

Venues NSW

**SSD 9835**

**Sydney Football Stadium  
Redevelopment**

**Section 4.55 Modification**

**Precinct Village and Car Park (MOD 7)  
Geotechnical Assessment**

Rev 4 | 12 October 2021

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 282684







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# Document verification

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# 1 Introduction

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On 6 December 2018, the then Minister for Planning approved a concept development application and concurrent early works package (SSD 9249) to facilitate redevelopment of the Sydney Football Stadium.

The concept approval established the maximum building envelope, design and operational parameters for a new stadium with up to 45,000 seats for patrons and allowing for 55,000 patrons in concert mode. The concurrent Stage 1 works, which were completed on 28 February 2020, facilitated the demolition of the former SFS and associated buildings.

Stage 2 of the Sydney Football Stadium (SFS) Redevelopment (SSD 9835) was approved by the Minister for Planning and Public Spaces on 6 December 2019. Stage 2 provides for:

- Construction of the stadium, including:
  - 45,000 seats (additional 10,000 person capacity in the playing field in concert mode) in four tiers including general admission areas, members' seating and corporate / premium seating;
  - roof cover over all permanent seats and a rectangular playing pitch;
  - a mezzanine level with staff and operational areas;
  - internal pedestrian circulation zones, media facilities and other administration areas on the seating levels;
  - a basement level (at the level of the playing pitch) accommodating pedestrian and vehicular circulation zones, 50 car parking spaces, facilities for teams and officials, media and broadcasting areas, storage and internal loading areas;
  - food and drink kiosks, corporate and media facilities; and
  - four signage zones.
- Construction and establishment of the public domain within the site, including:
  - hard and soft landscaping works;
  - publicly accessible event and operational areas;
  - public art; and
  - provision of pedestrian and cycling facilities.
- Wayfinding signage and lighting design within the site;
- Reinstatement of the existing Moore Park Carpark 1 (MP1) upon completion of construction works with 540 at-grade car parking spaces and vehicular connection to the new stadium basement level;
- Operation and use of the new stadium and the public domain areas within the site for a range of sporting and entertainment events; and

- Extension and augmentation of utilities and infrastructure.

SSD 9835 has been modified on five previous occasions:

- MOD 1 amended Conditions B14 and B15 to satisfy the regulatory requirements of the Contaminated Land Management Act 1997;
- MOD 2 approved the design, construction and operation of the Stadium Fitness Facilities;
- MOD 3 approved design refinements to the western mezzanine and introduced a new condition to facilitate approval of signage details within the approved signage zones;
- MOD 4 relocated the approved photovoltaic array from the SFS roof to the Level 5 plant room roofs and revised the approved sustainability strategy; and
- MOD 5 updated plan references and dates in the Instrument of Consent.

A sixth modification which seeks approval for the fit out and operation of the SFS' eastern mezzanine for the Sydney Roosters Centre of Excellence (MOD 6) was placed on public exhibition by the Department of Planning, Industry and Environment between 19 August and 1 September 2021.

## 2 Precinct Village and Car Park

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### 2.1 Vision

Venues NSW (VNSW) is proposing to introduce a village community space, event plaza and multi-level car park to complement the SFS and adjoining Moore Park and Centennial Parklands. The proposed development will facilitate the permanent closure of the EP2 on-grass parking areas within Moore Park opposite the MP1 car park and enable its use for open space purposes consistent with the Moore Park Masterplan.

The vision for the Precinct Village and Car Park is set out below:

*The Precinct Village and Car Park provides a platform and canvas for an exceptional community asset and iconic design, that visually and physically connects to the adjacent Moore Park East and Kippax Lake. It provides patrons with quality café and dining experiences in an idyllic parkland setting and well-being play and relaxation nodes which engage with all ages. An event plaza, connected to the Stadium plaza provides a seamless opportunity for greater patron and community engagement through non-event and event day functions (Architectural Design Statement, Cox August 2021).*

## 2.2 Location

The Precinct Village and Car Park is proposed to be located on the land west of the SFS, currently approved under SSD 9835 as the MP1 Car Park. It will extend to Moore Park and Driver Avenue and will adjoin the existing UTS / Rugby Australia and Rugby League Central buildings, both of which are to be retained and do not form part of the project site. A Location Plan is provided at Figure 1.



Figure 1 – Precinct Village and Car Park Location

## 2.3 Development Description

The Precinct Village and Car Park has been designed to align with the conditions and commitment established within SSD 9835, particularly relating to delivering a LEED Gold rated sustainable precinct, and will include:

- 1,500 space multi-level carpark below ground level with the following access arrangements:
  - 1 x egress point onto Moore Park Road to be used on event days only;
  - 1 x two lane access point from Driver Avenue to be used on event and non-event days; and
  - dedicated area within the car park for operation/servicing vehicles.
- Reconfiguration of the currently approved drop off requirements for the elderly and mobility impaired.
- Free flow level pedestrian access to and from the SFS concourse from Driver Avenue and Moore Park Road.



- Electric car charging provision.
- A versatile and community public domain, comprising:
  - provision for 4 x north-south orientated tennis courts on non-event days with the potential to become an event platform on event days;
  - children's playground;
  - 1,500m<sup>2</sup> cafe / retail / restaurants with associated amenities in a single storey pavilion;
  - customer service office and ticket window; and
  - vertical transport provisions.
- Utilities provision augmentation.

Figure 2 illustrates the proposed Precinct Village and Car Park concept. Refer to the architectural within the Architectural Design Statement (Cox, August 2021) and landscape plans (Aspect, August 2021) for further details.

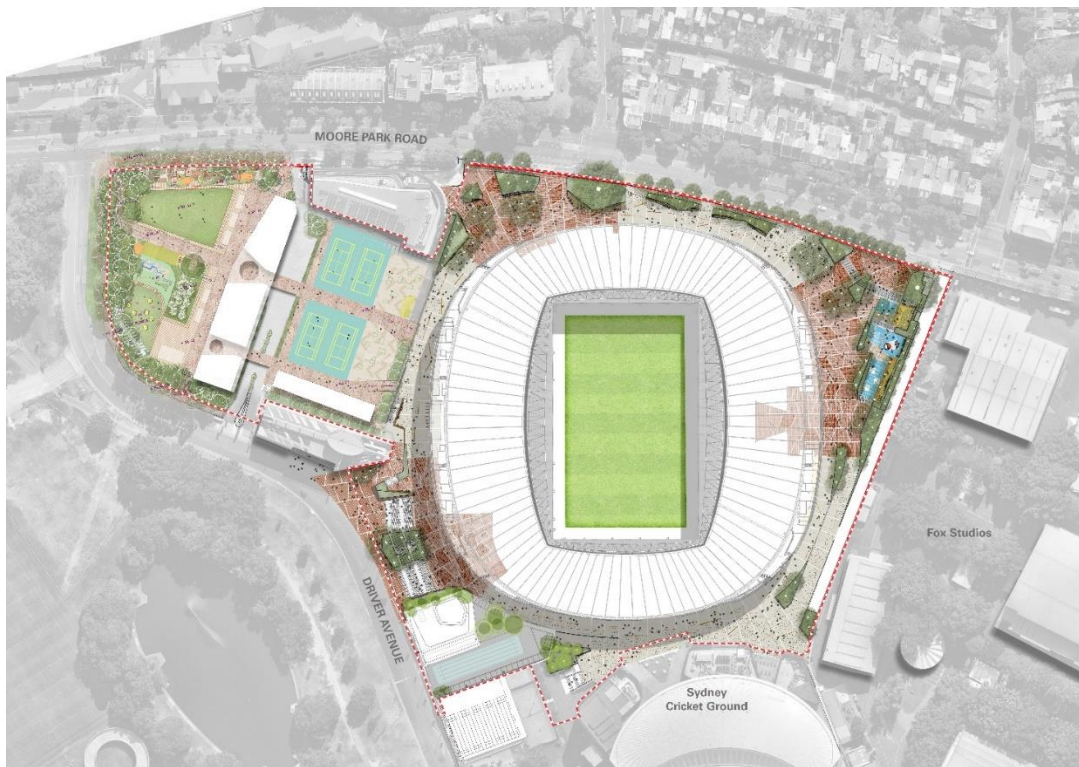


Figure 2 – Precinct Village and Car Park Development

## 2.4 Proposed Operation

The Precinct Village is proposed to be accessible from 8am to 11pm to align with the approved operating hours for the SFS.

The tennis court operating hours are proposed to be the same as the approved operating hours for the Stadium Fitness Facilities.

The car park will be automated, replicating the existing arrangements at the nearby Entertainment Quarter, and will be accessible 24 hours a day, 7 days a week.

The public domain is proposed to be curated as a series of distinct, flexible and purpose specific settings for event day patrons and the general public. These inviting public places will offer rich, engaging and shared experiences. An indication of the activity types, frequencies and durations proposed within the public domain is provided in the Architectural Design Statement (Cox Architecture, August 2021) and Planning Statement (Ethos Urban, August 2021).

## 2.5 Delivery

The Precinct Village and Car Park is proposed to be delivered in two stages:

- Stage 1, herein referred to as the East Car Park, consists of the area between the Rugby Australia and Rugby League Central buildings, immediately adjacent to the SFS concourse.
- Stage 2, herein referred to as the West Car Park, consists of the residual area immediately adjacent to the proposed East Car Park, bounded by Driver Avenue and Moore Park Road.

The East Car Park is proposed to be delivered ahead of the opening of the SFS in 2022. The West Car Park is proposed to be delivered after the SFS opening.

## 3 Proposed Modifications

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To facilitate the Precinct Village and Car Park, SSD 9249 and SSD 9835 are required to be modified. The proposed modification to SSD 9249 (concept development application) has been submitted under separate cover. SSD 9835 is proposed to be modified to facilitate construction, fit-out and operation of Precinct Village and Car Park as described above.

## 4 Purpose of this Report

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This Geotechnical Desk Study Report has been prepared to support the Precinct Village and Car Park modification. This Report specifically addresses the following Secretary's Environmental Assessment Requirements (SEARs) issued in respect of SSD 9825 and as relevant to the Precinct Village and Car Park project:

Secretary's Environmental Assessment Requirements	Report Section
17. Heritage (Busby's Bore)	8.3
27. Water and Natural Resources (Groundwater)	7.1, 8.6

## 5 Reference Documents

This Geotechnical Report is to be read in conjunction with the following reports and documents:

- Planning Statement prepared by Ethos Urban (August, 2021);
- Architectural plans/elevations/sections and Architectural Design Statement, prepared by Cox Architecture (August, 2021);
- Design Integrity Assessment Report prepared by Cox Architecture (August, 2021);
- Landscape plans and Landscape Design Report prepared by Aspect (August, 2021);
- Transport Assessment prepared by JMT (August, 2021);
- Noise and Vibration Assessment prepared by Arup (August, 2021);
- Stormwater and Flooding Assessment prepared by Arup (August, 2021);
- Visual Impact Assessment prepared by Ethos Urban (August, 2021);
- Social/Economic Statement prepared by Ethos Urban (August, 2021);
- Heritage Impact Statement prepared by Artefact (August, 2021);
- Sustainability Assessment prepared by LCI (August, 2021);
- Security Statement/CPTED prepared by Intelligent Risks (August, 2021);
- Contamination Assessment prepared by Douglas Partners (August, 2021);
- Arboricultural Assessment prepared by Tree IQ (August, 2021);
- Wind Assessment prepared by Arup (August, 2021);
- Infrastructure Services Strategy prepared by Arup (August, 2021);
- Public Domain Lighting Assessment prepared by Arup (August, 2021);
- and
- BCA and Accessibility Statement prepared by Before Compliance (August, 2021).

The following documents have been reviewed and utilised as part of this assessment:

- Arup, Sydney Football Stadium Redevelopment, Groundwater Assessment Report, Ref. 260159-GEHG-RPT-0001, 21 May 2018. (Arup, 2018)

- Douglas Partners, Report on Geotechnical Investigation, Sydney Football Stadium Redevelopment, Moore Park, NSW, Project 86529, May 2019. (DP, 2019a)
- Douglas Partners, Report on Detailed Site Investigation (Contamination), Sydney Football Stadium Redevelopment, Moore Park, NSW, Project 86529, May 2019. (DP, 2019b)
- Douglas Partners, Report on Geotechnical Investigation, Australian Rugby Development Centre Moore Park Road, Moore Park, Project 84881.00 August 2015.
- Jeffery and Katauskas, Report on Geotechnical Investigation for Proposed NRL Headquarters, 24 August 2010.
- ‘The water supply, sewerage, and drainage of Sydney’ compiled by W. V. Aird.; with a foreword by S. Haviland, 1961 Sydney
- Bish, S., Realica, S., Wischusen, J., 2000. Botany Sand Beds (GWMA 018), Botany Basin, NSW. Northern, Southern and Western Zones. Status Report No. 2. Department of Land and Water Conservation – Sydney-South Coast Region.

## 6 Site Conditions

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### 6.1 Description

The site is highest in elevation along the northern frontage to Moore Park Road at approximately RL44-45m and falls in a southerly direction to the lower end of the site along Driver Avenue at approximately RL39-40m. The existing site is currently a combination of impervious road/car park pavement with existing trees and landscape along the street frontages. The existing UTS / RA and RLC buildings on the north and south side of the site are to be retained without modification.

### 6.2 Regional Geology

The 1:100,000 Sydney Geology Sheet (Sheet 9130, Edition 1, 1983) indicates that the site is underlain by Botany Sands. This unit is typically comprised of fine to medium grained marine sands with podsols. The Botany Sands are underlain at depth by Hawkesbury Sandstone bedrock. These marine sand deposits are expected to predominantly comprise unconsolidated to semi-consolidated permeable sands.

Hawkesbury Sandstone is of Triassic Age and characterised as medium to coarse-grained quartz sandstone, with very minor shale and laminite lenses.

## 7 Ground Conditions

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The project site is underlain by a variable thickness of fill of approximately 2m average thickness, over 5 m to 10 m of saturated (wet) marine sand deposits, typically loose to medium dense, potentially over firm to very stiff residual clayey soil. The sandstone rock is anticipated to vary between RL34 to RL24, becoming deeper from north to south (i.e., 10m to over 15m depth below ground level).

The inferred top of rock and groundwater contours are presented Appendix A. This information has been extrapolated from limited data available to the east and north of the site and, will need to be verified through a site-specific geotechnical investigation prior to detailed design.

### 7.1 Groundwater conditions

There are two aquifers present in the project area, the Botany Sands aquifer underlain by the porous rock Hawkesbury Sandstone aquifer. The proposed development is considered to primarily interact the former.

The Botany Sands aquifer is primarily recharged by rainfall, where open spaces such as the Centennial Park and Moore Park parklands offer large areas for rainfall to infiltrate. Groundwater flow in the project area is considered likely to be in the south-westerly direction and to broadly follow the topography and surface drainage features (e.g. Kippax Lake), as supported by available data in the site vicinity (Arup, 2018).

The groundwater level is anticipated to vary between approximately RL38 to RL33 across the site (i.e. 3m to 8m depth below existing ground level). It should be noted that the groundwater level is subject to seasonal fluctuation and variation due to reasons such as heavy rainfalls, future development nearby, and termination of water pumping from existing wells in this area. The existing long-term groundwater monitoring data available from the SFS project shows  $\pm 3$  m fluctuation in the mean groundwater level over time. We understand that some of the groundwater pumping has been terminated over the last few years from the Botany sands, which could result in higher groundwater levels from those previously measured on the SFS site.

Groundwater yield from the northern area of the Botany Sands aquifer typically ranges from 1 to 41 L/s, with an average yield of 5 L/s (Bish et al., 2000).

## 8 Comments and Recommendations

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### 8.1 Information to inform the SSDA

Sufficient information regarding the site ground conditions is available to Arup to inform the design of the substructure for the SSDA. This information includes information from site investigations undertaken immediately adjacent and nearby to the subject site (refer Section 5), combined with geological mapping and our experience in similar conditions locally and across Sydney.

### 8.2 Excavation

The proposed three level basement carpark comprises excavation to approximately RL 32mAHD, up to 12.5m below existing ground. The excavation material is anticipated to mainly comprise fill, sands, clay with sandstone bedrock encountered to the north half of the site.

The other than rock (OTR) materials can be readily excavated using conventional earthmoving equipment such as hydraulic excavator with bucket attachment. For sandstone bedrock excavation it is recommended that vibratory rock breaking processes be complemented with saw cutting using an appropriate excavator mounted rock saw to minimise transmission of vibrations to adjoining buildings and infra-structures. Hammering should be carried out horizontally along bedding planes where possible.

Induced vibrations in structures adjacent to the excavation should not exceed a peak particle velocity (PPV) of 10mm/sec at the location of structures in good condition or 2mm/sec for heritage or poor-conditioned structures, unless it can be demonstrated that an existing structure can safely tolerate higher PPV.

Dilapidation surveys should be undertaken on the adjoining properties and streetscapes prior to excavation.

### 8.3 Site Constraint – Busby's Bore

Historical information and DBYD search indicate that an abandoned spur of Busby's Bore may extend near Driver Avenue and potentially intersect the south-west corner of the site, as shown in Figure 3.



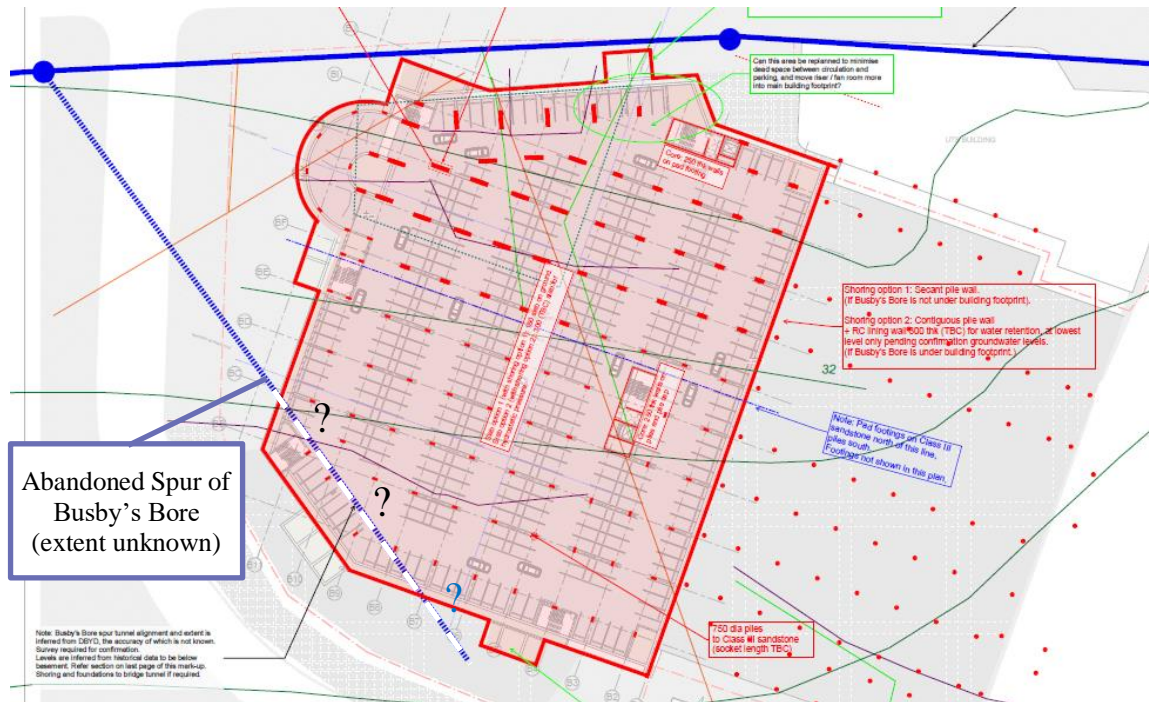


Figure 3 – Inferred location of Busby's bore (shown with blue line)

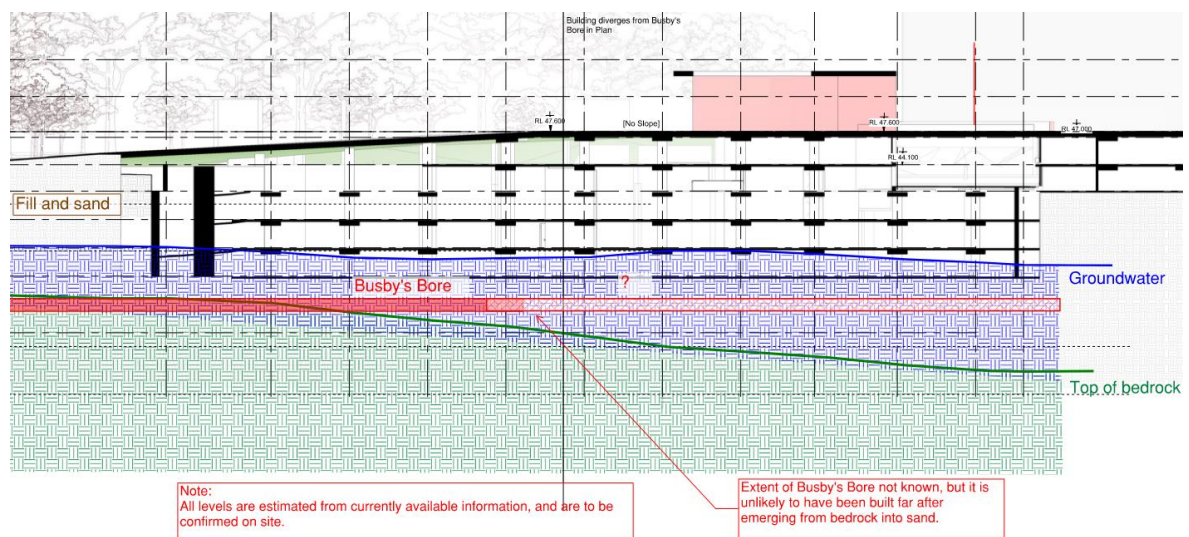


Figure 4 – Inferred level of Busby's bore across the site

Busby's Bore is a heritage-listed former water conduit, constructed between 1827 and 1837. This bore tunnel is between 1.2m to 1.5m wide and up to 3m high at some places. The exact location, depth and extent of the spur is unknown and should be surveyed prior to construction. Figure 4 shows the inferred elevation of the tunnel across the site. Should the inferred rock level be correct, we consider this spur is likely to have been abandoned as it came out of rock, so may not cross the site footprint. This is to be confirmed prior to the construction to identify potential constraints for construction of a shoring system around the proposed basement, as further discussed below.

Busby's Bore is discussed further in the heritage report prepared by Artefact as part of this SSDA modification. This includes requirements for protection of Busby's Bore from potential impacts of new construction.

## 8.4 Basement Retention System

The underlying marine sand deposits require batter or retention in the temporary and permanent conditions upon excavation. Temporary batter slopes of not steeper than 1.5H:1V (subject to onsite inspection) can be adopted for excavation up to 3m depth in the absence of any groundwater or surcharge. Where such batters cannot be formed within the project boundaries or deeper excavation is required, the following options may be adopted for temporary and/or permanent retention:

Table 1: retention options

Retention System	Suitable for Temporary Retention	Suitable for Permanent Retention
Secant Pile Wall	Yes	Yes
Diaphragm Wall (D-Wall)	Yes	Yes
Contiguous Pile Wall	Yes (Note 1)	Yes (Note 1)
Cutter Soil Mixing (CSM)	Yes	Not recommended

Note 1: A contiguous pile wall is recommended only along the excavation boundaries where groundwater is assessed to be below, or can be dewatered to below, the proposed excavation level. In the case of a dewatered approach an internal tanked basement would be required below permanent groundwater levels if a contiguous wall is used.

## 8.5 Ground Anchors

Temporary anchors will be required during excavation. Permission for installation of temporary anchors beyond the site boundaries is likely to be required under the conditions of consent, as per standard practice.

Relatively low bond resistance is achievable within sand which can dictate longer anchors to be bonded within deeper competent material or bedrock. Alternatively, other anchor types such secondary-grouted anchors could be used to achieve higher anchor capacities.

Consideration of existing services, utilities, established tree root zones, and existing structures will be required during selection of anchor system and geometry.

## 8.6 Groundwater Management

The design groundwater level is anticipated to be above the bulk excavation level and vary between RL 33 to RL 38m AHD. A water-tight shoring system or cut-off wall (e.g. secant pile wall or diaphragm wall) can be constructed around the basement excavation, adequately socketed into low permeable bedrock, to reduce the water ingress into the basement excavation to manageable volumes for a sump pump system.



This wall can be designed and constructed to form the permanent water retention system or alternatively an undrained (tanked) structural system can be adopted to a level equal to or above the adopted design groundwater level. It should be noted that the basement wall will retard the water flow and could potentially result in an increase in the groundwater level on the upstream side. A hydrogeological flow model would be required to assess upstream impacts along with any other underground structures.

## 8.7 Building Foundations

The proposed development will be founded within the sandstone bedrock and marine sands. Where bedrock is expected at or above the proposed founding level, conventional pad and strip footings can be adopted onto the bedrock, with piled foundations across the remainder of the site where rock is below bulk excavation.

High level pad or strip footings are not recommended for the proposed works due to the risk of excessive total and differential settlement over variably dense sand deposits.

Suitable piling methodologies include cast-in situ concrete bored piles with temporary or permanent casing or continuous flight auger (CFA) piles. Driven piles are not considered appropriate due to anticipated noise and vibration levels at adjacent buildings and infrastructure.

Subject to further investigation, a raft slab may be a feasible alternative option for the eastern side carpark. If this option is investigated, the interface/connections with other structure and existing buildings will need to allow relatively high raft foundation settlements (up to 50mm).

Groundwater level is anticipated to be above the base of the proposed carpark. If a tanked basement is selected, tension piles or pre-stressed vertical anchors might be required to resist the uplift of the structure if the building mass is insufficient to resist the hydrostatic uplift.

## 8.8 Seismicity

A site sub-soil class of Class C<sub>e</sub> in accordance with AS 1170.4 – 2007 is considered based on the anticipated ground condition.

## 8.9 Aggressivity

Existing aggressivity data from redevelopment of the SFS suggests that soil deposits at this site are non-aggressive to steel and reinforced concrete. However, this should be confirmed prior to construction by a site-specific investigation.

## 8.10 Acid Sulfate Soils

Further to Acid Sulfate Soil risk map presented in the NSW Department of Planning, Industry and Environment website, there is no evidence of Acid Sulfate Soil (ASS) or Potentially Acid Sulfate Soil (PASS) at this site.

## 8.11 Contamination

Further to contamination investigation previously undertaken at the SFS redevelopment site (DP, 2019b), we consider that there is a moderate risk of contamination within existing fill. A contamination report has been prepared by Douglas Partners as part of this SSDA modification.

## 8.12 Additional Site Investigations

Further geotechnical site investigation should be undertaken within the site to confirm the ground conditions for detailed design. The site investigation should be planned and undertaken in accordance with AS 1726:2017 Geotechnical Site Investigations.

Considering the envisaged construction programme, it is recommended that a groundwater monitoring system is set up at this site as early as possible to enable assessment and verification of the groundwater level, its variation and flow condition at the site for the longest period possible prior to the construction of the permanent water retention system.

The NSW Department of Planning has presented its requirements for groundwater investigations in 'Minimum requirements for building site groundwater investigations and reporting-information for developers and consultant' in January 2021. Further to this document there are at least three monitoring bore locations required at or around the site. The monitoring wells are recommended to be installed at the north, east, south and west sides of the proposed basement car park excavations. The bores should be located to avoid any damage during construction, as these bores potentially need to be available for periodic future measurements of the groundwater levels and quality.

Daily groundwater level measurement is required over at least a three month period within the six months immediately prior to any dewatering application with the Department of Planning, and needs to be continued throughout the dewatering period and for one month after dewatering finishes.

A survey of existing in-ground infrastructure, including Busby's Bore, should be undertaken ahead of detailed design, in order to determine the constraints for piling.

## 9 Conclusions

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Our conclusions are as follows:

- The proposed excavation is predominantly within soil, with sandstone bedrock encountered in the deeper excavation over part of the site footprint;
- Natural soil and rock on site are likely non-aggressive with extremely low risk of Acid Sulfate Soil, however the existing fill may potentially be contaminated;
- Foundations are recommended to be a combination of piles and pad foundations bearing on rock. Subject to further investigation, a raft could be considered for the eastern portion;
- The groundwater level is anticipated to be above the bulk excavation level;
- A retention system with ground anchors is required for the basement construction. This may comprise a secant or diaphragm wall to retain earth and cut off water, or a contiguous pile wall with an internal tanking structure below groundwater level;
- An abandoned spur of Busby's Bore (heritage water conduit tunnel) potentially crosses through the south-west corner of the site which may clash with a proposed shoring system.
- A site specific geotechnical investigation should be undertaken ahead of the detailed design phase, accompanied with laboratory testing and groundwater monitoring to verify the site conditions.

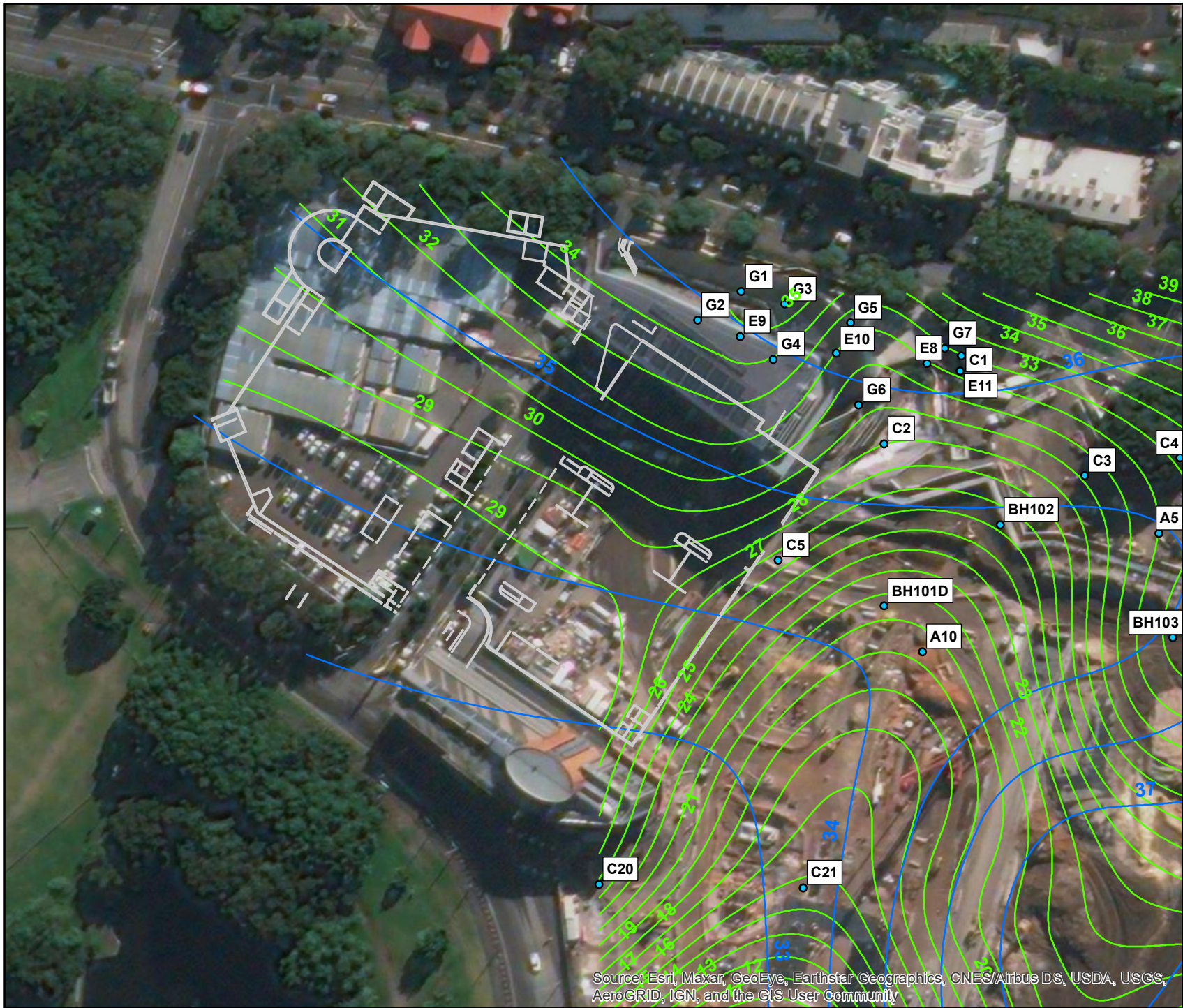
In addition to a site-specific geotechnical investigation, further assessments are required for the following:

- Hydrogeological model – to assess the impact of groundwater on the proposed structure (and vice versa);
- Contamination assessment – to assess potential contamination within existing fill on site. (It is noted that a contamination report has been prepared by Douglas Partners as part of this SSDA modification.); &
- Survey of Busby's Bore – to investigate the extent and depth of Busby's Bore in the south-western corner of the site. (It is noted that Busby's Bore is discussed in the heritage report prepared by Artefact as part of this SSDA modification.)

## Appendix A

### Inferred Top of Rock and Groundwater Contours

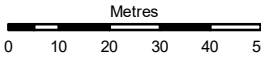




Legend

- Boreholes
- Groundwater Elevation Contours
- Top of Rock Elevation Contours
- Architectural plan

A	2/08/2021	LF	SZ	MVU
Issue	Date	By	Chkd	Appd



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Client

Venues NSW

Job Title

SFS Events Plaza

Figure Title

Top of Rock and Groundwater  
Contours (mAHD)

Scale at A4

1:1,500

Figure Status

Preliminary

Coordinate System

GDA 1994 MGA Zone 56

Job No

282684-02

Figure No

A-001

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community