Preliminary Geotechnical site investigation report
Proposed public school on Lot 1 DP1253855, Estella Road
Estella NSW 2650

Ref: R9930g
Date: 14 August 2018

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Environmental
Geotechnical
Asbestos
Services

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Interested authorities:	City of Wagga Wagga
Report number:	R9930g
Date:	31 October 2019

Executive Summary

Background

A new public school is proposed for Lot 1 DP1253855, Estella Road, Estella NSW. The school will consist of amenities building, classrooms and carparks. Pavement and parking areas will be located around the site.

A preliminary geotechnical investigation of the site is required to enable planning of civil works, design footings, design of pavements and provide advice on fill and earthworks.

Scope

Undertake a preliminary geotechnical investigation to determine site classification, soil bearing capacity, CBR, pavement parameters, evidence of fill and other site limitations.

Investigation

A site inspection and sampling was undertaken on 20 July 2018 to determine soil engineering properties. Boreholes were drilled to depths of 3 metres or refusal due to rock at seven representative locations (BH1-BH7). The boreholes were constructed with a Geoprobe 6610DT drilling rig fitted with a solid auger. The profile of each borehole was described along with moisture, consistency, density and plasticity.

Six samples were collected for laboratory analysis of liquid limit, plastic limit, plasticity index, linear shrinkage, pH electrical conductivity (EC) and linear shrinkage. The soil profile and laboratory testing data will enable the building site to be classified for reactivity.

Potential corrosive soils were assessed by soil analysis of a sample for pH and electrical conductivity.

Dynamic Cone Penetrometer (DCP) tests were undertaken at four locations adjacent to four boreholes (BH2, BH5, BH6 and BH7) to confirm soil consistency and enable estimation of shear strength and allowable bearing capacity.

The soil was investigated at the proposed pavement areas. Soil was sampled and the Californian Bearing Ratio (CBR) determined by the four day soak method. The CBR is a parameter used in pavement design.

Evaluation of engineering properties was undertaken to enable site classification, bearing capacity, soil aggressiveness and pavement parameters.

Conclusions and recommendations

The development site is a vacant lot to the west of Peter Hastie Oval located within the Charles Sturt University campus. The site is located on Lot 1 DP1253855, Estella Road, Estella NSW. The investigation area is approximately 3 hectares in size. The site occurs on a mid-slope.

The natural soil profile consists of brown to grey brown silty sand topsoil over brown/red, light brown to yellow brown sandy clay with increasing gravels and weathered rock. Granite float is located upslope of the investigation area on the crest.

The natural clay subsoils had a firm to hard consistency.

The subsoil was generally moist to dry to the drilling depth.

The site is not located in a mapped acid sulphate soil prone area. The soil is not aggressive to foundations. No obvious signs of salinity were observed on the site surface or within the subsoil. The laboratory results indicate all the soil samples collected were non-saline and the soil pH was neutral.

The soils within the investigation area have a moderate liquid limit, plastic limit and linear shrinkage. The soil has a maximum surface movement (y_s) of 40-45mm. The site has a classification of **Class H1-D** (Highly reactive with deep seated movements) at the borehole locations.

The allowable bearing capacity of the natural soil at the locations tested was estimated to be:

- 150kPa at a depth of 1.0m
- 250kPa at a depth of 2.0m
- 350kPa at a depth of 3.0m

The subsoils are from soft to hard consistency and are expected to be excavated with an excavator and tined bucket. Granite is known to occur in the area which is potentially high strength and difficult to excavate.

Subsoils on the site are suitable for use as general. Subsoil used for fill should not contain high moisture content, high silt content or rock greater than 70mm diameter.

The CBR result for sample analysed from the subgrade depth was low at 2.0%.

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1. Introduction

A new public school is proposed for Lot 1 DP1253855, Estella Road, Estella NSW. The school will consist of amenities building, classrooms and carparks. Pavement and parking areas will be located around the site.

A preliminary geotechnical investigation of the site is required to enable planning of civil works, design footings, design of pavements and provide advice on fill and earthworks.

2. Objectives

Envirowest Consulting Pty Ltd was commissioned by Hayball to undertake geotechnical investigations for the proposed public school for Lot 1 DP1253855, Estella Road, Estella NSW.

The investigation includes:

- Summary of surface and subsurface conditions
- Groundwater conditions and potential influences on structures
- Site classification including characteristic surface movement
- Foundation parameters including allowable bearing capacities
- Assessment of soil aggressiveness
- Suitability of subsoil for reuse as fill
- Excavation limitations
- Subgrade assessment / pavement parameters

3. Site location

The investigation area is located on Lot 1 DP1253855, Estella Road, Estella NSW. The investigation area is approximately 3 hectares.

4. General site description

The investigation area was a vacant block on the day of investigation and was historically used for grazing and cropping.

5. Site condition and environment

5.1 Surface cover

The investigation area comprised grasses with native trees along the western and southern perimeter boundary.

5.2 Topography

The site is located on a mid-slope. Aspect is predominantly south and slopes are very gently inclined and less than 8%. Elevation ranges between 223 and 235 metres above sea level. No groundwater seepage or discharge areas were observed on the site.

5.3 Soils and geology

The site is located within the East Bomen Soil Landscape. The soil landscape consists of undulating rises of Silurian Wantabadgery Granodiorite. Regolith consists of thick (>2m) clay sequences, with significant windblown (aeolian) clay deposited on most side slopes and in drainage depressions. The geological unit consists of Silurian aged Wantabadgery and Collingullie granites (Chen et all 1997).

5.4 Surface water

No dams or drainage lines are located within the proposed investigation area. Surface water flows south into the local storm water system.

5.5 Groundwater

There was no evidence of seasonal groundwater identified from soil profile to the drilling depth.

No bores are located within 500m of the site.

6. Investigation methods

A site inspection and field assessment was conducted on 20 July 2018. A total of seven boreholes (BH1 to BH7) were drilled on the site to depths of 3m and sampling undertaken to determine soil engineering properties. The boreholes were in the location of the proposed buildings and pavement areas. The profile of each borehole was described along with moisture, consistency, density, plasticity and rock weathering if applicable.

Six representative soil samples were collected from five boreholes (BH2, BH3, BH5, BH6 and BH7) for laboratory analysis of liquid limit, plastic limit, plastic index and linear shrinkage. The soil profile and laboratory testing data enabled the site to be classified for reactivity.

Dynamic Cone Penetrometer (DCP) tests were undertaken adjacent to borehole BH2, BH5, BH6 and BH7 to enable estimation of shear strength and allowable bearing capacity.

Samples were collected from boreholes and analysed for electrical conductivity (EC) and pH to determine the soil aggressiveness.

The soil was investigated for engineering parameters to enable pavement design in carpark. Soil was collected from the subgrade depth and the California Bearing Ratio (CBR) was determined on the sample by the 4 day soak method. The CBR parameter assists in pavement design.

All testing depths undertaken for the assessment were relative to existing ground level on the day of investigation.

A schedule of sampling locations and the tests undertaken are given in Table 1 and Figure 2.

Soil sampling was undertaken according to the Australian Standards 2870, by qualified field and laboratory personnel. All soil analysis was undertaken at the NATA accredited laboratory of Envirowest Testing Services.

Table 1. Sampling location and tests undertaken

Sampling location (Figure 2)	Proposed location	Tests undertaken	Testing depths (m)	Investigation total depth (m)
Borehole 1	Proposed carpark	Soil properties description	0 to 1.5	1.5
		CBR1	0.02 to 1.0	
Borehole 2	Proposed building	Soil properties description	0 to 3.0	3.0
		Index tests	1.5, 3.0	
		DCP	0 to 0.4	
		Electrical conductivity and pH	0.5 to 3.0	
Borehole 3	Proposed building	Soil properties description	0 to 3.0	3.0
		Index tests	2.0	
Borehole 4	Proposed building	Soil properties description	0 to 3.0	3.0
Borehole 5	Proposed building	Soil properties description	0 to 3.0	3.0
		Index tests	1.0	
		DCP	0 to 0.5	
Borehole 6	Proposed building	Soil properties description	0 to 3.0	3.0
		Index test	2.5	
		DCP	0 to 0.5	
		Electrical conductivity and pH	0.5 to 3.0	
Borehole 7	Proposed building	Soil properties description	0 to 3.0	3.0
		Index test	0.5	
		DCP	0 to 0.7	

7. Results

7.1 Surface condition

The site comprises grasses and native trees around the perimeter of the investigation area.

7.2 Soil profile and subsurface conditions

The natural soil profile consists of brown to grey brown silty sand topsoil over brown/red, light brown to yellow brown sandy clay with increasing weathered gravels. Granite float is located upslope of the investigation area on the crest.

Weathered rock was detected from a depth of 1.5m. The drilling was very stiff to hard.

The natural clay subsoils had a firm to hard consistency.

The subsoil was generally moist to dry to the drilling depth.

7.3 Soil index tests

Soil on the site had a moderate liquid limit and linear shrinkage (Table 2). The soil index properties laboratory report is presented in Appendix 2.

Table 2. Soil index test summary

Sampling location (Figure 2)	Proposed location (Figure 2)	Sample depth (m)	Plastic index %	Plastic limit %	Liquid limit %	Linear shrinkage %	Soil description
BH2	Proposed building	1.5	14	15	29	8.0	Sandy clay
BH2	Proposed building	3.0	25	18	43	11.0	Sandy clay
BH3	Proposed building	2.0	25	17	42	11.5	Sandy clay
BH5	Proposed building	1.0	22	15	37	10.5	Sandy clay
BH6	Proposed building	2.5	25	16	41	11.0	Sandy clay
BH7	Proposed building	0.5	23	15	38	10.5	Sandy clay

7.4 Dynamic cone penetrometer (DCP) tests

The DCP results indicate the soil consistency of the natural material was soft to 0.1m and firm to hard with depth. DCP refusal was encountered within the natural subsoil material and the test discontinued. The shear strength of the natural soil was estimated using drilling resistance (Table 3).

The DCP results at the testing locations indicate:

- The consistency of the natural material at a depth from 0.1 to 0.7m in borehole locations of BH2, BH5, BH6 and BH7 was firm to hard with estimated shear strength of 75kPa to 200kPa. DCP refusal was encountered from depths of 0.7m,

Table 3. DCP, consistency and shear strength results

Sampling location (Figure 2)	Proposed location (Figure 2)	Depth (m)	Soil type	Number of blows (N)	Consistency	Estimated shear strength (kPa)
BH2	New building	0.4	Sand clay	20	Hard	200
BH5	New building	0.4	Sand clay	20	Hard	200
BH6	New building	0.4	Sand clay	20	Hard	200
BH7	New building	0.6	Sand clay	20	Hard	50

7.5 Soil aggressiveness

No obvious signs of salinity were observed on the site surface or within the subsoil. The laboratory results indicate all the soil samples collected were non-saline and less than 4dS/m (Table 4).

The pH of the soil sample tested was near neutral (Table 4).

The site is not located in a mapped acid sulphate soil prone area.

Table 4. pH and electrical conductivity analysis results and salinity rating

Sampling location (Figure 2)	Sample depth (m)	pH	Electrical conductivity of a saturated extract (dS/m)	Salinity rating
BH2	0.5	7.7	0.3	Non-saline
BH6	1.0	7.8	0.2	Non-saline

7.6 Groundwater

No wet soil or groundwater indicators were encountered at the borehole locations on day of inspection.

8. Recommendations

8.1 Foundations

8.1.1 Soil reactivity

An estimation of design surface movement (Ys) of the natural soil was determined from the shrink swell index (AS7289.7.1.1-2011), soil index tests and soil profile identification as recommended in AS 2870.

The soils on the site had a moderate liquid limit, linear shrinkage and plastic limit. The site has a site classification of **Class H1-D** (Highly reactivity with deep seated movement). The natural soils have a maximum surface movement (Ys) of 40-45mm.

8.1.2 Exposure classification

Soil saturated extract electrical conductivity (EC_e) was determined to be <4dS/m in the soil samples tested. Soil pH was near neutral for the soil samples analysed. Exposure classification for concrete is A1. Minimum design characteristic strength for concrete is 20MPa and minimum curing requirement is continuous curing for at least 3 days (Appendix 4). Minimum reinforcement cover for concrete in soils is 40mm (Appendix 4).

8.1.3 Shear strength

The shear strength of the natural soil was estimated by drilling resistance and DCP tests adjacent to BH2, 5, 6 and 7. The shear strength was 75kPa to >200kPa.

8.1.4 Footing design parameters

The development will have an impact on underlying soils and would need to take into account of potential settlement and consolidation of up to 20mm.

Footings are not recommended to be founded in fill material. Footings should be founded into natural soil or fill compacted in layers less than 200mm and a minimum standard compaction density ratio of 98%.

8.1.5 Shallow footings

A summary of shallow footing parameters in natural soil is outlined in Table 5.

Table 5. Expected allowable bearing capacity for shallow footing 0.5m in natural soil

Founding stratum (0.5m depth)	Bulk unit weight (γ) kN/m^3	Soil friction angle ($\emptyset$) degrees	Cohesion (*c*) KPa	Allowable bearing capacity[a] kPa
Firm silty clay (natural soil)	16	20	10	100
Compacted fill	17	20	15	100

[a] strip footing minimum 0.5m embedment and less than 1.2m wide

8.1.6 Deep footings

Pile foundations shall be designed in accordance with and AS 2159. Pile type foundations should be founded below 1.0m depth and designed using the parameters in Table 6 for the new building. Pile type foundations should be founded at a level greater than 4 pile diameters (L/D>4) below existing ground levels. Lateral restraint from the soils in the top 0.6m should be ignored in design calculation due to possible excavation or disturbance.

A summary of footing parameters is outlined in Table 6.

Table 6. Soil parameter for engineering design for deep footings

		Geotechnical design parameters									
Material (natural soil)	**Depth (m)**	**γ kN/m³**	**C*u* kPa**	**Ø deg**	**E_s MPa**		**c kPa**	**Ultimate shaft adhesion kPa**	**Allowable shaft adhesion kPa**	**Ultimate bearing capacity kPa**	**Allowable bearing capacity kPa**
					E_{ss}	**E_{sl}**					
Firm clay	1.0	17.0	100	22.0	30	15	10	-	-	450	150
Stiff clay	2.0	17.0	150	22.0	30	15	10	75	25	750	250
Stiff clay	3.0	18.5	200	25.0	30	18	5	105	35	1050	350
Engineered compacted fill	-	17.0	100	20	20	10	15	30	10	300	100

γ - Bulk unit weight, Cu - undrained shear strength, Ø – soil friction angle, c – Cohesion
E_s – Young's modulus (E_{ss} short term, Esl long term)

Pile foundation allowable bearing capacity was determined in accordance with AS 2159 with a geotechnical reduction factor of Φ_g = 0.33. All foundations and piers should be inspected by a suitably qualified person to confirm geotechnical properties.

8.2 Earthworks

8.2.1 Excavations

The subsoils on the site are firm to hard and are expected to be excavated with an excavator and tined bucket. Granite float and outcrop occurs upslope of the investigation area and if encountered may require ripping.

8.2.2 Filling

Subsoils with high moisture content on the site are not recommended for reuse as fill.

Fill material should be compacted close to optimum moisture content in layers less than 200mm and a minimum standard compaction density ratio of 98% in accordance with AS3798.

Site inspections by a suitably qualified person are recommended during and after earthworks to confirm strata and subsurface conditions.

9. Pavement design

9.1 Subgrade preparation

Subgrade preparation in the pavement areas should include:

- Uncompacted loose fill is not suitable for use as subgrade or foundation. Compacted fill will require passing a proof roll prior to use as subgrade.
- Topsoil, vegetation, soft soil, wet material, debris and other foreign matter should be removed from the location of the proposed development.
- Stabilastion of the subgrade if required with an additive such as 3% lime to 300mm depth.
- Adjust the in-situ moisture of the subgrade to close to optimum moisture content.

- The exposed subgrade should be compacted to 98% of the dry density ratio. The exposed compacted surface should be rolled with a minimum 12 tonne roller to detect soft spots.

- Any soft, weak or saturated material should be removed and replaced by suitable fill material and compacted in layers less than 200mm close to optimum moisture content and to within 98% of the dry density ratio.

- All service trenches, select fill and other excavations should be backfilled with suitable material and compacted in layers less than 200mm close to optimum moisture content and to within 98% of the dry density ratio.

- Adequate drainage will be required to ensure water does not migrate into the subgrade layer.

9.2 Subgrade strength

The CBR samples were collected from natural soil. The samples collected had low CBR of 2.0%. The design subgrade is a CBR of 2.0%. The subgrade is not expansive. Stabilisation of the subgrade with an additive such as 3% lime to 300mm will increase the CBR value.

9.3 Pavement thickness

Pavements, based on information contained within the project brief, are expected to contain minimal heavy vehicle movement.

The design CBR strength of the fill material and natural soil in the pavement areas is 2.0%. The design CBR strength is based on the limiting factor from the CBR results. An indicative stabilisation CBR value of 5% was used.

The pavement parameters for flexible pavement are outlined in Table 7 and rigid pavement outlined in Table 8.

9.4 Design traffic

Flexible pavement traffic design is $8x10^4$ ESA which is local access with buses. Rigid pavement traffic design is $8x10^4$ HVAG.

Table 7. Pavement parameters for design traffic of **$8x10^4$ ESA**

Pavement parameter	**Natural subgrade (CBR 2.0%)**	**Natural subgrade (stabilised subgrade with indicative CBR value of 5.0%**
Surface layer	Sealed pavement: • AC wearing layer minimum 50mm	Sealed pavement: • AC wearing layer minimum 50mm
Base	• 150mm granular material such as DGB20 or equivalent • The base material shall be compacted in layers with moisture content at time of compaction to be 60% - 90% optimum moisture content (OMC).	• 100mm granular material such as DGB20 or equivalent
Sub-base	• 300mm granular material such as DGS40 or equivalent • The subbase material shall be compacted in layers with moisture content at time of compaction to be 60% - 90% optimum moisture content (OMC). Each layer shall pass a proof roll.	• 200mm granular material such as DGS40 or equivalent
Total granular material	450mm	300mm
Design subgrade CBR	• Natural subgrade CBR 2.0%	• Stabilised subgrade CBR 5.0%

Table 8. Rigid pavement parameters for traffic design of **$8x10^4$ HVAG**

Pavement parameter	Natural subgrade (CBR 2.0%)
Concrete base	Sealed pavement: • 160mm thickness jointed reinforced
Subbase	• 300mm crushed rock / DGS40 or equivalent • The subbase material shall be compacted in layers with moisture content at time of compaction to be 60% - 90% optimum moisture content (OMC). Each layer shall pass a proof roll.
Design subgrade CBR	• Natural subgrade CBR 2.0% • The subgrade material shall be compacted with moisture content at time of compaction to be 60% - 90% optimum moisture content (OMC). Each layer shall pass a proof roll. • Uncompacted or loose fill is not suitable for use as subgrade or foundation. Compacted fill will require passing a proof roll prior to use as subgrade.

Rigid pavement design is based on:

- Load safety factor (LSF) of 1.05
- Provision of concrete shoulders

9.6 Pavement material

Pavement materials shall be in accordance with council construction guidelines.

9.7 Surface water and groundwater mitigation

Drainage may be recommended to divert surface and groundwater from upslope around the buildings and pavement areas.

9.8 Geotechnical testing

Site inspections by a suitably qualified person are recommended during and after earthworks to confirm strata and subsurface conditions.

Foundations and pavement layers should be inspected by a suitably qualified person at the time of excavation and placement to confirm accordance with design parameters. The specification, execution and control testing of earthworks and site preparation should be undertaken according to AS3798.

Subgrade and subbase should be compacted to a minimum 98% of the dry density ratio and no deflection with a 12 tonne roller (proof roll).

Trenches should be compacted to a comparable condition as the surrounding ground.

Imported fill should be in accordance with AS3798.

10. Limitations of the investigation

The engineering logs describe subsurface conditions only at a specific borehole location and inferred boundaries between geotechnical units may vary.

Ground conditions can vary over relatively short distances and it may be necessary to carry out additional investigations for specific excavation and building sites. Once specific proposals are known a geotechnical review should be undertaken and if necessary additional investigations commissioned to provide the level of information required for assessing design parameters. A geotechnical engineer should be engaged to review subsurface condition during construction stages to confirm that subsurface conditions are consistent with design assumptions.

This report has been prepared for the use of the client to achieve the objectives given the client requirements and cost constraints. The level of confidence of the conclusion reached is governed by the scope of the investigation and the availability and quality of existing data. Where limitations or uncertainties are known, they are identified in the report. No liability can be accepted for failure to identify conditions or issues which arise in the future and which could not reasonably have been predicted using the scope of the investigation and the information obtained.

The investigation identifies the actual subsurface conditions only at those points where samples are taken, when they are taken. Data derived through sampling and subsequent laboratory testing are interpreted by geologists, engineers or scientists who then render an opinion about overall subsurface conditions, the nature and extent of the investigation and its likely impact on the proposed buildings Actual conditions may differ from those inferred to exist, because no professional, no matter how well qualified, and no sub surface exploration program, no matter how comprehensive, can reveal what is hidden by earth, rock or time. The actual interface between materials may be far more gradual or abrupt than a report indicates. Actual conditions in areas not sampled may differ from predictions. It is thus import to understand the limitations of the investigation and recognise that Envirowest Consulting Pty Ltd are not responsible for these limitations.

11. References

AS 2870 (2011) *Residential Slabs and Footings - Construction* (Standards Australia: Homebush)

AS 3727 (1993) *Guide to residential pavements* (Standards Australia: Homebush)

AS 3798 (2007) *Guidance on earthworks for commercial and residential buildings* (Standards Australia: Homebush)

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Landcom (2004) *Managing Urban Stormwater; Soils and Construction* (New South Wales Government)

Meyerhof GG, (1976) *Bearing Capacity and Settlement of Pile Foundations* (American Society of Civil Engineers)

Terzaghi K, and Peck K B, (1967) *Soil Mechanics in Engineering Practice (*New York: John Wiley & Sons, Inc.)

North

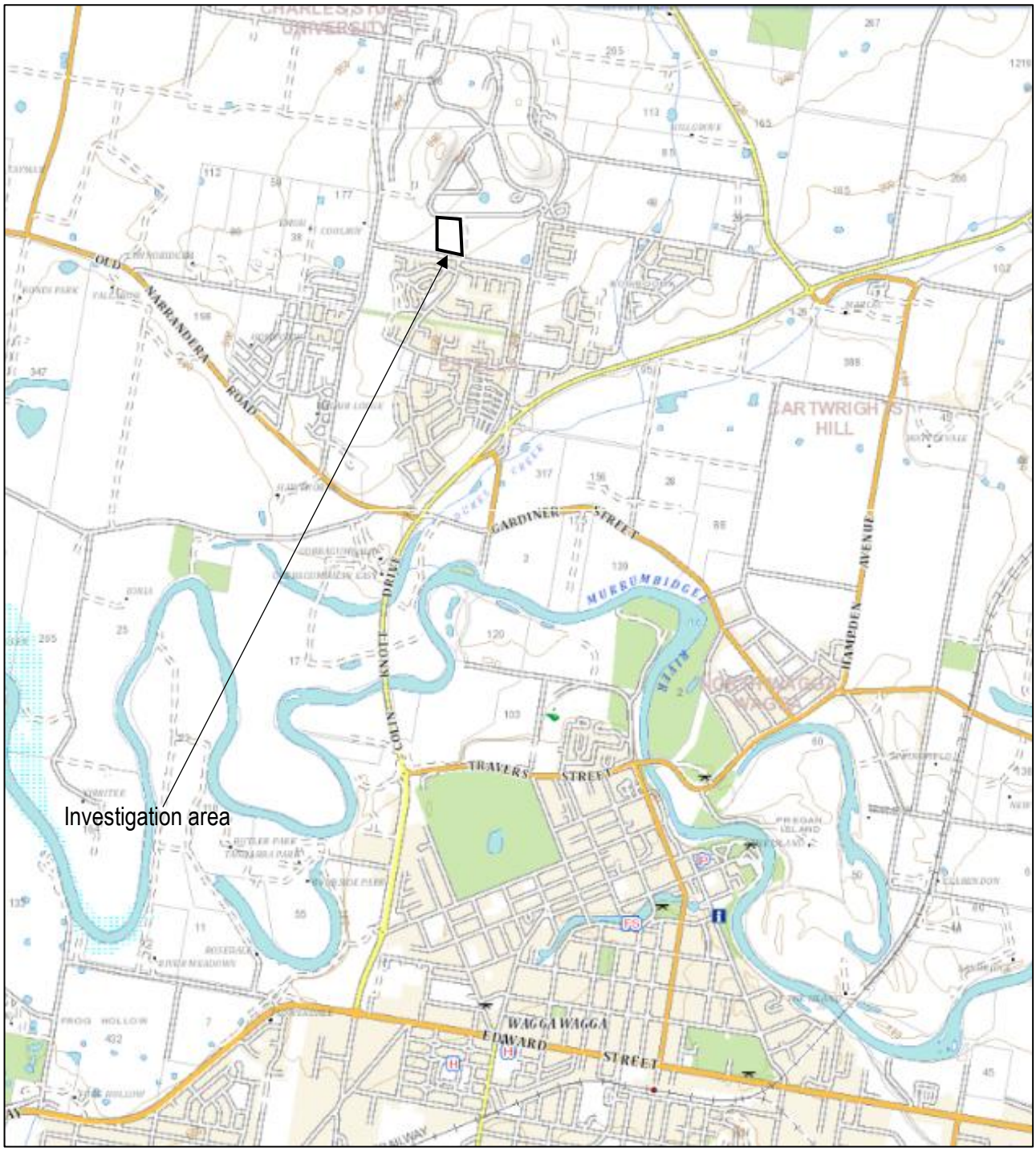
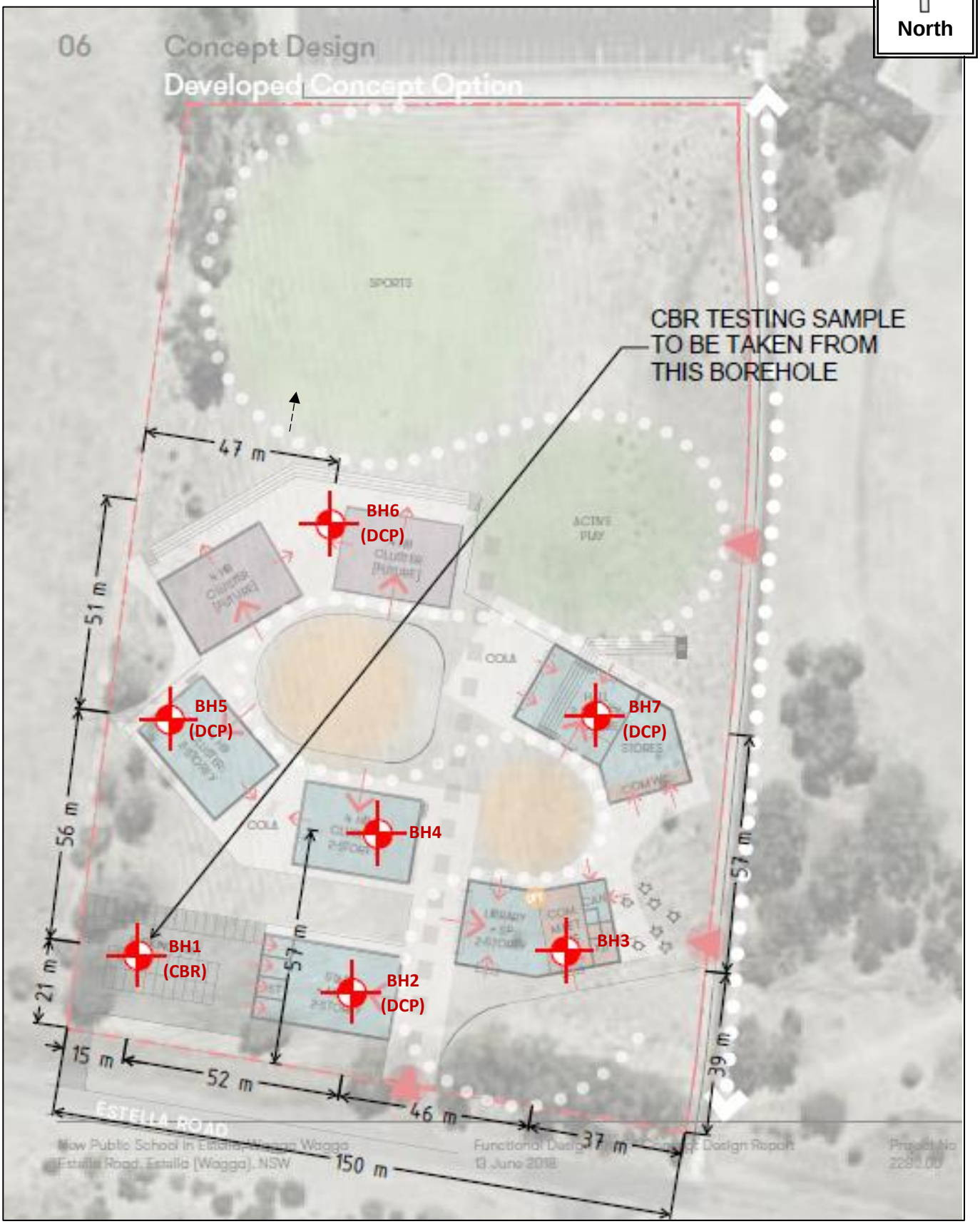


Figure 1. Site locality		
Lot 1 DP1253855, Estella Road, Estella NSW		
	Envirowest Consulting Pty Ltd	
Job: R9930g	Drawn by: DL	Date: 14/8/2018



Legend

⊗ **BH6** Borehole/DCP/CBR testing locations

Slope

Figure 2. Borehole locations		
Lot 1 DP1253855, Estella Road, Estella NSW		
	Envirowest Consulting Pty Ltd	
Job: R9930g	Drawn by: Northrop	Date: 14/8/2018

Figure 3. Aerial photograph

Lot 1 DP1253855, Estella Road, Estella NSW

Envirowest Consulting Pty Ltd

Job: R9930g	Drawn by: DL	Date: 14/8/2018

Appendix 1.

Bore Log Sheet

Job: R9930g Client: Hayball Site: Lot 1 DP1253855 Estella Road, Estella NSW	Borehole No: 1 Location: Proposed carpark	Sampling method: Geoprobe auger drill Logged by: DL Date: 20/07/2018

Depth (m)	Graphic log	DESCRIPTION. Soil type/rock, grain size, structure, colour, minor components	Unified symbol	Samples	Moisture	Consistency	Density	Plasticity	Rock description	DCP (blows /10cm)
		SILTY SAND, brown	SM		M	F	M	L	-	-
0.5		SANDY CLAY, brown red	CI	CBR 501	D	F	M	M	-	-
1.0		Trace fine gravel								
1.5										
2.0		End of hole at investigation depth								
2.5										
3.0										
3.5										
4.0										
4.5										

Slope/nature of surface:0-2% South
Ground water: Nil
Soil salinity: No evidence observed

Remarks (fill, odour, root holes): Nil

Samples	**Moisture**	**Consistency**	**Density**	**Plasticity**	**Rock strength**
U - undisturbed *D* - disturbed SPT-standard penetrometer test CBR-California Bearing Ratio DCP-Dynamic cone penetrometer	*D* - Dry *M* - Moist, can be moulded *W* - Wet, free water on hands *Wp* - plastic limit *Wl* - liquid limit	Shear strength (kPa) *VS* - very soft, *S* – soft *F* – firm *St* – stiff *VSt* - very stiff *H* – hard	*VL* - very loose *L* - loose *M* - medium *D* - dense *VD* - very dense	*NP* - non plastic *T* – trace *VL* – very low *L* – low *M* – medium *H* – high *VH* – very high	Point load (mPa) *EL* – extremely low (<0.03) *VL* – very low (<0.1) *L* – low (<0.3) *M* – medium (<1.0) *H* – high (<3.0) *VH* – very high (<10) *EH* – extremely high (>10)

Bore Log Sheet

Job: R9930g Client: Hayball Site: Lot 1 DP1253855 Estella Road, Estella NSW	Borehole No: 2 Location: Proposed building	Sampling method: Geoprobe auger drill Logged by: DL Date: 20/07/2018

Depth (m)	Graphic log	DESCRIPTION. Soil type/rock, grain size, structure, colour, minor components	Unified symbol	Samples	Moisture	Consistency	Density	Plasticity	Rock description	DCP (blows /10cm)
		SILTY SAND, brown	SM		D	F	M	L	-	3 9
0.5		SANDY CLAY, dark red	Cl		M	St	M	M	-	20 20+
1.0		Trace fine gravel								
1.5				D						
2.0		SANDY CLAY, light brown with weathered rock	Cl		M	H	M	M	XW	-
2.5		Increasing sand and weathered rock								
3.0				D						
3.5		End of hole at investigation depth								
4.0										
4.5										

Slope/nature of surface: 0-1% South
Ground water: Nil
Soil salinity: No evidence observed

Remarks (fill, odour, root holes): Nil

Samples	**Moisture**	**Consistency**	**Density**	**Plasticity**	**Rock strength**
U - undisturbed *D* - disturbed SPT-standard penetrometer test CBR-California Bearing Ratio DCP-Dynamic cone penetrometer	*D* - Dry *M* - Moist, can be moulded *W* - Wet, free water on hands *Wp* - plastic limit *Wl* - liquid limit	Shear strength (kPa) *VS* - very soft, *S* – soft *F* – firm *St* – stiff *VSt* - very stiff *H* – hard	*VL* - very loose *L* - loose *M* - medium *D* - dense *VD* - very dense	*NP* - non plastic *T* – trace *VL* – very low *L* – low *M* – medium *H* – high *VH* – very high	Point load (mPa) *EL* – extremely low (<0.03) *VL* – very low (<0.1) *L* – low (<0.3) *M* – medium (<1.0) *H* – high (<3.0) *VH* – very high (<10) *EH* – extremely high (>10)

Bore Log Sheet

Job: R9930g Client: Hayball Site: Lot 1 DP1253855 Estella Road, Estella NSW	Borehole No: 3 Location: Proposed building	Sampling method: Geoprobe auger drill Logged by: DL Date: 20/07/2018

Depth (m)	Graphic log	DESCRIPTION. Soil type/rock, grain size, structure, colour, minor components	Unified symbol	Samples	Moisture	Consistency	Density	Plasticity	Rock description	DCP (blows /10cm)
		SILTY SAND, brown	SM		D	F	M	L	-	-
0.5		SANDY CLAY, brown red	CI		M	F	M	M	-	-
1.0		Increasing fine gravel								
1.5										
2.0		SANDY CLAY, yellow brown with increasing weathered rock	CI	D	M	VSt	M	M	XW	-
2.5										
3.0										
		End of hole at investigation depth								
3.5										
4.0										
4.5										

Slope/nature of surface: 0-1%
Ground water: Nil
Soil salinity: No evidence observed

Remarks (fill, odour, root holes): Nil

Samples	**Moisture**	**Consistency**	**Density**	**Plasticity**	**Rock strength**
U - undisturbed *D* - disturbed SPT-standard penetrometer test CBR-California Bearing Ratio DCP-Dynamic cone penetrometer	*D* - Dry *M* - Moist, can be moulded *W* - Wet, free water on hands *Wp* - plastic limit *Wl* - liquid limit	Shear strength (kPa) *VS* - very soft, *S* – soft *F* – firm *St* – stiff *VSt* - very stiff *H* – hard	*VL* - very loose *L* - loose *M* - medium *D* - dense *VD* - very dense	*NP* - non plastic *T* – trace *VL* – very low *L* – low *M* – medium *H* – high *VH* – very high	Point load (mPa) *EL* – extremely low (<0.03) *VL* – very low (<0.1) *L* – low (<0.3) *M* – medium (<1.0) *H* – high (<3.0) *VH* – very high (<10) *EH* – extremely high (>10)

Bore Log Sheet

Job: R9930g Client: Hayball Site: Lot 1 DP1253855 Estella Road, Estella NSW		Borehole No: 4 Location: Proposed building	Sampling method: Geoprobe auger drill Logged by: DL Date: 20/07/2018

Depth (m)	Graphic log	DESCRIPTION. Soil type/rock, grain size, structure, colour, minor components	Unified symbol	Samples	Moisture	Consistency	Density	Plasticity	Rock description	DCP (blows /10cm)
		SILTY SAND, brown grey	SM		D	F	M	L	-	-
0.5		SANDY CLAY, brown red with trace fine gravel	CI		M	F	M	M	-	-
1.0										
1.5										
		SANDY CLAY, yellow brown with increasing gravel	CI		D	VSt	M	M	-	-
2.0										
2.5										
3.0										
		End of hole at investigation depth								
3.5										
4.0										
4.5										

Slope/nature of surface: 0-1% South
Ground water: Nil
Soil salinity: No evidence observed

Remarks (fill, odour, root holes): Nil

Samples	**Moisture**	**Consistency**	**Density**	**Plasticity**	**Rock strength**
U - undisturbed *D* - disturbed SPT-standard penetrometer test CBR-California Bearing Ratio DCP-Dynamic cone penetrometer	*D* - Dry *M* - Moist, can be moulded *W* - Wet, free water on hands *Wp* - plastic limit *Wl* - liquid limit	Shear strength (kPa) *VS* - very soft, *S* – soft *F* – firm *St* – stiff *VSt* - very stiff *H* – hard	*VL* - very loose *L* - loose *M* - medium *D* - dense *VD* - very dense	*NP* - non plastic *T* – trace *VL* – very low *L* – low *M* – medium *H* – high *VH* – very high	Point load (mPa) *EL* – extremely low (<0.03) *VL* – very low (<0.1) *L* – low (<0.3) *M* – medium (<1.0) *H* – high (<3.0) *VH* – very high (<10) *EH* – extremely high (>10)

Bore Log Sheet

Job: R9930g Client: Hayball Site: Lot 1 DP1253855 Estella Road, Estella NSW	Borehole No: 5 Location: Proposed building	Sampling method: Geoprobe auger drill Logged by: DL Date: 16/07/2018

Depth (m)	Graphic log	DESCRIPTION. Soil type/rock, grain size, structure, colour, minor components	Unified symbol	Samples	Moisture	Consistency	Density	Plasticity	Rock description	DCP (blows /10cm)
		SILTY SAND, grey brown	SM		D	F	M	L	-	2 3 8
0.5		SAND CLAY, brown red with gravel	CI	D	M	VSt	M	M	-	20 20+
1.0										
1.5										
2.0		SANDY CLAY, yellow brown with increasing weathered rock fragments	CI		D	VSt	M	M	XW	-
2.5										
3.0										
3.5		End of hole at investigation depth								
4.0										
4.5										

Slope/nature of surface: 0-2% South
Ground water: Nil
Soil salinity: No evidence observed

Remarks (fill, odour, root holes): Nil

Samples	**Moisture**	**Consistency**	**Density**	**Plasticity**	**Rock strength**
U - undisturbed *D* - disturbed SPT-standard penetrometer test CBR-California Bearing Ratio DCP-Dynamic cone penetrometer	*D* - Dry *M* - Moist, can be moulded *W* - Wet, free water on hands *Wp* - plastic limit *Wl* - liquid limit	Shear strength (kPa) *VS* - very soft, *S* – soft *F* – firm *St* – stiff *VSt* - very stiff *H* – hard	*VL* - very loose *L* - loose *M* - medium *D* - dense *VD* - very dense	*NP* - non plastic *T* – trace *VL* – very low *L* – low *M* – medium *H* – high *VH* – very high	Point load (mPa) *EL* – extremely low (<0.03) *VL* – very low (<0.1) *L* – low (<0.3) *M* – medium (<1.0) *H* – high (<3.0) *VH* – very high (<10) *EH* – extremely high (>10)

Bore Log Sheet

Job: R9930g Client: Hayball Site: Lot 1 DP1253855 Estella Road, Estella NSW	Borehole No: 6 Location: Proposed building	Sampling method: Geoprobe auger drill Logged by: DL Date: 16/07/2018

Depth (m)	Graphic log	DESCRIPTION. Soil type/rock, grain size, structure, colour, minor components	Unified symbol	Samples	Moisture	Consistency	Density	Plasticity	Rock description	DCP (blows /10cm)
		SILTY SAND, brown/grey	SM		D	F	M	L	-	2 3 13
0.5		SANDY CLAY, brown red with gravel	CI		M	VSt	M	M	-	20 20+
1.0										
1.5										
2.0		SANDY CLAY, dark red brown with weathered gravel	CI		M	VSt	M	M	XW	-
2.5				D						
3.0										
		End of hole at investigation depth								
3.5										
4.0										
4.5										

Slope/nature of surface: 0-1% South
Ground water: Nil
Soil salinity: No evidence observed

Remarks (fill, odour, root holes): Nil

Samples	**Moisture**	**Consistency**	**Density**	**Plasticity**	**Rock strength**
U - undisturbed *D* - disturbed SPT-standard penetrometer test CBR-California Bearing Ratio DCP-Dynamic cone penetrometer	*D* - Dry *M* - Moist, can be moulded *W* - Wet, free water on hands *Wp* - plastic limit *Wl* - liquid limit	Shear strength (kPa) *VS* - very soft, *S* – soft *F* – firm *St* – stiff *VSt* - very stiff *H* – hard	*VL* - very loose *L* - loose *M* - medium *D* - dense *VD* - very dense	*NP* - non plastic *T* – trace *VL* – very low *L* – low *M* – medium *H* – high *VH* – very high	Point load (mPa) *EL* – extremely low (<0.03) *VL* – very low (<0.1) *L* – low (<0.3) *M* – medium (<1.0) *H* – high (<3.0) *VH* – very high (<10) *EH* – extremely high (>10)

Bore Log Sheet

Job: R9930g Client: Hayball Site: Lot 1 DP1253855 Estella Road, Estella NSW	Borehole No: 7 Location: Proposed building	Sampling method: Geoprobe auger drill Logged by: DL Date: 16/07/2018

Depth (m)	Graphic log	DESCRIPTION. Soil type/rock, grain size, structure, colour, minor components	Unified symbol	Samples	Moisture	Consistency	Density	Plasticity	Rock description	DCP (blows /10cm)
		SILTY SAND, brown grey	SM		D	F	M	M	-	NA NA NA
0.5		SANDY CLAY, brown red with trace gravel	Cl		M	St VSt	M	M	-	NA NA 20+
1.0										
1.5										
2.0		SANDY CLAY, yellow brown with increasing gravel	Cl		D	VSt	M	M	-	-
2.5										
3.0										
3.5		End of hole at investigation depth								
4.0										
4.5										

Slope/nature of surface: 0-2% South
Ground water: Nil
Soil salinity: No evidence observed

Remarks (fill, odour, root holes): Nil

Samples	**Moisture**	**Consistency**	**Density**	**Plasticity**	**Rock strength**
U - undisturbed *D* - disturbed SPT-standard penetrometer test CBR-California Bearing Ratio DCP-Dynamic cone penetrometer	*D* - Dry *M* - Moist, can be moulded *W* - Wet, free water on hands *Wp* - plastic limit *Wl* - liquid limit	Shear strength (kPa) *VS* - very soft, *S* – soft *F* – firm *St* – stiff *VSt* - very stiff *H* – hard	*VL* - very loose *L* - loose *M* - medium *D* - dense *VD* - very dense	*NP* - non plastic *T* – trace *VL* – very low *L* – low *M* – medium *H* – high *VH* – very high	Point load (mPa) *EL* – extremely low (<0.03) *VL* – very low (<0.1) *L* – low (<0.3) *M* – medium (<1.0) *H* – high (<3.0) *VH* – very high (<10) *EH* – extremely high (>10)

Appendix 2. Soil index properties

Envirowest Consulting Pty Ltd ABN 18 103 955 246 trading as

Envirowest Testing Services

• 9 Cameron Place, PO Box 8158, Orange NSW 2800 • Tel (02) 6361 4954 •

• Email admin@envirowest.net.au • Web www.envirowest.net.au •

Environmental
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Rec 51002 Soil Index Properties - Test Report

Client	Hayball	Report no.	R9930g
Address	11-17 Buckingham Street Surry Hills NSW 2010	Site location	Lot 1 DP1253855 Estella Road, Estella NSW

Borehole		BH2	BH2	BH3
Depth (mm)		1500	3000	2000
Tests	***Methods***			
Liquid Limit (%)	AS 1289.3.1.2	40	29	42
Plastic limit (%)	AS 1289.3.2.1	16	15	17
Plasticity index (%)	AS 1289.3.3.1	24	14	25
Linear Shrinkage (%)	AS 1289.3.4.1	12.0	8.0	11.5
-characteristics (curling or crumbling)		curling	curling	curling
Field Moisture (%)	AS 1289.2.1.1	-	-	-
I_{SS}	AS 1289.7.1	-	-	-
USCS	AS 1726 *	Cl	Cl	Cl
Description	AS 1726 *	SANDY CLAY	SANDY CLAY	SANDY CLAY
Colour	AS 1726 *	Reddish brown	Light brown	Yellowish brown

Disturbed samples

Sample preparation:	-drying	-	Air	x	Oven	-	Natural state
	-sieving	-	Wet			x	Dry
	-material	-	Pass 2.36 mm			x	Pass 425 µm
Linear shrinkage:	-mould	x	250 mm			-	125 mm
Liquid Limit:	-method	-	Standard			x	One Point

Undisturbed samples

Inert inclusions in specimen	-	%				
Soil crumbling during shrinkage affecting mass	-	Yes	-	No		
Extent of cracking of sample	-	Major	-	Minor	-	Nil

Samples tested as received

* Not NATA test

Test authorised by:

G. Madafiglio PhD
Date: 14/08/2018

NATA

Accredited for compliance with ISO/IEC 17025

Accred. No. 15372

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Rec 51002 Soil Index Properties - Test Report

Client	Hayball	Report no.	R9930g
Address	11-17 Buckingham Street Surry Hills NSW 2010	Site location	Lot 1 DP1253855 Estella Road, Estella NSW

Borehole		BH5	BH6	BH7
Depth (mm)		1000	2500	500
Tests	***Methods***			
Liquid Limit (%)	AS 1289.3.1.2	37	41	38
Plastic limit (%)	AS 1289.3.2.1	15	16	15
Plasticity index (%)	AS 1289.3.3.1	22	25	23
Linear Shrinkage (%)	AS 1289.3.4.1	10.5	11.0	10.5
-characteristics (curling or crumbling)		curling	curling	curling
Field Moisture (%)	AS 1289.2.1.1	-	-	-
I_{SS}	AS 1289.7.1	-	-	-
USCS	AS 1726 *	CI	CI	CI
Description	AS 1726 *	SANDY CLAY	SANDY CLAY	SANDY CLAY
Colour	AS 1726 *	Brown red	Dark red brown	Brown red

Disturbed samples

Sample preparation:	-drying	-	Air	x	Oven	-	Natural state
	-sieving	-	Wet			x	Dry
	-material	-	Pass 2.36 mm			x	Pass 425 µm
Linear shrinkage:	-mould	x	250 mm			-	125 mm
Liquid Limit:	-method	-	Standard			x	One Point

NP* = non-plastic

Undisturbed samples

Inert inclusions in specimen	-	%				
Soil crumbling during shrinkage affecting mass	-	Yes	-	No		
Extent of cracking of sample	-	Major	-	Minor	-	Nil

Samples tested as received
* Not NATA test

Test authorised by:

G. Madafiglio PhD
Date: 14/08/2018

NATA

Accredited for compliance with ISO/IEC 17025

Accred. No. 15372

Appendix 3. Dynamic cone penetrometer (DCP) report

Envirowest Consulting Pty Ltd ABN 18 103 955 246 trading as
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Dynamic cone penetrometer - Test report

Client	Hayball	Report no.	R93930g
Address	11-17 Buckingham Street Surry Hills NSW 2010	Site location	Lot 1 DP1253855 Estella Road, Estella NSW

Test information: Date 20/07/2018

Test location	**BH2**	**BH5**	**BH6**	**BH7**
Commencement of penetration	0mm	0mm	0mm	600mm
Soil description	Silty sand, sandy clay	Silty sand, sandy clay	Silty sand, sandy clay	Silty sand, sandy clay
Soil Moisture	Moist to dry	Moist to dry	Moist to dry	Moist to dry
Groundwater	-	-	-	-
Results				
Depth (mm)	Penetration resistance (number of blows)	Penetration resistance (number of blows)	Penetration resistance (number of blows)	Penetration resistance (number of blows)
0-100	3	2	2	NA
100-200	9	3	3	NA
200-300	20	8	13	NA
300-400	20+	20	20	NA
400-500	-	20+	20+	NA
500-600	-	-	-	NA
600-700	-	-	-	20+
700-800	-	-	-	-
800-900	-	-	-	-
900-1000	-	-	-	-
1000-1100	-	-	-	-
1100-1200	-	-	-	-
1200-1300	-	-	-	-
1300-1400	-	-	-	-
1400-1500	-		-	-
1500-1600	-	-	-	-
1600-1700	-	-	-	-
1700-1800	-	-	-	-
1800-1900	-	-	-	-
1900-2000	-	-	-	-
2000-2100	-	-	-	-

Method AS1289.6.3.2-1997 Method of testing soil for engineering purposes Method 6.3.2: Soil strength and consolidation tests - Determination of the penetration resistance of a – 9 kg dynamic cone penetrometer test >20 blows / 100mm indicates test discontinued due to refusal

Test authorised by:
G. Madafiglio PhD
Date: 14/08/2018

Appendix 4. Aggressive soils, extract from Australian Standards, *AS 2870-2011*, 2011

Exposure classification for concrete in saline soils

Saturated extract electrical conductivity (EC_e), *dS/m*	Exposure classification
<4	A1
4-8	A2
8-16	B1
>16	B2

Notes:

1. Guidance on concrete in saline soils can be found in CCAA T56
2. Exposure classifications are from AS 3600
3. The currently accepted method of determining the salinity level of the soil is by measuring the extract electrical conductivity (*EC*) of a soil and water mixture in deciSiemens per metre (dS/m) and using conversion factors that allow for the soil texture, to determine the saturated extract electrical conductivity (EC_e)
4. The division between a non-saline and saline soil is generally regarded as an EC_e value of 4dS/m, therefore no increase in the minimum concrete strength is required below this value

Exposure classification for concrete in sulphate soils

Exposure conditions			Exposure classification	
Sulphates (expressed as SO_4)*		pH	Soil conditions A**	Soil conditions B†
In soil (ppm)	In groundwater (ppm)			
<5,000	<1,000	>5.5	A2	A1
5,000-10,000	1,000-3,000	4.5-5.5	B1	A2
10,000-20,000	3,000-10,000	4-4.5	B2	B1
>20,000	>10,000	<4	C2	B2

* Approximately 100ppm SO_4 = 80ppm SO_3

** Soil conditions A – high permeability soils (e.g. sands and gravels) that are in groundwater

† Soil conditions B – low permeability soils (e.g. silts and clays) or all soils above groundwater

Minimum design characteristic strength (f_c') and curing requirements for concrete

Exposure classification	Minimum f_c' MPa	Minimum initial curing requirement
A1	20	Cure continuously for at least 3 days
A2	25	
B1	32	Cure continuously for at least 7 days
B2	40	
C1	≥50	
C2	≥50	

Minimum reinforcement cover for concrete

Exposure classification	Minimum cover in saline soils * mm	Minimum cover in sulfate soils ** (mm)
A1	See Clause 5.3.2	40
A2	45	50
B1	50	60
B2	55	65
C1	†	70
C2	†	85

* Where a damp-proofing membrane is installed, the minimum reinforcement cover in saline soils may be reduced to 30mm.

** Where a damp-proofing membrane is installed, the minimum reinforcement cover in sulfate soils may be reduced by 10mm.

† Saline soils have a maximum exposure classification of B2 as per Table 5.1.

Appendix 5. Important information about the report

Background

The intention of the Australian Standard 2870-1996, Residential slabs and footings, is to provide guidance in the design of slabs and footings of residential building on commonly encountered foundations. The standard is also considered to provide useful guidance for commercial and industrial buildings. This involves (1) site classification, (2) structural design and construction and (3) site maintenance after construction. The classification assessment in this report is the first step in providing a footing system for a building, which will have a low risk of inadequate performance (Appendix B AS2870-1996). Even significant cracking to widths of over 3 mm usually presents only aesthetic rather than structural problems. Some minor problems should be expected during settlement or in periods of drought.

Classification

AS2870-1996 establishes a classification system whereby reactive sites (unaffected by filling) are designated slightly, moderately, highly or extremely reactive based on the range of ground surface movements anticipated and which are likely to have a less than 5% chance of being exceeded in the design life of the structure. Where the foundation conditions at a site need to consider aspects in addition to, or other than soil reactivity, the site is classified P.

It is neither possible nor economical to design for the extreme conditions that could occur in the foundation if a site is not properly maintained. The recommended foundation maintenance is described below. Some minor cracking and movement will occur in a significant proportion of houses, especially on reactive clays.

The method of subsurface investigation has been described in the attached report and it usually involves one or more boreholes or test pits in each lot. It may also involve the inspection of exposures in road cuttings and trenches. In making the assessment there is a risk that variations which may occur between tests or exposure locations may not be detected. The number of test pit locations undertaken is a professional estimate to provide a description of the general soil profile at the site. No subsurface investigation, no matter how comprehensive, can reveal all details and anomalies. Small local variations such as deep topsoil, fill associated with local grubbing of tree stumps and previous trenches or pits may be undetected. If subsoil conditions encountered during the footing excavation are different from those described in the report, reclassification may be necessary. The site should be reassessed and may require revision of the classification and footing design.

Most sites are not level and often require cutting and filling to provide a level platform for construction. AS2870-1996 specifies the classification should be revised if (a) the depth of the cut exceeds 0.5m, or (b) the depth of compacted fill exceeds 0.4 m for clay or 0.8 m for sand.

Foundation maintenance

All soils are affected by water. Silts are weakened by water and some sands can settle if heavily watered, but most problems arise on clay foundations. Clays swell and shrink due to changes in moisture. Sands, silts and clays should be protected from becoming extremely wet. Sites classified as M, H or E shall be maintained at essentially stable moisture conditions and extremes of wetting and drying prevented. This requires attention to the following:

(a) Drainage of the site. The site shall be graded and drained so that water cannot pond against or near the house. The ground immediately adjacent to the house shall be graded to a uniform fall of 50mm minimum away from the house over the first metre. The sub floor space for houses with suspended floors shall be graded or drained to prevent ponding, where this may affect the performance of the footing system. The site drainage requirement shall be maintained for the economic life of the building.
(b) Limitation on gardens. The buildings shall not interfere with the drainage requirements or the sub floor ventilation and weep hole drainage systems. Garden beds adjacent to the house should be avoided. Care should be taken to avoid over watering of gardens close to the house footings.
c) Restrictions on trees and shrubs. Planting of trees and shrubs should be avoided near the foundations of a house on reactive sites as they can cause damage, even at substantial distances, due to the drying of the clay. To reduce, but not eliminate the possibility of damage, trees should be restricted to a distance of 1 times the mature tree height for Class H and M, and 1.5 times mature tree height for Class E. Where groups of trees are involved, distances should be increased. Removal of trees from the site can also cause similar problems.
(d) Repair of leaks. Leaks in plumbing, including storm water and sewage should be repaired promptly.

Class P sites

The presence of fill, compressible soils at depth or slope may influence footing performance and these need to be considered in foundation design.

Appendix 6. CBR laboratory report