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UTILA PTY LTD

Proposed Residential Subdivision at Lot 112 DP1073791 Lyons Road, North Bonville

Preliminary Groundwater Assessment

301015-01381 – 301015-01381-SS-REP-0001

17 May 2010

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UTILA PTY LTD
PROPOSED RESIDENTIAL SUBDIVISION AT LOT 112 DP1073791 LYONS ROAD, NORTH BONVILLE
PRELIMINARY GROUNDWATER ASSESSMENT

.

Disclaimer

PROJECT 301015-01381 - PROPOSED RESIDENTIAL SUBDIVISION AT LOT 112 DP1073791 LYONS ROAD, NORTH BONVILLE

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
A	Issued for internal review	L. Missen	P. Smith	N/A	24-Mar-10	N/A	
B	Issued for WSUD+client review	L. Missen	J. Fielding/ C. Moon	N/A	6-April-10		N/A
C	Issue to client	L. Missen	P. Smith	L. Missen	17-May-10		N/A

CONTENTS

1 INTRODUCTION

WorleyParsons Services Pty Ltd (WorleyParsons) was commissioned to undertake a baseline groundwater assessment at the site of the proposed subdivision, Lot 112 DP1073791, Lyons Road, North Bonville.

The purpose of the investigation was to enable preliminary design of stormwater management measures as well as to address project planning requirements relating to the groundwater. As part of the project application, the NSW Government Department of Planning has nominated The Director General's Environmental Assessment Requirements (DGRs) for the environmental assessment of the project application (refer NSW Government Department of Planning's letter for application No. 08_0080 dated 4 June 2008). Appended to this document were submissions from several government agencies. One of these submissions was prepared by NSW Government Department of Water & Energy which highlighted the need for the nature and profile of the groundwater regime at the site to be defined to enable an assessment of the potential for the proposed development to be adversely impact on this regime.

Further clarification was sought from NSW Government Department of Water & Energy (now the NSW Government Office of Water). Verbal discussions revealed that the major issue of concern was the potential for any Water Sensitive Urban Design (WSUD) that may be proposed as part of the development to "cut across" the water table. A subsequent request for written clarification (refer WorleyParsons email dated 28 September 2009 and NSW Government Office of Water letter response for planning application MP08-0080 dated 2 October 2009) clarified that the key outcome of the groundwater assessment would be to,

> '*ensure that the general water table across the site doesn't decline beyond normal seasonal fluctuations, to ensure that any groundwater dependent vegetation in the surrounding national park is not affected, particularly during dry seasons. ICWM and Water Sensitive Urban Design practices employed for the development should factor in the possible consequences of the groundwater regime*.'

This document presents the findings of this baseline groundwater assessment together with calculations and comments which have been used to inform the WSUD process. This report also contains comments on mitigation measures to minimise the potential for direct connectivity between the water table and the drainage system. The methodology for the assessment was developed in consultation with government Departmental representatives.

The WSUD has been carried out by WorleyParsons concurrently to this assessment and is presented in a separate report.

2 SCOPE OF WORK AND METHODOLOGY

In summary, work was carried out in several stages, as follows:

- Installation of four groundwater monitoring wells at the site;
- Groundwater elevation monitoring and sampling for physio-chemical testing;
- Development of groundwater profile;
- Determination of potential for groundwater / WSUD system connectivity and identification of associated mitigation measures;
- Present findings of the assessment in a report.

Further details of the methodology are provided in the following sections

2.1 Groundwater Well Installation and Near-Surface Hydraulic Conductivity Tests

Prior to groundwater well installation, a walkover inspection was carried out by WorleyParsons staff undertaking the WSUD so that wells could be installed in preferred location for WSUD features.

The local office of Coffey Geotechnics Pty Ltd (Coffey) was subcontracted to install, develop and monitor four groundwater wells at the site.

Prior to the fieldwork groundwater licences were obtained. Groundwater wells were installed (designated MW1 to MW4) to nominally 6m or prior refusal of the auger rig on rock or until groundwater inflows were observed, which resulted in wells between 4.1m and 7.6m depth. Pressure transducer / data loggers (PT/DLs) were then installed into three of the four wells (MW1 to MW3). Further details of the groundwater well installation are contained in the Coffey report (report reference GEOTCOFH02592AA-AB dated 15 December 2009) attached in Appendix 1. Locations of the groundwater monitoring wells are shown on the site contour plan on Figure 301015-01381-SS-IDX-0001.

The installation of groundwater monitoring wells was undertaken in the presence of an experienced environmental scientist from WorleyParsons. This environmental scientist also drilled shallow holes adjacent to each monitoring well location to nominally 1m depth and performed falling head hydraulic conductivity tests in each. The purpose of this testing was to provide a measure of the hydraulic conductivity of the near-surface soils for the purpose of assisting in WSUD.

Following the fieldwork, well locations were surveyed by Newnham Karl Weir & Partners Pty Ltd relative to Australian Height Datum, as well as their position determined relative the MGA coordinate system.

Groundwater well locations, as provided by the survey, are summarised in Table 1.

Table 1: Summary of well locations

Test Site ID	Elevation (m)	Depth of investigation (m)	Easting	Northing
MW1	5.464	7.4	506497.7	6641018.4
MW2	6.551	5.9	506551.0	6640758.3
MW3	7.331	7.1	506369.3	6640485.0
MW4	9.241	4.1	506543.1	6640444.9

2.2 Groundwater Monitoring Program

Information was collected from the PT/DLs dataloggers and the groundwater levels in the wells were manually measured at nominally fortnightly intervals from 18 September 2009 to 27 November 2009. For each well, Coffey used a calibrated water quality meter to measure the following physico-chemical water quality parameters:

- temperature
- pH
- turbidity
- electrical conductivity
- dissolved oxygen.

Further details of the groundwater monitoring program are contained in Coffey report contained in Appendix 1.

2.3 Data Analysis and Interpretation

Data and interpretation was carried out to enable an integrated water management strategy for the site that incorporates WSUD measures to be prepared.

Groundwater level data gathered was analysed together with rainfall data from a nearby rain gauge to develop a groundwater profile for the site. Analysis was carried out of the baseline groundwater conditions, specifically:

- current water table elevation
- groundwater flow directions
- inferred quality determined from the monitoring.

This was used to provide recommendations to inform the WSUD process and construction protocols that may need to be implemented to protect the groundwater system and prevent unsuitable discharges (ASS related) to nearby Bonville Creek. The potential for excavation for the development to intersect the water table and thereby lead to connectivity with drainage infrastructure (e.g. constructed wetlands and bio-retention swales) was also considered. Future sampling and monitoring requirements are provided in the following sections.

3 BACKGROUND INFORMATION

3.1 Previous Assessments

This investigation follows a preliminary geotechnical and acid sulfate soil (ASS) assessment at the site, as well as a Phase 1 environmental site assessment. These reports were provided for review and the information potentially relating to this groundwater assessment is summarised in the following sections.

3.1.1 Preliminary geotechnical and acid sulfate assessment

Coffey carried out a preliminary geotechnical and ASS assessment on the site (report titled Preliminary Geotechnical and Acid Sulphate Soil Assessment lot 112 DP1073791, Lyons Road, Sawtell NSW referenced GEOTCOFH0267AA-AC dated 24 February 2009).

During the field investigation for that investigation, a portion of land on the western boundary was being excavated for select fill and replaced with imported fill of unknown source which did not appear to be uniformly well compacted. It is understood that during site regrading that this fill will be removed from site, however if it is to remain then the soil should be tested to confirm that the fill does not contain leachable contamination that could impact on regional groundwater quality.

The ASS assessment identified material classified as Potentially Acid Sulphate Soils (PASS) in the south-west corner of the site. During construction, when the soil is exposed to the air, PASS can oxidise and produce sulphuric acid and result in acidic runoff, if the PASS soils are not stabilised. An ASS management plan should therefore be prepared for the construction phase to stabilise the PASS soils that have been exposed to oxygen, so that acidic run-off does not impact on regional groundwater.

Near-surface water seeps were also observed during this assessment. It was also reported that it appeared tree stumps have been removed and depressions remained on the site. Perched water may be encountered in near-surface soils and poorly compacted fill, such as where stumps have been removed or fill has not been uniformly well compacted as on the western portion of the site, immediately following rain events.

The geotechnical assessment found ground conditions at the site typically encountered up to a 1m thickness of silt or clay inferred to be alluvial or colluvial clay, overlying clay inferred to be residual and derived from the weathering of the underlying bedrock.

3.1.2 Phase 1 environmental site assessment

Coffey carried out a Phase 1 environmental site (report titled Phase 1 Environmental Site Assessment Lot 112 DP1073791, Lyons Road Sawtell, NSW referenced GEOTCOFH02467AA-AB dated 24 February 2009).

A site history review carried out as part of that assessment indicates that the site has always been undeveloped. Tomato crops were reported on the site in the 1970s, potato and banana plantations during the 1980s and the site used for cattle grazing since that time. At the time of the fieldwork there was a cattle yard on the western central side of the site and several small stockpiles of fill comprising building rubble over the northern portion of the site. Contaminant tests indicate that there were low levels of pesticides, but otherwise no other elevated contaminants present.

3.2 Geological Setting

Reference to the 1:250,000 scale map of Coffs Harbour indicates that the north-east, east, and south-west low lying are of the site is underlain by Quaternary age alluvium which typically comprises clay, silt, sand or gravel. Underlying this formation and outcropping over the remainder of the site is shown to be Carboniferous age Brooklana Formation siliceous argillite, slate or greywacke and, by inference, soils (clay to silt) derived from the weathering of the rock.

3.3 Rainfall and Weather Data

Daily weather records were obtained from the Bureau of Meteorology for the Coffs Harbour gauge. This gauge is based at Coffs Harbour Airport, 1km from the coast and 5m above sea level, which is a similar distance from the coast and elevation as the lower lying areas of this site. Rainfall was only recorded on 18 days during the monitoring period between 18 September 2009 and 27 November 2009. These rainfall events and the rainfall events in the two weeks prior are summarised in Table 2.

Table 2: Summary of rainfall events measured during the monitoring period

Month	Date	Rainfall (mm)	Month	Date	Rainfall (mm)
Sep-09	4	0.6	Oct-09 (continued)	19	10
	5	1.6		26	2.8
	8	1.8		27	141.8
	22	3		28	8.6
	23	2	Nov-09	5	0.4
Oct-09	3	1.4		6	96
	4	3.6		7	371
	5	14.8		8	4.8
	6	1.4		9	58
	11	11		14	17
	12	0.2		29	9.8

Source: Bureau of Meteorology 2010

Further details on monthly averages for rainfall are contained in the Coffey report in Appendix 1. In summary, the rainfall encountered through September was well below the average and the rainfall during October and November was well above the average monthly rainfall but in both of these months, the majority of this rainfall occurred during single events in each month, with 142mm recorded on 27 October and 360mm recorded on 7 November 2009. It is understood that the rainfall on 7 November is considered to be an approximately a 1 in 30 year event for this area.

4 ASSESSMENT FINDINGS

4.1 Site Description

Lot 112 DP1073791 is 38.78 hectares (ha) in area, although only about 25 ha has been cleared and was being used for grazing. The remainder of the site is bushland which was excluded from this assessment.

The site is generally undulating with an approximately 10m to 15m high saddle running north-west to south-east across the middle of the site.

On the north side of the saddle is a gently sloping gully. Runoff from most of the site drains towards a small creek on the north side of the site, except at the eastern end of the north side of the saddle where water drains to the north-east. A small dam is located on the north-east side of the site.

On the south side of the saddle there are two steeper gullies, one that drains to the south-western corner of the site and one that drains to the south-eastern corner of the site.

The site is bounded by vacant land and residential properties to the north, bushland to the east, south and west.

4.2 Falling Head Hydraulic Conductivity

Falling head hydraulic conductivity tests were performed in nominally 1m deep borehole drilled close to each monitoring well location.

The results of the tests are shown in Appendix 2 together with calculations to estimate the near-surface hydraulic conductivity of the soils. In summary, the hydraulic conductivity (K) values of the near-surface soils in the upper 1m of the site is typically in the range of 10^{-6}m/s and 10^{-8}m/s (approximately between 10^{-1}m/d and 10^{-3}m/d) corresponding to clayey silt to silty clay soils.

For WSUD, it is suggested that the average near-surface hydraulic conductivity in this range be used over the whole site.

4.3 Ground Conditions

Details of the ground conditions encountered in boreholes are given on the logs contained in Appendix 1.

In summary, ground conditions encountered in the four monitoring holes were generally consistent with what had been encountered in the previous geotechnical investigation, although, as these boreholes were deeper, all penetrated to the underlying bedrock. All boreholes encountered around 0.12m of topsoil. The borehole for MW1 encountered 1.1m of inferred colluvial medium plasticity clay. All boreholes encountered inferred residual medium or medium to high plasticity clay to between 0.9m to 5.1m depth, all overlying extremely weathered argillite weathered to the extent that it is the consistency of medium to high plasticity clay. Less weathered argillite with the consistency of a low strength rock was encountered in MW4 at 3.4m depth and the auger refused at 4.1m depth.

4.4 Water Quality

The results of water quality tests are given in the Coffey report attached in Appendix 1.

In summary, the EC measurements indicate that the groundwater is relatively low salinity such that it would be suitable for a potable water supply. The pH of the groundwater was in the range of 5.6 to 6.8 which indicates that it is slightly acidic, slightly more acidic than potable water supply target range of a pH of 6 to 8.

4.5 Groundwater Levels

Groundwater levels were manually recorded in all monitoring wells on a nominally fortnightly basis and also recorded at 10 minute intervals using PT/DLs datalogger in three of the four boreholes, MW1, MW2 and MW3.

The depth to water data manually recorded is given in the Coffey report in Appendix A and summarised in Table 4 together with the reduced level of the water table mAHD. The depth to water manually recorded in wells together with the PT/DL datalogger measurements and the rainfall recorded are shown on Figures 2, 3, 4 and 5 below. Plots of the reduced level of PT/DL datalogger measurements in monitoring wells MW1, MW2 and MW3 and the reduced level from the manual measurements from MW4 are shown on Fig 5.

Table 4: Summary of manual groundwater level measurements

Test Site ID	Collar Elevation (mAHD)	Date	Time	Depth to Water (m)	RL Water (mAHD)
MW1	5.464	18 Sep 09	11:08 am	0.25	5.214
		25 Sep 09	3:50 pm	0.38	5.084
		2 Oct 09	3:30 pm	0.45	5.014
		19 Oct 09	10:25 am	0.78	4.684
		30 Oct 09	3:50 pm	0	5.464
		16 Nov 09	11:50 am	0	5.464
		27 Nov 09	11:16 am	0	5.464
MW2	6.551	18 Sep 09	11:42 am	1.62	4.931
		25 Sep 09	3:30 pm	1.72	4.831
		2 Oct 09	3:21 pm	1.84	4.711
		19 Oct 09	10:10 am	2.05	4.501
		30 Oct 09	3:23 pm	1.12	5.431
		16 Nov 09	11:25 am	0.7	5.851
		27 Nov 09	10:57 am	1.03	5.521

Test Site ID	Collar Elevation (mAHD)	Date	Time	Depth to Water (m)	RL Water (mAHD)
MW3	7.331	18 Sep 09	12:30 pm	2	5.331
		25 Sep 09	3:10 pm	2.09	5.241
		2 Oct 09	3:00 pm	2.17	5.161
		19 Oct 09	9:55 am	2.49	4.841
		30 Oct 09	3:10 pm	1.43	5.901
		16 Nov 09	11:05 am	0.67	6.661
		27 Nov 09	10:40 am	1.27	6.061
MW4	9.241	18 Sep 09	12:15 pm	2.6	6.641
		25 Sep 09	2:55 pm	2.68	6.561
		2 Oct 09	2:48 pm	2.78	6.461
		19 Oct 09	9:49 am	3.1	6.141
		30 Oct 09	2:45 pm	1.92	7.321
		16 Nov 09	10:40 am	0.1	9.141
		27 Nov 09	10:20 am	0.92	8.321

Figure 2: Groundwater depth MW1 and rainfall

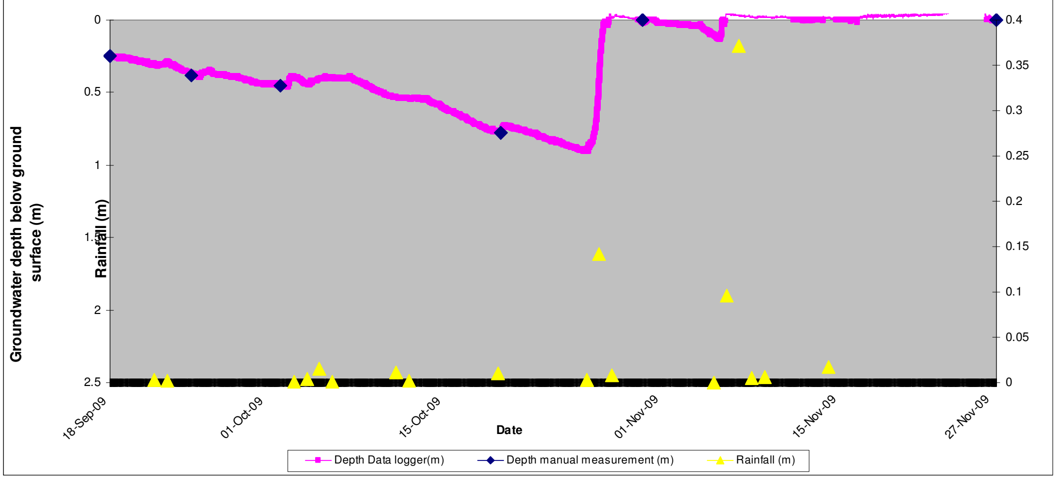


Figure 3: Groundwater depth MW2 and rainfall

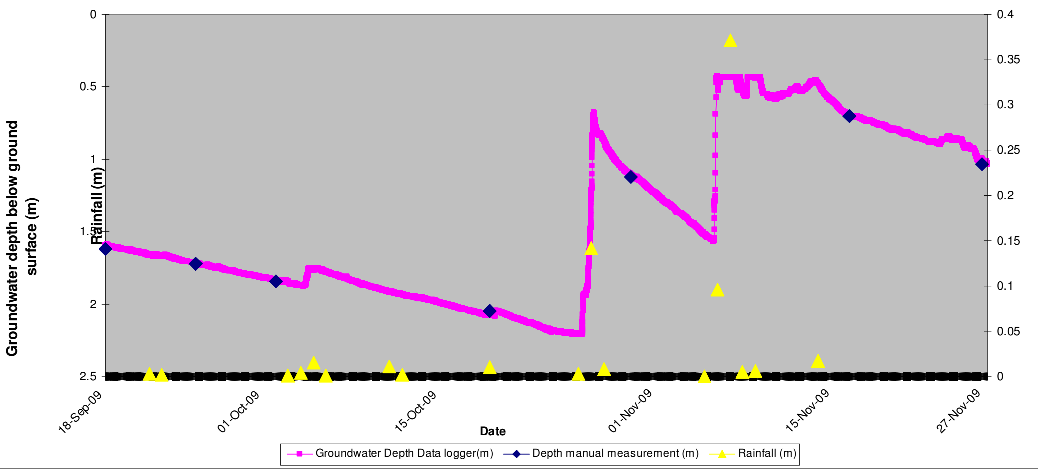
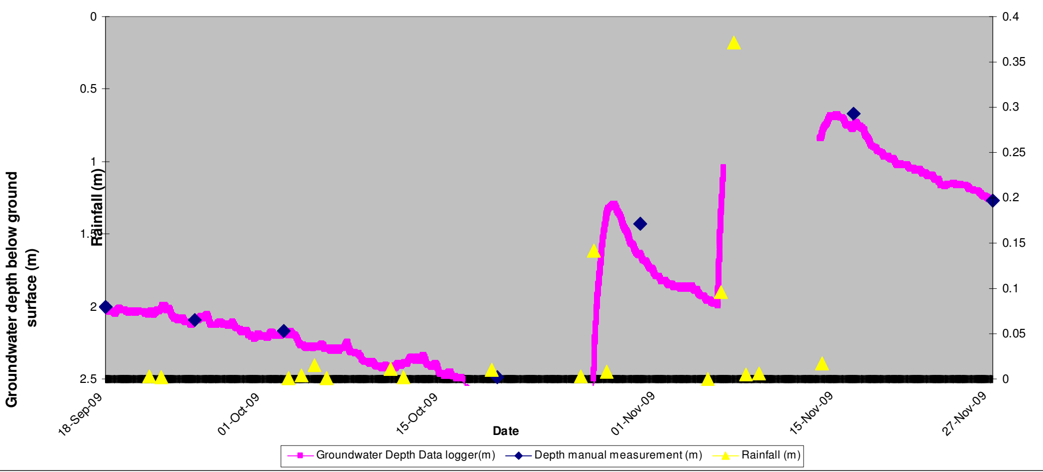


Figure 4: Groundwater depth MW3 and rainfall



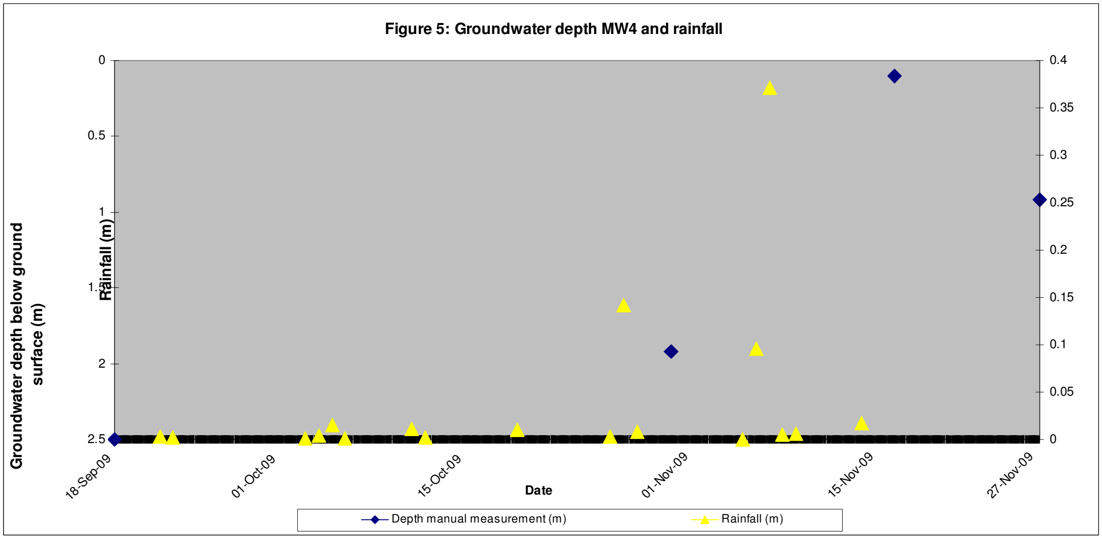


Figure 5: Groundwater depth MW4 and rainfall
Groundwater depth below ground surface (m)
Rainfall (m)
Date
18-Sep-09
01-Oct-09
15-Oct-09
01-Nov-09
15-Nov-09
27-Nov-09
Depth manual measurement (m)
Rainfall (m)

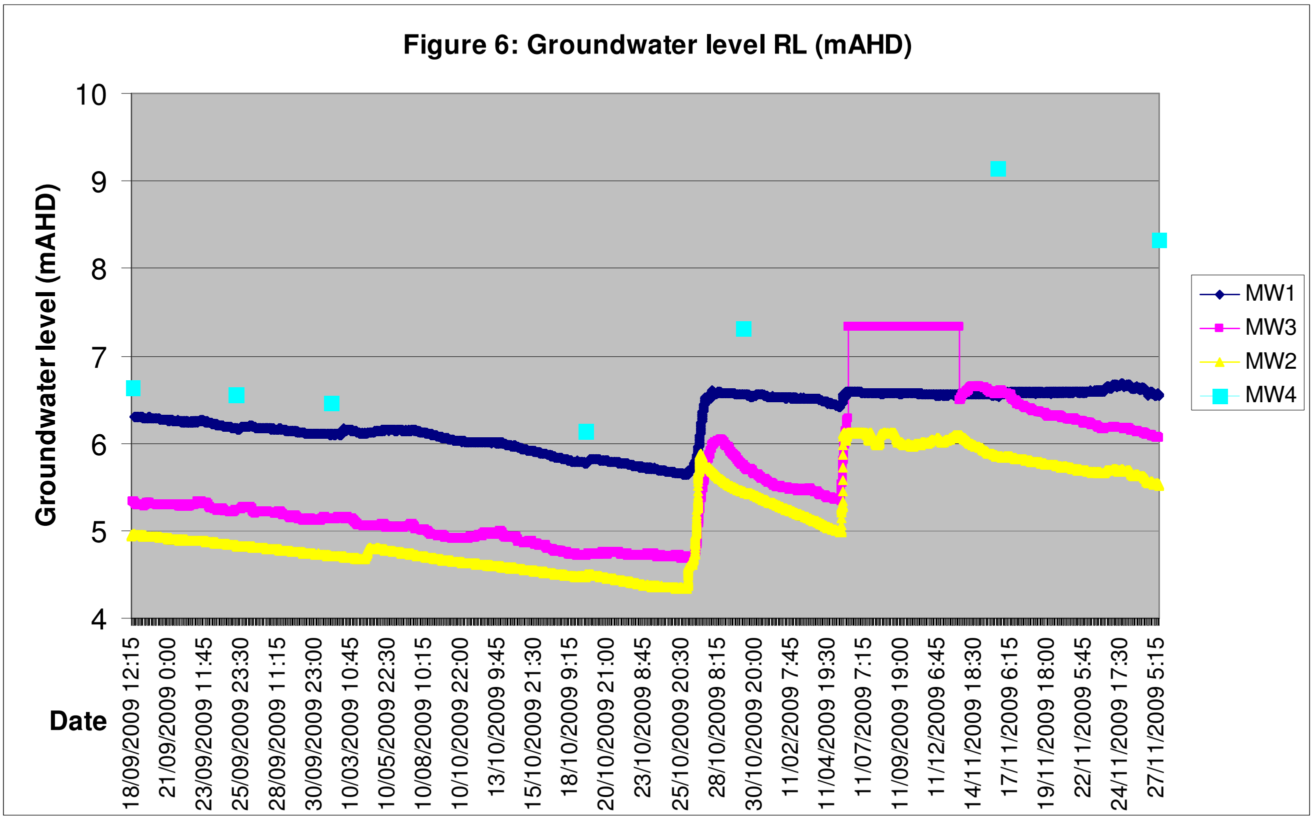


Figure 6: Groundwater level RL (mAHD)
Groundwater level (mAHD)
Date
MW1
MW3
MW2
MW4

5 COMMENTS AND RECOMMENDATIONS

5.1 Background

It is understood that WSUD is proposed at the site. At the time of report writing, lined spoon drains and lined wetlands were the preferred WSUD solution and it was not proposed to rely on infiltration to dispose of water. It is understood that preliminary flood modelling indicates a flood level of 4.1m AHD for a 1 in 100 year event. Riparian zones have been identified as shown on Figure 301015-01381-SS-IDX-0001. WSUD is not likely to be located within the flood prone areas.

If infiltration forms of WSUD are proposed, it is suggested hydraulic conductivity values provided in Section 4.2 are used for calculations.

5.2 Groundwater Profile

The groundwater monitoring information indicates that groundwater is within about 0.5m of the surface following heavy rain and it was found to take between two days and two weeks to dissipate below 1m depth. This indicates that there can be significant surface infiltration following rain, potentially caused by conduits remaining after tree stump removal and/or vertical fissures due to cracking within the medium to high plasticity clays which constitute the soils and regolith. The soils have relatively low bulk lateral and vertical hydraulic conductivity hence there is considerable lag after rainfall events and infiltration to surficial material, for groundwater levels to recede.

It is assessed that groundwater recharge would be sourced from infiltration of a proportion of incident rainfall on the site. There is potential for groundwater baseflow to the surface drainage feature which occurs on the northern boundary of the site. It is likely that prior to clearance, native vegetation would have intercepted and evapo-transpired incident rainfall at a higher rate than the pasture grasses now covering the site. The implication of this is that natural saturation of surficial materials may not have occurred and recharge to groundwater would have been lower.

Although groundwater level data is insufficient to develop meaningful groundwater contours, the water table surface is likely to be a muted expression of the topography with groundwater flow away from the higher parts of the topography toward the lower at relatively low gradient and rate.

5.3 Implications of Development on Groundwater

Development of the site is likely to change near surface soil structure even in unsealed areas effectively lowering the vertical hydraulic conductivity and, by implication, rainfall infiltration. This will have the effect of lowering recharge to groundwater. Previous clearance of indigenous vegetation however, has probably allowed greater recharge to groundwater since the time of clearance to the present i.e. there are two competing effects which will take some time to reach a new equilibrium. It is unlikely however that development will have a demonstrable effect on groundwater dependent vegetation associated with the adjacent riparian zone or the national park.

5.4 Implications of Groundwater on Site Development

Cuts made for site leveling works may encounter surficial groundwater particularly after high intensity or prolonged rainfall events. It is recommended that spoon drains be installed at the base of the cuts to manage this eventuality. Controls would need to be put in place to minimise overland flow of sediment laden water caused by earthworks from entering any surface water drainage.

If there is development on the site, reduced infiltration would mean groundwater would not be expected within 1m of the surface. If the base of the spoon drain is above 5m AHD the probability of groundwater intersection is assessed to be low.

The stability of any cuts and retaining walls should consider the presence or the potential presence of surficial groundwater.

Because groundwater quality beneath the site is potable, water produced by site works could be released to surface drainage without treatment unless contaminated by site work activity.

5.5 Implications of Groundwater on WSUD

Site development is likely to lead to reduced infiltration which in turn would affect surficial groundwater levels in the short term. However, at stated in Section 5.3, previous clearance of indigenous vegetation has probably increased infiltration of rainfall into the near surface soil profile causing short term saturation which dissipates over time as a result of deeper infiltration, evapotranspiration and possibly, a contribution to surface drainage i.e. a new equilibrium will be established between post vegetation clearance and residential development.

The expected implication of groundwater on WSUD is for minimal impact with the exception of relatively short term saturation of the soil profile following rainfall events.

5.6 Additional investigation

It is recommended that no additional investigation is required with respect to answering the NSW Office of Water's main groundwater concern i.e. *'to ensure the general water table across the site doesn't decline beyond normal seasonal fluctuations, to ensure that any groundwater dependent vegetation in the surrounding national park is not affected particularly during dry seasons. IWCM and Water Sensitive Urban Design practices employed for the development should factor in the possible consequences on the groundwater regime'.*

It is recommended, however that the four monitoring wells established at the site (MW1-4) be monitored monthly during construction and for 12 months post development so as to assess impact the development may have on groundwater in the immediate vicinity of the site. The results of monitoring should be reviewed by a competent groundwater practitioner and recommendations made on modifying, or the need for, further groundwater monitoring.

Figure 301015-01381-SS-IDX-0001

Legend

- Flood Level
- Inferred Riperian Zone

MW1	506497 N	6641021 E	5.47mAHD
MW2	506548 N	6640758 E	6.57mAHD
MW3	506371 N	6640508 E	5.82mAHD
MW4	506545 N	6640431 E	8.92mAHD

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WorleyParsons
resources & energy

(CAD) A1
JOB No. 301015-01381
REFERENCE No.

NO.	DATE	REVISION	PROJ. NO.	DRAWN	CHKED	ENG.	PROJECT ENG
A	1/4/2010	Monitoring Well Location Plan	301015-01381	SR	LM		

DRAWING NO | REFERENCE DRAWINGS

DRAWN: SR DATE: 1/4/2010
CHECKED: LM DATE: 1/4/2010
ENGINEER: DATE:
PR ENG.: DATE:
SCALE: 1 : 2000 (A3)
DRG.NO. 301015-01381-SS-IDX-0001
REV. A

Proposed Residential Subdivision at Lot 112
DP1073791 Lyons Road, North Bonville
Monitoring Well Location Plan

Appendix 1 Coffey report GEOTCOFH02592AA-AB

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

BASELINE GROUNDWATER MONITORING PROGRAM

Lot 112 Lyons Road Sawtell NSW

Worley Parsons

GEOTCOFH02592AA-AB

15 December 2009

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

15 December 2009

Worley Parsons
Level 12,
333 Collins Street
Melbourne VIC 3000

Attention: Lucie Missen

Dear Lucie,

RE: Installation of Groundwater Monitoring Wells and Baseline Monitoring Program, Lot 112 Lyons Road Sawtell NSW

Coffey Geotechnics Pty Ltd (Coffey) was engaged by Worley Parsons Pty Ltd to undertake a baseline groundwater monitoring program (BMP) at Lot 112 Lyons Road, Sawtell NSW.

The following report presents the results of a baseline monitoring program (BMP), undertaken by Coffey Geotechnics Pty Ltd (Coffey) at Lot 112 Lyons Road Sawtell NSW, on behalf of Worley Parsons. The BMP was undertaken in accordance with the proposal prepared by Coffey (Ref: GEOTCOFH02592AA-AA, dated 7 July 2009).

The BMP objective was to assess what impacts, if any, the proposed development may have on groundwater present on the site.

The scope of work carried out for the BMP is summarised below:

- A site walkover and photographs were taken by a Coffey Environmental Scientist on 14 September 2009.
- Four boreholes were drilled using a truck mounted drill rig. Engineering logs were prepared by a Coffey Geotechnics Environmental Scientist for each borehole.
- Installation of four groundwater monitoring wells (MW1-MW4) and installation of data loggers into monitoring wells MW1-MW3, to record water level data.
- Undertook 7 monitoring events at approximately 2 week intervals to download water level data from data loggers and measure physico-chemical water quality of groundwater in each monitoring well.

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1 FIELD INVESTIGATIONS

1.1 Installation of Groundwater Monitoring Wells

A total of four boreholes were drilled using a 4WD mounted drill rig to a maximum depth of 7.4m. Four groundwater wells were installed at the site in MW1 – MW4, see attached Figure 1 for monitoring well locations.

The lower 3m section of the well was screened with 50mm machine slotted, threaded PVC. MW4 was an exception with only 1.5m of screened used, as TC-bit refusal was encountered during drilling works. Solid (unslotted) 50mm PVC was used to case the well to the ground surface. Coarse sand was placed within the well annulus to a level approximately 0.6m to 1.4m above the slotted PVC, followed by an annular seal of granular bentonite pellets to approximately 0.4m to 0.9m above the coarse sand. Drill rig spoils were then used to fill the boreholes to near surface where a steel protective cover was concreted into the ground surface.

Each of the wells was developed on the 14 September 2009 by purging three well volumes and allowed to recharge before the first monitoring event on 18 September 2009.

2 BASELINE GROUNDWATER MONITORING PROGRAM

2.1 Data Loggers

Data loggers were installed in three of the monitoring wells (MW1, MW2 and MW3) on the 18 September 2009. Water level information was downloaded and physio-chemical measurements collected at about fortnightly intervals from the 18 September to 27 November 2009. The water level data has been corrected for atmospheric pressure and is presented in separate MS Excel files, one for each monitoring well, as a measurement in metres from the top of the well casing.

2.2 Physio-chemical Measurements

The results of the physio-chemical water quality measurements have been tabulated and are summarised in Table LR1, attached to this report.

For each fieldwork event the monitoring wells were gauged by measuring depth to water and a water sample was collected using a bailer. Water quality measurements were recorded for parameters dissolved oxygen, electrical conductivity, pH, temperature and turbidity. Groundwater physico-chemical water quality in each of the monitoring wells was measured in the field using a calibrated field water quality meter.

The first water quality monitoring event results indicated unusually high pH levels for all four groundwater wells, with values ranging from pH 8.47 (MW4) to pH 12.4 (MW1). Similarly the dissolved oxygen valves were uniform at 0.05 mg/L in all wells. It was decided to undertake an additional water quality assessment a week later using another calibrated water quality meter and the pH results for the site were within range from pH 5.65 to pH 5.85.

The dissolved oxygen values ranged from 2.12 to 2.58 mg/L. The pH and dissolved oxygen results for event 1 have been highlighted and may be unreliable due to instruments calibration issues. Other calibrated water quality meters were used for the remaining 6 monitoring events.

2.3 Rainfall

The rainfall monthly records for the 3 months of the baseline monitoring program are shown below in Table 1.

Table 1: Monthly rainfall for the months of September, October and November

	Month		
	September	**October**	**November**
Rainfall (mm)	9	195.6	546.6
Average Monthly Rainfall (mm)	63	91.2	133

Source: Bureau of Meterology 2009

The rainfall encountered through September was well below the average and the rainfall during October and November was well above the average monthly rainfall. The majority of this rainfall occurred during a single wet weather event in each month with 142mm recorded on 27 October and 360mm recorded on 7 November.

The November wet weather event caused an increase in standing water levels in MW3 which exceeded the logging range of the monitoring instrument for the period of time from 6 November to 13 November 2009. This shows as a gap in the level data for MW3 during this period. The remaining two wells were not similarly affected by this event.

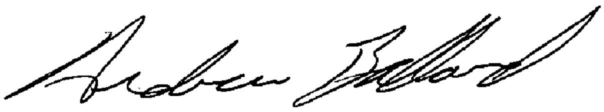
3 LIMITATIONS

The findings contained in this report are the result of discrete/specific methodologies used in accordance with normal practices and standards. To the best of our knowledge, they represent a reasonable interpretation of the past and present uses of the site. Under no circumstances, however, can it be considered that these findings represent the actual state of the site at all points.

This report does not address issues relating to potentially hazardous building materials or services which may be present on the site. This report does not address geotechnical issues at the site.

Please note that this report may not be reproduced except in full and must be read in conjunction with the attached *'Important Information about your Coffey Environmental Site Assessment.'*

For and on behalf of Coffey Geotechnics Pty Ltd



Andrew Ballard

Associate Environmental Scientist
Environmental Team Leader – Coffs Harbour

Distribution: Original held by Coffey Geotechnics Pty Ltd
1 electronic pdf copy to Worley Parsons

Attachments: Important Information about Your Coffey Environmental Site Assessment
Figure 1: Monitoring Well Location Plan
Table LR1: Summary of Physio-chemical Measurements for MW1-MW4
Engineering Logs and explanation sheets

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SPECIALISTS MANAGING THE EARTH

Important information about your **Coffey** Environmental Site Assessment

Uncertainties as to what lies below the ground on potentially contaminated sites can lead to remediation costs blow outs, reduction in the value of the land and to delays in the redevelopment of land. These uncertainties are an inherent part of dealing with land contamination. The following notes have been prepared by Coffey to help you interpret and understand the limitations of your environmental site assessment report.

Your report has been written for a specific purpose

Your report has been developed on the basis of a specific purpose as understood by Coffey and applies only to the site or area investigated. For example, the purpose of your report may be:

- To assess the environmental effects of an on-going operation.
- To provide due diligence on behalf of a property vendor.
- To provide due diligence on behalf of a property purchaser.
- To provide information related to redevelopment of the site due to a proposed change in use, for example, industrial use to a residential use.
- To assess the existing baseline environmental, and sometimes geological and hydrological conditions or constraints of a site prior to an activity which may alter the sites environmental, geological or hydrological condition.

For each purpose, a specific approach to the assessment of potential soil and groundwater contamination is required. In most cases, a key objective is to identify, and if possible, quantify risks that both recognised and unrecognised contamination pose to the proposed activity. Such risks may be both financial (for example, clean up costs or limitations to the site use) and physical (for example, potential health risks to users of the site or the general public).

Subsurface conditions can change

Subsurface conditions are created by natural processes and the activity of man and may change with time. For example, groundwater levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Because a report is based on conditions which existed at the time of the subsurface exploration, decisions should not be based on a report whose adequacy may have been affected by time. Consult Coffey to be advised how time may have impacted on the project and/or on the property.

Interpretation of factual data

Environmental site assessments identify actual subsurface conditions only at those points where samples are taken and when they are taken. Data derived from indirect field measurements and sometimes other reports on the site are interpreted by geologists, engineers or scientists to provide an opinion about overall site conditions, their likely impact with respect to the report purpose and recommended actions. Actual conditions may differ from those inferred to exist, because no professional, no matter how well qualified, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions. For this reason, parties involved with land acquisition, management and/or redevelopment should retain the services of Coffey through the development and use of the site to identify variances, conduct additional tests if required, and recommend solutions to unexpected conditions or other problems encountered on site.

Your report will only give preliminary recommendations

Your report is based on the assumption that the site conditions as revealed through selective point sampling are indicative of actual conditions throughout an area. This assumption cannot be substantiated until project implementation has commenced and therefore your report recommendations can only be regarded as preliminary. Only Coffey, who prepared the report, is fully familiar with the background information needed to assess whether or not the report's recommendations are valid and whether or not changes should be considered with redevelopment or on-going use of the site. If another party undertakes the implementation of the recommendations of this report there is a risk that the report will be misinterpreted and Coffey cannot be held responsible for such misinterpretation.

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SPECIALISTS MANAGING THE EARTH

Important information about your **Coffey** Environmental Site Assessment

Your report is prepared for specific purposes and persons

To avoid misuse of the information contained in your report it is recommended that you confer with Coffey before passing your report on to another party who may not be familiar with the background and the purpose of the report. In particular, a due diligence report for a property vendor may not be suitable for satisfying the needs of a purchaser. Your report should not be applied for any purpose other than that originally specified at the time the report was issued.

Interpretation by other professionals

Costly problems can occur when other professionals develop their plans based on misinterpretations of a report. To help avoid misinterpretations, retain Coffey to work with other professionals who are affected by the report. Have Coffey explain the report implications to professionals affected by them and then review plans and specifications produced to see how they have incorporated the report findings.

Data should not be separated from the report

The report as a whole presents the findings of the site assessment and the report should not be copied in part or altered in any way. Logs, figures, laboratory data, drawings, etc. are customarily included in our reports and are developed by scientists, engineers or geologists based on their interpretation of field logs (assembled by field personnel), field testing and laboratory evaluation of field samples. This information should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

Contact Coffey for additional assistance

Coffey is familiar with a variety of techniques and approaches that can be used to helo reduce risks for all parties to land development and land use. It is common that not all approaches will be necessarily dealt with in your environmental site assessment report due to concepts proposed at that time. As a project progresses through planning and design toward construction and/or maintenance, speak with Coffey to develop alternative approaches to problems that may be of genuine benefit both in time and cost.

Responsibility

Environmental reporting relies on interpretation of factual information based on judgement and opinion and has a level of uncertainty attached to it, which is far less exact than other design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded. To help prevent this problem, a number of clauses have been developed for use in contracts, reports and other documents. Responsibility clauses do not transfer appropriate liabilities from Coffey to other parties but are included to identify where Coffey's responsibilities begin and end. Their use is intended to help all parties involved to recognise their individual responsibilities. Read all documents from Coffey closely and do not hesitate to ask any questions you may have.

Source: Google Earth, 2009

drawn:	JP	coffey geotechnics SPECIALISTS MANAGING THE EARTH	client:	Worley Parsons
approved:	AB		project:	Installation of Groundwater Monitoring Wells and Baseline Monitoring Program, Lot 112 Lyons Road Sawtell NSW
date:	15-Dec-2009			
scale:	1:375		title:	Monitoring Well Location Plan
original size:	A4		project no.: GEOTCOFH02592AA-AB	drawing no: Figure 1

Table LR1: Summary of Physio-chemical Water Quality measurements for MW1-MW4

Sampling Event	Monitoring Well ID	Date	Time of Day	Depth to Water (m)	Dissolved Oxygen (mg/L)	Electrical Conductivity (mS or µS/cm)	pH (pH units)	Tempertaure (°C)	Turbidty (ntu)
Event 1	MW1	18-Sep-09	11:08 am	0.25	**0.05**	336.5	**12.4**	20.35	62
	MW2	18-Sep-09	11:42 am	1.62	**0.05**	0.93	**8.52**	20.5	82.5
	MW3	18-Sep-09	12:30 pm	2	**0.05**	215	**8.57**	21.4	63.5
	MW4	18-Sep-09	12:15 pm	2.6	**0.05**	213	**8.47**	20.95	60
Event 2	MW1	25-Sep-09	3:50 pm	0.38	2.12	201.55	5.74	20.1	23
	MW2	25-Sep-09	3:30 pm	1.72	2.31	105.4	5.7	20.25	91
	MW3	25-Sep-09	3:10 pm	2.09	2.58	185.85	5.84	22.65	23.4
	MW4	25-Sep-09	2:55 pm	2.68	2.41	149.15	5.65	21.7	337
Event 3	MW1	02-Oct-09	3:30 pm	0.45	8.69	206.8	5.84	21.90	39.5
	MW2	02-Oct-09	3:21 pm	1.84	2.84	97.6	5.59	22.4	180
	MW3	02-Oct-09	3:00 pm	2.17	2.5	149.8	5.77	23.65	14.4
	MW4	02-Oct-09	2:48 pm	2.78	1.34	175.4	6.66	22.8	389
Event 4	MW1	19-Oct-09	10:25 am	0.78	2.46	410	6.05	22.85	14.1
	MW2	19-Oct-09	10:10 am	2.05	2.61	166.5	5.65	22.25	56.1
	MW3	19-Oct-09	9:55 am	2.49	1.76	258.5	5.78	22.5	4.8
	MW4	19-Oct-09	9:49 am	3.1	2.37	240	5.81	21.25	596
Event 5	MW1	30-Oct-09	3:50 pm	0	1.76	495	6.38	22.2	4.59
	MW2	30-Oct-09	3:23 pm	1.12	1.81	137.7	6.33	22.6	24.5
	MW3	30-Oct-09	3:10 pm	1.43	1.57	336	6.44	22.9	7.12
	MW4	30-Oct-09	2:45 pm	1.92	2.4	213	6.51	22.4	263
Event 6	MW1	16-Nov-09	11:50 am	0	2.97	282	6.11	23	13.5
	MW2	16-Nov-09	11:25 am	0.7	5.82	68.6	6.78	25.35	10.2
	MW3	16-Nov-09	11:05 am	0.67	2.76	162.4	6	24	14.5
	MW4	16-Nov-09	10:40 am	0.1	3.43	152.1	6.06	24.9	48
Event 7	MW1	27-Nov-09	11:16 am	0	1.84	363	6.19	24.1	42.1
	MW2	27-Nov-09	10:57 am	1.03	3.17	225	6.5	22.7	12.1
	MW3	27-Nov-09	10:40 am	1.27	2.29	215.4	6.01	23.7	15
	MW4	27-Nov-09	10:20 am	0.92	2.45	304	6.38	23.5	59

Notes:

Bold Highlighted results may be unreliable due to instrument calibration and not representative of groundwater quality

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Soil Description Explanation Sheet (1 of 2)

DEFINITION:

In engineering terms soil includes every type of uncemented or partially cemented inorganic or organic material found in the ground. In practice, if the material can be remoulded or disintegrated by hand in its field condition or in water it is described as a soil. Other materials are described using rock description terms.

CLASSIFICATION SYMBOL & SOIL NAME

Soils are described in accordance with the Unified Soil Classification (UCS) as shown in the table on Sheet 2.

PARTICLE SIZE DESCRIPTIVE TERMS

NAME	SUBDIVISION	SIZE
Boulders		>200 mm
Cobbles		63 mm to 200 mm
Gravel	coarse	20 mm to 63 mm
	medium	6 mm to 20 mm
	fine	2.36 mm to 6 mm
Sand	coarse	600 µm to 2.36 mm
	medium	200 µm to 600 µm
	fine	75 µm to 200 µm

MOISTURE CONDITION

Dry Looks and feels dry. Cohesive and cemented soils are hard, friable or powdery. Uncemented granular soils run freely through hands.

Moist Soil feels cool and darkened in colour. Cohesive soils can be moulded. Granular soils tend to cohere.

Wet As for moist but with free water forming on hands when handled.

CONSISTENCY OF COHESIVE SOILS

TERM	UNDRAINED STRENGTH s_u (kPa)	FIELD GUIDE
Very Soft	<12	A finger can be pushed well into the soil with little effort.
Soft	12 - 25	A finger can be pushed into the soil to about 25mm depth.
Firm	25 - 50	The soil can be indented about 5mm with the thumb, but not penetrated.
Stiff	50 - 100	The surface of the soil can be indented with the thumb, but not penetrated.
Very Stiff	100 - 200	The surface of the soil can be marked, but not indented with thumb pressure.
Hard	>200	The surface of the soil can be marked only with the thumbnail.
Friable	–	Crumbles or powders when scraped by thumbnail.

DENSITY OF GRANULAR SOILS

TERM	DENSITY INDEX (%)
Very loose	Less than 15
Loose	15 - 35
Medium Dense	35 - 65
Dense	65 - 85
Very Dense	Greater than 85

MINOR COMPONENTS

TERM	ASSESSMENT GUIDE	PROPORTION OF MINOR COMPONENT IN:
Trace of	Presence just detectable by feel or eye, but soil properties little or no different to general properties of primary component.	Coarse grained soils: <5% Fine grained soils: <15%
With some	Presence easily detected by feel or eye, soil properties little different to general properties of primary component.	Coarse grained soils: 5 - 12% Fine grained soils: 15 - 30%

SOIL STRUCTURE

ZONING		CEMENTING	
Layers	Continuous across exposure or sample.	Weakly cemented	Easily broken up by hand in air or water.
Lenses	Discontinuous layers of lenticular shape.	Moderately cemented	Effort is required to break up the soil by hand in air or water.
Pockets	Irregular inclusions of different material.		

GEOLOGICAL ORIGIN

WEATHERED IN PLACE SOILS

Extremely weathered material — Structure and fabric of parent rock visible.

Residual soil — Structure and fabric of parent rock not visible.

TRANSPORTED SOILS

Aeolian soil — Deposited by wind.

Alluvial soil — Deposited by streams and rivers.

Colluvial soil — Deposited on slopes (transported downslope by gravity).

Fill — Man made deposit. Fill may be significantly more variable between tested locations than naturally occurring soils.

Lacustrine soil — Deposited by lakes.

Marine soil — Deposited in ocean basins, bays, beaches and estuaries.

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Soil Description Explanation Sheet (2 of 2)

SOIL CLASSIFICATION INCLUDING IDENTIFICATION AND DESCRIPTION

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 60 mm and basing fractions on estimated mass)						USC	PRIMARY NAME
COARSE GRAINED SOILS More than 50% of materials less than 63 mm is larger than 0.075 mm	GRAVELS More than half of coarse fraction is larger than 2.0 mm	CLEAN GRAVELS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.			GW	GRAVEL
			Predominantly one size or a range of sizes with more intermediate sizes missing.			GP	GRAVEL
		GRAVELS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below)			GM	SILTY GRAVEL
			Plastic fines (for identification procedures see CL below)			GC	CLAYEY GRAVEL
	SANDS More than half of coarse fraction is smaller than 2.0 mm	CLEAN SANDS (Little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate sizes missing			SW	SAND
			Predominantly one size or a range of sizes with some intermediate sizes missing.			SP	SAND
		SANDS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below).			SM	SILTY SAND
			Plastic fines (for identification procedures see CL below).			SC	CLAYEY SAND
FINE GRAINED SOILS More than 50% of material less than 63 mm is smaller than 0.075 mm		IDENTIFICATION PROCEDURES ON FRACTIONS <0.2 mm.					
			DRY STRENGTH	**DILATANCY**	**TOUGHNESS**		
	SILTS & CLAYS Liquid limit less than 50		None to Low	Quick to slow	None	ML	SILT
			Medium to High	None	Medium	CL	CLAY
			Low to medium	Slow to very slow	Low	OL	ORGANIC SILT
	SILTS & CLAYS Liquid limit greater than 50		Low to medium	Slow to very slow	Low to medium	MH	SILT
			High	None	High	CH	CLAY
			Medium to High	None	Low to medium	OH	ORGANIC CLAY
HIGHLY ORGANIC SOILS			Readily identified by colour, odour, spongy feel and frequently by fibrous texture.			Pt	PEAT

(A 0.075 mm particle is about the smallest particle visible to the naked eye)

• Low plasticity – Liquid Limit W_L less than 35%. • Modium plasticity – W_L between 35% and 50%.

COMMON DEFECTS IN SOIL

TERM	DEFINITION	DIAGRAM
PARTING	A surface or crack across which the soil has little or no tensile strength. Parallel or sub parallel to layering (eg bedding). May be open or closed.	
JOINT	A surface or crack across which the soil has little or no tensile strength but which is not parallel or sub parallel to layering. May be open or closed. The term 'fissure' may be used for irregular joints <0.2 m in length.	
SHEARED ZONE	Zone in clayey soil with roughly parallel near planar, curved or undulating boundaries containing closely spaced, smooth or slickensided, curved intersecting joints which divide the mass into lenticular or wedge shaped blocks.	
SHEARED SURFACE	A near planar curved or undulating, smooth, polished or slickensided surface in clayey soil. The polished or slickensided surface indicates that movement (in many cases very little) has occurred along the defect.	

TERM	DEFINITION	DIAGRAM
SOFTENED ZONE	A zone in clayey soil, usually adjacent to a defect in which the soil has a higher moisture content than elsewhere.	
TUBE	Tubular cavity. May occur singly or as one of a large number of separate or inter-connected tubes. Walls often coated with clay or strengthened by denser packing of grains. May contain organic matter	
TUBE CAST	Roughly cylindrical elongated body of soil different from the soil mass in which it occurs. In some cases the soil which makes up the tube cast is cemented.	
INFILLED SEAM	Sheet or wall like body of soil substance or mass with roughly planar to irregular near parallel boundaries which cuts through a soil mass. Formed by infilling of open joints.	

Rock Description Explanation Sheet (1 of 2)

The descriptive terms used by Coffey are given below. They are broadly consistent with Australian Standard AS1726-1993.

DEFINITIONS: Rock substance, defect and mass are defined as follows:

Rock Substance In engineering terms roch substance is any naturally occurring aggregate of minerals and organic material which cannot be disintegrated or remoulded by hand in air or water. Other material is described using soil descriptive terms. Effectively homogenous material, may be isotropic or anisotropic.

Defect Discontinuity or break in the continuity of a substance or substances.

Mass Any body of material which is not effectively homogeneous. It can consist of two or more substances without defects, or one or more substances with one or more defects.

SUBSTANCE DESCRIPTIVE TERMS:

ROCK NAME Simple rock names are used rather than precise geological classification.

PARTICLE SIZE Grain size terms for sandstone are:

Coarse grained	Mainly 0.6mm to 2mm
Medium grained	Mainly 0.2mm to 0.6mm
Fine grained	Mainly 0.06mm (just visible) to 0.2mm

FABRIC Terms for layering of penetrative fabric (eg. bedding, cleavage etc.) are:

Massive	No layering or penetrative fabric.
Indistinct	Layering or fabric just visible. Little effect on properties.
Distinct	Layering or fabric is easily visible. Rock breaks more easily parallel to layering of fabric.

CLASSIFICATION OF WEATHERING PRODUCTS

Term	Abbreviation	Definition
Residual Soil	**RS**	Soil derived from the weathering of rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported.
Extremely Weathered Material	**XW**	Material is weathered to such an extent that it has soil properties, ie, it either disintegrates or can be remoulded in water. Original rock fabric still visible.
Highly Weathered Rock	**HW**	Rock strength is changed by weathering. The whole of the rock substance is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable. Some minerals are decomposed to clay minerals. Porosity may be increased by leaching or may be decreased due to the deposition of minerals in pores.
Moderately Weathered Rock	**MW**	The whole of the rock substance is discoloured, usually by iron staining or bleaching , to the extent that the colour of the fresh rock is no longer recognisable.
Slightly Weathered Rock	**SW**	Rock substance affected by weathering to the extent that partial staining or partial discolouration of the rock substance (usually by limonite) has taken place. The colour and texture of the fresh rock is recognisable; strength properties are essentially those of the fresh rock substance.
Fresh Rock	**FR**	Rock substance unaffected by weathering.

Notes on Weathering:

1. AS1726 suggests the term "Distinctly Weathered" (DW) to cover the range of substance weathering conditions between XW and SW. For projects where it is not practical to delineate between HW and MW or it is judged that there is no advantage in making such a distinction. DW may be used with the definition given in AS1726.
2. Where physical and chemical changes were caused by hot gasses and liquids associated with igneous rocks, the term "altered" may be substituted for "weathering" to give the abbreviations XA, HA, MA, SA and DA.

ROCK SUBSTANCE STRENGTH TERMS

Term	Abbrev-iation	Point Load Index, I_S50 (MPa)	Field Guide
Very Low	**VL**	Less than 0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with a knife; pieces up to 30mm thick can be broken by finger pressure.
Low	**L**	0.1 to 0.3	Easily scored with a knife; indentations 1mm to 3mm show with firm bows of a pick point; has a dull sound under hammer. Pieces of core 150mm long by 50mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.
Medium	**M**	0.3 to 1.0	Readily scored with a knife; a piece of core 150mm long by 50mm diameter can be broken by hand with difficulty.
High	**H**	1 to 3	A piece of core 150mm long by 50mm can not be broken by hand but can be broken by a pick with a single firm blow; rock rings under hammer.
Very High	**VH**	3 to 10	Hand specimen breaks after more than one blow of a pick; rock rings under hammer.
Extremely High	**EH**	More than 10	Specimen requires many blows with geological pick to break; rock rings under hammer.

Notes on Rock Substance Strength:

1. In anisotropic rocks the field guide to strength applies to the strength perpendicular to the anisotropy. High strength anisotropic rocks may break readily parallel to the planar anisotropy.
2. The term "extremely low" is not used as a rock substance strength term. While the term is used in AS1726-1993, the field guide therein makes it clear that materials in that strength range are soils in engineering terms.
3. The unconfined compressive strength for isotropic rocks (and anisotropic rocks which fall across the planar anisotropy) is typically 10 to 25 times the point load index (Is50). The ratio may vary for different rock types. Lower strength rocks often have lower ratios than higher strength rocks.

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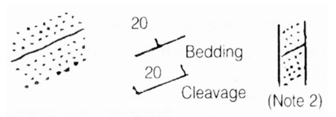
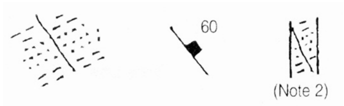
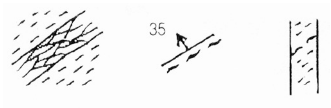
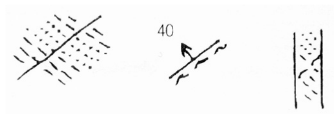
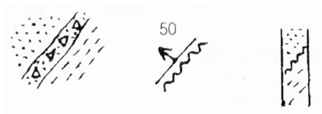
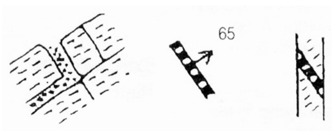
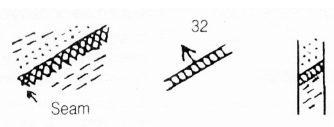
Rock Description Explanation Sheet (2 of 2)

COMMON DEFECTS IN ROCK MASSES

Term	Definition	Diagram / Map Symbol / Graphic Log (Note 1)
Parting	A surface or crack across which the rock has little or no tensile strength. Parallel or sub parallel to layering (eg bedding) or a planar anisotropy in the rock substance (eg, cleavage). May be open or closed.	
Joint	A surface or crack across which the rock has little or no tensile strength. but which is not parallel or sub parallel to layering or planar anisotropy in the rock substance. May be open or closed.	
Sheared Zone (Note 3)	Zone of rock substance with roughly parallel near planar, curved or undulating boundaries cut by closely spaced joints, sheared surfaces or other defects. Some of the defects are usually curved and intersect to divide the mass into lenticular or wedge shaped blocks.	
Sheared Surface (Note 3)	A near planar, curved or undulating surface which is usually smooth, polished or slickensided.	
Crushed Seam (Note 3)	Seam with roughly parallel almost planar boundaries, composed of disoriented, usually angular fragments of the host rock substance which may be more weathered than the host rock. The seam has soil properties.	
Infilled Seam	Seam of soil substance usually with distinct roughly parallel boundaries formed by the migration of soil into an open cavity or joint, infilled seams less than 1mm thick may be described as veneer or coating on joint surface.	
Extremely Weathered Seam	Seam of soil substance, often with gradational boundaries. Formad by weathering of the rock substance in place.	

Notes on Defects:

1. Usually borehole logs show the true dip of defects and face sketches and sections the apparent dip.
2. Partings and joints are not usually shown on the graphic log unless considered significant.
3. Sheared zones, sheared surfaces and crushed seams are faults in geological terms.

DEFECT SHAPE TERMS

Planar	The defect does not vary in orientation
Curved	The defect has a gradual change in orientation
Undulating	The defect has a wavy surface
Stepped	The defect has one or more well defined steps
Irregular	The defect has many sharp changes of orientation

Note: The assessment of defect shape is partly influenced by the scale of the observation.

ROUGHNESS TERMS

Slickensided	Grooved or striated surface, usually polished
Polished	Shiny smooth surface
Smooth	Smooth to touch. Few or no surface irregularities
Rough	Many small surface irregularities (amplitude generally less than 1mm). Feels like fine to coarse sand paper.
Very Rough	Many large surface irregularities (amplitude generally more than 1mm). Feels like, or coarser than very coarse sand paper.

COATING TERMS

Clean	No visible coating
Stained	No visible coating but surfaces are discoloured
Veneer	A visible coating of soil or mineral, too thin to measure; may be patchy
Coating	A visible coating up to 1mm thick. Thicker soil material is usually described using appropriate defect terms (eg, infilled seam). Thicker rock strength material is usually described as a vein.

BLOCK SHAPE TERMS

Blocky	Approximately equidimensional
Tabular	Thickness much less than length or width
Columnar	Height much greate than cross section

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Engineering Log - Piezometer

Borehole No.	**MW1**
Sheet	1 of 1
Project No:	**GEOTCOFH02592AA**
Date started:	**14.9.2009**
Date completed:	**14.9.2009**
Logged by:	**JP**
Checked by:	**AH**

Client: **WORLEY PARSONS**

Principal:

Project: **BASELINE MONITORING PROGRAM LYONS ROAD**

Borehole Location: **REFER TO FIGURE 1**

drill model & mounting:	MD200	Easting:		slope:	-90°	R.L. Surface:	Not Measured
hole diameter:		Northing:		bearing:		datum:	

drilling information / material substance

method	penetration 1 2 3	support	water	notes samples, tests, etc	well details	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	structure and additional observations
ADV		N					0			**TOPSOIL:** Silty Clay, medium plasticity, dark grey			TOPSOIL
									CL	**CLAY:** medium plasticity, pale brown/orange	MC<PL		RESIDUAL/COLLUVIAL SOIL
							1		CH	**Silty CLAY:** medium to high plasticity, pale grey/grey			RESIDUAL SOIL
							2						
							3						
							4			Colour change to dark grey/grey mottled brown/orange, increase in moisture, some quartz fine to medium subangular gravel.	MC<<PL		
							5		CL	**Silty CLAY:** medium plasticity, grey mottled brown/orange			EXTREMELY WEATHERED ARGILLITE
							6			Band of pale grey/grey .			
			►				7			Some minor water inflow.			
										Borehole terminated at 7.4m			MW1 terminated due to limit of required investigation.
							8						

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
DT	diatube
B	blank bit
V	V bit
T	TC bit
TBX	Tubex
*bit shown by suffix	
e.g.	ADT

support

C casing N nil

penetration

1 2 3 4 — no resistance ranging to refusal

water

▼ 10/1/98 water level on date shown

► water inflow

◄ water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
P	pressure meter
Bs	bulk sample
R	refusal
E	environmental sample
PID	PID measurement
WS	water sample
PZ	piezometer
ALT	air lift test

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Piezometer

Borehole No. **MW2**

Sheet 1 of 1

Project No: **GEOTCOFH02592AA**

Client: **WORLEY PARSONS**

Date started: **14.9.2009**

Principal:

Date completed: **14.9.2009**

Project: **BASELINE MONITORING PROGRAM LYONS ROAD**

Logged by: **JP**

Borehole Location: **REFER TO FIGURE 1**

Checked by: **AH**

drill model & mounting: MD200 | Easting: | slope: -90° | R.L. Surface: Not Measured

hole diameter: | Northing: | bearing: | datum:

drilling information / material substance

method	penetration 1 2 3	support	water	notes samples, tests, etc	depth metres	classification symbol	material (soil type: plasticity or particle characteristics, colour, secondary and minor components)	moisture condition	consistency/density index	structure and additional observations
ADV		N			0.0		**TOPSOIL:** Silty Clay, medium plasticity, dark brown			TOPSOIL
						CL	**CLAY:** medium to high plasticity, brown/orange	MC<<PL		RESIDUAL SOIL
					1					
					2					
						CH	**Silty CLAY:** medium to high plasticity, grey mottled brown/dark red, some quartz subangular gravel			EXTREMELY WEATHERED ARGILLITE
					3					
			►—							
					4		Colour change to grey mottled dark red.			
					5					
					6		Borehole terminated at 5.9m			MW2 terminated due to limit of required investigation.
					7					
					8					

method
AS auger screwing*
AD auger drilling*
RR roller/tricone
W washbore
CT cable tool
DT diatube
B blank bit
V V bit
T TC bit
TBX Tubex
*bit shown by suffix
e.g. ADT

support
C casing N nil

penetration
1 2 3 4
no resistance ranging to refusal

water
10/1/98 water level on date shown
water inflow
water outflow

notes, samples, tests
U_{50} undisturbed sample 50mm diameter
D disturbed sample
N standard penetration test (SPT)
N* SPT - sample recovered
Nc SPT with solid cone
P pressure meter
Bs bulk sample
R refusal
E environmental sample
PID PID measurement
WS water sample
PZ piezometer
ALT air lift test

classification symbols and soil description
based on unified classification system

moisture
D dry
M moist
W wet
Wp plastic limit
W_L liquid limit

consistency/density index
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

coffey geotechnics

Engineering Log - Piezometer

Borehole No.	**MW3**
Sheet	1 of 1
Project No:	**GEOTCOFH02592AA**
Date started:	**14.9.2009**
Date completed:	**14.9.2009**
Logged by:	**JP**
Checked by:	**AH**

Client: **WORLEY PARSONS**

Principal:

Project: **BASELINE MONITORING PROGRAM LYONS ROAD**

Borehole Location: **REFER TO FIGURE 1**

drill model & mounting: MD200	Easting:	slope: -90°	R.L. Surface: Not Measured
hole diameter:	Northing:	bearing:	datum:

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	well details	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	structure and additional observations
ADV		N					0.0			**TOPSOIL:** Silty Clay, medium plasticity, dark brown			TOPSOIL
									CL	**CLAY:** medium plasticity, brown/orange	MC<PL		RESIDUAL SOIL
							1						
										Red/pale brown mottling.			
							2		CH	**Silty CLAY:** medium to high plasticity, grey mottled pale brown			EXTREMELY WEATHERED ARGILLITE
							3			Colour change to dark grey/grey.			
										Some dark red mottling.			
							4						
							5						
							6			**CLAY:** medium plasticity, brown/pale brown, some interbedded silty clay, medium to high plasticity, dark grey/grey bands, with a higher moisture content			
			►				7			Some highly weathered argillite fragments grading to highly weathered argillite.			MW4 terminated due to V-bit refusal.
										Borehole terminated at 7.1m			
							8						

method
AS auger screwing*
AD auger drilling*
RR roller/tricone
W washbore
CT cable tool
DT diatube
B blank bit
V V bit
T TC bit
TBX Tubex
*bit shown by suffix
e.g. ADT

support
C casing N nil

penetration
1 2 3 4
no resistance ranging to refusal

water
10/1/98 water level on date shown
water inflow
water outflow

notes, samples, tests
U_{50} undisturbed sample 50mm diameter
D disturbed sample
N standard penetration test (SPT)
N* SPT - sample recovered
Nc SPT with solid cone
P pressure meter
Bs bulk sample
R refusal
E environmental sample
PID PID measurement
WS water sample
PZ piezometer
ALT air lift test

classification symbols and soil description
based on unified classification system

moisture
D dry
M moist
W wet
Wp plastic limit
W_L liquid limit

consistency/density index
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

PIEZOMETER GEOTCOFH02592AA.GPJ COFFEY.GDT 15.12.09

Form GEO 5.10 Issue 3 Rev.0

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Borehole No. **MW4**

Engineering Log - Piezometer

Sheet 1 of 1

Project No: **GEOTCOFH02592AA**

Client: **WORLEY PARSONS**

Date started: **14.9.2009**

Principal:

Date completed: **14.9.2009**

Project: **BASELINE MONITORING PROGRAM LYONS ROAD**

Logged by: **JP**

Borehole Location: **REFER TO FIGURE 1**

Checked by: **AH**

drill model & mounting: MD200	Easting:	slope: -90°	R.L. Surface: Not Measured
hole diameter:	Northing:	bearing:	datum:

drilling information / material substance

method	support	water	depth metres	classification symbol	material (soil type: plasticity or particle characteristics, colour, secondary and minor components)	moisture condition	consistency/density index	structure and additional observations
ADV	N		0.0		**TOPSOIL:** Silty Clay, medium plasticity, dark brown			TOPSOIL
				CL	**CLAY:** medium plasticity, brown/orange, mottle	MC<PL		RESIDUAL/COLLUVIAL SOIL
			1	CH	**Silty CLAY:** medium to high plasticity, dark grey mottled dark red/pale brown			EXTREMELY WEATHERED ARGILLITE
			2		Some highly weathered argillite fragments.			
			3	MH	**CLayey SILT:** grey/dark grey mottled brown, clay is low to medium plasticity, some highly weathered argillite fragments	D		
		►	4		**ARGILLITE:** highly weathered, dark grey mottled brown	HW	LS	HIGHLY WEATHERED ARGILLITE
					Borehole terminated at 4.1m			MW4 terminated due to TC-bit refusal.
			5					
			6					
			7					
			8					

method		support		notes, samples, tests		classification symbols and soil description		consistency/density index	
AS	auger screwing*	C casing	N nil	U_{50}	undisturbed sample 50mm diameter	based on unified classification system		VS	very soft
AD	auger drilling*			D	disturbed sample			S	soft
RR	roller/tricone	**penetration** 1 2 3 4	no resistance ranging to refusal	N	standard penetration test (SPT)	**moisture**		F	firm
W	washbore			N*	SPT - sample recovered	D	dry	St	stiff
CT	cable tool	**water**		Nc	SPT with solid cone	M	moist	VSt	very stiff
DT	diatube	▼	10/1/98 water level on date shown	P	pressure meter	W	wet	H	hard
B	blank bit	►	water inflow	Bs	bulk sample	Wp	plastic limit	Fb	friable
V	V bit	◄	water outflow	R	refusal	W_L	liquid limit	VL	very loose
T	TC bit			E	environmental sample			L	loose
TBX	Tubex			PID	PID measurement			MD	medium dense
*bit shown by suffix				WS	water sample			D	dense
e.g.	ADT			PZ	piezometer			VD	very dense
				ALT	air lift test				

Appendix 2 Falling head hydraulic near-surface permeability test results

WorleyParsons
resources & energy

Calculation Cover Sheet

Customer	Utila P/L	**Proj No**	301015-01381
Project Title	Lot 112 Lyons Road, Sawtell	**Calc No**	1
Calculation Title	Falling Head Permeability Results	**Phase/CTR**	Groundwater
Elec File Location	K:\FRASER\GEOTECHNICAL\PROJECTS\301015-01381 Bonville\10_Engineer\10-01_CI-Civils\[Falling Head Permeability.xls]Calculation Cover Sheet		
Project File Location		**Page**	1 **of 2**

Calculation Objective

To establish permeability of near surface soils for use in Water Sensitive Urban Design assessment

Calculation Method

Talsa & Hallam 1980 after Zangar 1953

Assumptions

Isotropic permeability

Software Used

Title	Version	Validation (Y / N / N/A)
Spreadsheet		*N/A*

References

Jarvis 1949, p.284 in USGWM 1977

Conclusions

Coefficient of permeability k in the range of 1 x 10-6 to 1 x 10-8m/s

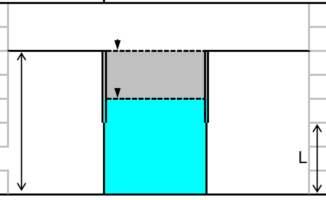
Rev	**Date**	**Description**	**By**	**Checked**	**Approved**

Calculation Sheet

Customer	Utila P/L	**Proj No**	301015-01381
Project Title	Lot 112 Lyons Road, Sawtell	**Calc No**	1
Calculation Title	Falling Head Permeability Results	**Phase/CTR**	Groundwater
Elec File Location	K:\FRASER\GEOTECHNICAL\PROJECTS\301015-01381 Bonville\10_Engineer\10-01_CI-Civils\[Falling Head Permeability.xls]Calculation Cover Sheet		
Project File Location		**Page**	1 of 1

Rev	Date	By	Checked	Rev	Date	By	Checked	Rev	Date	By	Checked
1	21-Oct-09	L. Missen	L. Missen								

Radius 0.0625 m



$$K = \frac{R^2 C}{2L(t_2 - t_1)}$$

Where : $C = 0.5 \sinh^{-1}(L/R) \left[\ln\frac{(2h_1 - L)}{(2h_2 - L)} - \ln\frac{(2h_1h_2 - Lh_2)}{(2h_1h_2 - Lh_1)} \right]$

MW1

Depth = Date	1.13 Time	Water Level	L= Elapsed Time (min)	1.13 Height h (m)
14-Sep-09	11:38:00	0.18		0.95
	11:43:00	0.19	5	0.94
	11:48:00	0.2	10	0.93
	11:52:00	0.205	14	0.925
	12:00:00	0.22	22	0.91
	13:00:00	0.29	82	0.84
	13:44:00	0.33	126	0.8
	14:17:00	0.37	159	0.76
	15:10:00	0.42	212	0.71
	15:50:00	0.44	252	0.69
	16:25:00	0.46	287	0.67
15-Sep-09	9:10:00	0.73	1292	0.4
	9:19:00	0.49		0.64
	9:50:00	0.52	31	0.61
	10:00:00	0.53	41	0.6
	10:47:00	0.555	88	0.575
	11:03:00	0.56	104	0.57
	11:45:00	0.57	146	0.56
	12:34:00	0.585	195	0.545
	13:15:00	0.6	236	0.53
(t1, h1)	=	252.0	0.69	
(t2, h2)	=	287.0	0.67	
C		0.168		
Hydraulic Conductivity, k			1.4E-07	

MW2

Depth = Date	1.07 Time	Water Level (m bgl)	L= Elapsed Time (min)	1.07 Height h (m)
14-Sep-09	12:52:00	0.21		0.86
	13:35:00	0.45	43	0.62
	14:22:00	0.58	90	0.49
	14:47:00	0.64	115	0.43
	14:57:00	0.66	125	0.41
	15:07:00	0.68	135	0.39
	15:24:00	0.71	152	0.36
	15:30:00	0.71	158	0.36
	15:34:00	0.72	162	0.35
	15:37:00	0.74	165	0.33
	15:47:00	0.75	175	0.32
	16:05:00	0.78	193	0.29
	16:06:00	0.29		0.78
	16:20:00	0.36	14	0.71
	16:35:00	0.4	29	0.67
15-Sep-09	9:25:00			
	9:28:00	0.47		0.6
	10:05:00	0.56	37	0.51
	10:15:00	0.58	47	0.49
	10:20:00	0.59	52	0.48
	10:25:00	0.597	57	0.473
	10:50:00	0.63	82	0.44
	11:10:00	0.66	102	0.41
	11:40:00	0.7	132	0.37
	12:40:00	0.8	192	0.27
(t1, h1)	=		0.86	
(t2, h2)	=	43.0	0.62	
C		1.356		
Hydraulic Conductivity, k			9.6E-07	

MW3

Depth = Date	1.05 Time	Water Level	L= Elapsed Time (min)	1.05 Height h (m)
14-Sep-09				
	12:12:00	0.13		0.92
	12:21:00	0.15	9	0.9
	12:30:00	0.16	18	0.89
	13:00:00	0.17	48	0.88
	13:15:00	0.18	63	0.87
	13:50:00	0.19	98	0.86
	14:30:00	0.2	138	0.85
	15:15:00	0.22	183	0.83
	15:54:00	0.24	222	0.81
15-Sep-09	9:33:00	0.41	1281	0.64
	10:37:00	0.412	1345	0.638
	10:58:00	0.415	1366	0.635
	11:20:00	0.417	1388	0.633
	13:00:00	0.43	1488	0.62
	13:06:00	0.43	1494	0.62
(t1, h1)	=	222.0	0.81	
(t2, h2)	=	1281.0	0.64	
C		0.923		
Hydraulic Conductivity, k			2.7E-08	

MW4

Depth = Date	1.06 Time	Water Level (m)	L= Elapsed Time (min)	1.06 Height h (m)
14-Sep-09				
	12:40:00	0.15		0.91
	13:22:00	0.18	42	0.88
	13:30:00	0.18	50	0.88
	13:53:00	0.18	73	0.88
	14:37:00	0.21	117	0.85
	15:20:00	0.21	160	0.85
	16:00:00	0.21	200	0.85
15-Sep-09	9:38:00	0.265	1258	0.795
	10:30:00	0.265	1310	0.795
	10:55:00	0.265	1335	0.795
	11:15:00	0.265	1355	0.795
	12:46:00	0.275	1446	0.785
(t1, h1)	=	1335.0	0.80	
(t2, h2)	=	1446.0	0.79	
C		0.042		
Hydraulic Conductivity, k			1.2E-08