GEOTECHNICAL INVESTIGATION:

New Boarding House at **16 Wyatt Avenue, Belrose**

1. Proposed Development

1.1 Demolish the existing house and pool and construct a new boarding house consisting of two new part four-storey modules with basement parking by excavating to a maximum depth of ~5.4m into the slope.

1.2 Details of the proposed development are shown on 16 drawings prepared by Platform Architects, project number WAB2, numbered 01-08 and 13-20, dated APR 2021.

2. Site Description

2.1 The site was inspected on the 19th March, 2021.

2.2 This residential property is on the low side of the road and has a NW aspect. The block is located on the gentle to moderately graded upper reaches of a hillslope. The slope falls across the property at angles averaging ~8°.

2.3 At the road frontage, a concrete driveway runs to a stable brick garage on the uphill side of the house (Photo 1). Between the road frontage and the house is a gently sloping lawn. The two-storey brick house will be demolished as part of the proposed works. An excavation has been made in the slope below the house for a pool that will also be demolished as part of the proposed works. Filling has been placed around the pool to create a level platform. The fill is supported by a concrete block retaining wall that appears stable (Photo 2). Competent Medium Strength Sandstone outcrops below the retaining wall. The outcrop is undercut along the majority of its length to ~1.0m. The undercut joint block has a relatively thick cantilever arm relative to its overhang length, is bridged at both sides, and displays no cracking as observed from

above or below. Thus, it is considered stable (Photo 3). A timber clad garage has been constructed below the outcropping sandstone. The garage will also be demolished as part of the proposed works. A concrete driveway runs down the E side of the property to a sheet metal outbuilding supported on a concrete slab in the NE of the property which will also be demolished as part of the proposed works (Photo 4). A gentle to moderately sloping lawn falls to the lower boundary. Stable Competent Medium Strength Sandstone outcrops near the lower boundary (Photo 5).

3. Geology

The Sydney 1:100 000 Geological sheet indicates the site is underlain by Hawkesbury Sandstone. It is described as a medium to coarse grained quartz sandstone with very minor shale and laminite lenses.

4. Subsurface Investigation

One Auger Hole (AH) was put down to identify the soil materials. Nine Dynamic Cone Penetrometer (DCP) tests were put down to determine the relative density of the overlying soil and the depth to bedrock. The locations of the tests are shown on the site plan attached. It should be noted that a level of caution should be applied when interpreting DCP test results. The test will not pass through hard buried objects so in some instances it can be difficult to determine whether refusal has occurred on an obstruction in the profile or on the natural rock surface. This is not expected to be an issue for the testing on this site. However, excavation and foundation budgets should always allow for the possibility that the interpreted ground conditions in this report vary from those encountered during excavations. See the appended “Important information about your report” for a more comprehensive explanation. The results are as follows:

GROUND TEST RESULTS ON THE NEXT PAGE

AUGER HOLE 1 (~RL13.4) **–** AH1 (Photo 6)

Depth (m)	**Material Encountered**
0.0 to 0.2	**SOIL**, dark brown, low density, dry, fine to medium grained with fine trace organic matter and rock fragments.

Refusal @ 0.2m on Medium Strength Sandstone. No water table encountered.

DCP TEST RESULTS – Dynamic Cone Penetrometer

Equipment: 9kg hammer, 510mm drop, conical tip. Standard: AS1289.6.3.2 - 1997

Depth(m) Blows/0.3m	DCP 1 (~RL168.3)	DCP 2 (~RL169.8)	DCP 3 (~RL169.6)	DCP 4 (~RL171.0)	DCP 5 (~RL170.5)	DCP 6 (~RL170.0)	DCP 7 (~RL175.6)	DCP 8 (~RL181.6)	DCP 9 (~RL181.5)
0.0 to 0.3	40	17	25	Rock Exposed at Surface	10	36	4	2	3
0.3 to 0.6	#	17	23		7F	#	13	#	#
0.6 to 0.9		22	32		4		23		
0.9 to 1.2		34	#		12		#		
1.2 to 1.5		#			7				
1.5 to 1.8					45				
1.8 to 2.1					#				
	End of Test @ 0.3m	End of Test @ 1.2m	End of Test @ 0.9m		Refusal on Rock @ 1.6m	End of Test @ 0.3m	Refusal on Rock @ 0.9m	Refusal on Rock @ 0.3m	Refusal on Rock @ .25m

#refusal/end of test. F=DCP fell after being struck showing little resistance through all or part of the interval.

DCP TEST NOTES ON THE NEXT PAGE

DCP Notes:

DCP1 – End of test @ 0.3m, DCP still slowly going down, mottled, brown and orange clayey sand on wet tip.
DCP2 – End of test @ 1.2m, DCP still slowly going down, dark brown muddy sand on wet tip.
DCP3 – End of test @ 0.9m, DCP still slowly going down, clean dry tip, grey sand in collar.
DCP4 – Rock Exposed at Surface.
DCP5 – Refusal on rock @ 1.6m, DCP bouncing off rock surface, dark brown muddy sand on wet tip.
DCP6 – End of Test @ 0.3m, DCP still slowly going down, clean dry tip, grey sand in collar.
DCP7 – Refusal on rock @ 0.9m, DCP bouncing off rock surface, dark brown muddy sand on wet tip
DCP8 – Refusal on rock @ 0.3m, DCP bouncing off rock surface, clean damp tip, brown sandy soil in collar.
DCP9 – Refusal on rock @ 0.25m, DCP bouncing off rock surface, clean damp tip, brown sandy soil in collar.

5. Geological Observations/Interpretation

The surface features of the block are controlled by the outcropping and underlying sandstone bedrock that steps down the property forming sub-horizontal benches between the steps. Where the grade is steeper, the steps are larger and the benches narrower. Where the slope eases, the opposite is true. Where the rock is not exposed, it is overlain by sandy soils and sandy clays that fill the bench step formation. In the test locations, the depth to rock ranged between 0.3 to 1.6m below the current surface, being slightly deeper due to the stepped nature of the underlying bedrock. The outcropping sandstone on the property is estimated to be medium strength or better and similar strength rock is expected to underlie the entire site. It is interpreted that a thin layer of Very Low Strength Sandstone overlies the buried rock in some locations as the DCP ended after a high blow count for some tests. See Type Section attached for a diagrammatical representation of the expected ground materials.

6. Groundwater

The ground was saturated during testing. This is likely due to the heavy rains that occurred on the day prior to the inspection. Normal ground water seepage is expected to move over the buried surface of the rock and through the cracks. Due to the slope and elevation of the block, the water table is expected to be many metres below the base of the proposed excavation.

7. Surface Water

Surface flows were observed on the property during the inspection. As above, this is likely due to the heavy rains that occurred on the day prior to the inspection. Normal sheet wash from the slope above will be intercepted by the street drainage system for Wyatt Avenue above.

8. Geotechnical Hazards and Risk Analysis

No geotechnical hazards were observed above or beside the property. The gentle to moderately graded slope that falls across the property and continues below at gradually increasing angles is a potential hazard (**Hazard One**). The proposed excavations are a potential hazard until retaining walls are in place (**Hazard Two**). The vibrations from the proposed excavations are a potential hazard (**Hazard Three**).

RISK ANALYSIS ON THE NEXT PAGE

Risk Analysis Summary

HAZARDS	Hazard One	Hazard Two	Hazard Three
TYPE	The gentle to moderate slope that falls across the site and continues below at gradually increasing angles failing and impacting on the proposed works.	The excavations (up to a depth of ~5.4m) collapsing onto the work site before retaining walls are in place.	The vibrations produced during the proposed excavation impacting on the surrounding structures.
LIKELIHOOD	'Unlikely' (10^{-4})	'Possible' (10^{-3})	'Possible' (10^{-3})
CONSEQUENCES TO PROPERTY	'Medium' (12%)	'Medium' (25%)	'Medium' (15%)
RISK TO PROPERTY	'Low' (2×10^{-5})	'Moderate' (2×10^{-4})	'Moderate' (2×10^{-4})
RISK TO LIFE	5.5×10^{-7}/annum	5.9×10^{-5}/annum	5.3×10^{-7}/annum
COMMENTS	This level of risk is 'ACCEPTABLE'.	'UNACCEPTABLE' level of risk to life and property. To move risk to 'ACCEPTABLE' levels, the recommendations in **Section 13** are to be followed.	'UNACCEPTABLE' level of risk to life and property. To move risk to 'ACCEPTABLE' levels, the recommendations in **Section 12** are to be followed.

(See Aust. Geomech. Jnl. Mar 2007 Vol. 42 No 1, for full explanation of terms)

9. Suitability of the Proposed Development for the Site

The proposed development is suitable for the site. No geotechnical hazards will be created by the completion of the proposed development provided it is carried out in accordance with the requirements of this report and good engineering and building practice.

10. Stormwater

As the soil on this property is shallow a spreader pipe system is suitable provided flows are kept close to natural runoff for the site. All stormwater is to be piped through any tanks that may be required by the regulating authorities.

11. Excavations

An excavation to a maximum depth of ~5.4m is required to construct the proposed upper boarding house. The excavation is expected to be through sandy soils and firm to stiff sandy clays with Medium Strength Sandstone expected at a maximum depth of ~0.9m below the current surface.

An excavation to a maximum depth of ~3.7m is required to construct the proposed lower boarding house. The excavation is expected to be through sandy soils and firm to stiff sandy clays with Medium Strength Sandstone expected at a maximum depth of ~0.9m below the surface on the uphill side. On the downhill side, Very Low Strength Sandstone was encountered at depths between 0.3m and 1.2m. It is likely that Medium Strength Sandstone can be expected between 1.0-1.5m below the Very Low Strength Rock.

It is envisaged that excavations through sandy soil and sandy clays can be carried out with a bucket and excavations through rock will require grinding or rock sawing and breaking.

12. Vibrations

Possible vibrations generated during excavations through sandy soils and sandy clays will be below the threshold limit for building damage.

It is expected the majority of the excavation will be through Medium Strength Sandstone or better. Excavations through rock should be carried out to minimise the potential to cause vibration damage to the W neighbouring house. The W neighbouring house will be as close as ~12.0m from the edge of the excavation. Close controls by the contractor over rock excavation are recommended so excessive vibrations are not generated.

Excavation methods are to be used that limit peak particle velocity to 10mm/sec at the property boundaries. Vibration monitoring will be required to verify this is achieved.

If a milling head is used to grind the rock, vibration monitoring will not be required. Alternatively, if rock sawing is carried out around the perimeter of the excavation boundaries in not less than 1.0m lifts, a rock hammer up to 600kg could be used to break the rock without vibration monitoring. Peak particle velocity will be less than 10mm/sec at the property boundaries using this method provided the saw cuts are kept well below the rock to broken.

It is worth noting that vibrations that are below thresholds for building damage may be felt by the occupants of the neighbouring properties.

13. Excavation Support Requirements

No structures or boundaries will be within the zone of influence of either excavation. In this instance, the zone of influence is the area above a theoretical 30° line from the top of Medium Strength Rock towards the surrounding structures and boundaries.

The overlying soil and clay is to be removed from the surface and scraped back from the line of the excavation ~0.5m. The shallow soil cut batters for the bulk excavation are to be battered temporarily at 1.0 Vertical:2.0 Horizontal (26°) until permanent retaining walls are in place. Excavations through natural firm to stiff clay will stand unsupported for a short period of time until the retaining walls are in place provided they are kept from becoming saturated. Excavations through Medium Strength Sandstone or better will stand at vertical angles unsupported subject to approval by the geotechnical consultant.

During the excavation process the geotechnical consultant is to inspect the cut in 1.8m intervals as it is lowered to ensure the ground materials are as expected and no wedges or other geological defects are present that could require additional support. Should additional ground support be required, this will likely involve the use of mesh, sprayed concrete, and rock bolts.

Upon completion of the excavation, it is recommended all cut faces be supported with retaining walls to prevent any potential future movement of joint blocks in the cut face that can occur over time, when unfavourable jointing is obscured behind the excavation face. Additionally, retaining walls will help control seepage and to prevent minor erosion and sediment movement. Excavation spoil may be used for landscaping on site. Any filling is to be battered back to 1.0 Vertical to 2.0 Horizontal (26°) or be supported by engineered retaining walls.

All excavation spoil is to be removed from site following the current Environmental Protection Agency (EPA) waste classification guidelines.

14. Retaining Walls

For cantilever or singly-propped retaining walls, it is suggested the design be based on a triangular pressure distribution of lateral pressures using the parameters shown in Table 1. For multiple braced or anchored walls, a rectangular distribution can be used.

Table 1 – Likely Earth Pressures for Retaining Walls

Unit	Earth Pressure Coefficients		
	Unit weight (kN/m^3)	'Active' K_a	'At Rest' K_0
Fill, Sandy Soil, and Residual Clay	20	0.40	0.55
Medium Strength Sandstone	24	0.00	0.10

For rock classes refer to Pells et al "Design Loadings for Foundations on Shale and Sandstone in the Sydney Region". Australian Geomechanics Journal 1978.

It is to be noted that the earth pressures in Table 1 assume a level surface above the structure, do not account for any surcharge loads and assume retaining walls are fully drained. Rock

strength and relevant earth pressure coefficients are to be confirmed on site by the geotechnical consultant.

All retaining walls are to have sufficient back-wall drainage and be backfilled immediately behind the structure with free-draining material (such as gravel). This material is to be wrapped in a non-woven Geotextile fabric (i.e., Bidim A34 or similar), to prevent the drainage from becoming clogged with silt and clay. If no back-wall drainage is installed in retaining walls, the likely hydrostatic pressures are to be accounted for in the structural design.

15. Foundations

A concrete slab and shallow piers supported directly off Medium Strength Sandstone are suitable footings for the proposed boarding houses. This ground material is expected to be exposed almost entirely across the base of the excavations. In the NW corner of the downhill boarding house, the underlying sandstone bedrock may step down past the base of the excavation. In this case, the proposed construction can be supported off brick piers taken to the Medium Strength Sandstone where necessary. A maximum allowable bearing pressure of 1000kPa can be assumed for footings on Medium Strength Sandstone.

Naturally occurring vertical cracks (known as joints) commonly occur in sandstone. These are generally filled with soil and are the natural seepage paths through the rock. They can extend to depths of several metres and are usually relatively narrow but can range between 0.1 to 0.8m wide. If a footing falls over a joint in the rock, the construction process is simplified if, with the approval of the structural engineer, the joint can be spanned or, alternatively, the footing can be repositioned so it does not fall over the joint.

NOTE: If the contractor is unsure of the footing material required, it is more cost effective to get the geotechnical consultant on site at the start of the footing excavation to advise on footing depth and material. This mostly prevents unnecessary over-excavation in clay like shaly rock but can be valuable in all types of geology.

16. Inspections

The client and builder are to familiarise themselves with the following required inspection as well as council geotechnical policy. We cannot provide geotechnical certification for the owners or the regulating authorities if the following inspection has not been carried out during the construction process.

- During the excavation process, the geotechnical consultant is to inspect the cut face in 1.8m intervals as it is lowered to ensure ground materials are as expected and that there are no wedges or other defects present in the rock that may require additional support.

- All footings are to be inspected and approved by the geotechnical consultant while the excavation equipment is still onsite and before steel reinforcing is placed or concrete is poured.

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Photo 1

Photo 2

Photo 3

Photo 4

Photo 5

Photo 6

Important Information about Your Report

It should be noted that Geotechnical Reports are documents that build a picture of the subsurface conditions from the observation of surface features and testing carried out at specific points on the site. The spacing and location of the test points can be limited by the location of existing structures on the site or by budget and time constraints of the client. Additionally, the test themselves, although chosen for their suitability for the particular project, have their own limiting factors. The testing gives accurate information at the location of the test, within the confines of the test's capability. A geological interpretation or model is developed by joining these test points using all available data and drawing on previous experience of the geotechnical consultant. Even the most experienced practitioners cannot determine every possible feature or change that may lie below the earth. All of the subsurface features can only be known when they are revealed by excavation. As such, a Geotechnical report can be considered an interpretive document. It is based on factual data but also on opinion and judgement that comes with a level of uncertainty. This information is provided to help explain the nature and limitations of your report.

With this in mind, the following points are to be noted:

- If upon the commencement of the works the subsurface ground or ground water conditions prove different from those described in this report, it is advisable to contact White Geotechnical Group immediately, as problems relating to the ground works phase of construction are far easier and less costly to overcome if they are addressed early.

- If this report is used by other professionals during the design or construction process, any questions should be directed to White Geotechnical Group as only we understand the full methodology behind the report's conclusions.

- The report addresses issues relating to your specific design and site. If the proposed project design changes, aspects of the report may no longer apply. Contact White Geotechnical if this occurs.

- This report should not be applied to any other project other than that outlined in section 1.0.

- This report is to be read in full and should not have sections removed or included in other documents as this can result in misinterpretation of the data by others.

- It is common for the design and construction process to be adapted as it progresses (sometimes to suit the previous experience of the contractors involved). If alternative design and construction processes are required to those described in this report, contact White Geotechnical Group. We

are familiar with a variety of techniques to reduce risk and can advise if your proposed methods are suitable for the site conditions.