Transport Infrastructure Development Corporation

South West Rail Link
Glenfield to Leppington rail line

Environmental Assessment
Volume 2a - Technical Reports 1 to 2

PARSONS BRINCKERHOFF

South West Rail Link Glenfield to Leppington Rail Line Project Approval Environmental Assessment

Volume 2a – Technical Papers 1-2

May 2010

Transport Infrastructure Development Corporation

Parsons Brinckerhoff Australia Pty Limited ABN 80 078 004 798

Ernst & Young Centre,
Level 27, 680 George Street
Sydney NSW 2000
GPO Box 5394
Sydney NSW 2001
Australia
Telephone +61 2 9272 5100
Facsimile +61 2 9272 5101
Email sydney@pb.com.au

NCSI Certified Quality System ISO 9001

ISBN: 0-9775523-2-2

2106669A PR_1907

List of Technical Papers

Technical Paper 1

Noise and Vibration

REPORT 10-6055-R3

Revision 0

South West Rail Link

Noise and Vibration Assessment

Stage 2

Glenfield to Leppington Train Stabling Facility

PREPARED FOR

Transport Infrastructure Development Corporation
Locked Bag 6501
ST LEONARDS NSW 2065

11 MAY 2010

HEGGIES PTY LTD
ABN 29 001 584 612

South West Rail Link

Noise and Vibration Assessment

Stage 2

Glenfield to Leppington Train Stabling Facility

PREPARED BY:
Heggies Pty Ltd
2 Lincoln Street Lane Cove NSW 2066 Australia
(PO Box 176 Lane Cove NSW 1595 Australia)
Telephone 61 2 9427 8100 Facsimile 61 2 9427 8200
Email sydney@heggies.com Web www.heggies.com

DOCUMENT CONTROL

Reference	Status	Date	Prepared	Checked	Authorised
10-6055-R3	Revision 0	11 May 2010	Briony Croft	Andrew Parker	Andrew Parker

Background

The South West Rail Link (SWRL) is a major transport project that will assist the NSW Government in providing a modern, integrated and efficient transport system to cater for Sydney's growth as a major global city.

The SWRL has been developed to provide improved transport services for existing and future residents in the South West Growth Centre (SWGC). The SWRL will provide fast connections to the Sydney CBD, Liverpool and Parramatta. Development of the project will provide opportunities to increase the patronage of the existing railway system, reduce congestion on existing roads and achieve operational benefits for RailCorp. The new line will be fully integrated with RailCorp's existing network.

The SWRL will consist of a dual track, electrified passenger railway line, approximately 11 km long, from the existing junction of the East Hills Line and the Main South Line near Glenfield out to Leppington. The SWRL will also incorporate an upgraded station at Glenfield, new stations at Edmondson Park and Leppington, and a train stabling facility (TSF) west of the planned Leppington town centre at Rossmore.

The SWRL will service the planned residential areas at Edmondson Park and Leppington and the broader SWGC. The proposed TSF will provide greater operational rail capacity on the CityRail network in the south west region.

To progress with the further design and development of the SWRL, the project has been split into two stages:

Stage 1	Delivery of the Glenfield station, transport interchange and commuter car park
Stage 2	Delivery of the northern and southern flyovers, SWRL corridor to Leppington, Edmondson Park and Leppington stations, and the TSF.

Heggies Pty Ltd (Heggies) has been engaged by the Transport Infrastructure Development Corporation (TIDC) to provide specialist acoustic advice during the Environmental Assessment (EA) and engineering design stages of the SWRL corridor project Stage 2 Works. TIDC is the proponent of the project, and the EA is being prepared by Parsons Brinckerhoff (PB).

The noise and vibration assessment for the Glenfield Station Interchange works (formerly Stage B1) between chainage 31.4 km (East Hills Line) and 42.9 km (Main South Line) is covered in another Heggies Report 10-6245 R1 dated 4 August 2008.

This report covers the SWRL corridor works encompassing all new sections of track from south of Glenfield Station. This includes the southern flyover, the new stations at Edmondson Park and Leppington, and the TSF. This report assesses the potential noise and vibration issues associated with both the construction and operation of the SWRL corridor project.

The noise and vibration assessment processes comply with the Minister's Conditions of Approval for the Concept Plan and the TIDC *Statement of Commitments* in relation to the SWRL corridor works. The assessment embodied within this report is based entirely upon the Environmental Assessment Design. This represents one example of how the project could be constructed, operated and maintained. Should circumstances arise that result in minor changes to the Environmental Assessment Design, the noise and vibration impacts of the SWRL project would not be expected to be greater than those described and assessed within this report.

If the detailed design phase does result in significant changes, these will need to be assessed and approved on a case by case basis in accordance with the laws and Statutory Requirements. It is also noted that the project noise and vibration design goals are unlikely to change throughout the delivery of the project, which would be required to comply with the Conditions of Approval and Statement of Commitments described in this report.

Project Description

The proposed railway line will be predominately above ground, except where the alignment passes beneath the Hume Highway. The above ground sections include the grade-separated flyover south of Glenfield Station and surface rail located at grade, in cutting and on embankment. The track gradient was determined after consideration of ground topography and the need to pass over several major roads. The chosen alignment has resulted in several deep cuttings which form effective noise barriers, and a number of high embankments where the track is in an exposed position.

The new track will have an estimated maximum design speed of 125 km/h. The actual maximum operating speed will be less than this. At this stage, the anticipated maximum operating speed is 115km/hr. The track design speed and train operating speeds will be confirmed during detailed design.

When the line opens in 2016, it is anticipated that approximately 70% of the rolling stock will be Millennium or Waratah train sets with the remaining vehicles being the older (and noisier) double deck suburban sets. By 2026 it is expected that the older sets will have been retired from service and replaced by Waratahs. Noise emissions from the new Waratah trains are anticipated to be no greater than those of the Millennium sets.

It is planned to run up to 136 trains per day in each direction on the SWRL. Maximum traffic volumes of 12 city bound trains per hour are planned for the morning peak with a similar volume of Leppington bound trains forecast for the evening peak.

The proposed new stations at Edmondson Park and Leppington will be designed to act as a focal point for the adjoining retail/commercial activities planned within the respective town centres. Both stations will include concourse areas, pedestrian overbridges/connections to adjoining facilities, access for the mobility impaired (Easy Access), park-and-ride facilities, and facilities for transport interchange between bus and rail modes.

The TSF will be built partly in cutting and partly on fill. The facility will initially have capacity to stable twelve 8-car sets on 6 stabling roads, with the potential to expand capacity to twenty 8-car sets on 10 stabling roads.

Existing and Future Acoustical Environment

The existing noise environment varies significantly along the length of the proposed SWRL corridor project. Land use is primarily suburban and rural with some areas being affected by their proximity to major roads. These major roads include the Hume Highway, Campbelltown Road, Bringelly Road, Camden Valley Way and Cowpasture Road. The noise emissions from these roads contribute to increased ambient noise levels at nearby residences. It is planned that some of these roads will be upgraded in parallel with the SWRL construction. Noise from these roads is not addressed in this report.

The absence of significant residential, commercial or industrial development in the vicinity of the SWRL corridor means that night-time ambient noise levels (ie the most critical period) are presently very low.

The development of the SWGC will ensure that the lightly populated rural nature of many areas in the vicinity of the SWRL corridor will change as new residential and commercial centres develop to take advantage of the new rail transport corridor. It is with these new developments in mind that noise mitigation measures must be addressed.

Noise and Vibration Sources Considered in this Study

The potential noise and vibration issues associated with both the construction and operation of the SWRL corridor project have been examined and may be divided into the following areas:

- Airborne construction noise
- Ground-borne construction noise
- Construction vibration
- Operational railway noise
- Operational vibration
- Airborne noise from the stabling facility
- Airborne noise from substations and ancillary facilities

These areas are discussed in detail in the report. The most significant noise issues associated with the project are airborne construction noise, operational railway noise and noise from the stabling facility.

Construction Noise

Construction noise modelling indicates exceedances of the Noise Management Levels at existing receivers as described in DECCW's *Interim Construction Noise Guideline.* These exceedances result primarily from the relatively close distances between construction plant and the nearest receivers.

Where the Noise Management Levels are exceeded, the *Interim Construction Noise Guideline* requires all feasible and reasonable mitigation measures to be applied. TIDC's *Construction Noise Strategy* requires the preparation of a Construction Noise and Vibration Management Plan (CNVMP) at a later stage in the assessment process when more detailed information on plant and processes become available. Whilst this report provides an indication of the likely mitigation measures that may be required during construction, more specific measures will be provided in the CNVMP.

The identification of potential exceedances highlights the importance of managing the works to minimise both the noise levels and the durations of the predicted exceedances. For new track sections, construction works would be limited to daytime hours only (unless essential for traffic management or safety reasons) in order to reduce any potential impacts as much as possible.

Operational Rail Noise

Guidance in relation to operational noise goals for the proposal is provided in the Department of Environment, Climate Change and Water's (DECCW) *Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects* (IGANRIP). The guideline provides "noise trigger" levels that trigger the need for a project to conduct an assessment of the potential noise and vibration impacts and examine what measures would be feasible and reasonable to apply to ameliorate the project's impacts. Compliance with the appropriate IGANRIP noise trigger levels is not mandatory.

On the SWRL, the "new railway line" noise trigger levels are applicable. $L_{Aeq(9hour)}$ levels (for night-time noise exposure between 10.00 pm and 7.00 am) along with the L_{Amax} were determined to be the governing noise parameters along the rail corridor.

For the SWRL (a "greenfield" project) there is an opportunity for the operator (RailCorp) and planning agencies such as the NSW Department of Planning (DoP) and Landcom to "share responsibility" and work together with TIDC to achieve acceptable noise environments for future land uses along the rail corridor. The IGANRIP states that "It is important for land-use planning authorities to adopt an interactive partnership with the rail industry to ensure that existing and planned rail corridor use is considered when making and/or determining land-use planning instruments, including rezoning proposals and development applications." The responsibilities of the developers are described in the NSW DoP guideline *Development Near Rail Corridors and Busy Roads - Interim Guideline*.

Operational Noise Control Measures

The noise modelling has shown that where the track is in exposed locations (at grade or on embankment) near existing or future sensitive land uses, the noise trigger levels are likely to be exceeded and there is a need to adopt some noise control measures. A range of noise control options was considered to reduce potential noise impacts from the project. These include operational management (eg speed, train types, etc), wheel and rail maintenance, rail dampers, earth mounds, noise barriers, appropriate land use, the use of industrial and commercial buildings to form noise barriers and treatment of individual noise-sensitive buildings.

The phasing out of the older Double Deck Suburban vehicles represents a move to quieter rolling stock. The project design will specify continuously welded rail, which is significantly quieter than jointed track. The range of additional potential noise and vibration mitigation measures identified for the project (summarised below) is based on the Environmental Assessment Design. The application of these measures is subject to change, based on the finalisation of the detailed design and further site investigations. Further noise and vibration studies will be undertaken during the detailed design process to finalise the noise mitigation strategies to be implemented for the project.

Land Use

Being a greenfield area, the presently-undeveloped zones alongside the rail corridor offer an excellent opportunity for land use planning measures to play a significant part in delivering desirable noise environments for the community as a whole. Through land use planning measures, for example, noise sensitive land uses (such as hospitals, schools and residential dwellings) could be separated from the rail corridor either by open space, recreational parkland, roads, commercial land uses and/or industrial land uses. Appropriate building orientation can also be used as a noise control measure with sensitive areas of building occupancy being placed away from the noise source.

Land use planning will be implemented over the longer term. Planning measures cannot, therefore, be relied upon to protect existing land users from noise generated by the SWRL in the first years of operation of the SWRL.

Earth Mounds

Where space permits, earth mounds are proposed as a baseline noise mitigation measure. They offer the advantages of relatively low cost, low maintenance and minimum visual impact. Effective landscaping and erosion control requires a batter on both sides of an earth mound. This means that their widespread use is restricted by land availability. Gabion walls could be used to reduce/stabilise slopes, thereby increasing the height of earth mounds without increasing their footprint. Space restrictions preclude the use of earth mounds on high embankments. Mounds take advantage of available spoil from the project to provide a noticeable acoustic benefit but can only be used in areas where there will be no significant impact on flora, fauna or heritage sites. Possible mound locations and sizes were optimised during the noise modelling process in consultation with the relevant environmental and engineering disciplines.

Noise Barriers

Noise barriers are most effective when located close to the track, however there are restrictions on how close to the track barriers can be positioned. For safety and access reasons, there are defined clearances required between the track centreline and a structure, with a minimum of 6.2 m, where road vehicle access is required. Clearance issues are greater on an embankment than with at-grade track due to space restrictions on embankments.

There are also ongoing issues with maintenance and graffiti where barriers are installed. Large barriers may have a negative visual impact on both the broader community and on commuters. There is sometimes a mixed reaction from affected residents living in the vicinity of noise barriers. Some residents have unreasonable expectations about barrier performance and are disappointed with the perceived poor performance of barriers.

From the viewpoint of practicality, reasonability and cost-effectiveness (in the light of guidance from IGANRIP), it is recommended that where noise mitigation in the form of noise barriers additional to earth mounds is required, that the noise barrier height is limited to 1 m above the top of the rail.

Results of Operational Noise Modelling

Computer noise modelling, based on the Environmental Assessment Design, showed a need for noise mitigation in areas where the track is in an exposed location at grade or on embankments.

A baseline scenario was modelled with earth mounds constructed where space permits, to take advantage of available spoil from the project. The earth mound locations are:

Earth Mound Locations	**Approximate Height**	**Up / Down Side**
Ingleburn Gardens Estate Exit from Hume Highway cutting 44.15 km to 44.30 km	1.5 m to 3.5 m	Up Side Only
Edmondson Park Town Centre Development In Reserve approaching Denham Court 45.75 km to 45.96 km	0.5 m to 2.75 m	Up Side Only
Edmondson Park Town Centre Development In Reserve adjoining Denham Court 46.37 km to 46.62 km	0.25 m to 3.5 m	Up Side Only
Existing and future residential receivers At grade track Denham Court 47.22 km to 47.32 km	0.25 m to 3.25 m	Up and Down Sides
Existing and future residential receivers Shallow cutting Denham Court 47.50 km to 47.72 km	0.25 m to 3.5 m	Up and Down Sides
Leppington Town Centre Transition from embankment to cutting approaching Leppington Station 50.58 km to 50.76 km	0.25 m to 3.75 m	Up and Down Sides

In this baseline case, the IGANRIP trigger levels are exceeded at a number of existing residences and at distances up to 120 m from the edge of the rail corridor.

An analysis has also been completed to determine the noise barrier height that would be required along the rail corridor to meet the IGANRIP trigger levels at the corridor boundary. The resulting barrier heights are not considered feasible or reasonable in the context of the SWRL.

An alternative scenario has been modelled with noise barriers (1 m above top of rail) in addition to the earth mounds, at the following locations:

Noise Barrier Locations[1]	Justification	Length
Up 44.285 km to 44.605 km Down 44.205 km to 44.630 km	Ingleburn Gardens Estate	Up 320 m Down 425 m
Up 46.595 km to 47.200 km Down 46.750 km to 47.220 km	Denham Court existing residential and Edmondson Park future residential development	Up 475 m Down 480 m
Down 47.880 km to 48.355 km	Cemetery Curve - Forest Lawn Memorial Park	Down 475 m
Up 49.650 km to 50.565 km Down 49.755 km to 50.590 km	Existing low density residential area on approach to Leppington Station, after Sydney Water Canal.	Up 915 m Down 835 m

Note 1: The Up side is the northern side of the rail corridor; the Down side is to the south in this instance

The noise modelling showed that in this scenario, IGANRIP noise trigger levels would generally be achieved within 30 m of the rail corridor boundary. With this scenario, the noise trigger levels are achieved at all existing residences except at two locations, 1692 and 1701 Camden Valley Way, Leppington.

When the track is operational, compliance monitoring will be carried out to confirm the predicted noise levels.

Train Stabling Noise

Noise from the TSF was assessed according to the DECCW's *Industrial Noise Policy* (INP). The INP sets two separate noise criteria to meet environmental noise objectives: one to account for intrusive noise and the other to protect the amenity of particular land uses. In addition, the DECCW normally requires the risk of sleep disturbance to be assessed. Guidance on sleep disturbance is provided in DECCW guidelines the *Environmental Criteria for Road Traffic Noise* (ECRTN) and also in the Application Notes to the INP.

The major sources of noise emission from trains during the stabling operations are the air compressors, roof mounted static invertors and air conditioning units. In addition, horn and brake testing are currently undertaken at both ends of trains prior to trains entering service. Since trains from the TSF will be used in the morning peak, these noise sources can be expected to occur from an early hour. Despite their short duration, the high levels emitted from horns have the potential to cause disturbance, particularly in the early hours of the morning when it will be most prevalent.

Stabling Facility Noise Control Measures

A number of options were considered for noise mitigation at the TSF. Three scenarios were modelled to predict the noise impacts on the surrounding area:

- No noise mitigation other than that provided by locating the facility partly in a cutting
- A 6 m high perimeter noise barrier on three sides
- Enclosure of the facility in a shed (included as an option to mitigate horn test noise if no other solution is found)

Alternative potential mitigation measures for the TSF are the subject of ongoing investigation, and include the development of low-noise horn tests, treatment of individual existing residential buildings and land use planning measures. TIDC and the NSW DoP are investigating longer term options that aim to minimise potential noise impacts from the TSF on future surrounding land uses. This may include the placement of commercial and industrial buildings around the boundary of the TSF site.

Results of Stabling Facility Noise Modelling

Modelling of the noise from the stabling facility (excluding horn and brake testing) indicates that the INP intrusiveness and amenity criteria can be met in all directions within 90 m of the source. This means that the criteria can be met at the boundary of the facility, based on the land acquired for the stabling facility and subject to its detailed design. Note that because the noise from the stabling facility is directional, areas to the north, south and west of the facility benefit more from the proposed 6 m noise barriers

The 6 m high noise barrier is predicted to provide adequate mitigation of brake test noise over the same area, as the 65 dBA L_{Amax} contour is restricted to within 90 m of the source (ie within the boundary of the facility). The 50 dBA L_{Amax} contour extends to a maximum distance of 285 m from the source, or approximately 200 m from the boundary of the facility.

Modelling of horn testing noise indicates exceedances of the L_{Amax} sleep disturbance criteria over a large area, especially in the unmitigated case with the maximum volume horn blast. In the context of the future development of the area around the stabling facility (including residential development), mitigation of the noise from horn testing is clearly necessary. Even with a 6 m above rail noise barrier around the proposed stabling facility, L_{Amax} noise emission levels are predicted to exceed 65 dBA in an area extending beyond Bringelly Road to the north, McCann Road to the south and Eastwood Road to the east. Enclosing the facility would provide a benefit on three sides of the facility, but noise would still be projected out the doors of the facility if these are permitted to remain open as modelled.

The highly recognisable character of horn noise may also increase the potential for disturbance.

If horn noise levels are found to cause sleep disturbance to the occupants of existing residences, in the area surrounding the TSF, then individual treatment of buildings would be an option to mitigate these noise levels. This option is not satisfactory if future development plans for the area include new residential developments. Alternative mitigation measures are recommended (and are under investigation by RailCorp and the DoP) including the development of low-noise horn tests and land use planning measures.

Conclusions

This report addresses all of the noise and vibration issues set out in the Minister's Conditions of Approval for the Concept Plan and TIDC's *Statement of Commitments* made in the Concept Plan Environmental Assessment. It has been prepared after consultation with TIDC and State government agencies including the Strategic Land Release Project Office of the NSW DoP, DECCW and RailCorp.

Construction noise modelling indicates exceedances of the Noise Management Levels at existing receivers as described in DECCW's *Interim Construction Noise Guideline.* TIDC's *Construction Noise Strategy* requires the preparation of a CNVMP at a later stage in the assessment process when more detailed information is available.

Guidance in relation to operational noise goals for the project is provided in DECCW's IGANRIP. Noise modelling has shown a need for noise mitigation at a number of locations along the rail corridor. Earth mounds and noise barriers may be used to mitigate noise along the proposed rail corridor, allowing the SWRL to integrate into the SWGC with a minimum of disturbance. Appropriate land uses, including set-back zones for sensitive land uses and the location of commercial buildings at some locations along the rail corridor, is considered an essential part of the strategy to deliver acceptable noise levels along the rail corridor. Future developments near the rail corridor should also be designed in accordance with the NSW DoP guideline *Development Near Rail Corridors and Busy Roads - Interim Guideline*.

The potential noise impact from the proposed TSF has been assessed in accordance with the DECCW's INP. The noise from train horn testing will impact on existing and future residences in the vicinity of the TSF. If night time maximum noise levels from horn testing cause sleep disturbance to the occupants in existing residences surrounding the TSF, then individual treatment of noise-sensitive buildings may be used as a means of noise mitigation. Further investigation into alternative mitigation options for horn test noise is required.

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1.1 Overview

The South West Rail Link (SWRL) is a major transport project which will assist the NSW Government in providing a modern, integrated and efficient transport system to cater for Sydney's growth as a major global city.

The SWRL consists of a dual track, electrified passenger railway line, approximately 11 km long, from the existing junction of the East Hills Line and the Main South Line near Glenfield out to Leppington. The SWRL also incorporates an upgraded station at Glenfield, new stations at Edmondson Park and Leppington, and a train stabling facility (TSF) west of the planned Leppington town centre at Rossmore. The track layout will be configured to allow for a possible future expansion of rail services to Bringelly and/or Badgerys Creek (see **Figure 1**).

The SWRL will service the planned residential areas at Edmondson Park and Leppington and the broader South West Growth Centre (SWGC). The proposed TSF will also provide greater operational rail capacity on the CityRail network in the south west region.

To progress with the further design and development of the SWRL, the project has been split into two stages:

Stage 1 Delivery of the Glenfield station, transport interchange and commuter car park

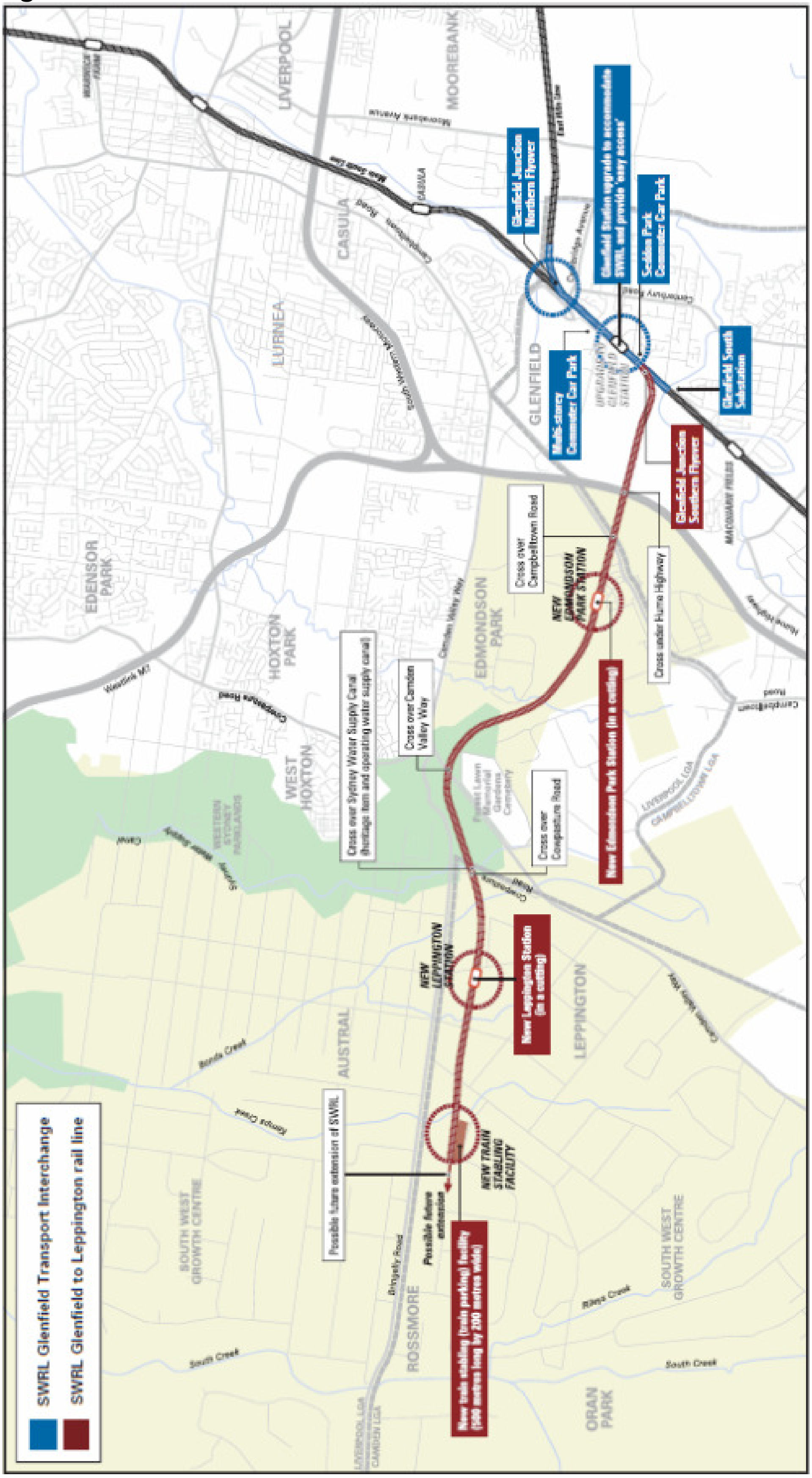
Stage 2 Delivery of the northern and southern flyovers, SWRL corridor to Leppington, Edmondson Park and Leppington stations, and the TSF.

Heggies Pty Ltd (Heggies) has been engaged by the Transport Infrastructure Development Corporation (TIDC) to provide specialist acoustic advice during the Environmental Assessment (EA) and engineering design stages of the SWRL corridor project. TIDC is the proponent of the project, and the EA is being prepared by Parsons Brinckerhoff (PB).

The noise and vibration assessment for the Glenfied Station Interchange works (formerly Stage B1) between chainage 31.4 km (East Hills Line) and 42.9 km (Main South Line) is covered in another Heggies Report 10-6245 R1 dated 4 August 2008.

This report covers the SWRL corridor works encompassing all new sections of track from south of Glenfield Station. This includes the southern flyover, the new stations at Edmondson Park and Leppington, and the TSF. This report assesses the potential noise and vibration issues associated with both the construction and operation of the SWRL corridor project.

Figure 1 South West Rail Link



1.2 Objectives

The objectives of this report are:

- To comply with the Minister's Conditions of Approval (MCoA) for the Concept Plan and TIDC's Concept Plan *Statement of Commitments* (SoC) for the SWRL; and
- To inform the EA for the SWRL corridor project and be included as a Technical Paper.

Following exhibition of the Concept Plan EA and preparation of the associated Submissions Report, the Minister for Planning granted concept approval on 29 August 2007. This concept approval confirmed the location of the stations and the rail corridor.

In accordance with MCoA 2.4 f) dated 29 August 2007, this assessment *"describes the operational noise and construction noise and vibration impacts of the project, considering all reasonable and feasible mitigation measures (where relevant)"*. The noise and vibration assessment processes comply with the MCoA 2.4 f) dated 29 August 2007 and the TIDC SoC in relation to the SWRL corridor works (see **Table 1** and **Table 2** - including cross-references to the relevant sections of this report).

Table 1 Stage B2 Minister's Conditions of Approval for the Concept Plan

Ref	Action	Where in Report
2.4 f)	Operational Noise • for the stabling facility, review operational noise impacts in accordance with the ***Industrial Noise Policy*** (EPA, 2000), considering all reasonable and feasible mitigation options (including full enclosure and the feasibility of low volume horn tests) at existing and planned future receivers; • for the rail corridor, review operational noise impacts in accordance with the ***Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects*** (DECC, 2007), considering all reasonable and feasible mitigation options at existing and planned future receivers. At Glenfield this shall involve confirming noise impacts for the long-term scenario, based on further design development; • for all other aspects of the project, describe operational noise impacts where a facility/ activity is deemed to be an intrusive noise source, considering all reasonable and feasible mitigation options for existing and planned future receivers; and • for all aspects of the project, describe regenerated noise impacts where proposed mitigation options for airborne noise have the potential to result in regenerated noise levels becoming perceptible at existing or planned future receivers, with consideration to all reasonable and feasible mitigation options.	Ambient noise levels were measured to determine amenity, intrusiveness and sleep disturbance criteria for areas surrounding TSF. Noise modelling was done with a number of noise mitigation options. RailCorp was consulted on use of low volume horns in TSFs. **Section 7** Proposed operational noise mitigation was based on rail traffic levels predicted for Year 2026. **Section 5** Substation noise emissions assessed. **Section 8**. No locations identified where regenerated noise will cause annoyance. **Section 6.1**
2.4 f)	Operational Vibration • for the rail corridor and stabling facility, review operational vibration impacts in accordance with Assessing Vibration: A Technical Guideline (DEC, 2006), considering all reasonable and feasible mitigation options for existing and planned future receivers.	Operational vibration levels along the SWRL corridor were predicted using a conservative approach. **Section 6**
2.4 f)	Construction Noise and Vibration • for all aspects of the project (as relevant), describe construction noise and vibration impacts, considering cumulative impacts from surrounding development and potential vibration impacts on sensitive items such as the Sydney Water Supply Canal and other heritage items, considering all reasonable and feasible measures for minimising impacts.	Airborne noise, ground-borne noise and vibration were assessed at all proposed construction locations along corridor. **Sections 9, 10** and **11**

Table 2 Stage B2 TIDC's Concept Plan SoC for Noise and Vibration

Outcome		
Design development and assessment adopts best practice measures to minimise construction and operational noise and vibration impacts.		
Action		
B31	Construction noise and vibration assessment and review would be undertaken as part of the future design development and assessment, in accordance with relevant policies and guidelines.	Construction noise and vibration assessed in detail. **Section 9, 10 and 11.**
B32	In regard to operational noise, the Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects (DECC, 2007) would be utilised and where appropriate any other relevant guideline to implement the following activities: a) Modelling of operational noise impacts (including ground-borne noise) in more detail as part of the design development; b) Identification of reasonable and feasible acoustic mitigation measures to meet the design goals; and c) Select representative locations for the project at which it is appropriate to later assess compliance.	Range of operational noise mitigation controls investigated to identify measures which will deliver best outcome for community. **Section 5** Locations for compliance monitoring nominated. **Section 5.13**
B33	In regard to train stabling operational noise, the following would be undertaken: a) Determine the extent of any physical noise mitigation measures in consultation with the DECCW and RailCorp; and b) Review the results of RailCorp's investigations into addressing horn noise and consider the feasibility in consultation with RailCorp in implementing a low volume horn test.	Discussions held with DECCW, RailCorp and the Strategic Land Release Project Office of the NSW Department of Planning to formulate strategies for minimising noise impact from TSF.
B34	Investigate feasible and reasonable mitigation measures for operational vibration in consultation with local Councils, the DECCW and RailCorp.	Operational vibration found not to require mitigation. **Section 6.5**
B35	Design development and assessment would include assessment of potential construction and operational vibration impacts on the Sydney Water Canal, in consultation with the Sydney Catchment Authority.	Sydney Water Canal vibration levels to be monitored during construction. **Section 11.5**

1.3 Background

The SWGC is targeted as one of the major areas for expanded development in the Sydney Metropolitan Region. The NSW Government proposes to build the SWRL between Glenfield and Leppington as part of the commitment to infrastructure for the SWGC.

The SWRL was announced by the Government in June 2005 and has been developed to provide improved transport services for existing and future residents in the SWGC. The SWRL will provide fast connections to the Sydney central business district, Liverpool and Parramatta. Development of the project will provide opportunities to increase the patronage of the existing railway system, reduce congestion on existing roads and achieve operational benefits for RailCorp. The new line will be fully integrated with RailCorp's existing network.

Construction is planned to commence in 2010, with the line becoming operational by 2016. As well as the new line from Glenfield Station to Leppington, there are long term plans for a possible western extension to either Bringelly and/or Badgerys Creek. This potential for future expansion does not form part of the current project.

It is intended to complete the SWRL early in the development of the SWGC to improve access to employment and educational opportunities for existing and future residents. The region is planned to accommodate a population increase of 280,000 people over the next 30 years.

1.4 Relevant Guidelines

Operational train noise was assessed according to the NSW Department of Environment, Climate Change and Water (DECCW) *Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects* (IGANRIP), with the SWRL being clearly defined as a "new rail line development". Following the steps laid out in IGANRIP for a new line, it was determined that noise mitigation would be required. Computer noise modelling was used to determine the effectiveness of proposed noise mitigation measures.

IGANRIP also offers guidance in assessing operational vibration levels and ground-borne noise. Further advice in assessing both operational and construction vibration levels is contained in DECCW's *Assessing Vibration: a technical guideline*.

Construction noise has been assessed in accordance with the DECCW *Interim Construction Noise Guideline*.

Noise from the TSF and three new electrical substations was assessed in accordance with the DECCW's Industrial Noise Policy (INP). The potential for sleep disturbance (resulting from horn and brake testing) in the vicinity of the TSF was assessed with guidance from the NSW Government Environmental Criteria for Road Traffic Noise (ECRTN) and Application Notes to the INP.

There are provisions in the State Environmental Planning Policy (Infrastructure) 2007 (the 'Infrastructure SEPP') to ensure that noise mitigation is a shared responsibility between the operator (RailCorp) and the community. The Infrastructure SEPP is supported by the guideline *Development Near Rail Corridors and Busy Roads - Interim Guideline*, published by the NSW Department of Planning in 2008, which is intended to assist in the planning, design and assessment of development occurring adjacent to major road and rail corridors. A key objective of this guideline is to *"ensure that adjacent development achieves an appropriate acoustic amenity by meeting the internal noise criteria specified in the Infrastructure SEPP"*. It is assumed in this report that the concept of shared responsibility will be used mitigate noise at some locations adjacent to the SWRL corridor.

1.5 Stakeholder Consultation

Heggies conducted several meetings with staff from DECCW, RailCorp and the Strategic Land Release Project Office of the NSW Department of Planning (DoP) to discuss noise issues related to the SWRL. Noise modelling results for operational train noise and for the TSF were presented at the meetings.

Discussions with DECCW and the DoP were focused on potential noise mitigation measures for the corridor and at the TSF. Mitigation measures discussed included noise barriers, enclosures and appropriate land zoning. RailCorp was also involved in discussions about the potential to reduce horn noise in TSFs. Other operational noise mitigation options discussed with RailCorp included earth mounds, noise barriers, rail dampers, wheel and rail maintenance and appropriate land use.

1.6 Terminology

Specific acoustic terminology is used within this assessment. An explanation of common terms is included as **Appendix A**.

Consistent with normal rail terminology, track chainages are referenced to 0 km at Sydney Terminal Station. Up and Down directions refer to trains travelling to Sydney and from Sydney, respectively. The Up and Down sides of the corridor are the left-hand and right-hand sides, respectively, when facing towards Sydney (ie facing in the direction of decreasing chainage).

Within the project area, the centre of the existing Glenfield Station is located at track chainage 41.9 km. The track chainage at the centre of the proposed stations at Edmondson Park and Leppington are 45.4 km and 51.0 km respectively, and the track chainage at the end of the train stabling facility is 53.4 km.

2 PROJECT DESCRIPTION

2.1 General

The proposed railway line will be predominately above ground, except where the alignment passes beneath the Hume Highway. The above ground sections include the grade-separated flyover south of Glenfield Station and surface rail located at grade, in cutting and on embankment. The track gradient was determined after consideration of ground topography and the need to cross several major roads. The chosen alignment has resulted in several deep cuttings which form effective noise barriers, and a number of high embankments where the track is in an exposed position.

The SWRL corridor project comprises the following broad components:

- Construction of a grade separated flyover over the Main South and Southern Sydney Freight Lines to the south of Glenfield Station.
- Construction of approximately 11 km of dual track within a corridor width of approximately 40 m to the south and west of the existing Glenfield Station.
- Construction of new railway stations and interchanges at Edmondson Park and Leppington.
- Construction of a TSF.
- Construction of ancillary facilities such as power supply, substations, sectioning huts, overhead wiring (OHW), signalling structures, access roads, and other infrastructure required for the operation and maintenance of rail services and infrastructure.
- Operation and maintenance of the new rail line.

2.2 Operations

The new track will be used exclusively for electric passenger rolling stock. Existing rolling stock such as Double Deck Intercity and Outer Suburban train types will not be timetabled to use the new line on a routine basis. However, when the line opens in 2016, it is anticipated that around 30% of rolling stock using the line will be the older Double Deck Suburban K and C-sets, with around 45% being Millennium sets and the balance made up by the new Waratah sets. By 2026, it is anticipated that all K and C-set trains will have been retired from service and replaced by the quieter Waratah sets or other trains, which should have similar or superior noise profiles to the Millennium sets.

No freight operations are planned for the new line. Diesel electric locomotives and diesel powered track machines will however use the line occasionally during construction and later for maintenance.

The speed will vary over the length of the new line. The assumed maximum track design speed is 125 km/h. At this stage, the anticipated maximum operating speed will be 115 km/h. The track design speed and train operating speeds will be confirmed during detailed design.

RailCorp has indicated that empty trains or so called “dead runners” may run at track speed through stations when moving to and from the stabling facility.

The maximum traffic volumes for the planned opening date in 2016 and for the year 2026 are listed in **Table 3**. These volumes are considered to be the maximum train plan for both years, but the actual future timetable will be subject to ongoing development in response to passenger demands. It is therefore possible that at opening, train volumes will be lower than those shown here. A maximum of 12 trains per hour is planned in a single direction for peak periods, with those trains travelling in the Up direction in the morning peak and in the Down direction in the evening peak.

Table 3 Summary of Train Types Using SWRL

	Train Type	Trains Per Weekday Period			
		Day 7.00 am - 10.00 pm		Night 10.00 pm - 7.00 am	
		Up	Down	Up	Down
2016	Waratah	26	28	7	6
	Millennium	48	49	14	12
	Double Deck Suburban	32	33	9	8
	Total	106	110	30	26
2026	Waratah	58	61	16	14
	Millennium	48	49	14	12
	Double Deck Suburban	0	0	0	0
	Total	106	110	30	26

2.3 Modifications to Glenfield Station and Glenfield Junction

As part of the SWRL project, extensive modifications are planned to both Glenfield Station and the track layout of Glenfield Junction. Noise and vibration issues relating to these changes in the vicinity of Glenfield Station have been addressed in another Heggies Report 10-6245 R1 dated 4 August 2008.

2.4 New Track - Glenfield Station to Leppington TSF

Approximately 11 km of dual track electrified railway will be constructed between Glenfield Junction North and the proposed Leppington TSF at Rossmore (see **Figure 1**).

Approximately 400 m south of the Glenfield Station, the alignment will swing west from the existing rail corridor and proceed on embankment through an area known as the James Meehan Estate and south of Hurlstone Agricultural High School. At the western extent of this area, the land rises steeply and the alignment will pass from embankment into cutting, passing under the Hume Highway/South-western Freeway.

West of the Hume Highway, the alignment enters the Ingleburn Gardens Estate area, passing over Campbelltown Road into the former Ingleburn Military Camp area. Edmondson Park Station will be located adjacent to the northern extent of the former military camp at track chainage 45.4 km. The rail alignment and single island platform will be in cutting, approximately 5 m deep. This will facilitate integration with the proposed Edmondson Park town centre.

The alignment will then head to the north-west, remaining in a cutting of up to 10 m in depth, until it crosses an embankment extending from chainage 46.6 km to 47.2 km. This embankment places the track in an exposed position as it passes to the north of the existing residential area of Denham Court. In this area, the alignment lies to the south and south-east of a rural region called the Edmondson Park release area. The embankment leads to a bridge crossing of Cabramatta Creek at chainage 47 km.

After passing through a short cutting, the alignment passes onto an exposed embankment on a sweeping curve which carries it around the northern edge of the Forest Lawn Memorial Gardens Cemetery and over a bridge crossing Camden Valley Way at chainage 48.4 km. In this area the track lies adjacent to the north-western part of the Edmondson Park release area and some distance to the south of the existing Prestons residential development. The embankment carries the track to the south of, and roughly parallel to, Bringelly Road.

Between Camden Valley Way and Cowpasture Road the track passes through a short cutting and emerges onto an embankment which gives sufficient height to bridge both Cowpasture Road and the Sydney Water Upper Canal at approximate chainage 49.7 km. West of the Sydney Water Canal, the alignment will be on embankment as the track passes through rural residential allotments in Leppington.

Leppington Station will be located in a cutting, immediately to the west of Rickard Road and east of Bonds Creek at approximate chainage 51.0 km. Leppington Station will have two island platforms serviced by 4 tracks, allowing more than one terminating train to stand at the station before returning to the city or continuing on to the stabling facility. The four tracks will extend from chainage 50.4 km to 51.4 km, widening the rail corridor to a maximum of 60 m for most of this distance.

Between chainage 50.2 km and 50.4 km, on the approaches to Leppington station, there are four points which allow trains to cross between the Up and Down tracks and to access any of the four platforms at Leppington. Simulations indicate that trains will reach their maximum allowable speed, briefly, in the vicinity of the first of these points, when travelling in the Down direction. Potential noise level increases resulting from the discontinuities in rail head associated with points and the high speeds have been considered in the operational noise assessment.

At the western end of Leppington Station, the track will emerge from cutting onto an embankment which will extend all the way to the TSF at chainage 52.8 km. Between Leppington Station and the stabling facility, the track bridges Dickson Road, Eastwood Road and Kemps Creek. The maximum track speed between Leppington Station and the TSF entrance is 60 km/h.

Existing land use in the vicinity of the Leppington Station site and around the TSF is rural residential. When this area is developed in the near future, the land use is anticipated to be suburban residential.

2.5 New Stations at Edmondson Park and Leppington

The proposed new stations at Edmondson Park and Leppington will be designed to act as a focal point for the adjoining retail/commercial activities planned within the respective town centres. Both stations will include concourse areas, pedestrian overbridges/connections to adjoining facilities, access for the mobility impaired (Easy Access), park-and-ride facilities, and facilities for transport interchange between bus and rail modes.

Edmondson Park Station is planned to be serviced directly by an extension of the existing Liverpool to Parramatta strategic bus corridor. Park-and-ride facilities will also be provided to service local demand.

At Leppington, the station is located in close proximity to newly developing areas. Its relatively remote location from existing developed areas will make it an attractive location for park-and-ride commuters, particularly in the short term as development and public transport networks become established. It is likely that many residents who currently park at other stations would shift to Leppington when park-and-ride supply is made available.

Both stations will be located in cuttings. This will facilitate easier access to platforms because there will be only one set of stairs or lifts when changing between rail and road transport. The cuttings will also provide for better connection between activities on opposite sides of the rail corridor. Another advantage of placing the stations in cuttings is that they form an effective noise barrier for noise from station operations such as PA systems. Because of the generally lower train speeds in and around stations, train noise emissions are also significantly lower at stations.

Noise from station operations has not been examined in detail in this report. The detailed design of stations (when detailed information relating to aspects such as plant selection and PA system design are known) should include an assessment of the potential noise impacts on any sensitive receivers in the vicinity. It is noted that Railcorp is in the process of implementing an upgrade of existing PA systems and any systems to be implemented at the new SWRL stations should be consistent with the design requirements of these upgrades.

2.6 Train Stabling Facility

A TSF will be located at Rossmore between Kemps Creek and existing woodland near Allenby Road with an entrance at approximately 52.8 km and extending to 53.4 km at its western end. The alignment through this section will run generally parallel to, and approximately 300 m to the south of, Bringelly Road.

The TSF will cover an area approximately 400 m long and 60 m wide in a mix of cutting and embankment. Initially the capacity of the stabling facility will allow the stabling of up to twelve 8-car train sets on six storage roads, but the design of the facility will allow for future expansion to a capacity of up to twenty 8-car train sets on ten storage roads.

It is envisaged that additional facilities in the TSF will include cleaning/light maintenance facilities, ablutions and administration. The facility will be lit by floodlights and fenced for security reasons. Access is proposed to be provided from McCann Road.

The cutting in which the stabling facility will be set will reduce both noise and visual impacts on adjacent land uses. Approximately 60% of the length of the proposed stabling facility will be in a cutting with a maximum depth in the order of 6 m at its western end. The stabling roads will be approximately 2 m above the natural ground level at the southern end of the yard.

Major sources of noise from the stabling facility will be onboard equipment which is left running while trains are stabled, such as air compressors, invertors and air conditioning units. While trains are prepared for service, prior to leaving the stabling facility, additional noise is generated during the testing of horns and brakes. Noise from these sources are of very short duration, however they are of relatively high level and have the capacity to cause disturbance to potential future sensitive receivers, particularly in the late evening and early morning.

2.7 Substations

Three new substations are planned to provide 1500 volt DC traction supplies to the new line, at chainages 47.750 km and 48.780 km, and also at the TSF. The major noise sources at substations are step down transformers and circuit breakers. Transformer noise is sometimes perceived as a continuous low level 100 Hz hum. The project also includes sectioning huts at a number of locations, the noise from these has not been modelled. The only significant noise source from sectioning huts is that from circuit breakers, which can cause loud impulsive noises, but only when fault conditions cause over-current trips.

3 EXISITING AND FUTURE NOISE ENVIRONMENT

The existing noise environment varies significantly along the length of the proposed SWRL corridor project. Land use is primarily suburban or rural residential, with some areas being affected by their proximity to major roads. These major roads include the Hume Highway, Campbelltown Road, Bringelly Road, Camden Valley Way and Cowpasture Road. The noise emissions from these roads contribute to increased ambient noise levels at nearby residential and other sensitive receiver locations. It is planned that some of these roads will be upgraded in parallel with the SWRL construction.

The development of the SWGC will result in increased traffic on the area's road network in general, and an associated increase in road traffic noise. Assessment of increased road traffic noise in the general SWGC area is not part of the scope of this study, as it is not directly attributable to the SWRL.

The absence of any significant commercial or industrial development in the vicinity of the SWRL corridor means that night-time ambient noise levels are presently very low.

The development of the SWGC will ensure that the lightly populated rural nature of many properties in the vicinity of the SWRL corridor will change as new residential and commercial centres develop to take advantage of the new rail transport corridor. Planning agencies such as the Strategic Land Release Office of the NSW DoP and Landcom are co-ordinating the proposed development around Edmondson Park and Leppington Stations and their respective release areas through an ongoing master planning process.

It is with these new developments in mind that noise mitigation measures must be addressed. Ideally, the most sensitive land uses would be separated from the rail corridor by less sensitive land uses such as commercial or industrial buildings, which would form practical and cost effective noise barriers. In the absence of commercial or industrial buildings being used to shield sensitive receivers, some separation could be maintained by reserving land along the edge of the rail corridor for roadways or open recreation areas.

3.1 Ambient Noise Measurements

3.1.1 Ambient Noise Monitoring Locations

Ambient noise surveys have been undertaken at five representative locations between Glenfield and Leppington. Noise monitoring locations were selected to yield typical existing noise levels in the vicinity of proposed construction sites, Leppington Station and the proposed stabling facility.

3.1.2 Methodology

The purpose of the ambient noise monitoring is to determine the existing background noise levels, which are used as a basis for assessing the impact of noise emissions during both the construction and operation of the SWRL. Operational noise includes noise emitted by moving trains as well as emissions from fixed facilities, which include the TSF, stations and substations.

Unattended noise logging was undertaken in April and July 2006 using Acoustic Research Laboratories (ARL) noise loggers, type EL215 and EL316, positioned at each of the monitoring locations for a period of approximately one week. The noise loggers were set to record ambient noise levels continuously in consecutive 15 minute intervals. These loggers store statistical descriptors, which reflect the range of noise levels in the preceding interval.

All equipment used for the surveys carries current manufacturer's calibration certification. Calibration was checked before and after each measurement and at the downloading of data from the noise loggers. In all cases, the calibration drift was less than the acceptable limit of 0.5 dBA.

Weather details for the period of noise logging were obtained from the Bureau of Meteorology. The wind speed and direction information was sourced from the weather station located at Holsworthy.

Ambient noise levels in the areas where noise monitoring was undertaken are not expected to have changed significantly since the time when monitoring was done in 2006.

3.1.3 Noise Monitoring Results

The full results from the unattended noise monitoring are presented graphically in **Appendix B**. The weather records obtained from the Bureau of Meteorology for the monitoring period are overlaid on the daily noise plots.

To determine the Rating Background Level (RBL) during the daytime, evening and night-time periods, the L_{A90} background noise levels were processed in accordance with the procedure in the DECCW's *Industrial Noise Policy* (INP). The RBL is the overall single figure background level representing quiet ambient conditions in each assessment period (daytime, evening and night-time).

The existing L_{Aeq} noise levels for the daytime, evening and night-time periods were also processed in accordance with the procedure in the INP. These values represent the typical "energy-averaged" noise levels during each assessment period.

A summary of the processed noise levels is presented in **Table 4**.

Table 4 Summary of Ambient Noise Levels at Unattended Noise Monitoring Locations

Monitoring Location	Daytime Noise Level* (dBA)		Evening Noise Level* (dBA)		Night-time Noise Level* (dBA)	
	LA90	LAeq	LA90	LAeq	LA90	LAeq
615 Bringelly Road, Rossmore	43	58	38	57	30	55
198 McCann Road, Rossmore	34	66	33	59	30	54
25 Cassidy Street, Denham Court	36	47	37	43	33	42
135 Croatia Avenue Edmondson Park	38	49	42	48	37	45
18 Newtown Road, Glenfield	41	61	42	59	37	56

Note * DECCW's preferred definition of daytime, evening and night-time hours. Daytime refers to standard daytime construction hours, namely 7.00 am to 6.00 pm Monday to Friday and 7.00 am to 1.00 am on Saturday. Evening refers to the period 6.00 pm to 10.00 pm. Night-time refers to the period 10.00 pm to 7.00 am.

The summary results in **Table 4** are derived from a minimum of a week of noise logging. The data has been segregated into the relevant time of day (daytime, evening and night-time) to assist in setting noise criteria for construction, substation and train stabling operations.

4 IDENTIFICATION OF SENSITIVE RECEIVERS

To assess the potential noise and vibration impacts from the project, it was first necessary to identify potentially affected receivers in the vicinity of the proposed rail corridor. Information on building occupancy type (residential, commercial, industrial, educational, hospital, worship, etc) was obtained by visiting the site and sighting each building within a distance of approximately 300 m from the rail corridor.

Within some of the project area, land uses are likely to substantially change. Some of this change will have occurred by the time the project is scheduled to commence operations. The proposed land uses are indicated in **Appendix C** in colour coded aerial photos which also show plots of $L_{Aeq(9hour)}$ and L_{Amax} noise contours. Proposed land uses were determined from the following documents:

- Campbelltown City Council's *Campbelltown (Urban Area) Local Environmental Plan 2002*
- Liverpool City Council's *Edmondson Park Precinct Development Control Plan 2008*
- NSW DoP's *South West Growth Centre Structure Plan*

A brief description of the existing and anticipated future land use and noise sensitivity along the route as shown in **Appendix C** is provided in **Table 5**.

Table 5 Existing and Future Land Use and Noise Sensitivity Along Corridor

Ref[1]	Location Description	Land Use	
		Existing	**Future Proposed**
Drawing 1	Glenfield Station to the southern flyover	The corridor to the south of Glenfield station is primarily bounded by residential land. A small area of light commercial property is situated adjacent to Glenfield Station. Macquarie Links International Golf Club is located immediately to the south-west of the flyover, with Hurlstone Agricultural College to the north. The Main South Railway would be the dominant noise source.	No confirmed future development
Drawing 2	Between the southern flyover and the Hume Highway, and Ingleburn Gardens Estate	The corridor is bounded by rural land, with schools to the north. Heritage listed Macquarie Fields House is located to the south of the corridor. Across the Hume Highway, Ingleburn Gardens Estate is currently under development. The Hume highway and Campbelltown Road would be the dominant noise sources.	Macquarie Links residential development is under development to the south but is not immediately adjacent to the rail corridor. Ingleburn Gardens Estate is currently under development, with residential areas, an aged care facility and a school approved by Council.
Drawing 3	Campbelltown Road to Edmondson Park Station	The former Ingleburn Military Camp is predominantly undeveloped, apart from buildings (some heritage listed) over several hundred metres along the southern boundary of the proposed rail corridor. Generally quiet area. Noise environment would be controlled by distant road traffic noise.	This area is covered by the *Edmondson Park Precinct Development Control Plan 2008*. The zoning maps indicate nature reserves and town centre areas on the southern (Down) side of the proposed railway corridor and part of the northern (Up) side of corridor. Closer to the station the northern (Up) side is bordered by a medium density residential zone.

Ref[1]	Location Description	Land Use	
		Existing	Future Proposed
Drawing 4	West of Edmondson Park Station to Culverston Avenue	Currently undeveloped.	This area is covered by the *Edmondson Park Precinct Development Control Plan 2008*. The zoning maps indicate nature reserves on the southern (Down) side of the proposed railway. The Up side is a medium density residential zone.
Drawing 5	Culverston Avenue and Cassidy St (Denham Court)	The proposed rail corridor is bounded by rural residential properties (ie single dwellings on blocks of typically 1 Ha). Quiet residential area.	The character and housing density of this area is likely to remain relatively unchanged in the medium term.
Drawing 6	Curve adjacent to Lawn Cemetery, Camden Valley Way and Bringelly Road	The proposed rail corridor is bounded by rural residential properties to the north on the approach to Camden Valley Way. A lawn cemetery and memorial garden is adjacent to the rail corridor on the Down side. Beyond Camden Valley Way, land use is mainly rural and undeveloped including Western Sydney Parklands. Generally quiet area. Noise environment would be controlled by road traffic noise from Camden Valley Way.	The character and housing density of this area is likely to remain relatively unchanged in the medium term.
Drawing 7	Sydney Water Canal and Cowpasture Road to the approach to Leppington Station	The proposed rail corridor is bounded by rural land, exposed to noise from Cowpasture Road.	Based on the *South West Growth Centre Structure Plan*, development in this area is expected to be medium density residential.
Drawing 8	Rickard Road to Dickson Road (including new Leppington Station and town centre)	This area is mainly rural land. Leppington Primary School is also in the vicinity of the rail corridor. Generally quiet area. Noise environment would be controlled by distant road traffic noise.	Based on the *South West Growth Centre Structure Plan*, development in this area is expected to be a mix of town centre (commercial, services etc) and high density residential.
Drawing 9	Eastwood Road to Leppington TSF	The proposed rail corridor is bounded by rural land. Generally quiet area. Noise environment would be controlled by distant road traffic noise.	Based on the *South West Growth Centre Structure Plan*, development in this area is expected to a mix of low and medium density residential

Note 1: Reference areas correspond to the drawing numbers in Appendix C, as shown on the key plan at the beginning of each set of drawings.

4.1.1 Compliance Assessment Locations

The ambient measurement locations described in **Section 3.1.1** would also be adopted for assessing noise and vibration emission level compliance during construction and when the project becomes operational. It is likely that supplementary locations would also be selected, especially in relation to the construction noise monitoring.

5 OPERATIONAL NOISE ASSESSMENT

5.1 Assessment Process

Guidance in relation to the operational assessment process for the project is provided in DECCW's IGANRIP. The main purpose of the guideline is to assist the ongoing expansion of rail transport by ensuring that potential noise impacts associated with rail developments are assessed in a consistent and transparent manner. The guidelines are not mandatory and are intended to encourage the best outcomes for the community as a whole, given the application of feasible and reasonable means to control noise and vibration generated by rail traffic.

For new and upgraded railway lines, the assessment process is illustrated in **Figure 2**.

Figure 2 Assessment Process (based on Figure 2 in IGANRIP)

Pre Environmental Assessment Stage (Completed)

Consult with the community and relevant agencies to determine the environmental noise and vibration values to be protected.

↓

Environmental Assessment (This Report)

1. Determine the noise and vibration trigger levels (refer **Sections 5.3** and **6.3**).
2. Undertake a noise and vibration assessment to determine locations where the noise and vibration trigger levels are likely to be exceeded as a result of the project (refer **Section 5** and **Section 6**).
3. At locations exceeding the noise and vibration trigger levels, undertake a cost-benefit analysis of feasible and reasonable mitigation measures and prioritise these to maximise the protection of the environment. This includes noise, vibration, community views and aesthetic impacts.
4. Incorporate the proposed mitigation measures and identify the noise and vibration levels achievable for the project (refer **Section 5**).

↓

Public Exhibition and Submissions Report Stage

1. Consult with the affected community to review the noise and vibration levels achievable for the project (exhibition stage of the Environmental Assessment).
2. Review the proposed mitigation measures following community consultation and produce a report (eg submissions report) documenting the proposed mitigation measures and achievable noise and vibration levels for the project.

↓

Planning Approval Stage

Achievable noise and vibration levels and/or mitigation measures for the project are included in the approval conditions.

5.1.1 Pre Environmental Assessment Stage

The pre-environmental assessment stage includes a community information session to inform and consult with local residents and other stakeholders about the project, the assessment process and to obtain feedback on the environmental values that need to be protected.

5.1.2 Environmental Assessment Stage

This report forms part of the EA and describes in detail, the noise and vibration assessment process. This includes:

- Determining the noise and vibration "trigger levels" at sensitive receiver locations in accordance with the relevant guidelines.
- Identifying sensitive receiver locations where the project-related noise and vibration "trigger levels" are likely to be exceeded.
- At locations where the noise and vibration trigger levels are likely to be exceeded as a result of the project, the guideline requires further assessment to be undertaken to identify the feasible and reasonable mitigation measures and achievable noise and vibration levels for the project.

Section 3.1 of IGANRIP provides the following guidance in relation to determining feasible and reasonable mitigation measures:

Feasibility relates to engineering considerations and what can practically be built or modified, given the opportunities and constraints of a particular site.

Reasonableness relates to a judgement which takes into account the following factors:

- Noise-mitigation benefits - noise reduction provided, number of people protected
- Cost of mitigation - total cost and cost variation with level of benefit provided
- Community views
- Aesthetic impacts
- Track maintenance and access requirements
- Noise levels for affected land uses - existing and future levels, expected changes in noise levels
- Benefits arising from the development or its modification

In this report, the reasonableness assessment firstly addresses the noise mitigation benefits and cost of mitigation. Other factors including community opinions, aesthetic impacts and the wider community benefits of the project have also been considered and assessed. The community vistas noted above include those of train travellers as well as those of the wider community. Any noise mitigation used along the rail corridor has, therefore, to consider any adverse impact on commuters' views.

The assessment embodied within this report is based entirely upon the Environmental Assessment Design. This represents one example of how the project could be constructed, operated and maintained. Should circumstances arise that result in minor changes to the Environmental Assessment Design, the noise and vibration impacts of the SWRL project would not be expected to be greater than those described and assessed within this report. If the detailed design phase does result in acoustically significant changes, these will need to be assessed and approved on a case by case basis in accordance with the laws and Statutory Requirements. As the design develops, the noise modelling and mitigation requirements will be reviewed and updated. It is also noted that the project noise and vibration design goals are unlikely to change throughout the project, which would be required to comply with the MCoA and SoC described in this report.

5.1.3 Public Exhibition and Submissions Report Stage

During the public exhibition stage, the community and other stakeholders are invited to provide formal feedback on the EA (via written submissions), including the indicative noise and vibration mitigation measures.

Once all of the submissions are reviewed, the proponent is required to produce a Submissions Report responding to all of the queries and suggestions made during the public exhibition period. This report will provide a summary of any changes to the proposed mitigation measures and the achievable noise and vibration levels (after considering the input from the community, other stakeholders, and feasible/reasonable measures).

5.1.4 Planning Approval Stage

During the planning approval stage, the achievable noise and vibration levels and/or the proposed mitigation measures (as documented in the Submissions Report) are included in the approval of the project.

5.2 Operational Noise Metrics

The primary noise metrics used to describe railway noise emissions in the modelling and assessments are:

L_{Amax}	The "Maximum Noise Level" occurring during a train passby noise event.
$L_{Aeq(24hour)}$	The "Equivalent Continuous Noise Level", sometimes also described as the "energy-averaged noise level". The $L_{Aeq(24hour)}$ may be likened to a "noise dose", representing the cumulative effects of all the train noise events occurring in one day.
$L_{Aeq(15hour)}$	The Daytime "Equivalent Continuous Noise Level". The $L_{Aeq(15hour)}$ represents the cumulative effects of all the train noise events occurring in the daytime period from 7.00 am to 10.00 pm.
$L_{Aeq(9hour)}$	The Night-time "Equivalent Continuous Noise Level". The $L_{Aeq(9hour)}$ represents the cumulative effects of all the train noise events occurring in the night-time period from 10.00 pm to 7.00 am.
$L_{Aeq(1hour)}$	The busiest 1-hour "Equivalent Continuous Noise Level" The $L_{Aeq(1hour)}$ represents the typical L_{Aeq} noise level from all the train noise events during the busiest 1-hour of the assessment period.
L_{AE}	The "Sound Exposure Level", which is used to indicate the total acoustic energy of an individual noise event. This parameter is used in the calculation of L_{Aeq} values from individual noise events.

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

5.3 Operational Noise Goals

IGANRIP provides "noise trigger" levels that flag the need for an assessment of the potential noise and vibration impacts from a project. IGANRIP also suggests measures that may be feasible and reasonable to apply to reduce a project's impacts.

For airborne noise created by the operation of surface track, trigger levels are provided for rail infrastructure projects including a "new railway line" or "redevelopment on an existing railway line". The SWRL corridor project clearly falls into the former category for its entire length, from the southern flyover at Glenfield to the entrance of the Leppington TSF.

The noise trigger levels for residential and other sensitive receiver locations are provided in **Table 6** and **Table 7**.

Table 6 Airborne Noise Trigger Levels for Surface Track - Residential

Type of Development	Residential Noise Trigger Levels (dBA)		
	Day (7 am to 10 pm)	Night (10 pm to 7 am)	Commentary
New rail line development	Development increases existing rail noise levels AND Resulting rail noise levels exceed:		These numbers represent external levels of noise that trigger the need for a rail infrastructure project to conduct an assessment of its potential noise impacts.
	60 $L_{Aeq(15hour)}$ 80 L_{Amax}	55 $L_{Aeq(9hour)}$ 80 L_{Amax}	An increase in existing rail noise levels is taken to be an increase of 2.0 dB or more in L_{Aeq} in any hour or an increase of 3.0 dB or more in L_{Amax}.

Table 7 Airborne Noise Trigger Levels for Surface Track - Other Sensitive Land Uses

Sensitive Land Use	Noise Trigger Levels (dBA)
	New Rail Line Development
	Development increases existing rail noise levels by 2.0 dBA or more in L_{Aeq} in any hour AND Resulting rail noise levels exceed:
Schools, educational institutions - internal	40 $L_{Aeq(1hour)}$
Places of worship - internal	40 $L_{Aeq(1hour)}$
Hospitals - internal	35 $L_{Aeq(1hour)}$
Hospitals - external	60 $L_{Aeq(1hour)}$
Passive recreation	L_{Aeq} as per residential noise level values in **Table 6** (does not include maximum noise level component)
Active recreation (eg golf course)	65 $L_{Aeq(24hour)}$

In assessing noise levels at residential receiver locations, the outdoor noise level to be addressed is that prevailing at a location 1 m in front of the most affected building facade. Any “internal noise level” refers to the noise level at the centre of the habitable room that is most exposed to the noise source and apply with windows open sufficiently to provide adequate ventilation (notionally an open area equal to 5% of the floor area of the room).

For new rail projects, the noise trigger levels apply both immediately after operations commence and for projected traffic volumes at an indicative period into the future to represent the expected typical level of rail traffic usage (ten years or similar period into the future). The Year 2026 is taken as a representative period into the future.

It is noted that RailCorp’s current Environmental Protection Licence (EPL) stipulates noise goals that are different to those provided in IGANRIP. EPL12208 states that "In the development of new works the licencee is required to work towards the planning goals of 55dBA $L_{Aeq(24hour)}$ and 80 dBA L_{Amax} pass by noise at one metre from the facade of the nearest affected residential property." RailCorp’s licence $L_{Aeq(24hour)}$ noise goal is slightly more stringent that the IGANRIP trigger levels, which are defined in terms of daytime and night-time levels with higher levels permitted during daytime hours.

RailCorp's licence is reviewed regularly and for other major new works (for example, the Epping to Chatswood Rail Link) special licence conditions have been imposed to define project specific noise goals. It is expected that similar licence conditions would be defined for the SWRL project. At this stage in the absence of project specific licence goals, the operational noise levels of the project are assessed against the IGANRIP trigger levels.

5.4 Operational Noise Sources - Noise Modelling

5.4.1 Noise Modelling and Reference Noise Levels

SoundPLAN Version 6.5 has been used to calculate railway noise emission levels for this project. Of the train noise prediction models available within SoundPLAN, the Nordic Rail Traffic Noise Prediction Method (Kilde 1984) has been used, since it is capable of efficiently calculating both the L_{Amax} and L_{Aeq} noise levels.

Noise emissions from suburban electric passenger trains are predominantly caused by the rolling contact of steel wheels on steel rails. Even under ideal conditions with "smooth" rail and wheels, noise would occur as a result of the elastic deformation at the rolling contact point and due to the finite residual roughness of typical wheel and rail running surfaces. Other noise sources on electric passenger trains (such as air-conditioning plant and air compressors) are generally insignificant in noise level when compared with the wheel-rail interaction, unless the train is travelling at very low speed or is stationary.

Impact noise from rail discontinuities such as turnouts and mechanical joints or uneven welded joints also has an effect on the level of wheel-rail noise emission, as impulsive noise is emitted as each wheel of the train impacts the discontinuity. Radiation from some types of rail bridges (especially open-transom, steel bridges) may also increase overall levels of noise emission.

In areas where there are tight radius curves, flanging noise or curve squeal may also increase the levels of noise emission.

The SoundPLAN input data used in the modelling for this project were adapted to ensure that the calculated noise levels accurately reflect local conditions (ie the in-service fleet of suburban electric trains, etc). The reference noise levels used for the noise modelling (**Table 8**) were based on measurements undertaken by Heggies on recent projects, including the Cronulla Line Upgrade and Duplication Project, the Kingsgrove to Revesby Quadruplication Project and measurements undertaken adjacent to the Main North Line.

Additional noise and vibration measurements were made recently to ensure that levels recorded on these earlier projects are still typical. Levels recorded in these recent measurements showed good correlation with the earlier results. Levels with trains operating at higher speeds were also recorded during the recent measurements to give greater confidence in the reference noise levels, given that it is planned to run services at speeds up to 125 km/h on the SWRL.

Table 8 Reference Noise Levels used for Electric Passenger Train Modelling

Train Types	Reference Conditions	L_{Amax}	L_{AE}
Millennium/Waratah	15 m, 80 km/h	85.5 dBA	88.5 dBA
Double Deck Suburban	15 m, 80 km/h	87 dBA	91 dBA

The noise model uses the noise values listed above as a reference and calculates noise levels at varying train speeds according to the following relationships;

For L_{Amax},

$$L_{Amax} = L_{Amax}(80) + 30.5 \times \log10(\text{speed}/80 \text{ km/h})$$

Where L_{Amax} is the noise level at a given train speed in km/hr and $L_{Amax}(80)$ is the relevant value listed in **Table 8**.

For L_{AE},

$$L_{AE} = L_{AE}(80) + 23.5 \times \log10(\text{speed}/80 \text{ km/h})$$

Where L_{AE} is the noise level at a given train speed in km/hr and $L_{AE}(80)$ is the relevant value listed in **Table 8**.

5.4.2 Track Features

Bridges and Viaducts

When trains operate on elevated structures, including bridges and viaducts, vibration from the rails is transmitted into the structure, resulting in noise radiation from the surfaces of the bridge or viaduct.

Noise emissions from elevated structures are partially dependent on the damping properties and resonant behaviour of the structural elements. Unballasted steel bridges typically generate the highest noise emissions, whereas noise emissions from concrete bridges with ballasted or resiliently fixed track may be almost as low as "at grade" noise emission levels. Some bridge designs incorporating parapets may actually reduce noise emissions to below "at grade" levels by virtue of the noise barrier effect, however even these bridges may produce some annoying low frequency noise. The use of low (approximately 1 m high) concrete parapets on the over-bridges and flyover would reduce the wheel-rail emission from the associated tracks by at least 5 dBA. It is recommended that low level parapets be used as a noise mitigation measure where feasible and reasonable.

For this assessment, it has been assumed that the elevated rail crossings over Campbelltown Road, Camden Valley Way, the Sydney Water Supply Canal (the Upper Canal) and Cowpasture Road are all ballasted concrete spans with no side screens in the baseline case. For these types of bridges, no correction is required in the noise modelling. The grade-separated flyover is also assumed to be ballasted concrete span with no side screens.

Rail Surface Discontinuities

Discontinuities in the rail running surface occur at turnouts, crossings, track defects, etc. For an eight-car train, a single rail discontinuity would result in 32 impulsive noise emissions. For this assessment, the modelled location of turnouts and crossovers was based on the information supplied by TIDC. The most significant turnouts and crossovers, from a noise perspective, are those to the east of Leppington Station where trains travelling in the Down direction will be travelling at or near to maximum speed.

No corrections were made in the modelling for rail joints, as it was assumed that all insulated joints and welded joints will be maintained in a condition such that they do not cause any significant increase in train passby noise levels.

Within SoundPLAN, rail surface discontinuities are modelled over a track length of 10 m. The correction is applied to both the L_{Amax} and L_{AE} values.

Conventional Turnout = +6 dBA (L_{Amax} and L_{AE})

Flanging Noise

Flanging noise is the high frequency, broadband or multi-tonal (tissh-tissh) noise which is common on tight curves. For this assessment, the modelled location of flanging noise was based on the horizontal (and vertical) alignment drawings.

Within SoundPLAN, the following corrections were made to the wheel-rail noise source:

Curves < 300 m radius:	+8 dBA (L_{AE} and L_{Amax})
Curves ≥ 300m and < 500 m radius	+ 3 dBA (L_{AE} and L_{Amax})

On the proposed SWRL corridor route there are no curves with a radius of < 300 m and the only curve with a radius between 300 m and 500 m is located on the southern flyover.

Horn Noise Departing Stations

Train horns are sounded to signal impending movement when departing stations. These warning horn blasts are considered to be safety critical. Therefore, horn noise in general operations (which include departure from stations) are considered to be exempt from standard noise assessment criteria for safety reasons. Horn noise from trains departing stations is not examined in this report.

At train stabling facilities, horn testing activities are assessed as industrial noise in accordance with the requirements of the NSW Industrial Noise Policy (see **Section 7.4)**.

5.4.3 Assumptions for SWRL Noise Modelling Assessment

For this assessment, a series of assumptions have been made:

- Train speed profiles for the modelling were obtained from *Worley Parsons* (for the SWRL rail traffic) along with train speeds through corners provided by Aurecon and Aecom. This is a slightly conservative measure as trains not using the maximum acceleration would have slower speeds and hence marginally lower noise levels.
- For the 2016 Scenario, electric passenger services on the SWRL were assumed to consist of 70% Millennium or Waratah sets, and 30% Double Deck Suburban sets.
- For the 2026 Scenario, electric passenger services on the SWRL were assumed to consist of 100% Millennium or Waratah sets, with Double Deck Suburban sets phased out of operation.
- The new Waratah vehicles, which will replace the existing Double Deck Suburban sets, will have similar or superior passby noise characteristics to those of the Millennium sets.

5.5 Other Noise Modelling Inputs

5.5.1 Track Alignment and Ground Terrain within Rail Corridor

The track alignments for the proposed railway line were provided by Aurecon and Aecom in the form of 3D digital track strings in AutoCAD format.

The ground terrain data for the current modelling was also provided by Aurecon and Aecom in the form of digital 3D contours in AutoCAD format.

5.5.2 Rail Traffic Data

The IGANRIP specifies that the noise trigger levels apply both immediately after operations commence (Year 2016) and for projected traffic volumes at an indicative period into the future to represent the expected typical maximum level of train usage. For this project, RailCorp has advised that the proposed train timetable for Year 2026 is appropriate for long-term noise modelling purposes.

Rail traffic data provided by RailCorp and used in the future modelling scenarios (Year 2016 and Year 2026) are summarised in **Table 3** and repeated here in **Table 9**.

Table 9 Summary of Train Movements for Modelling Scenarios SWRL for Year 2016 and Year 2026

Year	Train Type	Trains Per Weekday Period			
		Day 7.00 am to 10.00 pm		Night 10.00 pm to 7.00 am	
		Up	Down	Up	Down
2016	Waratah	26	28	7	6
	Millennium	48	49	14	12
	Double Deck Suburban	32	33	9	8
	Total	106	110	30	26
2026	Waratah	58	61	16	14
	Millennium	48	49	14	12
	Double Deck Suburban	0	0	0	0
	Total	106	110	30	26

5.6 Validation of the Noise Modelling

Noise modelling, using SoundPLAN, has been used by Heggies on many RailCorp and TIDC projects. Predicted noise levels in previous rail modelling projects have shown good correlation with the values measured at the completion of the projects, once operations began.

For the purpose of the SWRL modelling, Heggies has used train noise data collected over a number of years during surveys carried out by both Heggies and others. More recent train noise passby data was also collected to ensure that the previous data is still representative of RailCorp's current fleet of electric passenger rolling stock.

The modelling uses L_{Amax} 95th percentile levels, measured over a large sample of trains at various speeds and locations. For the purposes of noise modelling, two train types were used. The first type consists of Millennium and Waratah train sets. The second type consists of the older style S, R and K sets which are collectively referred to as Double Deck suburban (DD Suburban).

The newer Millennium vehicles show lower maximum passby noise levels when compared with DD Suburban sets (measured under similar operating conditions). The new Waratah trains are expected to emit maximum noise levels which are similar to or lower than those of Millenniums.

The passby noise levels used in the noise modelling assume that the track is in good condition and that the running surface of the rail head is free of visible defects. Wheel tread condition is also assumed to be in good to fair condition (representative of the current in-service fleet).

The operational noise modelling predicts noise levels at a height of 2 m above receiver ground level (ie for a first floor receiver) over a grid spaced at 15 m intervals. The model then interpolates noise values at locations between the grid points.

5.7 Summary of the Approach to Noise Mitigation

As described in the IGANRIP, at existing receivers where the noise trigger levels are exceeded, the need for further assessment of reasonable and feasible mitigation options is warranted. Because the SWRL is a greenfield project, the number of existing receivers that might be affected is relatively low. However, the plans for the SWGC indicate that in future, many more receivers may be located near the rail corridor. Therefore, although the IGANRIP only requires consideration of existing receivers, the approach to noise mitigation undertaken for the SWRL project also considers future residential areas as identified in council land use plans and DoP master planning documentation. Areas where future residential development is confirmed or proposed are the Ingleburn Gardens Estate development, the Edmondson Park Town Centre development and the town centre surrounding the proposed Leppington Station.

The construction of the SWRL includes excavations that are expected to produce a quantity of spoil. The project proposes to take advantage of this available spoil to provide an acoustic benefit, by constructing earth mounds at locations where there are existing sensitive receivers or future residential development is expected and where there is sufficient space for mounds greater than 1 m high above the top of rail level. The construction of these earth mounds is subject to sufficient spoil being available and will be confirmed in the detailed design phase. In the event that the proposed earth mounds are not realised, alternative mitigation measures may need to be considered at these locations.

The approach taken to determine locations where additional noise mitigation measures may be required can be summarised as follows:

- Predict the baseline operational noise levels including the effect of the earth mounds, but without any other mitigation.
- Using the baseline analysis, identify locations where IGANRIP trigger levels are exceeded for existing receivers or in areas where future residential development is expected.
- Consider reasonable and feasible noise mitigation options for these locations.
- Include the proposed additional noise mitigation options and predict the resulting operational noise levels.
- Assess the potential residual noise impacts and discuss any further mitigation that may be required.

The proposed locations of earth mounds (included in all noise modelling scenarios) are listed below in **Table 10**. The earth mounds are assumed to have a batter on both sides to facilitate landscaping and minimise erosion. Heights listed in **Table 10** are heights above the undisturbed ground level at each barrier location.

Table 10 **Summary of Proposed Earth Mound Locations - Used for all Operational Noise Modelling Scenarios**

Location	Approximate Height	Up / Down Side
Ingleburn Gardens Estate Exit from Hume Highway cutting 44.15 km to 44.30 km	1.5 m to 3.5 m	Up Side Only
Edmondson Park Town Centre Development In Reserve approaching Denham Court 45.75 km to 45.96 km	0.5 m to 2.75 m	Up Side Only
Edmondson Park Town Centre Development In Reserve adjoining Denham Court 46.37 km to 46.62 km	0.25 m to 3.5 m	Up Side Only
Existing and future residential receivers At grade track Denham Court 47.22 km to 47.32 km	0.25 m to 3.25 m	Up and Down Sides
Existing and future residential receivers Shallow cutting Denham Court 47.50 km to 47.72 km	0.25 m to 3.5 m	Up and Down Sides
Leppington Town Centre Transition from embankment to cutting approaching Leppington Station 50.58 km to 50.76 km	0.25 m to 3.75 m	Up and Down Sides

5.7.1 Noise Trigger Levels and Assessment Parameters

In order to undertake an assessment of the SWRL rail operations at opening in 2016 and in the future, **Table 6** provides noise trigger levels for both the daytime and night-time assessment periods. In terms of the L_{Amax} assessment parameter, the noise trigger levels at residential receiver locations are the same during the daytime and night-time periods. The $L_{Aeq(9hour)}$ noise levels during the night-time period are 5 dBA lower (ie more stringent) than the daytime period.

On the basis of the proposed train movements during the daytime and night-time periods, the calculated $L_{Aeq(15hour)}$ daytime noise levels would be approximately 3 dBA to 4 dBA higher than the $L_{Aeq(9hour)}$ night-time levels.

Predicted night-time noise levels are therefore closer to the noise trigger levels than daytime noise levels. If predicted night-time noise levels are less than or equal to the night-time noise trigger levels, then the daytime noise levels will also be below the noise trigger levels. Consequently, for all of the L_{Aeq} noise modelling scenarios, noise calculations have been performed for the night-time period only - as it is the controlling condition.

5.7.2 Noise Trigger Levels for other Sensitive Receiver Locations

Hurlstone Agricultural High School and Ajuga School are located north of the proposed SWRL, immediately to the west of the southern flyover. For these receivers, noise trigger levels for the typical highest 1 hour period (when in use) are provided in **Table 7**.

For schools, the $L_{Aeq(1hour)}$ noise trigger level is 40 dBA (internal) and the increase in L_{Aeq} noise levels must be 2 dBA or more in order to trigger further assessment of potential mitigation measures. An internal noise trigger level of 40 dBA typically equates to an external level of 50 dBA with windows open. Noise modelling predicts that neither school will be exposed to external noise levels from the SWRL project which are greater than 50 dBA $L_{Aeq(1hour)}$.

5.8 Baseline Prediction of Operational Noise Emissions

The baseline predictions of operational noise emissions are presented in **Appendix C**. The baseline refers to the scenario with earth mounds as listed in **Table 10**, but without any additional noise mitigation.

5.8.1 After Opening Situation (2016)

Noise contours for the night-time $L_{Aeq(9hour)}$ and L_{Amax} noise levels for the 2016 traffic volumes and vehicle mix were calculated using SoundPLAN. The noise contours are presented in **Appendix C**. For the baseline case, predicted $L_{Aeq(9hour)}$ night-time noise levels of 55 dBA will extend up to 120 m from the SWRL corridor. The greatest potential impact would occur at locations where the track is on high embankments or on viaduct and where train speeds are at or approaching their maximum.

5.8.2 Long-term Situation (2026)

The predicted night-time $L_{Aeq(9hour)}$ train noise levels for the Year 2026 and onwards are also presented in **Appendix C**. L_{Amax} and $L_{Aeq(9\ hour)}$ noise levels are predicted to decrease by a small amount between the planned opening in 2016 and the longer term. This is due to the planned withdrawal from service of the old Double Deck Suburban sets which usually have higher noise emissions than Tangaras and Millenniums.

5.9 Discussion of Operational Noise Mitigation Options

The noise modelling results identified several locations along the SWRL corridor where the IGANRIP trigger levels are exceeded either at existing residences or at locations of expected future residential development. These areas include the Ingleburn Gardens Estate residential development, the proposed Edmondson Park Town Centre development, existing residences at Denham Court and the proposed development of the area around Leppington Station. There is therefore a need to undertake a further assessment of feasible and reasonable noise mitigation measures along the SWRL corridor.

The IGANRIP notes that the control of noise and vibration issues resulting from rail traffic should be the joint responsibility of the rail operator and of surrounding land uses. Given that the SWRL is being built in a partially greenfield area, there is potential for land use planning measures to be applied as a means of controlling the potential impacts of rail noise and vibration. Through land use planning measures, for example, commercial or industrial buildings could be used to shield sensitive land uses (such as hospitals, schools and residential dwellings) from rail noise.

It may be possible to achieve such shielding with a combination of appropriate land zoning and building restrictions which prescribe building placement and minimum height (near the rail corridor for maximum screening effect). The number of locations where this may be an effective tool to shield sensitive land users from rail noise is somewhat limited. The area of development land available along the rail corridor far exceeds the requirements for commercial and industrial uses. It is inevitable (and desirable) that a proportion of this land closest to the corridor also be used for residential purposes.

Increased separation distance from the rail corridor by the placement of roads or open recreational space can also be used as a noise mitigation measure. Acoustic setbacks and buffer zones can be employed, with roadways or open recreation areas providing the buffer zone. Where a buffer zone is insufficient or impractical for controlling noise, it may be necessary to control the layout and construction of buildings, with sensitive areas of occupancy in a building being placed away from the noise source.

A summary of operational noise control options considered for the SWRL corridor project are listed in **Table 11**, along with comments on their feasibility and reasonableness.

Table 11 Summary of Operational Noise Control Options Considered

Description	Estimated Noise Reduction	Comments on Feasibility / Reasonableness
Planning Measures		
Incorporate receiver controls from below, or, orientation of single family dwellings such that habitable rooms are located away from facades exposed to rail noise	5 dB to 10 dB reduction in LAmax and LAeq noise levels	Can be achieved through statutory planning and Development Control Plans. Part 87 of the Infrastructure SEPP requires sensitive non-rail developments to achieve internal LAeq noise levels of 35 dBA during 10 pm to 7 am night-time period within bedrooms and 40 dBA in other habitable areas at any time of the day. Advice to developers on how to achieve these levels is given in the NSW DoP's *Development Near Rail Corridors and Busy Roads - Interim Guideline*
Increase offset distance between railway line and sensitive receiver locations	Increasing receiver distance from 20 m to 40 m would reduce LAmax,95% noise levels by 4 dB and LAeq noise levels by 3 dB	To be discussed with Land Use Planners Limits land use along rail corridor. Where track is on embankment, a certain offset distance is normally required in any case for land to level off.
Locate less sensitive land uses (including roadways, playing fields, etc) adjacent to rail corridor to provide buffer to residential areas	Distance benefit as above, plus noise shielding from any buildings	To be discussed with Land Use Planners Commercial buildings located between rail corridor and sensitive receivers can be seen as practical and cost effective noise barriers. Co-ordinated design of adjacent commercial buildings could optimise noise shielding.
Locate multiple occupancy developments closest to railway rather than single family dwellings	5 dB to 15 dB reduction in LAmax and LAeq noise levels for second row of sensitive receiver locations	Increased scope for designing layout and orientation to minimise noise intrusion to habitable rooms.
Acceptance of higher noise levels	No noise reduction	Compliance with the Infrastructure SEPP noise limit of 35 dBA within bedrooms at night with windows open would approximately equate to an external LAeq(9hour) noise level of 45 dBA. This compares with the IGANRIP noise trigger level of 55 dBA. Note that RailCorp's Environmental Protection Licence goals are different from IGANRIP levels. It is feasible to achieve an external to internal noise reduction of 25 dB or more with high quality glazing and seals, and air-conditioning. For examples see the NSW DoP's *Development Near Rail Corridors and Busy Roads – Interim Guideline*. This reduction equates to an external noise level of LAeq(9hour) 60 dBA. An external LAeq noise goal of 60 dBA (night-time) and 65 dBA (daytime) may be reasonable for future land use developments.
Path Control Options - Within Rail Corridor		
Earth mounds	Smaller noise reduction than noise barriers of similar height, performance compromised by need to be located further from near track than a barrier	Can be cost effective if sufficient spoil and space available. Not feasible on all embankments due to extra footprint required for embankment. Barriers may need to replace earth mounds if future quadruplication of the rail line occurs. Less visual impact than sheer barrier wall.

Description	Estimated Noise Reduction	Comments on Feasibility / Reasonableness
Noise barriers on at-grade track	2 dB (1 m above rail) to 12 dB (4 m above rail) depending on distance and source to receiver geometry	Noise barriers will be most effective located close to the near track. Minimum structure clearance, to track centreline, is 4.25 m and 6.2 m if vehicle access is required. Ongoing issues with maintenance and graffiti. Negative visual impact on broader community and commuters. Mixed reaction from affected residents due to overshadowing, loss of views and visual impact. Some residents have unreasonable expectations about barrier performance and are disappointed with perceived poor performance of barriers.
Noise barriers on embankment track	Additional 2 dB compared to at-grade barriers of similar height	Can be effective for 1-2 storey dwellings due to reduced barrier height requirements. Clearance issues greater than at-grade track due to space restrictions on embankment. Same issues as above in relation to maintenance, graffiti and visual impact.
Receiver Controls		
Property boundary fence	Up to 5 dB at ground floor for 1.8 m solid fence Less than 2 dB reduction for upper floor receivers	Cost effective option for new developments where rear boundary fence faces rail corridor. Noise benefit is reduced for track on embankment.
Noise barrier close to railway corridor boundary	Noise reduction dependent on distance, geometry, etc	This option may be cost effective for track in cutting or at-grade for sensitive receiver locations with property access facing rail corridor. Same issues as for barriers within rail corridor, as listed above, in relation to maintenance, graffiti and visual impact. Sometimes considered by residents as a refuge for “undesirables”.
Ventilation in accordance with Building Code requirements to allow windows to be closed (if desired)	10 dB to 15 dB reduction in internal noise levels compared with windows open No benefit for outdoor areas or if windows are opened	This option is only applicable as a final measure for existing developments or as a final mitigation strategy to achieve acceptable indoor noise levels for future developments. Part 87 of the Infrastructure SEPP requires sensitive non-rail developments to achieve internal L_{Aeq} noise levels of 35 dBA during 10 pm to 7 am night-time period within bedrooms and 40 dBA in other habitable areas at any time of the day.
Operational Measures		
Reduce train speeds	A 20% reduction in maximum train speed would reduce $L_{Amax,95\%}$ noise levels by 2.5 dB and L_{Aeq} noise levels by 1.5 dB	Not feasible due to impact on services.
Reduce train speeds during night-time period	As above, but noise reductions only applicable for night-time period	Not feasible due to significant impact on services. RailCorp’s morning peak lies within DECCW’s night-time period.

Description	Estimated Noise Reduction	Comments on Feasibility / Reasonableness
Reduce overall number of train passbys	No change in $L_{Amax,95\%}$ 1 dB reduction in L_{Aeq} for 20% change 2 dB reduction in L_{Aeq} for 35% change	Not feasible, train numbers required to meet service frequency demands.
Reduce train lengths	Negligible change in $L_{Amax,95\%}$ 1.3 dB reduction in L_{Aeq} for 6-car trains in lieu of 8-car trains 3 dB reduction in L_{Aeq} for 4-car trains in lieu of 8-car trains No change in L_{Aeq} noise levels if total number of cars is the same (ie one 8-car train is the same as two 4-car trains)	Not feasible, train lengths required to meet capacity demand.
Reduce train lengths for night-time period	As above, but noise reductions only applicable for night-time period	Not feasible, 8-car sets required to maintain train balance within system.
Exclude "noisier" trains from SWRL	Up to 3 dB reduction in $L_{Amax,95\%}$ Up to 2 dB reduction in L_{Aeq} Estimated noise reductions based on the noisiest 20% of trains not operating on SWRL.	This option would require a permanent monitoring system to identify louder trains and a strategy to remove/fix louder trains. Not considered feasible due to significant impact on RailCorp's maintenance strategy, fleet allocation and budget
Exclude "noisier" trains during night-time period	As above, but noise reductions only applicable for night-time period	This option would require a strategy to hold noisier trains in a stabling facility during night-time periods. Not considered feasible due to significant impact on RailCorp's maintenance strategy, fleet allocation and budget
Operate only Waratah, Tangara and Millennium Trains on SWRL	Approximate 3 dB reduction in $L_{Amax,95\%}$ and 2 dB reduction in L_{Aeq}	This will occur as oldest rolling stock is retired.
Track Design Measures		
Rail dampers	Approximate 2 dB reduction in $L_{Amax,95\%}$ and L_{Aeq} noise levels. The reduction achievable depends on the track decay rate, determined by the dynamic stiffness of the rail pad.	Rail dampers are fixed to the rail web (both sides of the rail) by either mechanical means or by adhesive. Noise radiated from the rail is reduced by the damping afforded by tuned dampers. Rail dampers have been approved for use by RailCorp and used successfully on the Epping to Chatswood Rail Line project. Rail dampers are more effective on track with soft rail pads rather than stiff rail pads. Typically it is thought that rail pads on the Sydney network are relatively stiff, Further detailed assessment of the rail pad stiffness of the SWRL track design is required to determine the likely noise reduction achievable through rail dampers for this case.

Description	Estimated Noise Reduction	Comments on Feasibility / Reasonableness
Optimise track design (rail pad stiffness, rail fastening system etc)	Possible reduction of 1 dB in $L_{Amax,95\%}$ and L_{Aeq} noise levels	Would require detailed analysis using a predictive computer program such as TWINS. Would need to be considered on an individual basis. Using very stiff rail pads to control noise is not normally considered as an option, because softer pads are normally preferred to protect sleepers from damage.
Continuously welded rail	Elimination of impact noise from rail joints	Likely to be required by the track design specification
Low profile noise barriers located close to track	Likely noise reduction of 5 dB in $L_{Amax,95\%}$ and L_{Aeq}	More cost-effective than barriers located on rail corridor boundary. Not considered further here as type approval is likely to be required. Barriers close to the track also have implications for track maintenance.
Lower rail level by 1 m for at-grade sections	1 dB reduction at 30 m and 2 dB at 40 m ($L_{Amax,95\%}$ and L_{Aeq})	Not feasible due to implications for track gradient which has been optimised to take into account road crossings and land contours.
Lower rail level by 2 m for at-grade sections	5 dB reduction at 30 m and 5 dB at 40 m ($L_{Amax,95\%}$ and L_{Aeq})	Not feasible due to implications for track gradient which has been optimised to take into account road crossings and land contours.
Quieter crossings	Locate turnouts away from residential receiver locations (ie, close to future stations assuming commercial use)	Good environmental outcome for sensitive receiver locations. RailCorp reportedly has concerns about reliability of swing nose crossings on ballasted track.
	3 dB reduction in L_{Aeq} at 30 m and elimination of impulsive noise associated with standard turnouts	May be possible to east of Leppington Station if track speeds are to be maintained at points while meeting desirable noise goals.
Construction of quiet bridges	Concrete ballasted bridges are up to 10 dB quieter than open transom steel bridges	Required as part of RailCorp's Pollution Reduction Program Strategy. RailCorp's standards require ballasted bridges on concrete.

Of the noise mitigation options listed in **Table 11,** those considered to be feasible and reasonable for reducing the impact of operational noise from the SWRL corridor project are summarised below:

- Source control measures - quieter rollingstock, continuously welded rail and rail dampers
- Acoustic shielding - earth mounds and low height noise barriers
- Setback zones - parks and roads planned to separate sensitive users from rail corridor
- Appropriate land use - commercial buildings planned along rail corridor
- Prescribed building design and orientation
- Dwelling treatments including property fences and upgraded glazing

The hierarchy of noise control is to give preference to source control measures, then to physical mitigation measures (barriers and set back zones) between the source and receiver and as a final measure, receiver controls.

5.9.1 Source Control Measures

The source control measure of quieter rolling stock is being implemented in the phasing out of the Double Deck Suburban vehicles. The project design will specify continuously welded rail, which is quieter than the alternatives because there is no impact noise from joints.

Rail dampers consist of tuned masses fixed to the rails via resilient material and fasteners. Rail dampers are a source control measure that can be very effective in some situations, depending on the combination of track components used in the design. They are most effective on track with soft rail pads, as in this situation the decay of vibrations along the track is low. If track has inherently stiff rail pads, vibrations decay in a shorter distance along the rail, giving less noise from the rail than if the rail pads are soft. Therefore if the rail pads used to construct the SWRL are relatively stiff, as is thought to be the case on other parts of the Sydney network with ballasted track, rail dampers are not likely to represent an effective noise control measure. Using very stiff rail pads to control noise is not normally considered as an option, because softer pads are normally preferred to protect sleepers from damage. Further analysis during detailed design would be required to determine if the application of rail dampers are a cost effective mitigation option for the SWRL.

5.9.2 Acoustic Shielding

Acoustic shielding includes the construction of earth mounds and noise barriers (which shield some of the direct airborne noise that propagates between the source and receiver locations). The locations where earth mounds could be used on the project are limited because of the space required for an earth mound which is usually constructed with a batter.

Noise barriers can provide significant noise reductions in locations where source control measures alone do not provide sufficient noise reduction or where effective or feasible source control options are not available. Noise levels on the ground floor (including back yards and living areas) can usually be significantly reduced through the use of noise barriers. In situations where the track is located at grade or within a cutting, the incorporation of a solid property boundary fence (ie without gaps) will normally provide a significant noise reduction to ground floor areas and protect the outdoor amenity. These should be incorporated into the design of any future residential developments where possible. Noise barriers are not as effective, however, for upper floor receivers and are usually ineffective above the second level.

In terms of noise reduction, noise barriers and earth mounds can be regarded as providing similar acoustic performance if the top of the barrier and mound are at the same height above rail and distance from the track. In practice, earth mounds may be preferred because they can be visually less intrusive and are less likely to be vandalised. The disadvantage, however, is that they require a larger land area (due to the batter) and this may result in the top of an earth mound being located further from the track than an equivalent noise barrier. Earth mounds are generally not suitable for use where track is on embankment, as the resultant widening of the embankment can require substantial additional land-take and fill material. It is understood that there is a surplus of fill on the SWRL project, and this will be used to form earth mounds where appropriate.

5.9.3 Setback Zones and Land Use

Setbacks can reduce or eliminate the need for noise barriers. Roads, recreation areas and commercial activities can be used to act as buffer zones to separate sensitive receivers from the rail corridor. Future land use planning could designate areas along the rail corridor where commercial activities would form an integral part of the noise mitigation strategy.

5.9.4 Receiver Controls

Receiver controls generally involve the inclusion of specific acoustical measures as part of the design of individual dwellings in order to reduce noise levels inside buildings. They can also include consideration of the noise benefit that can be provided by property fencing (discussed above).

Treatments to buildings usually involve higher performance windows, doors and seals to keep noise out. Building treatments effectively require occupants to keep their windows and doors closed and hence alternative ventilation is usually required to maintain adequate air flow. An obvious disadvantage is that building treatments would not have any effect on the noise levels outside the dwelling in their front or back yards. Building treatments are generally not favoured until after all other options have been explored.

Whilst the provision of noise barriers can significantly reduce noise levels at ground floor and first floor receiver locations, noise barriers are usually ineffective at upper floor receiver locations. For upper floor receiver locations, it is anticipated that a combination of source/receiver measures (eg noise barriers or earth mounds) would be required in conjunction with receiver controls as the most cost effective mitigation option in situations where noise mitigation is required.

5.10 Discussion of Feasible and Reasonable Noise Mitigation Principles

The determination of feasible and reasonable mitigation measures is based on a number of factors including engineering considerations, noise mitigation benefits, cost, community views, track maintenance and access requirements, aesthetic impacts, the change in noise levels and the wider community benefits of the project.

5.10.1 Reasonableness Assumptions

As the SWRL project represents a new railway line in a predominantly greenfield area, consideration of feasible and reasonable mitigation measures needs to be given in areas where the predicted L_{Amax} and L_{Aeq} future noise levels are above the overall IGANRIP trigger levels (see **Table 6** and **Table 7**).

At locations where the future noise levels do not exceed the trigger levels, residential and other sensitive receiver locations will benefit from long-term source mitigation measures such as the retiring of older, noisier rollingstock and maintenance of track and rollingstock.

The IGANRIP provides a hierarchy of noise control that gives preference to source control measures, then to physical mitigation measures (eg noise barriers) between the source and receiver and as a final measure, receiver controls. Thus, for this proposal, noise barriers will only be considered at locations where source noise mitigation measures are not available, are not feasible or not effective. It should be noted that for the SWRL project, preference has been given to the use of earth mounds over noise barriers subject to space and spoil availability requirements being met.

5.10.2 Feasibility Issues

Issues of engineering feasibility must also be taken into account in the design of noise barriers or other mitigation measures. If barriers cannot be physically constructed within the available space or present an operational impediment or safety hazard, then this must be taken into account in the design process. Such issues may include (but are not limited to):

- Civil/structural limitations (such as the size of footings required to withstand wind loads)
- Safe access requirements for inspection staff and, where required, train drivers

- Safe access requirements for future railway maintenance (including access for large machines)
- Signal sighting (which may be compromised by barriers on track curves)
- Safe access for future barrier maintenance (including for graffiti removal)

To address the feasibility issues, it may be necessary to redesign the barrier with a change in location, height or structure or, if an engineering solution cannot be found to omit the barrier from the design.

5.10.3 Cost Considerations

Capital cost, whole of life cost and cost-effectiveness are important when considering whether mitigation measures are reasonable. The costs of the construction and long term maintenance of any proposed noise barriers will be addressed by TIDC as part of the design process.

5.10.4 Community Considerations

In all cases where noise barriers are proposed, the community should be consulted to address issues such as overshadowing, loss of outlook, damage to existing vegetation, vandalism concerns, etc. Where there is a clear community preference for no barriers, or for a particular style or scale of noise barrier, this should be given due consideration in the final assessment of what constitutes "reasonable". Community consultation meetings were conducted so that the design and environmental teams could gather information and feedback to inform the design and impact assessment processes.

5.10.5 Reflected Noise from Barriers

Noise barriers are normally constructed from hard materials that reflect, rather than absorb incident sound waves. While noise is reduced on the "shadow" side of a barrier, some noise is reflected away from the face of the barrier back in the direction of the noise source.

In the case of a noise barrier located adjacent to a railway line, it is therefore possible in some instances for noise emissions to be reflected over the top of (or under) the train towards receivers on the opposite side of the track. This effect generally only occurs with high noise barriers where the top of the noise barrier is higher than the top of the train. The heights of noise barriers used in the modelling are not sufficient to cause a potential problem with reflected noise.

5.10.6 Acoustic Treatment of Individual Dwellings

At some existing residences where the noise trigger levels are exceeded as a result of the project, the feasibility and reasonableness considerations discussed above may indicate that the construction of a noise barrier is not feasible, reasonable or cost effective. Treatment of individual dwellings would only be considered for existing residences. Mitigation of potential noise impacts on future developments would be dealt with via land use planning and development controls, as described in the Infrastructure SEPP and the NSW DoP's *Development Near Rail Corridors and Busy Roads - Interim Guideline*. Developers may need to incorporate acoustic treatment into the design to meet the Infrastructure SEPP internal noise level requirements if sensitive areas are located on the building facade closest to the railway line.

At existing dwellings where residual impacts remain after all feasible and reasonable approaches are exhausted, noise mitigation in the form of acoustic treatment to individual dwellings may be considered to achieve a reduction in the internal noise levels.

The acoustic treatment of individual dwellings is generally not favoured for reasons including:

- It may not be cost effective if required on a widespread basis
- It may not be effective for lightweight buildings
- It provides no protection to outdoor areas
- Windows must be kept closed for acoustic treatment to be effective. Alternative mechanical ventilation would then be required in accordance with the Building Code of Australia, that may result in higher energy consumption

5.11 Proposed Noise Mitigation Options

The range of potential noise and vibration mitigation measures identified for the project is based on the Concept Design. The application of these measures is subject to change based on the finalisation of the detailed design and further site investigations. Further noise and vibration studies will be undertaken during the detailed design process to finalise the noise mitigation strategies to be implemented for the project.

The "absolute" noise trigger levels listed in IGANRIP (which indicate the need for noise mitigation to be considered) are predicted to occur at a number of locations along the length of the SWRL corridor.

The use of earth mounds is considered a base case for possible noise mitigation. A summary of proposed locations and approximate heights of earth mounds (used for all operational noise modelling) is listed in **Table 10**. The limited number of locations where earth mounds can be used and their restricted size dictates that further assessment of additional noise mitigation is required. If at the detailed design phase it is determined that the earth mounds are unfeasible (for example due to insufficient spoil), they would be replaced by alternative noise mitigation.

As an initial step to determine appropriate additional noise mitigation, an analysis has been undertaken to determine the noise barrier height that would be required along the length of the SWRL corridor to achieve the IGANRIP trigger levels at the rail corridor boundary. It has been calculated that the necessary barrier height along the full length of the project would range between 1 m and 5.5 m (see **Appendix D**).

Noise barriers of these heights and lengths are clearly not feasible or reasonable for reasons of cost, civil-structural limitations, safe access requirements and community considerations as discussed above. It is also not appropriate to provide noise barriers on a widespread basis in the context of a largely greenfield site, where it is considered unlikely that residences will be built hard up against the rail corridor and there are several alternative mitigation options for reducing the potential noise impacts (such as property fences, land use planning and appropriate building orientation).

An intermediate solution has been proposed with noise barriers to a height of 1 m above top of rail level at locations where residential development is confirmed or proposed and where the IGANRIP trigger levels are exceeded in the baseline case at distances of more than 30 m from the rail corridor. This distance represents a typical setback distance of new residential developments constructed adjacent to busy roads or railway lines. These locations (subject to future planning decisions and detailed design) are:

- Ingleburn Gardens Estate - between the Hume Highway and Campbelltown Road. Note mitigation is only proposed after the track emerges from the underpass below the Highway to return to grade.

- Edmondson Park Town Centre - the site of the former Ingleburn Military Camp. Noise barriers are not proposed through the town centre itself, as Liverpool Council Plans show high density development (including commercial areas) in this area. Noise barriers do not provide effective mitigation for tall buildings. In addition, a number of conservation areas are proposed in this area which do not require mitigation. Mitigation is proposed along both sides of the section of track adjacent to Denham Court, to protect existing residences and proposed residential areas in Edmondson Park.
- Forest Lawn Memorial Gardens Cemetery - Mitigation proposed to protect the amenity of the Memorial Gardens.
- Approach to Leppington Station - The area between the Sydney Water Canal and the new Leppington Station is currently low-density residential, but is likely to develop in the future around the station. Note that after Leppington Station the tracks continue to the stabling facility, however train speeds are lower through this section so mitigation is not proposed to the west of Leppington Station.

The proposed locations for noise barriers or alternative mitigation, subject to detailed design are summarised in **Table 12**. Barriers were placed 4.25 m from the Down track centreline and 6.2 m from the Up track centreline to allow vehicle access and appropriate structure clearance. The exceptions are where barriers are proposed for overpasses, where they form a parapet.

Table 12 Potential Noise Barrier Locations - Used for Operational Noise Modelling

Chainage[1]	Justification	Length[2]
Up 44.285 km to 44.605 km Down 44.205 km to 44.630 km	Ingleburn Gardens Estate	Up 320 m Down 425 m
Up 46.595 km to 47.200 km Down 46.750 km to 47.220 km	Denham Court existing residential and Edmondson Park future residential development	Up 475 m Down 480 m
Down 47.880 km to 48.355 km	Cemetery Curve - Forest Lawn Memorial Park	Down 475 m
Up 49.650 km to 50.565 km Down 49.755 km to 50.590 km	Existing low density residential area on approach to Leppington Station, after Sydney Water Canal	Up 915 m Down 835 m

Note 1: The Up side is the northern side of the rail corridor, the Down side is to the south in this instance.
Note 2: Noise barrier length. Barrier indicative height is 1 m above top of rail.

5.12 Residual Impacts with Proposed Noise Mitigation

In the baseline case with earth mounds only, the IGANRIP trigger levels are exceeded at distances of up to 120 m beyond the rail corridor where the track is on embankment as shown in **Appendix C**. With additional mitigation in the form of noise barriers, this distance is predicted to reduce to less than 30 m at most locations with existing receivers or expected future residential development, as shown in **Appendix C**.

5.12.1 Impacts on Existing Receivers

A small number of existing residences (refer **Table 13**) may experience noise levels greater than the trigger levels in the baseline case (with earth mounds only). With additional noise mitigation in the form of noise barriers, trigger level exceedances are predicted at only two existing residences (1692 and 1701 Camden Valley Way, Leppington) for the 2016 case. At a point in time 10 years after opening, the noise levels would reduce by approximately 0.5 dBA at these locations due to the retirement of older rollingstock. At these properties, further assessment of potential mitigation measures outside the corridor (eg treatment of individual dwellings) may be required.

Properties where the $L_{Aeq(9hour)}$ 55 dBA or the L_{Amax} 80 dBA levels are predicted to be exceeded in the baseline case are listed in **Table 13**. Also shown in the table are the predicted noise levels with the indicative low-level noise barriers listed in **Table 12**. Existing residential buildings located on land to be acquired for the SWRL corridor project are not listed in **Table 13**.

Note that the prediction of noise levels for 2016 are based on the maximum train numbers as provided by RailCorp and listed in **Table 9**. These traffic volumes are considered to be the maximum train plan for both years, but the actual future timetable will be subject to ongoing development in response to passenger demands. It is therefore possible that at opening in 2016, train volumes will be lower than those used in this modelling. If so, the noise levels at opening will be lower than those described in this report.

Table 13 Existing Residential Properties Where Noise Trigger Levels are Predicted to be Exceeded (Year 2016 After Opening)

Address	Location (km)	Year 2016[1] Noise Levels with Baseline Noise Mounds		Year 2016 Noise Levels with Baseline Noise Mounds and Barriers	
		LAeq(9hour)	LAmax	LAeq(9hour)	LAmax
21 Culverston Ave Denham Court	46.95 (Down Side)	56	79	51	73
23 Culverston Ave Denham Court	47.00 (Down Side)	57	80	53	75
25 Culverston Ave Denham Court	47.10 (Down Side)	56	80	53	75
27 Culverston Ave Denham Court	47.10 (Down Side)	56	79	52	75
35 Cassidy St Denham Court	47.35 (Down Side)	56	78	55	78
85 Cassidy St Denham Court	47.65 (Down Side)	56	79	54	79
1692 Camden Valley Way Leppington[2]	48.25 (Up Side)	58	82	58	82
1701 Camden Valley Way Leppington[2]	48.80 (Down Side)	62	88	62	88
85 Cowpasture Road Leppington	49.85 (Down Side)	56	81	51	75
111 Cowpasture Road Leppington	49.75 (Up Side)	57	82	53	77
155 Bringelly Road Leppington	49.70 (Up Side)	56	78	53	77

Note 1: Noise levels presented for 2016 only. 2026 levels are predicted to be lower than 2016 levels as modelled due to the retirement of older rolling stock.

Note 2: With low-level noise barriers, the noise trigger levels exceeded $L_{Aeq(9hour)}$ 55 dBA and L_{Amax} 80 dBA at only two existing locations (1692 and 1701 Camden Valley Way).

5.12.2 Impacts on Future Residential Developments

The noise mitigation proposed in this assessment is targeted towards areas where future residential developments are expected. With the earth mounds and noise barriers described in this report, and at locations where the track is at grade or within a cutting, it is anticipated that the IGANRIP noise trigger levels would be achieved at the ground floor of future residential buildings with the provision of a standard height solid fence at the property boundary. However, the noise levels that may be experienced by residents of future developments would be highly dependent on the design and placement of those future developments.

In addition to the mitigation measures described in this assessment, the Infrastructure SEPP (Clause 87) refers to guidelines which must be taken into account where the development of noise or vibration sensitive receivers is proposed adjacent to railway corridors. New residential or other sensitive developments should be designed in accordance with the NSW DoP's *Development Near Rail Corridors and Busy Roads - Interim Guideline*. The guideline states internal noise criteria that must be met for new developments. "If the development is for the purpose of a building for residential use, the consent authority must be satisfied that appropriate measures will be taken to ensure that the following L_{Aeq} levels are not exceeded:

- in any bedroom in the building: 35 dBA at any time 10pm – 7am
- anywhere else in the building (other than a garage, kitchen, bathroom or hallway): 40 dBA at any time"

The guideline emphasises the importance and benefit of strategic land use planning of sensitive developments. "Strategic planning should ensure that residential and other sensitive developments are sited so that the direct impacts of rail corridors and busy roads can be avoided or appropriately managed. By following the strategic planning and design recommendations in this Guideline, the need for mitigation measures at the site planning or building construction stage can be reduced or avoided all together."

In addition to planning measures and building location, the guideline describes in detail, design strategies to minimise noise impacts, such as building orientation, room layout, podiums, balconies and courtyards, noise barriers and screens, building treatments and suitable construction methods and materials for building elements such as walls, windows, doors, roofs and floors.

5.13 Compliance Monitoring

The IGANRIP guideline recommends the selection of representative noise monitoring locations in order to later assess compliance with the design goals (noise levels achievable for the project). The design goals for the SWRL will be the predicted noise levels in this assessment (subject to a detailed design) with reasonable and feasible mitigation measures in place. If compliance monitoring indicates that these levels are not achieved, additional mitigation measures may be applied.

For the SWRL it is recommended that approximately 10 noise monitoring locations are selected. The representative receiver locations should be reasonably distributed along the alignment and represent a mix of the existing and proposed occupancy types. The receiver locations should be selected in consultation with the communities along the alignment.

It is also intended to carry out compliance monitoring at the following locations where previous unmanned noise monitoring was done.

- 25 Cassidy Street, Denham Court
- 135 Croatia Avenue Edmondson Park

It is anticipated that compliance monitoring at the selected locations would need to be based on operator-attended measurements for a minimum of 20 train passbys at each monitoring location. These measurements should be undertaken at the commencement of train operations. When assessing compliance, it should be recognised that noise emissions from electric passenger trains are highly variable and that it is usual practice to base assessments of noise emissions on the 95th percentile of trains (ie the typically loudest trains, but excluding a small number (5%) of the absolute loudest trains).

6 OPERATIONAL RAIL VIBRATION

6.1 Introduction

6.1.1 Overview

Railway vibration is generated by dynamic forces at the wheel-rail interface. It will occur, to some degree, even with continuously welded rail and smooth wheel and rail surfaces (due to the moving loads, finite roughness of the surfaces and elastic deformation). Significantly higher vibration levels can occur due to rail and wheel surface irregularities, including some irregularities that do not cause significant levels of airborne noise.

This vibration passes via the sleepers or rail mounts into the ground or track support structure. It then propagates through the ground and may sometimes be felt or perceived as tactile or visible vibration by the occupants of buildings.

The effects of vibration in buildings can be divided into three (3) main categories; those in which the occupants or users of the building are inconvenienced or possibly disturbed, those where the building contents may be affected and those in which the integrity of the building or the structure itself may be prejudiced.

6.1.2 Human Perception of Vibration

The actual perception of motion or vibration may not, in itself, be disturbing or annoying. An individual's response to that perception, and whether the vibration is "normal" or "abnormal", 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. Industrial environments are clearly less sensitive than say, commercial buildings, where the usual expectation is that there should be little perceptible vibration.

Although people are able to perceive relatively low vibration levels, it is not appropriate to set vibration emission limits requiring "no vibration", since there will always be some vibration in any environment. It is necessary therefore to set realistic design criteria which minimise disturbance and adverse impacts on amenity. The recommended approach is discussed in **Section 6.3**.

6.1.3 Effects on Building Contents

People can perceive floor vibration at levels well below those likely to cause damage to building contents or affect the operation of typical equipment. As such, the controlling vibration criterion at most locations would be the human comfort criterion, and it is therefore not necessary to set separate criteria for this project in relation to the effect of railway vibration on most building contents.

Some high technology manufacturing facilities, hospitals and laboratories include equipment that is highly susceptible to vibration. Typical examples of sensitive equipment include scanning electron microscopes and microelectronic manufacturing facilities. No such facilities have currently been identified adjacent to the proposed alignment.

6.1.4 Effects of Vibration on Structures

The levels of vibration required to cause damage to buildings tend to be at least an order of magnitude (10 times) higher than those at which people consider the vibration acceptable. Hence, the controlling criterion would still be the human comfort criterion, and it is therefore not necessary to set separate criteria for this project in relation to building damage from railway vibration. This also applies to heritage structures, unless there is some reason to believe they are structurally unsound.

6.1.5 Ground-borne Noise from Rail Operations

Ground-borne (regenerated noise) noise in buildings adjacent to railway lines is most common in railway tunnel situations where there is an absence of airborne noise to mask the ground-borne noise emissions. Ground-borne noise results from the transmission of ground-borne vibration rather than the direct transmission of noise through the air. The vibration is generated by wheel/rail interaction and is transmitted from the trackbed, via the ground and into the building structure.

The vibration entering the building then causes the walls and floors to faintly vibrate and hence to radiate noise (commonly termed "ground-borne noise" or "regenerated noise").

If of sufficient magnitude to be audible, this noise has a low frequency rumbling character, which increases and decreases in level as a train approaches and departs the site. This type of noise can be experienced in buildings adjacent to many urban underground rail systems.

For surface rail projects, the effect of ground-borne noise tends to be less of an issue than for underground rail projects. This is because the airborne noise emissions in most circumstances are much higher than the ground-borne noise levels. In some situations, however, the ground-borne noise emissions may be audible (for example, at locations where airborne noise emissions are attenuated by a noise barrier or where there are no windows facing the rail corridor).

No existing buildings have been identified as being especially sensitive to ground-borne noise from the proposed railway. If sensitive occupancies such as residential developments, recording studios, cinemas and the like are located within approximately 40 m of the proposed alignment, an assessment would be undertaken to determine if vibration mitigation at the source (as part of the planning process) or at the building (after project opening) is required. The level of attenuation potentially required depends amongst other factors, on the distance from the track, the sensitivity of the building occupancy and train speed.

6.2 Vibration Propagation

The propagation of vibration (and ground-borne noise) through the ground is a complex phenomenon. Even for a simple source, the received vibration at any point may include the arrival of several different wave types, plus other effects such as damping, reflection, and impedance mismatch caused by changes in ground conditions along the propagation path.

It is useful to note that predictions of vibration normally involve a combination of empirical and analytical methods as the various characteristics are normally not sufficiently defined to enable full analytical modelling.

6.3 Vibration Criteria

For new or upgraded railway lines, the IGANRIP specifies that *Assessing Vibration: a technical guideline* (DEC 2006) is to be applied. This guideline is based on British Standard BS 6472-1992 and provides vibration trigger levels to minimise the disturbance to building occupants from continuous, impulsive and transient vibration. For train passbys, vibration levels are classified as being intermittent.

For **intermittent** vibration at residential receiver locations, vibration trigger levels are expressed in terms of the Vibration Dose Value (VDV) during the daytime (7.00 am to 10.00 pm) and night-time (10.00 pm to 7.00 am) periods. The VDV is a measure that takes into account the overall magnitude of the vibration levels during a train passby, as well as the total number of train passbys during the daytime and night-time periods.

For residential receiver locations, the guideline nominates "preferred" vibration dose values of 0.2 $m/s^{1.75}$ (daytime) and 0.13 $m/s^{1.75}$ (night-time) and "maximum" vibration dose values of 0.4 $m/s^{1.75}$ (daytime) and 0.26 $m/s^{1.75}$ (night-time). For this project, the more stringent "preferred" vibration dose values have been applied.

For offices, schools, educational institutions and places of worship, the guideline nominates VDVs twice the residential daytime levels (ie, 0.4 $m/s^{1.75}$ during the daytime and night-time periods).

The proposed vibration dose trigger levels for intermittent vibration are summarised in **Table 14**.

Table 14 Trigger Levels for Intermittent Vibration

Location	VDV ($m/s^{1.75}$)[1]	
	Day[2]	Night[2]
Residential Properties	0.2	0.13
Offices, Schools, Educational Institutions and Places of Worship	0.4	0.4

Note 1 Vibration Dose Values (VDVs) are based on the "preferred" values in *Assessing vibration: a technical guideline* (DEC 2006).

Note 2 Daytime is 7.00 am to 10.00 pm and Night-time is 10.00 pm to 7.00 am.

There are several other sources from which vibration criteria may be drawn. These include:

- Australian Standard AS 2670.2 1990 "*Evaluation of Human Exposure to Whole Body Vibration - Part 2: Continuous and Shock Induced Vibration in Buildings (1 Hz to 80 Hz)*".
- The United States Department of Transportation guideline "*Transit Noise and Vibration Impact Assessment*", 1995.
- British Standard BS 6472-1992 "*Evaluation of Human Exposure Vibration in Buildings (1 Hz to 80 Hz)*".
- The NSW Department of Environment and Conservation document "*Assessing Vibration : a technical guideline*", 2006

The following discussion expresses vibration levels in terms of decibels (dB re 10^{-9} m/s). A level of 100 dB corresponds to 0.1 mm/s (rms) and a level of 120 dB corresponds to 1 mm/s (rms).

AS 2670 provides criteria corresponding to 106 dB to 112 dB for residential buildings during the daytime, and reducing to 103 dB during the night-time. These criteria apply to both continuous and intermittent vibration. For office and industrial buildings, the criteria are 112 dB and 118 dB, respectively.

For residential buildings, the US guideline recommends a criterion of 100 dB for frequent trains, or 108 dB for infrequent trains (ie less than 70 per day). These are understood to apply to the average train vibration levels. For schools, churches, quiet offices, etc, the recommended criteria are 3 dB higher than the residential criteria.

BS 6472 has similar criteria for continuous vibration, but also includes a dose relationship for intermittent events such as trains, which for a "low probability of adverse comment" would permit vibration levels of up to 110 dB, assuming 216 events of 8 second duration within the daytime period and/or 56 events of 8 second duration within the night-time period.

The DECCW's *Assessing vibration: a technical guideline* is based on the guidelines contained in BS 6472–1992. The vibration trigger levels of 0.2 $m/s^{1.75}$ daytime and 0.13 $m/s^{1.75}$ night-time would permit vibration levels of up to 112 dB during the day or night at residential properties. For offices, schools, educational institutions and places of worship, the vibration trigger levels would permit V_{rms} vibration levels 6 dB higher than residential properties.

6.3.1 Proposed Vibration Criteria

At levels of vibration above the perceptible level, generally considered to be 0.1 mm/s or 100 dB rms, a small percentage of affected occupants in a building are likely to be disturbed. If the 112 dB vibration trigger level (corresponding to an IGANRIP acceptable VDV of 0.2 $m/s^{1.75}$) is used as a target limit for ground vibration, it is certain that some building occupants will be disturbed during the night time period. The 112 dB vibration level is the upper day time limit listed in AS 2670 for residential buildings.

It is recommended that a night time target limit of 108 dB rms be adopted for ground vibration at residential buildings adjacent to the SWRL. This level is based on a vibration level of 103 dB, the recommended night time limit for residential buildings from AS 2670, plus an allowance of 5 dB for the transitory nature of the vibration. In the US Department of Transportation's document, *Transit Noise and Vibration Impact Assessment*, 108 dB re 10^{-6} mm/sec vibration velocity is quoted as the vibration level at which residential annoyance will occur as a result of infrequent events (but uses the "average" train vibration event rather than the "typically highest" 95% event as proposed for this project).

6.4 Source Vibration Levels

The US Department of Transportation's *Transit Noise and Vibration Impact Assessment* report provides indicative vibration levels versus distance for a variety of transport systems, including rapid transit rail systems. The base curve, shown in **Figure 3** shows the typical ground-surface vibration levels assuming rollingstock and rail in good condition and a train speed of 80 km/h. At other speeds, the vibration level is approximately proportional to 20 x log(speed/80 km/h), with a note that sometimes the speed has been observed to be as low as 10 to 15 x log(speed/80 km/h).

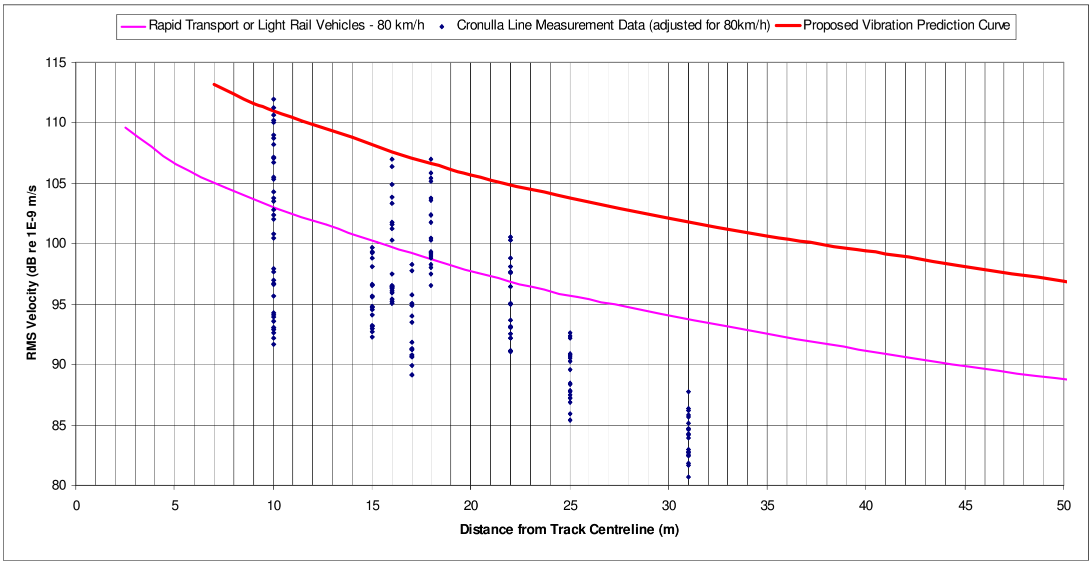
Vibration measurements undertaken by Heggies for the Cronulla Line Upgrade and Duplication Project are also presented in **Figure 3**, for comparison, adjusted for speed to represent the 80 km/h reference.

In **Figure 3** the vibration levels are expressed in terms of the rms vibration velocity level in dB (re 10^{-9} m/s). The measurement data obtained as part of that study represent the maximum vibration levels observed during each train passby.

From the measurement results at locations adjacent to the East Hills Line (2 measurement distances per location), it is evident that approximately 50% of the measurement results are above the reference line (for rapid transport or light rail vehicles) and 50% are below the reference line. The measurement results therefore appear to correlate well with the FTA reference levels for typical trains.

The upper line in **Figure 3**, labelled "Proposed Vibration Prediction Curve", represents the typical maximum vibration level and is 8 dB higher than the reference curve. On the basis of the measurement results at Cronulla and similar vibration measurements undertaken by Heggies on other projects, the difference between the 95th percentile (highest 1 in 20 trains) event and the median event is approximately 8 dB. This vibration curve, in conjunction with the typical 20 x log(speed/80 km/h) relationship has been used to predict the future vibration levels adjacent to the new SWRL.

Figure 3 Ground Surface Vibration Levels Versus Distance



(Adapted from Figure 10-1 in the US Department of Transportation's *Transit Noise and Vibration Impact Assessment*)

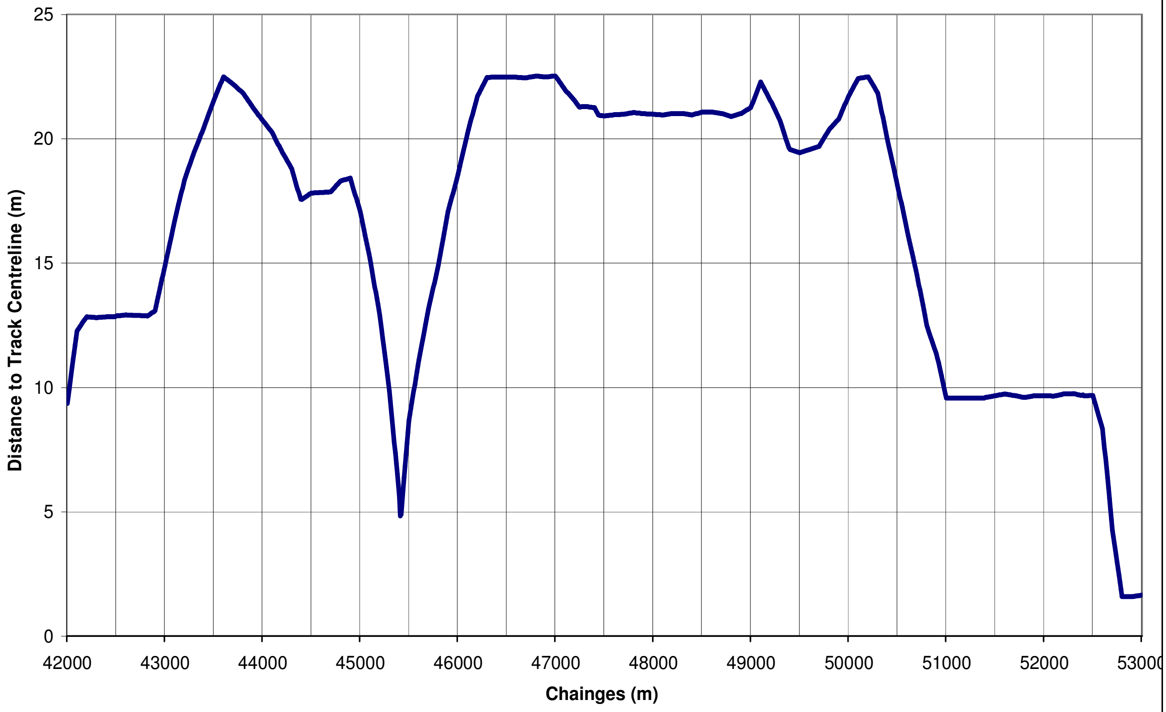
6.5 Assessment of Ground-Surface Vibration

Areas alongside the rail corridor falling within the 108 dB criteria were identified using predicted train speeds and the horizontal distance to the track centreline. Vibration levels generated by a train passby were calculated using the Proposed Vibration Prediction Curve values from **Figure 3**. The vibration predictions are considered conservative because only the horizontal separation between train and receiver were used during calculations. A more accurate, but less conservative approach, would use the total distance to the track, comprising both vertical and horizontal separations from the track, and referred to as the slant distance. The relatively low predicted vibration levels in the vicinity of the SWRL corridor do not warrant use of the refined analysis method based on slant distances between train and receiver.

Modelling of trackside vibration levels indicates that the 108 dB vibration contour generally falls within the rail corridor. At those few locations where the 108 dB vibration contour lies outside the rail corridor, the excursion outside the corridor is no greater than 5 metres.

Figure 4 shows a plot of the predicted location of the 108 dB ground vibration level along the SWRL corridor. The plot shows the maximum excursion, from either track centreline, of the suggested night-time target limit of 108 dB rms for ground vibration for residential buildings adjacent to the SWRL.

Figure 4 Operational Ground Vibration on SWRL 108 dB Contour



6.6 Operational Vibration Impacts on Existing and Future Receivers

The proposed operational vibration trigger level of 108 dB is expected to be met at all existing receivers. In general, vibration impacts on future developments are considered to be unlikely due to the small number of locations at which the 108 dB vibration contour falls outside the rail corridor boundary. However, developers should undertake noise and vibration assessments of all proposed developments in the vicinity of the SWRL in accordance with clauses 87 and 102 of the Infrastructure SEPP, and the DoP's *Development Near Rail Corridors and Busy Roads – Interim Guideline.*

7 TRAIN STABLING NOISE

This section addresses the relevant noise goals and emissions from the proposed TSF at Rossmore.

7.1 Introduction to Stabling Facility Noise Criteria

The TSF at Rossmore is not assessed according to IGANRIP because it does not involve noise generated by passing trains. It is considered to be a fixed facility and is assessed in accordance with the DECCW's *Industrial Noise Policy* (INP). All noise emissions emanating from within the stabling facility, including that from train movements, will need to be assessed in accordance with the INP.

The INP sets two separate noise criteria to meet environmental noise objectives: one to account for intrusive noise and the other to protect the amenity of particular land uses. In addition, the DECCW normally requires the risk of sleep disturbance to be assessed. Guidance on sleep disturbance is provided in the DECCW's guideline, the *Environmental Criteria for Road Traffic Noise* (ECRTN) and also in the Application Notes to the INP.

7.1.1 Assessing Intrusiveness

In order to assess the intrusiveness of a particular noise source, the background noise needs to be measured. The intrusiveness criterion dictates that the L_{Aeq} noise emission level from the source being assessed, measured over a period of 15 minutes, should not be more than 5 dBA above the rating background noise level (RBL) during the daytime, evening and night-time periods.

7.1.2 Assessing Amenity

The amenity assessment is based on the existing noise environment and noise criteria specific to land use and associated activities. If the noise emissions from the new sources approach the criterion value, the new sources need to be designed so that the cumulative effect does not produce levels that would significantly exceed the criterion.

7.1.3 Project Specific Noise Levels

When determining project specific noise criteria, both the amenity and intrusive criteria are considered. The more stringent of these two criteria sets the project specific noise levels. For both amenity and intrusiveness, night-time criteria are more stringent than daytime or evening criteria. As the train stabling facility will operate 24 hours a day, the night-time period is the controlling period in all cases.

7.2 Background Noise Monitoring and Project Specific Criteria

Two of the unattended noise monitoring locations (615 Bringelly Road and 198 McCann Road) are in the vicinity of the proposed TSF. The full results of the unattended noise monitoring are summarised in **Table 4** and presented in **Appendix B**.

7.2.1 Intrusive Noise Criteria

At both the measurement locations in the vicinity of the TSF the Rating Background Level during the night-time period was 30 dBA. During the daytime period, the Rating Background Level was 34 dBA at 198 McCann Road and 43 dBA at 615 Bringelly Road.

As the land around the stabling facility is developed, it is anticipated that the background noise levels in the area will also increase. Australian Standard AS 1055.2:2007 *Acoustics-Description and measurement of environmental noise Part 2: Application to specific situations* gives estimated background noise levels that may be used as a guideline for the proposed future land use. An extract from the standard is provided in **Table 15**.

Table 15 Estimated Average Background A-Weighted Sound Pressure Levels for Different Areas Containing Residences in Australia (from AS 1055.2-1997)

Noise area category (Notes 1 and 2)	Description of neighbourhood	Average background A-weighted sound pressure level, $L_{A90,T}$					
		Monday to Saturday			Sundays and public holidays		
		0700–1800	1800–2200	2200–0700	0900–1800	1800–2200	2200–0900
R1	Areas with negligible transportation	40	35	30	40	35	30
R2	Areas with low density transportation	45	40	35	45	40	35
R3	Areas with medium density transportation or some commerce or industry	50	45	40	50	45	40
R4	Areas with dense transportation or some commerce or industry	55	50	45	55	50	45
R5 (See Note 3)	Areas with very dense transportation or in commercial districts or bordering industrial districts	60	55	50	60	55	50
R6 (See Note 3)	Areas with extremely dense transportation or within predominantly industrial districts	65	60	55	65	60	55

NOTES:

1 The division into noise area categories is necessary in order to accommodate existing sound levels encountered at residential sites in predominantly commercial or industrial districts, or in areas located close to main land transport routes, i.e. road and rail.

2 The noise area category most appropriate should be selected irrespective of metropolitan or rural zoning and will vary from location to location.

3 Some industrial and commercial sites are not predominant sources of high background sound levels.

A review of the above table indicates that areas with negligible transportation (Noise Area Category R1) are likely to have a background noise level in the night-time of 30 dBA and in the daytime of 40 dBA. This corresponds to the situation prior to the construction of the SWRL.

As development occurs within the South West Growth Area, it is anticipated that the future noise area category in the area surrounding the stabling facility would be R2 or R3 with low density or medium density transportation with some commerce or industry. As such, it is considered likely that the future background noise levels in the area surrounding the stabling facility are likely to be in the order of 45 dBA to 50 dBA during the daytime period and 35 dBA to 40 dBA during the night-time period.

For the purposes of this assessment, a conservative approach has been adopted using the lower range of the anticipated background noise levels (anticipated RBLs) for the future situation, Noise Area Category R2. These RBLs result in intrusive noise goals for the opening of the SWRL in 2016 of 40 dBA $L_{Aeq(15\ minute)}$ for the night-time and 50 dBA $L_{Aeq(15\ minute)}$ for the daytime (5 dBA above the RBL in each case).

7.2.2 Amenity Noise Goals

Consistent with the above assumptions, at the anticipated opening of the SWRL in 2016, the noise amenity area classification is likely to be "Suburban" in the area surrounding the proposed stabling facility. As such, **Table 16** provides a summary of the DECCW's acceptable and recommended maximum L_{Aeq} noise levels from industrial sources during the daytime, evening and night-time periods (from the INP). For the night-time period, it is noted that the amenity criterion for "Rural" areas is the same as the night-time "Suburban" amenity criterion.

Table 16 DECCW's Recommended L_{Aeq} Noise Levels from Industrial Noise Sources in Suburban Residential Areas

Time of Day	Recommended Suburban L_{Aeq} Noise Level (dBA)	
	Acceptable	**Recommended Maximum**
Day	55	60
Evening	45	50
Night	40	45

7.2.3 Sleep Disturbance

The DECCW's current approach to assessing potential sleep disturbance is to apply an initial screening criterion of background plus 15 dBA (as described in the Application Notes to the INP), and to undertake further detailed analysis if the screening criterion cannot be achieved. The sleep disturbance screening criterion applies outside bedroom windows during the night-time period.

Where the screening criterion cannot be met, the additional analysis should consider the number of potential sleep disturbance events during the night, the level of exceedance and noise from other events. It may also be appropriate to consider other guidelines including the DECCW's ECRTN which contains additional guidance relating to the potential sleep disturbance impacts.

A review of research on sleep disturbance in the ECRTN indicates that in some circumstances, higher noise levels may occur without significant sleep disturbance. Based on studies into sleep disturbance, the ECRTN concludes that:

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

It is generally accepted that internal noise levels in a dwelling, with the windows open, are 10 dBA lower than external noise levels. Based on a worst case minimum attenuation, with windows open, of 10 dBA, the first conclusion above suggests that short term external noises of 60 dBA to 65 dBA are unlikely to cause awakening reactions.

7.2.4 Project Specific Noise Goals

For the proposed stabling operations, the intrusive, amenity and sleep disturbance noise goals will apply. A summary of the operational noise goals during the daytime and night-time periods are provided in **Table 17**.

Table 17 Summary of Operational Noise Goals for Train Stabling Operations

Period[1]	Intrusiveness LAeq(15minute) (dBA)	Amenity LAeq(period) (dBA)	Sleep disturbance[2] LAmax (dBA)
Daytime	50	55	n/a
Night-time	40	40	50-65

Note 1: Evening period used in the INP not assessed since evening levels are between day and night levels. Night levels are the controlling criteria.

Note 2: Sleep disturbance 65 dBA level is based on ECRTN "Maximum internal noise levels below 50-55 dBA are unlikely to cause awakening reactions" with an allowance of 10 dBA for attenuation in going from outdoors to indoors with open windows on a residential building. Sleep disturbance 50 dBA level is 15 dBA above background.

7.3 Summary of Attended Stabling Noise Measurements

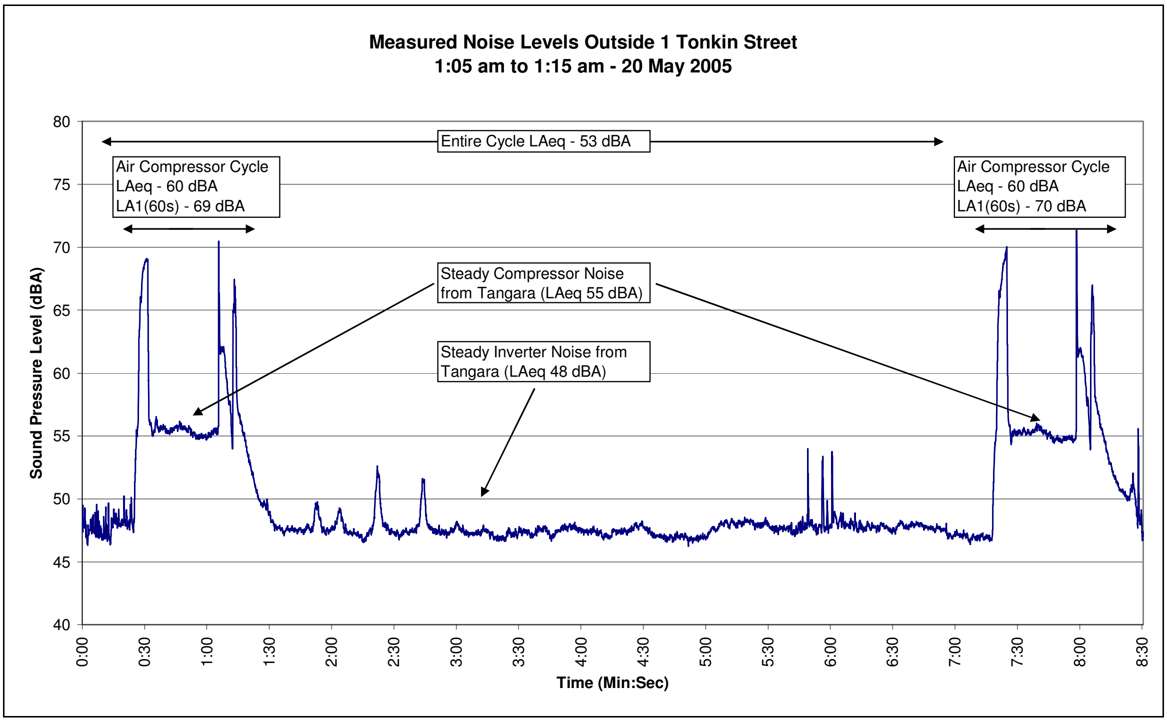
Attended noise measurements were undertaken on two occasions during night-time stabling operations as part of a previous stabling noise assessment. The purpose of the measurements was to survey the stabling operations and measure typical noise sources.

The major sources of noise emission from trains during the stabling operations were the air compressors. Other sources of noise on stabled trains are the roof mounted static invertors and air conditioning units. Outside the measurement location (located approximately 25 m from the nearest track), the typical LAeq noise levels from air compressors ranged from 54 dBA to 61 dBA. The typical LAmax noise levels ranged from 67 dBA to 71 dBA.

When a train is stabled and "powered up", the air compressors typically cycle on-off over an approximate time interval of 7 minutes. During the ON cycle, the compressor is operational for approximately 45 seconds.

Figure 5 shows an example of the measured noise levels during two compressor pumping cycles on a stabled Tangara set. Other train sets are assumed to produce similar noise levels. During the measurement, the steady LAeq noise level for the two compressor cycles was 60 dBA and the LAmax noise levels were 69 dBA and 70 dBA. In the period between the two compressor cycles, the steady LAeq noise level from the inverter was 48 dBA. For the entire 7 minute cycle, the LAeq noise level was 53 dBA.

Figure 5 Typical Noise Cycle for Tangara (Measurement Distance - 25 m)



7.4 Brake Test Noise and Horn Noise

Brake testing and horn testing are currently undertaken at both ends of train sets prior to entering service. This typically occurs up to an hour before the departure of a train from a stabling location. Since trains from the TSF will be used in the morning peak, these significant noise sources can be expected to occur from an early hour. The incidence of horn and brake testing will peak in the early morning and again in the early afternoon as trains leave the stabling facility.

On the arrival of a train at a stabling location, air is exhausted from the brake system as the train is prepared for stabling, resulting in emission of a high noise level of short duration. The incidence of this type of noise is expected to be greatest after the evening peak.

7.5 Noise Modelling Assumptions and Source Levels

7.5.1 Meteorological Conditions

The INP requires meteorological conditions to be considered in some situations, where temperature inversions or wind effects may increase noise levels by focusing sound wave propagation paths at a single point. These meteorological conditions can increase noise levels by 5 dB to 10 dB and sometimes more.

The INP describes a staged approach to the assessment of meteorological conditions, designed to require a detailed assessment only where initial screening tests show that effects on noise are potentially significant. Detailed analysis of meteorological data is not required where there is little or no potential for impact, for example in situations where the most affected premises are located close to the development, thus negating the effects of inversions (which focus noise at relatively large distances).

The TSF at Rossmore is located in an area where it is likely that inversion conditions would be present for at least 30% of winter nights. However, the most affected premises are those located close to the development so for most noise sources inversion effects would be insignificant. The exception is horn test noise, where longer distances and hence more premises are involved.

As an initial screening stage, Appendix D of the INP gives estimates of the increase in noise levels due to temperature inversions with distance. The SWGC is a non-arid area with rainfall greater than 500 mm per year. Drainage-flow wind (the localised flow of cold air in a downhill direction) is not applicable because the TSF is lower than its immediate surroundings, For these conditions, the estimated increase in horn test noise levels from the TSF is 1.0 dB to 1.5 dB for distances up to 5 km from the development. As described in the INP, additional noise impacts due to temperature inversions of less than 3 dB are not considered to be significant. Therefore in this case no further analysis of inversion effects is required.

Regional wind effects due to synoptic factors are independent of drainage flow wind and may occur in any direction. Wind effects need to be assessed where wind is a feature of the area, as determined by the frequency of occurrence of wind and wind speed. The Bureau of Meteorology wind rose for the Sydney area indicates that in all directions there is a less than 30% occurrence of wind up to 3 m/s and therefore in accordance with the INP wind effects are not included.

Modelling has been carried out assuming neutral meteorological conditions, using the CONCAWE algorithm in SoundPlan v6.5.

7.5.2 Auxiliary Noise Sources

Noise sources on stabled trains include alternators, inverters, air compressors and air-conditioning systems. These auxiliary systems are active during train arrival and departure procedures, and during cleaning.

Older train types such as Double Deck Suburban sets often stand for long periods with their electrical systems operating. Newer train sets including both Millennium and Waratah class trains are capable of entering a “Sleep Mode” during stabling. During this time all vehicle systems considered by this assessment to be considerable noise sources are shutdown.

Millennium and Waratah class train sets are also capable of a “Cleaning Mode” while routine cleaning is being performed. While these sets are in “Cleaning Mode” the static inverter, air conditioning and ventilation units are activated.

There may also be transient sources of noise, including compressed air discharges and train horn operation (either for warning during movements within the facility or for the purposes of testing prior to trains entering service each day).

On the basis of measurements undertaken by Heggies on similar projects, the Sound Power Levels in **Table 18** have been used in the SoundPLAN noise model to predict the L_{Aeq} and L_{Amax}) noise levels adjacent to the proposed stabling area. These levels correspond to full future usage of the capacity of the stabling facility, with twenty 8-car sets stabled overnight.

Note that at opening, the capacity of the stabling facility will be less, with up to twelve 8-car sets using the stabling facility. Some of these vehicles may be the older Double Deck rolling stock. On the basis that RailCorp has undertaken to phase out the older rolling stock by 2026, only the full twenty train scenario has been modelled with newer rolling stock.

The L_{Aeq} sound power levels in **Table 18** are representative of the equivalent steady noise level when train sets are stabled with all auxiliary equipment operating. The L_{Amax} sound power levels are representative of compressed air discharges during brake applications and testing and of horn operation.

For the compressed air cycle on Millennium (M-Sets) and Waratah (A-Set) trains, the source of noise emission will occur at four locations for each 8-car set (Cars 1, 4, 5 and 8). The static inverter noise will also be generated at four locations for each 8-car set (Cars 1, 4, 5 and 8) as per **Figure 6**.

During the day, if a Millennium or Waratah class train is not stabled in "sleep mode", air conditioning noise may occur at two locations on each train car, with a typical duty cycle of less than 50% with the cars unoccupied.

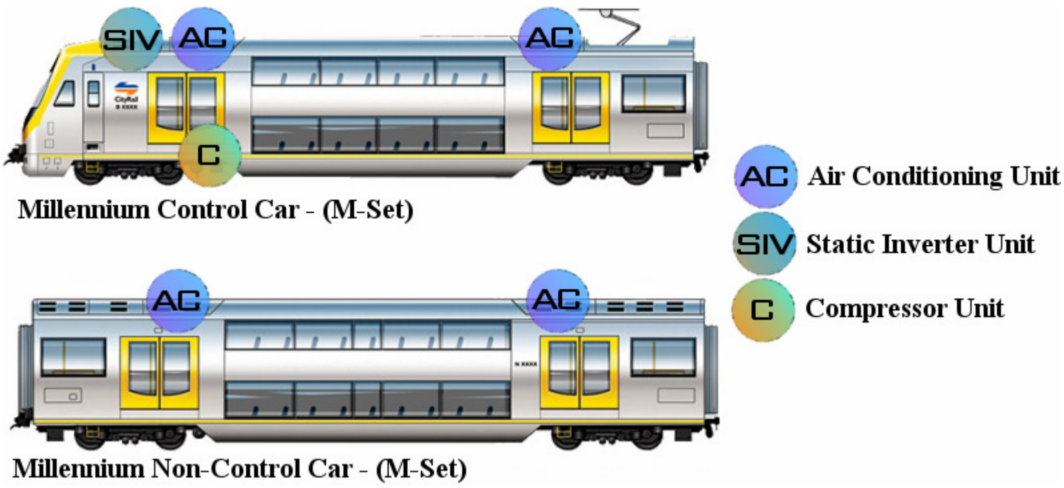
The location of modelled noise sources in relation to train dimensions is demonstrated in **Figure 6**.

Table 18 Sound Power Levels for Stabling Noise

Train Type	Noise Source	Sound Power Level	Location of Noise Source
A/M-Sets	Full Compressed Air Cycle [1]	90 dBA - LAeq 107 dBA - LAmax	Under floor
A/M –Sets	Inverter Noise	83 dBA - LAeq	Top of Train
All Passenger Sets	Air Conditioner	80 dBA - LAeq 50% duty <62 dBA - LAeq Ventilation only	Top of Train
All Passenger Sets	Brake Test	120 dBA - LAmax	End of train, under floor
All Passenger Sets	Horn	116-146 dBA - LAmax	End of train, under floor

Note 1: The term "Compressed Air Cycle" refers to the air compressor plus the cyclic air discharge noise associated with the air dryers, valves, etc.

Figure 6 Noise Source Locations



7.5.3 Train Movements

Train movements within the facility will occur at low speed, such that $L_{Aeq(15minute)}$ noise levels will be controlled by the train auxiliaries, rather than the wheel-rail noise. Train arrivals and departures will include intermittent noise from air brake valves, similar to that included above for brake tests.

7.5.4 Train Arrival and Shutdown

Heggies has been informed that once a train has entered the TSF and made its way to the designated stabling location, the driver initiates the shutdown procedure which takes no longer than a minute. It has been assumed that all systems would be powered on during this time.

A table of train arrival events modelled in a worst-case scenario is provided in **Table 19** for daytime and night-time periods. It can be seen from the values in **Table 19** that the worst case 15 minute event values are the same for the daytime and night-time periods.

Table 19 Worst Case TSF Operations

TSF Operation	Night Time (dBA)		Day Time (dBA)	
	10.00 pm - 7.00 am LAeq(9hour)	Worst Case LAeq(15minute)	7.00 am - 10.00 pm LAeq(9hour)	Worst Case LAeq(15minute)
Train Arrival	4	1	14	1
Train Departure	8	4	10	4
Train Cleaning	13	2	7	2

7.5.5 Train Preparation and Departure

Before a train enters active service, a series of system checks are performed. Based on information supplied by RailCorp, it has been assumed that the preparation and departure procedure takes approximately one hour. It has been assumed that all systems are active during the preparation and departure procedure.

A table of train preparation and departure events to be modelled in a worst-case scenario are provided in **Table 19** for daytime and night-time periods.

7.5.6 Train Cleaning

Cleaning is to be performed on all CityRail trains stabled at the TSF between 7.00 pm and 3.00 am every night. The cleaning process can take up to approximately one (1) hour for each train. It has been assumed for a worst-case scenario that at any given time between 7.00 pm and 3.00 am, up to two trains will be undergoing cleaning.

Both Millennium and Waratah train sets have a “Cleaning” Mode” where air conditioning and lighting is activated. The noise sources active for the purposes of modelling “Cleaning Mode” airborne noise include air conditioning and inverters.

A table of train cleaning events included in the model as a worst-case scenario is provided in **Table 19** for daytime and night-time periods.

7.5.7 Train Maintenance

No regular mechanical train maintenance, which would generate significant noise levels, is planned for the proposed stabling facility. Emergency maintenance could become necessary at any point on the network, but is unlikely to be sufficiently frequent or definable for inclusion in this assessment.

7.6 Summary of Noise Mitigation Options Considered for the Train Stabling Facility

A number of options were considered for noise mitigation at the TSF to protect surrounding areas from noise which will be generated by trains stabled in the TSF. These options are listed in **Table 20**.

Comments on the feasibility and reasonableness of each option are also provided in the table.

Table 20 Summary of Noise Mitigation Options Considered for TSF

Description	Estimated Noise Reduction	Comments on Feasibility / Reasonableness
Land use planning	5 dB to 15 dB reduction in LAmax and LAeq noise levels if residential land use is located behind commercial or industrial buildings.	Offers minimum impact on residential receivers, cost effective solution, however it does restrict land use in vicinity of stabling facility. Minimum visual impact.
Noise barriers on perimeter of site	5 dB to 10 dB reduction in LAmax and LAeq noise levels for noise sources located towards bottom of train. Noise reduction is greater if the stabling facility can be located in a cutting.	Reasonable cost, visual impact. Barriers can complement benefits of locating stabling facility partly in cutting.
Stabling shed	Greater than 20 dB noise reduction possible.	High cost, has implications on operation of stabling facility.
Low volume horn tests	Up to 30 dB reduction in LAmax noise levels.	High volume horns are considered essential for high speed operation, and testing of high volume horns is considered essential due to safety issues. The feasibility of a low volume horn test is the subject of further investigation.
No horn testing in stabling facility	Minimum of 40 dB reduction in LAmax noise levels at 100 m from stabling yard.	Horn testing considered essential due to safety issues. If horn testing is not conducted at the stabling facility as per RailCorp's normal operating procedure, it could be conducted outside the facility, en route to Leppington Station or alternative. This option is under consideration by RailCorp.
Use shore supplies for air and power on stabled trains	No reduction in LAmax, but LAmax and LAeq levels from auxiliary noise sources reduced for significant period of stabling time, however high levels will still occur from early hours of morning.	Additional staff/time needed to prepare trains for service. Additional stationary plant required at stabling facility. Does not change horn and brake test noise levels. Double Deck Suburban trains will be phased out of service.
Shut trains down completely during overnight stabling	No reduction in LAmax, but LAmax and LAeq levels from auxiliary noise sources reduced for significant period of stabling time, however high levels will still occur from early hours of morning.	Additional staff/time needed to prepare trains for service. Risk of failed trains due to flat batteries. Cold trains entering service during winter due to overnight shut down of AC. Reduced power consumption.

7.6.1 Discussion of Reasonable and Feasible Noise Mitigation Options:

- For reasons of operational efficiencies it is would not be feasible to use shore supplies for air and power supply or to shut down stabled trains.
- For reasons of safety it would not be reasonable to eliminate horn testing altogether.

- A low volume yard horn test is not currently available, although it remains a long term option for consideration for horn noise mitigation. Therefore this option not been included in the current assessment.
- Conducting horn testing en route to Leppington Station instead of at the TSF is under consideration, but at this time the normal operating procedure of horn testing at stabling facilities remains. This assessment therefore assumes horns will be tested at the TSF.

Therefore the following options are considered reasonable and feasible for further assessment:

- The implementation of noise barriers surrounding the TSF would provide a reasonable noise benefit for the costs involved and would not impact on operational efficiencies or safety. It is therefore considered reasonable to undertake a further assessment of the potential use of noise barriers at the TSF.
- A fully enclosed shed would not be required for controlling general stabling noise (stabled trains in the absence of horn and brake testing). However an enclosure may be an option for controlling horn noise to the north, south and west of the stabling roads. As such, an assessment of the potential benefits of an enclosure has been undertaken.

An assessment of the afore-mentioned options is included in the following sections.

Appropriate land use planning for the SWGC could also play a key role in managing potential impacts from the train stabling facility. Whilst the precinct planning for the area surrounding the TSF is in the early stages, consultation with the DoP is ongoing in order to ensure the best possible land use solution for the area.

7.7 Noise Modelling Scenarios

Noise from the TSF has the potential to cause annoyance, particularly in the night time period. A range of noise mitigation options were modelled to determine the most feasible and reasonable option for controlling noise in the area surrounding the stabling facility.

The following noise mitigation measures for stabled trains were modelled:

- No noise mitigation apart from natural terrain and site earthworks (the TSF is partially located in cutting).
- Noise barrier 6 m above rail height (where cutting does not already form a barrier), on the perimeter of earthworks, at the top of excavations or on the edge of fill, with 10 storage roads.
- Train stabling enclosure consisting of a steel shed, containing all arrival and departure activities. The perimeter of the enclosure is located at the edge of the northern, southern and western earthworks resulting in dimensions 410 m long and 60 m wide. This scenario has been included for the horn test case only, as enclosure of the facility is not required to adequately mitigate noise from other sources.

Modelling for the above configurations was carried out assuming that 100% of stabled trains were Millennium or Waratah class.

Modelling assumed that all 10 stabling roads were occupied by 20 train sets with two sets located on each road. All trains are assumed to be in sleep mode (with all auxiliary equipment powered off) during train stabling, unless a set is undergoing arrival, departure or cleaning processes.

For the planned daytime and night-time stabling operations, the $L_{Aeq(15minute)}$ predictions represent the typical maximum noise levels averaged over a 15-minute period. On the basis of previous observations and measurements of stabling operations, compliance with the $L_{Aeq(15minute)}$ intrusive noise goals will also result in compliance with the amenity noise goals.

Horn and brake test noise are modelled separately from the noise of stabled trains because they have different assessment criteria due to their short duration and higher noise levels.

For the brake and horn tests, the predicted L_{Amax} noise levels represent the typical maximum levels that can occur during testing.

There can be considerable variation in horn noise during testing. Through Heggies previous experience in the assessment of train horn noise levels, it has been determined that there is a strong correlation between the duration of a train horn sounding and the maximum noise emission level. A long duration horn "blast" can be up to 30 dBA louder than a shorter duration "toot". For this reason the train horn noise level contours found in **Appendix E** display a range of 30 dBA.

Horn and brake tests are typically undertaken up to an hour prior to a train entering service. The results of the stabling noise modelling are discussed in the following section.

7.8 Predicted Noise Levels

7.8.1 Noise Contour Modelling - Stabled Trains

Plots of the predicted $L_{Aeq(15minute)}$ night-time noise contours around the stabling facility are included in **Appendix E**. Approximate distances were calculated from these plots to indicate the areas that may be affected by trains stabled in the facility during the night-time period. These distances are taken from the noise source. The distances from the boundary of the TSF will be approximately 90 m less than the distances shown, based on the footprint of the land acquired for the TSF and subject to detailed design of the facility. Some occupants of residences located inside these distances may be affected by noise emitted by stabled trains.

Table 21 lists the potentially affected distances from the source for the unmitigated case and for the case with a 6 m high noise barrier. The noise goals are the amenity or intrusiveness goals listed in **Table 17**. The distances listed in **Table 21** are the range of distances from the source required to meet the targets where the noise source is the stabled trains. The noise source in this case does not include horn or brake testing noise. Minimum and maximum distances are presented because the predicted noise contours around the stabling facility are not symmetrical. For example, in the un-mitigated case, the affected distance is less to the west of the facility compared to in the other directions. This is because the TSF is located partly in a cutting, which acts as a noise barrier. See **Appendix E** for more detail of the areas affected by noise from the TSF.

Table 21 Approximate Distances Affected by Noise from Stabled Trains (Does not include Horn or Brake Test Noise)

Noise Control	Distance From Source to Meet Noise Goals (Daytime)		Distance From Source to Meet Noise Goals (Night-time)[1]	
	Minimum	Maximum	Minimum	Maximum
Un-mitigated	50 m	155 m	50 m	160 m
6 m Barrier	0 m	50 m	0 m	90 m

Note 1 Evening period used in DECCW INP not assessed since evening levels are between day and night levels. Night levels are the governing levels with what is an essentially constant noise source. Distances derived from 40 dBA Night-time amenity and intrusive noise goals.

7.8.2 Noise Contour Modelling - Horn and Brake Testing

Plots of predicted L_{Amax} noise contours around the stabling facility are included in **Appendix E**. These levels result from horn and brake testing on trains prior to their entry into service. All values were calculated assuming typical maximum noise levels for horn and brake testing. To account for the possible variation in horn test volumes as described in **Section 7.7**, the horn test noise contours in **Appendix E** are presented in the form of a 30 dB range.

The indicative distances from the source that may experience exceedances of the sleep disturbance noise goals for brake and horn testing are listed below in **Table 22** and **Table 23** respectively. Again, the distances from the boundary of the TSF will be approximately 90 m less than the distances shown, based on the footprint of the land acquired for the TSF and subject to detailed design of the facility. Minimum and maximum distances are presented because the predicted noise contours around the stabling facility are not symmetrical. See **Appendix E** for more detail of the areas affected by noise from the TSF.

Due to the large distances involved, only those existing residences closest to the TSF have been included in the model. Other buildings will also affect the noise contours. In addition, any development in the vicinity of the TSF will affect the predicted noise contours. The contours for horn and brake test noise presented in **Appendix E** and the distances described in **Table 22** and **Table 23** respectively are therefore conservative. Noise impacts are expected to be reduced by the addition of new buildings to the landscape in the area around the TSF.

Table 22 Approximate Distances Affected by Brake Test Noise

Noise Control	Distance From Source to Meet LAmax of 65 dBA [1]		Distance From Source to Meet LAmax of 50 dBA [2]	
	Minimum	Maximum	Minimum	Maximum
Un-mitigated	30 m	120 m	140 m	315 m
6 m Barrier	0 m	90 m	10 m	285 m

Note 1 Sleep disturbance criteria: 65 dBA level is based on ECRTN “Maximum internal noise levels below 50-55 dBA are unlikely to cause awakening reactions” with an allowance of 10 dBA for attenuation in going from outdoors to indoors with open windows on a residential building.

Note 2 Sleep disturbance criteria: 50 dBA level is 15 dB above background.

Table 23 Approximate Distances Affected by Horn Test Noise

Noise Control	Distance From Source to Meet LAmax of 65 dBA [1]		Distance From Source to Meet LAmax of 50 dBA [2]	
	Minimum	**Maximum**	**Minimum**	**Maximum**
Un-Mitigated	670 m	800 m	2000 m	2100 m
6 m Barrier	220 m	770 m	970 m	2100 m
TSF Building Enclosure	80 m	510 m	490 m	1500 m

Note 1 Sleep disturbance criteria: 65 dBA level is based on ECRTN "Maximum internal noise levels below 50-55 dBA are unlikely to cause awakening reactions" with an allowance of 10 dBA for attenuation in going from outdoors to indoors with open windows on a residential building.

Note 2 Sleep disturbance criteria: 50 dBA level is 15 dB above background.

In the unmitigated case with the maximum volume horn blast, L_{Amax} noise emission levels from horn testing are predicted to exceed the sleep disturbance criteria over a large area. In the context of the future development of the area around the stabling facility including residential development, mitigation of the noise from horn testing is clearly necessary. With a 6 m above rail noise barrier around the proposed stabling facility, L_{Amax} noise emission levels are predicted to exceed 65 dBA in an area extending beyond Bringelly Road to the north, McCann Road to the south and Eastwood Road to the east. Enclosing the facility would provide a benefit on three sides of the facility, but noise would still be projected out the doors of the facility if these are allowed to remain open as modelled.

The highly recognisable character of horn noise also increases the potential for disturbance.

With the addition of a stabling enclosure building, horn test noise emissions from the TSF are reduced in areas perpendicular to the building facades. However, the sound field generated inside the enclosure would be projected through the open facility doors that face due east.

7.8.3 Discussion of TSF Noise Mitigation

Train Stabling Noise Emissions

The noise modelling indicated that without any mitigation, amenity and intrusiveness target noise levels would be achieved at all existing residential properties (excluding properties that are to be acquired to build the stabling facility).

The noise modelling incorporated a noise barrier around the stabling facility that was 6 m above rail level, restricted to locations where site excavation cutting height was less than 6 m in depth. In this arrangement the barrier complements the natural barrier effect of the edge of the site cutting. With this barrier configuration, the target night-time noise level of 40 dBA for stabled trains (excluding horn and brake test noise) can be met within 90 m of the stabling facility, which confines the noise to the land allocated to the facility.

Brake Test Noise Emissions

The 6 m high noise barrier is predicted to provide adequate mitigation of brake test noise over the same area, as the 65 dBA L_{Amax} contour is restricted to within 90 m of the source. The 50 dBA L_{Amax} contour extends further, up to 285 m from the source directly to the east of the stabling facility. Therefore land use planning may also need to be considered at some locations particularly to the east of the TSF alongside the rail corridor,

Horn Test Noise Emissions

The noise from horn testing at maximum volume is predicted to result in exceedances of the sleep disturbance criteria over a large area. The modelling has assumed that horn events will be long enough to develop the highest noise level listed in **Table 18**.

Enclosing the facility has been modelled as a possible mitigation measure for horn test noise in the event that no other solution to the problem can be found. As mentioned above, horns sounded for a brief period can yield noise levels up to 30 dBA quieter than the maximum level listed in **Table 18**. However, such horn soundings do not satisfy RailCorp's requirements for horn testing prior to a train entering service.

Drivers are presently required to operate the horn when preparing a stabled train for service and before moving a train. RailCorp has emphasised the importance of train horns as a primary safety device, which frequently prevent injury and/or loss of life. As discussed in **Section 7.6.1**, a low volume yard horn test option is not currently available for implementation, however this concept is under investigation and may form a long term solution for mitigating horn noise emissions from the TSF. The possibility of testing horns outside the stabling facility en route to Leppington station is also under consideration, but this is not current normal operating procedure.

Land use planning for the area is in the early stages; and there is a clear intent for the relevant planning authorities to work with TIDC towards an optimal land use solution for the surrounding area.

If horn noise levels are found to cause sleep disturbance to the occupants of existing residences, in the area surrounding the TSF, then individual treatment of buildings would be an option to mitigate these noise levels. This option is not satisfactory if future development plans for the area include new residential developments.

8 SUBSTATION NOISE

Substations are required as part of the project to feed the 1500 V DC traction supply for train operation. Similar to the TSF, substations are not assessed according to IGANRIP because they do not involve noise generated by passing trains. They are considered to be a fixed facility and are assessed in accordance with the INP*.* Three substations are proposed as part of the project:

- An Integral Energy substation is proposed to the south of Cemetery Curve at chainage 47.750 km, to be accessed via a 4 metre roadway linking to Cubitt Crescent, Denham Court.
- A RailCorp substation is proposed at a site west of Camden Valley Way, at chainage 48.780 km, to be accessed via a 4 m roadway linking to Bringelly Road.
- A further RailCorp substation is proposed, located within the TSF boundary.

8.1 Noise Criteria for Substations

Substation noise is assessed according to DECCW's INP with noise criteria determined in the same manner as those for the TSF (see **Section 7.2.4**). As described in **Section 7** The INP sets two separate noise criteria to meet environmental noise objectives: one to account for intrusive noise and the other to protect the amenity of particular land uses. The potential for sleep disturbance should also be considered.

8.2 Substation Noise Sources and Modelling Assumptions

Modelling of substation noise has been carried out using the CONCAWE algorithm in SoundPlan v6.5, assuming neutral meteorological conditions and specific ground contours to each location.

8.2.1 Source Noise Levels

Noise emissions from an existing RailCorp substation were used as a reference noise source for the modelling of the three substations. The actual source levels are subject to detailed design, following a traction supply study to determine the necessary capacity of the substations.

The overall sound power level assumed to emanate from each facade of the substations is 74 dBA. The broadband character of the noise is not classified as tonal under the INP.

8.2.2 Site Specific Noise Criteria

The noise criteria for the substation within the TSF are identical to those for the TSF as a whole (see **Table 17**). The controlling criterion is the intrusiveness criterion with a level of 40 dBA $L_{Aeq(15minute)}$. At the other substation locations, future land use in the surrounding areas has not been defined and it is assumed conservatively that background noise levels remain low at 30 dBA. At these locations the intrusiveness criterion is then background plus 5 dBA, ie 35 dBA $L_{Aeq(15minute)}$.

8.2.3 Sleep Disturbance Considerations

The only short duration, high level noise source likely at substations is that of circuit breakers. These would only operate under fault conditions (at infrequent intervals). The potential frequency of circuit breaker events has not been defined or estimated for this project. Previous studies of substation noise carried out by Heggies indicate that approximately two circuit breaker events per week might be expected at each substation, at any time of the day or night. On this basis the circuit breakers are not expected to disturb the sleep of the surrounding community.

8.3 Predicted Noise - Substations

Plots of noise contours for the substations are included in **Appendix F**. The 35 dBA $L_{Aeq(15minute)}$ noise contour generally falls within 30 m to 50 m of the substation perimeters. This means that the most stringent noise goal in DECCW's INP (35 dBA $L_{Aeq(15minute)}$ for residential areas where existing night-time background noise levels are 30 dBA) are met at a distance of 30 m to 50 m from the substations. Noise criteria are predicted to be met at all existing residential receivers for substations of the capacity modelled. Appropriate building design regulations could be used to ensure that substation noise does not adversely affect the occupants of any future residential development near the substations.

As discussed in **Section 8.2.1**, the detailed design and specification of each substation is subject to a traction supply study for the SWRL project. Therefore further noise assessment would be required in the event that the actual substations are anticipated to emit higher noise levels than those modelled in the current study.

9 CONSTRUCTION ASSESSMENT - AIRBORNE NOISE

TIDC has developed a *Construction Noise Strategy for Rail Projects* (CNS) (a current version of the Strategy is available on TIDC's website at www.tidc.nsw.gov.au). The CNS requires a *Construction Noise and Vibration Management Plan* (CNVMP) to be developed as part of the approvals process. The CNVMP would be produced at a later stage (after the EA) to ensure that the construction details are current and accurate.

Nonetheless, the CNS assessment requirements will be utilised in the preparation of the Construction Noise Impact Assessment which follows. This includes the assessment of predicted noise and vibration emission levels and feasible and reasonable mitigation measures to reduce the potential noise and vibration impacts of the proposed construction works on the SWRL corridor project.

The following provides a preliminary assessment of the potential noise impacts during construction and the likely mitigation measures that may be required.

9.1 Overview

The construction of the SWRL would comprise the following main construction phases:

- The Site Establishment Phase that would involve:
  - Clearing and demolishing existing structures in the work area;
  - Setting up working areas and boundary fences; and
  - The construction of construction contractor's temporary facilities and establishing the site security facilities.
- The Main Construction Phase to undertake major civil works including:
  - General corridor earthworks to achieve the required design levels;
  - Track works, including track laying;
  - Construction of grade separated flyover;
  - Construction of underbridges and overbridges;
  - Station construction at Edmondson Park and Leppington;
  - Construction of the TSF and TWF to the west of the new Leppington Station; and
  - Construction of ancillary facilities such as power supply, substations, sectioning huts, overhead wiring, signalling structures, access roads, and other infrastructure required for the operation and maintenance of rail services and infrastructure.

The contract time frame for the design, construction and commissioning of the SWRL is currently anticipated to be from 2013 to 2016 for the main works.

This **Section 9** covers the assessment of airborne noise levels relating to the above construction phases. **Section 10** covers the assessment of ground-borne noise and **Section 11** covers the assessment of ground-borne vibration.

9.2 Construction Noise Metrics

The three primary noise metrics used to describe construction noise emissions in this assessment are:

L_{Amax} or $L_{A1(60second)}$	The "Typical Maximum Noise Level" for an event, used in the assessment of potential sleep disturbance during night-time periods.
L_{A90}	The "Background Noise Level" in the absence of construction activities. This parameter represents the average minimum noise level during the daytime, evening and night-time periods respectively.
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.
RBL	The $L_{A90(15minute)}$ Rating Background noise Level, the "Background Noise Level" determined in accordance with the DECCW's INP. The $L_{Aeq(15\ minute)}$ construction Noise Management Levels (NMLs) are based on the L_{A90} RBLs.

The subscript "A" indicates that the noise level is adjusted to match the typical human hearing characteristics (ie A-weighted).

9.3 Construction Noise Control

The DECCW has published guidelines in its *Interim Construction Noise Guidelines (2009)* for the control of construction noise, which is similar to what has been adopted in the TIDC's CNS.

In summary, the DECCW's preferred approach to the control of construction noise involves the following:

- Level restrictions
- Time restrictions
- Silencing

9.3.1 Level Restrictions

The *Interim Construction Noise Guideline* sets out Management Noise Levels for noise at all types of sensitive receivers.

9.3.2 Time Restrictions

Monday to Friday	7.00 am to 6.00 pm
Saturday	8.00 am to 1.00 pm

No work on Sundays or Public Holidays.

Should any construction works be undertaken outside these hours, a separate assessment of their impacts will be carried out once the nature and extent of those works is known.

9.3.3 Silencing

All practical measures should be used to silence construction equipment, particularly in instances where extended hours of operation are required.

9.4 Existing Background Noise Environment

As part of the SWRL Concept Plan EA, unattended background noise monitoring was undertaken during April and July 2006 at five representative locations along the proposed route between Glenfield and Leppington. The background noise data has been segregated into the relevant times of day to assist in setting noise criteria for construction noise emissions. The results of the unattended noise monitoring are summarised in **Table 24**.

Table 24 Existing Background Noise Levels (dBA)

Monitoring Location	$L_{A90(15minute)}$ Rating Background Level		
	Day	Evening	Night
198 McCann Road	34	33	30
615 Bringelly Road	43	38	30
25 Cassidy Street	36	37	33
135 Croatia Avenue	38	42	37
18 Newtown Road	41	42	37

Note 1: Daytime 7.00 am to 6.00 pm; Evening 6.00 pm to 10.00 pm; Night Time 10.00 pm to 7.00 am.

9.5 Construction Noise Management Levels

For construction work during standard hours, a NML ($L_{Aeq(15minute)}$) of RBL + 10 dBA applies for residential receivers. Where the $L_{Aeq(15minute)}$ construction noise levels, during standard hours, are predicted to exceed 75 dBA, the relevant authority (consent, determining or regulatory) may require respite periods to be observed.

For construction work outside the recommended standard hours, a NML ($L_{Aeq(15minute)}$) of RBL + 5 dBA applies for residential receivers.

The management levels ($L_{Aeq(15minute)}$) for Educational Facilities and Places of Worship are 45 dBA and refer to internal noise levels when the premise is in use.

For commercial and retail buildings, other NMLs apply. Generally, the external noise levels should not exceed a $L_{Aeq(15minute)}$ of 70 dBA and 75 dBA for commercial buildings and industrial buildings respectively. However, there is a range of noise-sensitive business which requires special investigation to determine suitable NMLs. Examples of these are child care centres, theatres, etc. The NMLs for these receiver types would only apply to when the premise is in use.

An external $L_{Aeq(15minute)}$ NML of 60 dBA applies for passive recreational areas, such as golf courses, that generate little noise and where benefits are compromised by external noise intrusion.

Table 25 presents a summary of the daytime construction NMLs for residential and commercial receivers in the vicinity of each representative noise monitoring location.

Table 25 Summary of Construction Noise Management Levels[1] ($L_{Aeq(15minute)}$ dBA)

Representative Monitoring Location	Residential Receivers			
	Standard Hours		Out of hours	
	Day	Day	Evening	Night
198 McCann Road	44	39	38	35
615 Bringelly Road	53	48	43	35
25 Cassidy Street	46	41	42	38
135 Croatia Avenue	48	43	47	42
18 Newtown Road	51	47	47	42

Note 1: Daytime 7.00 am to 6.00 pm; Evening 6.00 pm to 10.00 pm; Night Time 10.00 pm to 7.00 am.

9.6 Working Hours

The majority of works can be carried out during normal construction hours (daytime period), however for safety reasons and to avoid significant traffic disruptions, some activities would need to be undertaken outside normal hours, such as the construction of some road underbridges and overbridges.

Scheduled track possessions will be utilised during the construction period. The majority of work undertaken during track possessions will involve the Glenfield upgrade rather than the SWRL. A track possession is a planned shutdown of a section of the network taking place generally on a weekend between 2.00 am Saturday to 2.00 am Monday.

The *Interim Construction Noise Guideline* is generally very strict about construction works being undertaken outside of the recommended normal construction hours. However, public infrastructure works is used as an example where out of hours works is justified, for occupational safety reasons and for the impact on the community caused by the disruption.

Construction activities requiring track possessions include:

- Connections to existing track;
- New rail operating systems;
- Installing new flyover and viaducts; and
- Testing and commissioning.

9.7 General Approach to Noise Modelling

Construction noise modelling for this assessment has been undertaken using the SoundPLAN computer noise modelling software. The noise modelling includes ground topography and is based on the representative source noise levels listed in **Table 26**. At relatively small offset distances between construction sites and receivers, weather effects have little influence on noise propagation and hence neutral meteorological conditions were assumed.

The calculated construction noise levels will inevitably depend upon the number of plant items and equipment operating at any one time and their location relative to the receiver of interest. Predicted noise levels were based on typical construction operations using the appropriate plant placed within the works area.

In practice, the noise levels will vary due to the fact that plant and equipment will move about the site and will not all be operating concurrently. Noise levels will also vary as a result of the noise shielding provided by site buildings and other structures surrounding the construction sites.

At this stage in the assessment process, detailed construction methodologies and equipment are not available. The following sections, therefore, provide an assessment of the potential noise impacts a level of detail suitable for an environmental impact assessment.

9.8 Typical Sound Pressure Levels

Sound pressure levels for typical items of plant are listed in **Table 26**. These noise levels are representative of modern plant operating with noise control measures in good condition. The sound pressure levels are indicative only and have been obtained from Heggies previous experience in similar projects.

Table 26 Typical Sound Pressure Levels

Item	Typical Plant Type	Noise Level at 7 m (dBA)	
		Typical Maximum Level (L_{Amax})	$L_{Aeq(15minute)}$ Noise Level for Modelling
Heavy Rockbreaker	Hydraulic on excavator KATO 750	103	97
Excavator KATO	KATO 750	86	83
Boring Rig (Diesel)	-	85	82
Bulldozer	Crawler, Caterpillar D9	88	83
Bulldozer	Crawler, Caterpillar D10	93	88
Skidsteer	-	85	82
Crane	60 t Crawler	85	80
Crane	Truck Mounted	85	80
Front-end Loader	Wheeled	86	82
Backhoe	Wheeled	86	82
Air Track Drill	800 CFM Compressor	96	93
Compressor	600 CFM	75	75
Compressor	1500 CFM	80	80
Semi Trailer	25-28 Tonne	87	82
Dump Truck	15 tonne	83	78
Product Truck	12-15 Tonne	83	78
Water Cart	-	80	75
Vibratory Roller	10-12 Tonne	89	86
Vibratory Pile Driver	-	96	90
Generator	Diesel	79	78
Concrete Truck	-	83	78
Concrete Pump	-	84	82
Concrete Vibrator	-	80	78
Flood Lights	Daymaker	75	75
Shotcrete rig	-	85	82
Track Laying Machine		90	85
Ballast Regulator	-	96	93
Ballast Tamper	-	96	93
Rail Saw	-	88	85

9.9 Construction Activities Noise Assessment

9.9.1 General Earthworks

General earthworks would involve the use of excavators, graders, water trucks, dump trucks, rockbreakers, compactors and bulldozers.

9.9.2 Track Works

The laying of tracks and wiring would involve the use of locomotives and wagons, Franna, trucks, excavators, front end loaders, lighting towers, cranes, ballast regulators and ballast tampers.

9.9.3 Flyover Construction

The construction of the flyover south of Glenfield Station would involve both "in situ" concrete works and the erection of pre-cast concrete elements. These scenarios would involve the use of a dump truck, concrete truck and pump, a 50 tonne crane and possibly a 250-400 tonne crane.

9.9.4 Overbridge Construction

- Hume Highway, Macquarie Links and Quarter Sessions Road
- Rickard Road
- Eastwood Road
- Dickson Road

The construction of overbridges would involve the use of rockbreakers, skidsteers, dump trucks, concrete trucks and pumps, piling machines and cranes.

9.9.5 Underbridge Construction

- Campbelltown Road
- Camden Valley Way
- Cowpasture Road and Sydney Water Canal
- Cabramatta Creek
- Kemps Creek

The construction of underbridges would involve both "in situ" concrete works and the erection of pre-cast concrete elements. These scenarios would involve the use of a dump truck, concrete truck and pump, a 50 tonne crane and possibly a 250-400 tonne crane.

9.9.6 Station Construction

The construction of Edmondson Park and Leppington Stations would involve the use of cranes, trucks, generators, concrete saws, jackhammers, concrete trucks and concrete pumps.

9.9.7 Train Stabling Facility Construction

The construction of the TSF would involve the use of cranes, trucks, generators, concrete saws, jackhammers, concrete trucks and concrete pumps.

9.9.8 Substation Construction

Substation Construction would involve the use of concrete trucks and concrete pumps, cranes, trucks, generators, compressors, jackhammers and other hand tools.

9.9.9 On-Site Truck and Vehicle Movements

The maximum (L_{Amax}) noise emission level for a typical truck in good condition is in the order of 83 dBA at 7 m. This level applies only when the truck engine is at maximum RPM. The $L_{Aeq(15minute)}$, or average noise levels, would always be somewhat lower. Depending on the number of trucks operating, their positions and the general intensity of movements, the $L_{Aeq(15minute)}$, noise levels emitted would typically be 5 dBA or more lower than the L_{Amax} levels.

Noise sources associated with truck operations also include the short-term noise events of material being dumped into hoppers or into the trucks. While trucks move about on work sites, nearby receivers tend to aggregate truck noise emission with that of other excavation and construction equipment on the site. Hence, representative truck noise sources have been included in each of the appropriate site noise models.

9.9.10 Off-Site Truck Movements

On the local roads immediately adjacent to the site, the community will associate truck movements with the project. Once the trucks move onto collector and arterial roads, the truck noise may be perceived as part of the general road traffic.

9.10 Predicted Construction Airborne Noise Levels

9.10.1 Site Specific Works

The indicative "worst case" construction noise levels predicted at the nearest sensitive receivers are shown in **Table 27**. Noise contour plots for each site have also been provided in **Appendix G**, overlayed on an aerial photograph of the existing land use.

Table 27 Predicted $L_{Aeq(15minute)}$ Construction Noise Levels - Site Specific

Construction Site/Activity	Typical Receiver Location	Approximate Distance to Activity (m)	$L_{Aeq(15minute)}$ Noise Management Level (Normal Construction Hours) (dBA)	Predicted $L_{Aeq(15minute)}$ Construction Noise Level (dBA)
Rossmore Train Stabling Facility	108 Mark Road	160	44	60
	105 Mark Road	170	44	59
	215 McCann Road	150	44	62
	467 Bringelly Road	190	53	59
Eastwood Road Overbridge and Wash	50 Eastwood Road	120	44	68
	60 Eastwood Road	150	44	64
	40 Eastwood Road	90	44	74
	29 Eastwood Road	150	44	68
Dickson Road Overbridge	133 Dickson Road	110	44	71
	146 Dickson Road	100	44	73
Leppington Station and Rickard Road Overbridge	204 Rickard Road	110	44	67
	206 Rickard Road	120	44	66
	NW Rickard Road	250	44	57
	183 Rickard Road	160	44	62
	Rickard Road (Education)	410	45[1]	41[2]

Construction Site/Activity	Typical Receiver Location	Approximate Distance to Activity (m)	$L_{Aeq(15minute)}$ Noise Management Level (Normal Construction Hours) (dBA)	Predicted $L_{Aeq(15minute)}$ Construction Noise Level (dBA)
Cowpasture Road and Sydney Water Canal Underbridge	111 Cowpasture Road	60	53	65
	87 Cowpasture Road	160	53	50
Bringelly Road Stockpile	150 Bringelly Road	160	53	50
Camden Valley Way Underbridge	45 Tabletop Circuit	190	46	48
	1640 Camden Valley Way (Commercial)	170	70	49
Cabramatta Creek Underbridge	23 Culverston Avenue	170	46	48
	220 Jardine Drive	140	46	51
Edmondson Park Station	180 Croatia Avenue	270	48	50
	174 Croatia Avenue	260	48	50
	Nearest Military	120	48	59
Campbelltown Road Underbridge	Nearest Croatia Avenue	500	48	34
	Nearest Military	320	48	42
Glenfield Southern Flyover	6 Newtown Road	110	51	55
	18 Newtown Road	200	51	50
	51 Adrian Street	300	51	46
	Macquarie Links International Golf Course	70	60	59

Note 1: Refers to internal noise level.

Note 2: Assuming 10 dBA noise reduction from outside to inside, typically experienced when windows are partially open in order to allow for additional ventilation.

Due to the close proximity of residential receivers to the works, the construction NMLs would be exceeded at many locations along the rail corridor. This is relatively common on major infrastructure projects, particularly where there is no opportunity to provide a large buffer zone.

It is recognised that such exceedances may be of concern to potentially affected residents and particular effort should be directed towards the implementation of all feasible and reasonable noise mitigation and management strategies.

While exceedances of the NMLs can be expected, it is noteworthy that the predicted noise levels are below the limit for residential receivers being ‘highly noise affected’ (ie where the predicted noise level exceeds 75 dBA).

For new track sections, construction works would be limited to daytime hours only (unless essential for traffic management or safety reasons) in order to reduce any potential impacts as much as possible.

The fact that noise criteria exceedances have been identified highlights the importance of managing the works to minimise both the noise levels and duration of the predicted exceedances. Potential mitigation measures are discussed further in **Section 9.11**.

9.10.2 Corridor Earthworks and Track Works

Noise emissions from the track works are typically most intensive during earthworks and track laying and to a lesser extent, from overhead wiring and signal installation. The construction noise levels that have been summarised both numerically in **Table 28** and pictorially in **Appendix G** represent the predicted $L_{Aeq(15minute)}$ noise levels during operation of typical plant items.

The daytime construction noise objectives range from 44 dBA to 53 dBA for nearby residential receivers. These noise levels are appropriate for long term activities and are well within the range of other normal ambient noise.

For short periods of time, criterion exceedances of up to 35 dBA are likely at the nearest receivers. In all cases, the predicted noise levels will not be sustained. Lower noise levels will occur when the plant is located away from receivers or is operating on a less noise intensive task.

The typical offset distances between the construction works and the nearest sensitive receivers range between 30 m and 100 m in developed areas.

Noise emissions from the proposed track works, including earthworks, overhead wiring, signalling and track laying will progressively move along the rail corridor in stages. Depending on the locations of access points, construction traffic may continue to pass individual receivers for a longer duration.

The construction noise levels in **Table 26** and **Table 28** represent the predicted $L_{Aeq(15minute)}$ noise levels during operation of typical plant items.

Table 28 Noise Levels during Corridor Earthworks and Track Construction versus Offset Distance from Receiver Locations

Offset Distance to Receiver (m)	$L_{Aeq(15minute)}$ Track Construction Noise Level (dBA)	
	Earthworks[1] (Excavation and Compaction)	Track Installation[2]
10	86	90
20	79	86
30	73	80
40	70	76
100	60	65

Note 1 Rock breakers will generally not be required for excavation works, as the cuttings are predominantly in clay and shale. If required, noise from a rockbreaker would be 10 dBA to 15 dBA higher than predicted for earthworks (although this may be reduced by shielding if the works are being undertaken at the base of a cutting).

Note 2 Worst case scenario, with all expected equipment working concurrently.

The noise levels at the nearest part of Macquarie Links International Golf Club are predicted to up to 70 dBA during earthworks and track installation works undertaken in the vicinity.

9.10.3 Work Outside Normal Construction Hours

Wherever possible, noise intensive activities should be scheduled during the daytime period. Any particular works which gain approval to occur at night-time should be managed to avoid any unnecessary noise emissions. Activities such as rockbreaking and ballast tamping/regulating should therefore be undertaken during daytime hours where possible.

The following would need to be undertaken in relation to out of hours work:

- A detailed noise impact assessment for the specific activities, sites and time.
- Surrounding noise sensitive receivers to be provided with appropriate notice of all out of hours work.
- The noisiest construction activities to take place before 10:00 pm wherever feasible, and endeavour to undertake as much preparation work and noise-intensive work as feasible in the daytime hours.
- The identification of feasible and reasonable mitigation measures should be recognised and implemented in accordance with TIDC's *Construction Noise Strategy*.

9.10.4 Occupational Health and Safety Noise Criteria

There is also a requirement to protect the occupational health and safety (OHS) of patrons and staff during construction activities for the subject works.

Noise induced hearing loss generally occurs when individuals are exposed to excessive noise levels for extended periods of time (normally several years) or when exposed to extremely loud noise levels for a short period of time.

The Occupational Health and Safety Regulation 2001 states, in Section 49, that:

1. *An employer must ensure that appropriate control measures are taken if a person is exposed to noise levels that:*
   a) *exceed an 8-hour noise level equivalent of 85 dBA, or*
   b) *peak at more than 140 dBC*

It is generally possible to maintain construction noise levels below these limits; however the specific measures required to achieve this outcome need to be determined and documented during the process of preparing the CNVMP.

9.10.5 Noise from Construction Traffic on Local Roads

On the roads immediately adjacent to the site, the community may associate truck movements with the construction works. Once the trucks move onto collector and arterial roads the truck noise is likely to be perceived as part of the general road traffic.

Construction access routes were nominated in the SWRL Concept Plan EA. Construction access is proposed via appropriate easements and other suitable locations along the rail corridor, resulting in multiple site access points. Construction traffic impacts would be dependent on which work areas are active and the volume and number of days of heavy vehicle traffic using each access point.

Depending on final construction methodology and sequencing, construction traffic is likely to utilise the following roads:

- Macquarie Links Drive
- Quarter Sessions Road
- Campbelltown Road
- Zouch Road
- Camden Valley Way
- Bringelly Road

- Cowpasture Road
- McCann Road
- Eastwood Road
- Rickard Road
- Dickson Road

The relevant assessment criteria are set out in the ECRTN. The objectives applicable to residential areas in the daytime period range from 55 dBA for local roads to 60 dBA for collector and arterial roads. These criteria apply to permanent traffic noise.

The number of truck movements at each site has not yet been finalised. The assessment of noise from truck movements and suitable mitigation will be considered as part of the CNVMP.

Noise from idling and reversing trucks near construction sites can also impact on amenity in some instances, especially if they arrive early and wait on local streets. The current construction traffic arrangements are not likely to occur next to residences, so this is not anticipated to be a problem. The finalised construction traffic arrangements will be reviewed during the CNVMP assessment.

9.11 Potential Noise Mitigation

In view of the anticipated potential for noise goal exceedances during some construction activities, noise mitigation measures are recommended to minimise the impact of construction noise at nearby residential receivers.

The suite of standard mitigation measures described in TIDC's *Construction Noise Strategy* must be implemented on all rail construction projects. This includes:

- Implement community consultation measures
- Site inductions covering noise and vibrations
- Behavioural practices
- Equipment selection and usage

Where the Noise management Levels are exceeded, DECCW's *Interim Construction Noise Guideline* require all feasible and reasonable mitigation measures to be applied. The following measures would need to be considered:

- The construction contractor(s) would prepare and implement a site-specific Construction Noise and Vibration Management Plan (CNVMP) including consideration of the measures listed below and any other initiatives identified to minimise the noise impact.
- Noise intensive construction works would be carried out during normal construction hours wherever practical. Where works involving the operating line need to be carried out during weekend possessions, noise intensive activities should be scheduled to occur during the daytime, where possible.
- Quietest available plant suitable for the relevant tasks would be used.
- The duration of noise intensive activities would be minimised insofar as possible.
- Where appropriate and effective, site hoardings or temporary noise barriers would be used to provide acoustic shielding of noise intensive activities or fixed plant items.
- Rockbreakers would be of the "Vibro-silenced" or "City" type, where feasible and reasonable.

- Activities resulting in highly impulsive or tonal noise emission (eg rockbreaking) would be limited to 8.00 am to 12.00 pm Monday to Saturday and 2.00 pm to 5.00 pm Monday to Friday (except where essential during track possessions and subject to additional approvals where required).
- High noise generating activities should run for no longer than 3 continuous hours with a minimum respite of 1 hour.
- Noise awareness training would be included in inductions for site staff and contractors.
- Noise generating plant would be orientated away from sensitive receivers, where possible.
- Notification would be provided to residents via newspaper advertising and letterbox drops, advising of the nature and timing of works, contract number and complaint procedures.
- Discussions with nearby schools regarding the implementation of noise management measures such as the scheduling of the noisiest construction activities outside of exam periods.
- Noise monitoring would be carried out periodically to confirm that noise levels do not significantly exceed the predictions and that noise levels of individual plant items do not significantly exceed the levels shown in **Table 26**.
- Deliveries would be carried out within standard construction hours, except as directed by the Police or RTA, or as required for possession work.
- Non-tonal reversing beepers or equivalent would be fitted and used on all construction vehicles and mobile plant regularly used on site and other vehicles where possible.
- Trucking routes to be via nominated construction access routes and major roads, where possible.
- Construction vehicles to use rail corridor for movements, in preference to local roads.
- Trucks would not be permitted to queue near residential dwellings with engines running, wherever possible.
- Avoid the coincidence of noisy plant working simultaneously together and adjacent to sensitive receivers.
- Maximise the offset distance between noisy plant items and nearby sensitive receivers.

There is also a requirement to protect the occupational health and safety (OHS) of public and staff during the proposed construction activities. The CNVMP should address Section 49 of the Occupational Health and Safety Regulations 2001.

10 CONSTRUCTION ASSESSMENT - GROUND-BORNE NOISE

10.1 Ground-borne Noise Goals

Ground-borne or regenerated noise in buildings is caused by the transmission of ground-borne vibration rather than the direct transmission of noise through air. Vibration may be generated by construction equipment such as rockbreakers and transmitted through the ground into the adjacent building structures. After entering a building, this vibration causes the walls and floors to faintly vibrate and hence to radiate noise.

Attenuation with distance occurs due to the geometric spreading of the wave front and due to other losses within the ground material, known as "damping". In addition, losses occur with the transfer of vibration from floor-to-floor within buildings (typically 2 dBA per floor).

The DECCW *Interim Construction Noise Guideline* states ground-borne noise levels above which management actions should be implemented. The ground-borne noise trigger levels apply to the evening and night-time periods only, as the objectives are to protect the amenity and sleep of people when they are at home. During the evening period (6.00 pm to 10.00 pm) the trigger level is $L_{Aeq(15minute)}$ 40 dBA assessed at the centre of the most affected habitable room. During the night-time period the trigger level is $L_{Aeq(15minute)}$ 35 dBA.

During the daytime the human comfort vibration objectives presented in **Section 11.3.2** should be used.

10.2 Ground-borne Construction Noise Sources

The major source of ground-borne noise during the construction phase for this project would result from excavation using rockbreakers and soil compaction using vibratory rollers. Typical regenerated noise levels within a building from heavy, medium and light rockbreakers, operating in hard sandstone, are presented in **Table 29.**

Table 29 Typical Regenerated Noise Levels versus Distance

Equipment	Typical L_{Amax} Regenerated Noise Levels (dBA) at Given Distances							
	10 m	20 m	30 m	40 m	50 m	65 m	85 m	110 m
Heavy Rockbreaker (eg 1600 kg)	75	62	55	50	45	40	35	30
Medium Rockbreaker (eg 900 kg)	72	59	52	47	42	37	32	27
Light Rockbreaker (eg 300 kg)	69	56	49	44	39	34	29	24

Note: These ground–borne noise levels (inside buildings) are indicative only. Actual levels are dependent on factors such as geotechnical conditions, building construction, machine intensity etc.

10.3 Predicted Regenerated Noise Levels at Nearby Receivers

The typical L_{Amax} noise levels versus distance, in conjunction with the offset distance between the site and the receivers, have conservatively been used to predict the $L_{Aeq(15minute)}$ regenerated (ground floor) noise levels. The nearest receivers to any site activity are no closer than 40 m. These locations are found between chainage 44.9 - 45.6, 49.6 - 49.8, 50.4 - 50.9, 51.6 - 51.9 and 52.2 - 52.5. At these locations the predicted regenerated noise levels are expected to be approximately 44 dBA (for a light 300 kg rockbreaker) to 50 dBA (for a heavy 1600 kg rockbreaker). Regenerated noise levels of these magnitudes would exceed the evening and night-time trigger levels of 40 dBA and 35 dBA respectively as defined in the DECCW *Interim Construction Noise Guideline*

10.4 Ground-borne Construction Noise Mitigation Measures

In light of the above, at locations close to sensitive receivers, it is recommended that excavation and soil compaction construction activities are restricted to the daytime period.

11 CONSTRUCTION ASSESSMENT - GROUND-BORNE VIBRATION

11.1 Overview

Ground-borne vibration can occur due to a range of construction activities including excavation (using rockbreakers, excavators and bulldozers), soil compaction (using vibratory rollers) and pilling (using bored piles, vibratory piles or impact piles).

The effects of vibration in buildings can be divided into three main categories:

1. Those in which the occupants or users of the building are inconvenienced or possibly disturbed (human perception or human comfort vibration);
2. Those where the building contents may be affected; and
3. Those in which the integrity of the building or the structure itself may be prejudiced.

For most construction projects, the assessment of ground-borne vibration is primarily concerned with category 3, namely the protection of nearby structures from damage. This is on the basis that vibration emissions are usually of a relatively short duration during construction projects and there is limited scope for reducing the potential disturbance to building occupants or the satisfactory operation of sensitive equipment.

Vibration mitigation measures on construction projects are usually limited to using alternative equipment with lower source vibration levels, positioning the works away from sensitive receiver locations, providing respite periods or undertaking the construction works during the daytime period or when the building is not in use.

11.2 Vibration Damage Criteria - Surface Structures

11.2.1 British Standard 7385: Part 2 – 1993 Guidelines

In terms of the most recent relevant vibration objectives, Australian Standard AS 2187.2:2006 *Explosives - Storage and Use - Use of Explosives* recommends the frequency dependent guideline values and assessment methods given in British Standard BS 7385.2:1993 *Evaluation and measurement for vibration in buildings* as they "are applicable to Australian Conditions".

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 give a minimum risk of vibration-induced damage, where minimal risk for a named effect is usually taken as a 95% probability of no effect.

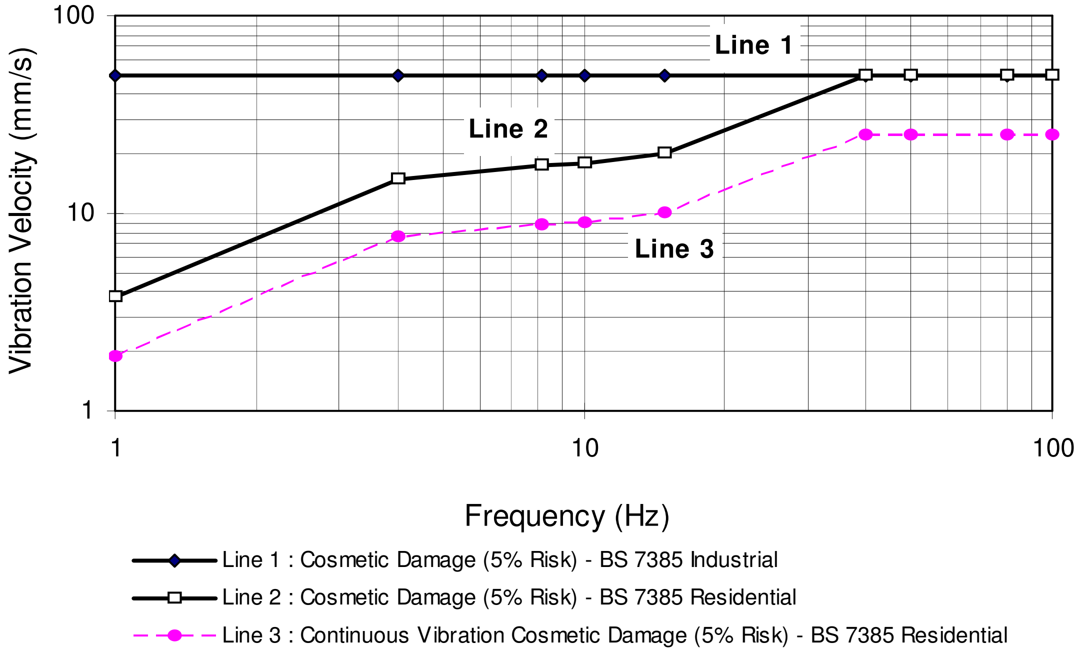
The recommended limits (guide values) for transient vibration to ensure minimal risk of cosmetic damage to residential and industrial buildings are presented numerically in **Table 30** and graphically in **Figure 7**.

Table 30 Transient Vibration Guide Values - Minimal Risk of Cosmetic Damage

Line	Type of Building	Peak Component Particle Velocity in Frequency Range of Predominant Pulse	
		4 Hz to 15 Hz	15 Hz and Above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
2	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 standard states that the guide values in **Table 30** relate predominantly to transient vibration which 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 30** may need to be reduced by up to 50%.

Figure 7 Graph of Transient Vibration Guide Values for Cosmetic Damage



In the lower frequency region where strains associated with a given vibration velocity magnitude are higher, the guide values for building types corresponding to Line 2 are reduced. Below a frequency of 4 Hz where a high displacement is associated with the relatively low peak component particle velocity value, a maximum displacement of 0.6 mm (zero to peak) is recommended. This displacement is equivalent to a vibration velocity of 3.7 mm/s at 1 Hz.

The standard goes on to state that minor damage is possible at vibration magnitudes which are greater than twice those given in **Table 30**, and major damage to a building structure may occur at values greater than four (4) times the tabulated values.

Fatigue considerations are also addressed in the standard and it is concluded that unless calculation indicates that the magnitude and number of load reversals is significant (in respect of the fatigue life of building materials) then the guide values in **Table 30** should not be reduced for fatigue considerations.

It is noteworthy that extra to the guide values nominated in **Table 30**, the standard states that:

> *"Some data suggests that the probability of damage tends towards zero at 12.5 mm/s peak component particle velocity. This is not inconsistent with an extensive review of the case history information available in the UK."*

Also that:

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

11.3 Human Comfort Vibration Criteria

11.3.1 General

Humans are far more sensitive to vibration than is commonly realised. They can detect vibration levels which are well below those causing any risk of damage to a building or its contents.

Human tactile perception of random motion, as distinct from human comfort considerations, was investigated by Diekmann and subsequently updated in German Standard DIN 4150 Part 2-1975. On this basis, the resulting degrees of perception for humans are suggested by the vibration level categories given in **Table 31**.

Table 31 Peak Vibration Levels and Human Perception of Motion

Approximate Vibration Level	Degree of Perception
0.10 mm/s	Not felt
0.15 mm/s	Threshold of perception
0.35 mm/s	Barely noticeable
1 mm/s	Noticeable
2.2 mm/s	Easily noticeable
6 mm/s	Strongly noticeable
14 mm/s	Very strongly noticeable

Note: These approximate vibration levels (in floors of building) are for vibration having a frequency content in the range of 8 Hz to 80 Hz.

Table 31 indicates that people will just be able to feel floor vibration at levels of about 0.15 mm/s and that the motion becomes "noticeable" at a level of approximately 1 mm/s.

11.3.2 Human Comfort Criteria for Continuous Vibration

Guidance in relation to assessing potential disturbance from ground-borne vibration is set out in the DECCW publication *Assessing Vibration - A technical Guide* (2006). It should be noted that both this document and Australian Standard AS 2670-2001 *Evaluation of human exposure to whole-body vibration* are based upon BS 6472-1992, which was revised in 2008. The DECCW guideline does however anticipate the 2008 revision of BS 6472, and states that *"this guideline can be considered interim until the revision is published"*.

British Standard 6472-2008 *Guide to evaluation of human exposure to vibration in building* nominates criteria for various categories of disturbance, the most stringent of which are the levels of building vibration associated with a "low probability of adverse comment" from occupants. The "low probability of adverse comment" level for residential buildings is:

0.2 to 0.4 $m/s^{1.75}$ (16 hour daytime Vibration Dose Value)

0.1 to 0.2 $m/s^{1.75}$ (8 hour night-time Vibration Dose Value)

BS 6472-2008 provides criteria for continuous, transient and intermittent (in the case of road traffic) events that are based on a Vibration Dose Value (VDV), rather than a continuous vibration level. The vibration dose value is dependant upon the level and duration of the short-term vibration event, as well as the number of events occurring during the daytime or night-time period.

The Vibration Dose Value for a single event may be determined by the following formula using vibration measured in frequency weighted rms acceleration:

$$VDV_{b/d,\ day/night} = \left(\int_0^T a^4(t)\,dt \right)^{0.25}$$

Where, $VDV_{b/d,\ day/night}$ = Vibration Dose Value (in $m/s^{1.75}$)

$a(t)$ = Frequency weighted acceleration (in m/s^2), using W_b or W_d weighting as appropriate

T = The total period of the day or night (in s) during which vibration can occur.

The total vibration dose is then calculated using the following formula:

$$VDV = \left(\sum_{n=1}^{n=N} VDV_{b/d,t_n}^4 \right)^{0.25}$$

Where, VDV = Total vibration dose value for the day

$VDV_{b/d,tn}$ = Vibration dose value for each vibration dose event

N = Total number of vibration dose events.

The BS 6472 human comfort criterion (the permissible total vibration dose level for residential buildings with a "low probability of adverse comment") is a preferred VDV of 0.2 $m/s^{1.75}$ and a maximum VDV of 0.4 $m/s^{1.75}$ during the daytime (7.00 am - 10.00 pm), and a preferred VDV of 0.1 $m/s^{1.75}$ and a maximum VDV of 0.2 $m/s^{1.75}$ during the night-time (10.00 pm - 7.00 am).

Situations exist where motion magnitudes above the dose levels given in BS 6472 can be acceptable, particularly for temporary disturbances and infrequent events of short-term duration. An example is a construction or excavation project.

When short-term works such as piling, demolition or compaction give rise to impulsive vibrations, it should be borne in mind that undue restriction on vibration levels can significantly prolong these operations and result in greater annoyance.

In certain circumstances, the use of higher magnitudes of acceptability may be considered, eg for projects having social worth or broader community benefits or in view of the economic or practical feasibility of reducing vibration to the recommended levels. In such cases, best management practices should be employed to reduce levels as far as practical.

11.4 Indicative Safe Working Distances for Vibration Intensive Plant

The main source of vibration would occur from the use of heavy rockbreakers and vibratory rollers that may be needed during excavation and compaction works. The sites that may use these vibration intensive plant items would be during corridor earthworks, excavation at each proposed station and during the construction of overbridges.

As a guide in terms of the potential damage and human comfort, safe working distances for typical items of vibration intensive plant are described in the TIDC *Construction Noise Strategy (Rail Projects)* as listed in **Table 32**.

Table 32 Recommended Safe Working Distances for Vibration Intensive Plant

Plant Item	Rating/Description	Safe Working Distance	
		Cosmetic Damage (BS 7385)	**Human Response (BS 6472)[1]**
Vibratory Roller	< 50 kN (Typically 1-2 tonnes)	5 m	15 m to 20 m
	< 100 kN (Typically 2-4 tonnes)	6 m	20 m
	< 200 kN (Typically 4-6 tonnes)	12 m	40 m
	< 300 kN (Typically 7-13 tonnes)	15 m	100 m
	> 300 kN (Typically 13-18 tonnes)	20 m	100 m
	> 300 kN (> 18 tonnes)	25 m	100 m
Small Hydraulic Hammer	(300 kg - 5 to 12t excavator)	2 m	7 m
Medium Hydraulic Hammer	(900 kg - 12 to 18t excavator)	7 m	23 m
Large Hydraulic Hammer	(1600 kg - 18 to 34t excavator)	22 m	73 m
Vibratory Pile Driver	Sheet piles	2 m to 20 m	20 m
Pile Boring	≤ 800 mm	2 m (nominal)	N/A
Jackhammer	Hand held	1 m (nominal)	Avoid contact with structure

Note 1: The safe working distances for Human Response assume that the source of the vibration is continuous throughout the 16-hour daytime period. The formulae in **Section 11.3.2** indicate that higher levels of vibration are acceptable when the vibration levels are intermittent or impulsive. The safe working distances are therefore considered to be conservative and it is likely that the safe working distances corresponding to a "low probability of adverse comment" would be lower than indicated.

The safe working distances presented in **Table 32** are indicative only and will vary depending on the particular item of plant, geotechnical conditions and machine intensity. **Table 32** indicates that exceedances of the structural damage criteria may occur if a 13 tonne (or larger) roller or a heavy hydraulic hammer is operated within 20 m to 25 m of a residential building. Therefore, monitoring at the commencement of vibratory compaction or hydraulic hammering within 30 m of residential buildings will confirm compliance or non-compliance. In the event that non-compliance occurs, immediate corrective action should be taken.

The safe working distances apply to structural damage of typical buildings and typical geotechnical conditions. Vibration monitoring is recommended to confirm the safe working distances at specific sites.

11.5 Construction Vibration Assessment

11.5.1 Cosmetic Damage

To avoid structural damage to buildings the safe working distances nominated in **Table 32** should be considered. The only three (3) locations that predicted construction works may fall within 30 m of a sensitive receiver are at and around chainage 52.300 - 52.400, on the west side of Eastwood Road, at approximately chainage 49.700 - 49.800, on the west side of Cowpasture Road and between chainage 44.900 - 45.600, near the Ingleburn Military Camp. Particular attention is drawn to the existing Sydney Water Canal between Camden Valley Way and Cowpasture Road. At these locations it may be necessary to avoid the use of large hydraulic hammers and vibratory rollers above 13 tonnes to avoid the potential for any structural damage.

11.5.2 Human Comfort

It is anticipated that construction activities will encroach within the limits set out in **Table 32**. For a large portion of the construction activity the works will be between 40 m and 100 m from sensitive receivers and at three (3) locations within 30 m of a sensitive receiver. These locations are listed in **Table 33**.

Table 33 Distances from Nearby Receiver Locations to Construction Activities

Chainage	Receiver Description	Distance to Construction Activity
44.900 - 45.600	Ingleburn Military Camp	20 m - 100 m
47.300 - 47.400	Culverston Avenue Residential	73 m - 100 m
48.200 - 48.400	Camden Valley Way Residential	73 m - 100 m
49.600 - 49.800	Cowpasture Road Residential	25 m - 100 m
50.400 - 50.900	Byron Road Residential	40 m - 100 m
50.900 - 51.000	Rickard Road Residential	73 m - 100 m
51.600 - 51.900	Dickson Road Residential	40 m - 100 m
52.200 - 52.500	Eastwood Road Residential	25 m - 100 m

It is anticipated that some degree of discomfort could occur at the locations presented in **Table 33**. At these locations it is recommended that "less" vibration intensive plant be chosen to minimise any distress.

It should be noted, however, that the values listed in **Table 32** are determined for continuous vibration over a 16 hour day. For the planned construction activities, any vibratory rolling or hydraulic hammering would only be transient and hence higher vibration dose levels would be acceptable to minimise any restrictions that could significantly prolong the operations and result in a greater level of annoyance.

It is recommended that attended vibration monitoring be undertaken at the commencement of any hydraulic hammering or vibratory rolling to determine the acceptable daily duration of any vibratory rolling or hydraulic hammering.

11.6 Construction Vibration Mitigation Measures

In view of the anticipated potential for vibration criteria exceedances during some construction activities, vibration mitigation measures are recommended to minimise the impact at nearby residential receivers. The following measures would need to be considered:

- Relocate any vibration generating plant and equipment to areas within the site to lower the vibration impacts.
- Investigate the feasibility of rescheduling the hours of operation of major vibration generating plant and equipment.
- Use lower vibration generating items of construction plant and equipment eg smaller vibratory rollers, smaller hydraulic rockbreakers and bored piles.
- Minimise consecutive works in the same locality (if applicable).
- High vibration generating activities may only be carried out in continuous block, not exceeding three (3) hours each, with a minimum respite period of one (1) hour between each block.
- Vibration monitoring should be undertaken at the commencement of vibration generating activities to confirm compliance with vibration criteria.
- It is essential that safe operating parameters be established for vibration producing construction equipment in the vicinity of the Sydney Water Canal. Attended vibration monitoring will be required to set operating limits for equipment to be used in the vicinity of the canal.

12 CONCLUSIONS

The proposed South West Rail Link (SWRL) corridor project will provide a new 11 km dual track rail line extending from south of the existing Glenfield Station to a proposed train stabling facility (TSF) at Rossmore with new stations at Edmondson Park and Leppington.

12.1 Operational Noise

Guidance in relation to operational noise goals for the project is provided in the Department of Environment, Climate Change and Water's (DECCW) *"Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects"* (IGANRIP). The guideline provides "noise trigger" levels that trigger the need for a project to conduct an assessment of the potential noise and vibration impacts from the project and examine what measures would be feasible and reasonable to apply to ameliorate the project's impacts. It should be noted that the trigger levels listed in IGANRIP are not mandatory levels which must be achieved at all costs. IGANRIP recommends interaction between land-use planning authorities and the rail industry to share responsibility for noise impact mitigation.

For airborne noise created by the operation of heavy rail surface track, the trigger levels relevant to new railway lines are 60 dBA $L_{Aeq(15hour)}$ for the daytime, 55dBA $L_{Aeq(9hour)}$ for the night-time and 80 dBA L_{Amax}.

A SoundPLAN model was developed to predict train noise levels along the length of the SWRL corridor. Full noise modelling was undertaken using two different levels of noise control: a baseline analysis with earth mounds at a limited number of locations and a scenario with earth mounds and noise barriers. Predictions were made for the maximum proposed rail traffic volumes for the year 2016 when the SWRL is scheduled to open. Predicted rail noise levels for the year 2026 were also calculated, in keeping with the IGANRIP requirement that trigger levels still apply at a representative time in the future.

The $L_{Aeq(9hour)}$ and the L_{Amax} levels were determined to be the defining noise parameters for operational noise along the SWRL corridor. Noise modelling indicated that the IGANRIP noise trigger levels are exceeded along some sections of the SWRL corridor in the baseline case and that noise mitigation measures in addition to earth mounds may need to be considered at some locations.

Noise mitigation proposed for the project concentrates on feasible and reasonable strategies at locations with existing or confirmed future residential areas. As promoted by IGANRIP, appropriate land use, including set-back zones for sensitive land uses and the location of less sensitive buildings at some locations along the rail corridor, is considered an essential part of the strategy to deliver acceptable noise levels along the rail corridor.

For the baseline case with earth mounds at a limited number of locations, the 55 dBA $L_{Aeq(9hour)}$ noise contour typically extends up to 120 m beyond the rail corridor where the track is on embankment. Noise modelling predicts that noise barriers (1.0 m above rail level) could be used to provide noise mitigation at locations with existing or proposed residential areas. With the proposed mitigation measures, the 55 dBA $L_{Aeq(9hour)}$ noise contour is generally contained within 30 m of the rail corridor. Areas falling within the 55 dBA $L_{Aeq(9hour)}$ noise contour could typically be used for roads, passive recreation or commercial activities.

The proposed noise barriers will be subject to a detailed design process whereby changes to the scheme proposed in this report may be required, as additional information becomes available and through consultation with the relevant stakeholders

Noise barriers have a visual impact with ongoing maintenance issues related to graffiti. If used, barriers would typically be installed on both sides of the rail corridor at locations where the track is at grade or on embankment, and no earth mounds have been proposed. It should be noted that a noise barrier 1.0 m above rail height will present as a barrier at least 1.5 m high due to the configuration of the track formation.

12.2 Train Stabling Facility Noise

The proposed TSF is assessed in accordance with the DECCW's *Industrial Noise Policy* (INP). The INP sets two separate noise criteria to meet environmental noise objectives: one to account for intrusive noise and the other to protect the amenity of particular land uses. In addition, the DECCW normally requires the risk of sleep disturbance to be assessed. Guidance on sleep disturbance is provided in the Application Notes to the INP and in the *Environmental Criteria for Road Traffic Noise* (ECRTN).

The intrusiveness criterion dictates that the L_{Aeq} noise level, measured over a period of 15 minutes should not be more than 5 dBA above the rating background noise level during the daytime, evening and night-time periods. Unattended noise logging was used to establish background noise levels at two representative locations in the vicinity of the proposed TSF. The planned development of the area means that at opening in 2016, background noise levels are conservatively anticipated to be around 5 dBA higher than the measured levels.

The amenity assessment is based on the existing noise environment and noise criteria specific to land use and associated activities. If the noise emissions from the new sources approach the criterion value, the new sources need to be designed so that the cumulative effect does not produce levels that would significantly exceed the criterion.

Noise modelling for the TSF was carried out with several noise mitigation options to provide information to help form an appropriate strategy. Locating the TSF partly in an excavated area forms an effective noise barrier around part of the facility. Modelling indicates that noise barriers 6 m above top of rail located on the perimeter of the site earthworks (where the facility is in shallower cutting or at grade) would provide an adequate degree of noise mitigation for all noise sources except horn testing noise. The TSF has therefore also been modelled in an enclosure, ie a shed with open doors to allow train access, for the horn test noise case.

High level but short duration noise from horn testing, which will occur in the early hours of the morning as trains are prepared for service, is likely to cause sleep disturbance over a large area without some form of mitigation. This is the case even with the enclosure with open doors. Individual treatment of existing residential properties affected by horn and brake noise (emanating from the TSF) may be a feasible means of mitigating the impacts of these noise sources. However in the context of future residential development in the area alternative mitigation options are desirable.

Appropriate land use in the immediate vicinity of the stabling facility can be used to separate any future residential developments from it, thereby achieving target noise levels for residential users. Residential areas may be further shielded from noise from the stabling facility by using commercial or industrial buildings as noise barriers. A low-volume yard horn test has been proposed as a possible solution, but the feasibility of this remains under investigation. Modifications to the existing normal operating procedure are also being considered, to allow horn testing outside the stabling facility (eg en route to Leppington Station) instead of horn testing at the TSF prior to entering service.

12.3 Substations

The noise contours corresponding to the most stringent residential noise goal in DECCW's INP are predicted to be met at a distance of 30 to 50 m from the substations. On the basis of the information available, all existing residential receivers are predicted to comply with the INP's criteria for substation noise. It should be noted that the exact type and size of each substation is currently unknown, hence further assessment may be required at the detailed design stage if the actual designs are not in line with the assumptions stated in this report.

12.4 Operational Rail Vibration

The effects of vibration in buildings can be divided into three main categories; those in which the occupants or users of the building are inconvenienced or possibly disturbed, those where the building contents may be affected and those in which the integrity of the building or the structure itself may be prejudiced. The levels of vibration required to cause damage to buildings are at least an order of magnitude (10 times) higher than those at which people consider the vibration acceptable.

The proposed human comfort criterion for vibration along the SWRL corridor is derived from the vibration dose values nominated in AS 2670 (106 dB day, 103 dB night). A vibration level of 108 dB re 10^{-6} mm/s is suggested as a target for the maximum trackside vibration level. This is based on a night-time vibration level of 103 dB with a 5 dB allowance for the intermittent nature of train induced vibration. This level of vibration will be perceptible and may result in adverse comment from sensitive receivers.

Conservative modelling of trackside vibration levels indicates that the 108 dB vibration contour generally falls within the rail corridor. At those few locations where the 108 dB vibration contour lies outside the rail corridor, the excursion outside the corridor is no greater than 5 metres. The operational vibration levels from the SWRL corridor are expected to comply with the suggested criterion.

12.5 Construction Noise and Vibration

Construction noise modelling indicates exceedances of recommended Noise Management Levels at existing receivers as described in DECCW's *Interim Construction Noise Guideline*. These exceedances result primarily from the relatively close distances involved between construction plant and the nearest receivers.

Where the Noise Management Levels are exceeded, the *Interim Construction Noise Guideline* requires all feasible and reasonable mitigation measures to be applied. TIDC's *Construction Noise Strategy* requires the preparation of a Construction Noise and Vibration Management Plan (CNVMP) at a later stage in the assessment process when more detailed information on plant and processes become available. Whilst this report provides an indication of the likely mitigation measures that may be required during construction, more specific measures will be provided in the CNVMP.

The identification of potential exceedances highlights the importance of managing the works to minimise both the noise levels and the durations of the predicted exceedances. For new track sections, construction works would be limited to daytime hours only (unless essential for traffic management or safety reasons) in order to reduce any potential impacts as much as possible.

At locations within 30 m of any sensitive receivers, construction vibration may be an issue. At these locations, the use of large hydraulic hammers and vibratory rollers above 13 tonnes should be avoided in order to remove the potential for any cosmetic damage.

The Sydney Water Supply Canal (the Upper Canal) should also be monitored for any vibration caused by construction works in the near vicinity. Any nearby bridge piling should be done by boring rather than pile driving and size limits for vibratory rollers and rockbreakers will need to be implemented.

13 REFERENCES

- Australian Standard AS 1055.2:2007 *Description and measurement of environmental noise - Application to specific situations*
- Australian Standard AS 2187.2:2006 *Explosives - Storage and use - Use of explosives*
- Australian Standard AS 2670.2:1990 *Evaluation of Human Exposure to Whole Body Vibration - Continuous and Shock Induced Vibration in Buildings (1 Hz to 80 Hz)*
- British Standard BS 6472:1992 (Superseded) *Guide to evaluation of human exposure to vibration in buildings (1 Hz to 80 Hz)*
- British Standard BS 6472.1:2008 *Guide to evaluation of human exposure to vibration in buildings. Vibration sources other than blasting*
- British Standard BS 7385.2:1993 *Evaluation and measurement for vibration in buildings. Guide for measurement of vibrations and evaluation of their effects on buildings*
- Campbelltown City Council (2002*) Campbelltown (Urban Area) Local Environmental Plan*
- Department of Environment and Climate Change NSW (Now DECCW) (April 2007) *Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects* (IGANRIP)
- Department of Environment and Climate Change NSW (Now DECCW) (July 2009*) Interim Construction Noise Guideline*
- Department of Environment and Conservation (Now DECCW) (February 2006) *Assessing Vibration: a technical guideline*
- Environment Protection Authority (Now DECCW) (January 2000) *NSW Industrial Noise Policy* (INP)
- Environment Protection Authority (Now DECCW) (May 1999) *Environmental Criteria for Road Traffic Noise* (ECRTN)
- German Standard DIN 4150.2:1975 *Structural vibration - Human exposure to vibration in buildings*
- Growth Centres Commission (Now the Strategic Land Release Project Office of the NSW Department of Planning) (November 2006) *Growth Centres Development Code*
- Liverpool City Council (2008*) Edmondson Park Precinct Development Control Plan*
- State Government of NSW (2007*) State Environmental Planning Policy (Infrastructure) 2007* (the 'Infrastructure SEPP')
- State Government of NSW Department of Planning (2008) *Development Near Rail Corridors and Busy Roads - Interim Guideline*
- State Government of NSW Department of Planning (July 2008) *South West Growth Centre Structure Plan*
- The United States Department of Transportation (May 2006) *Transit Noise and Vibration Impact Assessment*
- Transport Infrastructure Development Corporation (November 2007) *Construction Noise Strategy for Rail Projects* (CNS)