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105 Miller Street

Electrolysis Study

July 2025

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105 Miller Street
Electrolysis Study

Investa

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WSP acknowledges that every project we work on takes place on First Peoples lands.
We recognise Aboriginal and Torres Strait Islander Peoples as the first scientists and engineers and pay our respects to Elders past and present.

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Abbreviations

A	Ampere
DC	Direct Current
kg	Kilogram
MEN	Multiple Earthed Neutral
mm	Millimetre
MPa	Megapascal
OHW	Over Head Wiring
RFI	Request for Information
SM	Sydney Metro
VLD	Voltage Limiting Device

1 Introduction

1.1 Background

Investa has engaged WSP Pty Ltd (WSP) to undertake an electrolysis assessment for the proposed development at 105 Miller Street, North Sydney, NSW (the site) located in the vicinity of the Sydney Metro (SM) City & Southwest tunnels.

The site currently contains a 13-storey commercial building that will be demolished to enable construction of a new 22 storey mixed-use development with one level of basement. Refer Figure 1-1 for an aerial view of the site

This report details the electrolysis assessment WSP has undertaken in accordance with iCentral SM-20-00081444 - Sydney Metro Underground Corridor Protection Technical Guideline and TS 01717 – Development Near Rail Tunnel to assess the requirements for electrolysis effects on the development from metro operation.

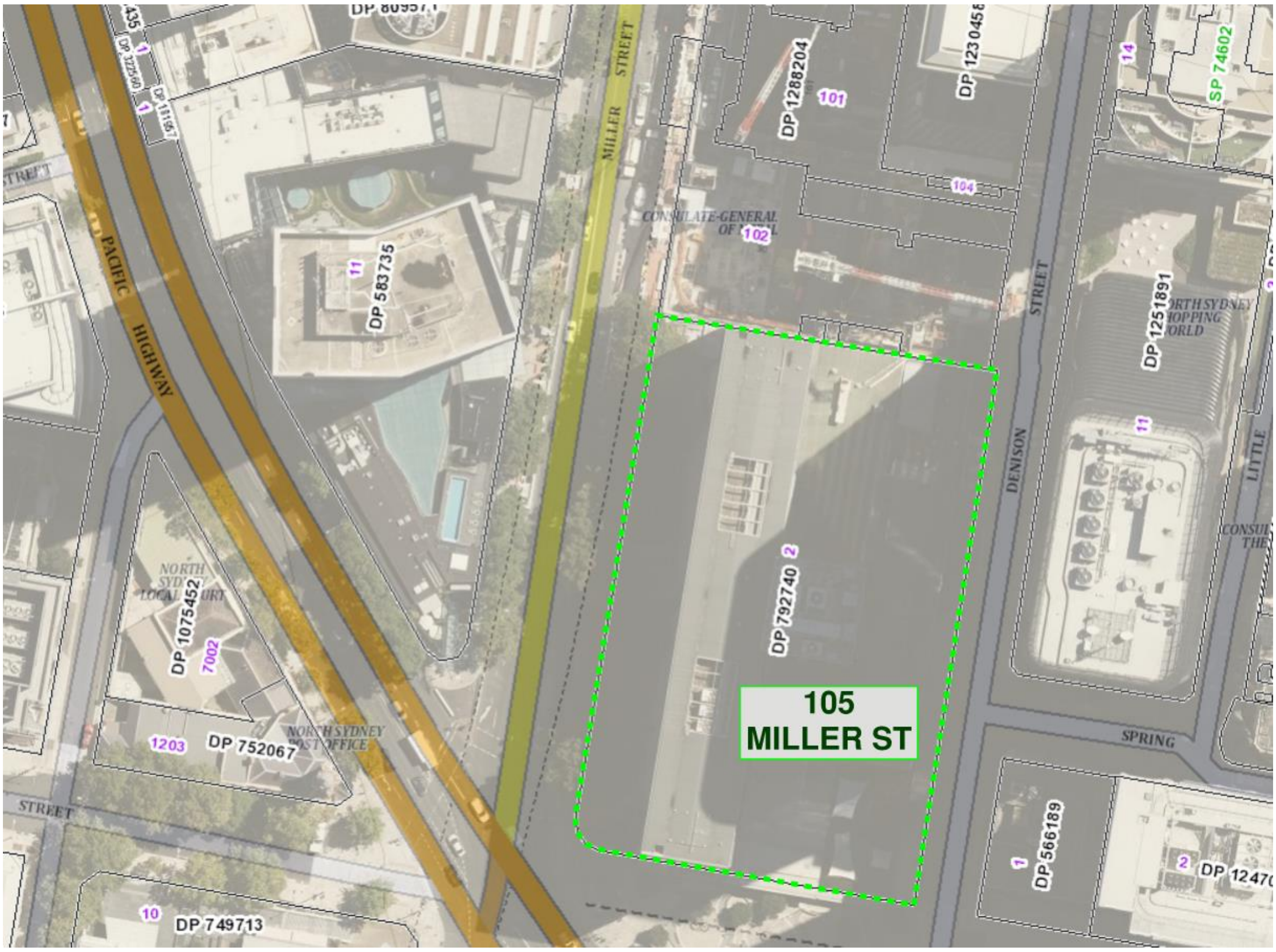

Figure 1-1 105 Miller St Aerial View

1.2 Site Description

The site is located on the northeast corner of the intersection at Miller St and Pacific Highway in North Sydney, adjacent Victoria Cross Station . The site boundary is rectangular in shape.

Figure 1-2 shows a top view of SM first and second reserves relative to the site in orange and pink dashed lines respectively. The area contained within the blue lines indicates the proposed excavation shows a cross-sectional view of SM first and second reserves relative to the site. The site is partially located within the second reserve of SM City & Southwest; the proposed building is clear of the SM first reserve which runs below the existing excavation and any proposed foundations.

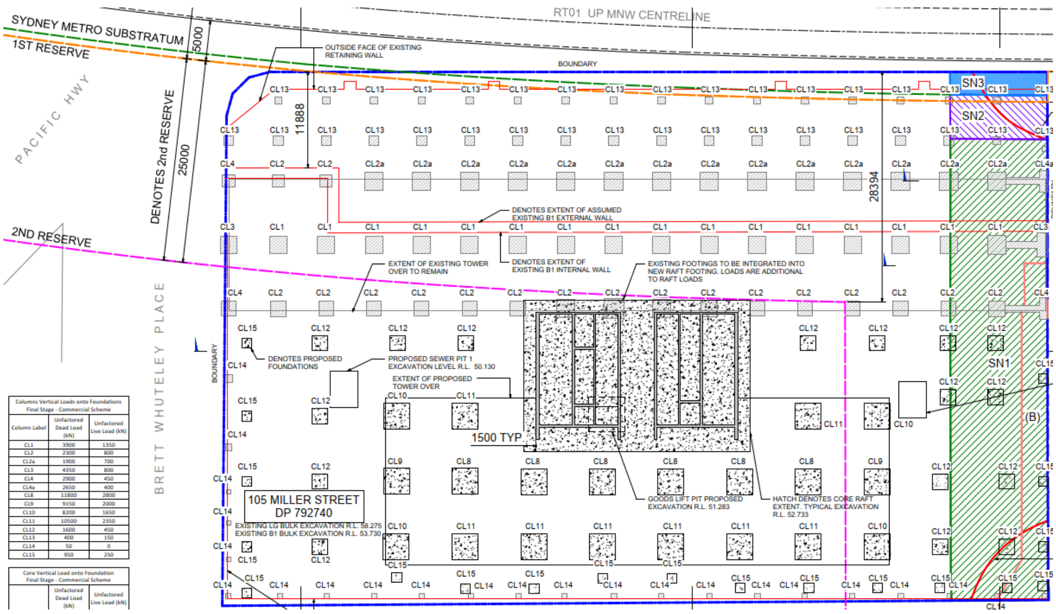

Figure 1-2 Plan View of Sydney Metro 1st and 2nd Reserve Regions

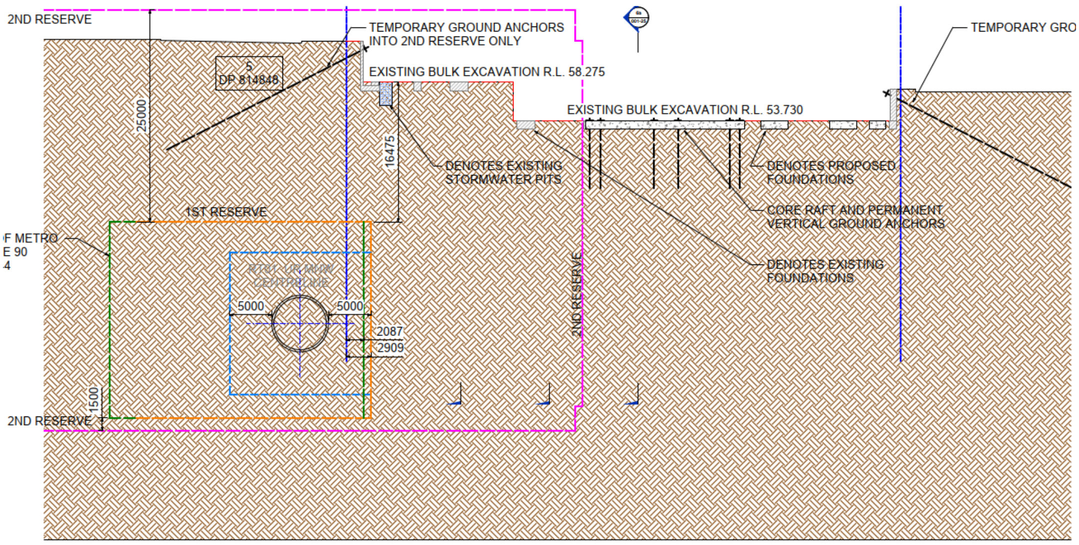

Figure 1-3 Cross Sectional View of Sydney Metro 1st and 2nd Reserves

1.3 Scope of Works

The scope of works of this report includes:

- Review of the proposed development structural design to identify potential electrolysis hazards to the proposed development.
- Provide mitigation recommendations to minimise electrolysis risk to the proposed development so far as is reasonably practicable

1.4 Assumptions, Constraints and Limitations

1.4.1 Assumptions and Constraints

- WSP. It is assumed that the information from a previous similar studies undertaken by WSP – City Tattersall's Club Redevelopment and 372 Pitt Street – can be applied to this project due to the similarities in scope and relative positioning to the Sydney Metro tunnels.
- Limited information of the SM tunnel alignment is available. The assessment is undertaken based on the relative position estimate of the best available information.

1.4.2 Limitations

- This Report is a product of work undertaken by WSP for Investa as technical consultant for the review of the site development. This report cannot be relied upon in any circumstance by any party without the approval and execution of WSP's reliance letter.
- To the best of WSP's knowledge, the facts and matters described in this Report indicate the Client's intentions in relation to the Project at the time of issuing of this Report. However, the passage of time, the manifestation of latent conditions or the impact of future events (including a change in applicable law) may result in changes to the site development. To the fullest extent permitted by law, WSP, its related bodies corporate and its officers, employees and agents assumes no responsibility and will not be liable to any third party (excluding those permitted upon execution of the reliance letter) for any loss, expense or damage (including any indirect, consequential or punitive losses or damages or any amounts for loss of income or profits, of any kind (arising in contract, tort or otherwise) suffered or incurred by a third party arising from any matter dealt with in the report, or conclusions expressed in the report.
- WSP takes no responsibility for the accuracy and completeness of this information. WSP is not obliged to update or revise this Report to consider any events or emergent circumstances or facts occurring or becoming apparent after the date of the Report.
- This Report is not a certification, warranty or guarantee. It is a report based on the instructions given to WSP set out in Section 1.1, limited by time and budget constraints. These time and budget constraints have meant that WSP's investigations have concentrated on significant and material items and issues. No testing or detailed inspection was undertaken. This Report may contain various remarks about and observations on legal documents, arrangements and agreements.
- Generally, a consulting engineer can make remarks and observations about the technical aspects and implications of those documents and make general remarks and observations of a non-legal nature about the contents of those documents. However, as a consulting engineer, WSP is not qualified, cannot express, and should not be taken as in any way expressing any opinion or conclusion about the legal status, validity, enforceability, effect, completeness or effectiveness of those arrangements or documents or whether what is provided for is effectively provided for. These are matters on which legal advice should be obtained.

- Unless and except to the extent that WSP expressly indicates otherwise in this report, WSP's comments, conclusions and recommendations are provided strictly on the basis that the facts, findings and assumptions contained in the information provided or made available to WSP (whether in writing, electronically, on-line, verbally or otherwise) and listed in Section 2 are reliable, accurate, complete and adequate.
- Any opinion expressed by WSP concerning predictions of cost are based on WSP's judgement and understanding of the commercial and contractual setting of the Project as is indicated in the documents listed in Section 2. WSP has no control over the cost of labour, materials, equipment or services to be furnished by others, or over third-party contractors' methods of determining prices, competitive bidding or market conditions. WSP does not warrant or guarantee the accuracy of any opinion expressed concerning predictions of cost of equipment and construction costs.

2 Inputs

2.1 Standards

Table 2.1 Standards

STANDARDS	REVISION	TITLE
Australian Standards		
AS 2832.7	2018	Cathodic protection of metals Part 5: Steel in Concrete Structures
AMB Standards		
T HR EL 12002 GU	1.0	Electrolysis from Stray DC Current
TS 01717	0.0	Development Near Rail Tunnels
International Standards		
BS EN 50122-2	2022	Railway applications — Fixed installations — Electrical safety, earthing and the return circuit Part 2: Provisions against the effects of stray currents caused by DC traction systems

2.2 Reference Inputs

Table 2.2 Reference Inputs

DOCUMENT NUMBER	REVISION	TITLE
iCentral SM-20-00081444	02	Sydney Metro Underground Corridor Protection Technical Guideline
ST-001-05 to ST-001-025	P1	105 Miller Street Site Metro Protection Zones

3 Electrolysis and Stray Current

3.1 Electrolysis

Electrolysis is an electro-chemical reaction that causes corrosion of steel structures or reinforced structures when DC current is discharged into an electrolyte. The structure may become a current path of DC stray current emitted by the traction system by proximity or extended parallelism. At locations far from traction substations, adjacent structures typically become pickup points and become cathodic. Near to traction substations, DC stray currents typically leave adjacent structures and become anodic and cause material loss. The loss of material is referred to as electrolysis corrosion and can create undetected structural risks. Typical rate of loss is estimated to be approximately 9 kg of steel for a continuous current of 1 A over one year.

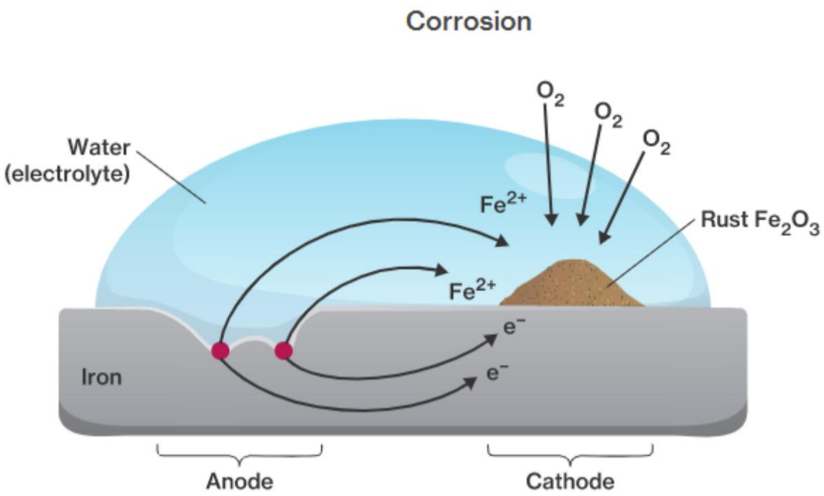

Figure 3-1 Electrolysis Corrosion Process

3.2 Sydney Metro Traction System

The Sydney Metro City & Southwest lines running adjacent to the proposed development are understood to be a 1500 V DC traction electrification system. The overhead wiring system supplies current to the train pantograph, which returns to the traction substation via the traction return rails. Ideally, all currents should return to the substation through the rails. However, since rail insulation is not perfect, some DC stray currents will leak to the track support system, the tunnel structure, and potentially conduct to adjacent structures via the general mass of the earth. Stray currents are attracted to low resistance parallel paths such as large spanning structures or structures attached to the utility MEN network. The stray current then leaves the adjacent structure at some point closer to the substation and back to the return rails. Structures can drop off DC stray current to pass onto other adjacent structures or attract stray currents conducted via a remotely earthed structure. Refer to Figure 3-2

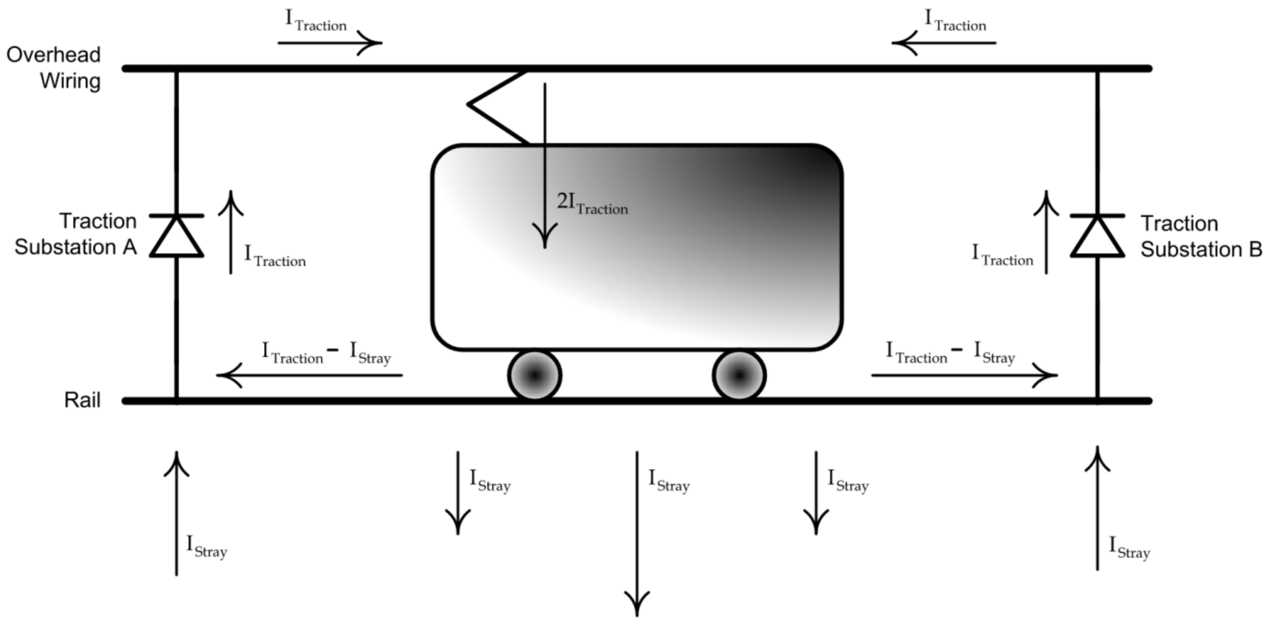

Figure 3-2 DC Traction Currents Distribution and Stray Current in the Traction System – Excerpt from T HR EL 12002 GY Standard

4 Electrolysis Assessment

4.1 Analysis

The structural footing of the redevelopment is located approximately 20 m vertically below the crown of the SM tunnel at its nearest point. The structural footings and basement levels of development have no direct connection to the SM tunnels. However, the development is considered moderate risk of stray current pickup emitted by the SM systems given that it is partially located within the protection reserves of SM.

In accordance with Section 5 of T HR EL 12002 GU standard, the electrolysis from stray DC current can be mitigated by:

- Maintaining high resistance to earth
- Isolation of structures from SM tunnel structures
- Breaking continuity in continuous structures parallel to the tracks.
- Implement protection measures so that corrosion protection system can be used in the development if found to be affected by stray current testing

4.1.1 Maintaining High Resistance to Earth

For a building, the most common means of minimising the electrolysis hazard from stray traction current is to increase the electrical resistivity of the embedded structure to earth. This increase in resistance reduces the flow of stray traction current through the reinforcement.

The resistivity of the concrete is increased by using high strength concrete in the range of 32 MPa or higher and providing a minimum of 50 mm clear concrete cover between soil and any reinforcement (including filaments). Concrete with 32 MPa and higher strength is considered as least conductive.

- The reinforced concrete pad footings have 40 MPa concrete strength.
- The foundation is assumed to be founded on low to medium strength sandstone (Class II)
- Slab in contact with soil has concrete strength of 40 MPa as per drawing set PS214031-105 Miller Street – SDA003.
- Values of concrete cover for the slabs, columns, rafts, footings, piles, and walls in contact with soil have not been provided at this stage. The steel reinforcement within these structures are required to have minimum 50mm cover.

4.1.2 Isolation of Structures from Tunnel Structures

Providing moisture barrier (waterproof membrane or heavy-duty plastic membrane) to buried reinforced concrete structures acts as an electrical insulator to the conduction of stray traction current. The moisture barrier or plastic membrane prevents water ingress from the ground, retaining the insulation property of concrete, thereby limiting the conduction of DC stray current to/from the reinforced structures.

It is recommended to provide waterproof membrane to the buried reinforced structures in contact with soil. Care should be taken using plastic membrane as it may be subject to tear from reinforcement bars during construction, which will compromise its ability to insulate against DC stray current. The joints are to be tapered to prevent any water ingress through the joint into the concrete structures.

4.1.3 Provisions for Future Protection Systems

To ensure the structure is guarded against future changes in traction system loads and stray current emission profiles from the Sydney Metro system, the reinforcements in the pad footings and slabs in the basement levels in contact with soil are to be made electrically continuous to allow future provision of cathodic protection should it be required.

To make the reinforced structures electrically continuous the following measures are to be implemented:

- For concrete reinforced slabs in contact with soil, the perimeter steel reinforcement bars and transverse bars shall be made electrically continuous by welding in accordance with AS 2832.5.
- Basement and other slab reinforcement shall be made electrically continuous with perimeter wall/column/footing reinforcement and starter bars using tack welding. Columns shall be made electrically continuous with the slab through a minimum of two vertical bars.
- The reinforcement slab construction joints are to be made electrically continuous using welded bonds with minimum 16mm^2 G/Y copper cable.
- Slab reinforcement continuity and stray current test points (e.g. ERICO FDB-16) are to be provided and welded to the opposite corners of the electrically continuous reinforcement. The test points shall be labelled and located in an accessible area.
- Electrical continuity testing in accordance with AS 2832 is to be undertaken before concrete pour and the resistance is to be measured. The pass criteria for testing is the resistance of the electrically continuous structure to be less than 2 Ohms when measured at diagonally opposite ends of the slabs, and less than 0.5Ω/10m.

Furthermore, making the buried reinforced structure electrically continuous avoids localised concentrated current flow in the reinforcement to earth and thereby minimises the effect of any possible electrolysis corrosion.

4.1.4 Sydney Metro Stray Current Mitigation Measures

The stray DC current emissions from SM City and South West tunnel are expected to be low risk considering the following:

- The track system is new and will adhere to strict rail to earth insulation levels when commissioned
- The new Sydney Metro system design is anticipated to have been developed with a Stray Current Management Plan, prescribing system wide mitigation controls to minimise the emission of stray currents and provide stray current monitoring systems where required.
- OHW supports installed in the tunnel are anticipated to be supplementary insulated without bonding circuit attached to earthed structures if used, thus minimising risk of direct rail to earth connection in the event of a short circuit VLD.
- The track support structure and tunnel structure reinforcement act as a ‘catch’ for DC stray current emitted from the rails as they are closer to the track. Thus, it minimises the risk of propagation to other adjacent structures.
- External metallic services entering and leaving SM tunnels have isolation sections installed as per T HR EL 12002 GU standard.

5 Conclusions and Recommendations

Review of structural drawings confirms that the reinforcement concrete slabs and footing in contact with soil utilise high strength concrete cover effectively increasing the structure to earth resistance to minimise the DC stray current flowing through the structure.

It is noted that the concrete strength and cover for slabs and footings must exceed the minimum requirements to mitigate corrosion of the reinforcement by DC stray traction current. Provision of water proofing membrane to buried reinforcement is not mandated but is a good practice to minimise the risk of water ingress to concrete which reduces the resistance to earth.

It is also recommended the reinforcements in the pad footings and slabs in the basement levels in contact with soil are to be electrically continuous to avoid localised concentrated DC stray current flow and for the future provision of implementing cathodic protection.

It is anticipated that Sydney Metro have implemented appropriate stray current mitigation measures to minimise stray current emissions to the surrounding areas. With the above considered, the proposed development design has undertaken sufficient measures to minimise the risk of electrolysis to the proposed structure from Sydney Metro.