11 Construction noise and vibration

A comprehensive noise and vibration impact assessment has been undertaken for the project and is presented as Technical Paper 3 *Noise and vibration*. This chapter summarises the key findings of this assessment in relation to construction noise and vibration. The assessment has been undertaken in accordance with the requirements of the Interim Construction Noise Guideline (DECC 2009).

The Director-General's requirements
The Environmental Assessment must include consideration of, and a management framework for construction noise and vibration, including a considered approach to scheduling construction works having regard to the nature of construction activities (including transport, blasting and tonal or impulsive noise-generating works), the intensity and duration of noise and vibration impacts, the nature, sensitivity and impact to potentially-affected human receivers and structures, the need to balance timely conclusion of noise and vibration-generating works with periods of receiver respite, and other factors that may influence the timing and duration of construction activities (such as traffic or spoil management). The Environmental Assessment must also present a strategy for monitoring and mitigating construction noise and vibration, with a particular focus placed on those activities identified as having the greatest potential for adverse noise or vibration impacts, and a broader, more generic approach developed for lower-risk activities.

11.1.1 Existing environment and sensitive receivers

Existing environment
The existing noise environment within the CBD Metro project area is relatively high and is dominated by road traffic noise and rail operations at the CityRail stations and rail lines.

Environmental noise monitoring was undertaken at a number of representative locations in order to characterise the existing ambient noise environment across the project area and to establish noise emission targets. The locations of attended and unattended noise monitoring, the methodology used and the results of the monitoring are provided in section 5.3 of Technical Paper 3 *Noise and vibration*.

Sensitive receivers
Sensitivity to noise and vibration varies according to the occupancy and activities within the affected premises and may also depend on the existing noise and vibration environment. The typical land uses within the project area are summarised in Table 11.1. Sensitive receivers within the project area were identified by classifying buildings into the following receiver categories: commercial, educational, industrial, mixed residential/commercial, residential, place of worship, museum, heritage item and special sensitive. The identified sensitive receivers at each project location are listed in section 6.1.2 of Technical Paper 3 *Noise and vibration* and identified in section 11.3 of this report.

Table 11.1 Land uses within the CBD Metro project area

Location	Description of land uses
Central to Barangaroo-Wynyard	Predominantly commercial. Residences almost entirely within hotels and apartment buildings. Open space (e.g. Belmore Park, Martin Place, Wynyard Park and Barangaroo [future])
Pyrmont	Mix of commercial and medium-density residential.
Rozelle	Predominantly low- and medium-density residential. Commercial – mainly along Victoria Road.
White Bay	Industrial – in the immediate vicinity. Residential – Rozelle and Balmain to the north.
Former Rozelle Marshalling Yard	Residential – to the north and south. Some industrial – along Lilyfield Road.

Causes of noise and vibration impacts

Construction noise impacts would occur at:

- All surface station construction sites.
- The White Bay construction site.
- The Rozelle stabling and maintenance depot site.
- Locations above the tunnel alignment.

These impacts may occur as a result of:

- Airborne noise – for example, noise generated from truck movements, excavation, spoil conveyors, loading operations, tunnel ventilation fans, dust collectors, materials and equipment deliveries and general station construction activities.
- Ground-borne noise – for example, noise generated from the operation of excavation equipment such as roadheaders, tunnel-boring machines (TBM) and rockbreakers.

Vibration has the potential to impact on sensitive receivers and structures near construction sites and at locations above the tunnel alignment. These impacts may occur as a result of surface works (such as vibratory rollers) or from the operation of excavation equipment such as roadheaders, TBMs and rockbreakers.

Duration of construction

Construction would continue for the entire five-year construction period at all station locations, but there may be some temporary construction sites that would be required for shorter durations. The main noise-generating activities (and the duration of the activity) would be:

- Demolition of existing structures (typically lasting three months, up to nine months for multi-storey buildings).
- Excavating the vertical shafts and station cavern headings (six to 12 months, depending on depth).
- Excavating the caverns (about nine months).
- Concreting and lining the caverns (about nine months).

- Completing the station structures (about nine months).

The tunnelling works would progress at an average rate of about 300 metres per month (where the TBM is used) and 110 metres per month (where the roadheader is used), thus potentially affecting any one receiver above the tunnels for a few days at some locations and up to three weeks at others.

Working hours for different construction activities are presented in section 7.8.6. The potential noise and vibration impacts of construction activities would vary over time, with the most significant impacts occurring during excavation of the station caverns.

The majority of the above-ground construction activities would be undertaken within standard NSW construction hours (7.00am to 6.00pm on weekdays and 8.00am to 1.00pm on Saturdays). However, some activities would need to be undertaken outside of these hours. The below-ground construction activities (tunnelling works and the construction of station caverns) would be undertaken 24 hours a day, up to seven days per week.

The scheduling of different activities would respond to local conditions and allow for receiver respite during periods of high noise-generating activities.

In addition, there may be instances where construction works could be undertaken outside standard construction hours to avoid potential impacts on sensitive receivers. For example, some specific sensitive receivers are less active (or have no activities) during the weekend or night. Therefore, flexible construction hours would be investigated where there would be a better environmental outcome.

11.1.2 Assessment methodology

The key noise- and/or vibration-generating construction activities were identified and the relevant design goals determined based on a review of current guidelines and practices for the assessment and subsequent mitigation of construction noise and vibration. These results are summarised below. A more detailed account is provided in Chapters 7, 9 and 10 of Technical Paper 3 *Noise and vibration.*

The noise and vibration modelling for this Environmental Assessment was undertaken to predict where relevant goals would be met or exceeded. Further modelling would need to be undertaken during construction planning to confirm appropriate mitigation strategies.

Airborne noise

Construction sites

Construction sites would be located at:

- White Bay for the TBM and roadheader launch site.
- The Rozelle stabling and maintenance depot.
- Belmore Park, for the retrieval of the TBM.
- Each of the station locations.
- Other smaller sites, which may be required for much shorter periods of time (for example, for utility relocations associated with the project).

Construction site activities, including those occurring at White Bay and Rozelle, are described in Chapter 7. The majority of the works would be undertaken in the daytime. The proposed construction hours are shown in Table 7.10.

The assessment of noise emissions from construction site activities was based on the assumption that:

- Some sites would use significant noise barriers or be fully enclosed with a noise enclosure, which would reduce noise levels by about 10–25 dBA. However, the use of noise barriers, and in particular noise enclosures, may often not be feasible before the demolition works are complete.
- The highest noise and vibration impacts would take place during the initial site demolition and excavation works, and that the $L_{Aeq(15minute)}$ sound power level (SWL) for demolition using jackhammers and rockbreakers and excavation using rockbreakers would be about 120 dBA, and about 110 dBA for earthworks and station construction. Demolition using jackhammers and rockbreakers represents a 'worst case' scenario, and noise levels would be typically 5 dBA to 10 dBA lower for the majority of demolition works.
- Ventilation fans, concrete pumps and compressors would be mitigated when in operation, where required to meet noise objectives.

Project-specific noise management levels have been determined for noise-affected receivers surrounding these construction sites. Where the construction noise levels are predicted to exceed the noise management levels, all reasonable and feasible work practices would be investigated to minimise noise emissions. Having investigated all reasonable and feasible work practices, if construction noise levels are still predicted to exceed the noise management levels, then Sydney Metro would manage the potential noise impacts via site-specific construction noise management plans.

The noise management levels for construction noise for residential, commercial and other sensitive receivers are shown in Table 11.2.

Table 11.2 Airborne construction noise management levels (NMLs)

Sensitive receiver	Time of day			
	During operation	**Daytime**[1]	**Evening**	**Night-time**
Residential	N/A	RBL or LA90 Background +10 dBA	RBL or LA90 Background + 5 dBA	RBL or LA90 Background + 5 dBA
Commercial	70 dBA	N/A	N/A	N/A
Schools/childcare centres	55 dBA	N/A	N/A	N/A
Places of worship	50 dBA[2]	N/A	N/A	N/A
Passive recreational areas[3]	60 dBA	N/A	N/A	N/A
Active recreational areas[4]	65 dBA	N/A	N/A	N/A

1 Daytime: 7.00am–6.00pm (Monday to Friday); 8.00am–1.00pm (Saturday); Evening: 6.00pm–10.00pm; Night-time: 10.00pm–7.00am.
2 External NML based on openable windows. The NML is 60 dBA if windows in the facility are fixed (i.e. cannot be opened).
3 Passive recreation (e.g. reading)
4 Active recreation (e.g. sporting activities)

It is noted that the above assessment approach is consistent with the Interim Construction Noise Guideline (DECC July 2009).

Construction traffic

Construction traffic would generate noise along the local and regional traffic network. It is likely that on the roads immediately adjacent to the various construction sites, the community would associate heavy vehicle movements with the project. Once the heavy vehicles move further from each of the sites onto major collector or arterial roads, however, the noise may be perceived as part of the general road traffic.

Construction vehicles would be required at the White Bay construction site, Rozelle stabling and maintenance depot construction site, and the station sites for the entire duration of the project. The majority of construction traffic movements would occur during the daytime and typically 10 (but up to 24) heavy vehicle movements per hour at each of the station construction sites is expected. A higher number of heavy vehicle movements are expected at White Bay. However, for certain activities, such as the delivery of large equipment (such as TBMs and roadheaders) and the removal of spoil from some station sites, night-time movements would occur. During the night-time, typically five (but up to 24) heavy vehicle movements per hour per construction site are expected. At locations where sensitive noise receptors are close to construction sites, significant construction vehicle movements are likely to be restricted during evening and night-time periods.

Construction traffic for the White Bay Station construction site and the Rozelle stabling and maintenance depot construction site would access the Western Distributor directly. Station construction sites would be accessed via local collector roads and then the Eastern Distributor or Western Distributor (for CBD construction sites or the Pyrmont Station construction site) and Victoria Road (for the Rozelle Station construction site).

The DECCW recommends noise goals for different road categories. However, where the L_{Aeq} traffic noise levels already exceed the noise goals, a 2 dBA increase in the overall traffic noise level is normally regarded as an acceptable alternative target (having investigated the application of all feasible and reasonable noise mitigation) in order to maintain the general acoustic amenity of the area. Given the existing traffic noise levels at each of the construction sites, this alternative target has been adopted for the project at all noise-sensitive receivers.

Sleep disturbance

With regards to sleep disturbance, the Environmental Criteria for Road Traffic Noise (DECC 1999) and the Environmental Noise Management Manual (RTA 2001) suggest that:

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

The external (open window) screening level is 10 dBA above the 55 dBA, internal screening level for openable windows (for example, at a residence), and 20 dBA above the 55 dBA internal screening level for fixed windows (for example, at a hotel).

In this assessment, sleep disturbance has been considered in relation to construction activities and project-related construction traffic.

Ground-borne noise

Ground-borne noise would also be generated during tunnelling activities using roadheaders and TBMs. Impacts are likely to be experienced at the nearest receivers when they are directly at or nearly above the works.

To ensure that the construction program can be met, tunnelling activities (using TBMs and roadheaders) would be undertaken for 24 hours each day, up to seven days per week. In addition, the horizontal excavation of the station caverns using roadheaders and spoil storage/removal would be

required to occur during the daytime and the night-time. Vertical excavation of the shafts using rock breakers may also be required to occur over the 24-hour period.

For most recent tunnelling projects in Sydney (including the Cross City Tunnel and Lane Cove Tunnel), the following internal ground-borne noise goals have been adopted for residential receivers:

- Evening: $L_{Aeq(15minute)}$ 40 dBA.
- Night-time: $L_{Aeq(15minute)}$ 35 dBA.

These goals have also been adopted for this project and are consistent with the guideline levels in the Interim Construction Noise Guideline. They are only applicable during the evening (6pm–10pm) and night-time (10pm–7am) periods, and when the ground-borne noise levels are higher than the airborne noise levels inside residences. During daytime periods, the human comfort vibration goals are applicable (see below).

Vibration

During construction, the major potential sources of vibration would include rockbreakers, vibratory pile drivers, vibratory rollers and, potentially, the penetrating cone fracture (PCF) system, which is a non-explosive rock breaker. Drill and blasting may be required to better manage regenerated noise from rock breaker or roadheader mechanical processes. If required, it would be undertaken in accordance with guidelines for managing noise and vibration of sensitive receivers.

Construction vibration can be continuous, intermittent or impulsive and the vibration guideline (DEC 2006b) provides different trigger levels for each category. The continuous vibration trigger levels are most stringent with higher vibration levels being acceptable for intermittent and impulsive vibration on the basis of the shorter exposure times. (Continuous vibration is typically caused by TBM and roadheader operations. Intermittent vibration is typically caused by rockbreaker operations. Impulsive vibration is typically caused by demolition and piling.)

In relation to damage to surface structures, a vibration trigger level of 7.5 millimetres per second at a residence or vibration-sensitive receiver would be adopted for the project. The trigger level provides a threshold for further assessment and/or monitoring (for both continuous and intermittent or impulsive vibration sources).

At locations where the predicted and/or measured vibration levels are greater than 7.5 millimetres per second, a more detailed analysis of the building structure, vibration source, dominant frequencies and dynamic characteristics of the structure would be required to determine the applicable safe vibration level.

In relation to human comfort, the trigger levels that have been set are shown in Table 11.3.

Table 11.3 Trigger levels for vibration impact on human comfort

Sensitive receiver	Type of vibration		
	Continuous vibration	Intermittent vibration	Impulsive vibration
Residential Daytime Night-time	 0.2 mm/s 0.14 mm/s	 1.4 mm/s -	 6 mm/s 6 mm/s
Commercial offices	0.4 mm/s	1.4 mm/s	13 mm/s

11.2 Objectives and strategy

The construction noise and vibration objectives for the project are:

- Objective 1: Minimise any unreasonable noise and vibration impacts on residents and businesses.
- Objective 2: Minimise community concern through active community consultation and the maintenance of positive, cooperative relationships with schools, childcare centres, local residents and building owners.
- Objective 3: Avoid any structural damage to buildings or heritage items as a result of construction vibration.

To achieve these objectives, Sydney Metro is developing a Construction Noise and Vibration Strategy, which would be adopted by all contractors. The Strategy would provide guidance on minimising airborne and ground-borne noise and vibration impacts, and would set a framework for detailed construction phase noise assessment, the implementation of reasonable and feasible mitigation measures, and monitoring and reporting. The strategy would be used to inform the Construction Noise and Vibration Management Sub-Plan, which would be implemented to manage the potential noise and vibration impacts. The Strategy is provided in full at Appendix D of this document.

In preparing this Strategy, consideration is being given to several guideline documents including:

- Interim Construction Noise Guideline (DECC 2009).
- Construction Noise Strategy (Rail Projects) (Transport Infrastructure Development Corporation 2007).
- Australian Standard AS 2436-1981 Guide to noise control on construction, maintenance and demolition sites (Standards Association of Australia 1981).

11.3 Specific issues

11.3.1 Airborne noise

Construction sites
The full results of the noise modelling (provided in Chapter 9 of Technical Paper 3 *Noise and vibration*) are summarised below. Higher exceedances are predicted during the evening and night-time periods as a result of the more stringent noise goals.

White Bay construction site
Sensitive receivers in the vicinity of the White Bay construction site are shown in Figure 11.1 and include residential receivers to the north of the site (Batty Street, Rozelle), to the west of the site (Hornsey Street, Rozelle) and to the south-east of the site (Glebe Point); and commercial receivers to the north of the site (Robert Street, Rozelle).

Three scenarios were modelled at this site:

- Daytime TBM boring with spoil removal.
- Night-time TBM assembly and night-time TBM boring with spoil removal.

- Spoil delivery from CBD construction sites.

This site is well placed for construction works, with sensitive receivers distant and in many instances shielded by topography or commercial/industrial buildings. The modelling results indicate that, even without the implementation of any noise controls, the residential and commercial noise management levels would not be exceeded at any of the nearby receivers, and therefore a detailed table of expected noise management level exceedances is not provided.

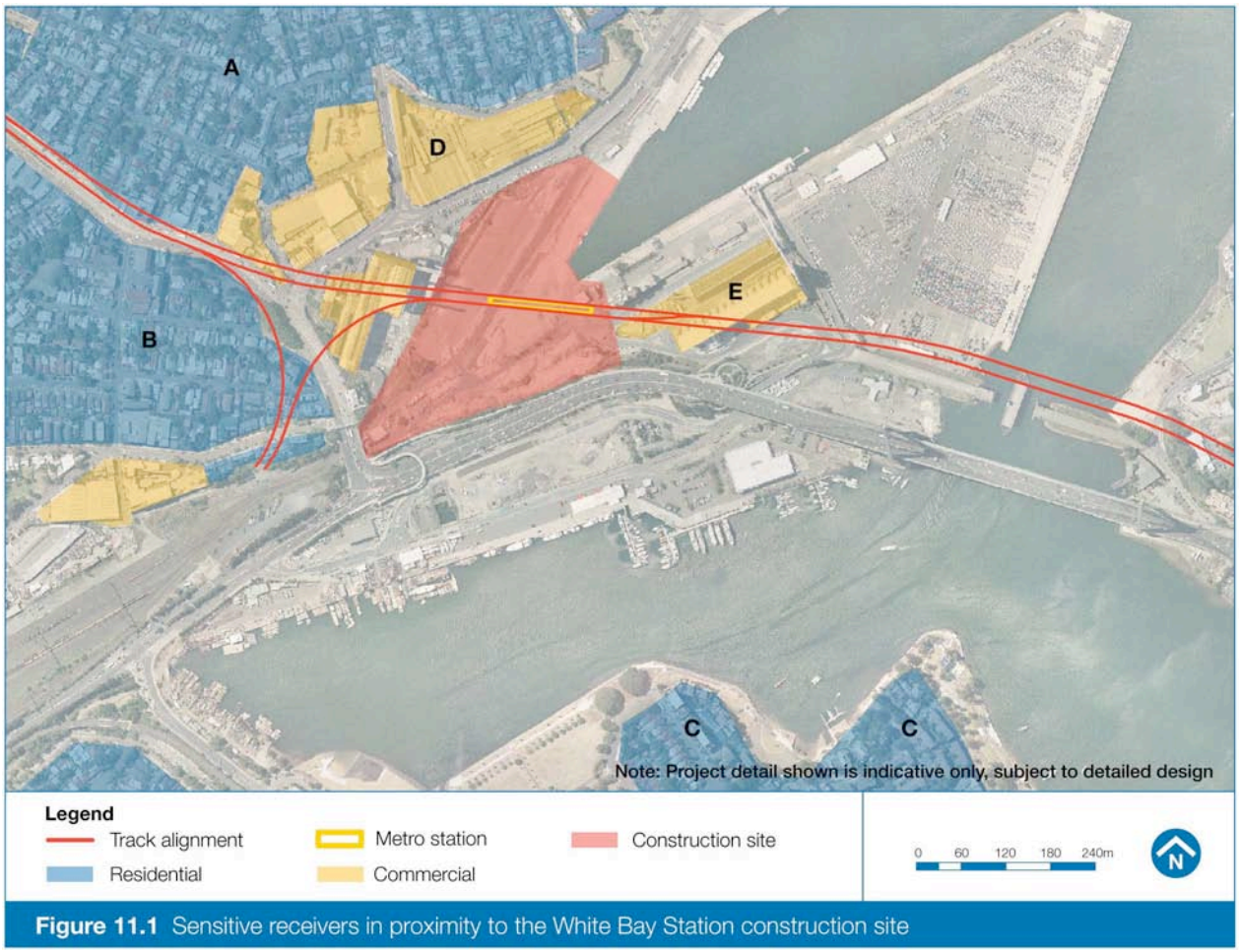

Figure 11.1 Sensitive receivers in proximity to the White Bay Station construction site

Rozelle stabling and maintenance depot construction site

Sensitive receivers in the vicinity of the Rozelle stabling and maintenance depot construction site are shown in Figure 11.2 and include residential receivers to the north (Lilyfield Road), and south (Brenan Street and Railway Parade), and commercial receivers to the north (Lilyfield Road).

For the three scenarios modelled at this site (general earthworks, construction of buildings and facilities, and construction and excavation of the portal and dive structure), the likely exceedances for a representative sample of receivers are shown in Table 11.4. The modelling for these scenarios was based on the absence of any noise controls.

During the daytime, the predicted levels indicate a minor exceedance at the nearest receivers for general earthworks, and compliance for construction of the building facilities. During portal and dive structure construction and excavation, a large exceedance of up to 11 dBA occurs primarily as a result of the high noise levels from the rockbreaking equipment, and the relatively close proximity of residential receivers.

During the evening period, minor exceedances are expected for construction of the building facilities, moderate exceedances for general earthworks, and larger exceedances for portal and dive structure construction and excavation.

Some works to construct the portal and dive structure may be required during the night-time period. Given the proximity to residential receivers, very high exceedances are expected. All reasonable and feasible mitigation measures would be implemented to minimise these impacts on the surrounding receivers (refer section 11.4).

Table 11.4 Expected noise management level (NML) exceedances at the Rozelle stabling and maintenance depot construction site without mitigation

Receiver area	Horizontal distance to works	Type of works	NML exceedance (dBA)		
			Daytime	Evening	Night-time
A	40 m	General earthworks	4	8	N/A
B	60 m	Construction of buildings/facilities	-	5	N/A
C	80 m	Construction of buildings/facilities	-	6	N/A
D	70 m	Construction and excavation of the portal and dive structure	11	17	25

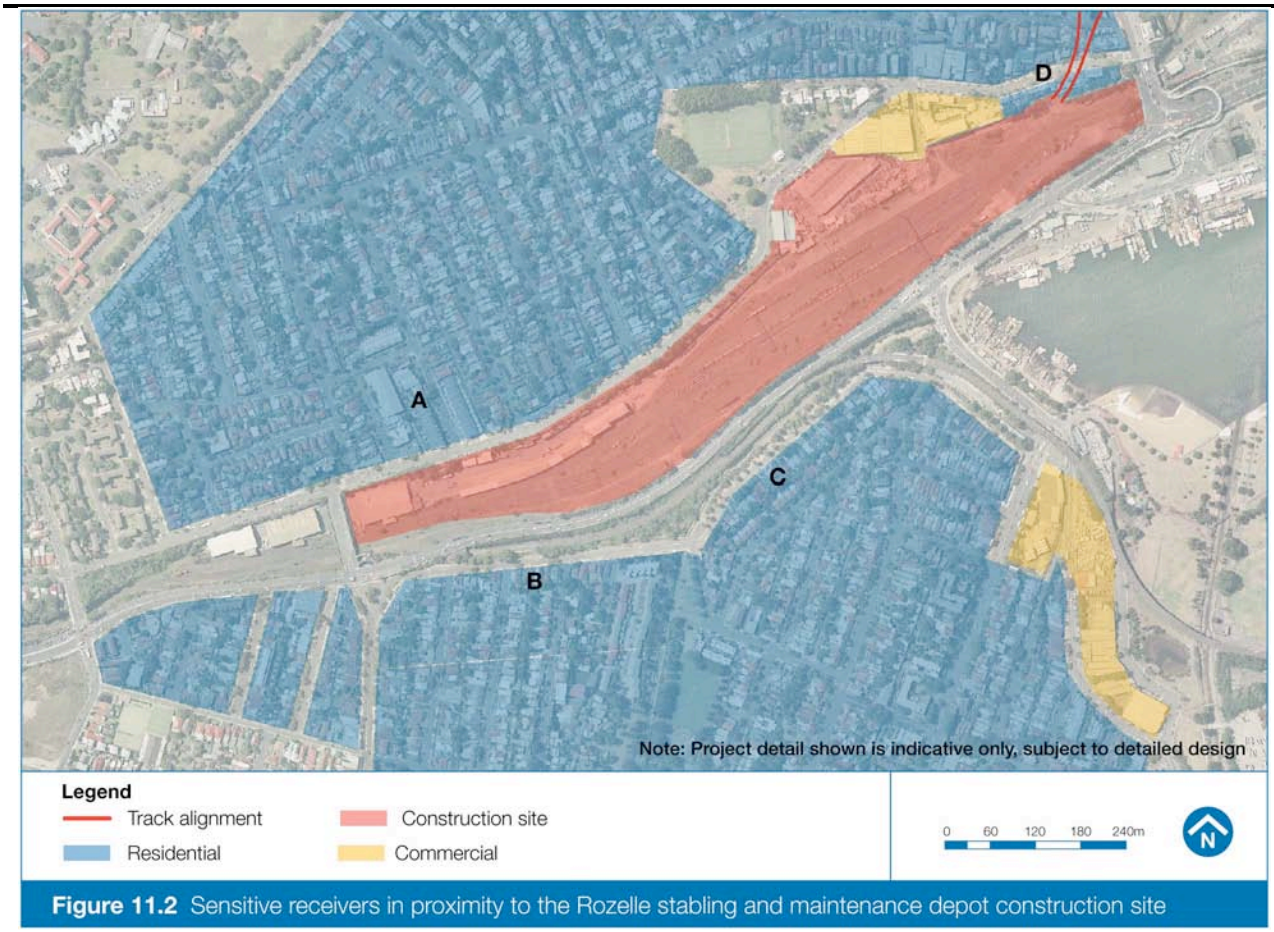

Figure 11.2 Sensitive receivers in proximity to the Rozelle stabling and maintenance depot construction site

Central Station construction site

Sensitive receivers in the vicinity of the Central Station construction site are shown in Figure 11.3. These receivers are located as close as two metres from the construction site and comprise mainly commercial receivers and hotels/hostels, but also include churches and CityRail's Central Station.

Sensitive receivers surrounding the site are likely to experience some exceedance of the noise management levels during demolition, excavation and/or construction. To reduce the noise impacts on nearby receivers, the construction sites would be surrounded by three or six metre high hoardings or a full noise enclosure.

Table 11.5 shows the likely exceedances for a representative sample of receivers, assuming that the site would be fully enclosed.

Table 11.5 Expected noise management level (NML) exceedances at Central Station[1]

Receiver	Horizontal distance to works	NML exceedance (dBA)					
		During demolition/excavation[2]			During other construction activities		
		Daytime	Evening	Night-time	Daytime	Evening	Night-time
A – Hotel[3]	2 m	(38) 13	22	29	3	12	19
K – Belmore Park	3 m	(42) 17	17	17	7	7	7
B – Hotel	10 m	(24) 0	8	15	0	0	5
F – Hotel	18 m	(19) 0	3	10	0	0	0
D – Hotel	20 m	(18) 0	2	9	0	0	0

1 Details of the modelling results based on three and six metre hoardings are provided in Chapter 9 of Technical Paper 3 *Noise and vibration.*
2 Noise mitigation may not be feasible during the demolition phase. The exceedance levels in brackets indicate the potential exceedances during the demolition stage during 'worst case scenario' activities if noise mitigation is not possible.
3 Night-time excavation activities are not expected at the Quay Street site.

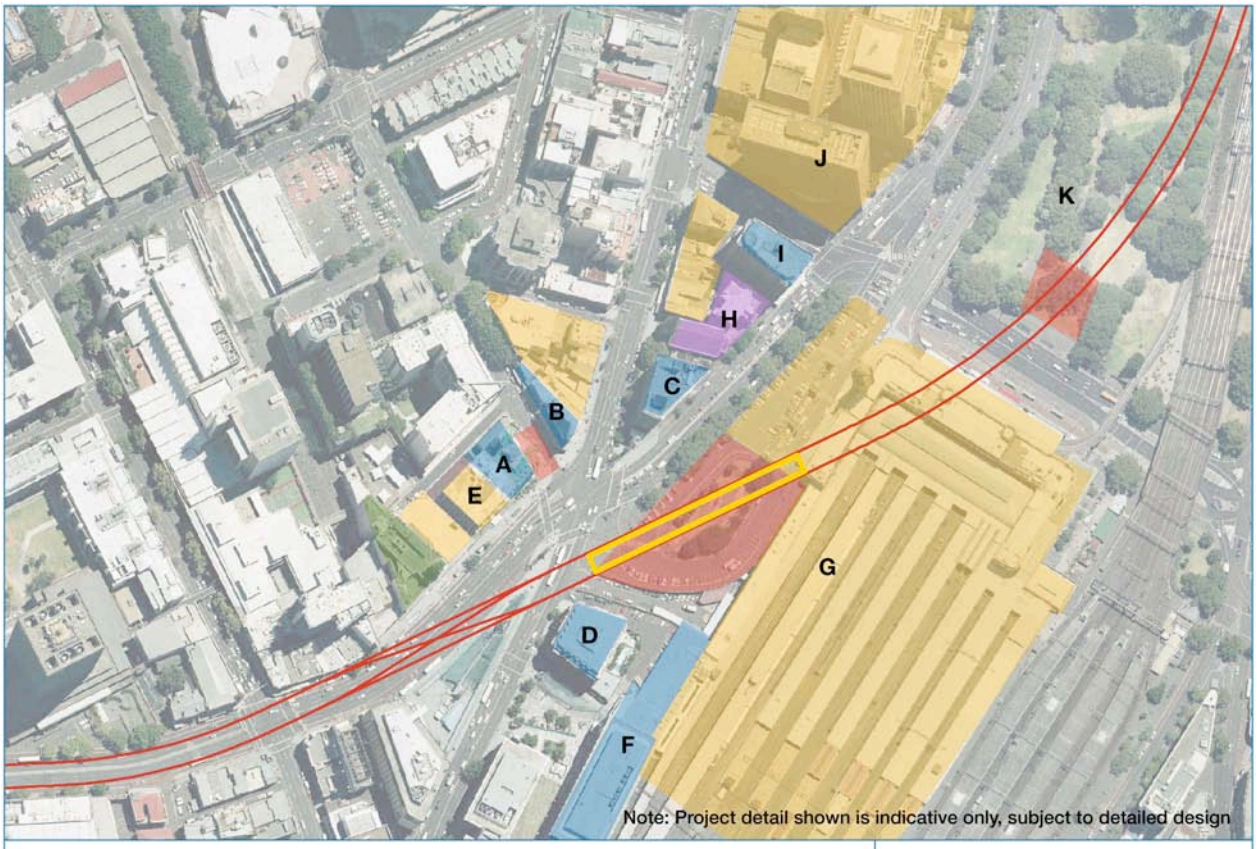

Figure 11.3 Sensitive receivers in proximity to the Central Station construction site

Town Hall Square Station construction site

Sensitive receivers in the vicinity of the Town Hall Square Station construction site are shown in Figure 11.4. These receivers are located as close as three metres from the construction works and comprise mainly commercial receivers and hotels plus some residences.

Sensitive receivers surrounding the site are likely to experience some exceedance of the noise management levels during demolition, excavation and/or construction. To reduce the noise impacts on nearby receivers, the construction sites would be surrounded by three or six metre high hoardings or a full noise enclosure.

Table 11.6 shows the likely exceedances for a representative sample of receivers, assuming that the site would be fully enclosed.

Table 11.6 Expected noise management level (NML) exceedances at Town Hall Square Station[1]

Receiver	Horizontal distance to works	NML exceedances (dBA)					
		During demolition/excavation[2]			During other construction activities		
		Daytime	Evening	Night-time	Daytime	Evening	Night-time
D – Commercial	3 m	(32) 7	7	N/A	0	N/A	N/A
H – Hotel	3 m	(32) 7	10	16	0	0	6
I – Commercial	3 m	(32) 7	7	N/A	0	N/A	N/A
F – Commercial	3 m	(32) 7	7	N/A	0	N/A	N/A
A – Hotel	12 m	(20) 0	0	4	0	0	0
C – Church	17 m	(37) 12	12	N/A	2	2	N/A

1 Details of the modelling results based on three and six metre hoardings are provided in Chapter 9 of Technical Paper 3 *Noise and vibration.*
2 Noise mitigation may not be feasible during the demolition phase. The exceedance levels in brackets indicate the potential exceedances during the demolition stage during 'worst case scenario' activities if noise mitigation is not possible.

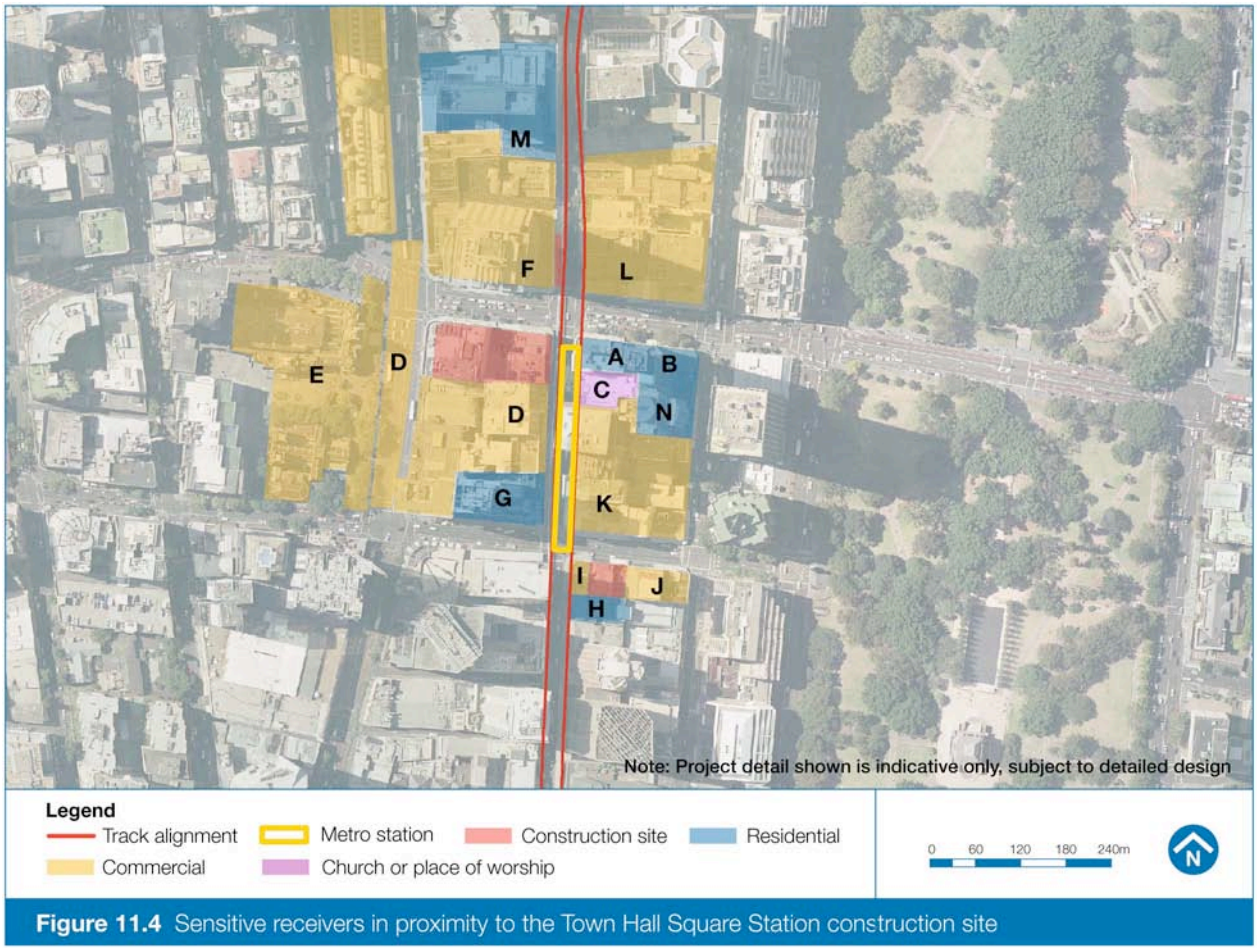

Figure 11.4 Sensitive receivers in proximity to the Town Hall Square Station construction site

Martin Place Station construction site

Sensitive receivers in the vicinity of the Martin Place Station construction site are shown in Figure 11.5. These receivers are located as close as three metres from the construction works and comprise mainly commercial receivers and hotels plus one residence.

Sensitive receivers surrounding the site are likely to experience some exceedance of the noise management levels during demolition, excavation and/or construction. To reduce the noise impacts on nearby receivers, the construction sites would be surrounded by three or six metre high hoardings or a full noise enclosure.

Table 11.7 shows the likely exceedances for a representative sample of receivers, assuming that the site would be fully enclosed.

Table 11.7 Expected noise management level (NML) exceedances at Martin Place Station[1]

Receiver	Horizontal distance to works	NML exceedances (dBA)					
		During demolition/excavation[2]			During other construction activities		
		Daytime	Evening	Night-time	Daytime	Evening	Night-time
A – Residential	3 m	(32) 7	12	21	2	2	11
B – Commercial	3 m	(32) 7	7	N/A	0	0	N/A
H – Commercial	3 m	(32) 8	8	N/A	0	0	N/A
N – Commercial	3 m	(32) 8	8	N/A	0	0	N/A
G – Hotel	9 m	(23) 0	3	12	0	0	2
C – Commercial	10 m	(22) 0	2	N/A	0	0	N/A
H – Commercial	13 m	(20) 0	0	N/A	0	0	N/A

1 Details of the modelling results based on three and six metre hoardings are provided in Chapter 9 of Technical Paper 3 *Noise and vibration.*
2 Noise mitigation may not be feasible during the demolition phase. The exceedance levels in brackets indicate the potential exceedances during the demolition stage during 'worst case scenario' activities if noise mitigation is not possible.

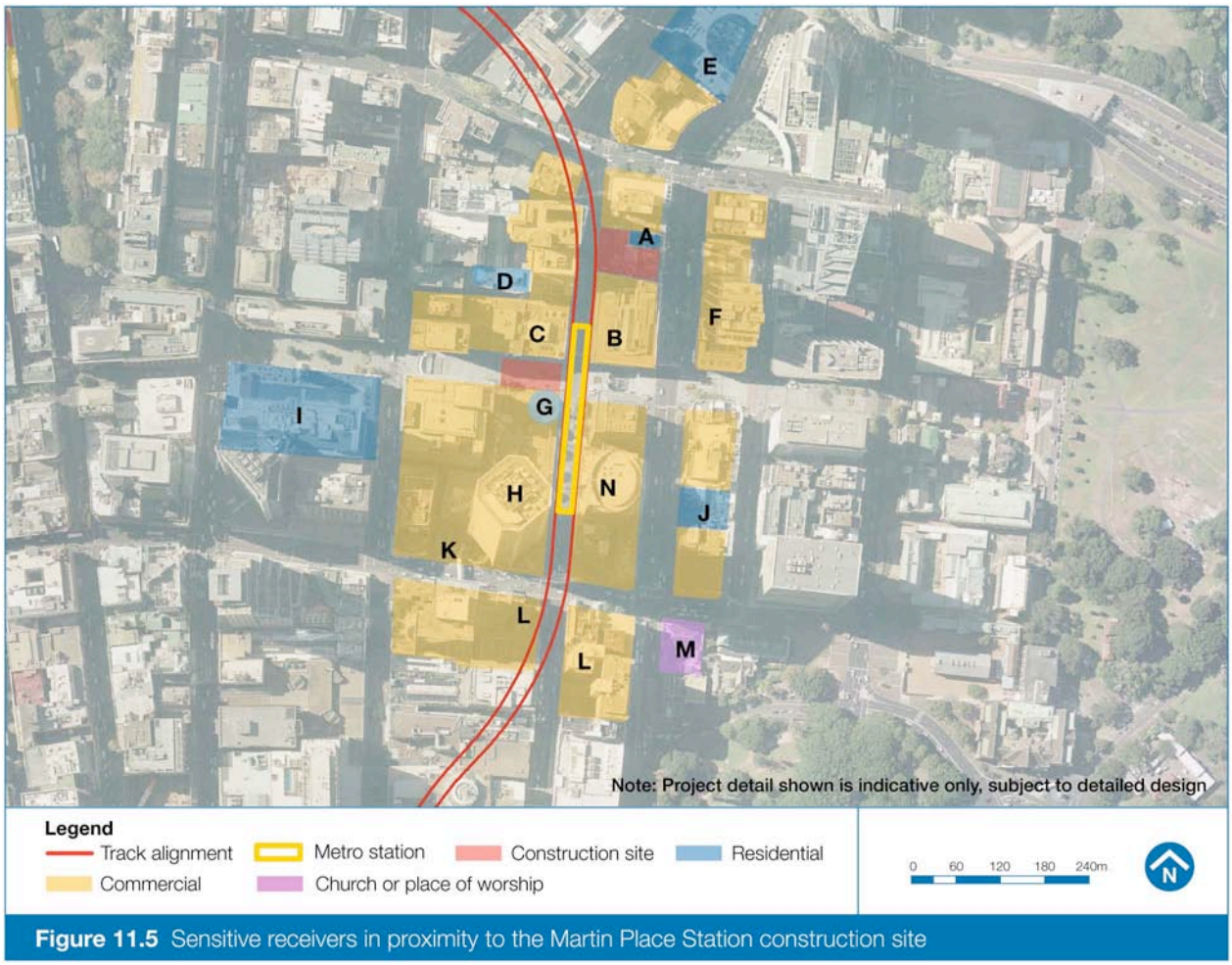

Figure 11.5 Sensitive receivers in proximity to the Martin Place Station construction site

Barangaroo-Wynyard Station construction site

Sensitive receivers in the vicinity of the Barangaroo-Wynyard Station construction site are shown in Figure 11.6. These receivers are located as close as three metres from the construction works and comprise mainly commercial receivers, hotels and residences.

Sensitive receivers surrounding the site are likely to experience some exceedance of the noise management levels during demolition, excavation and/or construction. To reduce the noise impacts on nearby receivers, the construction sites would be surrounded by three or six metre high hoardings or a full noise enclosure.

Table 11.8 shows the likely exceedances for a representative sample of receivers, assuming that the site would be fully enclosed.

Table 11.8 Expected noise management level (NML) exceedances at Barangaroo-Wynyard Station[1]

Receiver	Horizontal distance to works	NML exceedances (dBA)					
		During demolition/excavation[2]			During other construction activities		
		Daytime	Evening	Night-time	Daytime	Evening	Night-time
A – Napoleon Apartments	20 m	(5) 0	0	1	0	0	0
H – Commercial	20 m	(42) 17	17	N/A	7	7	N/A
B – Moreton's Hotel	33 m	(12) 0	0	8	0	0	0
C – Commercial	53 m	(28) 3	10	N/A	0	0	N/A

1 Details of the modelling results based on three and six metre hoardings are provided in Chapter 9 of Technical Paper 3 *Noise and vibration.*
2 Noise mitigation may not be feasible during the demolition phase. The exceedance levels in brackets indicate the potential exceedances during the demolition stage during 'worst case scenario' activities if noise mitigation is not possible.

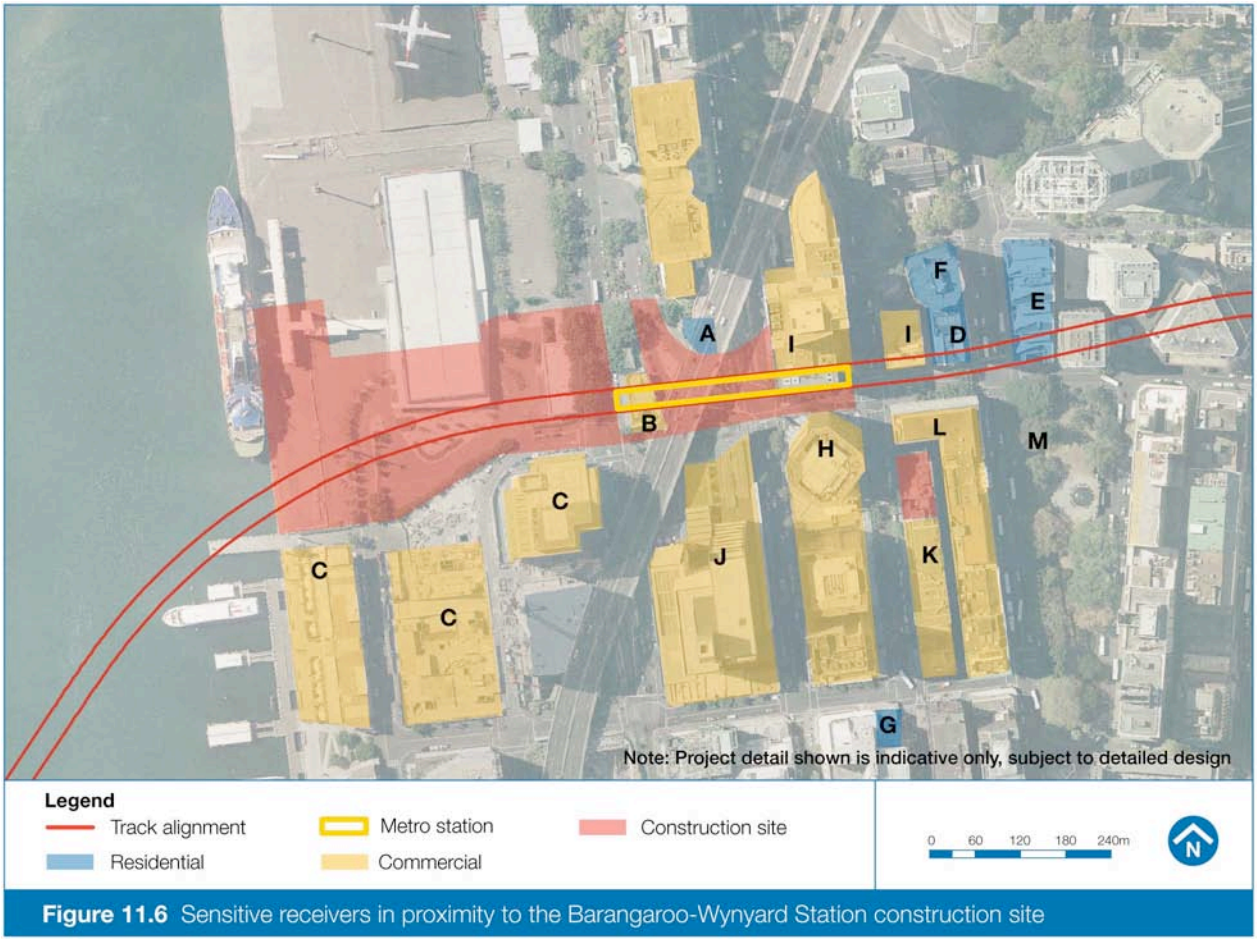

Figure 11.6 Sensitive receivers in proximity to the Barangaroo-Wynyard Station construction site

Pyrmont Station construction site

Sensitive receivers in the vicinity of the Pyrmont Station construction site are shown in Figure 11.7. These receivers mainly comprise commercial receivers, hotels and residences, with some receivers located adjacent to the construction sites.

Sensitive receivers surrounding the site are likely to experience some exceedance of the noise management levels during demolition, excavation and/or construction. To reduce the noise impacts on nearby receivers, the construction sites would be surrounded by three or six metre high hoardings or a full noise enclosure.

Table 11.9 (based on Alternative 1) and Table 11.10 (based on Alternative 2) show the likely exceedances for a representative sample of receivers, assuming that the site would be fully enclosed.

Table 11.9 Expected noise management level (NML) exceedances at Pyrmont Station (Alternative 1)[1]

Receiver	Horizontal distance to works	NML exceedances (dBA)					
		During demolition/excavation[2]			During other construction activities		
		Daytime	Evening	Night-time	Daytime	Evening	Night-time
C – Commercial	0 m	(26) 1	0	N/A	0	0	N/A
E – Commercial	2 m	(47) 22	11	N/A	12	16	N/A
B – Residential	2 m	(28) 3	9	14	0	0	4
H – Residential	2 m	(47) 22	26	30	12	16	20
L – Residential	3 m	(26) 1	7	7	0	0	2
A – Residential	10 m	(30) 5	11	16	0	1	6
F – Residential	17 m	(28) 3	7	11	0	0	1
G – Residential/ Commercial	17 m	(28) 3	7	11	0	0	0
D – Residential	19 m	(24) 0	5	10	0	0	0
K – Proposed residential	20 m	(27) 2	6	12	0	0	0

1 Details of the modelling results based on three and six metre hoardings are provided in Chapter 9 of Technical Paper 3 *Noise and vibration.*
2 Noise mitigation may not be feasible during the demolition phase. The exceedance levels in brackets indicate the potential exceedances during the demolition stage during 'worst case scenario' activities if noise mitigation is not possible.

Table 11.10 Expected noise management level (NML) exceedances at Pyrmont Station (Alternative 2)[1]

Receiver	Horizontal distance to works	NML exceedances (dBA)					
		During demolition/excavation[2]			During other construction activities		
		Daytime	Evening	Night-time	Daytime	Evening	Night-time
B – Residential	2 m	(28) 3	9	14	0	0	4
C – Commercial	3 m	(26) 1	0	N/A	0	0	N/A
E – Commercial	3 m	(32) 7	7	N/A	0	0	N/A
H – Residential	3 m	(43) 18	22	26	8	12	16
L – Residential	3 m	(26) 1	7	7	0	0	2
G – Residential/ Commercial	5 m	(39) 14	18	22	4	8	12
A – Residential	10 m	(30) 5	11	16	0	1	6
F – Residential	17 m	(28) 3	7	11	0	0	1
D – Residential	19 m	(24) 0	5	10	0	0	0
K – Proposed residential	26 m	(25) 0	4	8	0	0	0

1 Details of the modelling results based on three and six metre hoardings are provided in Chapter 9 of Technical Paper 3 *Noise and vibration.*
2 Noise mitigation may not be feasible during the demolition phase. The exceedance levels in brackets indicate the potential exceedances during the demolition stage during 'worst case scenario' activities if noise mitigation is not possible.

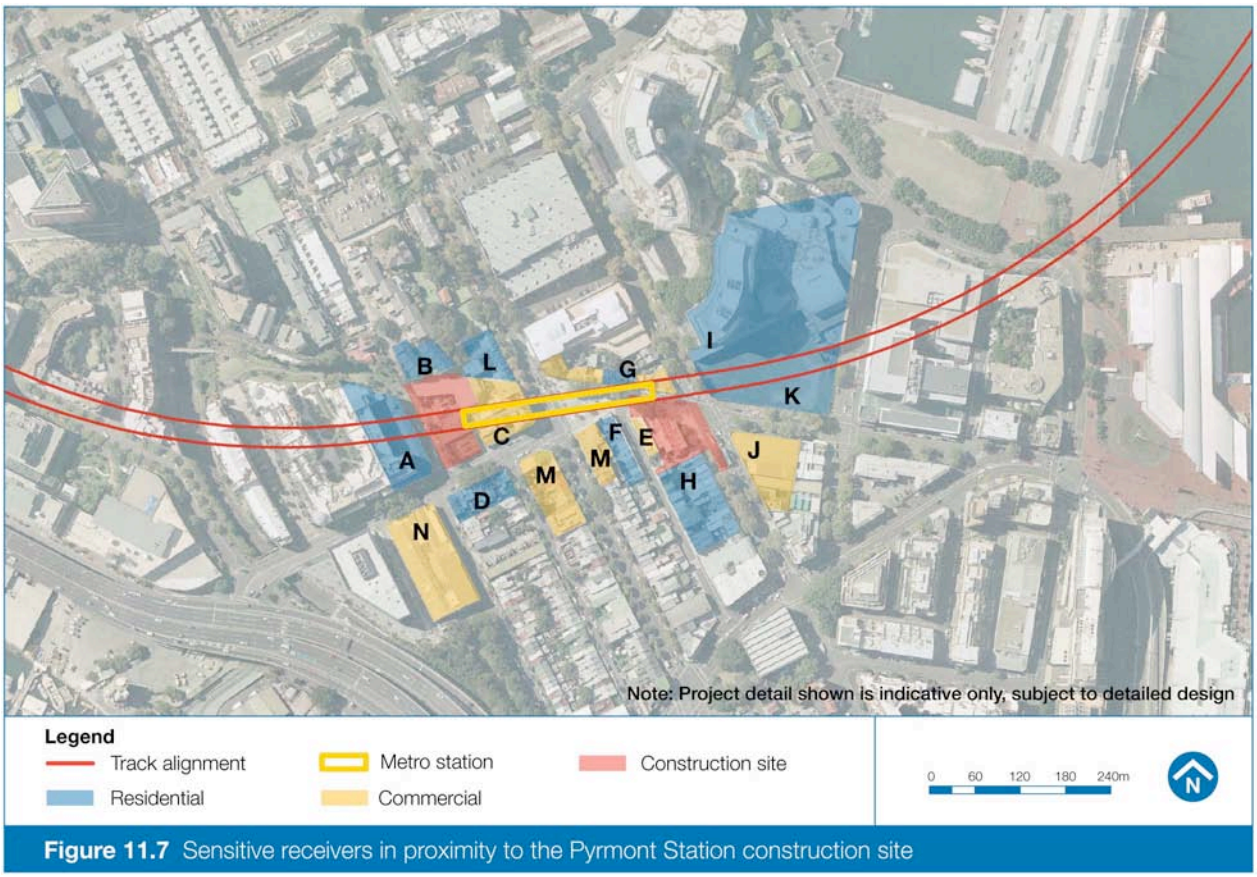

Figure 11.7 Sensitive receivers in proximity to the Pyrmont Station construction site

Rozelle Station construction site

Sensitive receivers in the vicinity of the Rozelle Station construction site are shown in Figure 11.8. These receivers are located as close as two metres from the construction works and include commercial, residential, educational and worship facility receivers.

Sensitive receivers surrounding the site are likely to experience some exceedance of the noise management levels during demolition, excavation and/or construction. To reduce the noise impacts on nearby receivers, the construction sites would be surrounded by three or six metre high hoardings or a full noise enclosure.

Table 11.11 shows the likely exceedances for a representative sample of receivers, assuming that the site would be fully enclosed.

Table 11.11 Expected noise management level (NML) exceedances at Rozelle Station[1]

Receiver	Horizontal distance to works	NML exceedances (dBA)					
		During demolition/excavation[2]			During other construction activities		
		Daytime	Evening	Night-time	Daytime	Evening	Night-time
L – Commercial	2 m	(36) 11	11	N/A	1	11	N/A
A – Commercial	4 m	(50) 25	25	N/A	15	15	N/A
I – Residential	5 m	(42) 17	21	30	7	11	20
C – Church (St Paul's)	6 m	(46) 21	10	N/A	11	11	N/A
E – St Thomas childcare centre	14 m	(34) 9	N/A	N/A	9	N/A	N/A
J – Residential	17 m	(31) 6	10	0	0	0	9
B – School	22 m	(30) 5	N/A	N/A	0	N/A	N/A
K – Bridge Hotel	29 m	(14) 0	0	11	0	0	1
C – Church	33 m	(32) 7	7	N/A	0	0	N/A
H – Residential	50 m	(9) 0	0	6	0	0	0
G – Residential	69 m	(6) 0	0	3	0	0	0

1 Details of the modelling results based on three and six metre hoardings are provided in Chapter 9 of Technical Paper 3 *Noise and vibration.*
2 Noise mitigation may not be feasible during the demolition phase. The exceedance levels in brackets indicate the potential exceedances during the demolition stage during 'worst case scenario' activities if noise mitigation is not possible.

Figure 11.8 Sensitive receivers in proximity to the Rozelle Station construction site

For all of the construction sites, the noise levels during demolition, excavation and/or construction activities are expected to exceed the noise management levels during the daytime, evening and/or night-time at some receivers. These exceedances are a direct result of the proximity of receivers to the construction activities and the absence of any appreciable shielding between sites and receivers. Section 11.4 identifies a number of mitigation measures that would be considered to minimise construction noise impacts on the surrounding communities.

Construction traffic

For receivers located in the CBD and on Victoria Road at Rozelle, construction-related daytime traffic activity would generally result in noise increases of less than 1 dBA. For the access roads of Miller Street and Pyrmont Street in Pyrmont, the construction-related daytime traffic activity would generally result in noise increases of less than 2 dBA. Therefore, at all sites, the increase in daytime traffic noise as a result of construction vehicles is not expected to exceed the acceptable 2 dBA increase.

In terms of night-time traffic noise, compliance with the 2 dBA increase is likely to be achieved at all CBD locations, with the exception of:

- The Criterion and Hilton hotels on Pitt Street (exceedance of up to 2 dBA).
- The CTA Business Club on Castlereagh Street (exceedance of up to 1 dBA).
- The Sofitel Wentworth Hotel on Bligh Street (exceedance of up to 9 dBA).
- The Wynyard Hotel and Occidental Hotel on Erskine Street (exceedance of up to 2 dBA and 4 dBA, respectively).

For receivers on the access routes to the Pyrmont Station sites, the noise level has been predicted to increase by up to 5 dBA on Miller Street and Pyrmont access routes, and 16 dBA on the Union Street access route.

For receivers on the Victoria Road access routes to the Rozelle Station sites, the LAeq(1 hour) noise level has been predicted to increase by less than 1 dBA, which complies with the 2 dBA acceptable increase.

Sleep disturbance

In terms of sleep disturbance from construction noise or project-related construction traffic, the external sleep disturbance screening criterion is either complied with or marginally exceeded (by up to 3 dBA), at all CBD receivers with fixed glazing (for example, air-conditioned hotel suites and apartments). Where exceedances exist, further investigation is recommended to determine the degree of external noise insulation that may already be incorporated into the design of potentially affected buildings.

For sensitive receivers in the CBD with openable windows, predicted exceedances range from 4 dBA at the Sydney City YHA to 8–12 dBA at apartments near Town Hall Square. While the 'external window' criterion is significantly exceeded near Town Hall, the Background + 15 dBA measurement is complied with, and on this basis, sleep disturbance is considered marginally acceptable. However, it would be recommended that further investigation be conducted during the detailed design to confirm the number of existing sleep disturbing events that may occur as well as the degree of external noise insulation that may already be incorporated into the design of potentially affected buildings.

At receivers in Pyrmont, the 'external window' criterion for openable windows applies. Exceedances at Pyrmont range from 13–19 dBA, due to the location of receivers adjacent to the access routes and the fact that existing volumes of heavy night-time traffic are low. Consequently, there is potential for significant sleep disturbance.

At receivers on Victoria Road, the 'external window' criterion for openable windows applies and exceedances of up to 18 dBA are predicted. While this is significant, indicative existing hourly heavy night-time traffic flow volumes on Victoria Road are much higher than the typical movements associated with the metro station site.

In terms of sleep-disturbance as a result of excavations, a technique known as the penetrating cone fracture (PCF) method may be used to minimise these impacts. The PCF method involves breaking rock using a high-pressure gas pulse and potentially offers the ability to conduct excavation works with a reduced impact on the surrounding area when compared to more conventional techniques. To avoid sleep disturbance, the following indicative night-time complying distances would need to be applied to the construction sites:

- Central – 10 metres.
- Town Hall – five metres.
- Martin Place – five metres.
- Wynyard – 15 metres.
- Pyrmont – 20 metres.
- Rozelle – 30 metres.

Modelling results indicate that with the implementation of these distances, and using a suitably designed noise enclosure, compliance with the airborne sleep disturbance noise management level would be achieved for PCF operations (using a 60 gram charge) during the night-time.

Similar to PCF, drill and blast techniques are anticipated to be able to offer the ability to conduct excavation with a reduced impact on the surrounding area when compared to more conventional techniques such as rockbreakers.

11.3.2 Ground-borne noise

For rockbreakers, indicative complying working distances were devised for the night-time ground-borne NMLs. The distances set for heavy, medium and light rockbreakers were 70, 60 and 50 metres respectively. This means that the night-time ground-borne noise management level is likely to be exceeded at sensitive receivers within about 70 metres of heavy rockbreaking occurring. Sensitive receivers are located within 70, 60 and 50 metres of all construction sites, so the criteria would likely be exceeded as a result of rockbreaking activities.

Roadheaders would be used for the station caverns, cross tunnels, and the tunnels from White Bay to Rozelle Station and White Bay to the Rozelle stabling and maintenance depot. The nearest receivers from these works were identified and the ground-borne noise levels predicted. The results of the modelling indicate that at all of the station construction sites, any exceedances of the 35 dBA night-time residential noise management level at the nearest residences or hotels would be mostly minor. However these exceedances may be experienced for up to about three weeks at some sites (refer Table 11.12).

As shown in Table 11.12, the construction of the tunnels using roadheaders would also result in some exceedances of the night-time noise management level. Exceedances are expected to occur at the following locations:

- At residences above the tunnelling works between White Bay and Rozelle. These locations may exceed the night-time noise management level by up to 5 dBA. These impacts would only be expected to occur for a period of about 12 days while the roadheader passes beneath these receivers.
- At residences near the portal to the stabling yards, where the night-time noise management level may be exceeded by 2 to 4 dBA (Quirk Street and Hornsey Street) and 6 to 13 dBA (Lilyfield Road). Ground-borne noise impacts of this level are expected to last up to fourteen days. (These receivers may also experience airborne noise impacts from construction activities at the Rozelle stabling and maintenance depot.)

Table 11.12 Expected exceedances of the night-time NML at residential receivers during roadheader operations

Station site/ excavation	Receiver	Location relative to works (metres)	Night-time NML exceedances (dBA)	Predicted number of days exceeding the night-time NML
Cavern construction[1]				
Town Hall	Criterion Hotel	24	2	12 days
Martin Place	CTA Business Club – residence	26	1	7 days
Barangaroo-Wynyard	Travelodge Hotel	22	2	16 days
Pyrmont	Union Square - Residential	24	6	22 days
Rozelle	Hotel	25	1	10 days
Tunnel construction[2]				
Rozelle to White Bay	Residential	16	5	12 days
Rozelle to depot	22-36 Lilyfield Road – residence	7	13	14 days
	19 Lilyfield Road – residence	15	6	12 days
	2-6 Hornsey Street – residence	19	4	10 days
	3 Hornsey Street – residence	22	2	9 days
	4 Quirk Street – residence	22	2	9 days
	5 Quirk Street – residence	23	2	8 days

1 Assumes roadheader advance rate for cavern construction of about two metres per day.
2 Assumes roadheader advance rate for tunnel construction at these locations of up to 110 metres per month.

The operation of the TBMs for the construction of the running tunnels is also likely to result in exceedances of the ground-borne noise management levels at some locations. If the receiver is located directly above the tunnel, the ground-borne noise levels are anticipated to exceed the recommended residential night-time noise management level of 35 dBA for a period of up to about 10 days. Most of the receivers directly above the tunnel are commercial. Table 11.13 presents the predicted noise levels for the affected residential receivers during TBM operations as well as the anticipated number of days of impact.

Table 11.13 Expected exceedances of the night-time noise management level at residential receivers during TBM operations

Street address	Receiver	Night-time NML exceedances (dBA)[1]	Maximum number of days exceeding the night-time NML[2]
303–307, 317–321 Castlereagh Street, Haymarket	Regis Apartments	6	4 days
300 Pitt Street, Sydney	Metro Hotel	9	6 days
329 Pitt Street, Sydney	Meriton Apartments	7	6 days
255–259 Pitt Street, Sydney	Hilton Hotel	15	8 days
27 O'Connell Street, Sydney	Radisson Hotel	6	3 days
7-9 York Street, Sydney	Travelodge	4	2 days
24 Union Street, Pyrmont	Proposed Star City Hotel	17	4 days
20 Pyrmont Street, Pyrmont	Star City Casino Apartment	6	4 days
91–93 Pyrmont Street, Pyrmont	Residential	8	9 days
1–19 Paternoster Road, Pyrmont	Residential	8	9 days
102–104 Miller Street, Pyrmont	Residential	8	9 days
13-15 Jones Street, Pyrmont	Residential	9	9 days
14 Quarter Master Drive, Pyrmont	Residential	6	9 days

1 The predicted maximum noise levels were predicted for the ground floor.
2 The number of days exceeding the night-time noise trigger level has been predicted based on a TBM rate of about 300 metres per month, and on predicted noise levels on the 2nd floor of multi-story hotels/city apartments and ground floor residential houses.

11.3.3 Vibration

During construction, the major potential sources of vibration include rockbreakers, other excavation plant and equipment, vibratory pile drivers, vibratory rollers and potentially PCF operations. Vibration trigger levels are provided in section 11.1.2 of this report, with a vibration trigger level of 7.5 millimetre per second at a building or vibration-sensitive receiver being set as a cosmetic damage threshold for further assessment and/or monitoring.

In order to meet the vibration trigger levels, indicative complying work distances have been established. Safe work distances are the nearest distance at which the maximum vibration level generated by the operation of a plant item is predicted not to exceed the 7.5 millimetre per second cosmetic damage threshold (noting that higher vibration levels may be permitted for typical building constructions). Indicative complying work distances for some typical plant that are likely to be used at the construction sites are one metre, four metres and 15 metres for small, medium and large rockbreakers respectively, six metres for a vibratory roller and one metre for a vibratory trench roller.

Given the proximity of the construction sites to nearby structures, it is likely that the complying work distances would not be practical at some locations. Provided construction activities are appropriately managed and monitored, the risk of structural damage is low. Appropriate mitigation measures for these situations are provided in section 11.4 below.

Indicative complying working distances for the PCF excavation method were calculated and modelled. The results of the modelling indicate that the guideline for maximum allowable vibration from an

impulsive event (DEC 2006b) is expected to be complied with (using a 60 gram charge) for PCF night-time operations.

11.4 Mitigation and management

As mentioned in section 0, Sydney Metro has prepared a CBD Metro Construction Noise and Vibration Strategy (refer Appendix D). This strategy would be used to inform the Construction Noise and Vibration Management Sub-Plan, which would be implemented to manage the potential noise and vibration impacts. Mitigation and management measures that would be included in the sub-plan are listed below.

11.4.1 Airborne noise

Construction sites

- At station construction sites, initial demolition and excavation works would be undertaken during the daytime period (where feasible).
- Where night-time works are required, the DECCW's Sleep Disturbance Screening Criteria would be adopted as a design goal and further analysis would be undertaken if exceedances are predicted.
- Perimeter noise barriers and site enclosures would be used as required. Typically, 5–15 dBA attenuation can be achieved with a well-constructed barrier. An enclosure with no openings would be expected to provide an insertion loss in the region of 15–25 dBA. Site-specific mitigation measures for the construction sites are provided in section 9.4 of Technical Paper 3 *Noise and vibration.*
- The coincidence of noisy plant working simultaneously close together and adjacent to sensitive receivers would be minimised where possible.
- The offset distance between noisy plant items and nearby noise-sensitive receivers would be as great as possible.
- Regular compliance checks on the noise emissions of all plant and machinery used for the project would be undertaken to indicate whether noise emissions from plant items are higher than predicted. This would also identify defective silencing equipment on plant items.
- Ongoing noise monitoring during construction at sensitive receivers during critical periods (that is, times when noise emissions are expected to be at their highest, such as during piling and hammering) would be undertaken to identify and assist in managing high-risk noise events.
- Engines and exhausts are typically the dominant noise sources on mobile plant such as cranes, graders, excavators and heavy vehicles. To minimise noise emissions, residential grade mufflers would be fitted on all mobile plant used on site.
- Regular maintenance of all plant and machinery used for the project would help to minimise noise emissions.
- Acoustic enclosure of plant items would be implemented, if required, as identified during compliance monitoring.

Construction traffic

- Where night-time works are required, the DECCW's Sleep Disturbance Screening Criteria would be adopted as a design goal and further analysis would be undertaken if exceedances are predicted. This includes noise from project-related vehicle movements.

- Where possible, heavy vehicle movements would be limited to daytime hours.
- The following mitigation measures would be considered for receivers identified within the 'noise management zone':
  - Noise monitoring on-site and within the community.
  - Prompt response to any community issues of concern.
  - Discussions with relevant landowners to assess concerns.
- The following mitigation measures would be considered for receivers identified within the 'noise affectation zone':
  - Discussions with the relevant landowners to assess concerns and define responses.
  - Consideration of acoustical mitigation at residences, where substantiated by monitoring results.
  - Consideration of negotiated agreements with landowners, where required.
- "Quiet trucks" would be used during night-time operations to reduce the overall night-time noise level as well as the potential for sleep disturbance.
- Heavy vehicle air parking brake engagement would be silenced for all permanent mobile plant operating at the construction sites.
- Non-tonal reversing alarms would be used for all permanent mobile plant.

11.4.2 Ground-borne noise

- Rock breaking during night-time periods would be avoided where feasible.
- The Penetrating Cone Fracture technique would be considered for excavation to minimise ground-borne noise levels at nearby sensitive receivers.
- Drill and blast techniques for excavation would be considered to minimise ground-borne noise levels at nearby sensitive receivers.
- Where practicable, the distance between the roadheaders and potentially affected receivers would be minimised during the night-time periods.
- When working adjacent to schools, childcare centres, churches and places of worship, particularly noisy activities (such as rock breaking) would be scheduled outside normal school hours and services, where possible.
- When working adjacent to churches and places of worship, particularly noisy activities (such as rock breaking) would be scheduled outside services, where possible.
- Dampened hammers would be used, where possible. These reduce the 'ringing' of the rock pick, cylinder and excavator arm that is commonly associated with rock-breaking works. (Damped hammers achieve about 10 dBA attenuation compared to undampened hammers of the same size.)

11.4.3 Vibration

- Work would be undertaken within the specified safe working distances, where practicable, to avoid cosmetic damage to buildings from construction vibration.
- Where construction works are undertaken closer than the safe working distance of nearby structures, site-specific vibration monitoring would be undertaken as well as consultation with potentially affected receivers and landowners to measure vibration damage criteria.
- Where nearby structures are likely to be affected by construction vibration, structural condition surveys would be prepared and reviewed during and following construction.

11.4.4 Other measures

All employees, contractors and subcontractors would undertake a site induction that would cover, as a minimum:

- All relevant project-specific and standard noise and vibration mitigation measures.
- Relevant licence and approval conditions.
- Permissible hours of work.
- Any limitations on high noise-generating activities.
- Location of nearest sensitive receivers.
- Construction employee parking areas.
- Designated loading/unloading areas and procedures.
- Site opening/closing times (including deliveries).
- Environmental incident reporting and management procedures.

Active community consultation and the maintenance of positive, cooperative relationships with schools, local residents and building owners assists in managing impacts from noisier operations and in alleviating concerns, and thereby minimising disturbance and complaint. Consultation would include, for example:

- Periodic notification of work activities and progress (such as regular letterbox drops, emails etc).
- Specific notification (letterbox drop) prior to especially noisy activities.
- Comprehensive website information.
- A project information line.
- A construction response line.

11.5 Conclusions

The CBD Metro would be a large and noticeable project within the Sydney CBD. Due to the location of the project and the proximity of sensitive receivers, its duration, scale and the excavation and tunnelling equipment required – as well as the related construction traffic – noise and vibration impacts would be unavoidable at some locations.

The residential and commercial noise management levels are not expected to be exceeded at any of the nearby receivers surrounding the main construction site at White Bay.

However, at the remaining construction sites, the noise management levels are expected to be exceeded at some receivers. Higher exceedances are predicted during evening and night-time periods as a result of the more stringent noise management levels. In particular, exceedances (up to about 19 dBA) of the sleep disturbance criterion are predicted at receivers at Pyrmont and up to 8 dBA at receivers on Victoria Road, Rozelle, due to night-time construction activities and/or vehicle movements. Some residences could experience ground-borne noise above the noise management levels determined for the project for up to about three weeks.

Construction traffic noise is likely to comply with the daytime traffic noise goals at all sites and with the night-time goals at most sites. More substantial exceedances of the night-time noise goals are predicted to occur from night-time vehicle movements near the Sofitel Wentworth Hotel on Bligh Street, and along the access routes to and from the Pyrmont Station construction site.

A Construction Noise and Vibration Strategy would be prepared and implemented to provide a framework for the implementation of mitigation measures to manage the expected exceedances, and inform the Construction Noise and Vibration Management Sub-Plan.

These measures would include an active community consultation program with the surrounding communities and significant physical noise mitigation, in the form of acoustic sheds, would be employed where feasible.

In addition, given the proximity of the construction sites to nearby structures, vibration impacts from plant and equipment such as rockbreakers and vibratory pile drivers, would be appropriately managed to minimise the risk of structural damage.