Central Barangaroo – EWDA-2
Electrolysis Risk Report (ERR)

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The Corrosion Problem and Stray Current from the DC Traction System

In the DC 1500V traction system, the rail currents are kept in the rails by insulating the rails via various methods using insulation to mechanically support the rails while electrically isolating them from the earth. These insulation methods typically involve sleepers on ballast or rubber/polymer encapsulation on track slab. It is unavoidable though that some current will leak from the traction rails and it will aim to find its way back to its source, being the DC substations. The current which leak from the rails and find alternative path to coming back to source is called “Stray Current”.

The structure to earth potential, at the point on a structure where the Stray Currents enters it will be negative while the structure to earth potential where the Stray Current leave the structure will be positive. The positive DC structure to earth potential of a metallic structures in the ground elevates their risk of corrosion through electrolysis. The negative DC potential of a metallic structures in the ground reduces their risk from such corrosion.

In the DC traction system, the rails are isolated from earth as far as is reasonably practical to minimise stray current. However, there are protection mechanisms to limit the rail to earth voltage from reaching levels which would be deemed unsafe to the exposed public as they touch the rail infrastructure while also touching or standing on an object which is bonded to earth. A Rail to Earth Contactor (REC) will close and connect the rails to earth at the traction substations if the rail voltage exceeds the pre-determined safety limits. When the REC closes significant stray currents can occur and this condition will be monitored by the rail system operator so that it is responded to quickly and the REC is reset in the open position. This protection mechanism should be noted when reviewing electrolysis recordings.

In order to avoid corrosion, it is therefore desirable to insulate metallic structures from the ground if they are exposed to stray currents. Concrete is an insulator when it is dry and it can mitigate the flow of stray currents in reinforcement if it stays dry. If the concrete becomes wet and stray currents are allowed to flow in the reinforcement, then the reinforcement will be susceptible to corrosion which then puts the concrete structure at risk of failure.

The Project

The proposed SSDA will seek approval for early works associated with the future mixed-use development of Central Barangaroo (set out under MP06_0162). The proposal sees to undertake bulk excavation and site establishment works for the installation of the perimeter retention wall, and conduct remediation and archaeological investigations within the site.

These works will facilitate the provision of future basements, consistent with the parameters set out under the approved Concept Plan for Barangaroo under MP06_0162.

The works subject of the SSDA include the following:

- Establish the site and installation of temporary plant and machinery, including dewatering and bentonite slurry plant and ancillary services,
- Construction of perimeter retention wall, including any required excavation, associated rock anchors and PRW capping beam construction,
- Associated remediation and Archaeological investigations in the area of excavation and works;
- Provision for future services,
- Associated “tie-in” works to Metro Interface Wall and the secant pile wall proposed by the applicant under SSD-39587022,
- De-stressing and removal of existing anchors supporting Sydney Metro pile wall,
- Bulk excavation for the provision of a future basement and associated rock anchors (including anchors to support the secant pile wall approved inSSD-39587022,
- Construction of foundation piling,
- Installation of waterproofing membrane,
- Construction of hydrostatic slab, and
- Structure and waterproofing for the Barangaroo Metro station southern entrance interface next to the existing Sydney Metro pile wall.

The proposal does not seek approval of any buildings, or the design, construct and use of the basement. These will be subject to future detailed SSDAs for Central Barangaroo, consistent with the outcomes of MP06_0162.

The Site

The site is located in Central Barangaroo, which forms part of the wider Barangaroo Precinct comprising a total area of 22ha. It is located in the north-western edge of Sydney CBD and falls within City of Sydney Local Government Area (LGA). Barangaroo Precinct interfaces with Hickson Road in the east, the foreshore in the west, Walsh Bay to the north and Darling Harbour in the south.

The Precinct is divided into three distinct development areas, including:

- Barangaroo South (approx. 7.5ha) – Located at the southernmost end of Barangaroo Precinct. Progressively built over the last six years and includes mixed-use neighbourhood comprising commercial office buildings, mixed use buildings, shops, cafes, hotel and community uses.
- Central Barangaroo (approx. 5.2ha and area subject of SSDA) – Located between Barangaroo South and Barangaroo Reserve. Currently vacant and undergoing site preparation works to facilitate a mixed-use area with a focus on retail activation, residential and community uses.
- Barangaroo Reserve (approve 6.1ha) – Located in the northern end of the Precinct featuring Barangaroo Reserve. Featuring open space and lookout points to Sydney Harbour, Nawi Cove and Marrinawi Cove. Barangaroo Reserve features the Cutaway – a future arts and cultural entertainment space.

The above results in a total area of 18.8ha. The residual 3.2ha is represented by the reshaping of the former industrial headland into Barangaroo Reserve and the creation of Nawi Cove as a substantial water body within the Barangaroo site, forming the original 22ha.

A summary of the site is provided in Table 1.

Item	**Description**
Site Area	5.2ha (approx.) of the 22ha Barangaroo Precinct
Ownership	Infrastructure NSW
Legal Description	Lot 52 Deposited Plan 1213772

Table 1

The area currently features a large concrete hardstand area/construction site that is occupied by temporary structures for site preparation works, machinery, materials and vehicle parking for site workers. Hoarding is currently erected around the Central Barangaroo site.

Site Review

Central Barangaroo is located adjacent to the Sydney Metro Barangaroo Station. With reference to Figure 1 the site may be adversely impacted by stray current from the Sydney Metro alignment and station box.

Developments above or adjacent to the underground metro system shall consider the adverse impact of stray current and electrolysis in accordance with the Sydney Metro Underground Corridor Protection Technical Guidelines section 9.4.

A previous Electrolysis Risk Report (ERR) has been submitted for Central Barangaroo development application EWDA-1 which included the construction of a secant pile wall (retaining wall) for the excavation of the site.

The electrolysis risk review conducted in this report is for the Central Barangaroo development application EWDA-2 which consists of the following scope related to electrolysis risks:

- Construction of a perimeter retention wall
- Tie in works to the Metro Interface Wall and EWDA-1 secant pile wall
- Foundation Piling
- Construction of Hydrostatic Slab
- Metro Station Southern Entrance Coordination (Demolition, waterproofing and structure)

Future electrolysis assessments shall be undertaken for additional development plans on the site.

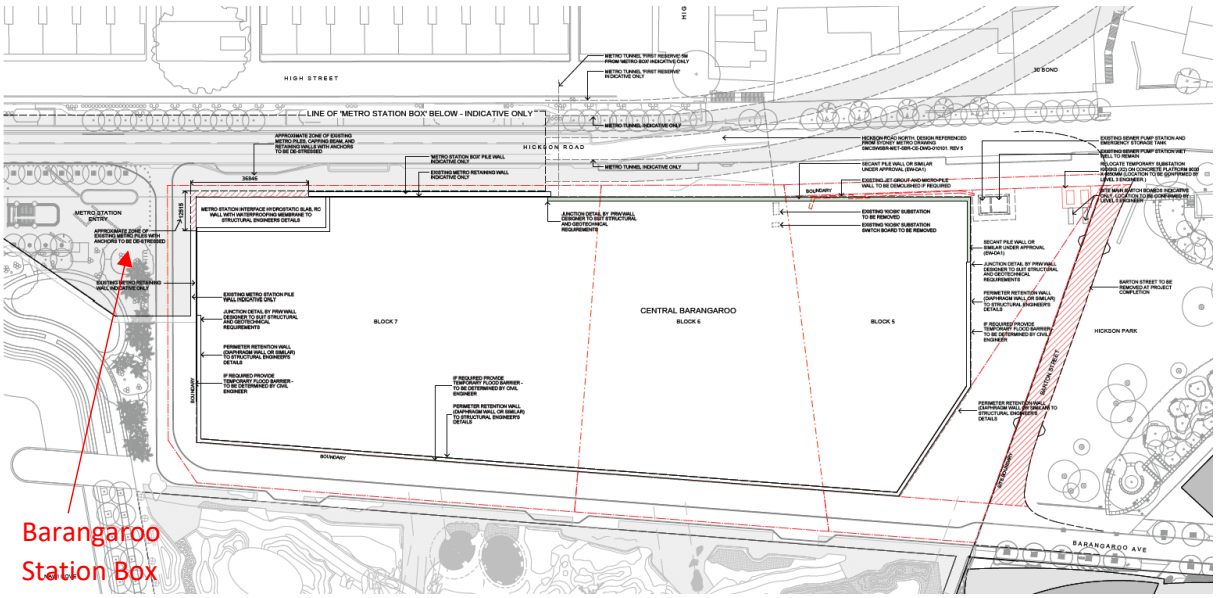

Figure 1: Development Site & Sydney Metro Infrastructure

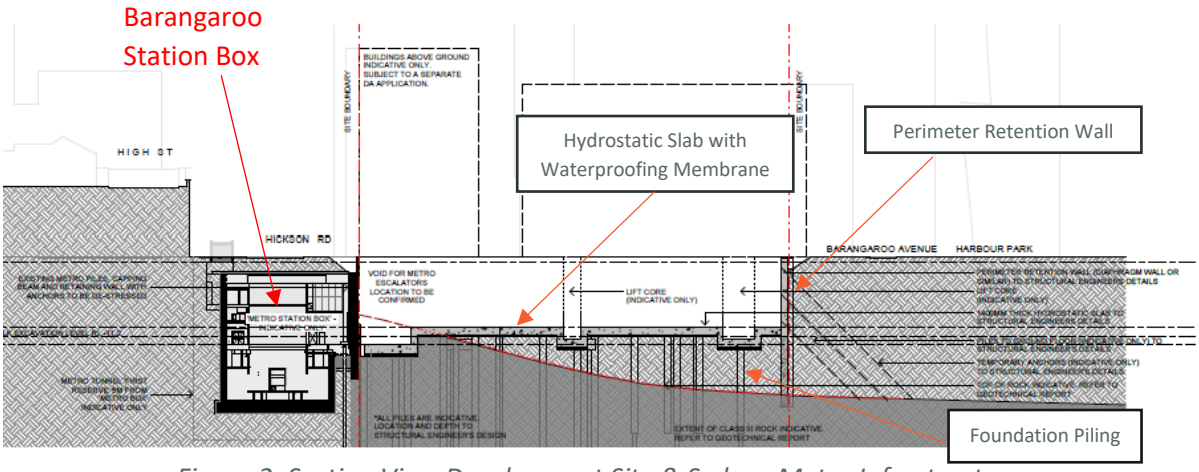

Figure 2: Section View Development Site & Sydney Metro Infrastructure

Electrolysis Risk

The site is in proximity the Sydney Metro City and Southwest alignment and thus at risk of stray current interference which will be most likely disseminated stray current flow through the ground to the site. However, the Sydney Metro Barangaroo Traction Substation is located in the adjacent station box precinct. The traction substation has a Rail to Earth Contactor (REC), which closes if the rail voltage rises above a predetermined safety levels. In the case where the Taction Substation REC closes, then it is expected that the subject site may be exposed to higher levels of stray current in the ground which present a corrosion risk to the local precinct. The REC is therefore alarmed at the railway control centre to alert the operators to send out a maintenance crew to investigate and reset the REC. The subject site should be built with resilience to stray current so in the event of the REC closing then the site itself, and any utilities and 3rd parties bonded to the sites structure are mitigated against the risk of corrosion.

To avoid corrosion caused by stray current originating from the rail system, a site-specific risk assessment is undertaken.

The following controls are recommended to mitigate the risk to SFAIRP (so far as is reasonably practicable).

Site Development Recommendations

Subject site is in proximity to the Sydney Metro DC railway system, the development is considered high risk of picking up or propagating stray current due to its close proximity to the Barangaroo Station box. Simple measures of protection and mitigation should be adopted such that:

a. Stray currents are not encouraged to flow in the development sites infrastructure so as to corrode the future development.
b. Stray currents are not picked up at the site such that they can be delivered to third party assets external to the site (such as neighbouring buildings or utility assets).
c. In the event that the site does become exposed to corrosion by stray currents, then means are available to mitigate the impacts of Stray Current by Cathodic Protection techniques.

The implementation of these recommendations can be affected by following some basic requirements:

a. All ground based concrete structures being concrete in contact with natural ground or engineering fill are recommended to be implemented with consideration to:
    - Avoid the concrete structure acting as an electrode in the ground which is able to pick up or deliver stray currents.
    - Avoid localised concentrated current flow in the reinforcement to earth

    To mitigate this risk the concrete constructed in contact with the ground, should repel water and provide a uniform dry layer around the reinforcement. Concrete with 32MPa or greater strength is generally considered water resistant and hence it can assist in keeping the internal parts of the concrete which surround the reinforcement dry if there is adequate cover around the reinforcement.

    The structural designer has specified the concrete strength of ground-based structures (foundation piles, hydrostatic slab, diaphragm retaining wall) exceeds 32MPa.

    Metallic rods or components which are touching the reinforcement and the ground will provide a low resistance bond in the reinforcement to earth and will make redundant the protection offered by the 50mm thick cover of concrete over the reinforcement.

    Metallic reinforcement supports must not be used. Nonconductive supports/spacers should be used. In case of metallic temporary anchors, it should be electrically separated from the reinforcement, the temporary anchors will be destressed, cut off and the opening will be waterproofed.

    Before concrete pouring, the builder must verify and ensure that no metallic rebars (or similar materials), such as those used in falsework or sacrificial embedded supports, are in contact with the ground. To prevent contact between piling reinforcement cages and the ground, plastic pile cage foot could be utilized, and metallic chairs or concrete blocks should not be used to support the slab reinforcement.

b. The developments ground based concrete structures are recommended to be electrically continuous. With consideration of the size of the proposed development the electrical continuity of he ground based structures could be separated into multiple electrically continuous sections. This provides allows provision for stray current interference testing/monitoring and cathodic protection of the structure if required in the future as retrofitting cathodic protection is costly and practically challenging if the internal reinforcement is not suitably electrically continuous. To provide guidance that adequate electrical connection of the reinforcement has been achieved, AS2832 states that a maximum resistance of 2 ohms should be measured from a location where a test point is added to the remote ends of the reinforcement structure that it protects.

- **The development concrete structure is therefore recommended to include at minimum two (2) Electrolysis Test Points (ETP) per electrically continuous section.**
- **Prior to concrete pouring the reinforcement on each level should be tested to have a continuity less than 2 ohms.**
- **Prior to concrete pouring, the ETP should be tested in accordance with AS2832 requirements for a continuity of less than 10 milliohms to the reinforcement cage.**
- **Before the placement of concrete is conducted, the electrical resistance measurements should be confirmed and recorded.**

c. **A heavy-duty waterproofing membrane placed between the concrete structure and the ground is recommended *where practical.***

The membrane is recommended to include treated joints such that water penetration from the ground, through the joint to the concrete is mitigated as far as is practical. The waterproofing membrane shall be sufficiently durable and remain without tears during the construction process.

Accordingly, the builder is advised to remain vigilant prior to concrete pours such that reinforcement bars have breached the waterproofing membrane.

d. The development structure interfaces with the Barangaroo Sydney Metro station box in the Northeast corner of the site. Any interface with the station box shall be in accordance with the Sydney Metro Earthing and Bonding & Electrolysis design strategy and Sydney Metro design approval.

It is imperative that both structures are electrically separated and care is taken in the construction to ensure suitable nonconductive waterproofing and joint material separated the structures. Verification and assurance testing is recommended to be undertaken periodically during the construction to validate the electrical separation during the construction process as limited assurance can be gained when testing is solely undertaken at the completion of the construction as both structures will have a very low resistance to earth due to their considerable and comparable footprint with the ground.

Permanent conductive structures or equipment shall not bridge the isolation interface joint.

Temporary construction structure or equipment should not bridge the isolation interface where this may be unavoidable specific electrolysis risk assessments shall be undertaken with consideration of the proposed time frame of the isolation join degradation and in consultation with Sydney Metro and the New South Wales Electrolysis Committee (NSWEC).

e. Stray current interference recordings are recommended to be undertaken at the site prior to (baseline) and post construction and annually after construction for a period of 5 years.

Recording shall coincide with Sydney Metro operating at normal capacity. Recordings will aim to determine the impacts from stray currents are tolerable and not corrosive to the structure.

f. Considering the significant size of the development and its proximity to the Sydney Metro station box it is recommended that the project interface with the New South Wales Electrolysis Committee (NSWEC) for consideration of stray current interference risk alteration to utility assets in the nearby area.

Conclusion

Adoption of the above controls mitigate the stray current electrolysis risk to SFAIRP (so far as is reasonably practicable) levels.

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