

90-102 Regent Street, Redfern

## Metro Tunnel Vibration Management Plan

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**SYDNEY**

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## 1 INTRODUCTION

This report presents the recommended criteria for the regulation of vibration to the Sydney Metro rail tunnel from construction works associated with the development at 90-102 Regent Street, Redfern. The T4 Eastern Suburbs and Illawarra Sydney Rail train tunnel to the west is a greater (more than 25m) distance than the Metro tunnel, and so a lower level of construction generated vibration would be expected.

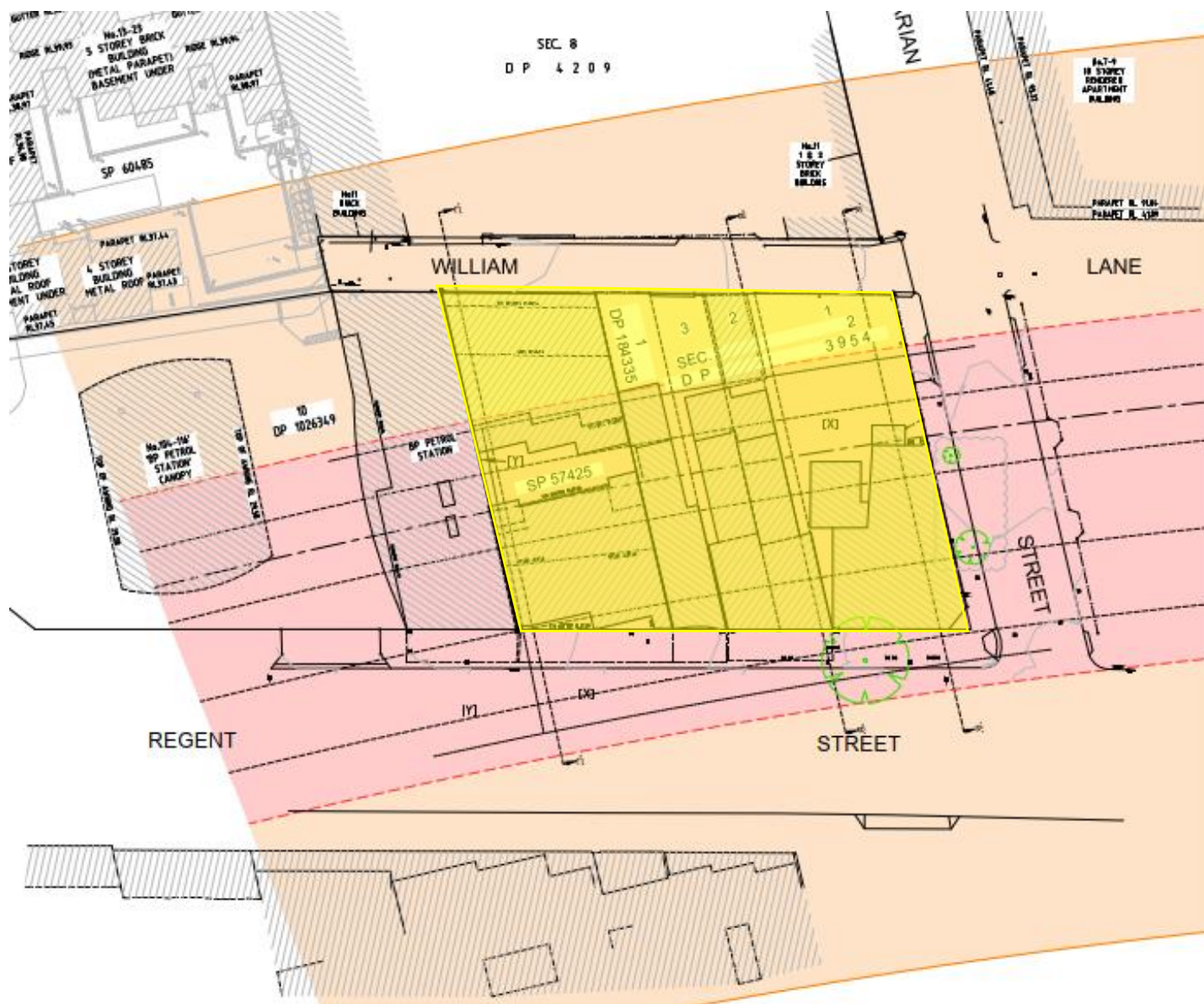
A vibration monitoring regime and a response and regulation protocol is also presented in the event that exceedance of the nominated vibration criteria occurs during construction.

## 2 SITE DESCRIPTION AND PROPOSED WORKS

The proposed development includes 18 levels of student accommodation with associated facilities, and 1 level of basement. The Sydney Metro tunnels are located directly below the site. Tunnel boring activities directly below the site have been completed, however the extent of remaining works to be undertaken in the area and the date for the commencement of the operational line is not currently known. Figure 1 indicates the location of the tunnels to the proposed development.

There is an existing basement level within one of the current properties on the site, which is proposed to be marginally lowered and extended to cover the full extent of the site. Piling will also be required within the second reserve. The geotechnical report for the site prepared by Douglas Partners (Project 86852.00, September 2020) indicates that the substrate consists of laminate and siltstone for the lower extent of piling depths.

Figure 2 indicates the location of the tunnel with respect to the structural elements of the building, and Figure 3 reproduces the measured geotechnical cross sections from the Douglas Partners report.





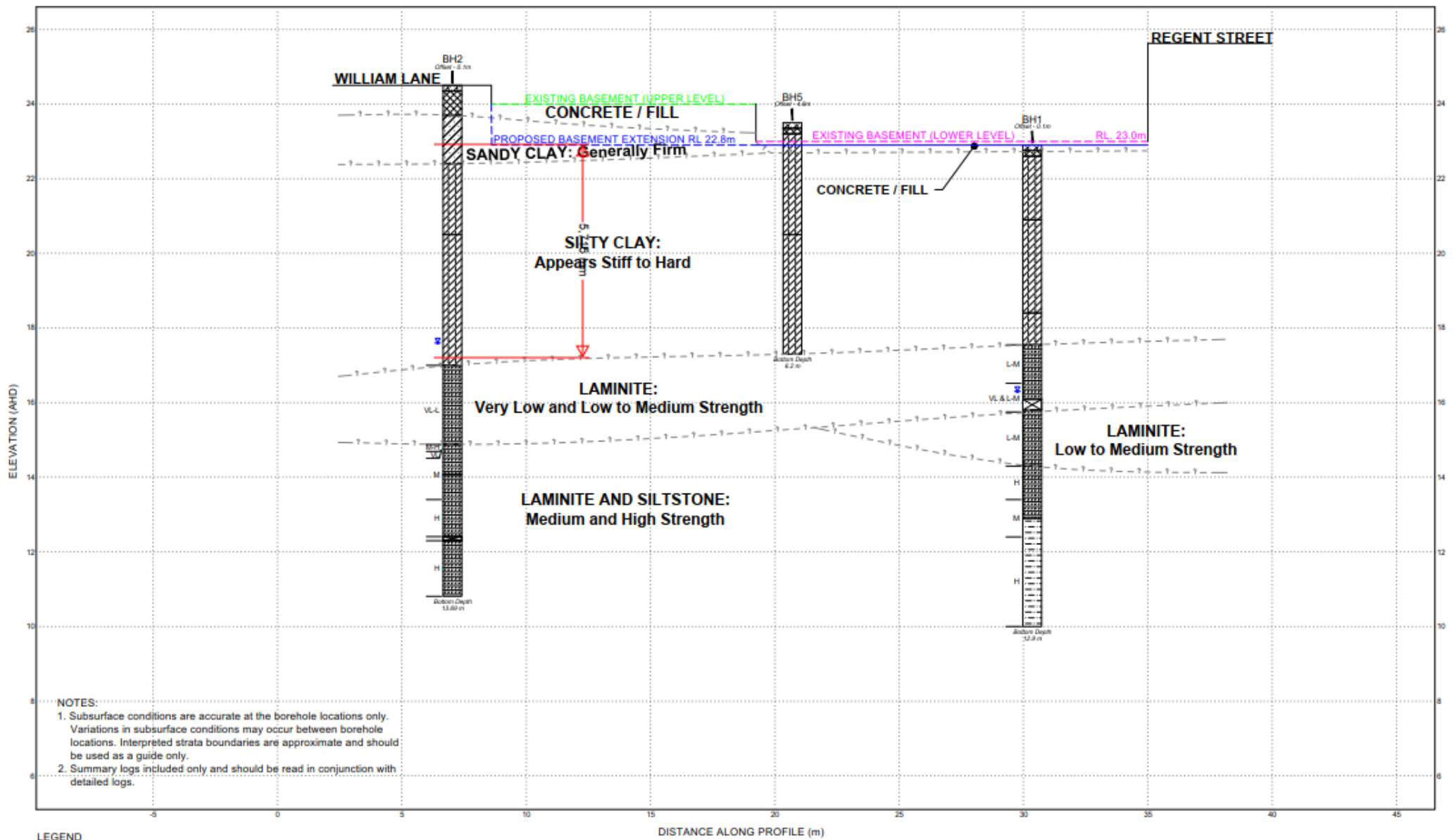


Figure 3 – Ground Subsurface Profile

### 3 VIBRATION CRITERIA

The following guidelines have been referenced to provide guidance on appropriate criteria. The criteria nominated in the following section have been developed based on relevant Australian Standards and vibration criteria typically adopted by Transport for NSW with respect to damage to rail infrastructure.

The following documents have been utilised to form vibration emission goals at the location of the Stabling Yard.

- Australian Standard AS2187.2 (2006) – “Explosives – Storage and Use – Part 2: Use of Explosives”;
- NSW Department of Planning document titled “*Development Near Rail Corridors and Busy Roads – Interim Guideline*”;
- Transport for NSW Standard “*External Developments*” (Ref: T HR CI 12080 ST).
- Transport for NSW Standard “*Development Near Rail Tunnels*” (Ref: T HR CI 12051 ST); and

These standards and their application at the site are discussed in the following sections.

#### 3.1.1.1 Australian Standard AS2187.2 (2006) – Building Damage

Australian Standard AS2187.2 (2006) – “*Explosives – Storage and Use – Part 2: Use of Explosives*” presents vibration guide values to determine the effect of ground movement on structures. The values in AS2187.2 are directly reproduced from British Standard BS7385-2.

The guidelines are presented in the table below:

**Table 3.2 AS 2187.2 (2006) - Guideline for Building Vibration**

Line	Type of Building	Peak component particle velocity in frequency range of predominant pulse	
		4 Hz – 15 Hz	15 Hz and above
1	Reinforced or framed structures. Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
2	Unreinforced or light framed structure. Residential or light commercial type buildings	15 mm/s at 4 Hz and above increasing to 20mm/s at 15 Hz	20 mm/s at 4 Hz and above increasing to 50mm/s at 40 Hz and above

Notes:

1. Values referred to are at the base of the building
2. For line 2, at frequencies below 4 Hz, a maximum displacement of 0.6 mm ZTP (zero to peak) should not be exceeded.

#### 3.1.1.2 NSW Department of Planning Development Near Busy Roads and Rail Corridors – Interim Guideline

Part D of the NSW Department of Planning document “*Development Near Busy Roads and Rail Corridors – Interim Guideline*” outlines potential impacts of adjacent development on roads and railway. As there are no specific



guidelines with regard to maximum vibration levels towards the rail corridor during construction, Transport for NSW standards have been used to assess recommended maximum vibration levels.

### 3.1.1.3 Transport for NSW External Developments (T HR CI 12080 ST)

Section 6.4 of the NSW Government document titled “*External Developments (Version 1.0)*” dated 5<sup>th</sup> February 2015 states the following with regard to noise and vibration levels from new development adjacent to rail infrastructure:

*“The effects of noise and vibration from rail operations shall be considered in the design of the development. The noise from construction and rail operation shall be considered against statutory and project noise vibration limit requirements.”*

### 3.1.1.4 Transport for NSW Development Near Rail Tunnels (T HR CI 12051 ST)

NSW Government Transport Asset Standards Authority Standard *Development Near Rail Tunnels* dated 15 November 2018 states:

*Any development that occurs within a distance of 25 m horizontally from first reserve shall assess the vibration on the rail tunnels. The assessment criteria shall be a maximum peak particle velocity (PPV) of 15 mm/s at the tunnel lining for brick or mass concrete in good condition or a maximum PPV of 20 mm/s at the tunnel lining for cast iron, steel or concrete segment lining*

### 3.1.1.5 Summary of Vibration Criteria

consideration of the above guidelines, we note:

- AS2178.2 provides reference for the point at which vibration is likely to cause structural damage. Considering the disruption structural damage to the rail infrastructure would provide, vibration should be below this level at all times.
- The TfNSW guideline relating to train tunnels provides further guidance on an appropriate maximum level of vibration that is acceptable to buried rail assets. This level is nominated as a maximum of 20mm/s PPV, which is consistent with the upper limits of AS2187.2.
- Based on the above, a maximum/stop work PPV vibration level of 15mm/s is considered acceptable to protect the light rail infrastructure.
  - A trigger/notification level is typically set below this maximum criterion to alert construction workers the maximum vibration limit is being approached - this is typically 25% lower than the maximum allowable vibration level, or 12.5mm/s PPV in this case.
  - If the nominated vibration levels are exceeded, the following should occur:
    - 12.5mm/s PPV – If this level is exceeded as a result of construction activities, a full review of the ongoing site activities and potential cause of exceedance is to be undertaken.
    - 15mm/s PPV - If this level is exceeded as a result of construction activities then work is to cease immediately.

**Table 1 – Summary of Vibration Criteria**

Scenario	Vibration Level
Trigger Level/Assessment Level	12.5 mm/s PPV
Stop Work Level	15 mm/s PPV

## 4 RECOMMENDED VIBRATION MONITORING

Typically, excavation in rock or vibrated piling are the activities with the greatest potential for generation of vibration.

For this project, remaining excavation of the basement level will be in soil/clay, with bored piling of building foundations at the lower extent to be in siltstone and laminate. Hydraulic hammers and vibrated piling will generally not be required, and therefore the excavation/piling works are not currently expected to produce vibration levels exceeding the criteria set out in section 5.2.

Our experience with similar projects above rail tunnels indicates that the vibration levels generated by bored piling is generally low and wouldn't result vibration exceedance.

Nevertheless, excavation and piling works should be subject to sample vibration testing or ongoing monitoring to ensure that if these levels are exceeded, appropriate construction management processes may be implemented.

Further, given that the tunnel below the project site is an active construction site, monitoring within the tunnel itself may not be possible, due to both access constraints as well as the potential for construction works impacting the monitoring location.

As such, monitoring from within the project site is proposed. Vibration levels measured on surface level will be sufficient for representing minor excavation works, however the proposed piles required for the site are expected to a depth of approximately 15m below surface level, which are approximately 10m from the first reserve of the tunnel.

In order to provide a representative location for the ongoing monitoring of potential vibration impacts from construction (in particular piling works), it is proposed to install a geophone at a depth of approximately 16m (being 1m below the level of piling required to satisfy structural requirements for the building). There should be one monitor installed over each of the rail tunnels which are located below the site. Refer to Figures 4 & 5 for indicative locations of monitors.

Once piling and excavation works have been completed on site, vibration levels from construction are unlikely to exceed requirements at the rail tunnel. Vibration monitoring should continue for 1-2 weeks after this phase of the project, with the requirement for ongoing monitoring to be reviewed following the measured results. If the measured levels are significantly below the nominated trigger level, or no vibration from construction is detected, then ongoing monitoring may cease.

### 4.1 MONITORING EQUIPMENT

The proposed vibration monitoring equipment are Texcel ETM type monitors with externally mounted geophones installed within the railway tunnel.

The monitor is to be fitted with GSM modems in order to provide an SMS alert for up to five mobile phones indicating any exceedances in the nominated vibration criteria. The vibration monitor can be remotely accessed to retrieve any vibration data.

### 4.2 NUMBER OF LOGGER AND LOGGER LOCATION

Two monitors are proposed, being one above each of the rail tunnels below the site. Refer to Figures 4 & 5 for detail on proposed indicative locations.

### **4.3 PERIOD OF MONITORING**

Monitors will be installed prior to commencement of works and remain operational until such time that piling works and the ground slab for the proposed building have been finished, or earlier as agreed with Sydney Metro. Once completion of works on the ground level structure has been completed, vibration intensive works will no longer be required, and there will be a sufficient distance between construction activities potentially generating vibration and the railway tunnel, so as not to exceed the recommended vibration criteria.

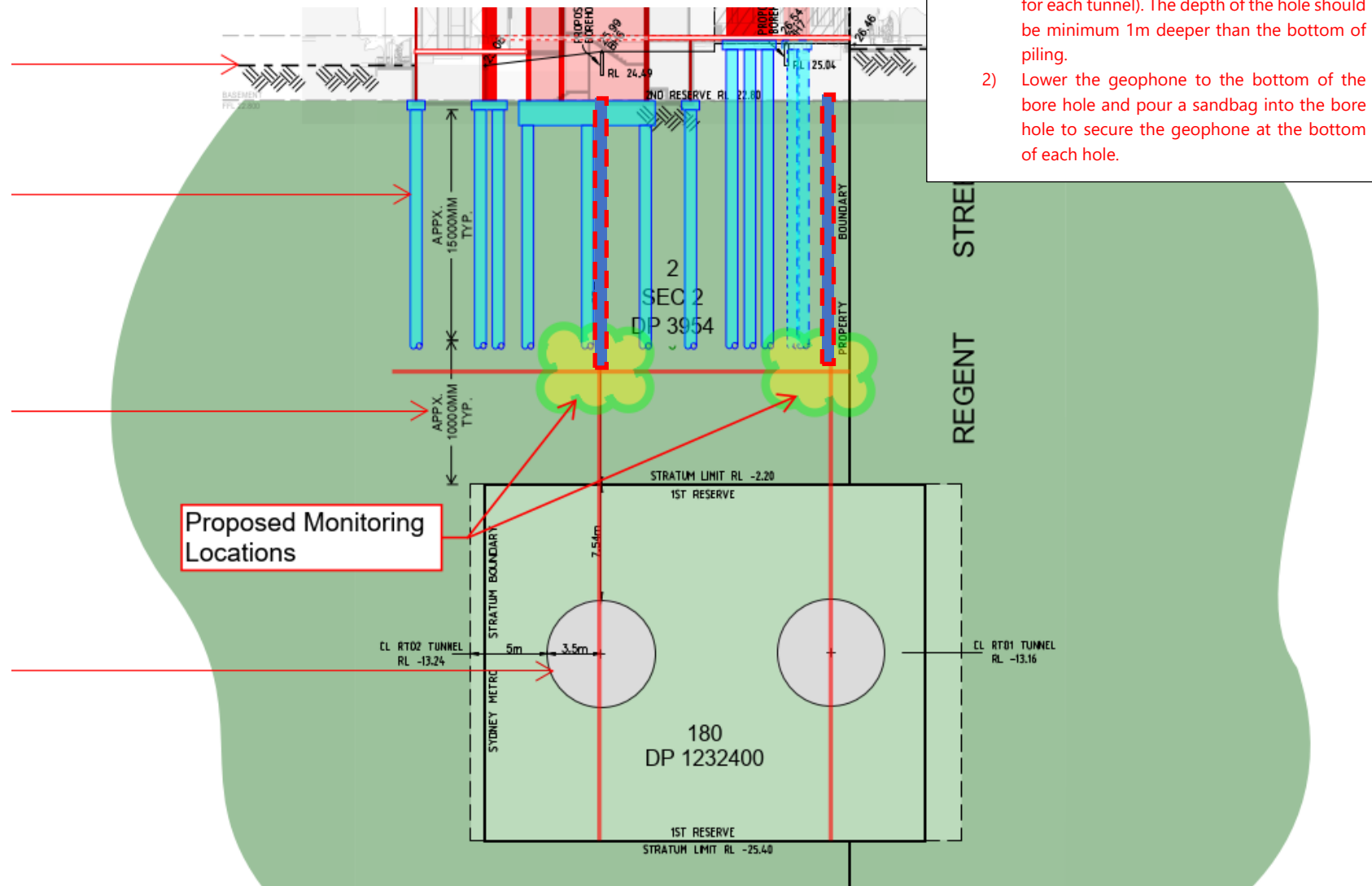
### **4.4 DOWNLOADING OF VIBRATION LOGGER**

Downloading of the vibration logger will be conducted on a regular basis. In the event exceedance of vibration criteria or alarms occurs, downloading of logger will be conducted more frequently. Results obtained from the vibration monitor will be presented in a graph format and will be forwarded to the nominated project personnel for review. It is proposed that reports are provided fortnightly with any exceedance in the vibration criteria reported as detailed in this report.

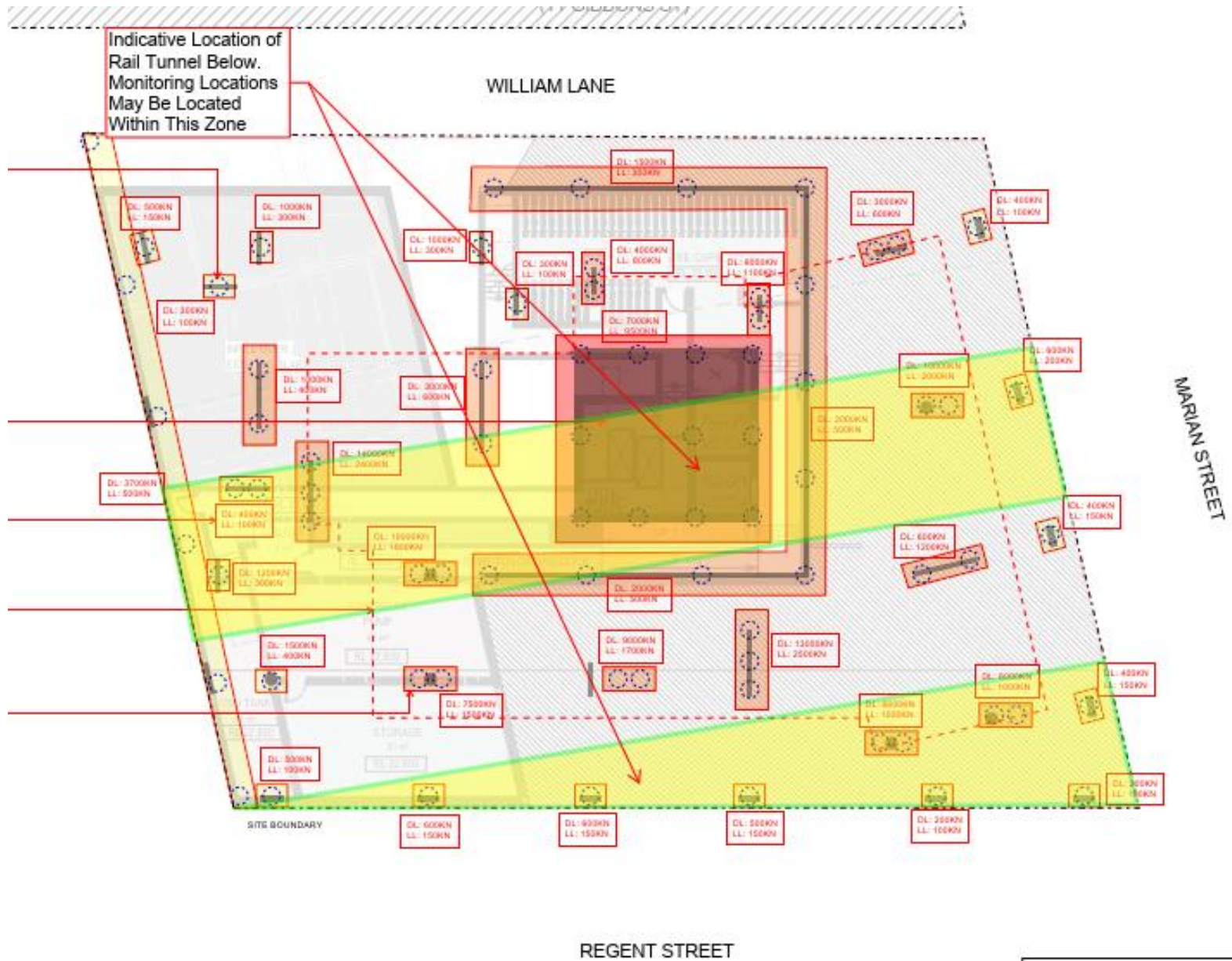
### **4.5 PERSONS TO RECEIVE ALARMS**

The visual and audible alarm system shall be established by subcontractor on site. The following personnel will receive GSM alarms:

- Acoustic consultant/advisor (1 person)
- Excavation site foreman
- Main builder foreman (where applicable)
- Sydney Metro/Tunnel Contractor nominated representatives (maximum 2)



**Figure 4 – Section View of Proposed Monitoring Locations**



**Figure 5 – Plan View of Acceptable Monitoring Locations Above Tunnel**

## 5 EXCEEDENCE IN PROJECT CRITERIA

In the event that the vibration levels associated with works on the project site exceed the project vibration criteria at the monitoring location, the event will be remotely forwarded to up to five mobile phones. This will warn that an event exceeding the pre-set alarm level has occurred.

After an event within this magnitude range the procedure to be followed is:

### **Warning Alarm Triggers (12.5mm/s PPV)**

- The builders will immediately stop all activities within the immediate area near to where the exceedance occurred. Sydney Metro and Acoustic Logic should be notified and will verify data received by other recipients. Recent event data from the remote vibration monitor will also be downloaded.
- Acoustic Logic shall conduct site investigation immediately. The cause of the vibration exceedance shall be found and analysed from the recorded data and site works notes. Vibration mitigation methods and/or change in work methodology will then be advised.
- A phone call to the nominated Sydney Metro representative is to be made within one hour of SMS alarm, followed by an incident report explaining how the alarm was triggered. This report will be required to be presented to the External Party Works Project Manager within 24 hours of the SMS alarm being issued. This report should include the following information:
  - 1) Date, time and identity of the alarm.
  - 2) The cause of the alarm.
  - 3) What recommendation is given to prevent the alarm level being reached again?
  - 4) What actions the Site Manager is taking to ensure the alarm levels is not reached again?
- Trial vibration testing will be carried out after the implementation of any vibration mitigation measures or changes in procedure. Measurements of vibration during the trial will be carried out on the surface and results will be compared to in tunnel/station recordings to ensure safe working vibration levels.
- Works will only be allowed to proceed in the area where the exceedance occurred once the work methods and restrictions to work zones of equipment or any other recommendations have been implemented to the satisfaction of Acoustic Logic.

### **Vibration Level Exceeded 15mm/s PPV**

From the time an alarm event occurs the following procedure will be followed:

- The builders will immediately stop all activities within the immediate area that the exceedance occurred and contact Sydney Metro. Note the remote GSM transmission from the GSM modem in the vibration logger would already have been received by the acoustic consultant, Sydney Metro, Project Manager, etc.
- Acoustic Logic shall conduct site investigation immediately. The cause of the vibration exceedance shall be analysed, and vibration mitigation method shall be determined.
- A review of work procedures will be conducted and restrictions limiting the working zones of equipment updated if required. Additionally, alternative methods of work will be devised to complete the required works so as vibration criteria will not be exceeded. Detailed revised work methods and required remediation works shall be reviewed by Sydney Trains.

- Works will only be allowed to proceed in the area where the exceedance occurred once work methods and restrictions to work zones of equipment have been agreed by Sydney Metro. Trial vibration testing shall be conducted and the testing report shall be submitted to Sydney Metro.
- Works will only be allowed to proceed in the area where the exceedance occurred once work methods and restrictions to work zones of equipment have been agreed by the Sydney Metro.

## 6 CONCLUSION

The equipment and works methodology associated with the monitoring of vibration generated by construction activities at 13-23 Gibbons St, Redfern on the Sydney Metro tunnel currently under construction have been addressed in this report. Provided the methods set out in this report are adopted, the structural integrity of the rail facilities will be safe guarded.

Please contact us should you have any further queries.

Yours faithfully,



Acoustic Logic Pty Ltd  
Alex Washer