

AGNSW

**Art Gallery of NSW Expansion
Project -
Sydney Modern**

**Development Application -
Hydraulic and Structural
Infrastructure Report**

247039

Issue | 30 October 2017

This report takes into account the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

Job number 247039-00

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Executive Summary

This report has been produced in response to the Secretary's Environmental Assessment Requirements Application Number SSD 6471 on behalf of The Art Gallery of NSW, in support of the State Significant Development Application for the Art Gallery of NSW Expansion Project – Sydney Modern.

This report addresses issues required for a SSD and specifically responds to the SSD SEARS Key Issue number 10, which reads:

(10) Infrastructure

- *Detail any infrastructure proposed to service the development and demonstrate that the site can be suitably serviced.*
- *Detail the existing infrastructure on site and identify any possible impacts on infrastructure (particularly on the Cahill Expressway/Eastern Distributor) arising from the construction of the proposed building.*
- *Where the proposed works affect existing infrastructure, the application should detail any mitigation works proposed including service relocations.*
- *Prepare an Infrastructure Management Plan. The applicant shall provide information on the required water and waste water services, electricity and gas and any augmentation of Sydney Water and RMS infrastructure that may be required for the proposed development.*

This report, which covers Hydraulic and Structural infrastructure, forms part of the Infrastructure Management Plan. The other part, which covers Electrical and Communications infrastructure, has been prepared by others.

This report has analysed the different building loads imposed on the surrounding utilities, and through review, discussion, meetings and correspondence we have determined that the development can be adequately served by the surrounding utility infrastructure.

The existing land bridge has been checked to be structurally adequate in carrying the new building's gravity loads based on the structural capacities derived from the existing as built structural drawings.

The proposed approach to lateral stability is to minimise seismic upgrading of the land bridge, by restricting the future loads such that future seismic demands are within the existing structure's capacity. This approach is to be validated during future design stages and is subject to review and agreement with RMS and AML.

1 Introduction

1.1 Detailed Description of Works

The Art Gallery of NSW proposes to undertake a major expansion of the existing art gallery adjacent to the Phillip Precinct of the Domain. The expansion, proposed as a separate, stand-alone building, is located north of the existing gallery, partly extending over the Eastern Distributor land bridge and includes a disused Navy fuel bunker located to the north east of this land bridge.

The new building comprises a new entry plaza, new exhibition spaces, shop, food and beverage facilities, visitor amenities, art research and education spaces, new roof terraces and landscaping and associated site works and infrastructure, including loading and service areas, services infrastructure and an ancillary seawater heat exchange system.

Development consent is sought for:

- Site preparation works, including:
 - Site clearing, including demolition of former substation, part of road surfaces, kerbs and traffic islands, pedestrian crossings, foot paths, retaining walls, stairs, and part of disused underground former Navy fuel bunkers;
 - Tree removal;
 - Excavation and site earthworks;
 - Remediation works;
- Construction of the new building comprising:
 - Covered public entry plaza;
 - Five building levels, including entry pavilion following the site topography down to Lincoln Crescent;
 - Retention of part of existing former underground Navy fuel bunker for use as gallery space and support spaces;
 - Art exhibition spaces;
 - Outdoor publicly accessible terraces;
 - Shop and cafe;
 - Multipurpose space;
 - Education spaces;
 - Ground level loading dock (accessed via Lincoln Crescent) with associated art handling facilities, workshops, service parking, plant, and storage areas.
- Landscaping and public domain improvements including:

- Continuation of the east-west pedestrian link over the land bridge between the Domain and Woolloomooloo Bay, including dedicated lift structure for universal access;
- Improved public access of the north south pedestrian link
- Enhancement of the public open space on the land bridge to create a landscape and art connection between the two buildings
- Hard and soft landscaping to roofs and terraces;
- Plantings and new pathways;
- Increased landscaped area to forecourt of existing Art Gallery building and removal of car parking
- Relocation of selected trees to the south-eastern corner of the site;
- Sound barrier to edge of land bridge;
- Upgrade works to part of Art Gallery Road, Cowper Wharf Road, Mrs Macquaries Road, and Lincoln Crescent, including new pedestrian crossings;
- Provision of vehicle drop off points including a taxi stand, private vehicle drop off and bus/coach drop off, at Art Gallery Road;
- Installation of an ancillary seawater heat exchange system to act as the new building's cooling system, adjacent to and within Woolloomooloo Bay;
- Diversion, extension and augmentation of physical infrastructure and utilities as required.

2 SEARs Issues Addressed

This report addresses the following issues identified within the State Significant Development Application (SSDA) Number SSD 6471, as contained within the SEARs issued by the NSW Department of Planning and Environment on 8 June 2016.

(10) Infrastructure

- *Detail any infrastructure proposed to service the development and demonstrate that the site can be suitably serviced.*
- *Detail the existing infrastructure on site and identify any possible impacts on infrastructure (particularly on the Cahill Expressway/Eastern Distributor) arising from the construction of the proposed building.*
- *Where the proposed works affect existing infrastructure, the application should detail any mitigation works proposed including service relocations.*
- *Prepare an Infrastructure Management Plan. The applicant shall provide information on the required water and waste water services, electricity and gas and any augmentation of Sydney Water and RMS infrastructure that may be required for the proposed development.*

This report, which covers Hydraulic and Structural infrastructure, forms part of the Infrastructure Management Plan. The other part, which covers Electrical and Communications infrastructure, has been prepared by others.

3 The Site

The site is located to the north of the existing Art Gallery of NSW, bounded by Art Gallery Road to the west, Lincoln Crescent to the east, and the existing zone substation to the north. The site slopes severely from west to east, from approximately RL24 at Art Gallery Rd at south-west extent of the site, to RL2.9 on Lincoln Crescent to the east.

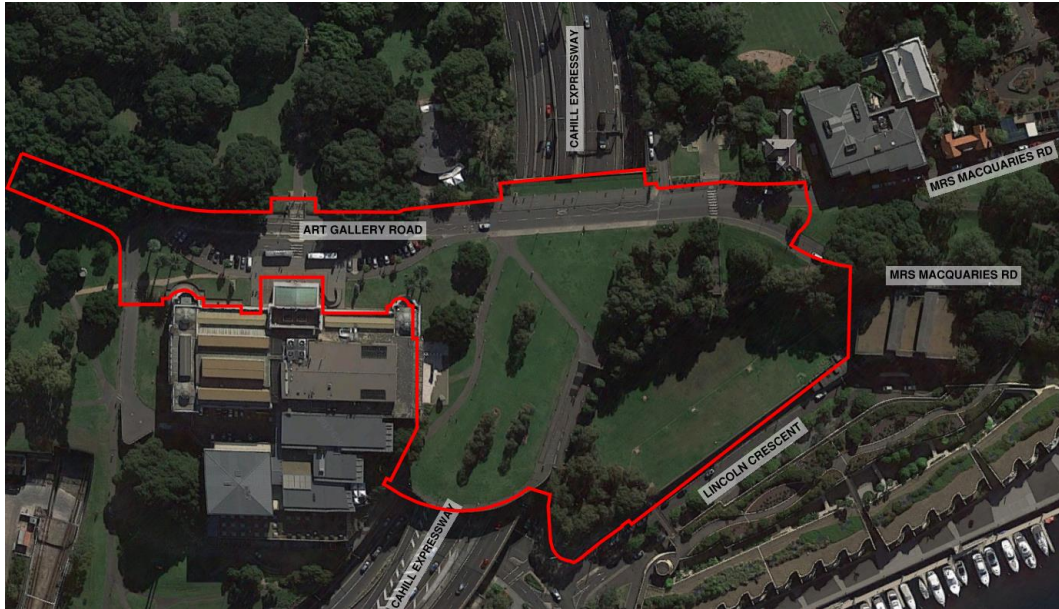


Figure 1: Site location

The new building is required to be located over both the existing land bridge constructed over the Eastern Distributor in 1999, and the disused WWII fuel bunkers located north of the Woolloomooloo exit ramp of the Eastern Distributor.

Existing utility services are available through and around the precinct. Details about the surrounding utility infrastructure are provided further within the report.

4 Building Hydraulic Loads

In order to assess the capabilities of the surrounding hydraulic services infrastructure, Arup has undertaken a preliminary load take down assessment for the precinct.

Our estimates of the demands imposed upon different existing utilities by the Sydney Modern project are as follows:

4.1 Sydney Modern Infrastructure Hydraulic Loads

The following loads have been calculated from proposed building populations, designated use of spaces and demands from HVAC load estimates. For water and sewer these follow recommendations of AS3500.1 and AS3500.2 respectively with added safety factors. Gas demands are benchmarked to the uses for similar kitchens with added DHW and HVAC loads. Naturally the loads are preliminary at this stage and will be refined with design development.

Table 1: Sydney Modern load estimates for utility services

Sydney Modern Loads	
Utility Service	Load Estimate
Potable Water Supply	4 L/s
Gas	9000MJ/hr
Sewer	6.5L/s
General Stormwater;	Roofs: 1:100 year ARI to be piped (270mm/hr, attenuated discharge flow to match existing site discharge) Roads and Plaza: 1:10 year ARI to be piped
Overland flow	1:100 year storm conveyed by overland flow

5 Utilities Services

The following provides an outline of the existing services available to the precinct and identifies any required alterations to serve the proposed development.

Details of the existing services through the ‘dial before you dig’ (DBYD) service and discussions with the utility authorities indicate the existence of the following services serving or traversing the site.

5.1 Water, Sewer and Stormwater

The Arup design team has reviewed the DBYD information for the precinct and have identified the differing utility infrastructure around the precinct.

5.1.1 Existing Services

Utility services are present around the precinct. These existing services are described as follows and are detailed in the Figures below.

Cold water

Existing water mains are available running along both Art Gallery Road and Lincoln Crescent.

These streets contain the cold water infrastructure as follows:

- Art Gallery Road – 150mm cast iron cement lined main.
- Lincoln Crescent – 150mm cast iron cement lined main.
- Eastern Distributor – Two 150mm diameter mains; one cast iron cement lined, the other of unknown material.

The water supply infrastructure within the Sydney CBD is considered a critical asset by Sydney Water. The mains are heavily interconnected and served from multiple reservoirs. The mains therefore are very liable and are maintained to a high degree by Sydney Water, commensurate with their critical asset status. Sydney Water has management plans in place to redirect supplies should failures occur, resulting in a high degree of security for the developments served from this infrastructure.

In general, the size of the town mains in the surrounding streets can easily support this development based on the flow rates identified in Section 3. The design is progressing with the water main connection entering the gallery from Art Gallery Road in order to serve the incoming hydrant boosters proposed for the entry plaza.

The final form of this connection will develop through detailed design.

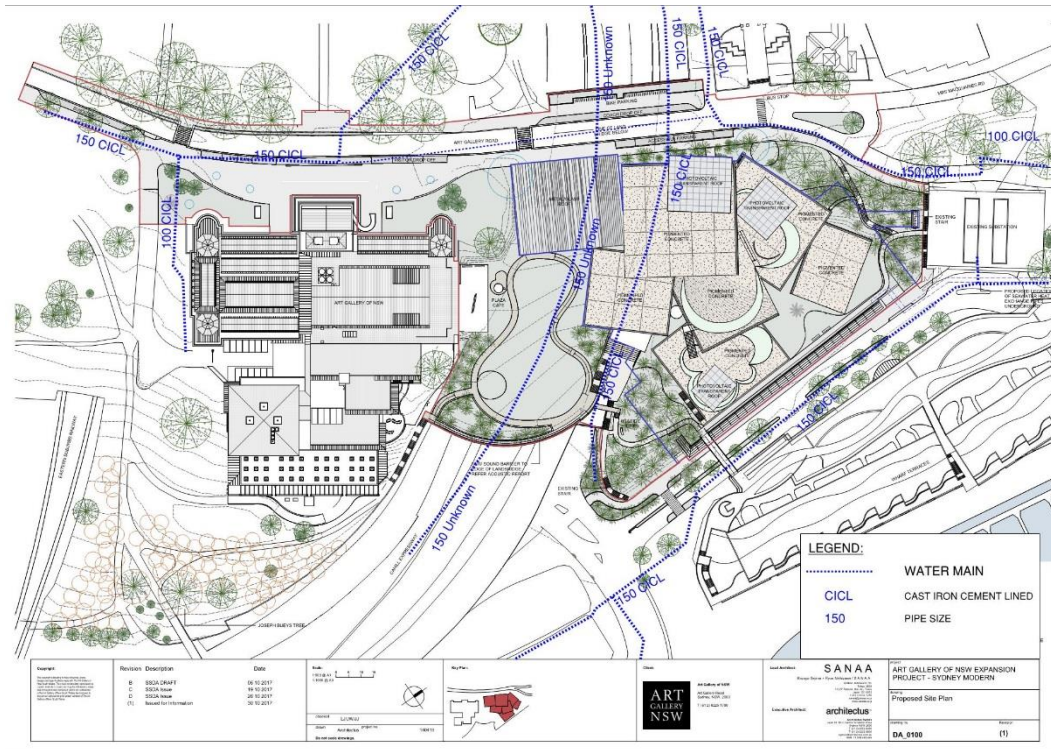


Figure 2: Water Supply

Sewer

Existing sewer mains are available running along Lincoln Crescent.

These streets contain the sewer infrastructure as follows:

- Lincoln Crescent – 225mm vitrified clay.

In general, the sewer from the building will be directed to Lincoln Crescent and discharge into the existing sewer. The sewer in Lincoln Crescent increases to 300mm diameter shortly below the Sydney Modern site and it is not expected that this will not be able to support the new development. A Section 73 application will be required during detailed design to establish if any extension to the 300mm diameter network is required.

Stormwater

- Art Gallery Road – A mix of 225 and 300mm diameter storm lines.
- Lincoln Crescent – Storm lines between 100 and 750mm diameter.

Stormwater collected from roofs and hard surfaces for the new buildings will be harvested and discharged to new basement level harvesting tanks. The primary use of the harvested water will be for fulfilling the needs of the existing building's cooling towers. Water not used for this purpose will be directed to the storage facilities dedicated to the support of irrigation needs around the precinct.

- Cooling Towers – 200m³;

- Irrigation -150m^3 ;
- Detention -500m^3 .

The storage volumes are located in the lowest levels and overflow is afforded to the storm drains in Lincoln Crescent. The total harvested volumes will be pumped to the cooling towers and when these are being used in detention mode to the gravity outfall. The system will incorporate level controls in order to evacuate the detention volumes at an acceptable rate.

The analysis undertaken has shown that the harvesting strategies in place will reduce the total load to the storm network by approximately 77%. This analysis utilises the last 50 years of rainfall data from the BOM website and runs a daily summation of water used and water received for all events.

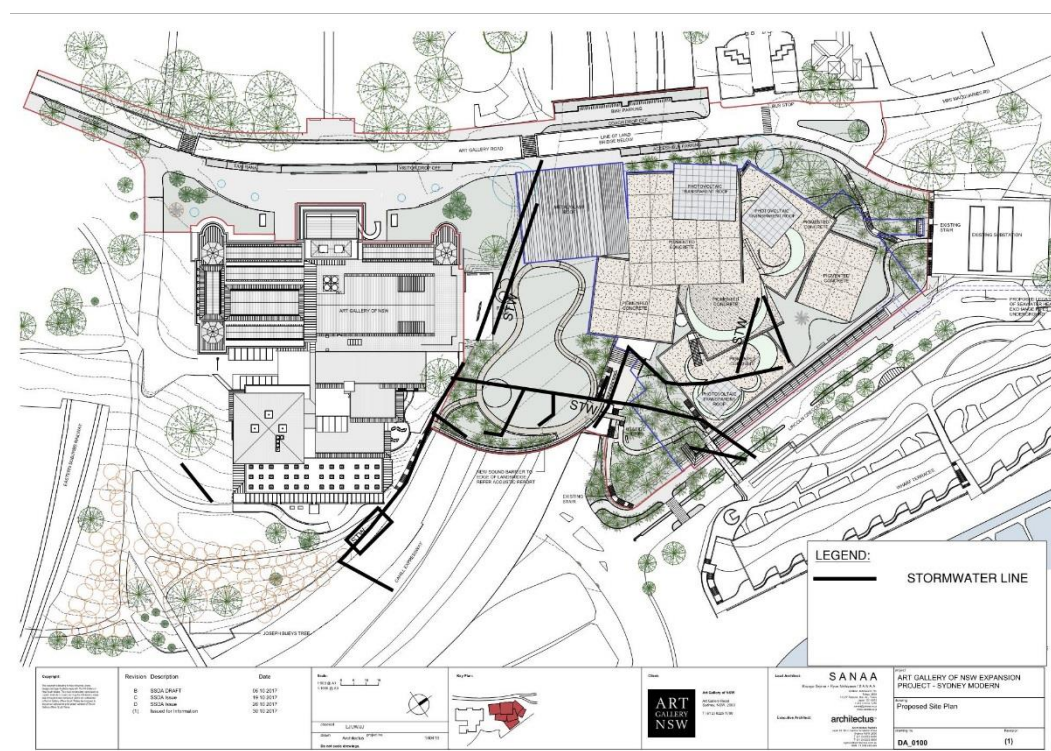


Figure 4: Stormwater

5.1.2 Required Alterations

Cold water

At present, we anticipate an increase in cold water demand over and above the existing site supplies. The supply requirements and connection point location(s) will need to be confirmed with Sydney Water as part of the Section 73 application and at present are anticipated to be from Art Gallery Road. The surrounding infrastructure is of sufficient size and can support the new development.

Sewer

At present, we anticipate increases in sewer discharge over and above the existing site capacity. The supply requirements and connection point location(s) will need to be confirmed with Sydney Water as part of the Section 73 application. The surrounding infrastructure is expected to be able to support the new development.

Stormwater

The details of the stormwater systems are covered in the Arup SSD Report specifically addressing Key Issue number 12.

5.2 Natural Gas

The design team has reviewed the dial before you dig information and the following existing services are available around the precinct.

5.2.1 Existing Services

The existing gas services are described as follows. (Refer to Figure 4 below for details.)

These streets contain the natural gas infrastructure as follows:

- Art Gallery Road – 150mm diameter gas service 210kPa.
- Lincoln Crescent – 75mm diameter gas service 210kPa.

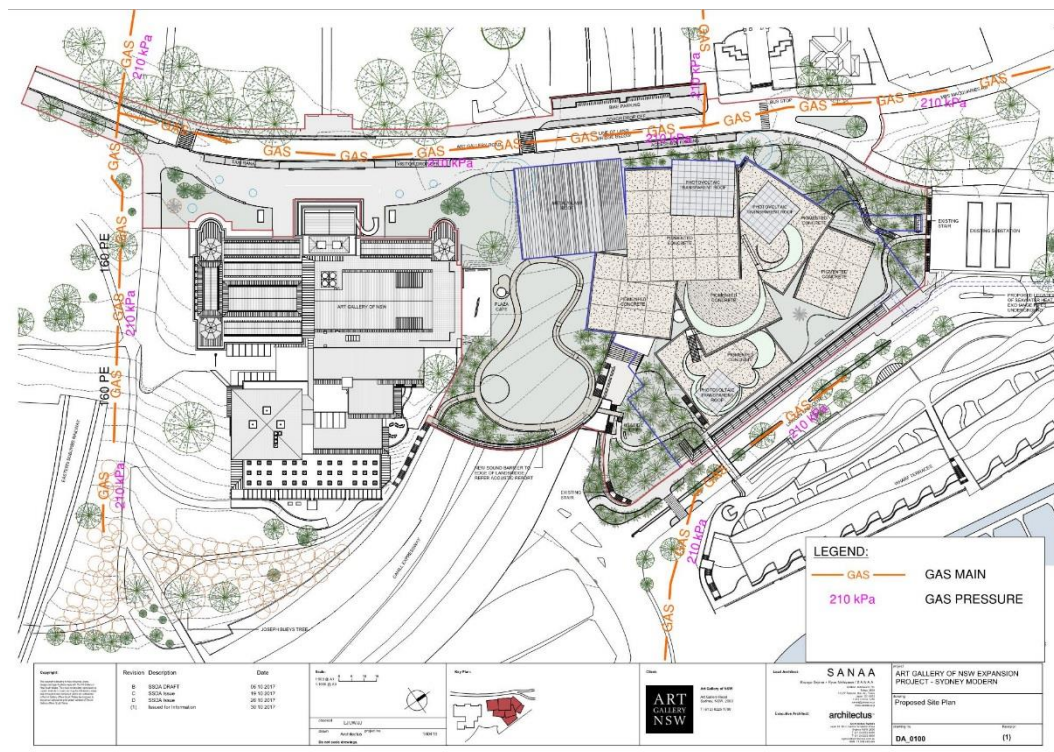


Figure 5: Existing gas services

5.2.2 Required Alterations

While we anticipate an increase in gas requirements to the site, based on our review of loads and available supplies, the site can be provided with natural gas infrastructure.

6 Impacts to Cahill Expressway and Eastern Distributor

6.1 Approach

The above SEARS requirements ask for the infrastructure report to:

Detail the existing infrastructure on site and identify any possible impacts on infrastructure (particularly on the Cahill Expressway/Eastern Distributor) arising from the construction of the proposed building.

To address this, the approach generally is to minimise any works to the land bridge, in particular to obviate or minimise the need for works from the Eastern Distributor. As such, the section of building to be constructed on the existing land bridge is being designed within the local and global load carrying capacity of the existing structure. To this end, Arup has reviewed all available information and conducted a detailed numerical assessment of the vertical and horizontal capacity of the existing structure to inform the development of the project. We have not relied solely on a like-for-like design load replacement.

An initial meeting with RMS and Transurban was held in February 2016 to discuss the approach described below. The proposed building scheme at that stage included two storeys of new structure on the land bridge. The scheme has since been reduced in size, and now comprises a single storey over the land bridge, covering a smaller total plan extent than before, significantly reducing the loads imposed on the existing structure. A meeting was held with RMS, Transurban and its reviewing engineer AECOM on 16 October 2017 to update them on the scheme. Further consultation with those parties will be undertaken in future design phases as required.

6.2 Gravity Load Analysis

Arup has conducted a gravity load capacity assessment of the girders, planks, columns, walls, and foundations based on the structural drawings provided by Transurban. The results of the assessment are shown in Figure 6, in the form of structural utilisations under the original design loading, incorporating both the construction phase and permanent load conditions. This assessment has informed the extent of new structure proposed on the land bridge, and the approach to local support and load distribution from the new structure over.

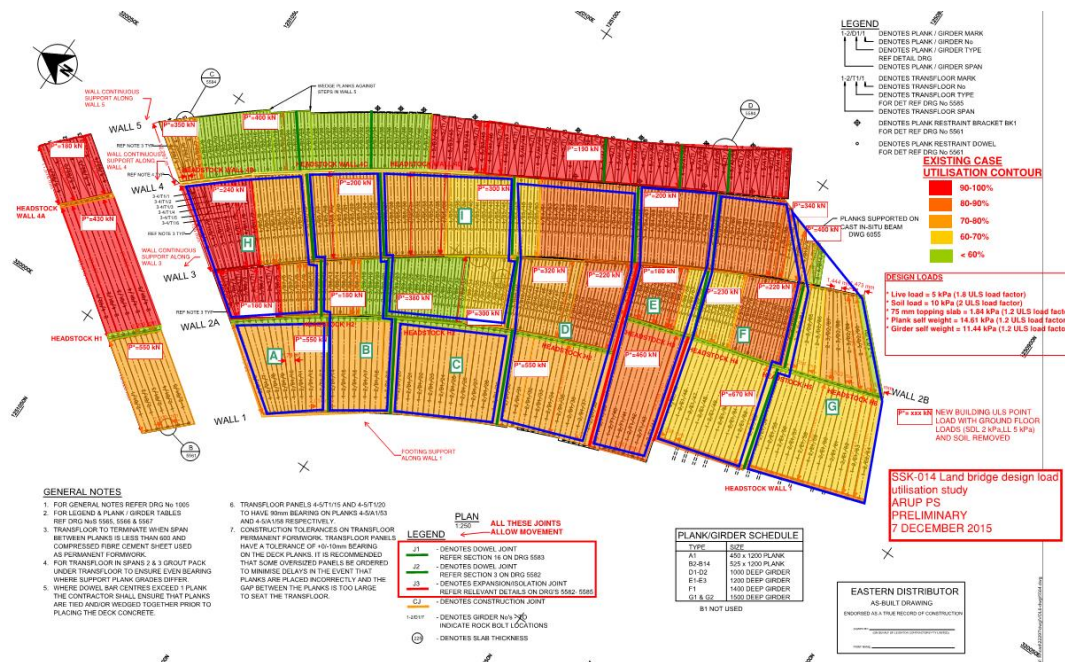


Figure 6: Structural utilisation of land bridge under original design loading (Arup sketch based on Maunsell McIntyre drawing N641/N/ST/5580 Rev AB0)

New foundations in the form of pad footings, footing beams, or grillages are required to spread proposed concentrated column loads onto the existing precast planks, girders, and composite slab, to avoid local overstress. The proposed foundations are as follows:

- Entry Plaza:
 - Pad footings poured directly on land bridge surface, in lieu of existing fill removed locally.
 - Footings support columns to Entry Canopy.
- Entry Pavilion (southern portion):
 - 150 thick reinforced concrete waffle slab over void formers on a nominal 5m grid of downstand walls. Continuous bearings (e.g. Granor or Hercuslip) under downstand walls.
 - Downstands support columns to a steel-framed roof.
 - Northern portion is not over land bridge. It is a suspended structure supported by columns through internal space below.
- Gallery 1 (southern portion):
 - Waffle slab similar to Entry Pavilion, with downstands supporting columns to a steel-framed roof.
 - Northern portion is not over land bridge. It is a suspended steel-framed structure, mostly supported by columns through internal space below. Along northern edge of land bridge, suspended structure is supported by existing land bridge wall via new steel bracket columns.

The floors of both the Entry Pavilion and Gallery 1 are founded directly on the land bridge and built up using loadbearing styrene, or a simple waffle slab, providing a distributed loading on the existing structure and minimising concentrated loading. Jacking of the system using flat-jacks or hydraulic jacks to distribute load evenly may be required where depth of new structure is limited, the supporting structure is very stiff, or preloading of adjacent planks is necessary.

An initial meeting with Transurban and RMS was held in February 2016 to discuss the approach described below. The proposed building scheme at that stage included two storeys of new structure on the land bridge. The scheme has since been reduced in size, and now comprises a single storey over the land bridge, covering a smaller total plan extent than before, significantly reducing the loads imposed on the existing structure. A meeting was held with Transurban and RMS on 16 October 2017 to update them on the scheme. Further consultation will be undertaken through the design process as required.

6.3 Lateral Stability

Based on the existing drawings, Arup has assessed that existing north-south stability of the land bridge has been/is provided by the rock bolts at the western side of the bridge. The original design drawings indicate that the land bridge was designed in accordance with the provisions of AS1170.4 (earthquake loading for building structures).

Transurban has provided Arup with a preliminary structural design report for the land bridge issued in June 1997 by Maunsell Pty Ltd and Connell Wagner Pty Ltd. The report confirms that passive rock anchors are required to resist lateral earthquake to AS1170.4 with the following parameters:

- *Importance factor:* 2;
- *Design category:* B;
- *Design lateral load:* 5% of the design vertical loads.

Seismic assessment of the existing structure in accordance with the current standard AS5100.2 undertaken by Arup indicates that the number of rock bolts currently provisioned has limited capacity to resist additional seismic load. The original drawings also indicate a number of locations of movement joints along the north-south and east-west directions that would be undesirable for adding significant extra loading to the structure.

Based on this assessment, the principles for ensuring lateral stability of both the land bridge and the new structure are as follows:

1. Limit the future global gravity load to within the original global design load, thus avoiding an increase in seismic demand on the land bridge. This will avoid the need for the seismic upgrading described for the previous scheme.
2. Provide a clear lateral load path from the new structures supported by the land bridge to stability structures in the new building, founded to the north of the land bridge.
3. Provide lateral load separation of the new structures and land bridge such that the lateral stability of each is provided independently.

The first part of the strategy is achieved as described in **Error! Reference source not found.** above. The second part is achieved through:

- a. The bearings under both pavilions, which allow relative lateral movement between the new structures and the land bridge, limiting the seismic actions that can be transferred between them.
- b. Reinforced concrete shear walls under both pavilions, which provide a stability system independent of the land bridge. The key stability elements are highlighted in Figure 7. It is noted that the key stability element under Gallery 1 is proposed to be founded on the base of the existing land bridge Wall 5.

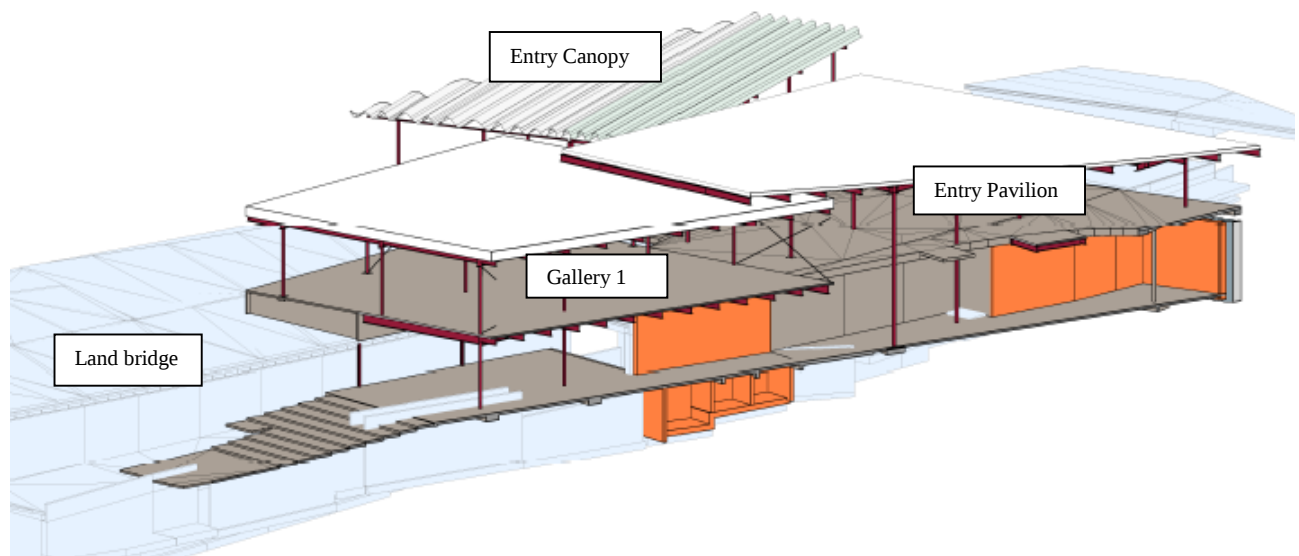


Figure 7: Key stability walls (orange). These elements resist lateral loading from new structures supported by land bridge under gravity (i.e. northern parts of Entry Pavilion and Gallery 1).

6.4 Northern Excavation & Rock Pillar

To protect the existing land bridge structure, Arup has proposed that a nominal 6m clear zone from the rock excavation/face of abutment wall on the north (road) side of the Woolloomooloo off ramp to the new excavation line is maintained. This 6m zone provides a pillar of minimum Class III sandstone that supports the existing abutment structures and clears the existing rock anchors installed from the road side. Class III sandstone is generally able to stand vertically unrestrained, however localised rock bolts and grouting/shotcreting at any weathered zones is likely to be required. It is expected that previous excavation associated with the fuel bunker and Eastern Distributor works has reduced horizontal in situ stresses, and that relief during excavation is likely to be significantly reduced.

A preliminary geotechnical assessment of the above approach was undertaken by Coffey, described in a memo dated 27 April 2016 and in the geotechnical report. Three cored boreholes were drilled in the vicinity of the proposed rock pillar, and the subsurface profile was found to be fill overlying Class V/IV and Class III sandstone. The assessment indicates that the proposed rock pillar work is feasible and can likely be carried out using rock slope protection techniques typically used in Sydney with retention of Class IV/V sandstone.

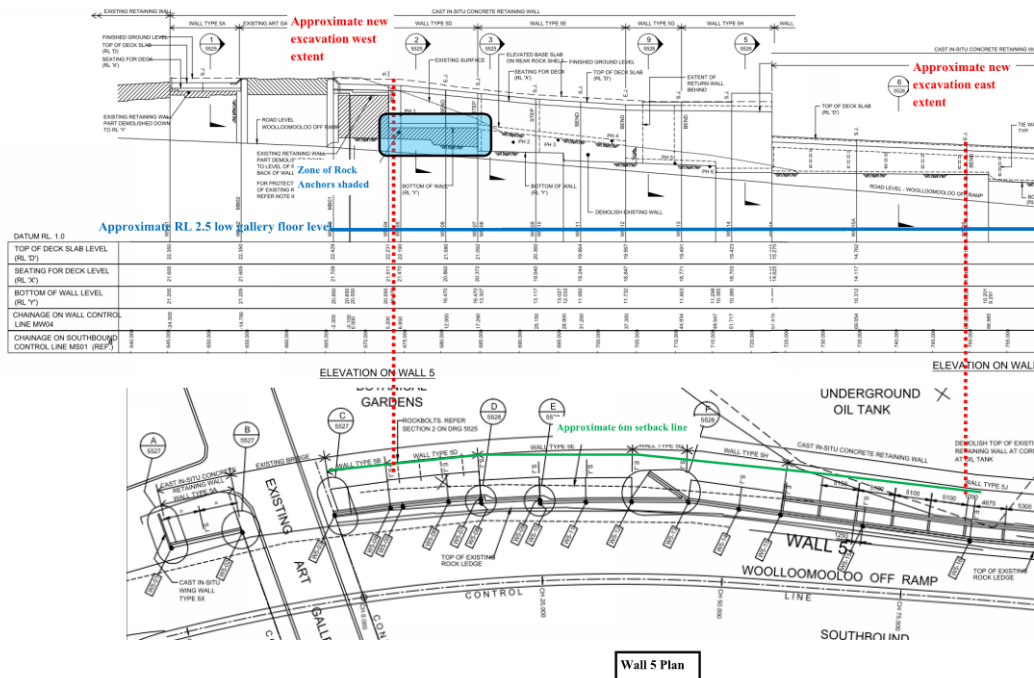


Figure 8: Proposed limit of nearest excavation below land bridge north wall footing (green line on plan)

7 Conclusion

This report has addressed SSD SEARS Key Issue number 10 regarding the utility services infrastructure and RMS infrastructure on and around the site. It has analysed the building hydraulic loads imposed on the surrounding utilities, and through discussion, meetings and correspondence it has been determined that the developments can be adequately served by the surrounding utility infrastructure.

The existing land bridge has been checked to be structurally adequate in carrying the new building's gravity loads based on the structural capacities derived from the existing as built structural drawings.

The proposed approach to lateral stability is to minimise seismic upgrading of the land bridge, by restricting the future loads such that future seismic demands are within the existing structure's capacity. This approach is to be validated during future design stages and is subject to review and agreement with RMS and AML.