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10 July 2017

Ref: CNVIS-Chatswood

Dear Stuart

**RE: Endorsement of Construction Noise and Vibration Impact Statement –
Chatswood Site, Sydney Metro City & Southwest**

Thank you for providing the following documents for Environmental Representative (ER) review and endorsement as required by the Condition of Approval E82 of the Sydney Metro City & Southwest project (SSI – 15_7400 January 9 2017).

- Construction Noise and Vibration Impact Statement (CNVIS) – Chatswood Site, (Revision D dated 7 July 2017).
- Acoustic Advisor (AA) Endorsement (of the above document) dated 10 July 2017

As an approved ER for the Sydney Metro City & Southwest project, I have reviewed the above document for its suitability for implementation. The review did not comprise a technical review, as the ER has relied upon the AA's review of technical aspects of the document. On the basis of the endorsement of the document by the AA, the ER endorses the document subject to the conditions of the AA endorsement being complied with.

Yours sincerely



Michael Woolley
Environmental Representative – Sydney Metro – City and South West

**ENDORSEMENT
CITY & SOUTHWEST ACOUSTIC ADVISOR**

Review of	CNVIS for Delta demolition works at Chatswood	Document reference:	Construction Noise & Vibration Impact Statement CHATSWOOD
Prepared by:	Dave Anderson (Acoustic Advisor) and Sav Shimada (Alternate Acoustic Advisor)		prepared by Osterman Consulting for Delta Pty Ltd
Date of issue:	10 July 2017		Report number 0116-041-02, Rev D

As approved Alternate Acoustic Advisor for the Sydney Metro City & Southwest project, I have reviewed and provided comment on the Construction Noise and Vibration Impact Statement for the Delta demolition works at Chatswood, as required under A27 (d) of the project approval conditions.

Dave Anderson, Acoustic Advisor, has met with Osterman Consulting to discuss earlier drafts of the impact statement and to discuss his formal comments. The impact statement has been revised to address those comments, but the applicable vibration criterion for the heritage Mowbray House building has not yet been established (pending confirmation of the structural condition of the building). I note that the structural assessment of Mowbray House is a requirement of the EIS approach for determining an appropriate vibration limit for this heritage structure.

My endorsement is therefore subject to a precautionary approach, with an interim vibration criterion of 2.5mm/s (consistent with section 3.1.9.2 of the Noise and Vibration Technical Paper in the EIS) and attended vibration monitoring during site trials of any high vibration activity (such as hammering) to determine safe working distances. After a structural engineering assessment of Mowbray House has taken place, there will be an opportunity to review and potentially increase the applicable vibration limit at this location.



Sav Shimada, City & Southwest (Alternate) Acoustic Advisor, on behalf of Dave Anderson



Construction Noise & Vibration Impact Statement

CHATSWOOD

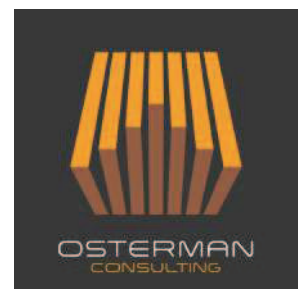
Sydney Metro

Prepared for: Delta Group

7 July 2017

Report number: 0116-041-02

Prepared by: Mark Della Sabina & Rauf Osterman



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Report Revision History				
Rev no.	Date	Description	Prepared by	Reviewed by
A	26/01/2017	Initial Draft	Mark Della Sabina	Rauf Osterman
B	21/02/2017	General update and revision following review by Delta and Project AA	Mark Della Sabina	Rauf Osterman
C	25/06/2017	Updated to incorporate comments from ER dated 21/02/2017 and additional comments from Project AA dated 13/02/2017.	Mark Della Sabina	Rauf Osterman
D	07/07/2017	Updated to incorporate comments from ER dated 03/07/2017 and additional comments from Project AA dated 03/07/2017.	Mark Della Sabina	Rauf Osterman

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1. Introduction

1.1 Context

This Construction Noise and Vibration Impact Statement (CNVIS) has been developed for Delta Pty Ltd (Delta) to assess the noise and vibration impacts associated with demolition and retention works at the Chatswood site (the site) on the Sydney Metro City & Southwest Project (the project). This CNVIS exists as a sub-plan to the Construction Noise and Vibration Management Plan 0116-041-01 (CNVMP) for the project.

The principal issues addressed within this CNVIS include:

- Identification of noise sensitive receivers near to the site;
- Prediction of the level of noise and vibration impact on these sensitive receivers from construction activities including assessment of predicted compliance with project-imposed Noise and Vibration Management Levels;
- Details of the plant and equipment to be used on site including details of sound mitigation measures to be employed to reduce noise impacts on adjacent noise sensitive receivers.

1.2 Site Overview

The Chatswood site is located south of Chatswood Station and north of Mowbray Road adjacent to the T1 North Shore Line at Chatswood. It borders the Pacific Highway, Mowbray Road and Nelson Street. Works on the site involve demolition of a number of low-rise commercial buildings. The site will be used to launch two Tunnel Boring Machines (TBM's) necessitating the construction of two dive structures and tunnel portals on the site.



Figure 1: Chatswood Site Overview

Structures to be demolished and those that are to be retained are highlighted in Figure 2 below.



Figure 2: Chatswood Retained Structures

1.3 Site Layout and Access

Site layout and access is illustrated in Figure 3 below.



Figure 3: Chatswood Site Layout and Access

2. Applicable Criteria

2.1 Airborne Noise Management Levels

Noise Management Level's (NML's) on this site are assessed under the broader requirements of the approval conditions which are consistent with the EIS and CNVS and based on the Interim Construction Noise Guideline (ICNG). The NML's applicable to Delta's scope of works on this site are outlined in Table 1.

Table 1. ICNG Noise Criteria		
Time of Day	Management Level $L_{Aeq} (15 \text{ min})^*$	How to apply
Recommended standard hours: Monday to Friday 7am to 6pm Saturday 8am to 1pm No work on Sundays / Public Holidays	Noise affected RBL + 10 dB	The noise affected level represents the point above which there may be some community reaction to noise. <ul style="list-style-type: none"> Where the predicted or measured $L_{Aeq} (15 \text{ min})$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75 dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. <ul style="list-style-type: none"> Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: <ol style="list-style-type: none"> times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5 dB	<ul style="list-style-type: none"> A strong justification would typically be required for works outside the recommended standard hours. The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community. For guidance on negotiating agreements see section 7.2.2.

*Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5 m above ground level. If the property boundary is more than 30 m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 m of the residence. Noise levels may be higher at upper floors of the noise affected residence.

For the purpose of establishing construction Noise Management Levels in accordance with Table 1, RBL's have been based on updated noise monitoring conducted by Osterman Consulting during May to July 2017.

Unattended noise monitors were placed at 4 locations around the Chatswood site for a minimum period of one week. The location of unattended noise monitors are shown on the site plans in Appendix B. The results of the unattended noise survey and the resultant NML's for the Site are summarised in Table 2.

Table 2. Rating Background Levels				
Location	Monday to Friday (7am - 6pm)		Saturday (8am - 1pm)	
	RBL	NML L_{Aeq} (15 min)	RBL	NML L_{Aeq} (15 min)
2 Nelson St	48	58	48	58
15 Nelson St	53	63	49	59
Mowbray House	58	68	57	67
Great Northern Hotel	61	71	61	71

Other Sensitive Land Uses

The project specific L_{Aeq(15minute)} NML's for other non-residential noise sensitive receivers from the ICNG are provided in Table 3.

Table 3. ICNG Noise Criteria for 'Other' Sensitive Receivers	
Land Use	Management Level L_{Aeq} (15 min) (Applied when the land is in use)
Classrooms at schools and other education institutions	Internal noise level of 45dB(A)
Hospital wards and operating theatres	Internal noise level of 45dB(A)
Places of worship	Internal noise level of 45dB(A)
Active recreation areas (characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion)	External noise level of 65dB(A)

Table 3. ICNG Noise Criteria for ‘Other’ Sensitive Receivers

Land Use	Management Level L_{Aeq} (15 min) (Applied when the land is in use)
Passive recreation areas (characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, e.g. reading, meditation)	External noise level of 60dB(A)
Community centres	Depends on the intended use of the centre. Refer to the recommended ‘maximum’ internal levels in Australian Standard 2107 – Acoustics – Recommended design sound levels and reverberation times for building interiors for specific uses.

Other noise-sensitive businesses require separate project specific noise goals. The Interim Construction Noise Guideline recommends that the internal construction noise levels at these premises are determined based on the ‘maximum’ internal levels presented in AS 2107. These recommended ‘maximum’ internal noise levels are provided in Table 4.

Table 4. AS2107 Noise Criteria for ‘Other’ Sensitive Receivers

Description	Time Period	AS2107 Classification	Recommended ‘Maximum’ Internal L_{Aeq} (15 min)
Hotel	Daytime and evening	Bars and lounges	50
	Night-time	Sleeping areas (hotels near major roads)	40
Cafe	When in use	Coffee bar	50
Bar/Restaurant	When in use	Bars and lounges / Restaurant	50
Library	When in use	Reading areas	45
Recording studio	When in use	Music recording studios	25
Theatre / Auditorium	When in use	Drama theatres	30

Commercial and industrial premises

NMLs for commercial and industrial premises have been set based on the Interim Construction Noise Guidelines. For commercial premises, including offices, retail outlets and small commercial premises an external NML of $L_{Aeq}(15 \text{ minute})$ 70 dBA has been adopted. An external NML of $L_{Aeq}(15 \text{ minute})$ 75 dBA has been

adopted for industrial premises. For both land use types, the external noise levels should be assessed at the most affected occupied point on the premises.

Notwithstanding the above, at no time can noise generated by construction exceed the National Standard for exposure to noise in the occupational environment of an eight-hour equivalent continuous A-weighted sound pressure level of $L_{Aeq,(8h)}$, of 85dB(A) for any employee working at a location near the CSSI.

2.2 Ground-borne Noise Management Levels

Ground-borne Noise Management Levels for residential receivers are provided in Table 5.

Table 5. ICNG NML's for Ground-borne Noise	
Land Use	Noise Management Level L_{Aeq} (15 min)
Daytime 7am - 6pm	Internal noise level of 45dB(A)
Evening 6pm - 10pm	Internal noise level of 40dB(A)
Night-time 10pm - 7am	Internal noise level of 35dB(A)

2.3 Construction Vibration

Condition E28 of the Conditions of Approval for the project stipulate that vibration from construction activities shall not exceed the vibration limits set out in the British Standard BS 7385-2:1993 Evaluation and measurement for vibration in buildings. Guide to damage levels from ground-borne vibration.

British Standard 7385: Part 2 1993 suggests levels of vibration at which 'cosmetic', 'minor' and 'major' damage may occur. This standard is based on data collated from a wide range of national and international sources which collectively saw relatively few cases of damage caused by vibration. BS7385 suggests that vibration levels up to the cosmetic damage level are considered 'safe' and have produced no observable damage for particular building types.

For the purposes of this standard, damage includes minor non-structural effects such as hairline cracks on drywall surfaces, hairline cracks in mortar joints and cement render, enlargement of existing cracks and separation of partitions or intermediate walls from load bearing walls.

BS7385 is based on peak particle velocity and specifies damage criteria for transient vibration within the range of frequencies usually encountered in buildings, being 4Hz to 250Hz. This criteria is reproduced in Table 6.

Table 6. BS7385: Part 2 Structural Damage Criteria

Group	Type of Structure	Damage Level	Peak component particle velocity, mm/s		
			4 Hz - 15 Hz	15 Hz - 40 Hz	40 Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	Cosmetic	50 (all frequencies)		
		Minor	100 (all frequencies)		
		Major	200 (all frequencies)		
2	Unreinforced or light framed structures Residential or light commercial type buildings	Cosmetic	15 to 20	20 to 50	50
		Minor	30 to 40	40 to 100	100
		Major	60 to 80	80 to 200	200

Where dynamic loading caused by continuous vibration may result in magnification of vibration through a building structure the guideline values may need to be reduced by up to 50 per cent. Rock breaking, rock hammering and sheet piling activities are considered to have the potential to cause dynamic loading in some structures (eg residences).

For construction activities involving intermittent vibration sources such as rock breakers, piling rigs, vibratory rollers, excavators and the like, the predominant vibration energy occurs at frequencies greater than 4 Hz (and usually in the 10 Hz to 100 Hz range). On this basis, and consistent with the guidance from BS 7385, the following conservative vibration damage screening level per receiver type have been adopted for the project:

- Reinforced or framed structures: **25.0 mm/s**
- Unreinforced or light framed structures: **7.5 mm/s**
- Heritage structures: **7.5mm/s**

Where vibration levels are predicted to exceed the screening criteria, a more detailed assessment of the structure and attended vibration monitoring would be carried out to ensure vibration levels remain below appropriate limits for that structure.

With regards to heritage items, BS7385 states that “a building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive”. Therefore any detailed assessment would specifically consider:

1. The structural condition of the building (in consultation with a structural engineer where required); and
2. The heritage values of the structure in consultation with a heritage specialist to ensure sensitive heritage fabric is adequately monitored and managed.

Derivation of suitable vibration limits for heritage structures shall consider the above and, where required, a suitable reduction factor applied based on industry best practice.

2.3.1 Warning Levels

The INFRA Monitoring System used on this project features a number of real time alerts and alarms that enable instant notification where limits are approached or exceeded. Where vibration-intensive works are planned to occur in close proximity to sensitive receivers, and works are expected to approach the limits for cosmetic damage, monitoring equipment shall be equipped with visual and/or audible alarms that are triggered when the levels of vibration exceed the control criteria presented in Table 7.

Table 7. Operator Warning and Halt Levels

Structure	Site Control Criteria (PPV in any Orthogonal Direction)	
	Operator Warning Level	Operator Halt Level
Reinforced or framed structures	20 mm/s	25 mm/s
Unreinforced or light framed structures	5 mm/s	7.5 mm/s
Heritage structures	5 mm/s	7.5 mm/s

3. Noise and Vibration Assessment

3.1 Sensitive Receivers

A full list of sensitive receivers surrounding the site are listed in Appendix A. A subjective classification of the noise & vibration impact has been evaluated for each sensitive receiver and documented as:

- Low Impact
- Moderate Impact
- High Impact

The classifications were determined on a case-by-case basis using the metrics defined in the CNVS, including:

- The location of the works in relation to the NSR's with consideration of the noise attenuation features such as distance to NSR's, noise barriers, attenuation factor of NSR's windows and elements, Topographical features etc.
- The type and sensitivity of the NSR's:
 - Lower impact: e.g. commercial buildings/scattered residential (low density)
 - Moderate impact: eg standard residential (typical density)
 - High impact: e.g residential home for elderly/high density unit blocks/persistent complainers/residents deemed to have "construction noise fatigue", highly sensitive commercial (jewellers, etc.) or health applications e.g. operating theatres, MRI's, Psychotherapy units, Audio & video production studios etc. and schools/childcare centres.
- Predicted noise and vibration levels and extent of noise exceedance above Noise Management Level
- The type of and intensity of noise emitted from works (ie tonal or impulsive):
 - Lower Impact: No high noise and/or vibration intensive activities
 - Moderate Impact: Short/intermittent high noise and/or vibration intensive activities
 - High Impact: Prolonged high noise and/or vibration intensive activities.
- The duration of any OOHW required.

Site plans illustrating the location of, and degree of impact to, sensitive receivers can be found in Appendix B.

3.2 Construction Activities and Sources of Noise

The degree of noise impact on adjacent sensitive receivers from demolition activities is highly dependent on the type and size of machinery used. In consultation with Delta, a list of the construction activities to be undertaken and the associated machinery is provided in Table 8.

Table 8. Construction Activities and Equipment Noise

Equipment	Number	Construction Activity	Assumed Sound Power* Level dB(A)
2T Excavators	2	Strip Out	88
20T Excavators w/hammer	1	Structural Demolition	118
47T Excavators w/hammer ⁺	2	Low Level Structural Demolition	119
20T Excavators w/hydraulic shears/pulverisers	1	Structural Demolition	104
Mustang Bobcats	3	Strip Out and Structural Demolition	110
Powered Hand Tools		Strip Out	100
Trucks	2	Haulage	105

* Sound power levels provided in the table above should be verified against specifications of actual equipment used onsite.

+ Proposed for use on lower levels only. Hoarding may provide up to 10dB reduction in predicted noise levels

3.3 Airborne Noise Predictions

Due to the significant number of sensitive receivers across the project, and for the purposes of reducing the required number of monitors, sensitive receivers with like characteristics have been grouped into 'noise catchment areas' (NCAs) that can be represented by a single monitor. For the purpose of simplicity, NCA's have been defined according to their general direction relative to the site.

Using the sound power levels stated in Section 3.2, predicted noise levels have been calculated for each NCA based on the distance between noise-emitting activities and the closest sensitive receivers for that location. These predictions assume that equipment is operating at the nearest point of works to the sensitive receiver and therefore represent worst-case scenarios. The predictions do not take into account any mitigation measures. Due to the staging of construction works and the expected spread of equipment across the full area of the site, cumulative noise impacts are expected to be minimal. Predicted noise levels are provided in Table 9 and are highlighted according to the following:

Exceeds Noise Affected Management Level

Exceeds Highly Noise Affected Management Level

Table 9. Predicted External Noise Levels

Equipment	Noise Prediction $L_{eq}(15 \text{ minute})$			
	North - Opp. Nelson St	East - Orchard Rd	South - Opp. Mowbray Rd	West - Opp. Pacific Hwy
2T Excavators	50	43	49	51
20T Excavators w/hammer	78	71	77	79
47T Excavators w/hammer	81	74	80	82
20T Excavators w/hydraulic shears/pulverisers	66	59	65	67
Mustang Bobcats	72	65	71	73
Powered Hand Tools	62	55	61	63
Trucks	67	60	66	68

The heritage listed Mowbray House is located at 339 Mowbray Rd and is surrounded on three sides by the demolition site. Noise criteria for this sensitive receiver is normally based on internal noise levels however in this instance, the building shall remain unoccupied during works and is therefore not considered to be noise-sensitive.

3.4 Ground-borne Noise

As demolition and retention works generally do not involve ground excavation, ground-borne noise is expected to be an issue only where sensitive receivers are directly coupled to the works (structure-borne noise). As there are no sensitive receivers directly coupled to the works, structure-borne noise is not expected to be of concern on the Chatswood site.

3.5 Vibration Predictions

Vibration at the nearest sensitive receivers (adjacent to the building foundation) has been estimated using the formula from the FTA's Guideline "Transit Noise and Vibration Impact Assessment".

$$PPV_{Receiver} = PPV_{Ref} \times \left(\frac{d_{ref}}{d} \right)^{1.5}$$

Where: $PPV_{Receiver}$ = peak particle velocity at the receiver in mm/s

PPV_{Ref} = peak particle velocity of the source, measured at the reference distance (7.6 m)

d_{ref} = reference distance for the vibration source (7.6 m)

d = horizontal distance from the source to the receiver (m)

The values of PPV_{Ref} are based on a review of current literature and are provided in Table 10 for reference.

Equipment	PPV @ 7.6m (mm/s)
2T Excavators	2.5
20T Excavators w/hammer	5.1
47T Excavators w/hammer	7.6
20T Excavators w/hydraulic shears/pulverisers	2.5
Mustang Bobcats	0.3
Powered Hand Tools	0.2
Trucks	1.9

The predicted levels of vibration at the nearest sensitive receivers are provided in Table 11. Note that:

- these predictions assume that equipment is operating at the nearest point of works to the sensitive receiver and therefore represent worst-case scenarios.
- these predictions represent maximum instantaneous levels for the purpose of assessing the likelihood of cosmetic damage and are not applicable for the assessment of human comfort which is measured as vibration dose values.

Equipment	Predicted PPV (mm/s)				
	North (Nelson St)	East (Orchard Rd)	South (Mowbray Rd)	West (Pacific Hwy)	Mowbray House
2T Excavators	0.3	0.1	0.2	0.4	1.7
20T Excavators w/hammer	0.7	0.2	0.5	0.8	3.4
47T Excavators w/hammer	1.0	0.3	0.7	1.1	5.0
20T Excavators w/hydraulic shears/pulverisers	0.3	0.1	0.2	0.4	1.7

Table 11. Predicted Ground Vibration

Equipment	Predicted PPV (mm/s)				
	North (Nelson St)	East (Orchard Rd)	South (Mowbray Rd)	West (Pacific Hwy)	Mowbray House
Mustang Bobcats	<0.1	<0.1	<0.1	<0.1	0.2
Powered Hand Tools	<0.1	<0.1	<0.1	<0.1	0.1
Trucks	0.2	0.1	0.2	0.3	1.3

The German Standard DIN 4150 Part 2 - 1975 presents information on the degree of human perception of various levels of motion. The threshold for 'noticeable' vibration is stated as 1mm/s, with 'easily noticeable' at 2.2mm/s. In light of this, and with reference to Table 11, it is evident that vibration from demolition works is not anticipated to be a significant issue on this site.

4. Noise and Vibration Management

4.1 Environmental Monitoring

Noise and vibration monitoring shall be undertaken using permanent installations at the nearest representative sensitive receivers around the site. Results from these monitors shall be reviewed on a weekly basis to ensure ongoing compliance. Where complaints are received, additional monitoring may be conducted at the specific location of complaint. Monitor locations are detailed in Table 12 and illustrated in Appendix B.

Table 12. Monitoring Locations

Property	Monitor Category	Installation Type	Location	
2 Nelson St	Noise & Vibration	Permanent	Carport	Representative monitor for compliance
15 Nelson st	Noise & Vibration	Permanent	Roof of garbage bin room	Representative monitor for compliance
Mowbray House	Vibration	Permanent	Western facade, foundation level	Representative monitor for compliance
	Noise	Permanent	Southern (street facing) facade	Representative monitor for compliance at apartments across Mowbray Rd
Great Northern Hotel	Noise & Vibration	Permanent	Eastern (street facing) - Lvl 1 above awning	Representative monitor for compliance

The number and location of monitoring points shall be reviewed after an initial period of 2 - 3 months. Where noise and vibration levels are negligible and, in consideration of the works still to be completed, those levels are not expected to increase for the remainder of the project, consideration shall be given to the removal of redundant monitoring points.

For further detail on environmental monitoring, refer to Section 6.3 of the CNVMP.

4.1.1 Heritage-listed Structures

Effective monitoring of heritage-listed structures can pose unique challenges where sensitive heritage fabrics are involved. CoA E31 stipulates that a heritage specialist shall provide advice regarding noise and vibration monitoring of heritage-listed structures. Such advice is provided in Appendix C.

4.2 Mitigation Measures

4.2.1 Standard Mitigation Measures

A range of standard noise and vibration mitigation measures shall be adopted on the site so as to minimise the impact of works on neighbouring sensitive receivers. These are outlined in Table 13. Where it is predicted that NML's will be exceeded even with the implementation of standard mitigation measures, additional mitigation measures shall be put in place (See Section 4.2.2).

Note that CoA E33 states that specific mitigation measures must be identified through consultation with affected sensitive receivers. On this site, the noise sensitive receivers are residential therefore standard hours are appropriate and no specific "sensitive periods" have been identified where provision for respite is required.

Table 13. Noise and Vibration Mitigation Measures			
No.	Control	Anticipated Noise Reduction	Timing
Administration			
NVM1	Conduct a site induction addressing the requirements of this CNVMP for all new personnel undertaking site activities	N/A	Prior to starting works
NVM2	Educate staff on noise and the impacts of workers activities on the noise environment	N/A	Prior to starting works / following noise complaints
NVM3	Develop a complaints handling procedure and respond to complaints	N/A	Prior to starting works / as required
NVM4	Conduct regular toolbox talks to reiterate the appropriate noise and vibration management methodologies	N/A	Periodically
Procedural			
NVM5	Turn off machinery when not in use	Up to 10 dB	Daily
NVM6	Conduct regular noise measurements in the vicinity of the site to assess compliance with noise criteria	N/A	As needed / following changes in activities

Table 13. Noise and Vibration Mitigation Measures

No.	Control	Anticipated Noise Reduction	Timing
NVM7	The coincidence of noisy plant working simultaneously close together would be avoided	Up to 10 dB	Daily
NVM8	Operate and maintain equipment according to manufacturers' specifications.	Up to 3 dB	Daily
NVM9	Do not use crane whistles, amplified external telephone ringers/ horns or alarms (excluding emergencies)	N/A	Daily
NVM10	Preference the use of the following in lieu of hydraulic hammers: <ul style="list-style-type: none">• hydraulic concrete shears• hydraulic concrete pulverisers• saw cutting and lifting	Up to 15 dB	At all times so far as is practicable
NVM11	Maximise offset of noisy plant to sensitive receivers as much as possible.	N/A	Where practicable
NVM12	Sequencing of demolition work to retain noise shields (walls, etc.) as long as possible ie floor by floor leaving the perimeter wall	5 to 15 dB	Where practicable
NVM13	Positioning of load out areas and dump chutes away from neighbouring walls and enclosing dump chutes	N/A	Where practicable
NVM14	Unless compliance with the relevant traffic noise criteria can be achieved, night time heavy vehicle movements at the Chatswood dive site, Crows Nest Station, and Victoria Cross Station and Waterloo Station sites would be restricted to: <ul style="list-style-type: none">• The Pacific Highway and Mowbray Road at the Chatswood dive site• The Pacific Highway, Hume Street and Oxley Street at the Crows Nest Station construction site• McLaren Street, Miller Street and Berry Street at the Victoria Cross Station construction site• Botany Road and Raglan Street at the Waterloo Station construction site.	N/A	Night time works only
NVM15	Where vibration levels are predicted to exceed the screening criteria, a more detailed assessment of the structure and attended vibration monitoring would be carried out to ensure vibration levels remain below appropriate limits for that structure. For heritage items, the more detailed assessment would specifically consider the heritage values of the structure in consultation with a heritage specialist to ensure sensitive heritage fabric is adequately monitored and managed.		Ongoing
Engineering			
NVM16	Use site offices, sheds as noise barriers during demolition works	5 to 15 dB	Prior to starting works
NVM17	Use equipment appropriately sized for each task.	Up to 2 dB	Daily
NVM18	Use a noise reduction kit on the jack hammer to limit its sound power level to 115 dBA.	6 dB per source	When selecting equipment

Table 13. Noise and Vibration Mitigation Measures

No.	Control	Anticipated Noise Reduction	Timing
NVM19	Use smart broadband reversing alarm on mobile equipment where possible.	2 to 5 dB	When selecting equipment
Hours of Work			
NVM20	Operate during standard work hours wherever possible	N/A	Daily
NVM21	Introduce respite periods and/or take smoke and lunch breaks when noisy equipment is operating close to the site boundaries.	N/A	Daily
NVM22	Demolition, Excavator works to be undertaken between 8am and 5pm, Monday to Friday (excluding breaks and respite periods).	N/A	Daily
NVM23	Delta will not undertake noisy works during 7am – 8am providing a respite period.	N/A	Daily
NVM24	No hard demolition works (unless required for safety measures) between 5pm and 6pm.	N/A	Daily
Site-Specific			
NVMCH1	All site access via Pacific Highway. No Delta vehicles or movements along Nelson St or Mowbray Rd	N/A	Daily

4.2.2 Additional Mitigation Measures

The Sydney Metro Construction Noise and Vibration Strategy outlines additional mitigation measures that shall be adopted where exceedance of imposed limits is expected, with the level of measure commensurate with the degree of exceedance.

The latest version of the strategy, as referenced in Section 6, outlines the following additional measures for works within standard construction hours:

Noise

- Letterbox Drops - Information to neighbours on expected duration of noise-intrusive activities
- Monitoring - Monitoring at the nearest affected sensitive receiver (may include attended monitoring where permanent monitors do not reflect the nearest affected sensitive receiver)

It is anticipated that these measures will be required where hammering activity approaches the boundaries of the site.

Vibration

None required

5. Conclusion

Given the proximity to occupied sensitive receivers, airborne noise will be the key environmental impact arising from demolition works on the Chatswood site while ground-borne vibration and noise are expected to be of minor impact. It has been identified that Noise Management Levels are likely to be exceeded where hammering activities approach the boundary of the site and can be mitigated by the use of hydraulic shears/pulverisers. Where this is not possible, additional mitigation measures will need to be adopted.

The heritage listed Mowbray House shall remain unoccupied during the works and is therefore not considered noise-sensitive. Providing demolition works are restricted to buildings on the site, ground vibration is expected to remain within the limits for cosmetic damage.

6. References

Additional guidelines and standards relating to the management of construction noise and vibration from this project include:

- NSW Interim Construction Noise Guideline (ICNG), Department of Environment and Climate Change 2009
- NSW Road Noise Policy, Dept. of Environment, Climate Change and Water 2011
- NSW Industrial Noise Policy, Environment Protection Authority 2000
- NSW Assessing Vibration – a technical guideline (AVTG), Department of Environment and Conservation 2006
- Australian Standard AS/NZS 2107:2000 Acoustics - Recommended design sound levels and reverberation times for building interiors
- Australian Standard 2834-1995 Computer Accommodation, Chapter 2.9 Vibration
- Australian Standard AS 2187.2 Explosives - Storage and use - Part 2 Use of explosives
- Australian Standard AS2436-1981 Guide to Noise Control on Construction, Maintenance and Demolition Sites
- British Standard BS 6472-2008, 'Evaluation of human exposure to vibration in buildings (1- 80Hz)
- British Standard 7385: Part 2-1993 'Evaluation and measurement of vibration in buildings'
- German Standard DIN4150-1999 Structural vibration Part 3: Effects of vibration on Structures
- Sydney Metro Construction Noise and Vibration Strategy, Report No. 610.14213-R3, Transport for NSW 2016
- Sydney Metro City and Southwest Environmental Impact Statement, Transport for NSW 2016
- Sydney Metro City and Southwest Submissions and Preferred Infrastructure Report, Transport for NSW 2016
- Sydney Metro City and Southwest Conditions of Approval, Department of Planning and Environment 2017
- Transit Noise and Vibration Impact Assessment, Federal Transit Administration 2006
- Environmental Noise Management Manual (ENMM), Roads and Traffic Authority 2001

Appendices

Appendix A - List of Sensitive Receivers

Property Number	Address	Business	Business Category	Distance	Impact		Sensitive Equipment
					Noise	Vibration	
1	522 Pacific Hwy	Great Northern Hotel	Public Buildings	29m	Moderate Impact	Low Impact	None
2	524- 542 Pacific Hwy	Grand Pacific Apartments	Residential Buildings	26m	Moderate Impact	Low Impact	None
3	544 Pacific Hwy	Residential	Residential Buildings	25m	Moderate Impact	Low Impact	None
4	546 Pacific Hwy	Real Flame	Shop Buildings	25m	Low Impact	Low Impact	None
5	552 - 554 Pacific Hwy	Demir Leather	Shop Buildings	30m	Low Impact	Low Impact	None
5	552 - 554 Pacific Hwy	Meira House	Residential Buildings	30m	Low Impact	Low Impact	None
6	621 - 627 Pacific Hwy	Sorento Terrace Apartments	Residential Buildings	53m	Low Impact	Low Impact	None
7	613 - 319 Pacific Hwy	Dulux Australia	Shop Buildings	31m	Low Impact	Low Impact	None
8	19 Nelson St	Residential	Residential Buildings	31m	Moderate Impact	Low Impact	None
9	17 Nelson St	Residential	Residential Buildings	28m	Moderate Impact	Low Impact	None
10	15 Nelson St	Residential	Residential Buildings	28m	Moderate Impact	Low Impact	None
11	9-11 Nelson St	Residential	Residential Buildings	30m	Moderate Impact	Low Impact	None
12	5 Nelson St	Residential	Residential Buildings	91m	Low Impact	Low Impact	None
13	3 Nelson St	Residential	Residential Buildings	99m	Low Impact	Low Impact	None
14	2 Nelson St	Residential	Residential Buildings	71m	Low Impact	Low Impact	None
15	12 Orchard St	Residential	Residential Buildings	90m	Low Impact	Low Impact	None
16	10 Orchard St	Residential	Residential Buildings	95m	Low Impact	Low Impact	None
17	8 Orchard St	Residential	Residential Buildings	92m	Low Impact	Low Impact	None

Property Number	Address	Business	Business Category	Distance	Impact		Sensitive Equipment
					Noise	Vibration	
18	6 Orchard St	Residential	Residential Buildings	82m	Low Impact	Low Impact	None
19	2 Orchard St	Residential	Residential Buildings	71m	Low Impact	Low Impact	None
20	340 Mowbray Rd	Residential	Residential Buildings	71m	Low Impact	Low Impact	None
21	342 Mowbray Rd	Residential	Residential Buildings	35m	Moderate Impact	Low Impact	None
22	344 Mowbray Rd	Residential	Residential Buildings	38m	Moderate Impact	Low Impact	None
23	348 Mowbray Rd	Ausgrid Substation	No Receivers	28m	No	Low Impact	None
24	366 Mowbray Rd	Sydney Water Storage Tanks	No Receivers	25m	No	Low Impact	Heritage
25	Cnr Pacific Hwy (500-520) And 3 Mowbray Road	Chatswood South Uniting Church	Public Buildings	57m	Moderate Impact	Low Impact	Heritage
26	339 Mowbray Rd	"Mowbray House"	No Receivers	10m	No	High Impact	Heritage

Appendix B - Monitoring Locations and Sensitive Receivers

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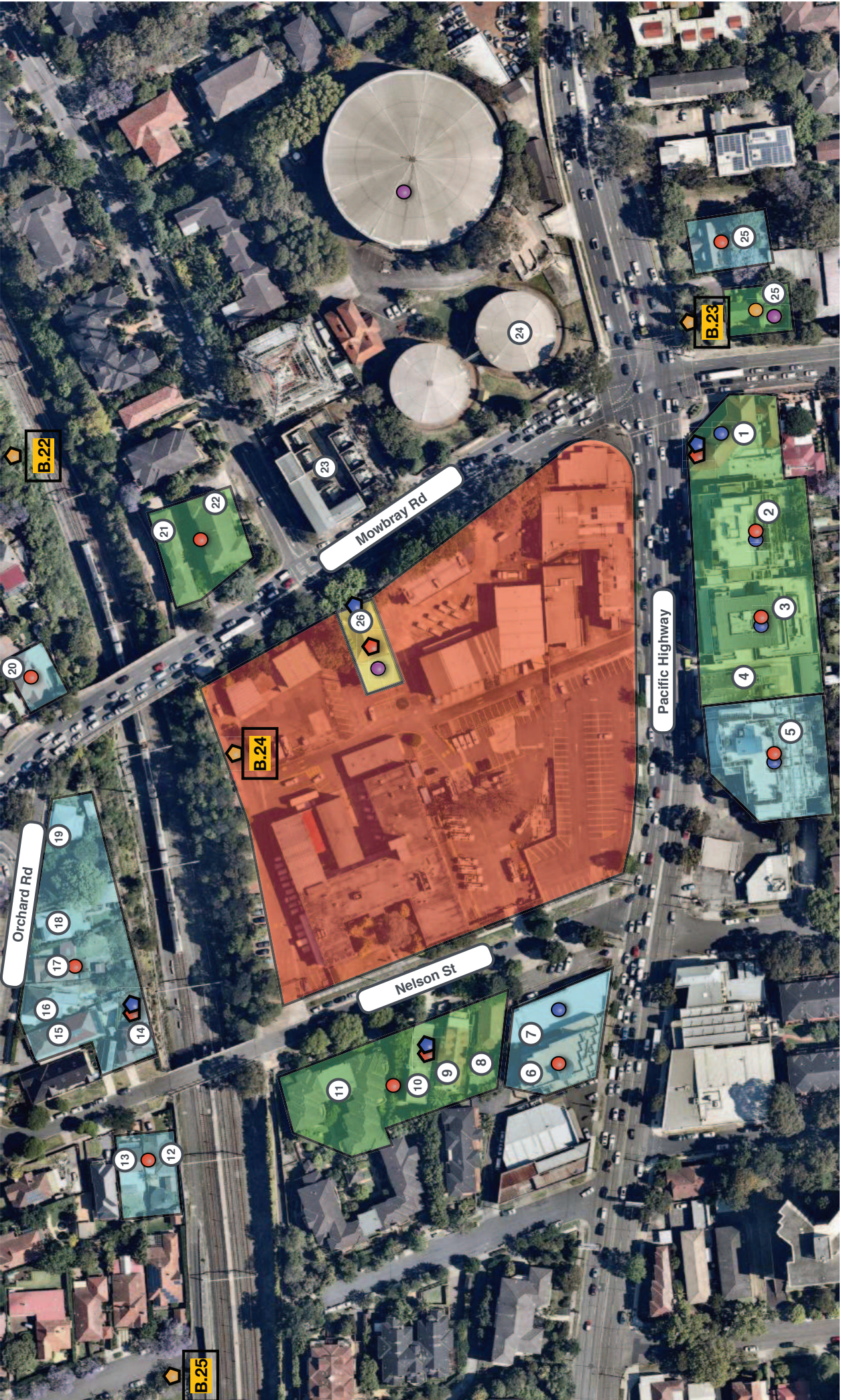
Sydney Metro Demolition - Chatswood Noise and Vibration Receivers & Land Uses

Date: 06/07/2017
 Created by: RO
 Report No: 0116 041 02

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Impact Category	Monitoring Category	Sensitive Receiver Category
Low Impact	Noise	Commercial
Moderate Impact	Regenerated Noise	Residential
High Impact	Vibration	Educational/Childcare
Demolition Zone	Noise & Vibration	Industrial
		Heritage
		Place of worship
		Property no.
		EIS RBL Location

Appendix C - Heritage Specialist Advice on Monitoring Methods and Locations

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MEMO



DATE: 5 May 2017

AMBS Ref: 16278 VM

TO: Rauf Osterman, Director Osterman Consulting

FROM: Jennie Lindbergh, Director Historic Heritage, AMBS Ecology & Heritage

SUBJECT: Sydney Metro Demolitions – Vibration Monitoring, Mowbray House

Background

The Sydney Metro City & Southwest Chatswood to Sydenham Metro was approved as a SSD on 7 January 2017. The Minister's Conditions of Approval (CoA) that are relevant to vibration monitoring on heritage structures are:

E30 The Proponent must conduct vibration testing before and during vibration generating activities that have the potential to impact on heritage items to identify minimum working distances to prevent cosmetic damage. In the event that the vibration testing and monitoring shows that the preferred values for vibration are likely to be exceeded, the Proponent must review the construction methodology and, if necessary, implement additional mitigation measures.

E31 The Proponent must seek the advice of a heritage specialist on methods and locations for installing equipment used for vibration, movement and noise monitoring of heritage-listed structures.

The standard equipment and methodology to be used for monitoring heritage structures adjacent to buildings to be demolished is described below.

Equipment

The noise and vibration monitoring equipment consists of:

- a logger for data storage, communication and power supply;
- a vibration sensor – Geophone;
- a Noise sensor – Microphone; and,
- associated data cables

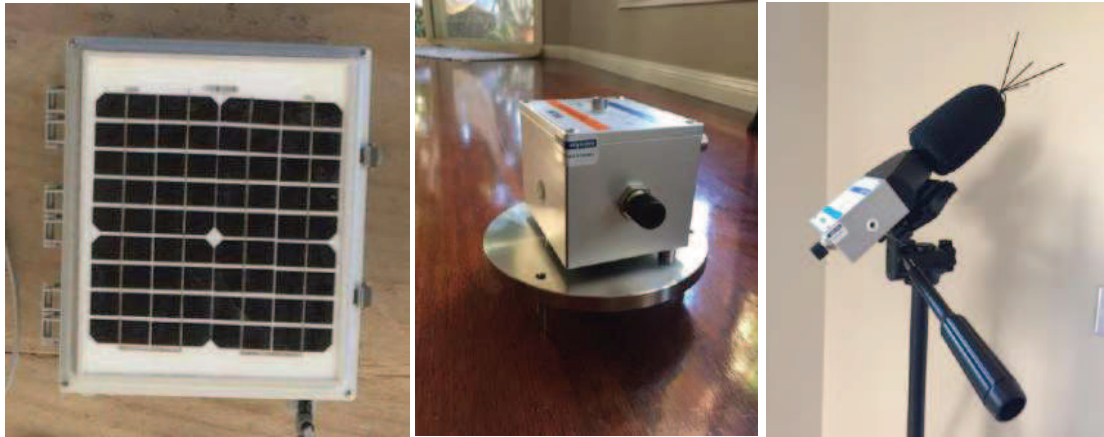


Figure 1 The components of the vibration monitoring; the logger (left), geophone set on comfort plate (centre) and microphone (left).

The *logger* can be installed on a wall or a pole or at ground level.

The preferred installation of the *geophone* is on the foundation of the structure being monitored. The best level of coupling is achieved when the geophone is coupled using a bolt positioned through the centre of the geophone. The process requires an 8mm masonry brass expander to be inserted into an 8mm drill hole and the geophone fastened using a 6mm stainless bolt through the centre of the geophone. In rare cases when drilling into the foundation is not permitted, the geophone may be installed on nearby structures. There is also the option of fastening a plate to the foundation using a two part epoxy putty. The geophone is then screwed onto the plate. The least preferred option is the use of a comfort plate. A comfort plate is generally for internal use when measuring for human comfort and is not ideal for vibration monitoring for cosmetic/structural damage.

The *microphone* can be installed on a pole or wall using the bolt hole in the centre of the sensor or it can be zip tied to an object. There is also the possibility to install the microphone on a tripod when in a secure environment. The preferred height of installation is 1.5 metres but for practical reasons (to prevent theft or damage) the monitor can be positioned at a height of 2.5 to 3 metres.



Figure 2 Typical layout of the vibration monitoring equipment.

Mowbray House

The following describes the methodology to be used at Mowbray House, 339 Mowbray Road, Chatswood. Mowbray House is a typical Federation Arts and Crafts school building built in 1906. Mowbray House is Item 96 on the heritage schedule of the Willoughby Local Environmental Plan 2012, having historical, associative, aesthetic and rarity significance with moderate integrity. The Statement of Significance is:

Mowbray House is a modified but still recognisable example of an early 20th century Federation Arts and Crafts school building. Initially opened in 1906 as Chatswood Preparatory School, it operated as a school until 1954 and has been used as a part of an electricity depot since 1957. The site had been the location of previous schools (now demolished or relocated) since the 1870s. While the remainder of the site is heavily modified, Mowbray House remains reasonably intact and makes an important contribution to the streetscape.



Figure 3 View north-east to Mowbray House.

Vibration Monitoring

The preferred location for the monitoring equipment will be the west wall of the building adjacent to the engaged pier at the south-west corner behind the side fence. All monitoring equipment should be set at a height below the fence to ensure the security of the equipment and to avoid extensive damage to the masonry wall. In addition:

- The geophone and microphone should be located no higher than 1m – 2m above ground level to reduce visibility of repairs following removal of equipment.
- The geophone and microphone will be fixed to the wall by a single 8mm diameter brass expansion bolt. Following removal, the brass bolt sleeve will be left in place.
- All fixings should be into mortar joints, not into the bricks, and following removal any damage will be made good based on the principle of like-for-like.
- Care will be taken to avoid damage during fixing and removal of the equipment and any damage will be made good.
- Following removal of the monitoring equipment, any damage is to be made good based on the principle of like-for-like.
- The composition of the existing mortar, if not known, should be 1:1:6 (cement:lime:sand) and should match existing in colour.



Figure 4 Views of the south-west (left) and south-east corners of Mowbray House. The vibration monitoring equipment will be located on the west wall behind the fence in the location as indicated on the east wall.

Conclusion

Installation of the vibration monitoring would have a negligible effect on the fabric of Mowbray House that is mitigated by monitoring the building, in its entirety, against damage from vibration. There would not be an adverse effect on the local heritage significance of the house and as such, the work complies with the requirements of Conditions E30 and E31.