Douglas Partners
Geotechnics / Environment / Groundwater

Integrated Practical Solutions

Report on
Geotechnical Desktop Study

Proposed Mixed-Use Building
38 to 40 Orth Street and 26 Somerset Street, Kingswood

Prepared for
AC Homes Pty Ltd

Project 94564.00
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Douglas Partners
Geotechnics / Environment / Groundwater

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The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

	Signature	Date
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Report on Geotechnical Desktop Study
Proposed Mixed- Use Building
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1. Introduction

This report presents the results of a geotechnical desktop study carried out for a proposed mixed-use building at 38 to 40 Orth Street and 26 Somerset Street, Kingswood. The study was commissioned in an email dated 24 July 2019 by Mr Joe Yuan of AC Homes Pty Ltd and was carried out in accordance with Douglas Partners Pty Ltd (DP) proposal NWS180112 dated 19 December 2018.

It is understood that the construction a 7 storey building with three basement levels is proposed. The geotechnical desktop study was carried out to provide background information on expected subsurface conditions for planning and preliminary design purposes. An intrusive geotechnical investigation will be carried out at a later stage to determine the actual subsurface conditions.

The study included a review of previous geotechnical investigations undertaken near the subject site, published geological maps, and experience in the local area. A summary of the findings of the desktop study are provided in this report, together with preliminary comments relating to design and construction practice. No intrusive sampling or testing was conducted on the site so the comments are based on experience on nearby sites in the area.

A preliminary site investigation (PSI) for contamination is also being carried out and the results will be presented in a separate report.

2. Site Description

The site comprises 38 to 40 Orth Street and 26 Somerset Street, Kingswood and is located on the south-east corner of the intersection of Orth and Somerset Streets (refer to Figure 1 on following page). The site is an irregular shape of about 1800 m^2 with maximum north-south and east-west dimensions of approximately 40 m and 60 m respectively.

The site comprises three residential lots currently occupied by single storey brick and weatherboard houses with associated garages, sheds, driveways, garden and grassed areas. Some mature trees are present on the northern and southern boundaries.

The ground surface slopes towards the east at gradients less than 1°, with site levels estimated to range from RL 48.5 m to RL 47.0 m (relative to Australian Height Datum [AHD]).

The site is bordered by Orth Street to the north, Somerset Street to the west and similar residential properties to the subject site on all other boundaries. The Nepean Hospital precinct is located approximately 20 m to the west of the site.

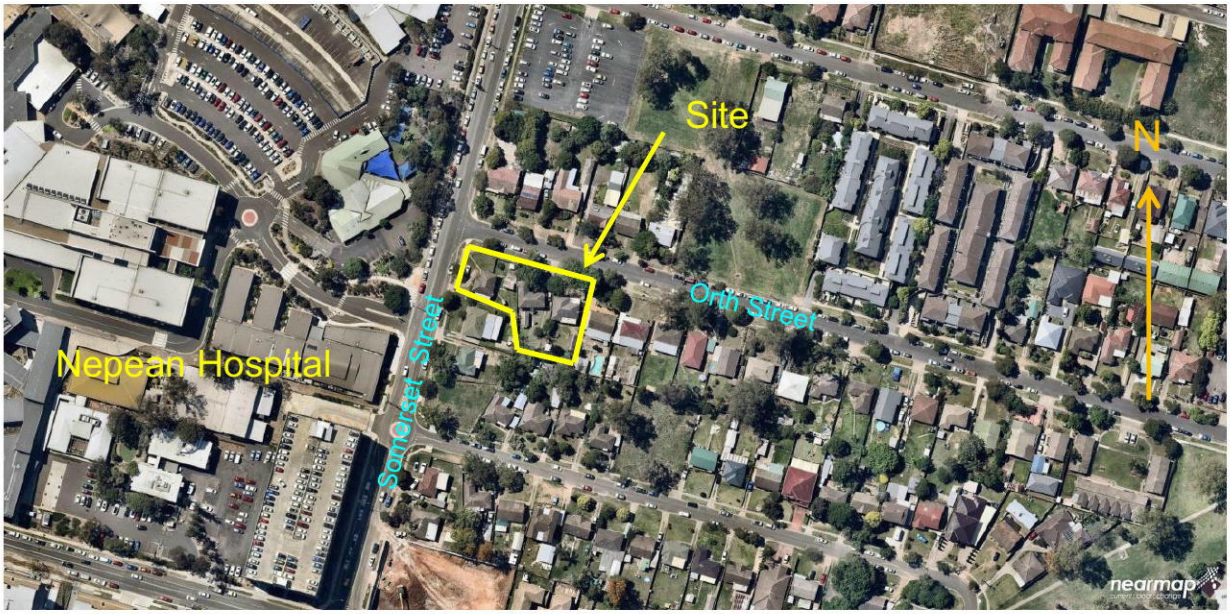

Figure 1: Site Location Plan (Source: Nearmap)

3. Topography, Geology and Hydrogeology

3.1 Topography

Review of topographic maps indicates that site levels fall towards the east and it is located in-between two areas which appear to be minor valleys (or old creek line). There is a ridgeline present approximately 180 m west of the site.

Figure 2 shows the 2 m ground surface levels for the site and local area together with mapped watercourses.

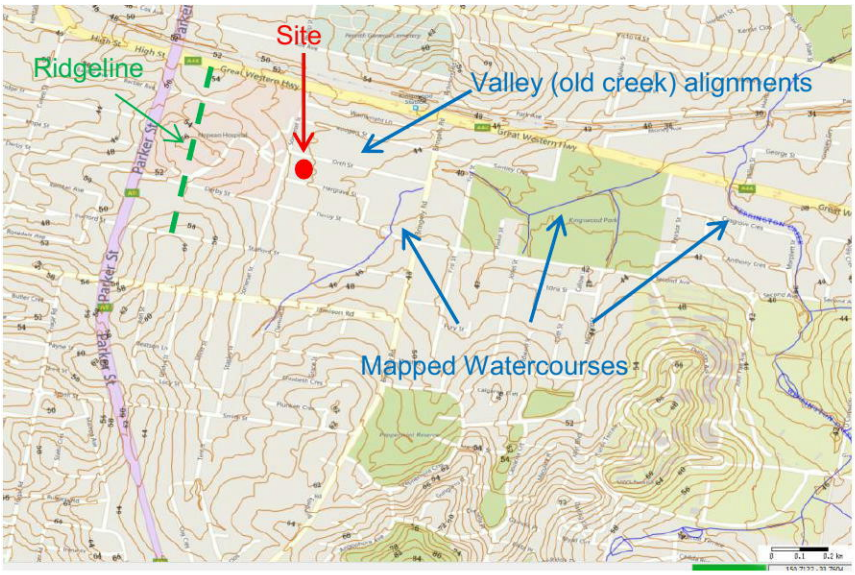

Figure 2: Contour Plan (2 m elevations)

3.2 Geology Mapping

Reference to the Sydney 1:100 000 Series Geological Sheet indicates the site is underlain by Bringelly Shale which typically comprises shale, carbonaceous claystone, laminite and fine to medium grained lithic sandstone.

Reference to Acid Sulfate Soil (ASS) mapping indicates that the site is located at least 3 km east of areas mapped as having ASS. The Acid Sulfate Soil Management Advisory Committee (ASSMAC) guidelines indicate that ASS normally occurs in alluvial or estuarine soils below RL 5 m AHD. Given that the site above an elevation of RL 40 m AHD and the site soils are expected to be residual clays, ASS is not likely to be present on-site.

3.3 Hydrogeology

Review of Sydney Watercourses Map (Refer Figure 2) indicates that the site is located within the Werrington Creek catchment. Topographic maps suggest that surface water in the area would generally flow along the lower elevation alignments (valley) east towards Werrington Creek. These creeks are not expected to be significant watercourses as the proximity to the ridgeline to the west suggests relatively small up-gradient water catchments.

4. Geotechnical Model

The expected geological profile is as follows;

Fill (Unit 1)	-	Minor amounts of fill (including topsoil) generally across the site. It is possible that there are localised deeper pockets of fill at some locations; overlying,
Natural Clays (Unit 2)	-	Stiff (or stronger) residual clays; overlying,
Weathered Rock (Unit 3)	-	Extremely low to low strength, extremely to highly weathered, highly fractured to fractured, grey shale with some high strength ironstone banding and clay seams is expected below depths of 2 m to 4 m below existing site levels. In the local area the top of the rock profile has been observed to be dipping towards the west overlying,
Low and Medium Strength Shale (Unit 4)	-	Low and medium strength, moderately weathered, fractured to slightly fractured, grey shale with some ironstone banding is expected at depths of 3 m to 5 m. The strength of rock is expected to increase with depth while the rock weathering and fracturing is generally expected to reduce with depth (i.e. become less weathered and less fractured).

It is noted that experience within the Bringelly Shale has indicated that there are numerous fractures (e.g. joints, faults and bedding planes) and weak seams or bands in the rock.

Based on available information groundwater seepage is expected to occur at the soil/rock interface. It is also likely that groundwater seepage flows will occur within the upper weathered shale profiles and along discontinuities in the rock. Groundwater levels are expected to fluctuate with changing climatic conditions.

5. Proposed Development

Based on the architectural plans by AC Project Group (dated 22 November 2018) the construction of a 7 storey building with three basement levels is proposed.

The lower basement floor level is at RL 38.3 m, and will require excavation to a depth of approximately 9 m. Deeper localised excavations are expected for footings, services and lift wells.

Details of structural loads have not been provided, however based on previous experience, the column working loads for the 7 storey building are estimated by DP to be in the order of 6000 kN to 8000 kN.

6. Comments

6.1 Excavation Conditions

Bulk excavation to RL 38.3 m AHD for the proposed basement will encounter Geological Units 1 to 4.

Excavation within the Unit 1 and 2 soils and the Unit 3 weathered rock should be readily achievable by bulldozer blade or an excavator with bucket attachment. Some light to medium ripping assistance or the careful use of rock hammers, grinders or rock saws may be required for layers of higher strength ironstone within Unit 3 rock.

Any excavation within Unit 4 (low and medium strength shale) will require medium to heavy rock breaking equipment. Low strength rock is expected to have an unconfined compressive strength (UCS) in the range of 2 – 6 MPa. Medium strength rock is expected to have a UCS of 6 – 20 MPa. If high strength rock is encountered it is expected to have a UCS of 20 – 60 MPa. Low productivity during excavation should be expected with such materials. Rock breaking equipment will generally cause noise and vibrations that could be disturbing to neighbours.

All excavated materials disposed of off-site will need to be classified in accordance with the provisions of the current legislation and guidelines including the *Waste Classification Guidelines* (EPA, 2014). This includes filling and natural materials that may be removed from the site.

Further comments regarding groundwater are included in Section 6.2.

Noise and vibration will be associated with the excavation of bedrock materials.

6.2 Groundwater and Seepage

Installation of groundwater wells will be required to monitor groundwater levels on-site as these levels may influence the choice of construction methods and basement design. If groundwater inflows into the basement are expected in both the short and long-term, then approvals and permits will need to be obtained from the relevant government department (currently WaterNSW), for off-site disposal of groundwater and temporary (and permanent) dewatering. Licence fees may apply.

Based on previous experience seepage into the excavation should be readily controlled by perimeter drains connected to a "sump-and-pump" system.

6.3 Excavation Support

6.3.1 General

Vertical excavations in Units 1 to 4 will not be stable for any extended period of time due to either the low shear strength of the soils/weathered rock (Units 1 to 3) or the fracturing of the shale (Units 3 and 4).

The sidewalls of the basement excavation will therefore require temporary shoring support during excavation and permanent retaining wall support as part of the final construction. The following methods of support are recommended:

- **Soldier pile/infill panel wall system)** - the excavation could be supported by temporary shoring and permanent retaining walls such as a soldier pile/infill panel wall system (drained basement). The soldier piles would generally be spaced at about 2 m centres and should be founded at least two pile diameters below the lowest excavation level (both bulk and detailed) adjacent to the pile location. Soldier piles typically involve either bored piles or continuous flight auger (CFA) piles.

  At the completion of the each excavation lift (typically 2 m), reinforced shotcrete infill panels should be constructed. Regular inspections by a geotechnical professional following each progressive lift of excavation is needed to determine if further stabilisation measures are required.

  Strip drains should be installed behind the shotcrete of the soldier pile/infill panel wall system to facilitate drainage and prevent build-up of water pressures behind the shoring.
- **Continuous pile wall** – for retaining walls requiring greater stiffness a continuous pile wall could be designed. A continuous pile wall involves the installation of either bored or CFA piles immediately adjacent to each other to provide a continuous pile wall.

6.3.2 Design of Lateral Support

The design of retaining walls should take due account of both lateral earth pressures and surcharges acting on the walls. The preliminary earth pressure coefficients and bulk unit weights in Table 1 are suggested for the design of a single anchored/propped wall using a triangular pressure distribution.

Table 1: Design Parameters for Retaining Structures

Strata	Earth Pressure Coefficients			
	Bulk Unit Weight, (kN/m^3)	'Active' Permanent K_a	'At Rest' Temporary K_o	Passive*
Filling and Residual Soils (Units 1 and 2)	20	0.35	0.5	NA
Weathered shale (Unit 3)	22	0.25	0.3	400 kPa
Low and medium strength shale (Unit 4)	24	0.0	0.0	4000 kPa

Note: * Only applicable below bulk excavation level.

The active earth pressure coefficient, $K_{a,}$ to be used for estimating soil pressures in Table 1 is for a flexible wall allowing some lateral or outward "tilting" movement. Where it is necessary to limit movement, it is suggested that the wall be designed for K_0 (lateral earth pressure coefficients "at rest") conditions in combination with an analytical approach that considers the excavation and propping or anchoring sequence.

The design for lateral earth pressures for a multi-anchored wall system may be based on a uniform rectangular earth pressure distribution. The following preliminary earth pressure distributions are considered appropriate:

- Units 1 to 3 = 4H (where H= height to be retained)
- Units 1 to 3 = 8H (where lateral movements are to be limited)
- Unit 4 = 2H
- Unit 4 = 4H (where lateral movements are to be limited)

Wall design using the preliminary parameters given in Table 1 and above for multi-anchored wall systems assumes the following:

- A level surface behind the top of the excavation;
- Retaining walls will need to allow for hydrostatic pressures from the ground surface level if drainage is not installed or maintained;
- Construction traffic and other surcharge loadings (e.g. stacked materials) are not applied at the crest of the retaining walls, for a distance of say 5 m behind the wall/shoring (otherwise the resultant additional lateral loads need to be considered);
- Passive resistance may be developed in Unit 4 from beneath one pile diameter below the bulk excavation level or below the base of any adjacent localised excavation. The passive pressures calculated are ultimate values to which an appropriate factor of safety (say 3) should be incorporated so as to limit the movement that otherwise is required to develop full passive pressure.

The design of temporary and permanent support will need to consider the possibility that 45° joints in the shale (Unit 4) will daylight near the base of the excavation leading to large wedges of rock requiring support by the temporary and permanent retaining structures. Sufficient anchoring of the

shoring wall should be undertaken to prevent movements along 45° joints, even though there is a low probability that a joint would run the full length and height of the excavation. It is suggested that design be carried out such that the support system has a factor of safety of 1.2 against the ultimate sliding force along the most unfavourable 45° joint. Additional anchors may be required to increase the factor of safety if large wedges are observed during excavation.

The final or detailed design of retaining walls is normally undertaken using interactive computer programs such as WALLAP, PLAXIS or FLAC, which can account for soil-structure interaction during the progressive stages of wall construction, anchoring and bulk excavation.

6.3.3 Ground Anchors

Temporary ground anchors will be required for the lateral restraint of most boundary shoring walls greater than 3 m height (unless soil nails are used) until such time that the walls are permanently propped by the building floor slabs. The anchors should preferably have their bond length within low and medium strength shale (Unit 4).

An ultimate bond stress of 500 kPa in the low and medium strength shale (Unit 4) is suggested for preliminary design. Higher stresses may be appropriate with additional investigation. Ground anchors should be designed to have a free length that extends beyond an imaginary line drawn upwards at an angle of 45° from the toe of the wall with a minimum free length should be 3 m.

Further advice regarding ground anchors can be provided once intrusive investigation is carried out.

Where anchors are required to extend below neighbouring properties, roads or public access areas approval must be sought from the relevant property owners.

6.4 Foundations

It is expected that bulk excavation for the basement will expose low and medium strength shale (Class III and II with reference to Pells, P.J., Mostyn, G. and Walker, B.F. *"Foundations on Sandstone and Shale in the Sydney Region".* Australian Geomechanics Journal, Vol. No. 33 Part 3, Dec. 1998.).

Recommended maximum preliminary design pressures for the various rock strata are presented in Table 2 (following page). The foundation design parameters given in this table assume that the footing excavations (strip footings, pads or piles) are clean and free of loose debris.

Table 2: Recommended Preliminary Design Parameters for Foundation Design

Foundation Stratum	Maximum Allowable		Maximum Ultimate		Young's Modulus E (MPa)
	End Bearing (kPa)	Shaft Adhesion (Compression) (kPa)	End Bearing (kPa)	Shaft Adhesion (Compression) (kPa)	
Low and Medium Strength Shale (Class III and II respectively)	3500	350	10000	600	500

Notes:
1. Rock classification is based on Pells et al.
2. Shaft adhesion applicable for the design of bored piers, uncased over rock socket length, where adequate sidewall cleanliness and roughness is achieved.
3. Higher bearing pressures may be applicable with additional investigation.

Foundations proportioned on the basis of the allowable bearing pressures in Table 2 would be expected to have total settlements of less than 1% of the footing size / pile diameter under the applied working load, with differential settlements between adjacent columns expected to be less than half of this value.

All footings and pile excavations should be inspected by a geotechnical engineer prior to the placement of steel and concrete.

6.5 Seismic Loading

In accordance with AS1170-2007 "Structural Design Actions, Part 4: Earthquake Actions in Australia" a preliminary site subsoil Class C_e is considered to be appropriate for the site, although if shallow rock is proven in intrusive investigation, the classification may be modified.

7. Further Investigation

Intrusive geotechnical investigation and analysis will be required to assess the subsurface conditions at the site prior to detailed design and construction. It is expected that this will include at least three cored boreholes to depths of at least 4 m below the lowest proposed finished floor level. Groundwater monitoring must also be carried out for basement design. Further, geotechnical review and advice will be required once the investigation has been completed and the detail design progresses.

8. Limitations

DP has prepared this report for this project at 38 to 40 Orth Street and 26 Somerset Street, Kingswood in accordance with DP's proposal NWS190090 dated 30 May 2019 and acceptance received from Joe Yuan of AC Homes dated 24 July 2019. The work was carried out under DP's Conditions of Engagement. This report is provided for the exclusive use of AC Homes, and their agents, for this project only and for the purposes as described in the report. It should not be used by or relied upon

for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

This report must be read in conjunction with all of the attached notes and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

The contents of this report do not constitute formal design components such as are required, by the Health and Safety Legislation and Regulations, to be included in a Safety Report specifying the hazards likely to be encountered during construction and the controls required to mitigate risk. This design process requires risk assessment to be undertaken, with such assessment being dependent upon factors relating to likelihood of occurrence and consequences of damage to property and to life. This, in turn, requires project data and analysis presently beyond the knowledge and project role respectively of DP. DP may be able, however, to assist the client in carrying out a risk assessment of potential hazards contained in the Comments section of this report, as an extension to the current scope of works, if so requested, and provided that suitable additional information is made available to DP. Any such risk assessment would, however, be necessarily restricted to the environmental components set out in this report and to their application by the project designers to project design, construction, maintenance and demolition.

Douglas Partners Pty Ltd

Appendix A

About This Report

About this Report

Douglas Partners

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

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Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

About this Report

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.