



Assessing community responses to noise and vibration impacts from large construction projects in a CBD environment

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ABSTRACT

Delivering a large infrastructure project in CBD and high-rise urban environments presents significant challenges to the management of construction noise. Tolerance to construction noise varies vastly depending on whether nearby receivers are commercial, offices or residential. It is also influenced by the time of noise impact, duration, and any special characteristics of the noise, such as rock hammering or concrete saw cutting. Additionally, community expectations, ideological sentiment for the project or impact to property value can also be an influencing factor. This paper examines the adverse comment and incident history of a section of a major metro rail project in Sydney. This included the demolition of over 50 buildings, excavation of 15 km of twin tunnel and spoil removal, and the subsequent construction of 7 stations and over-station development at some locations. From this data, noise and vibration related issues have been extracted, analysed and compared with other environmental impacts. An outline of innovative project conditions of approval is provided along with a discussion of community expectations, effectiveness of implemented feasible and reasonable mitigation measures, and some lessons learnt.

1 INTRODUCTION

The NSW Government is building, operating, and maintaining a network of four metro rail lines, 46 stations and 113 km of new metro rail across Sydney. Construction is occurring concurrently on up to three of these projects at any one time. Whilst construction noise impacts are discussed generally, the focus of this paper is the underground city section of the Sydney Metro City & Southwest project, spanning from Chatswood to Sydenham which was constructed between 2017 and its opening in August 2024. Figure 1 shows that the line connects the highly urbanised Chatswood, where only minor works were required to the existing Metro line that opened in 2019. From there, the line extends below the harbour and the Sydney CBD to Sydenham, where construction was limited to relatively minor works to an existing above ground station.

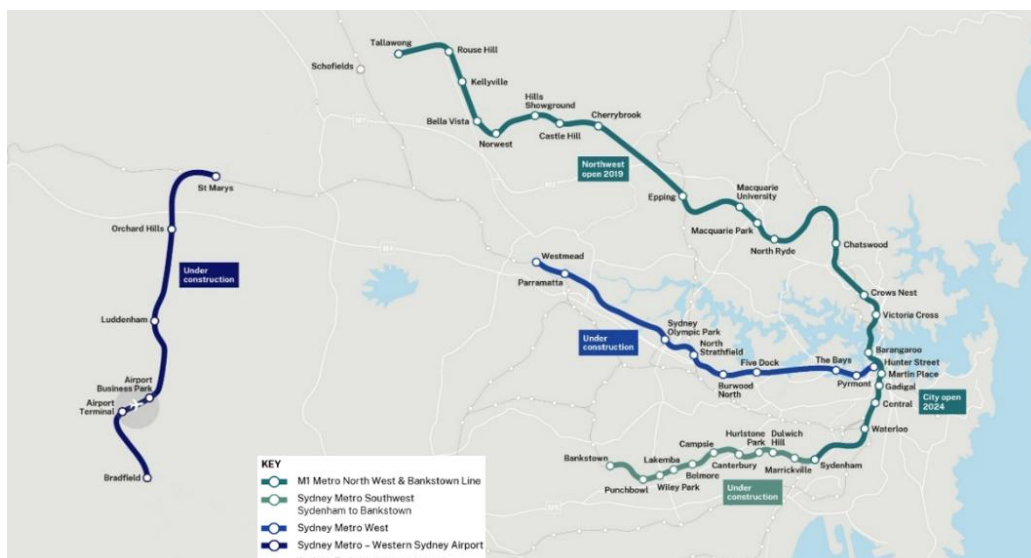


Figure 1. Current Sydney Metro lines (operational and under construction)

The core component of the project was the construction of a new 15.5 km twin-tunnel metro line from Chatswood to Sydenham, passing through the Sydney CBD. This was the most complex portion of the project, involving the construction of a new platform at Central Station six new underground stations at Crows Nest, Victoria Cross (North Sydney), Barangaroo, Martin Place, Pitt Street and Waterloo. In addition to significant demolition of existing buildings at most locations, over-station development occurred at Crows Nest, Victoria Cross and Pitt St (centre of the Sydney CBD). At Waterloo demolition was restricted to smaller buildings and significant station box excavation in a more residential setting.

When considered in isolation, construction noise impacts are typically of short duration and usually only affect a small number of receivers. However, since 2000, there has been a significant influx of residents to the city centre, thereby increasing the number of receivers potentially exposed to CBD construction impacts. Around 20 years ago, the Sydney CBD had around 3,500 residents, now as a result of changes in demographics and facilitated by the building of high-rise residential apartments, the CBD houses in the order of 28,000 residents (ABS, 2021).

Confounding factors which had the potential to influence the perception of construction noise were identified as including:

- High level of residential and commercial development in the CBD
- Increased density of residents in the CBD
- Infrastructure development to service the CBD
- Changing demographics and expectations
- Sequential construction resulting in construction activities that may impact a single site for years
- Conflict between satisfying commercial concerns and residential concerns
- Need to undertake some construction activities at night
- Applicability of current guidance and policies and
- Work-from-home arrangements that were in place in Sydney from early 2020 to 2022 due to Covid.

Not only has this combination of events increased the potential pool of residents impacted by construction, it also has consequences for when to plan noisy or disruptive activities. This paper examines how this challenge was addressed and compares the expectation of residents exposed to noise and vibration impacts against anticipated responses.

2 PROPENSITY OF A PROJECT TO CAUSE NOISE ANNOYANCE

During the assessment phase of the project, the then Department of Planning and Environment (DPE; now Department of Planning, Housing and Infrastructure) raised significant concerns regarding the long-term impacts associated with the planned construction activities, which were scheduled to span more than seven years. State Significant Infrastructure (SSI) projects such as metro rail projects, are largely determined on a concept plan rather than a fully developed program of works. While this approach was accepted, it remained unclear when and how such a long duration project would begin to trigger adverse community annoyance. Moreover, DPE recognised that existing guidance and management of construction as provided in the Interim Construction Noise Guideline (ICNG) (EPA, 2009) may not reflect the constraints and opportunities for the highly urbanised Sydney CBD (DPE, 2016).

The impacts of noise on human health are well documented (Berglund et al., 1999; Seidman & Standring, 2010), but what is less well understood is what factors result in adverse comments being made. In this respect, the successful management of community concerns requires not only ensuring that noise is minimised and approved levels are observed, but that the non-acoustic factors are also addressed to the greatest extent possible. Whilst it is beyond the scope of this paper to examine these factors in more detail, some discussion on the two key considerations is provided below:

2.1 Direct noise impacts

Key noise sources and issues for the project were identified as:

- Demolition
- Excavation of station boxes
- Noise and vibration from TBM operation
- Material removal, including the haulage

- Delivery of building products and structures
- Realignment of utilities and public domain works
- Station construction and fitout
- Construction of over-station development and
- Construction impact fatigue in the community.

2.2 Non-acoustic factors

Noise annoyance is a very subjective perception, as evidenced by dose-response studies and the varying objectives set in guidelines for different noise sources, such as roads, rail, aircraft, industry, windfarms and construction (Miedema and Oudshoorn, 2001, etc.). Whilst much of the variation in response can be attributed to characteristics of the noise and other psychoacoustic factors, there are also a number of non-acoustic drivers. These include the time and duration of the noise, ideological support or otherwise for the project or noisemaker, impact on property values, etc. that are important non-acoustic factors which all contribute to community annoyance (Parnell and Wassermann, 2014; Schromer, 2005).

3 RELEVANT POLICIES AND GUIDELINES

3.1 Limitations and gaps in NSW

Noise guidance documents in NSW allow for a variance in the community acceptance of noise depending on the source, such as aircraft, road transport, rail transport, industry, and construction by setting different objectives for each. Notwithstanding, it is recognised that no practical level of noise will satisfy everyone in a community. Consequently, noise objectives in NSW and across Australia are typically designed to protect 90% of the population from being highly annoyed 90% of the time (EPA, 2017). It is therefore expected that a section of the community will experience levels of annoyance at some point by a project, and that adverse feedback is a consequence. It is how this annoyance and any compounding non-acoustic factors are minimised, that defines best practice.

The most relevant guidance on construction noise in NSW is provided in the *Interim Construction Noise Guideline* (ICNG), a non-mandatory guidance document released by the EPA in 2009. The ICNG largely sought to address issues of the day, with a focus on major upgrade works on the Pacific Highway between Newcastle and the Queensland border. These roadworks were being undertaken in regional and rural settings, with little need for night time construction. In contrast, night works were required for maintenance works on transport infrastructure in Greater Sydney, where road or rail possession were required. These works would typically be transient or only occur for periods of two or three nights and were managed by internal protocols such as the Construction Noise Strategy (TIDC, 2007) and the Environmental Noise Management Manual (RTA, 2001). These documents have since been superseded respectively by recent Transport for NSW documents (TfNSW, 2023; 2024).

The major central Sydney transport building program that began around 2012 required a very different approach to construction, with road possessions and construction spoil haulage necessitating significant work during the night and weekends. Many of these projects involved tunnelling under the city or harbour with the removal of spoil material being a significant task that needs to occur 24 hours a day. As a result, activity around truck marshalling sites and tunnel portals is constant and may occur for several years. When combined with significant private and commercial development, (it is reported that in early 2019 more than 300 cranes were operating in Greater Sydney with 107 in Inner Sydney (RLB Crane Index, 2019)), the potential for large areas of the CBD and surrounds to be exposed to ongoing construction noise is high.

A consequence of this high level of sustained construction activity has been that some receivers are not only experiencing night-time construction activity for the extent of a major project, but they may be experiencing construction fatigue from sequential construction work affecting the same impacted receivers. This is not a scenario that the existing regulatory guidance contemplated and therefore there was a need to examine whether the current guidance and regulatory tools were managing the impacts of construction noise appropriately whilst supporting the development of a modern global city.

The ICNG sets idealised noise objectives relative to the existing background level for standard working daytime hours (background rating background levels L_{eq} plus 10 dB) but is largely silent on recommended night time levels although it is inferred that background rating level plus 5 dB is acceptable.

3.2 Unique Conditions and Requirements

As a result of concerns regarding the appropriateness of the ICNG providing a pragmatic guidance on the management of construction noise for the Sydney Metro projects (DPE, 2016), the Department issued conditions

(DPE, 2017) which utilised the flexible nature of the ICNG (EPA, 2020). In particular, and in recognition that the glazing provided in high rise apartment buildings provide a very different façade transmission loss than was assumed in the ICNG, the Department developed conditions as follows:

- preparation of a construction noise and vibration strategy setting out how the proponent will meet the requirements in the planning approval
- permission to work outside the recommended standard hours where there is a negotiated agreement with a 'substantial majority' of affected receivers
- requirement to appoint a suitably qualified and experienced independent acoustics advisor to, principally, review all noise and vibration plans, assessments and reports; make recommendations for improvements to manage noise, as appropriate; and oversee implementation of all noise and vibration requirements.

With these best practice measures in place, the Department made three key departures from previous SSI approvals as summarised below:

- There was a move from a relative background (i.e. rating background level + 10 dB), to an absolute noise level (i.e. 65 dB(A))
- Noise level objectives were based on internal levels rather than external façade levels
- There was recognition that even with all feasible and reasonable noise mitigation, there would be periods when it was unrealistic to set unachievable noise objectives. Rather, other measures ensuring best practice were favoured over the setting of noise levels.

Condition E38 of Sydney Metro City & Southwest - Chatswood to Sydenham (SSI 7400) project approval set internal noise objectives of:

- a) $L_{eq, 15 \text{ minute}} 60\text{dB(A)}$ inclusive of a 5dB penalty if rock breaking or any other annoying activity likely to result in ground-borne noise or a perceptible level of vibration is planned between 7am–8pm for more than 50 percent of the time; and
- b) $L_{eq, 15 \text{ minute}} 55\text{dB(A)}$ inclusive of a 5dB penalty if rock breaking or any other annoying activity likely to result in ground-borne noise or a perceptible level of vibration is planned between 7am–8pm for more than 25 percent of the time.

This condition is not applicable where an agreement is reached with affected receivers or to noise generated by a tunnel boring machine as it passes beneath receivers. It also contains the following provision to require that:

... noise levels be less than $L_{eq, 15 \text{ minute}} 60\text{dB(A)}$ for at least 6.5 hours between 7am–8pm, of which at least 3.25 hours must be below $L_{eq, 15 \text{ minute}} 55\text{dB(A)}$. Noise equal to or above $L_{eq, 15 \text{ minute}} 60\text{dB(A)}$ is allowed for the remaining 6.5 hours between 7am–8pm.

Furthermore, Conditions E41 and E42 required the proponent to ensure that:

residential receivers, located in non-residential zones, likely to experience an internal noise level exceeding $L_{eq, 15 \text{ minute}} 60\text{dB}$ between 8pm–9pm or $L_{eq, 15 \text{ minute}} 45\text{dB}$ between 9pm–7am (inclusive of a 5dB penalty if rock breaking or any other annoying activity likely to result in regenerated noise, or a perceptible level of vibration is planned [including works associated with utility adjustments]) must be offered additional mitigation.

... residential receivers in residential zones likely to experience an internal noise level of $L_{eq, 15 \text{ minute}} 45\text{dB}$ or greater between 8pm–7am (inclusive of a 5dB penalty if rock breaking or any other annoying activity likely to result in ground-borne noise, or a perceptible level of vibration is planned [including works associated with utility adjustments]) must be offered additional mitigation.

The EPA concluded (EPA, 2020) that the above conditions appropriately sought to balance the need for major construction works in the vicinity of commercial and residential premises in and around Sydney's CBD with respite periods for amenity. The EPA then went on to adopt this project as a case study, where there is no ideal solution where construction works can be undertaken without causing disruption. It found that the respite periods and noise management levels sought to minimise the total duration of construction at any one location while managing noise impacts on sensitive receivers. The case study emphasised the flexibility of EPA's guidance to identify the selection of feasible and reasonable mitigation (subject to justification), rather than focusing on meeting specified noise management levels on a case-by-case basis.

Collectively, these conditions normalised the external levels of façade noise exposure by around 20 dB higher and increased standard construction hours by 2 hours beyond what would have been typically advocated by the ICNG.

3.3 Best Practice

The Approval also required Sydney Metro to commit to a range of 'best practice' noise and vibration initiatives. In particular Condition E35 required that:

The Proponent must review alternative methods to rock hammering and blasting for excavation as part of the detailed construction planning with a view to adopting methods that minimise impacts on sensitive receivers. Construction Noise and Vibration Impact Statements must be updated for each location or activity to adopt the least impact alternative in any given location unless it can be demonstrated, to the satisfaction of the AA, why it should not be adopted.

To satisfy this condition, Sydney Metro employed the following strategies:

- Concrete shears to replace jack hammering where possible
- Acoustic Advisor (AA) role established
- Prepare detailed and justified site specific work statements
- Acoustic sheds constructed over station boxes
- Comprehensive community communication and consultation across the project.
- Adoption of a respite strategy to minimise continuous and extended night works, consistent with NSW EPA noise management guidance and endorsed by the Acoustic Advisor
- Implementation of standard mitigation measures for public domain works, including the use of noise blankets, acoustic tents, and careful scheduling to minimise community impacts.

4 PROJECT PERFORMANCE

4.1 Predicted Impacts vs Actual Impacts

As discussed in Section 2, there were serious concerns regarding the level and duration of construction noise impacts being predicted. The concerns were such that the Department requested a detailed case study be undertaken at two sites to allow it to better understand the predicted impacts. Whilst there is currently a separate review being undertaken to assess how well the predictions of construction noise matched actual impacts; this has not yet been completed. Nevertheless, it can be stated that construction of the city section of the project employed one of the the most contemporary and comprehensive noise mitigation practices and communication strategies of any project in NSW to date.

4.2 Community submissions

Sydney Metro assigned a dedicated communications and engagement team to manage the interface with the community, inform on project progress and understand local issues. Importantly, the team was responsible for responding to community concerns/enquires, particularly if systemic issues or opportunities to improve were identified.

4.3 Record of Adverse Comments

For the purposes of recording adverse comments, the communications and engagement team refers to Sydney Metro's internal *Construction Complaints Management System* (Sydney Metro, 2017). This document classifies complaints into two categories for reporting purposes (for all types of complaints i.e. noise, parking, sediment control etc.).

- Unavoidable complaints - this includes a stakeholder's opposition to the project or government policy or complaints about issues that are within project planning approvals. For example:
 - A complaint about noise generated at night when planning approval has been granted for night works and noise generated is within approved criteria.
- Avoidable complaints. - complaints about issues outside planning approval, or a commitment that has been given to the community or stakeholders. These commitments may be contained in staff inductions or written notifications. For example:
 - A complaint about noise at night where work is being performed outside of approved (or notified) construction hours or approved noise levels.

Whilst there are only two main categories and it was not intended to provide for more granular categorisation, there is generally enough additional information captured in the system to allow for some generalised sub-categorisation that can assist in better understanding and predicting the level of community comment on a project during its construction phase. This is the core objective of this paper with a focus on the city section of Sydney Metro City & Southwest project.

4.4 Data Analysis

The graph presented in Figures 2 and 3 show that respectively, 253 and 423 adverse comments were made about construction noise during standard construction hours (nominally 7am – 6pm Monday – Saturday) and out-of-hours works (nominally Sundays and from 6pm – 7am on all days) across the city section between 2017 and the opening in 2024. The peaks in adverse comments recorded in 2021 and 2022 correspond with the peak construction period for the City section of the project. This phase involved intensive works, including station box excavation which was initially undertaken primarily in standard hours before moving to include a night time component when acoustic sheds were erected and 24 hour spoil removal occurred at some locations. The data from both graphs clearly reflects this increase in community interaction and resultant peak of around 95 adverse comments related to standard hours work recorded in 2021, and a peak of around 120 adverse comments related to out-of-hours works recorded in 2022.

It should be noted that whilst standard hours generally occurred at every work site 6 days per week, Work was not always regularly scheduled for the out-of-hours times, or at every site. Consequently, whilst a much lower percentage of construction was undertaken outside of standard hours, it still elicited more adverse comments which is reflective of the greater sensitivity of the community to noise and vibration impacts during evenings, nights, and weekends which are periods when there is an expectation of a higher level of noise amenity. As construction activities began to scale down approaching project completion, a notable decline in comments across all categories was observed. This downward trend in 2023 and 2024 aligns with the reduction in high noise works.

Across both standard and out-of-hours works, General Noise and Vibration were the most frequently cited comment category, reflecting the broader sensitivity of the community to construction noise. These comments typically refer to general disturbances without identifying a specific source and are often linked to overall construction activity. However, in 2021 and 2022, there can be seen a notable increase in comments specifically attributed to Plant and Equipment, indicating a shift where community members were not only affected by noise but also more aware of, and more likely to report the specific sources of that noise. During standard hours, Plant and Equipment comments often referenced jackhammering, saw cutting, vacuum trucks, and the use of tonal alarms as common sources of disturbance. These are distinct from general noise comments, as they indicate that the community was able to identify particular machinery or operations contributing to the impact. This shift may suggest increased transparency of construction activities due to station box works during daylight hours or greater attentiveness due to prolonged exposure. For out-of-hours works, the trend continues but with even greater sensitivity. Adverse comments in this category frequently cited jackhammering, use of beepers and alarms, generators, crane operations, vacuum trucks, and two-way radios. These types of equipment were potentially perceived as more disruptive during evenings and overnight periods when background noise levels are lower, and community expectations for an improved amenity are higher.

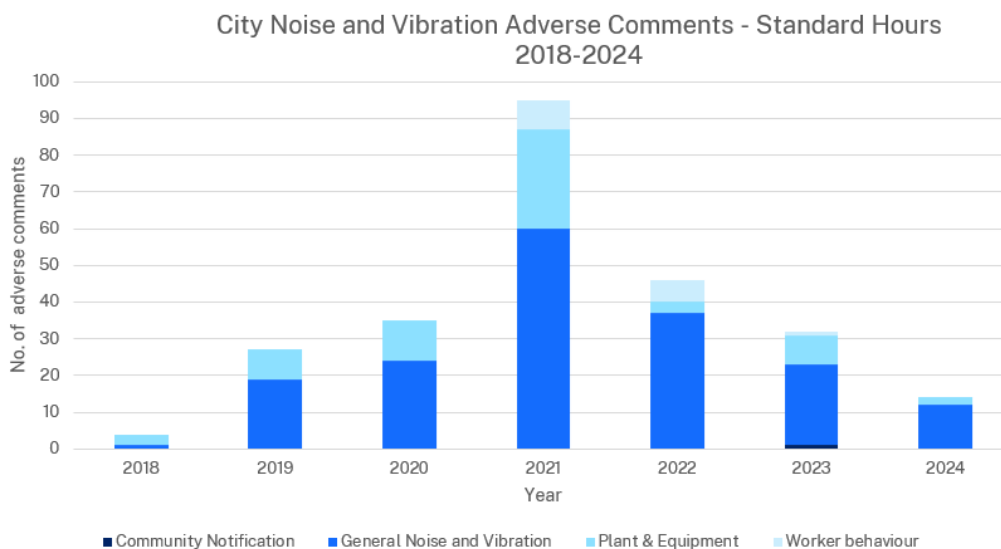


Figure 2. Total adverse comments received on the city section of the Sydney Metro City & Southwest project by subcategory during standard Construction Hours.

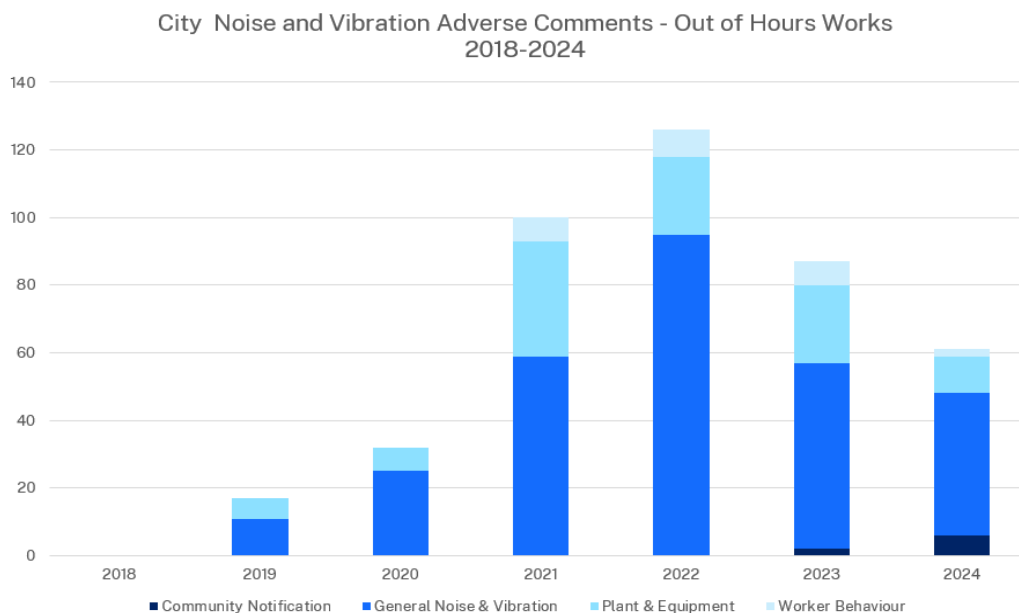


Figure 3. Total adverse comments received on the city section of the Sydney Metro City & Southwest project by subcategory during OOH Works.

Importantly, a large proportion of noise and vibration adverse comments across both periods were assessed and found to be associated with unavoidable works as follows.

- 216 (85%) of adverse comments during standard hours were deemed unavoidable, indicating that activities generating noise were necessary and conducted in compliance with approved conditions.
- Similarly, 353 (83%) of adverse comments related to out-of-hours works were also assessed as unavoidable, due to factors such as safety, access restrictions, or operational requirements that mandated works occur outside normal hours.

Noise and vibration adverse comments deemed to be avoidable that were received across standard hours and out of hours were 37 (15%) and 71 (17%) respectively indicating a low incident of noisy works that could potentially have been avoided. Whilst noise and vibration was expected to be the source of the majority of community comments, it also needs to be recognised that it is one of the environmental outcomes that was always going to be more difficult to anticipate and proactively manage (Parnell, 2023) despite the implementation of best management practices.

5 SUMMARY

The data presented in this paper show that whilst noise related comments may have constituted the largest category of community submissions on the project when considered in more detail, it can be seen that a high proportion of those comments relate to events classified as ‘unavoidable’, with those classified as ‘avoidable’ being a much smaller subset. Unavoidable events are those which did not exceed noise objectives or were expected impacts for which acceptable feasible and reasonable mitigation measures were provided. The data also shows that despite providing very good communications regarding upcoming noisy works, there will be significant numbers of adverse comments regarding the impact of noise even though in greater than 83% of cases, the levels were found to be within the predicted and approved levels. To this extent it is evident that there is a disconnect between the expectations of the community and the practical reality of delivering large infrastructure projects in close proximity to residents. Whilst it is difficult to estimate the number of receivers impacted by construction noise over the course of the project, the noise catchments for the project contained several thousand residents who were exposed to varying levels and duration of noise impact at some point. When considering the objectives of noise guidance documents (such as EPA, 2017) and expectations of protection from being highly annoyed, the project received much less adverse comment regarding noise and vibration than was anticipated.

To achieve this result, the project implemented significant construction noise mitigation measures and technology and had very good oversight via having acoustic advisors to ensure that good practice was continually assessed,

and regulatory noise objectives were enforced. This approach resulted in what was considered a low number of adverse comments. When investigated in more detail, it was shown that the vast majority of these adverse comments related to noise impacts which had been considered in full and were well within expectations. This outcome demonstrates the combined effectiveness of pragmatic approval conditions, mitigation measures employed, and community engagement strategy undertaken in mitigating construction noise and vibration impacts in a CBD environ, and provides a best practice template for future projects.

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REFERENCES

- ABS. 2021. *2021 Census*. Australian Bureau of Statistics. Canberra, Australia.
- Berglund, B., Lindvall, T. and Schwela, D. H. (Eds.). 1999. *Guidelines for Community Noise*. London: World Health Organization (WHO).
- DPE. 2016. *State Significant Infrastructure. Sydney Metro City & Southwest Chatswood to Sydenham. Environmental Assessment Report. SSI 15_7400*. NSW Department of Planning and Environment. <https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSI-7400%2120190227T104333.614%20GMT>
- DPE. 2017. *State Significant Infrastructure. Sydney Metro City & Southwest Chatswood to Sydenham. Conditions of Approval. SSI 15_7400*. NSW Department of Planning and Environment. <https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSI-7400%2120190227T104332.940%20GMT>
- Miedema, H.M. and Oudshoorn, C. G. 2001. Annoyance from transportation noise: relationships with exposure metrics DNL and DENL and their confidence intervals. *J. Env. Health. Perspectives*. 109(4), 409-16.
- NSW EPA. 2006. *Assessing Vibration: a Technical Guideline*. Department of Environment and Conservation. Sydney, Australia.
- NSW EPA 2009. *Interim Construction Noise Guideline*. Environment Protection Agency. Sydney, Australia.
- NSW EPA 2017. *Noise Policy for Industry*. Environment Protection Agency. Sydney, Australia.
- NSW EPA. 2020. *Draft Construction Noise Guideline*. EPA. <https://www.epa.nsw.gov.au/sites/default/files/20p2281-draft-construction-noise-guideline.pdf> Last accessed 2025-10-29.
- Parnell, J. and Wassermann, J. 2014. Communicating the noise message. *Proc. Inter-noise 2014 Conf*. Melbourne, Australia.
- Parnell, J. 2023. Challenges in predicting and managing construction noise impacts in urban environments. Case studies from Sydney, Australia. *Proc. Inter-noise 2023 Conf*. Tokyo, Japan.
- Rider Levett Bucknall. 2017. *RLB Crane Index*. <https://www.rlb.com/oceania/> Last accessed 2019.
- RTA. 2001. *Environmental noise management manual*. Roads and Traffic Authority, NSW, Sydney.
- Schomer, P.D. 2005. Criteria for assessment of noise annoyance. *Noise Control Eng. J.* 53(4), 132-144.
- Seidman, M.D. and Standing, R.T. 2010. Noise and quality of life. *Int. J. Environ. Res. Public Health*. 7(10) 3730-8.
- Sydney Metro 2017. *Construction Complaints Management System* (internal document SM-17-00000248).
- Sydney Metro 2017. *City and Southwest, Sydenham to Bankstown Environmental Impact Statement. Technical Paper 2: Noise and vibration assessment*. Transport for NSW. <https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSI-8256%2120190228T022149.914%20GMT> Last accessed 2025-10-29.
- TfNSW. 2023. *Construction Noise and Vibration Guideline Public Transport Infrastructure*. <https://www.transport.nsw.gov.au/system/files/media/documents/2024/EMF-NV-GD-0060-Construction-noise-and-vibration-guideline-public-transport-infrastructure.pdf>
- TfNSW. 2024. *Construction Noise and Vibration Guideline (Roads)*. https://www.transport.nsw.gov.au/system/files/media/documents/2024/EMF-NV-GD-0056_Construction_%20Noise_and_Vibration_Guideline%20_Roads_0.pdf
- TIDC. 2007. *Construction noise strategy*. Transport Infrastructure Development Corporation, NSW, Sydney.