10 Noise and vibration

10.1 Assessment

The following information was extracted from the Noise and Vibration Assessment prepared by Heggies Pty Ltd. A full copy is found in Volume 2, Appendix D.

10.1.1 Construction (airborne) noise assessment criteria

The Department of Environment and Climate Change (DECC), being the published guidelines in its Environmental Noise Control Manual (Chapter 171-1) for the control of construction noise.

In summary, the DECC’s preferred approach to the control of construction noise involves the following:

- noise level restrictions;
- time restrictions; and
- silencing.

Noise level restrictions

The Environmental Noise Control Manual (ENCM) recommends that the $L_{A10}$ (15-minute) (average maximum construction noise levels assessed over a 15-minute period) arising from a construction site and measured within the curtilage of an occupied noise-sensitive premises (i.e. at the boundary or within 30 m of the noise-sensitive premises, whichever is the lesser) should not exceed the levels indicated in Table 10.1.

<table>
<thead>
<tr>
<th>Period of noise exposure</th>
<th>$L_{A10}$ (15minute) noise goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cumulative noise exposure period not exceeding 4 weeks</td>
<td>$L_{A10}$ (15minute) plus 20 dBA</td>
</tr>
<tr>
<td>Cumulative noise exposure period of between 4 weeks and 26 weeks</td>
<td>$L_{A10}$ (15minute) plus 10 dBA</td>
</tr>
<tr>
<td>Cumulative noise exposure period longer than 26 weeks</td>
<td>$L_{A10}$ (15minute) plus 5 dBA</td>
</tr>
</tbody>
</table>

Time restrictions

- Monday to Friday: 0700 hours to 1800 hours.
- Saturday: 0700 hours to 1300 hours if inaudible at residential premises otherwise, 0800 hours to 1300 hours.
- No work on Sundays or Public Holidays.

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

(Note that it is a Project requirement for all tunnelling works to be undertaken on a continuous basis, as far as practicable and possible, and this would be subject to a rigorous assessment of the noise and vibration impacts of undertaking night-time tunnelling works).

Silencing

All practical measures should be used to silence construction equipment, particularly in instances where extended hours of operation are required. Furthermore, silencing can be achieved by the use of specially designed acoustic cladding around noisy tunnel construction activities such as the Riley Street Site.

At the Riley Street Site, it is envisaged that an acoustic enclosure over the construction site would be installed – in a similar manner to what has been adopted by EnergyAustralia at the City West Cable Tunnel Project compound at Mary Ann Street, see Figure 10.1.
10.1.2 Regenerated (structure-borne) noise assessment criteria

The Project would involve significant tunnelling activities, which are proposed to be conducted using a roadheader machine and TBM, to be launched from the Riley Street Site for the CSCT Extension and the CECT, respectively.

Whilst regenerated noise was not identified in the Director General’s Requirements and input from agencies (see Volume 2, Appendix A), there is potential for regenerated noise to be an issue for noise-sensitive receivers near to construction (excavation) sites and near to (above) the tunnel alignment, with the potential for greater impact when the proposed tunnel alignment is closer to the ground surface and therefore foundations of noise-sensitive premises.

Regenerated noise in buildings is caused by the transmission of ground-borne vibration rather than by the direct transmission of noise through the air. Vibration may be generated by construction equipment such as TBMs 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 (also commonly referred to as ‘structure–borne’ or ‘ground-borne’ noise).

Structure-borne noise is not usually a significant disturbance to building occupants during daytime periods due to higher ambient noise levels which mask the audibility of structure-borne noise emissions. During night-time periods however, when ambient noise levels are often much lower, structure-borne noise is more prominent and may result in adverse comment from building occupants.

Table 10.2 provides a summary of the structure-borne noise objectives that have been applied on recent tunnelling projects in NSW.
### Table 10.2 Structure-borne noise objectives on recent NSW tunnel projects

<table>
<thead>
<tr>
<th>Construction project</th>
<th>Structure-borne noise objectives (residential)</th>
<th>Daytime</th>
<th>Night-time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross-City Tunnel</td>
<td>Vibration objectives only (BS 6472)</td>
<td>$L_{A90}^{(15\text{minute})}$ 40 dBA (6 pm to 10 pm)</td>
<td>$L_{A90}^{(15\text{minute})}$ 35 dBA (10 pm to 7 am)</td>
</tr>
<tr>
<td>EnergyAustralia 132kV cable tunnels in CBD</td>
<td>Vibration objectives only (BS 6472)</td>
<td>$L_{A90}^{(15\text{minute})}$ 40 dBA (6 pm to 10 pm)</td>
<td>$L_{A90}^{(15\text{minute})}$ 35 dBA (10 pm to 7 am)</td>
</tr>
<tr>
<td>Lane Cove Tunnel</td>
<td>Vibration objectives only (BS 6472)</td>
<td>$L_{A90}^{(15\text{minute})}$ 40 dBA (6 pm to 10 pm)</td>
<td>$L_{A90}^{(15\text{minute})}$ 35 dBA (10 pm to 7 am)</td>
</tr>
<tr>
<td>Epping to Chatswood Rail Line</td>
<td>$L_{A90}^{(15\text{minute})}$ 45 dBA</td>
<td>$L_{A90}^{(15\text{minute})}$ 40 dBA (6 pm to 7 am)</td>
<td>$L_{A90}^{(15\text{minute})}$ 35 dBA &gt; 7 Days (10 pm to 7 am)</td>
</tr>
</tbody>
</table>

On this basis, it is likely for the Project that the same criteria that were applied to the 132kV cable tunnels in Sydney CBD are appropriate, and on this basis, this document adopts these criteria, being:

- daytime: vibration objectives only (BS 6472).
- night-time: $L_{A90}^{(15\text{minute})}$ 40 dBA (6 pm to 10 pm), $L_{A90}^{(15\text{minute})}$ 35 dBA (10 pm to 7 am).

### 10.1.3 Vibration assessment criteria

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

- those in which the occupants or users of the building are inconvenienced or possibly disturbed (Human Comfort); and
- those in which the integrity of the building or the structure itself may be prejudiced (Structural Damage).

The Department of Environment and Climate Change (DECC) requires an assessment of vibration in accordance with (DECC's document), *Assessing Vibration: A Technical Guideline*, (August 2006) specifically Table 2.2 and 2.4. These tables (and indeed the whole document) in the DECC Technical Guideline only take Human Comfort into account. They provide acceptable values for continuous and impulsive vibration in terms of vibration acceleration (m/s$^2$) 1 to 80 Hz and also acceptable values for intermittent vibration in terms of Vibration Dose Value (VDV) (m/s $^{1.75}$).

The means by which the criteria set out in the DECC Technical Guideline are measured and assessed (acceleration and dose) are not straightforward to measure, and, in the case of acceleration particularly, would impose an onerous burden upon the Project if assessment was required to be undertaken in this manner, with no additional benefit to the community. It is far more straightforward to assess vibration in terms of Peak Particle Velocity (PPV).

On past, similar projects, Heggies Pty Ltd has determined equivalent vibration criteria consistent with the values in the DECC Technical Guideline, but expressed in terms of PPV. The Technical Guideline is based upon some of the references set out below in the British Standards (BS 6472).

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 10.3.
Table 10.3  Peak vibration levels and human perception of motion

<table>
<thead>
<tr>
<th>Approximate vibration level</th>
<th>Degree of perception</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.10 mm/s</td>
<td>Not felt</td>
</tr>
<tr>
<td>0.15 mm/s</td>
<td>Threshold of perception</td>
</tr>
<tr>
<td>0.35 mm/s</td>
<td>Barely noticeable</td>
</tr>
<tr>
<td>1 mm/s</td>
<td>Noticeable</td>
</tr>
<tr>
<td>2.2 mm/s</td>
<td>Easily noticeable</td>
</tr>
<tr>
<td>6 mm/s</td>
<td>Strongly noticeable</td>
</tr>
<tr>
<td>14 mm/s</td>
<td>Very strongly noticeable</td>
</tr>
</tbody>
</table>

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 10.3 suggests that people would 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.

10.1.4 Construction traffic noise assessment criteria

For traffic operating on public roads to and from construction sites the DECC “Environmental Criteria for Road Traffic Noise” 1999 (ECRTN) are appropriate for assessing road traffic noise. The DECC’s recommended criteria for collector roads are set out in Table 10.4.

Table 10.4  DECC road traffic noise criteria

<table>
<thead>
<tr>
<th>Development</th>
<th>Day (7.00 am to 10.00 pm)</th>
<th>Night (10.00 pm to 7.00 am)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. Land use development with potential to create additional traffic on FREEWAYS/ARTERIAL roads</td>
<td>L_{Aeq}(15hour) 60 dBA</td>
<td>L_{Aeq}(9hour) 55 dBA</td>
</tr>
<tr>
<td>8. Land use development with potential to create additional traffic on COLLECTOR roads</td>
<td>L_{Aeq}(1hour) 60 dBA</td>
<td>L_{Aeq}(1hour) 55 dBA</td>
</tr>
<tr>
<td>13. Land use development with potential to create additional traffic on LOCAL roads</td>
<td>L_{Aeq}(1hour) 55 dBA</td>
<td>L_{Aeq}(1hour) 50 dBA</td>
</tr>
</tbody>
</table>

Where L_{Aeq} noise levels already exceed the above targets, a 2 dBA increase in the overall traffic noise levels is normally regarded as an alternative target (having investigated the application of all feasible and reasonable noise mitigation) in order to maintain the general acoustic amenity of the area.

It is likely that on the roads immediately adjacent to the various work sites, the community would associate truck movements with the Project. Once the trucks move further from each of the sites, the truck noise may be perceived as part of the general road traffic.

10.1.5 Construction noise

Construction noise goals for airborne noise emission, (when established in accordance with relevant NSW Government and DECC policies and guidance) are based on the existing ambient or background noise levels within a given area and an allowable increase due to the temporary nature of construction works.

In some instances, construction noise goals may also be based on the sensitivity of particular building spaces. For example, the acceptable noise level within a factory would be much higher than for a recording studio.

On the basis of Project scheduling information presented in Figure 4.2 and Table 9.1, it is likely that work at most, if not all work sites that form part of the Project would require construction activities of 26 weeks or greater. Based on the ENCM criteria presented in Table 10.1, airborne noise emission from Project construction activities would be assessed for compliance with relevant NSW Government and DECC policies and guidance based on a Rating Background Noise Level (RBL) Background (RBL) + 5 dBA criterion for residential receivers.

Specifically, this means that noise from construction activities should be managed such that the LA_{eq} noise level, measured over a period of not less than 15 minutes, should not exceed the background LA_{eq} noise level by more than 5 dBA.

For commercial and retail buildings, it is generally accepted that receivers are 5 dBA to 10 dBA less sensitive to construction noise emissions than residential receivers. For commercial and retail receivers such as the outdoor eating areas, restaurants, take away shops, hair salons, and the like, an LA_{eq}(10min) noise objective of Background (RBL) + 10 dBA has conservatively been applied.
The establishment and derivation of airborne noise criteria for residential receivers was undertaken as part of a construction noise assessment for the Belmore Park Zone Substation and the stub tunnel connection from the existing CSCT. Details are presented in Chapter 9 of the Belmore Park Zone Substation and Commercial Development Project EAR.

For the remaining Project elements subject to future project approval EARs commitments have been proposed to conduct the necessary investigations which establish and derive airborne noise criteria.

10.1.6 Construction noise & vibration assessment

Tunnelling activity associated with the CECT and the CSCT Extension would primarily warrant acoustical assessment in terms of regenerated (structure-borne) noise and vibration.

There would be a 12 metre tunnel section, (CSCT stub tunnel), which connects the Belmore Park Zone Substation with the existing tunnel infrastructure, this section of tunnelling would be undertaken as part of the Belmore Park Zone Substation bulk excavation works. It is expected that a small excavator or roadheader machine would be used to break through the small section of rock.

Further details of the development can be found in the separate EAR seeking project approval under Part 3A of the EP&A Act.

Construction noise

Airborne noise emission would also require consideration at the locations where the TBM and roadheader machine are launched (Riley Street Site), where spoil is brought to the surface and transported from (also Riley Street) and where the tunnel is required to interface with the surface (eg at any vertical shafts mid-tunnel and at the CBD zone substations).

Construction vibration

It is anticipated that the most significant potential long-term source of construction-related vibration would be the use of the TBM and roadheader machine, used to construct the CECT and the CSCT Extension. Based on the findings presented by the Australian Acoustical Society (Technical Meeting, December 2003), at a slant distance of 65 metres, vibration due to the operation of a tunnel boring machine is likely to meet the human ‘threshold of perception (0.15 mm/s), at 30 metres the vibration would be ‘barely noticeable’ and at distances closer than 30 metres, the vibration would become increasingly noticeable.

Safe working distances for typical items of ‘above-ground’ vibration-intensive plant are listed in Table 10.5. These distances are indicative only and can vary depending upon the particular item of plant and geotechnical conditions. For the purpose of this study, a ‘safe distance’ would correspond to the distance at which the maximum vibration level generated by the operation of a subject plant item is predicted not to exceed 2 mm/s.

Table 10.5 Safe working distances for vibration intensive plant items

<table>
<thead>
<tr>
<th>Item</th>
<th>Rating</th>
<th>Safe working distance</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rockbreaker</td>
<td>Light (eg Krupp HM 170)</td>
<td>5 metres</td>
<td>Based on a 5 mm/s criterion</td>
</tr>
<tr>
<td></td>
<td>Medium (eg Krupp HM 580)</td>
<td>10 metres</td>
<td>Based on a 5 mm/s criterion</td>
</tr>
<tr>
<td></td>
<td>Heavy (eg Krupp HM 960)</td>
<td>30 metres</td>
<td>Based on a 5 mm/s criterion</td>
</tr>
<tr>
<td>Vibratory Hammer (Piling)</td>
<td>12 t Down force</td>
<td>15 metres minimum</td>
<td>Based on a 5 mm/s criterion</td>
</tr>
<tr>
<td>Hand held jack hammer</td>
<td>-</td>
<td>1 metre (nominal)</td>
<td>Avoid contact with structure</td>
</tr>
</tbody>
</table>

Note: The safe working distances apply to structural damage of typical buildings and typical geotechnical conditions. They do not address heritage structures or human comfort considerations. Vibration monitoring is recommended to confirm the safe working distances at specific sites.

Construction regeneration noise

It is anticipated that the most significant potential long-term source of construction-related regenerated noise would be the use of the TBM and the roadheader machine, used to construct the CECT and the CSCT Extension respectively. Based on findings presented by the Australian Acoustical Society (Technical Meeting, December 2003), at 50 metres slant distance, the operation of a tunnel boring machine results in regenerated noise levels of approximately 35 dBA, and a distance of 30 metres results in 40 dBA.
At this stage of the Project, it is reasonable to consider allowing a buffer distance of:

- 50 metres between the crown of the CECT tunnel and surface (residential) structures on the basis of regenerated noise control (assuming a Project preference to undertake tunnelling on a continuous basis, including during the 10.00 pm to 7.00 am night-time period); and
- 30 metres between the crown of the CECT tunnel and surface (residential) structures on the basis of regenerated noise control (assuming a project preference to undertake tunnelling during 6.00 pm and 10.00 pm).

10.1.7 Operations

Operations have the potential to generate noise and vibrations from activities such as:

- noise would be generated by the operation of the proposed zone substations and STSS; and
- minimal noise would be generated by the operation of the tunnel (ventilation fans and similar) as these are likely to be located underground.

An operational noise and vibration assessment was conducted for the Belmore Park Zone Substation development (see separate Belmore Park Zone Substation and Commercial Development EAR seeking project approval).

For the Project elements subject to concept approval, further investigations would be conducted during future project approval EARs.

10.2 Mitigation measures and safeguards

A summary of the key mitigation measures and safeguards is provided below. Further details can be found in Volume 2, Appendix D.

**Belmore Park Site**

A range of noise and vibration mitigation measures were developed for the Belmore Park Zone Substation and integrated development.

Details of the mitigation measures and safeguards developed for the Belmore Park Zone Substation are provided in Chapter 9 of the separate Belmore Park Zone Substation and Commercial Development Project EAR.

**Riley Street Site (CECT, CSCT Extension and STSS)/City East Zone Substation/Dalley Street Zone Substation/Alternative Service & Control Room**

During the preparation of future project approval EARs for the above Project elements the following investigations would be undertaken:

- undertake a noise survey;
- derive construction noise emission criteria in accordance with the principles set out in Volume 2, Appendix D;
- conduct a detailed construction noise assessment;
- assess the need for required noise controls during the construction stage;
- this noise and vibration assessment should be refined for the future project approval EARs for each work site and tunnel alignment. Site-specific regenerated noise and vibration rules can be established following early works, the results of which may require increased buffer distances to be allowed, alternatively, may permit a smaller buffer distance where closer-to-surface tunnelling works are preferable (and the regenerated noise and vibration impacts are proven to be less than anticipated at this Concept EA stage); and
- an operational noise and vibration assessment would be conducted for the zone substations and STSS generally following the methodology used to assess the Belmore Park Zone Substation.

**CSCT Extension**

Based on Heggies Pty Ltd review of the site, it is recommended that a week-long unattended noise survey is undertaken in Little Albion Street, Surry Hills. The most suitable location for the survey appears to be any of the terraced houses at 14-22 Little Albion Street.
Riley Street Site

It is recommended that a week-long unattended noise survey is undertaken in up to four locations around the work site. The most suitable locations for the survey appear to be:

- East of work site - Rear of strata units at 329 Crown Street
- North of work site - Front of terrace house at 82 Ann Street
- West of work site - Front of townhouse at 299 Riley Street
- South of work site - Mid/upper floor balcony of a residential unit in 300 Riley Street/127 Albion Street facing Albion Street