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PRELIMINARY GEOTECHNICAL ASSESSMENT

MAJORS BAY DEVELOPMENT

Prepared for

Mortlake Consolidated Investments Pty Ltd

Report No. GS3944

21st December 2010

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ATTENTION: Mr. Ian Edwards

Dear Sir,

RE: Proposed Majors Bay Development
Preliminary Geotechnical Assessment Report

This report presents our geotechnical comments and recommendations from a preliminary nature for the proposed residential apartment development at the subject sites on various lots located at Mortlake overlooking Majors Bay. The proposed site locations are listed below. This preliminary geotechnical assessment was commissioned by Mr. Ian Edwards of Aust Equity Pty Ltd.

It is our understanding that the subject site is divided into three subdivisions namely Site 1, Site 2 and Site 3. Site 1 comprises of a block area enclosed by Edwin Street to the South, Bennett Street to the West, Hilly Street to the East and Northcote Street to the North. Site 2 comprises of two lots namely Nos 16-18 and No 20-22 Bennett Street located west to the Bennett Street overlooking Majors Bay in the Parramatta River. Similarly Site 3 includes the areas enclosed by Northcote Street to the South and Hilly Street to the East including sites 1 Northcote Street, 8 Hilly Street, 14-22 Hilly Street and 16-18 Hilly Street.

Further more, it is also understood that, Site 1 is proposed to be divided into two areas namely Site 1 North (to be developed at Stage 2 of the project) and Site 1 South (to be developed at Stage 6 of the project) each constituting three individual apartment complexes. Site 2 (to be developed at Stage 5 of the project) consists of two individual apartment buildings as proposed. Also, Site 3 is divided into three areas namely Site 3 West (to be developed at the Stage 1 of this project and constitutes two apartment complexes), Site 3 South (to be developed at the Stage 4 of this project and constitutes 3 apartment complexes) and Site 3 North (to be developed at Stage 3 of the Project and constitutes 2 apartment complexes).

The purpose of this geotechnical site assessment is to conduct a preliminary investigation of the subject sites, in order to assess the anticipated site conditions expected within the site. The preliminary geotechnical investigation study included the desktop study of the subject site based on available aerial photographs, previous environmental studies completed by Aargus environmental in the year 2005 for the subject sites and a walkover survey of the sites on 13th December 2010 by a senior Geotechnical Engineer from our company to assess the current site conditions. Therefore, this report serves to provide preliminary recommendations from a geotechnical viewpoint for the design and construction of the proposed residential apartment buildings.

The proposed development is comprised of several residential apartment buildings including up to three level basements which will be discussed later in the report.

It is understood that the proposed residential apartment development involves the demolition of the existing structures within the site and construction of new multi-storey residential apartment buildings as listed above. Formation of the basement level is expected to entail excavations ranging from about 2.0m to 12.0m deep relative to existing ground surface levels and will be discussed in the later sections of the report.

Based on the results of this geotechnical site appraisal, it is considered that the subject site is **suitable** for the proposed residential apartment development, provided that a geotechnical investigation encompassing investigation fieldwork, drilling of boreholes, installation of groundwater monitoring standpipes, and rock strength testing, be carried out at a later stage following site clearance, to confirm that the preliminary recommendation as presented in this report are applicable, and to further complement the geotechnical assessments made herewith backed by factual findings.

EXECUTIVE SUMMARY

The purpose of this preliminary geotechnical assessment is to assess the anticipated site conditions expected within the site for the proposed developments. All the available published resources pertaining to the scope of works has been reviewed in order to assess the preliminary geotechnical conditions of the sites listed above. Similarly, a walkover survey of the site following the regional geological review and aerial photographs review has been conducted in order to better assess the existing site conditions. Therefore, this report serves to provide preliminary recommendations from a geotechnical viewpoint for the design and construction of the proposed residential apartment buildings.

Aargus Pty Ltd had conducted a various environmental site assessment reports in the year 2005 for the Sites 2 and 3. At the time of investigation, several bore holes were advanced on site to assess subsurface conditions by using hand held equipments. Subsurface investigations under the scope of this report will include a review of the boring logs obtained from the previous environmental report and will be discussed in detail in the subsurface conditions section later in this report.

As groundwater level was observed at depths ranging from approximately 1.3m to 2.5m relative to ground surface levels on Site 3 during earlier Aargus investigations, groundwater inflow can be anticipated during basement bulk excavations on all Sites 1, 2 and 3. De-watering should be carried out to lower the groundwater table to about 500mm below design excavation level to facilitate a workable base. Basement excavation dewatering on all sites would involve the installation of cut-off walls along the boundaries of the excavation. The founding depths of cut-off walls are to be confirmed by means of groundwater modelling assessment.

Materials to the anticipated depth of proposed basement excavations, being in the order of up to 2.5m deep relative to existing ground surface levels, comprise concrete slab, underlain by man made fill comprising of concrete pieces, brick pieces, silty clay and some sand as well and are assessed to be of soft consistency, grading to possibly firm consistency underlain by sandstone bed rock at the design basement bulk excavation levels. For portions of Site 1 and Site 3, it is anticipated that bedrock level is fairly shallow as evidenced from the existing vacant lot across Hilly Street east to Site 3. It is expected that excavation of the surficial materials will be achieved using conventional tracked mounted earthmoving equipment, such as excavators or dozers. However, as bedrock is anticipated at the bulk excavation level on all sites, we recommend that, prior to use of vibratory equipment, the excavation perimeter is saw cut with the aid of an excavator mounted rock saw or opened by drill and split techniques so as to minimise transmission of vibrations to adjoining structures.

As the basement floor slabs are founded below the groundwater table, hydrostatic uplift pressures associated with the excess head of water should be accounted for in design. Likewise, hydrostatic pressures on the cut-off walls should be accounted for in design.

All the excavations will need to be retained by engineer designed retaining structures prior to excavation. Appropriate retaining structures for the proposed excavation are expected to include secant pile walls and/or diaphragm walls, installed prior to excavation. Sub-sections 4.5 of this report provide guidance on the design of such retaining structures.

The loading conditions for the proposed development are not known at the time of preparation of this report. However, considering the scale of the development, it is envisaged that foundation materials required to support the proposed structure would need to comprise sandstone bedrock. It is envisaged that deep foundations comprising concrete injected piles found and socketed appropriately in the underlying sandstone bedrock would be required.

Based on the outcomes of this preliminary geotechnical site report, it is considered that the subject sites are **suitable** for the proposed residential apartments development, provided that a supplementary geotechnical investigation encompassing investigation fieldwork, as discussed in sub-section 4.7 of this report be carried out at a later stage following site clearance, to confirm that the preliminary recommendation as presented in this report are applicable, and to further complement the geotechnical assessments made herewith backed by factual findings.

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TABLE OF CONTENTS

1.0 INTRODUCTION 9

2.0 OBJECTIVES 9

3.0 AVAILABLE INFORMATION 10

3.1. Documents Reviewed 10
3.2. Location 12
3.3. Regional Geology 12
3.4. Groundwater 13
3.5. Subsurface Conditions 13

4.0 DISCUSSION & RECOMMENDATIONS 16

4.1. General 16
4.2. Excavation Conditions 17
4.3. Dewatering Conditions 18
4.4. Groundwater Pressure & Floor Slabs 20
4.5. Retaining Structures 21
4.6. Foundations 24
4.7. Additional Geotechnical Investigation 25

5.0 CONCLUSION 26

LIST OF APPENDICES

APPENDIX A IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL REPORT

REFERENCES

1. Australian Standard – Geotechnical Site Investigation, AS1726-1993.
2. Pells, P J N, Mostyn, E and Walker, B F – Foundations on Sandstone and Shale in the Sydney Region, Australian Geomechanics Journal, Dec 1998.
3. Aargus Australia – Environmental Site assessment, Properties 1 Northcote Street,8 Hilly Street, 14-22 Hilly street Mortlake, NSW “Site 3”, 11th May 2005.
4. Aargus Australia – Environmental Site assessment, Properties 16-18 ad 20-22 Bennett Street, Mortlake, NSW “Site 2”, February 2005.

1.0 INTRODUCTION

This geotechnical site appraisal report was commissioned by Mr. Ian Edwards of Aust Equity Pty Ltd on behalf of Mortlake Consolidated Investments Pty Ltd.

This report presents geotechnical comments and recommendations of a preliminary nature for the proposed residential apartment development at the subject site, known as Site 1 Site 2 and Site 3 with the street addresses as stated earlier on this report.

2.0 OBJECTIVES

The purpose of this preliminary geotechnical assessment is to conduct a document review of available published information on the subject sites, in order to assess the anticipated geotechnical site conditions expected within the site. Therefore, this report serves to provide preliminary recommendations from a geotechnical viewpoint for the design and construction of the proposed residential apartment buildings, which includes the following:

- Anticipated surface and sub-surface conditions as referenced from the boring logs stated on the environmental assessment report conducted by Aargus engineering in the year 2005.
- Anticipated groundwater conditions and management.
- Recommendations on dewatering
- Recommendations on excavation conditions.
- Recommendations on temporary safe batter slopes during excavation if appropriate.
- Recommendations on excavation retention.
- Provision of earth pressure parameters for preliminary design of retaining structures.
- Preliminary recommendations on deep foundations, including serviceability end bearing pressures and anticipated settlements.
- Recommendations on additional geotechnical investigation.
- Identify areas of potential dilapidation surveys along the proposed developments.

3.0 AVAILABLE INFORMATION

3.1. Documents Reviewed

At the time of preparation of this report, the following documents were provided to us:

- Eighteen sets of preliminary DA drawings including site plan, site sections, site elevations, public domain plans, street sections, basement plans, cadastral plan, street layout plan, public parking plan, basement extents, public domain landscape plan and indicative staging plan prepared by Cox Richardson, dated April 2007.

Upon review of the above listed preliminary DA drawings, Aargus Engineering understands the following:

1. The proposed development has been divided into three sites namely Site 1, Site 2 and Site 3. The proposed developments on each of these sites are discussed below. The proposed developments will include the demolition of the existing structures on site.

***Site* 1:**

Site 1 is divided into two subdivisions namely Site 1 North and Site 1 South and comprises of following structures as proposed.

Site 1 North:

Consists of four Apartment Blocks with triple basement parking, namely Block A and A2 at (4 storeys with FRL 19.2) facing Bennett Street, Block D (9 storey WITH FRL 42.8) facing Hilly Street, and attached blocks B and C (4 storeys with FRL 20.7).

- One Apartment block terraced structure (Combined Blocks B and C) with single level basement and 4 storeys tall at FRL 17.20m for building facing Northcote Street.
- 1 apartment block (Block D) facing Hilly Street (9 storeys tall with FRL @ 35.8m as proposed with triple basement) and
- A four storey tall apartment (Block A) complex with single basement (with FRL @16.2m) proposed facing Bennett Street to the west.

Site 1 South:

One four storey apartment complex, Block A (9 storeys with FRL 29.8) facing Edwin Street.

- Triple basement apartment block (terraced structure at four storeys with FRL @ 24.8m connected with nine storey apartment structure with FRL @ 39.8m, Combined Blocks B and C) at the corner of Hilly Street and Edwin Street.
- A single basement four storeys apartment complex (Block D) facing Edwin Street with FRL @ 21.5m and,
- A single basement four storeys apartment complex (Block A) at the corner of Bennett Street and Edwin Street with FRL @ 17.2m

Site 2:

Two apartment blocks with single basement, Facing west proposed to be 3 storeys towards Majors Bay (Block A) and apartment (FRL @ 12.30m) facing east towards Bennett Street (Block B) proposed to be 4 storeys(FRL @15.30m).

***Site 3*:**

Site 3 is subdivided into Site 3 North, Site 3 South and Site 3 West and comprises of following structures as proposed.

Site 3 West:

- Two apartment blocks (Blocks A and B), three storeys with single basement each overlooking Majors bay at 12.3m FRL

Site 3 North:

- A double basement four storeys apartment complex (Block B) facing Hilly Street with FRL @ 17.5m and,
- A single basement three storeys apartment complex (Block A) overlooking Majors Bay with FRL @ 12.3m

Site 3 South:

- A double basement six storeys apartment complex (Block B) facing Hilly street with FRL @ 23.5m
- A single basement three storeys apartment complex (Block A) overlooking Majors Bay with FRL @ 12.30m
- A double basement apartment block (terraced structure at four storeys with FRL @ 17.5m connected with three storey single basement apartment structure with

FRL @ 13.1m, Combined Blocks C and D) along east west direction towards Majors bay from Hilly Street.

2. Site 1 occupies an area of 8,065 square meters, Site 2 occupies an area of 2,943 square meters and Site 3 occupies an area of 14,075 square meters.
3. Site 1 includes several residential housing units facing Edwin Street to the South and an abandoned paint manufacturing business enclosed by Bennett Street, Northcote Street and Hilly Street to the North.
4. Similarly Site 2 and Site 3 also include several industrial/commercial developments.
5. Ground surfaces are mostly concrete covered apart from the existing building footprints.
6. The basement excavation extends to the northern, eastern, southern and western site boundaries on Sits 1 and 3 and is expected to be up to 9m for some of the triple basement residential apartments as proposed along the Hilly Street.

3.2. Location

The site is located centrally within Canada Bay Council on Mortlake. More specifically, it is located on the western side of Hilly Street overlooking Majors Bay on Parramatta River. The site is low lying and based on information presented on the supplied drawings, backs onto the original bank of Majors Bay at Site 2 and Site 3. Total site area is close to 40,000m^2.

3.3. Regional Geology

Reference to the Sydney 1:100,000 Geological Series Sheet 9130, Edition 1, 1983, indicates that the site comprises of man made fill (mf) at the immediate coastal areas and Hawkesbury Sandstone (Rh) inlands.

Hawkesbury Sandstone is described as a medium to coarse grained quartz sandstone with very minor shale and laminite lenses and is believed to be formed at middle Triassic age of Mesozoic area.

The Soil Landscape Map of Sydney, Series Sheet 9130, Second Edition, indicates that the site is underlain by soils associated with disturbed landscapes. The disturbed terrain is defined as:

> "Landscape- *level to hummocky terrain, extensively disturbed by human activity including complete disturbance, removal or burial of soil, variable relief and slopes. Includes quarries, tips, land reclamation and large cut and fill features. Original vegetation cleared, weeds may be abundant."*

> "Soils- *Original soil as been removed, gratly disturbed or buried. Landfill includes soil, rock, building and waste materials."*

> "Limitations- *Soils with high variability that may include engineering hazard, unconsolidated low strength bearing materials, impermeability, poor drainage, very low fertility, toxic materials and wind erosion hazard. Sources of sediment and ground water contamination."*

3.4. Groundwater

Based on the previous works done by Aargus on site for contamination assessment, ground water level has been encountered on site at various locations on Site 3 on 1 Northcote Street and 8 Hilly Street in the depth ranging from 1.3m to 2.5m across the site. It is to be noted that actual ground water level can be assessed only upon installation of water monitoring wells across the site. The references taken here from our previous limited works are for indicative purposes only and should not be taken as a definitive. Also depth of the ground water table as mentioned earlier were measured relative to then existing ground surface level at the time of earlier Aargus investigation on 2005.

3.5. Subsurface Conditions

Based on available information, it is understood that Aargus had previously carried out contamination assessments on Site 1, Site 2 and Site 3. The contamination assessments included the drilling of boreholes across the sites terminating either upon refusal on sandstone bedrock and/or sandstone boulders within the fill stratum near the shoreline or within the natural subsoil stratum.

Boreholes within the subject properties, located close to the foreshore of Majors Bay and considered relevant to our assessment, are summarised as follows on Table 1.

TABLE 1
Bore Holes Summary

Site Location	Borehole No	Materials Encountered	Termination Material
1 Northcote Street (On Site 3)	BH7	0m – 0.2m Concrete 0.2m - 0.6m Fill	Possible Sandstone Bedrock / Boulder (Fill)
	BH8	0m – 0.2m Concrete 0.2m – 1.0m Fill	Possible Sandstone Bedrock / Boulder (Fill)
16 – 18 Hilly Street (On Site 3)	BH7	0m – 0.5m Fill 0.5m – 2.0m Sandy Clay	Possible Sandstone Bedrock
	BH8	0 – 0.5m Fill 0.5m – 1.5m Sandy Clay	Possible Sandstone Bedrock
	BH9	0m – 0.7m Fill	Possible Sandstone Boulder within Fill Stratum
	BH10	0m – 0.7m Fill	Possible Sandstone Boulder within Fill Stratum
	BH11	0m – 0.1m Concrete 0.1m – 0.6m Fill	Possible Sandstone Boulder within Fill Stratum
	BH12	0m – 0.1m Concrete 0m– 0.6m Fill 0.6m – 2.4m Clay	Natural Sandy Clays
14 Hilly Street (On Site 3)	BH6	0m – 1.0m Fill 1.0m – 1.3m Silty Clay	Natural Silty Clay
	BH7	0m – 0.1m Concrete 0.1m – 0.7m Fill	Fill
16 – 18 Bennett Street (On Site 2)	BH23	0m – 0.25m Concrete 0.25m – 0.6m Sand 0.6m – 1.6 Sand 1.6m – 3.0 Sand (Estuarine Mud)	Possible Sandstone Bedrock
20 – 22 Bennett Street (On Site 2)	BH2	0m – 1.0m Fill	Possible Sandstone Boulder within Fill Stratum

Definitive subsurface investigation has not been carried out for the areas encompassed by Site 1. However, it is assumed that similar conditions as encountered on Site 2 and Site 3 can be expected for Site 1 as well. As indicted on the bore log summary listed above, depth of bed rock on all sites 1, 2 and 3 can be expected at a depth of 0.5m and beyond from existing ground surface level. However, rock strength cannot be assessed until further exploratory holes are drilled on site.

4.0 DISCUSSION & RECOMMENDATIONS

4.1. General

Based on the DA plans supplied, it is understood that the proposed residential apartment development involves the construction of several new three to nine-storey residential apartment with one to three level basement below. The least Finish Floor Level (FFL) for the basement is RL0.00m at Site 3. Formation of the basement level is expected to entail excavations ranging from about 2.0m to 12.0m deep relative to existing ground surface levels at various locations. The basement excavation extends to up to 12m .for the proposed developments on Site 3 and Site 1 towards Hilly Street.

As groundwater table was encountered at depths ranging from 1.3m to 2.5m on 1 Northcote Street and 8 Hilly Street on Site 3 relative to ground surface levels at the time of the investigation, it is expected that the depth of the groundwater table will fluctuate, and is likely to be affected by tidal influences, variations in rainfall and/or other factors. It is envisaged that the groundwater table will be intercepted during basement bulk excavations on all Sites 1, 2 and 3.

The scope of the investigations carried out by Aargus Engineering on 2005 did not encompass recovery of the underlying sandstone bedrock. Therefore, the serviceability end bearing capacity of the bedrock and rock classification for purposes of foundation design would need to be confirmed by means of geotechnical fieldwork pertaining to a further geotechnical investigation.

Site 2 is neighboured by an apartment complex on 24-30 Bennett Street to the north and 8 Bennett Street to the South. As it meets common site boundary, it is recommended that a dilapidation survey be carried out on these property prior to the commencement of the earthworks for Site 2. Also, it is recommended that dilapidation surveys be carried out on sites south of Edwin street between Bennett Street and Hilly Street (Ref Nos. Lot 44, 18, 20, 24, 28, 30 and 32-38 Edwin Street) as well as sites encompassed between Edwin Street and Northcote Street across Hilly Street to the east prior to commencement of excavation works for Site 1. Similarly, prior to the excavation commencement for earthworks for Site 3, it is recommended that a dilapidation survey be carried out to properties 24, 33, 31,29,27,25, 23, 17-19, and 15 Hilly Street and 8 and12 Hilly Street.

4.2. Excavation Conditions

Materials to the anticipated depth of proposed basement excavations, being in the order of 2.0m to 12m deep relative to existing ground surface levels, comprise concrete slab, and man made fill materials constituting silty clay, brick pieces, concrete pieces and sand and are not assessed for consistency. However, since the area comprises of man made fill, it is likely that the materials present on site underlain by bed rock may be in soft consistency and it is expected that excavation of these materials will be achieved using conventional tracked mounted earthmoving equipment, such as excavators or dozers.

Excavation for the underlying sandstone bed rock can be done in the following steps. The upper layer highly weathered sandstone bed rock can be easily excavated by using conventional tracked mounted earth moving equipment like excavators and dozers. However, following recommendation needs to be followed to excavate on higher strength sand stone bed rocks underlying highly weathered sandstone on Sites 1, 2 and 3.

Vibratory rock breaking equipment may be required for the proposed excavations in high strength sandstone bedrock. Therefore, we recommend that, prior to use of vibratory equipment, the excavation perimeter is saw cut with the aid of an excavator mounted rock saw or opened by drill and split techniques so as to minimise transmission of vibrations to adjoining structures. Following sawing / splitting of the perimeter of the excavation, sandstone bedrock may be broken up using a vibratory hammer suited to an excavator no larger than 12.0 tonnes.

Induced vibrations in structures adjacent to the excavation should not exceed a peak particle velocity (PPV) of 5mm/sec. If vibrations in adjacent structures exceed a PPV of 5mm/sec or if vibrations appear excessive, this office should be contacted immediately.

Based on the groundwater conditions encountered during the investigation fieldwork carried out earlier by Aargus Engineering on 2005, it is expected that groundwater will be intercepted during basement excavations for the proposed development. Therefore, dewatering as per recommendations provided in sub-section 4.3 of this report will be required prior to excavation below the groundwater table.

We understand that basement excavations will entail excavations from 2m up to 3m on portions of Site 2 and portions of Site 3 on the Western face facing Majors Bay and from 2m up to 12m deep at the proposed buildings on portions of Site 3 on south and North as well as Site 1 South and North. It is therefore assessed that safe set back distances would not be sufficient to facilitate safe temporary batter slopes during construction on Site 1, Site 2 and Site 3 as the extent of safe setback distances for temporary batter slopes easily reaches the existing streets on the southern, northern and eastern sides and the excavation will be closer to Majors bay on the western side for sites 2 and 3. Therefore, temporary or permanent batter slopes could not be accommodated. We recommend that all proposed excavation faces must be retained prior to excavation. Recommended preliminary geotechnical parameters for the design of retaining structures are detailed in the following sub-section 4.5 of this report.

4.3. Dewatering Conditions

As groundwater level was observed at depths ranging from approximately 1.3m to 2.5m relative to ground surface levels on Site 3 during the Aargus earlier investigations, groundwater inflow can be anticipated during excavation. De-watering should be carried out to lower the groundwater table to about 500mm below design excavation level to facilitate a workable base.

Due to the anticipated depth of dewatering within the site being in the order of 2m to 10m lower than the anticipated groundwater table (subject to fluctuations), excavation dewatering without cut-off walls is anticipated to result in significant groundwater level drawdown along the site boundaries. Therefore, the use of a cut-off wall is recommended to minimise surrounding ground settlements.

Cut-off walls may be installed along the excavation boundaries in order to lower the rate of groundwater inflow into the basement excavation and to reduce the groundwater level drawdown during excavation dewatering. The cut-off walls must be impermeable and contiguous, comprising secant grout injected pile wall and/or bentonite diaphragm walls.

However, during site excavation, if it is confirmed that the excavated faces comprise of higher strength sandstone profile with less fractures and with low amounts of seepage, conventional sump pump may be used to dewater the site during foundation excavation and construction. It will depend upon the subsurface conditions encountered during the detailed geotechnical investigation of the site and appropriate recommendations on site by site basis will follow based on detailed geotechnical investigation later on.

Based on limited information available, as a general recommendation, a groundwater modelling assessment will need to be carried out by a specialist dewatering contractor. However, in order to facilitate groundwater modelling, groundwater monitoring standpipes will need to be installed across the site as part of a further geotechnical investigation to determine and monitor the fluctuations in groundwater levels. Groundwater monitoring will need to be carried out for at least one month such that design of cut-off walls and dewatering methodologies could be confirmed prior to commencement of earthworks.

Basement excavation dewatering would involve the installation of cut-off walls along the boundaries of the excavation. The founding depth of cut-off walls is to be confirmed by means of groundwater modelling assessment. Excavation dewatering is commonly carried out using spear points connected to pumps of adequate capacity. It is recommended that the water derived from the dewatering be recharged back into the ground outside the perimeter of the excavation to minimise groundwater level drawdown beyond the site boundaries.

Furthermore, it is recommended that monitoring of the groundwater levels adjacent to the excavation be carried out during excavation dewatering to ensure that the groundwater level drawdown estimates (to be confirmed by means of groundwater modelling) are representative of actual conditions. Monitoring of the groundwater levels may be achieved using conventional standpipes.

Furthermore, it should be noted that cut-off walls should be designed and founded appropriately where they act as retaining structures to withstand lateral loads due to the retained materials and surcharge loads such as building loads), hydrostatic pressures, and others. Retaining structures are to be designed by a Structural Engineer. Guidance for preliminary design of retaining structures is provided in the following sub-section 4.5 of this report.

4.4. Groundwater Pressure & Floor Slabs

During basement dewatering, the groundwater level inside the cut-off wall is lowered to below the groundwater level outside the wall, and will be maintained below the basement bulk excavation level during the excavation and construction stages. The groundwater outside the cut-off walls however, will be at a higher level resulting in hydrostatic pressures acting on the cut-off walls.

It is expected that floor slabs for the basement level will be founded at a depth of approximately 1.5m to 3m below groundwater table for Sites 2, 3 West and up to 10m for Sites 1 South ad North and Site 3 South and West(to be confirmed by means of groundwater monitoring). During construction stage, where the groundwater level inside the cut-off walls are maintained to 0.5m below the basement bulk excavation levels, the basement floor slab will not be subjected to groundwater pressures. Once dewatering and pumping ceases post construction stage, the groundwater table within the cut-off walls will rise, resulting in groundwater pressures on both floor slabs and cut-off walls (retaining structures). Excess head at the base of the excavation is anticipated to be in the order of 1.5m to 10m, resulting in uplift pressures of about 15kPa to 100kPa based on the depths of expected excavation below the existing ground water table (to be confirmed by means of groundwater monitoring). A number of methods could be adopted to overcome the buoyancy effect experienced on these structures. These include the following:

- Design and construction of the floor slab (designed to be a watertight tank structure) is to ensure the uplift capacity is counteracted. The uplift capacity is estimated to be approximately 15kPa, which is equivalent to about 1.5m head of groundwater (to be confirmed by means of groundwater monitoring, estimated based on the underside of the basement slab on Site 2 and Site 3 West being 1.5m below the groundwater table). Similarly, the uplift capacity is estimated to be in the range of 40kPa to 100kPa on Site 3 South and North as well as Site 1 South and North. The higher end value is applicable to triple basement constructions on Site 1 and is only estimation. Further confirmation on actual ground water table level is required to recommend the uplift capacity for each site.

- Continuous pumping of groundwater table to maintain groundwater levels below the basement level on all sites. A specialised contractor should design an appropriate pumping system for this purpose.
- Continuous pumping of groundwater table to maintain groundwater levels below the basement level, complemented with relief valves as a secondary prevention measure.

The maximum excess head on the cut-off walls is also estimated to be in the order of 10m, equivalent to about 100kPa at basement bulk level on Site 1 (to be confirmed by means of groundwater monitoring) decreasing linearly to zero at groundwater level.

4.5. Retaining Structures

At this stage of investigation, in absence of proper subsurface lithology of the proposed sites, specific recommendations cannot be made for the design of the retaining structures. However, it is possible that the depth to competent bed rock comprising of sandstone of various strength is fairly shallow in the range of depths of 1.5m below existing ground surface and beyond. High strength or better sandstone bedrock (Class II and above), if encountered during the detailed geotechnical investigation may not require retaining structures during excavation or in the long term subject to site inspection during excavation to assess the need for rock bolting. It may be possible to entail temporary or permanent batter slopes for the surficial materials above the ground watertable encountered during excavation on sites 1 and 3 towards Hilly Street.

If temporary or permanent batter slopes cannot be facilitated on Sites 1, 2 and 3 (it is envisaged that the excavation will extend closer to site boundaries on Sites 1 towards Northcote Street, Bennett Street and Edwin Street) all the excavations will need to be retained by engineer designed retaining structures prior to excavation and following recommendations will be applicable in general.

Appropriate permanent retaining structures for the proposed excavation may include contiguous reinforced pile walls, secant pile walls or diaphragm walls detailed below.

Contiguous Grout Injected Pile Walls

These piles are constructed in such a way that they are just touching each other. They are therefore not expected to produce a watertight retaining wall. Other de-watering measures must be allowed for during the excavation process. Furthermore, local shotcreting may be required to retain sands that may penetrate through the gaps between the piles. This wall is not recommended where retaining structures are required to prevent water seepage into the excavation

Secant Grout Injected Pile Walls

These are constructed in such a way that every second or third pile is drilled between previously constructed piles, encroaching within the circumferences of the previously bored piles. This is considered to be a permanent watertight wall. However, it should be noted that some seepage might occur, which could be redirected using a conventional pump, depending on the flow of groundwater into the excavation. Long-term sealing by shotcreting may be required upon completion of excavation and exposure of the piles.

Diaphragm Wall

These are typically installed in lengths of 2.8m and widths of 0.5m to 0.8m. The panels are vertically excavated using a specially built "Clam Shell" with the aid of bentonite, which is displaced with concrete upon completion of excavation and placement of reinforcement. The panels are keyed to create a permanent watertight wall.

It is assessed that an appropriate retaining structure for the proposed excavation would comprise contiguous grout injected pile walls or secant grout injected pile walls, installed prior to excavation. Secant piles or contiguous piles should be socketed into the underlying sandstone bedrock as a cantilever wall. The pressure distribution on socketed (cantilever type) retaining structures may be assumed to be triangular and estimated as follows:

$$p_h = \gamma kH + qk$$

Where,

p_h = Horizontal pressure (kN/m^2)

γ = Wet density (kN/m^3)

k = Coefficient of earth pressure (k_a or k_o)

H = Retained height (m)

q = Surcharge pressure behind retaining wall (kN/m^2)

For the design of flexible retaining structures, where some lateral movement is acceptable, an active earth pressure coefficient is recommended. Should it be critical to limit the horizontal deformation of a retaining structure, use of an earth pressure coefficient at rest should be considered. Recommended parameters for the design of retaining structures are presented in the following Table 2.

TABLE 2
Geotechnical Design Parameters

Materials	Unit Weight (kN/m^3)	Active Earth Pressure coefficient (K_a)	Passive Earth Pressure Coefficient (K_p) or Pressure	At Rest Earth Pressure Coefficient (K_o)
Fill / Disturbed	16	0.45	-	0.6
Residual – Stiff	18	0.40	-	0.55
Residual – Very Stiff and Hard	21	0.35	2.8	0.5
Sandstone Bedrock	22	0.2	175kPa	0.3

The above coefficients assume that ground level behind the retaining structures is horizontal and the retained material is effectively drained.

Full hydrostatic pressure should also be taken into consideration in the design of cut off wall and tanked structures.

Surcharge loading imposed by the neighbouring buildings (Specifically on Site 2) should also be accounted for in the design of retaining structures, as their footings are likely to be founded within the zone of influence of the basement excavation of the subject development. Alternatively, the neighbouring structures founded within the zone of influence of the excavation should be underpinned prior to commencement of excavation.

The zone of influence of an excavation is defined as a plane projected at 45 degrees from horizontal from the toe of the excavation into the excavation face.

The design of any retaining structure should be checked by a Structural Engineer for bearing capacity, overturning, sliding and overall stability.

4.6. Foundations

The loading conditions for the proposed developments are not known at the time of preparation of this report. However, considering the scale of the development and the poor strength of the overburden soils (predominantly soft man made fill) below the basement bulk excavation level, it is envisaged that foundation materials required to support the proposed structure would need to comprise sandstone bedrock. As no geotechnical investigations were carried out within the subject site to delineate the depth to various classes of bedrock and the observed variability in the depth to bedrock across the site, it is not possible to definitively identify appropriate founding depth of footings in this preliminary stage of assessment. Where depth to the underlying bedrock that is suitable as foundation materials exceeds a depth of about 1.5m below the design bulk excavation level, deep footings should be considered from a construction and/or footing excavation practicality point of view.

Deep foundations founded and socketed in the various classes of sandstone bedrock (to be identified by means of borehole drilling, rock coring, recovery and rock strength testing) may be designed as per the parameters presented in Table 3:

Table 3
Parameters for foundation Design

Foundation Material	Serviceability End Bearing Pressure	Allowable Skin Friction within Rock Socket
Class V	1000kPa	100
Class IV	2000kPa	200
Class III or better	3500kPa	350

The total settlement of footings founded in bedrock under the recommended serviceability end bearing pressure is estimated to be about 1% of the pile diameter and the differential settlements are estimated to be about half of the estimated total settlements.

4.7. Additional Geotechnical Investigation

This report presents geotechnical comments and recommendations of a preliminary nature for the proposed residential apartments development at the subject sites 1, 2 and 3, being based entirely on a document review of previous contamination investigation reports conducted by Aargus on 2005, that had been prepared under the scope of an environmental site assessment. In order that adequate information may be obtained for design of the proposed residential apartment's development, it is mandatory that a geotechnical investigation incorporating fieldwork be carried out. The fieldwork will need to encompass the following as a minimum:

- Owing to the variability of the subsurface profiles, drilling of at least the following numbers of boreholes within the proposed development footprint, taken to depth of at least 3m into the underlying sandstone bedrock underneath the proposed basement levels with rock core recovery.
  - Site 2 will require a minimum of 1 borehole each on proposed building blocks A and B drilled up to 3m below the proposed basement level. Site 3 West will also entail at most 2 bore holes each on blocks A and B. Similarly, Site 3 South and North will require two bore holes each on bocks A,B,C and D where as Site 1 North will require at least 2 bore holes on Blocks D and A and a minimum of 1 bore hole each on Blocks B and C. Similarly drilling of a minimum of 1 boreholes each on Blocks B,C and D on Site 1 South will be required and a minimum of 2 bore holes will be required to be drilled on Block A of Site 1. These entire bore holes will be required to be taken at least 3m into the sandstone bedrock from the proposed basement level on each block
- Installation of at least one groundwater monitoring standpipes on each block on each site in select open boreholes to facilitate future groundwater monitoring and modelling.
- In-situ testing of the subsoils during drilling in the overburden soils.

- Point Load strength testing of the recovered rock cores.
- Testing to determine the presence of potential or actual acid sulfate soils.
- Testing of soils to determine the exposure category for the design or steel and concrete structures.

5.0 CONCLUSION

This report presents geotechnical comments and recommendations of a preliminary nature for the proposed residential apartments development at the subject sites, known as Sites 1,2 and 3 on various locations at Hilly Street, Northcote Street and Bennett Street, as the recommendations presented herein are based on limited available subsurface information obtained by Aargus for a Site Contamination Report prepared for Site 2 and Site 3 on 2005 and the proposed development plans provided by Cox Richardson.

The recommendations presented in this report are based on the following:

- The information presented in the preliminary development application drawings provided to us by Cox Richardson.
- Limited subsurface conditions findings of the site based on contamination assessment carried out by Aargus on 2005.
- The geotechnical model developed based on interpolation of the available limited information carried out by others, which are yet to be confirmed by further geotechnical investigation fieldwork.
- Groundwater table will be encountered within the depth of proposed bulk excavations.

Based on the findings of the investigations carried out by others, it is considered that the subject sites are **suitable** for the proposed residential apartment development, provided that a geotechnical investigation encompassing investigation fieldwork, as discussed in sub-section 4.7 of this report be carried out at a later stage following site clearance, to confirm that the preliminary recommendation as presented in this report are applicable, and to further complement the geotechnical assessments made herewith backed by factual findings.

For and on behalf of

Aargus Engineering Pty Ltd

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Geotechnical Engineer

Reviewed By

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Managing Director

LIMITATIONS

The assessment of the sub-surface profile within the proposed development areas and the preliminary recommendations presented in this report are based on interpretation of results of earlier limited site investigations carried out by Aargus Engineering.

The recommendations and advice presented in this report is considered to be indicative only. A geotechnical investigation incorporating fieldwork, borehole drilling, rock core sampling and rock strength testing, and the installation of groundwater monitoring wells would be required to confirm the preliminary recommendations provided herein. Furthermore, site inspection by a consulting Geotechnical Engineer or Engineering Geologist are to be undertake at the time of excavation and possibly during footing excavation to confirm the groundwater and rock conditions on which this geotechnical investigation report has been based.

There is a possibility that the actual geotechnical conditions across the site could differ from the inferred geotechnical model (on which our recommendations are based) presented in this report. We recommend that this office be engaged to carry out a geotechnical investigation incorporating fieldwork at a later stage, and if sub-surface and groundwater conditions encountered during excavation and construction vary from those presented in this report.

APPENDIX A

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL REPOT