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DESKTOP REVIEW AND SUMMARY OF GEOTECHNICAL INVESTIGATIONS
PRECINCT 6 ROL 3 AND PRECINCT 8 ROL 1, YARRABILBA

1.0 INTRODUCTION

This letter presents the results of a geotechnical desktop review carried out for the Precinct 6 (P6) ROL 3 and Precinct 8 (P8) ROL 1 development areas. The work was commissioned by Stockland.

The purpose of the desktop review is to provide a summary of the expected geotechnical conditions in the development areas based on a review of the available information.

2.0 DEVELOPMENT AREA LOCATIONS AND LAYOUTS

Copies of the plans which show the proposed layouts for the P6 ROL 3 and P8 ROL 1 development areas are given in Figures 1 and 2.

Figure 1: Proposed layout for P6 ROL3 (pink border)

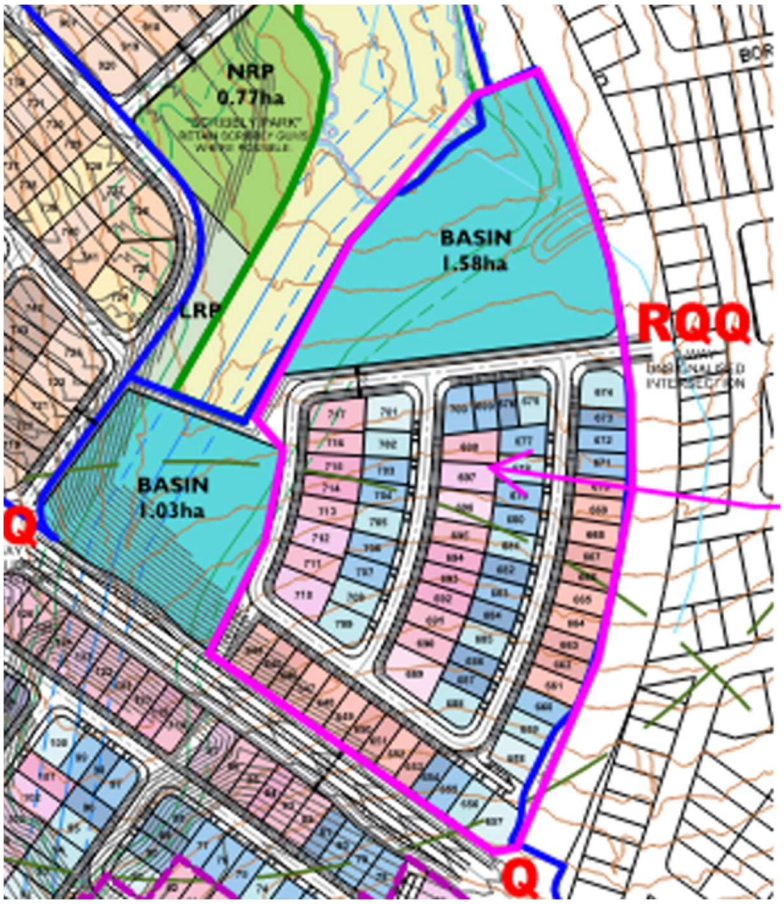
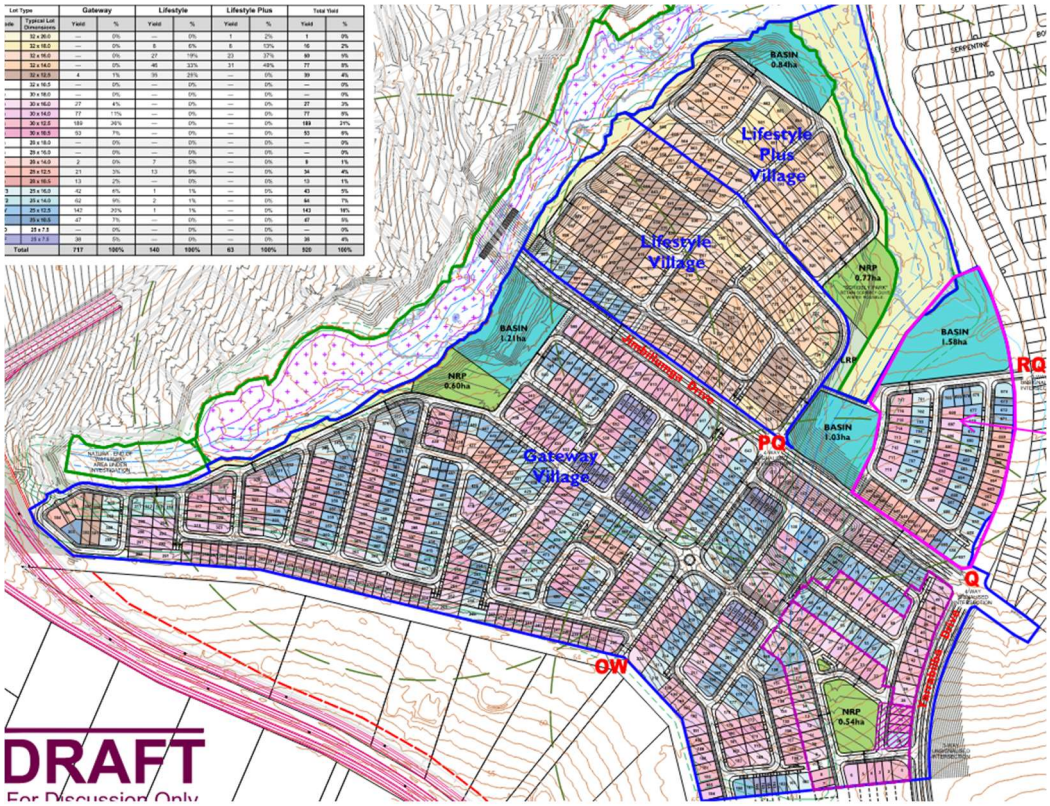


Figure 2: Proposed layout for P8 ROL1 (blue border)



Aerial images which show the locations of the P6 ROL 3 and P8 ROL 1 development areas are given in Figures 3 and 4.

Figure 3: Location of P6 ROL3 (image © Metro Maps)

Figure 4: Location of P8 ROL1 (image © Metro Maps)

3.0 PRECINCT 6 ROL 3

3.1 Geotechnical Reports

The following geotechnical reports contain test locations within or near P6 ROL 3 and were available for review:

- Morrison Geotechnic Pty Ltd – *Report on Geotechnical Investigation for Yarrabilba – Precincts 5 and 6*, Job No. DE21/264, Ref. No. 27330, dated 4 May 2022
- Morrison Geotechnic Pty Ltd – *Report on Geotechnical Investigation for Yarrabilba – Precinct 9*, Job No. DE21/264, Ref. No. 27434, dated 4 May 2022

The above reports are herein referred to as the MGPL P6 reports.

3.2 Summary of Testing

The fieldwork in the MGPL P6 investigations included the drilling of boreholes and the excavation of test pits within or near P6 ROL 3.

The test pits were excavated to depths ranging between 1.5m and 5.0m. The test pits terminated prior to 5.0m reached excavator bucket refusal.

The boreholes were drilled using a truck mounted drill rig incorporating auger, wash-bore and NMLC coring methods.

Laboratory testing from relevant test pits and boreholes included Shrink-Swell Index, Emerson Class and CBR.

3.3 Summary of Encountered Subsurface Conditions

The subsurface profiles encountered in the (relevant) MGPL P6 test pit / boreholes generally comprised upper topsoil and loose to medium dense sands, overlying residual clay soils of medium or high plasticity, underlain by weathered sandstone rock. The weathered rock was encountered at depths ranging between 1.2m and 4.7m

A copy of the summary tables given in the MGPL P6 reports (with the relevant test locations highlighted) is given in Figure 5.

Figure 5: Copy of subsurface summary tables from MGPL P6 reports (relevant test locations highlighted yellow)

Test Location	Topsoil (m)	Natural Sand (SM) (m)		Residual Sand (SC) (m)	Residual Clay (CI-CH) (m)			Weathered Rock			Termination Depth (m)[3]
		Very Loose to Loose	Medium Dense	Medium Dense	Stiff	Very Stiff	Hard	Very Low to low strength	Low to Medium Strength	Medium to High Strength	
BH6-4	0.0 – 0.1	NE	NE	NE	NE	0.1 – 0.9	0.9 – 2.0[4]	2.0 – TD	NE	NE	5.86
TP5-1	0.0 – 0.2	0.2 – 0.5	NE	NE	NE	0.5 – 1.3	1.3 – 1.7[4]	1.7 – 2.7	2.7 – TD	NE	2.80[5]
TP5-2	0.0 – 0.1	NE	0.1 – 0.3	NE	NE	0.3 – 0.7	0.7 – 1.3[4]	1.3 – 3.1	3.1 – TD	NE	3.20[5]
TP6-1	0.0 – 0.1	0.5 – 1.3	0.1 – 0.5	1.3 – 1.6	NE	NE	1.6 – 4.7[4]	4.7 – TD	NE	NE	5.00
TP6-2	0.0 – 0.1	0.1 – 0.3	NE	NE	NE	0.3 – 1.0	1.0 – 1.2[4]	1.2 – 1.9	1.9 – TD	NE	2.00[5]
TP6-3	0.0 – 0.1	NE	0.1 – 0.3	NE	NE	0.3 – 0.9	0.9 – 1.5 1.5 – 1.7[4]	1.7 – 4.0	4.0 – TD	NE	4.10[5]
TP6-4	0.0 – 0.1	0.1 – 0.3	NE	NE	NE	0.3 – 1.6	1.6 – 1.9[4]	1.9 – 3.0	3.0 – TD	NE	3.10[5]
TP6-5	0.0 – 0.1	0.1 – 1.1	NE	NE	NE	1.1 – 1.9	1.9 – 2.7[4]	2.7 – 4.7	4.7 – TD	NE	4.80[5]
TP6-6	0.0 – 0.1	0.4 – 0.7	0.1 – 0.4	NE	NE	0.7 – 1.3	1.3 – 1.6[4]	1.6 – 1.8	1.8 – TD	NE	1.90[5]
TP6-7	0.0 – 0.1	NE	0.1 – 0.3	NE	NE	0.3 – 1.0	1.0 – 1.2[4]	1.2 – 1.5	1.5 – TD	NE	1.60[5]
TP6-8	0.0 – 0.1	0.1 – 0.4	0.4 – 1.0	NE	NE	1.0 – 1.5	1.5 – 1.9 1.9 – 2.5[4]	2.5 – TD	NE	NE	5.00

Notes:
(1) TD – Termination Depth.
(2) NE – Not Encountered.
(3) Depth below the existing ground surface level as at the time of field work on the 25/01/2022, 01/02/2022, 07/02/2022, 08/02/2022, 15/02/2022, 16/02/2022, and 18/02/2022.
(4) Residual Sandy Clay material described as 'Extremely Weathered Sandstone'.
(5) Excavator bucket refusal reached prior to test pit target depth.

Test Location	Topsoil (m)	Natural Sand (SM) (m)		Residual Sand (SC) (m)		Residual Clay (CI-CH) (m)			Weathered Rock			Termination Depth (m)[3]
		Very Loose to Loose	Medium Dense	Loose	Medium Dense	Stiff	Very Stiff	Hard	Very Low to low strength	Low to Medium Strength	Medium to High Strength	
BH9-1	0.0 – 0.1	NE	NE	NE	NE	NE	0.1 – 1.0	1.0 – 2.0[4]	2.0 – 3.3 5.0 – TD	3.3 – 5.0	NE	5.83
BH9-2	0.0 – 0.1	NE	NE	NE	NE	NE	0.1 – 2.0	2.0 – 2.8[4]	2.8 – TD	NE	NE	5.50
BH9-3	0.0 – 0.1	0.1 – 0.5	NE	0.5 – 0.8	NE	NE	NE	NE	0.8 – 1.0 2.0 – 7.1	7.1 – TD	10.86	12.0
TP9-1	0.0 – 0.1	0.1 – 0.4	NE	0.4 – 0.6	NE	NE	0.6 – 1.1	1.1 – 1.4[4]	1.4 – 2.3	2.3 – TD	NE	2.40[5]

Test Location	Topsoil (m)	Natural Sand (SM) (m)		Residual Sand (SC) (m)		Residual Clay (CI-CH) (m)			Weathered Rock			Termination Depth (m)[3]
		Very Loose to Loose	Medium Dense	Loose	Medium Dense	Stiff	Very Stiff	Hard	Very Low to low strength	Low to Medium Strength	Medium to High Strength	
TP9-2	0.0 – 0.1	NE	0.1 – 0.3	NE	NE	NE	0.3 – 0.9	0.9 – 1.1[4]	1.1 – 2.1	2.1 – TD	NE	2.20[5]
TP9-3	0.0 – 0.1	NE	0.1 – 0.3	NE	0.3 – 0.9	NE	NE	0.9 – 1.8 1.8 – 2.0[4]	2.0 – 3.1	3.1 – TD	NE	3.10[5]
TP9-4	0.0 – 0.2	NE	0.2 – 0.6	NE	NE	NE	0.6 – 1.3	1.3 – 1.5[4]	1.5 – 2.0	2.0 – TD		2.10[5]
TP9-5	0.0 – 0.1	0.1 – 0.3	0.3 – 0.6	NE	NE	NE	0.6 – 1.2	NE	1.2 – 1.4	1.4 – TD	NE	1.50[5]
TP9-6	0.0 – 0.1	0.1 – 0.4	NE	NE	NE	NE	0.4 – 0.6	0.6 – 1.4 1.4 – 2.4[4]	2.4 – 2.8	2.8 – TD	NE	3.2[5]
TP9-7	0.0 – 0.1	0.1 – 0.5	NE	NE	NE	0.5 – 0.7	0.7 – 2.0	2.0 – 3.0[4]	3.0 – 3.5	3.5 – TD	NE	3.60[5]
TP9-8	0.0 – 0.1	0.1 – 0.5	NE	NE	NE	NE	0.5 – 1.8	1.8 – 2.0[4]	2.0 – 3.5	3.5 – TD	NE	3.80[5]
TP9-9	0.0 – 0.1	0.1 – 0.6	0.6 – 0.9	0.9 – 1.3	NE	1.3 – 1.8	1.8 – 2.0	2.0 – 2.8 2.8 – 3.6[4]	3.6 – 4.3	4.3 – TD	NE	4.40[5]
TP9-10	0.0 – 0.1	0.1 – 0.7	0.7 – 1.2	NE	NE	NE	1.2 – 1.6	1.6 – 2.7[4]	2.7 – TD	NE	NE	5.00

Notes:
(1) TD – Termination Depth.
(2) NE – Not Encountered.
(3) Depth below the existing ground surface level as at the time of field work on the 24/01/2022, 18/02/2022, 22/02/2022, and 17/03/22.
(4) Residual Sandy Clay material described as 'Extremely Weathered Sandstone'.
(5) Excavator bucket refusal reached prior to test pit target depth.

3.4 Summary of Laboratory Test Results

A copy of the laboratory test summary tables given in the MGPL P6 reports (with the relevant results highlighted) is given in Figure 6.

Figure 6: Copy of laboratory testing summary from MGPL P6 reports (relevant test locations highlighted yellow)

Precinct	Test Location	Depth (m)	Shrink (%)	Swell (%)	Shrink Swell Index (I_{ss} %)
6	BH6-1	0.50 – 0.72	2.4	0.3	1.4
8	BH8-2	0.30 – 0.58	2.6	0.5	1.6
9	TP9-6	0.60 – 0.80	5.4	0.8	3.2

Precinct	Test Location	Depth (m)	Material	Emerson Class Number
6	TP6-3	0.3 – 0.7	Residual – Silty CLAY (CH)[1]	6[(2)]
8	BH8-1	0.50 – 0.95	Residual – Silty CLAY (CH)[1]	6[(2)]
9	BH9-2	1.00 – 1.45	Residual – Sandy CLAY (CH)[1]	6[(2)]

Precinct	Test Location	Depth (m)	Material	Standard Maximum Dry Density (t/m³)	Optimum Moisture Content (%)	Field Moisture Content (%)	Soaked CBR (%)
6	TP6-3	0.3 – 0.7	Residual – Silty CLAY (CH)	1.67	21.0	24.3	2.5
8	TP8-9	0.2 – 0.8	Natural – Silty SAND (SM)	1.77	11.5	5.2	25
9	TP9-3	0.3 – 0.9	Residual – Clayey SAND (SC)	1.88	13.0	13.3	13

3.5 Engineering Assessment

The following sections provide a summary of each interpretive section of the MGPL P6 reports.

3.5.1 Soil Reactivity and Site Classification

The site classifications for the individual lots will depend on the predominant subsurface profile at each location, and the conditions existing after the bulk earthworks have been completed.

The MGPL P6 reports indicate that characteristic ground surface movements ys of up to approximately 35mm (Class M) are expected for the current site conditions. Following cut and fill earthworks, this may increase to up to 60mm to 65mm (Class H1).

Information is given in the MGPL P6 reports for the assessment of additional movements where trees are present.

3.5.2 Earthworks

The concept bulk earthworks plans in the MGPL P6 reports indicate that earthworks will predominantly comprise filling with only minor areas of cutting. Filling of generally up to 2.0m but locally up to about 5.0m is expected.

The MGPL P6 reports provide general earthworks information including information on foundation preparation, the suitability of the encountered materials for reuse as fill and fill compaction.

Upper silty sand soils up to about 1.0m deep were identified in the majority of the test locations. Groundwater seepage was also encountered in some of the test pits. Where the silty sand is present (and particularly where it is deeper), issues for earthworks likely include poor trafficability and inability to pass proof roll testing. Treatment may be required similar to that which was used in previous Precincts.

Excavations in the natural sand and clay-based soils and very low strength weathered sandstone rock should be within the capacity of conventional earthmoving equipment such as medium to large sized excavators (15t – 30t). Refusal was reached with a 25t excavator (fitted with a tooth bucket) in some of the test pits below 1.5m. Efficient excavations in the weathered sandstone rock below these depths may require the use of large excavators fitted with ripper attachments or pre-ripping with dozers.

Emerson Class laboratory testing indicates that the clay soil is non-dispersive. However, rill and gully erosion of the upper soil layers was observed on most slopes. This was likely caused by water turbulence or concentrated rapid water flow toward the vegetated gullies and the farm dams.

3.5.3 Footings

It is expected that the residential buildings will be supported by stiffened raft slabs. The footing systems supporting structures at shallow depth within P6 ROL 3 should be designed and constructed to accommodate the potential ground movement resulting from the volume instability of the reactive clay soils.

Allowable bearing pressures for high-level and deep footings for the encountered materials are given in the MGPL P6 report.

The report states that footings shall be designed to accommodate any differential self-weight settlement of the fill material that could be between 0.5% and 1% of the fill height.

3.5.4 Retaining Walls

The MGPL P6 reports provide strength parameters for the design of retaining walls.

The importance of surface and subsurface drainage for retaining walls is noted. Surface water must be diverted away from the back of retaining walls to prevent the ponding of surface water behind the top of the wall. Sub soil drainage must be placed behind the permanent retaining walls to prevent the buildup of groundwater pressures, and this must be freely discharged to a point of legal discharge.

3.5.5 Pavements

The MG investigation report notes that pavements are likely to be constructed on a wide variety of subgrade materials which should be compacted to achieve a minimum density ratio of 100% SMDD. Preliminary design CBR values of 10% for natural sandy materials and 1.5% for silty clay materials are given.

4.0 PRECINCT 8 ROL 1

4.1 Geotechnical Reports

The following geotechnical report contains test locations within or near P8 ROL 1 and was available for review:

- Morrison Geotechnic Pty Ltd – *Report on Geotechnical Investigation for Yarrabilba – Precinct 9*, Job No. DE21/264, Ref. No. 27434, dated 4 May 2022

The above report is herein referred to as the MGPL P8 report.

4.2 Summary of Testing

The fieldwork in the MGPL P9 investigation included the drilling of boreholes and the excavation of test pits within or near P8 ROL 1.

The test pits were excavated to depths ranging between 1.5m and 5.0m. The test pits terminated prior to 5.0m reached excavator bucket refusal.

The boreholes were drilled using a truck mounted drill rig incorporating auger, wash-bore and NMLC coring methods.

Laboratory testing from relevant test pits and boreholes included Shrink-Swell Index, Emerson Class and CBR.

4.3 Summary of Encountered Subsurface Conditions

The subsurface profiles encountered in the MGPL P8 test pit / boreholes generally comprised upper topsoil and loose to medium dense sands, overlying residual clay soils of medium or high plasticity, underlain by weathered sandstone rock. The weathered rock was encountered at depths ranging between 1.2m and 4.7m

A copy of the summary tables given in the MGPL P8 reports (with the relevant test locations highlighted) is given in Figure 7.

Figure 7: Copy of subsurface summary tables from MGPL P8 reports

Test Location	Topsoil (m)	Natural Sand (SM) (m)		Residual Sand (SC) (m)		Residual Clay (CI-CH) (m)			Weathered Rock			Termination Depth (m)[3]
		Very Loose to Loose	Medium Dense	Loose	Medium Dense	Stiff	Very Stiff	Hard	Very Low to low strength	Low to Medium Strength	Medium to High Strength	
BH9-1	0.0 – 0.1	NE	NE	NE	NE	NE	0.1 – 1.0	1.0 – 2.0[4]	2.0 – 3.3 5.0 – TD	3.3 – 5.0	NE	5.83
BH9-2	0.0 – 0.1	NE	NE	NE	NE	NE	0.1 – 2.0	2.0 – 2.8[4]	2.8 – TD	NE	NE	5.50
BH9-3	0.0 – 0.1	0.1 – 0.5	NE	0.5 – 0.8	NE	NE	NE	NE	0.8 – 1.0 2.0 – 7.1	7.1 – TD	10.86	12.0
TP9-1	0.0 – 0.1	0.1 – 0.4	NE	0.4 – 0.6	NE	NE	0.6 – 1.1	1.1 – 1.4[4]	1.4 – 2.3	2.3 – TD	NE	2.40[5]

Test Location	Topsoil (m)	Natural Sand (SM) (m)		Residual Sand (SC) (m)		Residual Clay (CI-CH) (m)			Weathered Rock			Termination Depth (m)[3]
		Very Loose to Loose	Medium Dense	Loose	Medium Dense	Stiff	Very Stiff	Hard	Very Low to low strength	Low to Medium Strength	Medium to High Strength	
TP9-2	0.0 – 0.1	NE	0.1 – 0.3	NE	NE	NE	0.3 – 0.9	0.9 – 1.1[4]	1.1 – 2.1	2.1 – TD	NE	2.20[5]
TP9-3	0.0 – 0.1	NE	0.1 – 0.3	NE	0.3 – 0.9	NE	NE	0.9 – 1.8 1.8 – 2.0[4]	2.0 – 3.1	3.1 – TD	NE	3.10[5]
TP9-4	0.0 – 0.2	NE	0.2 – 0.6	NE	NE	NE	0.6 – 1.3	1.3 – 1.5[4]	1.5 – 2.0	2.0 – TD		2.10[5]
TP9-5	0.0 – 0.1	0.1 – 0.3	0.3 – 0.6	NE	NE	NE	0.6 – 1.2	NE	1.2 – 1.4	1.4 – TD	NE	1.50[5]
TP9-6	0.0 – 0.1	0.1 – 0.4	NE	NE	NE	NE	0.4 – 0.6	0.6 – 1.4 1.4 – 2.4[4]	2.4 – 2.8	2.8 – TD	NE	3.2[5]
TP9-7	0.0 – 0.1	0.1 – 0.5	NE	NE	NE	0.5 – 0.7	0.7 – 2.0	2.0 – 3.0[4]	3.0 – 3.5	3.5 – TD	NE	3.60[5]
TP9-8	0.0 – 0.1	0.1 – 0.5	NE	NE	NE	NE	0.5 – 1.8	1.8 – 2.0[4]	2.0 – 3.5	3.5 – TD	NE	3.80[5]
TP9-9	0.0 – 0.1	0.1 – 0.6	0.6 – 0.9	0.9 – 1.3	NE	1.3 – 1.8	1.8 – 2.0	2.0 – 2.8 2.8 – 3.6[4]	3.6 – 4.3	4.3 – TD	NE	4.40[5]
TP9-10	0.0 – 0.1	0.1 – 0.7	0.7 – 1.2	NE	NE	NE	1.2 – 1.6	1.6 – 2.7[4]	2.7 – TD	NE	NE	5.00

Notes:
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(4) Residual Sandy Clay material described as 'Extremely Weathered Sandstone'.
(5) Excavator bucket refusal reached prior to test pit target depth.

4.4 Summary of Laboratory Test Results

A copy of the laboratory test summary tables given in the MGPL P6 reports (with the relevant results highlighted) is given in Figure 8.

Figure 8: Copy of subsurface summary tables from MGPL P8 report (relevant test locations highlighted yellow)

Precinct	Test Location	Depth (m)	Shrink (%)	Swell (%)	Shrink Swell Index (I_{ss} %)
6	BH6-1	0.50 – 0.72	2.4	0.3	1.4
8	BH8-2	0.30 – 0.58	2.6	0.5	1.6
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Precinct	Test Location	Depth (m)	Material	Emerson Class Number
6	TP6-3	0.3 – 0.7	Residual – Silty CLAY (CH)[1]	6[(2)]
8	BH8-1	0.50 – 0.95	Residual – Silty CLAY (CH)[1]	6[(2)]
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4.5 Engineering Assessment

The following sections provide a summary of each interpretive section of the MGPL P8 report.

4.5.1 Soil Reactivity and Site Classification

The site classifications for the individual lots will depend on the predominant subsurface profile at each location, and the conditions existing after the bulk earthworks have been completed.

The MGPL P8 report indicates that characteristic ground surface movements ys of up to approximately 35mm (Class M) are expected for the current site conditions. Following cut and fill earthworks, this may increase to up to 60mm to 65mm (Class H1).

Information is given in the MGPL P8 report for the assessment of additional movements where trees are present.

4.5.2 Earthworks

The concept bulk earthworks plan in the MGPL P8 report indicates that earthworks will comprise cutting and filling of up to about 7m.

The MGPL P68 report provides general earthworks information including information on foundation preparation, the suitability of the encountered materials for reuse as fill and fill compaction.

Upper silty sand soils up to about 1.2m deep were identified in the majority of the test locations. Groundwater seepage was also encountered in some of the test pits. Where the silty sand is present (and particularly where it is deeper), issues for earthworks likely include poor trafficability and inability to pass proof roll testing. Treatment may be required similar to that which was used in previous Precincts.

Excavations in the natural sand and clay-based soils and very low strength weathered sandstone rock should be within the capacity of conventional earthmoving equipment such as medium to large sized excavators (15t – 30t). Refusal was reached with a 25t excavator (fitted with a tooth bucket) in some of the test pits below 1.5m. Efficient excavations in the weathered sandstone rock below these depths may require the use of large excavators fitted with ripper attachments or pre-ripping with dozers.

Where the cuts are deeper and the harder sandstone is present, the report indicates that the excavation of these ranges between 'hard ripping' (CAT D8 dozer), 'very hard ripping' (CAT D9 dozer) and 'extremely hard ripping' (CAT D11 Dozer).

Emerson Class laboratory testing indicates that the clay soil is non-dispersive. However, rill and gully erosion of the upper soil layers was observed on most slopes. This was likely caused by water turbulence or concentrated rapid water flow toward the vegetated gullies and the farm dams.

4.5.3 Footings

It is expected that the residential buildings will be supported by stiffened raft slabs. The footing systems supporting structures at shallow depth within P8 ROL 1 should be designed and constructed to accommodate the potential ground movement resulting from the volume instability of the reactive clay soils.

Allowable bearing pressures for high-level and deep footings for the encountered materials are given in the MGPL P8 report.

The report states that footings shall be designed to accommodate any differential self-weight settlement of the fill material that could be between 0.5% and 1% of the fill height.

4.5.4 Retaining Walls

The MGPL P8 reports provide strength parameters for the design of retaining walls.

The importance of surface and subsurface drainage for retaining walls is noted. Surface water must be diverted away from the back of retaining walls to prevent the ponding of surface water behind the top of the wall. Sub soil drainage must be placed behind the permanent retaining walls to prevent the buildup of groundwater pressures, and this must be freely discharged to a point of legal discharge.

4.5.5 Pavements

The MGPL P8 report notes that pavements are likely to be constructed on a wide variety of subgrade materials which should be compacted to achieve a minimum density ratio of 100% SMDD. Preliminary design CBR values of 10% for natural sandy materials, 1.5% for silty clay materials and 5% for residual sandy clay soils are given.

Please do not hesitate to contact Simon Wynne at this office if you require any further information.

Regards,

PTG Consulting

Simon Wynne (RPEQ 17390)
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