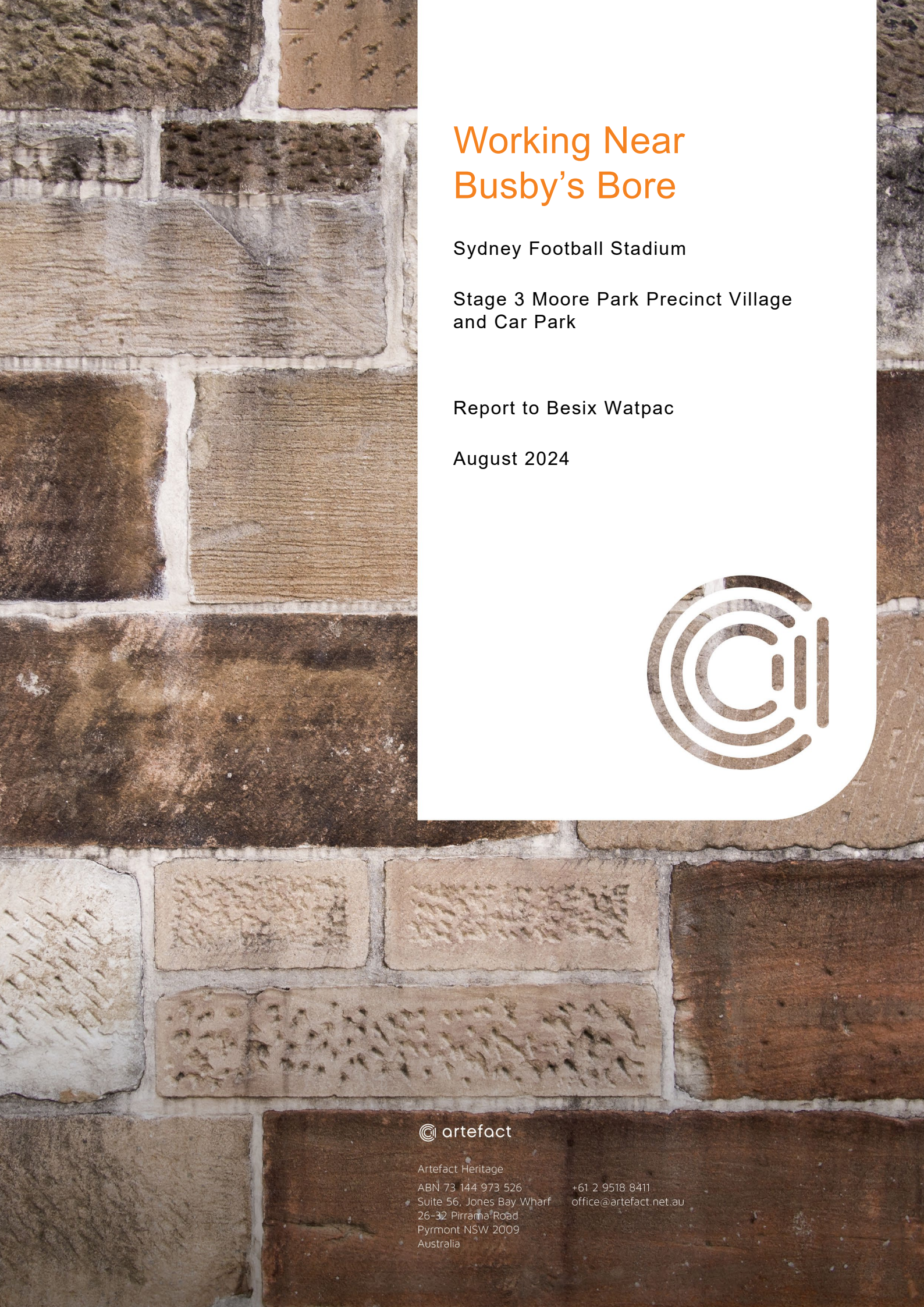

Working Near Busby's Bore

Sydney Football Stadium

Stage 3 Moore Park Precinct Village and Car Park

Report to Besix Watpac

August 2024

artefact

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1.0 INTRODUCTION

This methodology has been developed to support construction around Busby's Bore for the Sydney Football Stadium Redevelopment project. It has been developed with the input of Arup (acoustics and vibration), Curio Project (heritage and archaeology) and Aver (construction and demolition management).

In November 2022 the methodology was updated with input from John Holland and Artefact Heritage to respond to SSD-9835-Mod-7 which details the construction of a Precinct Village (including retail pavilion, tennis clubhouse and tennis courts) and up to 1,500 space multi-level carpark.

The modified consent (SSD-9835-Mod-7, dated 18 July 2022 requires that the Working near Busby's Bore methodology be modified, as stated:

> *B22. Prior to commencement of construction, the Applicant must prepare a Construction Environmental Management Plan (CEMP). This CEMP is to include:*
>
> *(viii) an updated Methodology Statement – Working Near Busby's Bore prepared by Infrastructure NSW dated September 2018, specifically including the details of the proposed works in this development consent, and the recommendations of the Addendum Heritage Impact Assessment, prepared by Artefact, dated 21 December 2021 and the Noise and Vibration Impact Assessment (Issue 2), prepared by Arup, dated 6 September 2021 for the Precinct Village and multi-level carpark stages;*

The recommendations and methodology set out in the updated Working Near Busby's Bore would be integrated into the CEMP as well as the supporting Construction Heritage Management Plan (CHMP) required under condition B39 of the modified consent.

The Working Near Busby's Bore methodology has been further updated following the discovery of a shaft relating to the Busby's Spur on 25 June 2024.

For the purposes of this updated version of the Working Near Busby's Bore methodology it should be noted that:

1. The original construction work for which the Working Near Busby's Bore methodology was developed, namely the Sydney Football Stadium project, has been completed
2. This revised Working Near Busby's Bore methodology applies to the Moore Park Precinct Village and Carpark (PV&C) approved under Mod 7 to the SSD
3. The works described are those relating to the piling program for construction, and
4. The element of Busby's Bore being discussed is the recently discovered Busby's Bore Spur Shaft 1 (BBS -1), which joins with a section of the bore but was abandoned due to poor underground conditions, reportedly "a bed of quicksand", resulting in the line being redirected into more suitable ground. The abandoned section is referred to as a 'spur'.

2.0 IDENTIFICATION AND ASSESSMENT

2.1 Remote sensing investigations

Since the finalisation of the Heritage Impact Assessment, in December 2021, John Holland commissioned a geophysical investigation of the location of Busby's Bore. Artefact has reviewed the results of the study and the implications of the results for the management of potential impacts to Busby's Bore.

The aim of the work was to attempt to see if geophysical investigation could establish whether the Busby's Bore spur lies within the construction footprint of the project.

Initial work involved Usher, surveyors, georeferencing historical plans of Busby's Bore to the known location of access shafts. This verified the location of Shaft 8 in Driver Avenue. Based on this location, the 1854 plan was georeferenced and a potential route for the Spur was established based on this plan.

John Holland and Douglas Partners commissioned GBG Australia Pty Ltd (GBG), geophysical professionals to attempt to locate the spur using the cross-hole tomography method. This method involves estimating the compression wave (P-wave) velocity of the materials between two adjacent boreholes. Different materials exhibit different P-wave velocities and therefore material properties can be inferred using this method. The aim was to determine whether material anomalies could be detected at the location and depth in which the tunnel spur was thought to be located.

The investigations identified the likely presence of the spur at BH 1 and BH 2, but not at BH 3 and BH 4 which were located on the boundary of the project construction footprint.

However, it should be noted that physical evidence of the Busby's Bore spur had not been confirmed via visual inspection as this would have involved test excavation to a depth of 10m, which was impractical due to the depth to the spur. The therefore the absence of the Busby's Bore spur could not be definitively confirmed within the footprint Car Park site.

Shaft 8 has previously been identified located in Moore Park Road near Driver Avenue. The proposed works are not likely to impact this site as the shaft is over 90m away. The remaining shafts (No. 9 and 10) and associated tunnel, forming the main Busbys Bore are located in Moore Park Road along the northern boundary of the construction site. The distances to the presumed location of Busby's Bore are in the order of 10 to 15m from the construction site.

In May 2024 BESIX Watpac and Douglas Partners commissioned GBG Australia Pty Ltd (GBG), geophysical professionals to attempt to locate the spur using the cross-hole tomography method. The investigations identified there is no evidence of the spur at bore hole HS13 and HS14

2.2 Discovery of the Shaft

During excavation for the piling platform on 25 June 2024 BESIX Watpac and their civil contractor uncovered what was described as "an old well / shaft". Dr Iain Stuart from Artefact Heritage and Environment, who is the approved Excavation Director for the project, attended the site on 26 June 2024.

Accompanying Dr Stuart was Nicholas Papanikolaou, Project Manager from BESIX Watpac, Deirdre O'Neill, Group General Manager of Infrastructure and Development at Venues NSW, and Aleks Kukolj, Superintendent, Venues NSW.

As required under the approved CHMP for this project work around the item ceased, protection against inadvertent damage was erected, and the Department of Planning, Housing and Infrastructure (DPHI) was notified of an unexpected find at the Sydney Football Stadium Redevelopment, Moore Park Precinct, Village and Car Park site. In addition, as a courtesy, Heritage NSW and Sydney Water were also notified of the discovery.

The location of the find, identified in this report as BBS 1, can be seen in Figure 1.

The location of the shaft has allowed further georeferencing of the 1854 plan based on the previously known location of the shafts and BBS 1. It should be noted that georeferencing is more an art than cartographic science. It relies on the accuracy of the original documents and the images derived from them used in a suitable program, and also the nature of the reference points as well as the algorithms used for the georeferencing. In this case Warners 1854 plan has been used and the image is from the scanned copy available on-line from the National Library of Australia.

The georeferencing was undertaken in ArcGIS using the shaft locations on Warners plans, the surveyed location of the Shafts provided by Usher and Company Surveyors, and the location of BBS 1. The transformation used was 1st Order Polynomial (Affine) using four control points. This transformation is commonly used to georeferenced historical maps.

After georeferencing a new predicted location for the Busby's Bore Spur and shafts was mapped (Figure 1).

In comparison with the predicted alignment of Busby's Bore Spur on which the cross hole tomography was used, the new predicted alignment runs to the south east from Shaft 8 whereas the former predicted alignment ran south south-east. Thus BH 1 and BH 2 were located 9m to the west of the new predicted line and BH 3 and BH 4 were located 23m west of the new predicted line. The conclusion is that the previous results of the cross hole tomography, based on the information that was available at the time (which did not include physical evidence), was not able to accurately predict the occurrence of the Busby's Bore Spur and shafts. This is shown in Figure 1.

Survey work had identified that the depth of the item as 8.8m from the top of the shaft. Aurecon report that the bottom of the visible portion of the shaft, about 8.5m from the top of the shaft, has roughly 200mm of finer gravelly sediment under it. The actual base of shaft was not found and there is no evidence of the base of the shaft at c8.5m (RL 32.65). Converting the measurements to decimal feet this is a depth of 27.98ft.

As the shafts intercepted the bore at the apex of the obvert it can be assumed that the top of the Busby's Bore Spur tunnel is below RL 32.65m.

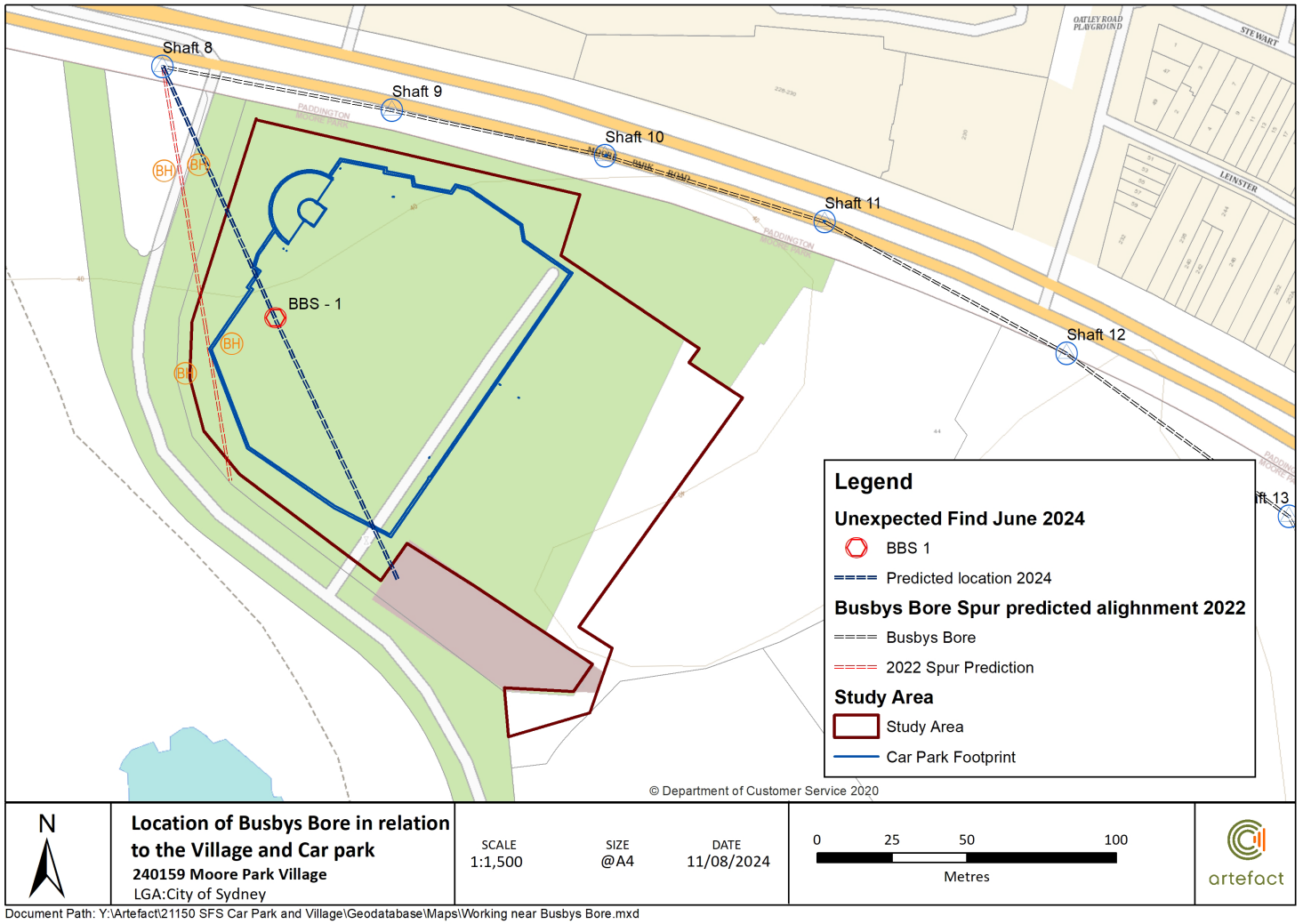

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Figure 1: Map of known and possible Busby's Bore shafts within SFS Redevelopment Site, revised to show the location of BBS-1 and the new predicted location of the spur

3.0 PROTECTION

This section discusses the protection of Busbys Bore spur from the first stage of construction work involving the piling platform and piling. The second stage of construction work is being reevaluated following the discovery of the shaft and once that design is completed this document will be revised to incorporate the revised design.

3.1 Proposed work near the Shaft and Tunnel

It is understood that the first stage of construction will be the construction of a structure to support the excavation of the car park. This is likely to involve bored piling to form the box for excavation of the car park. Archaeological monitoring of bored piles is not possible.

3.2 Assessment of impact

3.2.1 Shaft

There will be no direct impact on the shaft and the works will be above the presumed location of the associated tunnel.

Pulse White Noise Acoustics has revised their assessment of the vibration impact on Busby's Bore following the discovery of the shaft and presumed location of the tunnel.[1]

Their report notes that Vibration limits impacting the Heritage Well [ie BBS-1] have been developed in conjunction with the standards included in the sections above as well the limits included within the SSD for the project which details limits for the Busby's Bore including the following:

1. Heritage Well – unsupported
    a. Continuous Vibration – 3 mm/s
    b. Maximum Vibration limits – 5 mm/s

In addition to the vibration above, the following criteria was recommended in the event the recommended mitigation including supporting of the Well with an infill is undertaken.

2. Heritage Well - supported with infill
    a. Continuous Vibration – 5 mm/s
    b. Maximum Vibration limits – 7 mm/s

The effect of vibration on an unsupported structure has the potential to result in damage based on the movement of the structure, this is typical for heritage significant building which can include multiple stories above ground. As part of the protection of the shaft, it is proposed to fill the shaft with a quarry aggregate of 10mm. The method of filling the shaft is noted in Section 3.2.2 below.

[1] Pulse White Noise Acoustics. 'Moore Park Precinct Village and Car Park, Heritage Well, Construction Vibration Management Plan'. Report to BESIX Watpac, 2024.
Pulse White Noise Acoustics 'Moore Park Village & Carpark Construction Vibration Survey 11th July 2024'. Report to BESIX Watpac, 2024.

The shaft will be supported by filling in the well with an aggregate material. Once the well has been filled then an increase in the construction vibration limits would be possible allowing vibrating machines to work closer to the Shaft. The recommended vibration limits can be modified to include the following levels as set out in the table below which a show safe working distances from the Shaft.[2]

Table 6 Recommended indicative safe working distances for vibration intensive plant

Plant	Rating / Description	Safe Working Distances (m)	
		Unsupported Well	Supported Well
Hand Held Compactors	All Weights	No limit	No limit
Static Roller	All Weights	No limit	No limit
Vibratory roller	< 50 kN (Typically 1 – 2 tonnes)	2	2
	< 100 kN (Typically 2 – 4 tonnes)	3	3
	< 200 kN (Typically 4 – 6 tonnes)	4	3
	< 300 kN (Typically 7 – 13 tonnes)	6	4
	> 300 kN (Typically more than 13 tonnes)	8	6
Small hydraulic hammer	300 kg, typically 5 – 12 tonnes excavator	2	1
Medium hydraulic hammer	900 kg, typically 12 – 18 tonnes excavator	3	1
Large hydraulic hammer	1600 kg, typically 18 – 34 tonnes excavator	6	4
Auger Piling	Piling equipment	2	1
Jackhammer	Hand held	1	No limit

The option for supporting the well by filling would provide a greater security to the fabric of the well from construction impacts and is recommended.

3.2.2 Filling of the shaft

As mentioned above it is proposed that the shaft will be filled with a 10mm quarried blue metal aggregate. This will be picked up from the Boral Dunmore quarry. The below sequence of work is set out below:

1. The existing scaffold protecting the shaft from inadvertent impacts will be removed.
2. The stone capping at the top of the shaft will be left in place during the works and protected.
3. Due to the water within the shaft, it is not proposed that any lining would occur within the shaft prior to filling.
4. To control the backfill of the well, MLC (the construction contractors) propose using a concrete kibble with a 9m long hose. A 30t Excavator to lift the kibble with chains, and a 5t excavator will be used to load the kibble with aggregate.
5. To ensure there is minimal free fall of the material, the hose will be progressively cut shorter as the shaft is filled.
6. Step 4 repeated until the shaft is full to the top (i.e. RL40.960).

[2] Pulse White Noise Acoustics 'Moore Park Village & Carpark Construction Vibration Survey 11th July 2024'. Report to BESIX Watpac, 2024. Note the report calls the Busbys Bore shaft 1 a well.

The interior of the shaft has been laser scanned and recorded by photogrammetry, so it is archivally recorded. The aggregate is removable post construction.

Usually backfilling a well-like object uses some form of permeable fabric to form a barrier between the fill and the shaft so that there is no adhesion of the fill material to the bricks and stone. This allows the fill to be removed in the future without the risk of harm to bricks or stone during the removal process. However, there are practical constraints in installing the fabric below the water in the shaft and given the depth and width of the shaft it would be difficult to install the fabric safely. Therefore, no barrier fabric can be used for filling BBS 1. The implications of this are that the future removal of fill from BBS 1 would require additional care.

3.2.3 Piling above the tunnel

Piling works above the tunnel is for the perimeter shoring system of the carpark. This system is a secant piled wall which will use a cased continual flight auger (CFA). The below image in Figure 2 indicates the design of the perimeter pile wall. The toe of the pile is at RL34.000. Based on current information available it is believed that the crown of the tunnel is located at approximately RL32.460, providing a 1.5m clearance between the toe of the pile and the crown of the potential tunnel.

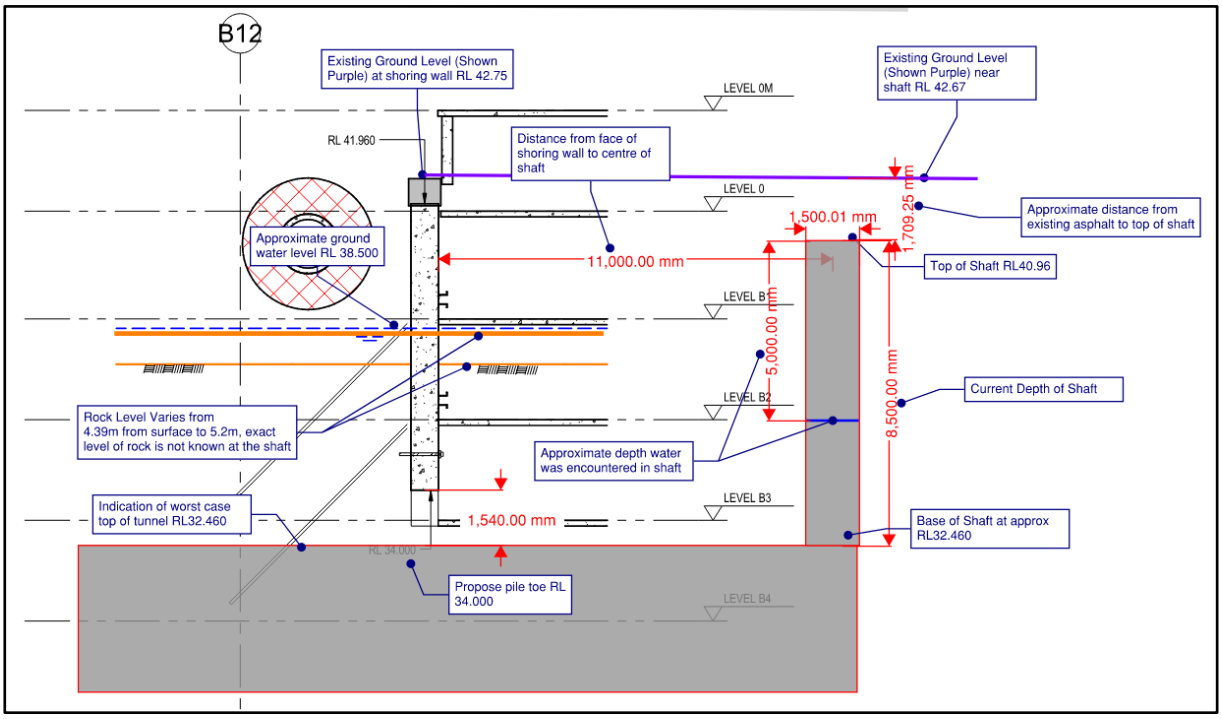

Figure 2 Details of potential piling impact

Pulse White Noise Acoustics has provided some general comments on the proposed piling:

> *Based on the proposed piling to be completed and the proximity to the below ground tunnel, the following is discussed:*
>
> 1. *The use of bore/auger/screw piling would be expected to result in magnitude of vibration which will be below the project required vibration limits, including 5mm/s for a unsupported well and 7 mm/s for a supported well.*

2. *To assess the potential vibration resulting from the required piling to be completed on the site an attended vibration survey on the commencement of the piling should be undertaken. The vibration survey is to include a measurement location which is 1.5m from the operational bore/auger/screw piling. Based on the results of the attended survey limits regarding the operational speed of the piling [rig] can be determined to ensure compliance with the construction vibration criteria will be achieved.*

3. *Based on the location of the below ground tunnel, vibration from other potential sources of vibration such as movement of constructed vehicles, materials movement and the like would be expected to be within the project required construction vibration limits based on the distance of the tunnel below ground.*[3]

[3] Pulse White Noise Acoustics. 'Moore Park Precinct Village and Car Park, Heritage Well, Construction Vibration Management Plan'. 240131-MPVC Well-CVMSP-R1, Report to BESIX Watpac, 2024.

4.0 MONITORING PROTOCOLS

Details of the monitoring and vibration plan is provided in Chapter 4 of the Pulse White Noise Acoustic Report.

A conservative vibration criterion of 3mm/s, based on structural damage criterion for 'sensitive structures' in DIN 4150 – Part 3will be applied.[4] The vibration monitors will be calibrated to generate real-time alerts (SMS messages and/or flashing lights) when vibration criterion is exceeded.

In the event that the vibration criterion is exceeded by works on site, an alert will be sent to the Site Manager. This alert will trigger a cessation of works and the project archaeologist and structural engineering advisor will be notified and requested to attend site. A visual inspect of the pits and/or bore will be undertaken to determine whether any damage has been sustained.

An exceedance of the vibration criterion will necessitate a review and potential change in demolition, piling and/or construction methodology as advised by the project archaeologist and structural engineering advisor. These changes could include:

- Re-evaluation of the vibration criterion based on results of the initial condition investigation and inspections of the structure following the commencement of works
- Maintain vibration monitoring throughout PV&C works
- Reduce the size of demolition and construction equipment and develop alternative methodologies to minimise vibration
- Use less vibration emitting demolition methods such as concrete pulverisers and smaller percussive hammers if necessary closer to Busby's Bore
- Use rubber tracked excavators and machinery if necessary closer to Busby's Bore
- Balance variable speed vibrating plant and operate at speeds that do not produce resonance
- Ensure all fixed plant at the site are appropriately selected (on a risk assessment approach), and where necessary, fitted with vibration attenuation measures
- Position vibrating plant and equipment as far apart as it practicable from each other and consider whether orientation and location of the plant can reduce vibration impacts at sensitive receivers such as Busby's Bore
- Use non-percussive piling techniques for all piles where practicable
- Ensure that vibratory compactors must not be used closer than 30 meters from sensitive receivers unless vibration monitoring confirms compliance with the vibration criteria specified.
- Maintain machinery and equipment
- If necessary, plan traffic flow, parking, loading/unloading areas to minimise movements within the area of Busby's Bore.

[4] German Standard DIN 4150-Part 3 'Structural vibration in buildings – Effects on Structure'

5.0 ARCHAEOLOGICAL SUPERVISION AND MONITORING

Archaeological monitoring during the piling works is required as follows:

1. Monitoring of the filling to verify that no impact on Busby's Bore has occurred
2. Review of the vibration data and the Construction Management Sub-Plan if required.

As the question of how the bulk excavation works may impact the Shaft and Tunnel of Busby's Bore Spur is currently being resolved, it is likely that further archaeological recording, supervision and monitoring will be required

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