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.

A strong justification would typically be required for works outside the recommended standard hours. The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5 dBA above the noise affected level, the proponent should consult with the community.

For transient receivers, the external noise level of 75 dBA could be considered acceptable as the receiver would be exposed to the noise source for a short duration.

Table 3-1 Construction noise management levels at residences

Time of day	Management level $L_{Aeq(15min)}$
Recommended standard hours: • Monday to Friday 7 am to 6 pm • Saturday 8 am to 1 pm • No work on Sundays or public holidays	Noise affected Rating background level plus 10 dBA
	Highly noise affected 75 dBA
Outside recommended standard hours	Noise affected Rating background level plus 5 dBA

Table 3-2 Construction noise management levels at sensitive land uses

Land use	Management level, $L_{Aeq(15min)}$ (when in use)
Industrial premises	External noise level 75 dBA
Offices and retail outlets	External noise level 70 dBA
Classrooms at schools and educational institutes	Internal noise level 45 dBA
Recreational area (Active)	External noise level 65 dBA

3.1.2 Sleep disturbance criteria during construction

The ICNG states that where construction works are planned to extend over more than two consecutive nights, the noise impact assessment should include maximum noise levels and the extent and number of times the maximum exceeds the rating background levels.

The INP application notes regarding sleep disturbance recommend that where the $L_{A1(1min)}$ or L_{Amax} exceeds the $L_{A90(15min)}$ by more than 15 dBA outside the bedroom window, a more detailed analysis is required.

The ICNG also refers to the *Environmental Criteria for Road Traffic Noise* (EPA, 1999) for more guidance on sleep disturbance from maximum noise level events. This guideline has since been superseded by the *Road Noise Policy*. Both guidelines provide a discussion on research into the effects of maximum noise events on sleep disturbance. The results of this research is aimed at limiting the level of sleep disturbance due to environmental noise and concludes that the L_{Amax} or $L_{A1(1min)}$ level of any noise should not exceed the ambient $L_{A90(15min)}$ noise level by more than 15 dBA. This guideline takes into account the emergence of noise events, but does not directly limit the number of such events or their highest level, which are also found to affect sleep disturbance.

The *Road Noise Policy* provides further guidance, which indicates that:

- maximum internal noise levels below 50–55 dBA are unlikely to cause awakening reactions
- one or two noise events per night with maximum internal noise levels of 65–70 dBA are not likely to significantly affect health and wellbeing.

For this assessment the background level plus 15 dBA has been used as a screening level assessment of sleep disturbance which is consistent with the *Industrial Noise Policy* (application notes and the *Sydney Trains Environmental Management System Guide Noise and Vibration from Rail Facilities* (refer to Table 3-3).

3.1.3 Proposal specific construction noise criteria

The construction noise criteria for the proposed construction activities during recommended standard hours and outside of the recommended standard hours are provided in Table 3-3 for each sensitive receiver and are based on Table 3-1, Table 3-2 and the *Sydney Trains Environmental Management System Guide Noise and Vibration from Rail Facilities* (Sydney Trains, 2013) guidance on sleep disturbance. The background noise levels used to calculate the construction noise criteria have been based on the Aurecon measurements as discussed in Section 2.2.1.

Table 3-3 Proposal specific construction noise criteria, dBA

Receiver	Construction noise management level, $L_{Aeq(15min}$					Sleep disturbance screening test L_{Amax} (external)
	During recommended standard hours[1]		Outside of recommended standard hours			
	7 am to 6 pm Monday to Friday, 8 am to 1 pm Saturday, no work on Sunday or public holidays		Day 7 am to 8 am and 1 pm to 6 pm Saturday, 8 am to 6 pm Sunday & Public Holidays	Evening 6 pm to 10 pm Monday to Sunday & Public Holidays	Night 10 pm to 7 am, Monday to Saturday; 10 pm to 8 am Sunday & Public Holidays	Night 10 pm to 7 am, Monday to Saturday; 10 pm to 8 am Sunday & Public Holidays
	Noise affected	Highly noise affected				
Residential receivers	53	75	48	43[2]	43	53
Classrooms at Nepean TAFE College[1]	55	-	-	-	-	-
Thornton Playground	65	-	-	-	-	-
Commercial receivers	70	-	-	-	-	-
Industrial receivers	75	-	-	-	-	-

Note 1: A 10 dBA noise reduction is assumed from outside to inside the building.

Note 2: Based on night-time background noise levels

3.1.4 Traffic noise criteria

The application notes for the *Road Noise Policy* (DECCW 2011) state that *"for existing residences and other sensitive land uses affected by additional traffic on existing roads generated by land use developments, any increase in the total traffic noise level as a result of the development should be limited to 2 dB above that of the noise level without the development. This limit applies wherever the noise level without the development is within 2 dBA of, or exceeds, the relevant day or night noise assessment criterion."*

This has been used to identify potential impacts as a result of noise produced by construction traffic and the potential for reasonable and feasible mitigation measures to be applied. If road traffic noise increases as a result of construction work and lies within 2 dBA of current levels then the objectives of the *Road Noise Policy* (DECCW 2011) are considered to be met and no specific mitigation measures would be required.

3.2 Construction vibration criteria

3.2.1 Human comfort

Vibration has been assessed based on the criteria in *Assessing Vibration: a technical guideline*. *British Standard (BS) 6472 – 1992, Guide to Evaluation of Human Exposure to Vibration in Buildings (1 Hz to 80 Hz)* is recognised by the guideline as the preferred standard for assessing the 'human comfort criteria'.

Typically, construction activities generate ground vibration of an intermittent nature. Intermittent vibration is assessed using the vibration dose value. Acceptable values of vibration dose are presented in Table 3-4 for sensitive receivers.

Whilst the assessment of response to vibration in *BS 6472-1:1992* is based on vibration dose value and weighted acceleration, for construction related vibration, it is considered more appropriate to provide guidance in terms of a peak value, since this parameter is likely to be more routinely measured based on the more usual concern over potential building damage.

Humans are capable of detecting vibration at levels which are well below those causing risk of damage to a building. The degrees of perception for humans are suggested by the vibration level categories given in *BS 5228.2 – 2009, Code of Practice Part 2 Vibration for noise and vibration on construction and open sites – Part 2: Vibration,* as shown below in Table 3-5.

Table 3-4 Human comfort intermittent vibration limits (BS 6472-1992)

Receiver type	Period[1]	Intermittent vibration dose value ($m/s^{1.75}$)	
		Preferred value	Maximum value
Residential	Day	0.2	0.4
	Night	0.13	0.26
Educational institutes	When in use	0.4	0.8

Note 1: Day is between 7 am and 10 pm and night is between 10 pm and 7 am

Table 3-5 Guidance on effects of vibration levels for human comfort (BS 5228.2 – 2009)

Vibration level	Effect
0.14 mm/s	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction.
0.3 mm/s	Vibration might be just perceptible in residential environments.
1.0 mm/s	It is likely that vibration at this level in residential environments will cause complaints, but can be tolerated if prior warning and explanation has been given to residents.
10 mm/s	Vibration is likely to be intolerable for any more than a very brief exposure.

3.2.1 Cosmetic damage

The *Construction noise strategy* refers to BS 7385 Part 2– 1993 *Evaluation and measurement for vibration in buildings Part 2* to assess the effects of transient vibration on structures. The BS 7385 values are presented in Table 3-6.

Table 3-6 Transient vibration guide values – minimal risk of cosmetic damage (BS 7385-2)

Type of building	Peak component particle velocity in frequency range of predominant pulse	
	4 Hz to 15 Hz	15 Hz and above
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	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above.

The conservative cosmetic damage value of 15 mm/s has been used in this assessment, where data is not provided in the CNS.

Guidance of limiting vibration values for heritage structures, or other structures particularly sensitive to vibration, is attained with reference to German Standard *DIN 4150-3: 1999 Structural Vibration – Part 3: Effects of vibration on structures* (refer to Table 3-7). The conservative value of 3 mm/s presented in the 1 Hz to 10 Hz range has been used to derive the safe working distances for heritage structures in this assessment. Note that safe working distances are not provided in the CNS for heritage structures.

Table 3-7 Guideline values for short term vibration on structures (DIN 4150-3) used for heritage structures

Type of structure	Guideline values for velocity, (mm/s)		
	1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz[1]
Buildings used for commercial purposes, industrial buildings, and buildings of similar design.	20	20 to 40	40 to 50
Dwellings and buildings of similar design and/or occupancy.	5	5 to 15	15 to 20
Structures that, because of their particular sensitivity to vibration, cannot be classified under lines 1 and 2 and are of great intrinsic value (for example heritage listed buildings).	3	3 to 8	8 to 10

3.3 Operational noise criteria

The INP provides guidance on the assessment of operational noise impacts. The guidelines include both intrusive and amenity criteria that are designed to protect receivers from noise significantly louder than the background level and to limit the total noise level from all sources near a receiver.

The intrusive noise criteria controls the relative audibility of operational noise compared to the background level at residential receivers. The intrusive criteria are determined by a 5 dBA addition to the measured (or adopted) background level with a minimum of 35 dBA. The INP recommends that the intrusive noise criteria for the evening period should not exceed the daytime period and the night-time period should not exceed the evening period. The intrusive noise criteria are only applicable to residential receivers.

The amenity criteria limits the total level of extraneous noise for all receiver types. The amenity criteria are determined based on the overall acoustic characteristics of the receiver area, the receiver type and the existing level of noise from commercial or industry in the area. Amenity criteria are also provided for residential receiver areas and other sensitive land uses such as schools, hospitals, places of worship and recreational areas.

Both the intrusive and amenity criteria are calculated and, in the case of continuous noise sources, the lower of the two in each time period (day, evening and night) normally apply.

3.3.1 Proposal specific operational noise criteria

The operational noise criteria for sensitive receivers within proximity to the Proposal are summarised in Table 3-8. The background noise levels used to calculate the operational noise criteria have been based on the Aurecon measurements as discussed in Section 2.2.1.

Table 3-8 Proposal specific operational noise criteria

Receiver	Time period[2]	Amenity criteria (acceptable noise level)[1] $L_{Aeq(period)}$	RBL, $L_{Aeq(15min)}$	Intrusive criteria, $L_{Aeq(15min)}$	Proposal specific noise criteria (external)
Residential receivers	Day	60	43	48	**48 $L_{Aeq(15min)}$**
	Evening	50	38[4]	43	**43 $L_{Aeq(evening)}$**
	Night	45	38	43	**43 $L_{Aeq(night)}$**
Commercial receivers	When in use	65	-	-	**65 $L_{Aeq(period)}$**
Industrial receivers	When in use	70	-	-	**70 $L_{Aeq(period)}$**
Classrooms at Nepean TAFE College	When in use	35 (internal)	-	-	**45[3] $L_{Aeq(1hr)}$**
Thornton Playground	When in use	55	-	-	**55 $L_{Aeq(period)}$**

Note 1: With consideration to the INP, 'noise amenity area' classification, the residential receivers surrounding the Proposal site have been classified as 'urban'.

Note 2: The INP defines day, evening and night time periods as:

- Day: the period from 7 am to 6 pm Monday to Saturday; or 8 am to 6 pm on Sundays and Public Holidays.
- Evening: the period from 6 pm to 10 pm.
- Night: the remaining period.

Note 3: A 10 dBA noise reduction is assumed from outside to inside the building for the educational facilities

Note 4: Based on night-time background noise levels.

4. Assessment of noise and vibration impacts

4.1 Construction methodology

4.1.1 Construction noise modelling methodology

The provided construction stages, proposed equipment and time periods are summarised in Appendix A for indicative construction scenarios S1 to S13. Construction scenarios have been created based on construction equipment likely to be operating for the relevant construction activities. Noise levels for equipment have been obtained from *AS2436 – 2010 Guide to noise and vibration control on construction, demolition and maintenance sites* unless otherwise stated and are provided in Table 4-1. Other equipment than that modelled may be used, however it is anticipated that they would produce similar noise emissions.

It is estimated that the work would take two years and would likely utilise seven weekend track possessions.

For each construction scenario, the noise levels at the modelled sensitive receivers in the vicinity of the Proposal have been predicted.

Noise modelling was undertaken using SoundPlan (v7.3). SoundPlan is a computer program for the calculation, assessment and prognosis of noise exposure. SoundPlan calculates environmental noise propagation according to *ISO 9613-2 'Acoustics – Attenuation of sound during propagation outdoors'.*

The following noise modelling assumptions were made:

- surrounding land was modelled assuming a mixture of hard and soft ground with a ground absorption coefficient of 0.5
- atmospheric absorption was based on an average temperature of 10 °C and an average humidity of 70%
- atmospheric propagation conditions were modelled with noise enhancing wind conditions for noise propagation (downwind conditions) or equivalently a well-developed moderate ground based temperature inversions
- modelled scenarios take into account the shielding effect from surrounding buildings and structures on and adjacent to the site. Attenuation from built up areas was included away from the site
- noise sources were modelled assuming noise propagation in the 500 Hz octave band frequency as per *ISO 9613-2*
- noise sources for each scenario are in some cases modelled at different locations. As such the noise modelling assesses the noise source at multiple locations and takes the maximum L_{Aeq} received noise level
- besides the generators it is assumed that each item of equipment would operate simultaneously on average for 20% of the time during each 15 minute period.

Additionally, the magnitude of off-site noise impact will be dependent upon a number of factors including the intensity and location of activities, the type of equipment used, the background noise levels during the construction period and the prevailing weather conditions.

Table 4-1 Construction equipment noise levels

Equipment	Adopted sound power level, dBA	Data source
Truck	107	AS2436 – 2010
Generator with acoustic enclosure	89	AS2436 – 2010 with acoustic enclosure.
Excavator (small)	100	AS2436 – 2010
Excavator (medium)	107	AS2436 – 2010
Scissor lift	105	AS2436 – 2010 based on a cherry picker
Jack hammer	126[1]	AS2436 – 2010
Concrete saw	122[1]	AS2436 – 2010
Compressor	101	AS2436 – 2010
Crane	105	AS2436 – 2010
Elevated working platform	105	AS2436 – 2010 based on a cherry picker
Concrete pump and truck	108	AS2436 – 2010
Hand tools (electric)	102	AS2436 – 2010
Piling rig (bored)	111	AS2436 – 2010
Wacker compactor	113[1]	Based on Wacker technical data sheet
Roller (vibratory)	108[1]	AS2436 – 2010

Note 1: The ICNG considers some activities to be particularly annoying to residents, such as jackhammering, concrete sawing, rock breaking, compacting and vibratory rolling. Hence, a +5 dBA modifying factor adjustment has been applied.

4.1.2 Predicted construction noise levels

Table 4-2 and Table 4-3 outline construction noise levels during standard construction hours and outside of standard construction hours at modelled sensitive receivers for each construction scenario. The cells have been shaded (as per the key) where the noise management levels for each time period are exceeded. Impacts to sensitive receivers have the potential to occur where sensitive receivers experience noise higher than the relevant construction noise management level.

During standard recommended hours the noise affected construction noise management level of 53 dBA is predicted to be exceeded at:

- Classrooms at the Nepean TAFE College (R1) during construction scenarios S3, S5, S11, S12 and S13
- The first few residences along Lemon Grove Road (R2) during scenario S12. It should be noted that the predicted noise levels from construction activities at the Penrith Station are less than the measured construction noise levels (55 to 68 dBA) from the Urban Growth development adjacent to these residences

- Residences north of Penrith Station (R3) which are part of the Urban Growth development during scenarios S5, S11 and S12. Construction activities within the Urban Growth site are likely to be the dominant noise contributors at these residences.

Noise levels are not predicted to exceed the highly noise affected construction noise management level of 75 dBA at any residential receivers.

Noise levels are also predicted to exceed the noise affected construction noise management level of 70 dBA at commercial receivers during construction scenarios S3, S5, S11, S12 and S13. Impacts would be limited to the first row of commercial properties south of the station.

Some activities have the potential to be undertaken outside of standard hours during possessions. Possessions will be both during the day and night time periods and have been assessed against the more stringent night time criteria (with the works classified as during out of hours work (OOHW) period 2 as per the CNS).

Noise levels are predicted to exceed the night time noise criteria at all identified residential receivers during construction scenarios S5 and S10. Activities during OOHW period 2 are also likely to exceed the sleep disturbance screening level of 53 dBA at residences located to the north of Penrith Station in the Urban Growth development. However, the exceedance of the screening level is minor (less than 3 dBA) and should not lead to sleep disturbance impacts.

Further details of the recommended noise mitigation measures, and noise management zones to manage these impacts are detailed in Section 5.1.

Table 4-2 Predicted construction noise levels at sensitive receivers compared against standard construction hour noise management levels (ICNG), dBA

Exceedence to noise management level cell shading key
75 dBA highly noise affected level
53 dBA during standard construction hours

Receiver ID	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13
R1[1]	46	49	61	48	66	n/a	54	50	n/a	n/a	64	71	60
R2	36	36	48	35	53	n/a	41	37	n/a	n/a	52	55	50
R3[2]	44	41	54	41	59	n/a	47	43	n/a	n/a	58	60	49
R4	40	38	50	38	56	n/a	44	39	n/a	n/a	54	56	46
R5	34	35	46	34	52	n/a	40	35	n/a	n/a	51	53	48
R6	33	34	44	34	51	n/a	40	35	n/a	n/a	51	52	41

Note 1: A 55 dBA external noise management level applies to receiver R1 when in use.

Note 2: A 65 dBA external noise management level applies to receiver R3 when in use.

Table 4-3 Predicted construction noise levels at sensitive receivers compared against outside standard construction hours noise management levels (ICNG), dBA

Exceedence to noise management level cell shading key
48 dBA during the day time (OOHW) Period 1
43 dBA during the evening and night (OOHW) Period 1 and 2

Receiver ID	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13
R1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
R2	n/a	n/a	n/a	n/a	53	41	n/a	n/a	36	53	n/a	n/a	n/a
R3[2]	n/a	n/a	n/a	n/a	59	47	n/a	n/a	42	58	n/a	n/a	n/a
R4	n/a	n/a	n/a	n/a	56	43	n/a	n/a	38	54	n/a	n/a	n/a
R5	n/a	n/a	n/a	n/a	52	39	n/a	n/a	34	50	n/a	n/a	n/a
R6	n/a	n/a	n/a	n/a	51	39	n/a	n/a	34	50	n/a	n/a	n/a

Note: Where activities are scheduled potentially during both OOHW Period 1 and Period 2, if noise levels are predicted to exceed the Period 1 criteria, they will automatically exceed the OOHW Period 2 criteria.

Note 2: A 65 dBA external noise management level applies to receiver R3 when in use.

4.2 Construction traffic

A significant increase in traffic volumes would be needed in order to increase road traffic noise by 2 dBA (a doubling in traffic corresponds to an approximate 3 dBA increase). It is estimated that construction activities would typically involve 4-6 movements per day to access the northern side of the station and 6-8 movements per day to access the southern side of the station. Approximately 18-22 movements per day would be required for construction works at the interchange. Approximately 10-12 light vehicle movements would be required for staff/contractors normally and 80-92 movements over a weekend possession.

These daily vehicle movements would not be significant when compared with the existing vehicle numbers in the area. As a result, no impacts from construction traffic movements are expected.

4.3 Construction vibration

Table 4-4 outlines typical vibration levels for vibration generating equipment associated with the Proposal construction. Potential vibration impacts would be limited to the construction period.

Table 4-4 Typical vibration levels – construction equipment

Item	Peak particle velocity	Data source
Vibratory roller (7-13 tonne)	7 to 8 mm/s at 10 m	Calculated based on *Construction Noise Strategy*
Vibratory roller (4-6 tonnes)	5-6 mm/s at 10 m	Calculated based on *Construction Noise Strategy*
Vibratory roller (2-4 tonne)	2 to 4 mm/s at 10 m	Calculated based on *Construction Noise Strategy*
Vibratory roller (1-2 tonne)	1 to 3 mm/s at 10 m	Calculated based on *Construction Noise Strategy*
Wacker compactor	1 to 3 mm/s at 10 m	No source data available however assumed similar to a small roller
Pavement or rock breaking using a hydraulic hammer (300 kg hydraulic hammer)	1 mm/s at 10 m	Calculated based on *Construction Noise Strategy*
Jackhammer	0.5 mm/s at 10 m	*Environmental Noise Management Manual* (RTA, 2001)
Piling (bored)	0.5 mm/s at 10 m	Calculated based on *Construction Noise Strategy*

4.3.1 Construction vibration impacts

Energy from equipment is transmitted into the ground and transformed into vibration, which attenuates with distance. The magnitude and attenuation of ground vibration is dependent on the following:

- the efficiency of the energy transfer mechanism of the equipment (i.e impulsive; reciprocating, rolling or rotating equipment)
- the frequency content
- the impact medium stiffness
- the type of wave (surface or body)
- the ground type and topography.

Safe working buffer distances to comply with the human comfort, cosmetic damage and heritage structural damage criteria were calculated for typical vibration values listed in Table 4-4 and are presented in Table 4-5 unless specifically provided in the CNS.

Table 4-5 Vibration safe working buffer distances, m

Activity[1]	Human comfort	Structural damage	
		Heritage building/structure	Standard dwellings
Vibratory roller (7-13 tonnes)	100 m	30 m	15 m
Vibratory roller (4-6 tonnes)	40 m	24 m	12 m
Vibratory roller (2-4 tonnes)	20 m	12 m	6 m
Vibratory roller (1-2 tonnes)	15 m	10 m	5 m
Wacker packer	15 m	10 m	5 m
Small hydraulic hammer	7 m	4 m	2 m
Jackhammer	Avoid contact with structure	2 m (nominal)	1 m (nominal)
Piling (bored) [1]	-	4 m (nominal)	2 m (nominal)

Note 1: These distances have been sourced from the *Construction Noise Strategy* (TfNSW, 2012)

Structural damage

With consideration to the building damage criteria for typical buildings, the expected magnitude of ground vibrations should not be sufficient to cause damage to buildings within 15 metres of the works. No standard dwellings have been identified within 15 m of Penrith Station.

With respect to the structural damage criteria for heritage structures, it is noted that Penrith Station is heritage listed and the existing buildings within the station area should be treated as heritage structures. Some non-significant heritage buildings/structures will be demolished. However, the existing heritage structures that will be retained and are likely to be most at risk are the station master's residence and Platforms 1, 2 and 3 heritage buildings.

At this stage of the project equipment selection is not known, however with the heritage structures discussed above, smaller equipment needs to be considered. It is recommended that smaller equipment (such as vibratory rollers less than 4 tonnes) and work methods that produce lower vibration emissions be considered, where feasible and reasonable, when work is required within the structural damage safe working buffer distances listed in Table 4-5. If no alternative work method is feasible or reasonable then additional mitigation measures as detailed in Section 5.2 should be undertaken which would include attended vibration monitoring, trigger warnings and condition reports.

Human comfort

Human comfort impacts would be limited to commercial properties located adjacent to the station along Jane Street if a 7-13 tonne vibratory roller is used. Short term human comfort impacts from other equipment would be limited to transient commuters and pedestrians in and around the station.

All potentially impacted receivers within the safe working buffer distances should be informed of the nature of the works, expected vibration levels, duration of works and a method of contact to raise vibration complaints.

4.4 Operational noise

Current operational noise sources on the railway station include:

- Public address systems
- Mechanical plant
- Commuter speech/travel
- Trains accelerating and decelerating into and out of the station.

Additional operational equipment on the station would include the new lifts which would not produce significant noise emissions. The reconfiguration of the interchange will result in the direction of travel to be reversed, however the number of buses/taxis and the kiss and ride activity would not significantly change as a result of the proposal.

Hence, the operational noise environment is expected to remain largely unchanged. It is assumed that at detailed design appropriate selection of mechanical plant and adjustments to the PA system would be undertaken to comply with Sydney Trains speech intelligibility requirements and the operational noise criteria provided in Table 3-8.

5. Mitigation measures

5.1 Construction noise

As discussed in the noise impact assessment (Section 4), construction activities have the potential to cause adverse noise impact on surrounding sensitive receivers.

It is recommended that the following CNS standard noise mitigation measures be implemented where feasible and reasonable and all potentially impacted residents should be informed of the nature of the works, expected noise levels, duration of works and provided a point of contact.

Table 5-1 Standard mitigation measures for construction noise and vibration

Action required	Details
Management measures	
Implement community consultation measures	• periodic notification (letterbox drop or equivalent) • website • project info-line • construction response line • email distribution list • community based forums (if required by approval conditions)
Site inductions	All employees, contractors and subcontractors are to receive an environmental induction. The induction must at least include: • all relevant project specific and standard noise and vibration mitigation measures • relevant licence and approval conditions • permissible hours of work • any limitations on high noise generating activities • location of nearest sensitive receivers • construction employee parking areas • designated loading/ unloading areas and procedures • construction traffic routes • site opening/closing times (including deliveries) • environmental incident procedures
Behavioural practices	No swearing or unnecessary shouting or loud stereos/radios on site. No dropping of materials from height, throwing of metal items and slamming of doors.
Attended vibration measurement	Attended vibration measurements are required at the commencement of vibration generating activities to confirm that vibration levels are within the acceptable range to prevent cosmetic building damage.
Source controls	
Construction hours and scheduling	Where reasonable and feasible, construction should be carried out during the standard daytime working hours. Work generating high noise and/or vibration levels should be scheduled during less sensitive time periods. Further to this, It is recommended that the use of mulchers, jack hammers, concrete saws, rock breakers, compaction or other equipment used in very close proximity to the receivers should be limited where feasible and reasonable to the standard construction hours.

Action required	Details
Construction respite period	If highly noise affected impacts are predicted high noise and vibration generating activities may only be carried out in continuous blocks, not exceeding three hours each, with a minimum respite period of one hour between each block. If highly noise affected impacts are predicted no more than four consecutive nights of high noise and/or vibration generating work may be undertaken over any seven day period, unless otherwise approved by the relevant authority.
Equipment selection	Use quieter and less vibration emitting construction methods where reasonable and feasible.
Maximum noise levels	The noise levels of plant and equipment must have operating Sound Power or Sound Pressure Levels compliant with the criteria listed in Table 2 of the *Construction Noise Strategy.*
Rental plant and equipment	The noise levels of plant and equipment items are to be considered in rental decisions and in any case cannot be used on site unless compliant with the criteria in Table 2 *Construction Noise Strategy.*
Use and siting of plant	Simultaneous operation of noisy plant within discernible range of a sensitive receiver is to be avoided. The offset distance between noisy plant and adjacent sensitive receivers is to be maximised. Plant used intermittently to be throttled down or shut down. Noise-emitting plant to be directed away from sensitive receivers.
Plan worksites and activities to minimise noise and vibration	Plan traffic flow, parking and loading/ unloading areas to minimise reversing movements within the site.
Non-tonal reversing alarms	Non-tonal reversing beepers (or an equivalent mechanism) must be fitted and used on all construction vehicles and mobile plant regularly used on site and for any out of hours work.
Minimise disturbance arising from delivery of goods to construction sites	Loading and unloading of materials/deliveries is to occur as far as possible from sensitive receivers. Select site access points and roads as far as possible away from sensitive receivers. Dedicated loading/unloading areas to be shielded if close to sensitive receivers. Delivery vehicles to be fitted with straps rather than chains for unloading, wherever possible.
Path controls	
Shield stationary noise sources such as pumps, compressors, fans etc.	Stationary noise sources should be enclosed or shielded whilst ensuring that the occupational health and safety of workers is maintained.
Shield sensitive receivers from noisy activities	Use structures to shield residential receivers from noise such as site shed placement; earth bunds; fencing; erection of operational stage noise barriers (where practicable) and consideration of site topography when situating plant.

Due to the highly variable nature of the activities and the potential for work to be undertaken outside the standard construction hours, the Proposal's noise management levels are likely to be exceeded at times. Consultation and cooperation with the neighbours of the site will assist in minimising uncertainty, misconceptions and adverse reactions to noise.

In circumstances where the noise levels are predicted to exceed construction noise management levels after implementation of the general work practices, the relevant additional mitigation measures detailed in Table 5-2 should be considered. Based on the predicted noise levels, additional mitigation measures are likely to be required for works during standard construction hours and any activities outside of standard construction hours. The noise management zones show the additional mitigation measures recommended by the CNS. Noise management zones have been calculated for each scenario showing the recommended additional mitigation measure for each time period. Noise management zones are shown in Figure 2 to Figure 14.

Table 5-2 Additional mitigation measures

Criteria	Time period	$L_{Aeq(15\ min)}$	noise level	above rating	background level
		0 to 10 dBA	10 to 20 dBA	20 to 30 dBA	>30 dBA
		Noticeable	Clearly audible	Moderately intrusive	Highly intrusive
Standard	Weekday (7 am– 6 pm)	-	-	LB, M	LB, M
	Saturday (8 am – 1 pm)				
OOHW Period 1	Weekday (6 pm–10 pm)	-	LB	M, LB	M, IB, LB, PC, SN
	Saturday (1 pm – 10 pm)				
	Sunday (8 am – 6 pm)				
OOHW Period 2	Weekday (10 pm–7 am)	LB[1]	M, LB	M, IB, LB, PC, SN	AA, M, IB, LB, PC, SN
	Saturday (10 pm – 8 am)				
	Sunday (6 pm – 7 am)				

Monitoring (M): Compliance noise monitoring

Individual Briefings (IB): Individual briefings are used to inform stakeholders about the impacts of high noise activities and mitigation measures that will be implemented. Communications representatives from the contractor would visit identified stakeholders at least 48 hours ahead of potentially disturbing construction activities. Individual briefings provide affected stakeholders with personalised contact and tailored advice, with the opportunity to comment on the Proposal.

Letter box drops (LB): Letter box drops or media advertisements.

Phone Calls (PC): Phone calls detailing relevant information would be made to identified/affected stakeholders within seven days of proposed work. Phone calls provide affected stakeholders with personalised contact and tailored advice, with the opportunity to provide comments on the proposed work and specific needs.

Specific Notifications (SN): Specific notifications are letterbox dropped or hand distributed to identified stakeholders no later than seven days ahead of construction activities that are likely to exceed the noise objectives. This form of communication is used to support periodic notifications.

Alternative accommodation (AA): Alternative accommodation options would be offered to residents.

Note 1: The minimum level was set at the ICNG background + 5 dBA criteria for determining the noise management zones

Source: *Construction Noise Strategy (Rail Projects),* (TfNSW, 2012)

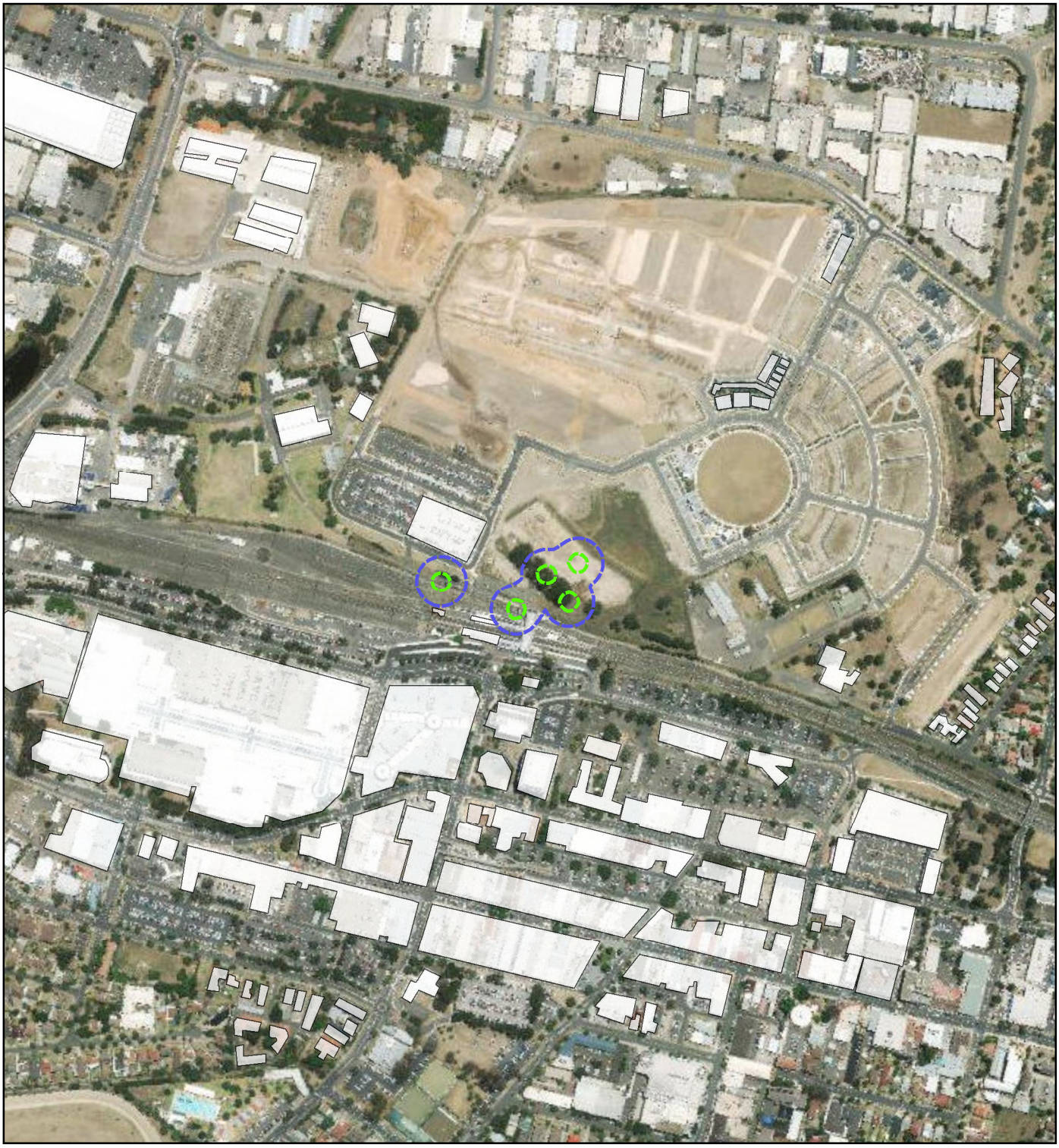
5.2 Construction vibration

Where construction is required within the safe working buffer distance and alternative work methods such as smaller equipment should be considered. If no alternative work method is feasible or reasonable then compliance vibration monitoring should be undertaken where works are required within the safe working buffer distances and include:

- Site tests to review of the measured frequency content to determine the structural damage criteria as per Table 3-7 for heritage structures
- Continuous vibration monitoring with a visual alarm installed to warn the equipment operator when the structural damage vibration criteria (considering frequency content) is exceeded
- A dilapidation / condition report before and after construction activities.

5.3 Operational noise

Operational noise levels are expected to remain within the operational noise criteria at all sensitive receivers. No specific operational noise mitigation measures are recommended. However it is recommended appropriate selection of mechanical plant and adjustment to the PA system should be undertaken at detailed design stage to comply with Sydney Trains speech intelligibility requirements and the operational noise criteria provided in Table 3-8.



Noise level contour dBA - Period - Impact - Mitigation measures

63 - Day - Moderately intrusive - [Standard hours (LB, M)]

73 - Day - Highly intrusive - [Standard hours (LB, M)]

Paper Size A4

0 50 100 200

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

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Job Number	21-24130
Revision	A
Date	21 Sep 2015

S1 noise management zones

Figure 2

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Level 15, 133 Castlereagh Street, Sydney NSW 2000 Australia **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com **W** www.ghd.com

Data source: Data source: NSW LPI, Aerial imagery, 2015 Created by: Afoddy

Noise level contour dBA - Period - Impact - Mitigation measures

63 - Day - Moderately intrusive - [Standard hours (LB, M)]

73 - Day - Highly intrusive - [Standard hours (LB, M)]

Paper Size A4

0 50 100 200

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

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Penrith Station Upgrade

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S2 noise management zones

Figure 3

Level 15, 133 Castlereagh Street, Sydney NSW 2000 Australia **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com **W** www.ghd.com

Data source: Data source: NSW LPI, Aerial imagery, 2015 Created by: Afoddy

Noise level contour dBA - Period - Impact - Mitigation measures

63 - Day - Moderately intrusive - [Standard hours (LB, M)]

73 - Day - Highly intrusive - [Standard hours (LB, M)]

Paper Size A4

0 50 100 200

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
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Date 21 Sep 2015

S3 noise management zones

Figure 4

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Data source: Data source: NSW LPI, Aerial imagery, 2015 Created by: Afoddy

Noise level contour dBA - Period - Impact - Mitigation measures

63 - Day - Moderately intrusive - [Standard hours (LB, M)]

73 - Day - Highly intrusive - [Standard hours (LB, M)]

Paper Size A4

0 50 100 200

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

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Penrith Station Upgrade

Job Number	21-24130
Revision	A
Date	21 Sep 2015

S4 noise management zones

Figure 5

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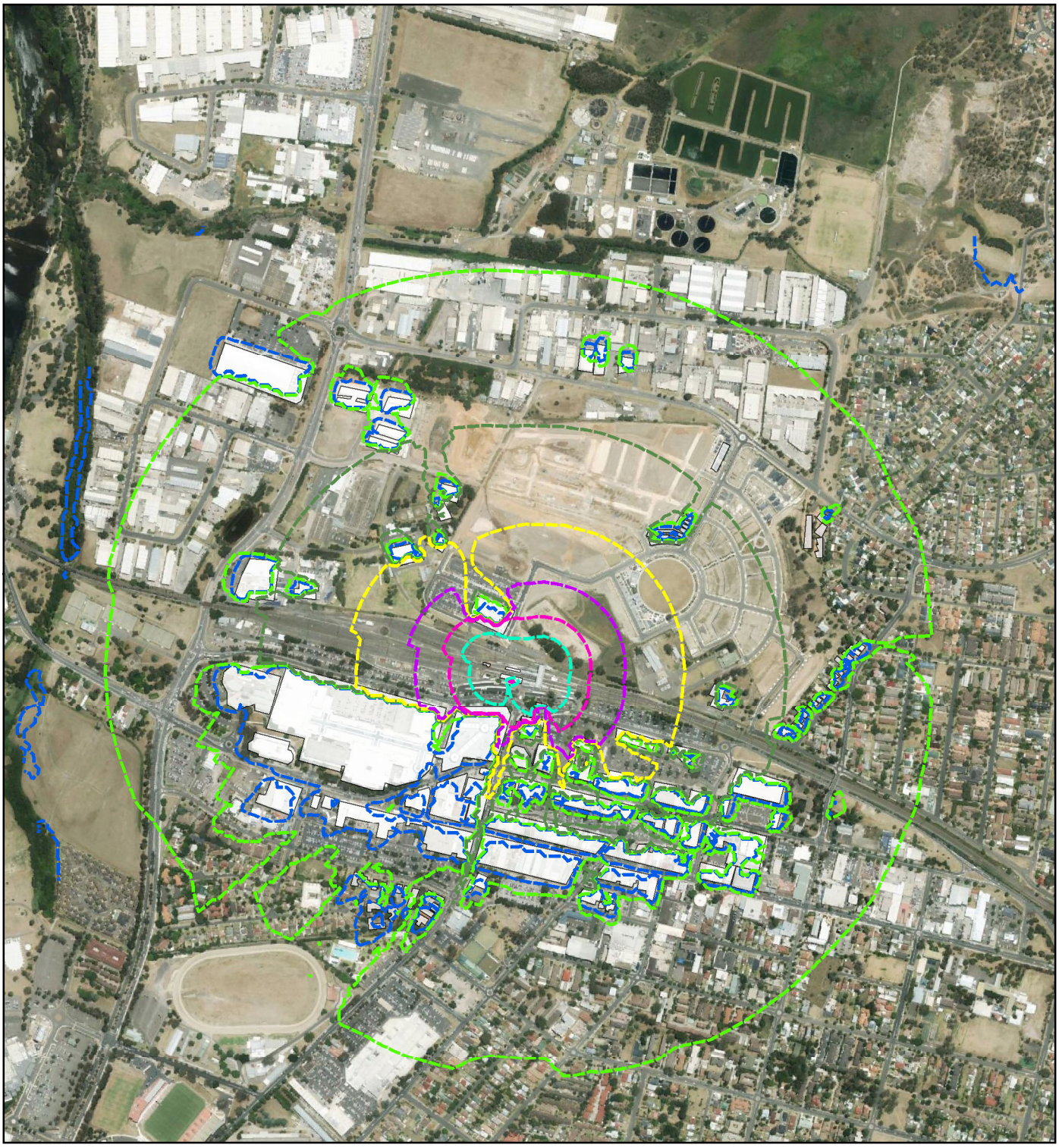
Data source: Data source: NSW LPI, Aerial imagery, 2015 Created by: Afoddy



Noise level contour dBA - Period - Impact - Mitigation measures

- 43 - Evening/Night - Noticeable - [OOHW Period 2 (LB)]
- 48 - Evening/Night - Clearly Audible - [OOHW Period 1 (LB)]; [OOHW Period 2 (LB, M)]
- 53 - Day - Clearly Audible - [OOHW Period 1 (LB)]
- 58 - Evening/Night - Moderately intrusive - [OOHW Period 1 (M, LB)]; [OOHW Period 2 (M, IB, LB, PC, SN)]
- 63 - Day - Moderately intrusive - [Standard hours (LB, M)]
- 68 - Evening/Night - Highly intrusive - [OOHW Period 1 (M, IB, LB, PC, SN)]; [OOHW Period 2 (AA, M, IB, LB, PC, SN)]
- 73 - Day - Highly intrusive - [Standard hours (LB, M)]

Paper Size A4

0 90 180 360

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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SX noise management zones

Figure 6

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Data source: Google Earth Pro, Aerial imagery, 2015. Created by:ppandey

Noise level contour dBA - Period - Impact - Mitigation measures

- 43 - Evening/Night - Noticeable - [OOHW Period 2 (LB)]
- 48 - Evening/Night - Clearly Audible - [OOHW Period 1 (LB)]; [OOHW Period 2 (LB, M)]
- 53 - Day - Clearly Audible - [OOHW Period 1 (LB)]
- 58 - Evening/Night - Moderately intrusive - [OOHW Period 1 (M, LB)]; [OOHW Period 2 (M, IB, LB, PC, SN)]
- 63 - Day - Moderately intrusive - [OOHW Period 1 (M, LB)]
- 68 - Evening/Night - Highly intrusive - [OOHW Period 1 (M, IB, LB, PC, SN)]; [OOHW Period 2 (AA, M, IB, LB, PC, SN)]
- 73 - Day - Highly intrusive - [OOHW Period 1 (M, IB, LB, PC, SN)]

Paper Size A4

0 55 110 220

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
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Date	14 Oct 2015

SX noise management zones

Figure 7

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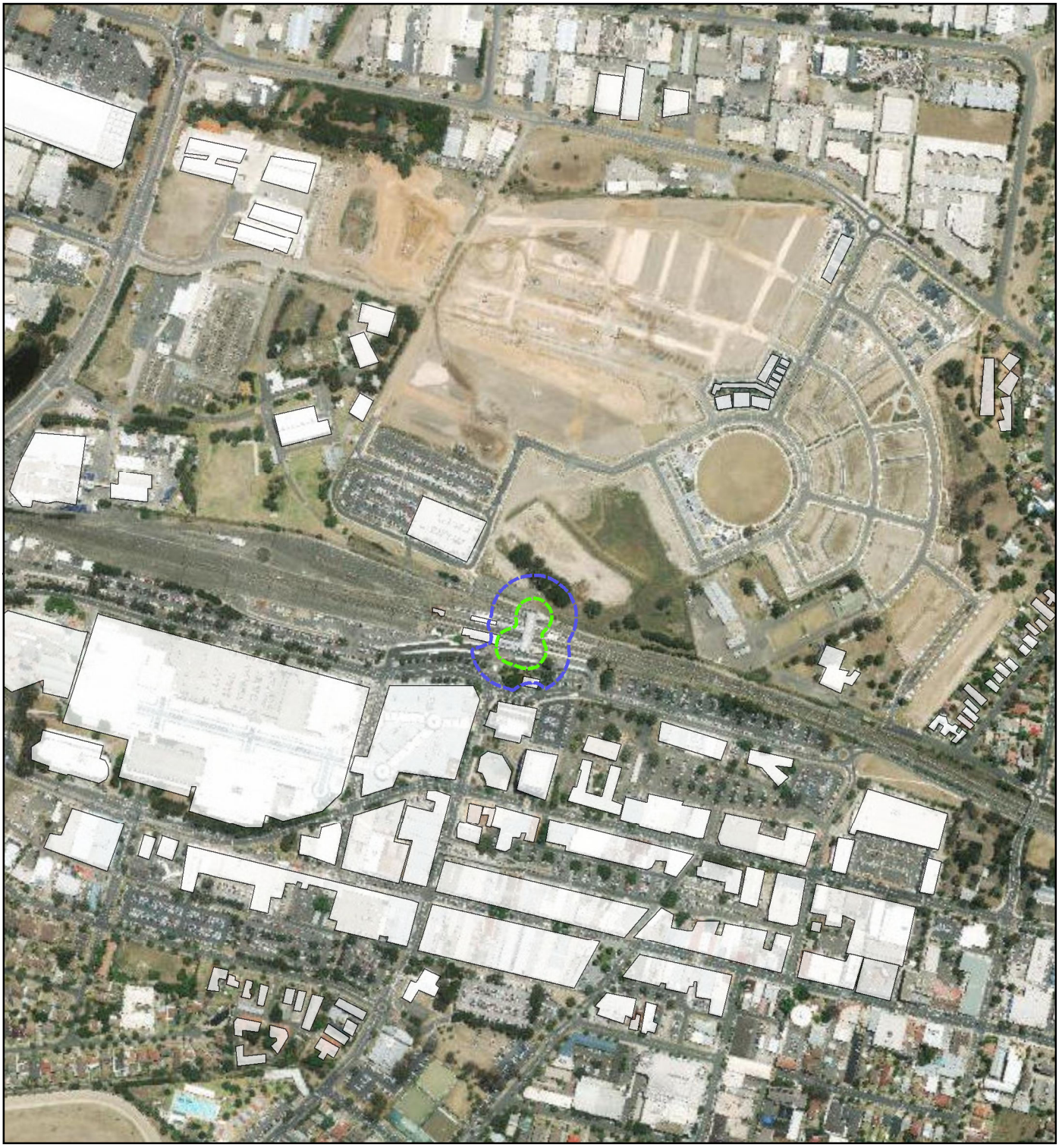
Data source: Google Earth Pro, Aerial imagery, 2015. Created by:ppandey



Noise level contour dBA - Period - Impact - Mitigation measures

63 - Day - Moderately intrusive - [Standard hours (LB, M)]

73 - Day - Highly intrusive - [Standard hours (LB, M)]

Paper Size A4

0 50 100 200

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
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Job Number	21-24130
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Date	21 Sep 2015

S7 noise management zones

Figure 8

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Data source: Data source: NSW LPI, Aerial imagery, 2015 Created by: Afoddy

Noise level contour dBA - Period - Impact - Mitigation measures

63 - Day - Moderately intrusive - [Standard hours (LB, M)]

73 - Day - Highly intrusive - [Standard hours (LB, M)]

Paper Size A4

0 50 100 200

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
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S8 noise management zones

Figure 9

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Data source: Data source: NSW LPI, Aerial imagery, 2015 Created by: Afoddy

Noise level contour dBA - Period - Impact - Mitigation measures

- 43 - Evening/Night - Noticeable - [OOHW Period 2 (LB)]
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- 53 - Day - Clearly Audible - [OOHW Period 1 (LB)]
- 58 - Evening/Night - Moderately intrusive - [OOHW Period 1 (M, LB)]; [OOHW Period 2 (M, IB, LB, PC, SN)]
- 63 - Day - Moderately intrusive - [OOHW Period 1 (M, LB)]
- 68 - Evening/Night - Highly intrusive - [OOHW Period 1 (M, IB, LB, PC, SN)]; [OOHW Period 2 (AA, M, IB, LB, PC, SN)]
- 73 - Day - Highly intrusive - [OOHW Period 1 (M, IB, LB, PC, SN)]

Paper Size A4

0 55 110 220

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
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Revision	A
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SX noise management zones

Figure 10

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Data source: Google Earth Pro, Aerial imagery, 2015. Created by:ppandey

Noise level contour dBA - Period - Impact - Mitigation measures

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- 48 - Evening/Night - Clearly Audible - [OOHW Period 1 (LB)]; [OOHW Period 2 (LB, M)]
- 53 - Day - Clearly Audible - [OOHW Period 1 (LB)]
- 58 - Evening/Night - Moderately intrusive - [OOHW Period 1 (M, LB)]; [OOHW Period 2 (M, IB, LB, PC, SN)]
- 63 - Day - Moderately intrusive - [OOHW Period 1 (M, LB)]
- 68 - Evening/Night - Highly intrusive - [OOHW Period 1 (M, IB, LB, PC, SN)]; [OOHW Period 2 (AA, M, IB, LB, PC, SN)]
- 73 - Day - Highly intrusive - [OOHW Period 1 (M, IB, LB, PC, SN)]

Paper Size A4

0 90 180 360

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Penrith Station Upgrade

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Revision	A
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SX noise management zones

Figure 11

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Data source: Google Earth Pro, Aerial imagery, 2015. Created by:ppandey

Noise level contour dBA - Period - Impact - Mitigation measures

63 - Day - Moderately intrusive - [Standard hours (LB, M)]

73 - Day - Highly intrusive - [Standard hours (LB, M)]

Paper Size A4

0 50 100 200

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
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N

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Penrith Station Upgrade

Job Number 21-24130
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Date 21 Sep 2015

S11 noise management zones

Figure 12

Level 15, 133 Castlereagh Street, Sydney NSW 2000 Australia **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com **W** www.ghd.com

Data source: Data source: NSW LPI, Aerial imagery, 2015 Created by: Afoddy

Noise level contour dBA - Period - Impact - Mitigation measures

63 - Day - Moderately intrusive - [Standard hours (LB, M)]

73 - Day - Highly intrusive - [Standard hours (LB, M)]

Paper Size A4

0 50 100 200

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
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Transport for NSW
Penrith Station Upgrade

Job Number 21-24130
Revision A
Date 21 Sep 2015

S12 noise management zones

Figure 13

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Data source: Data source: NSW LPI, Aerial imagery, 2015 Created by: Afoddy

Noise level contour dBA - Period - Impact - Mitigation measures

63 - Day - Moderately intrusive - [Standard hours (LB, M)]

73 - Day - Highly intrusive - [Standard hours (LB, M)]

Paper Size A4

0 50 100 200

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

GHD

Transport for NSW
Penrith Station Upgrade

Job Number 21-24130
Revision A
Date 21 Sep 2015

S13 noise management zones

Figure 14

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Data source: Data source: NSW LPI, Aerial imagery, 2015 Created by: Afoddy

6. Conclusions

Operational and construction noise impacts associated with the Penrith Station Upgrade have been assessed.

Construction activities during recommended standard construction hours are predicted to exceed the noise affected construction noise management level at sensitive receivers for some construction activities. Reasonable and feasible construction noise and vibration mitigation measures have been recommended, which would minimise noise impacts at potentially affected receivers.

Construction traffic noise is not expected to cause adverse impacts as it would not be significant when compared with the daily existing vehicle numbers in the area. Therefore no construction traffic noise impacts are anticipated at sensitive receivers.

There is potential for some human comfort vibration impacts at sensitive receivers when activities occur within the safe working buffer distances. The human comfort vibration impacts would be short-term in nature and where possible scheduled during standard construction hours.

There is the potential that vibration in the vicinity of Penrith Station heritage structures could exceed the building damage criteria during vibration intensive activities such as compaction and surface breaking. Reasonable and feasible construction vibration mitigation measures for heritage structures have been recommended.

Operational noise from the Proposal is expected to remain unchanged. No operational noise impacts are anticipated.

The Proposal should be acceptable from an acoustic perspective assuming the recommended mitigation measures are implemented.

References

Assessing Vibration a Technical Guideline, Department of Environment and Conservation, February 2006

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ISO 9613-2, Acoustics – Attenuation of sound during propagation outdoors, International Organization for Standardization, 1996.

Road Noise Policy, Office of Environment and Heritage, March 2011

Structural Vibration Part 3: Effects of vibration on structures, *DIN 4150-3 -1999,* German Standards, 1999

Sydney Trains Environmental Management System Guide Noise and Vibration from Rail Facilities (Sydney Trains, 2013)

Appendices

Appendix A – Indicative construction activity summary

Indicative construction activity summary

Scenario	Construction activity	Timing	• Equipment
S1	Establishment of site compound (erect fencing, tree protection zones, site offices, amenities and plant/material storage areas etc.)	Standard hours	• Trucks • Generator • Hand tools (electric) • Crane
S2	Removal of awnings on the Belmore Rd side of the station	Standard hours	• Elevated work platform (EWP) • Crane • Rattle guns • Trucks • Hand tools (electric)
S3	Services/ seats/ bins relocation on platforms	Standard hours	• Hand tools (electric) • Demo saw
S4	Erection of hoardings on the concourse	Standard hours	• Hand tools (electric) • Trucks • Crane
S5	Demolition of existing structures as required	Standard hours, Out of hours: Periods 1 and 2	• Demolition saw • Generation • Jack hammer • Grinder • Crane • Trucks-(tipper and semi-trailers) • Hand tools

Scenario	Construction activity	Timing	• Equipment
S6	Construction of footings for bridge columns, stairs and lift shaft on platforms Erection of precast headstocks, lift shafts, stairs and decks on platforms	Out of hours: Periods 1 and 2	• Piling rig • Crane • Concrete pump & concrete trucks (not operating simultaneously) • Trucks • Hand tools • Lighting towers
S7	Construction of footings for bridge columns, stairs and canopies outside the corridor	Standard hours	• Crane • Concrete pump & concrete tucks • Trucks • Excavator • Scissor lift
S8	Fit out of stairs, canopies and anti-throw screens	Standard hours	• Trucks • Grinder • Generator • Crane • EWP • Rattle gun • Hand tools
S9	Installation of lifts Installation of fixtures, lighting and CCTV cameras for affected areas	Out of hours: Periods 1 and 2	• Crane • Trucks • Hand tools • Lighting towers

Scenario	Construction activity	Timing	• Equipment
S10	Platform resurfacing and raising/regrading	Out of hours: Periods 1 and 2	• Trucks • Bob cat • Jack hammer • Excavator • Grinder • Generator • Balloon wheel dumpies • Hi rail • Wacker packer • Vibratory roller • Hand tools
S11	Construction and fit out of new rooms/facilities (i.e. Family Accessible Toilet, storeroom, etc.) on paid concourse and Platform 3	Standard hours	• Demolition saw • Jack hammer • Grinder • Nail gun • Hand tools
S12	Reconfiguration of interchange works	Standard hours	• Demolition saw • Compressor • Jack hammer • Grinder • Nail gun • Hand tools • Excavator • Concrete pump • Concrete trucks • Roller

Scenario	Construction activity	Timing	• Equipment
S13	Installation of new bus canopies, seats, bins, wayfinding to interchange	Standard hours	• EWP • Crane • Wacker packer • Trucks • Hand tools • Jackhammer

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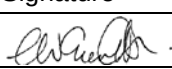
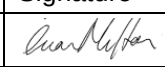
0	P Pandey	C Evenden		E Milton		22/10/15

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