
Preliminary Geotechnical
Investigation Baldivis Substation
Sites 2 and 3



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Document prepared by:

Western Power
ABN 18540492861

363 Wellington Street Perth WA 6000

Prepared by:

Zarnaz Mehryar

Geotechnical Engineer

Approved by:

Mark Bondiotti

Principal Engineer

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1 Introduction

This report presents the results of a preliminary geotechnical investigation for the proposed development of the Baldivis Substation. There are two possible sites that require investigation, located about 200 m apart near the corner of Eighty Road and Pike Road, in Baldivis. The location of the sites is shown in attachment A, Location Plan.

Based on the supplied information, we understand that each site covers an area of approximately 13,000 m². Both sites are generally cleared and currently used for farming activities. Some structures (including a house) are established at the south east part of site 3.

Golder Associates previously conducted the geotechnical investigation at the location of site 1 which is approximately 500 m north-east of the current locations of sites 2 and 3. The results were presented in the report referenced DMS #5567815.

The current work was performed by CSES at the request of Mr. Rudy Williams of Western Power. The sites plan is shown in attachment B.

The objectives of the geotechnical investigation were to:

- assess subsurface soil and groundwater conditions including site topography across the both sites;
- assess the site classification in accordance with AS 2870-1996 “Residential Slabs and Footings”;
- provide typical site preparation procedures and recommendations on site preparation requirements;
- assess excavation conditions across the both sites; and
- provide a comparison between sites 2, 3 and the original site 1.

2 Fieldwork

The fieldwork was performed on 3 August 2009 and comprised:

- A review on available geological information related to the site;
- Inspection of the site and a walk over survey; and
- Excavation of 10 hand auger boreholes, HA1 to HA10, extending from the surface to depths of about 2.0 m.

Details of Hand Auger Boreholes are provided in Table 1. The test locations were positioned based on information and plans provided to obtain a reasonable coverage of both sites.

Reports of hand auger boreholes are presented in Appendix C.

A geotechnical engineer from CSES positioned the test locations and logged the materials encountered at each test location.

Table 1. Detail of Hand Augur Boreholes

HA Location	Easting (MGA 94)	Northing (MGA 94)	Depth (m)	Reason for Termination
HA1	386460	6421766	1.85	Reached target depth
HA2	386454	6421817	2.0	Reached target depth
HA3	386476	6421852	2.0	Reached target depth
HA4	386540	6421853	1.5	Hit hard material – stopped due to possible services
HA5	386573	6421767	1.9	Reached target depth
HA6	386746	6421738	1.4	Refusal on cemented sand
HA7	386744	6421763	1.9	Reached target depth
HA8	386765	64217802	1.8	Reached target depth
HA9	386812	6421803	1.9	Reached target depth
HA10	386817	6421755	1.9	Reached target depth

3 Site Conditions

3.1 Geology

The Rockingham sheet of the 1:50,000 Environmental Geology series map indicates that both sites 2 and 3 are located on an area underlain by SAND derived from Tamala Limestone, overlying Tamala Limestone. The map also indicates that an area to the south of the sites is underlain by Sandy CLAY.

The ASS risk maps indicates that Site 3 is in the vicinity of an area with high to moderate risk of Acid Sulfate Soil (ASS) occurring within 3 m of the natural soil surface level.

3.2 Subsurface Conditions

Subsurface conditions across the site have been inferred from the results of the testing to comprise of loose sand overlying medium dense sand. Conditions can be summarized as follows:

- TOPSOIL: loose sand, fine to medium grained to a depth of about 100 mm; overlying
- SAND, loose to medium dense, fine to medium grained, extending to the investigated depth 2.0 m;

Cemented sand/limestone was encountered at depth of 1.4 m at the location of HA6 (in site 2). This caused refusal to the hand auger.

3.3 Ground Water

The Perth Groundwater Atlas produced by the Department of Water, indicates that the estimated maximum groundwater level in the area occurs at approximately RL 4 m AHD. This is relatively close to ground level as the natural ground level at site 3 varies between RL 4 to RL 5 m AHD.

The natural ground level in site 2 varies between RL 5m to RL 6 m AHD.

Moist to wet soil was observed towards the end of most hand auger boreholes. This is an indication of the high ground water level in the area. This is in line with expected ground water level based on the information from Perth Groundwater Atlas.

Hence, ground water is expected to have an effect on the construction activities.

4 Discussion

4.1 Site Preparation

Based on the subsurface conditions encountered during the investigation, the following site preparation procedure is recommended:

- Removal of topsoil and deleterious material: Strip topsoil, organics, deleterious fill and root material from beneath the site. Any significant excavations should be replaced with approved granular fill compacted to the requirements as provided for sand fill.
- Proof rolling of exposed surface after removal of topsoil: Prior to placement of structural fill, apply at least six passes of a 10 tone static mass vibratory roller over the whole exposed surface. Any weak areas identified should be over-excavated and backfilled to satisfy the specified compaction requirements. Over-excavation and compaction may be required to achieve an appropriate density where loose sand occurs.
- Placement of structural fill: Where fill is required, place and compact approved granular material on the prepared base following the compaction procedure outlined below, up to the required level.
- Footing preparation for buildings: Excavate to founding level at each footing location, compact the in situ sandy soil to achieve a PSP test result of not less than 8 blows per 300mm to a depth of 0.9 m below the founding level. Where limestone

is present at founding level, this should be over-excavated by 0.3 m and replaced with compacted sand fill.

- Sand fill: Where sand fill or backfill is required, it should be placed in horizontal layers not greater than 0.3 m loose thickness. Each layer should be compacted by approved compaction equipment to achieve a PSP test (Australian Standard AS 1289 6.3.3) result of not less than 8 blows per 300 mm. This is to ensure that a density index of at least 70% is being achieved in accordance with AS 1289 5.6.1. If difficulties arise in achieving this blow count for either in situ sand or sand fill material, then in situ density testing (AS 1289 5.3.1) should be performed to confirm the correlation between blow count and density.

It should be noted that although the coverage of the site by test locations is reasonable on the basis of accepted field investigation practices, the occurrence of old footings, disused services or undetected unsuitable fill cannot be dismissed. Any deleterious material must be removed from beneath building areas and replaced with approved granular fill.

Sand fill must comply with the material requirements as stated in AS 3798-2007, "Guidelines on Earthworks for Commercial and Residential Developments". The fill material should contain less than 5% fines (clay and silt particles less than 75 µm) to promote drainage at the site.

4.2 Excavation Condition

We anticipate that excavations in sand across the site can be conducted using standard earthmoving equipment. Should cemented sand or limestone be encountered, the use of dynamic plant may be required for excavation.

It should be noted that excavations in sand are prone to instability. Care must be exercised in such excavations and appropriate safety measures adopted where necessary. As a guide, a short term slope angle of 1V:1.5H should be acceptable for sands provided that structures are not present near the crest and that heavy vibration is not applied in the vicinity. In more critical areas, short term slope angles may need to be limited to 1V:2H. Even at this angle some erosion or riling could occur and for permanent slopes, the slope angle should not exceed 1V:2.5H.

5 Conclusion and remarks

Geotechnical investigation conducted by Golder Associates at the location of site 1 indicates that subsurface conditions at that site comprise SAND extending to depths of between 0.2 and 4.3 m; overlying CALCARENITE (LIMESTONE) to the maximum investigation depth of 10.0 m. Groundwater was not encountered at site 1.

Current preliminary investigation on sites 2 and 3 indicates that both sites are essentially sandy. Cemented sand/limestone was encountered at the depth of 1.4 m at one location (HA6).

This means excavation in limestone (or rock) is not likely to be required for either site 2 or site 3. As such, selection of either of these sites will save Western Power a few million dollars in earth work and site development (compare to site 1).

Due to high ground water table at these 2 sites, it will be required to raise the finished level of the selected site to at least 1m above the max ground water level. Hence, we anticipate needing at list 1m of sand fill across the entire area of site 3. This means additional

earthwork cost of about \$200,000 will be required to develop site 3 compared to the cost associated with development of site 2.

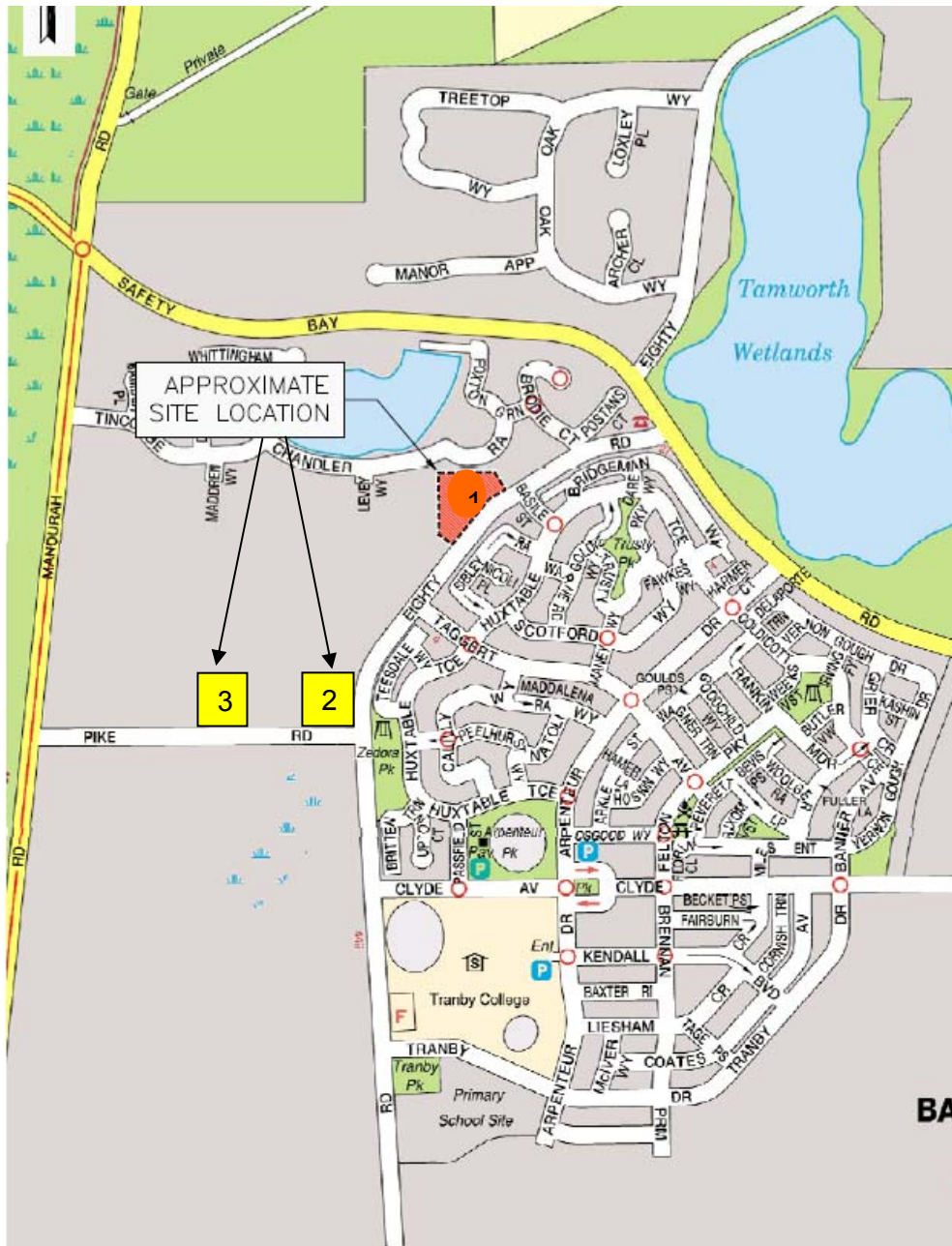
Furthermore, as site 3 is located in the vicinity of an area with high risk of Acid Sulfate Soil, some additional costs might be required to develop the site. The demolition of existing house on site 3 will attract additional costs as well.

Apart from this, from geotechnical and civil points of view, both sites 2 and 3 are suitable for development as an electrical substation. However, this cannot be commented further without conducting the proper geotechnical investigation.

6 Closure

We trust this provides the information you require. Please do not hesitate to contact us if you have any further queries relating to this report.

Appendix A - Location Plan



Appendix B - Site Plan



Appendix C - Report of Hand Augurs

HA1 (Excavated at the south west corner of the site 3)

Depth (m)	Description
0.00-0.1	Topsoil
0.10-1.85	SAND (SP), fine to medium grained, loose to medium dense, dark grey brown turning orange brown, moist
End of Hole @ 1.85 m Target depth achieved. Groundwater Not Observed.	

HA2 (Excavated at the west side of the site 3)

Depth (m)	Description
0.00-0.1	Topsoil
0.10-0.35	SAND (SP), fine to medium grained, loose, dark grey brown, moist to wet
0.35-2.00	SAND (SP), fine to medium grained, loose to medium dense, dark grey brown turning yellow brown, with silt, moist
End of Hole @ 2.0 m Target depth achieved. Groundwater Not Observed.	

HA3 (Excavated at the North part of the site 3)

Depth (m)	Description
0.00-0.1	Topsoil
0.10-1.10	SAND (SP), medium to coarse grained, loose to medium dense, yellow brown, moist
1.10-2.0	SAND (SP), medium to coarse grained, loose to medium dense, yellow brown, with silt, moist to wet
End of Hole @ 2.0 m Target depth achieved. Groundwater Not Observed.	

HA4 (Excavated at the north east side of the site 3)

Depth (m)	Description
0.00-0.1	Topsoil
0.10-1.1	SAND (SP), fine to medium grained, loose to medium dense, dark grey brown turning yellow brown, trace silt, moist to wet
1.10-1.50	SAND/Silty SAND, fine to medium grained, loose to medium dense, yellow brown, silt content increase with depth, moist to wet
End of Hole @ 1.5 m Terminated due to possible services (pipe) in the vicinity; Groundwater Not Observed.	

HA5 (Excavated at the south east side of the site 3, behind the existing house)

Depth (m)	Description
0.00-0.1	Topsoil
0.10-0.80	SAND (SP), fine to medium grained, loose to medium dense, dark grey brown turning yellow brown, trace fines, moist
0.80-1.90	SAND (SP), fine grained, loose to medium dense, turning yellow, with silt, moist
End of Hole @ 1.9 m Target depth achieved. Groundwater Not Observed.	

HA6 (Excavated at the south west corner of the site 2)

Depth (m)	Description
0.00-0.1	Topsoil
0.10-0.70	SAND (SP), fine to medium grained, loose to medium dense, dark grey brown turning orange brown, moist
0.70-1.40	SAND (SP), fine to medium grained, loose to medium dense, grey brown, turning yellow in parts, moist
End of Hole @ 1.4 m Refusal on cemented Sand/Limestone. Groundwater Not Observed.	

HA7 (Excavated at the west side of the site 2)

Depth (m)	Description
0.00-0.1	Topsoil
0.10-0.35	SAND (SP), fine to medium grained, loose, grey brown , with fines, moist
0.35-1.90	SAND (SP), fine to medium grained, loose to medium dense, turning yellow brown, no fines, moist
End of Hole @ 1.9 m Target depth achieved. Groundwater Not Observed.	

HA8 (Excavated at the north side of the site 2)

Depth (m)	Description
0.00-0.1	Topsoil
0.10-0.55	SAND (SP), fine to medium grained, loose to medium dense, dark grey brown, trace fine, moist to wet
0.55-1.80	SAND (SP), fine to medium grained, loose to medium dense, yellow brown, no fines, moist
End of Hole @ 1.8 m Target depth achieved. Groundwater Not Observed.	

HA9 (Excavated at the east side of the site 2)

Depth (m)	Description
0.00-0.1	Topsoil
0.10-0.45	SAND (SP), fine to medium grained, loose to medium dense, dark grey brown, trace fines, moist
0.45-1.50	SAND (SP), fine to medium grained, loose to medium dense, yellow brown, no fines, moist
1.50-1.90	SAND (SP), fine to medium grained, loose to medium dense, yellow brown, trace fines, moist
End of Hole @ 1.9 m Target depth achieved. Groundwater Not Observed.	

HA10 (Excavated at the south east corner of the site 2)

Depth (m)	Description
0.00-0.1	Topsoil
0.10-1.50	SAND (SP), fine to medium grained, loose to medium dense, dark grey brown turning yellow, moist to wet
1.50-1.90	SAND (SP), fine to medium grained, loose to medium dense, yellow, trace silt, wet
End of Hole @ 1.9 m Target depth achieved. Groundwater Not Observed.	