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7 March 2019

Mr Peter Jones Project Manager Greaton Development Pty Ltd Suite 3301, Level 33 52 Martin Place Sydney NSW 2000

peter.j@greatondevelopment.com.au

SUBJECT: Preliminary Groundwater Level Investigation

SITE: 23–31 Holdsworth Ave, 24–34 Berry Rd and 42–46 River Rd, St Leonards NSW

Dear Peter,

Geo-Logix Pty Ltd (Geo-Logix) was engaged by Greaton Development Pty Ltd (Greaton) to complete a Preliminary Groundwater Level Investigation at 23–31 Holdsworth Ave, 24–34 Berry Rd and 42–46 River Road, St Leonards NSW 2065 (Figure 1) to assist with preliminary design of underground car parking for proposed high density residential development. Geo-Logix understands that Greaton has acquired the following properties:

23 Holdsworth Ave;	24 Berry Rd;
25 Holdsworth Ave;	26 Berry Rd;
27 Holdsworth Ave;	28 Berry Rd;
29 Holdsworth Ave;	30 Berry Rd;
31 Holdsworth Ave;	32 Berry Rd;
	34 Berry Rd;

42 River Rd; 44 River Rd; and 46 River Rd.

At the time of investigation, Greaton was able to provide access to only 27 Holdsworth Ave and 24 Berry Rd for testing. Therefore, the Geo-Logix's investigation comprised a preliminary investigation of onsite groundwater levels at these two properties (Figure 2).

SCOPE OF WORK

To accomplish this preliminary investigation, Geo-Logix completed the following Scope of Work:

- Review of available geological maps for the area;
- · Review of relevant geotechnical reports within our files;
- Drilling of a boreholes within each accessible property (MW1 and MW2);
- Geology was logged in accordance with USCS and groundwater inflow depths recorded by experienced Geo-Logix staff;
- Conversion of the boreholes to groundwater monitoring wells;

- Gauging of standing groundwater level in the wells and performing of a rising head test in each well;
- Calculation of the aquifer hydraulic conductivity; and
- Provision of this letter report.

SITE DESCRIPTION

Site descriptions are based on a site inspection conducted by Geo-Logix on 25 February to 4 March 2018.

At the time of investigation the site consisted of 14 residential lots with single family dwellings, and comprised a portion of a residential neighbourhood bounded by Park Road, River Road and Holdsworth Avenue.

The site sloped steeply down from north to south with minor retaining walls used to level individual lots. Significant rock outcropping associated with a very steep slope existed between the properties on Berry Road and Holdsworth Avenue and those on River Road.

GROUNDWATER WELL INSTALLATION METHODOLOGY

Soil borings MW1 and MW2 were completed using track mounted drill rigs utilising solid stem augers and rotary air hammer. Boring MW1 was drilled to 7.0 metres below grade (mbg) on 25 February 2019 and boring MW2 was drilled to 7.4 mbg on 27 February 2019. During drilling the encountered soils were logged in accordance with the Unified Soil Classification System (USCS). The depth of encountered groundwater was logged for each well during drilling.

Soil borings MW1 and MW2 were converted to groundwater monitoring wells. The wells were installed in accordance with Minimum Construction Requirements for Water Bores in Australia, Edition 3 (NUDLC, 2012). The groundwater wells were constructed of Class 18, 50 mm diameter PVC pipe. Slotted PVC casing 3 m in length was installed from depths between 4.0 to 7.0 mbg in well MW1 and 4.4 to 7.4 mbg in well MW2. A sand filter pack extended from the base of the borings to 1.0 m above the top of the slotted PVC casing and was sealed with 1.0 m of hydrated bentonite pellets above the sand pack. A cement grout was used to seal the borehole annulus to surface. The wells were finished to grade with a traffic rated steel gatic. Construction details are presented in the attached boring logs (Attachment A).

AQUIFER HYDRAULIC CONDUCTIVITY TESTING

Hydraulic conductivity of the saturated zone was determined by performing a rising head slug tests in each well on 4 March 2019. The rising head tests were completed by measuring the initial groundwater head elevation, removing a volume of water equal to 4–5 L from the well and recording the recharging head elevation at 30 second intervals over a period of 5–27 minutes, this testing process was repeated three times for each well. Slug test data is presented in Attachment B. The recovery data from the slug tests was solved utilising aquifer software Aqtesolv® to obtain a value for hydraulic conductivity (K). A saturated zone extending 3 m below the base of the well was assumed for the purpose of these calculations (This is not indicative of any actual saturated zone). Copies of the output from Aqtesolv® is provided in Attachment C.

GEOLOGY

Regional

The site is underlain by Triassic age Hawkesbury Sandstone of the Wianamatta group, comprised of medium to coarse grained quartz sandstone with very minor shale and laminite lenses.

The majority of the onsite soil has been mapped as belonging to the Glenorie soil landscape typified by friable dark brown loam overlying hardsetting brown clay loam and reddish brown medium clay with a strongly pedal structure. The southern border of the site, comprising the properties along River Road, has been mapped as belonging to the Gymea soil landscape typified by loose coarse sandy loam underlain by yellowish brown clayey sand, sandy clay loam, sandy clay and light clay with a moderately to strongly pedal structure. The Gymea soil landscape is also characterised by shallow outcrops of Hawkesbury Sandstone.

Encountered

Encountered site geology comprised approximately 0.5 m of sandy fill. Natural soils comprised of yellowish orange clayey Sand (SC) from about 0.5–2.0 metres below grade (mbg), and were underlain by greyish orange pink to greyish pink weathered Sandstone. Sandstone competency appeared to increase with depth.

HYDROGEOLOGY

Regional

No registered groundwater bores were identified within 500 m of the site. Groundwater is expected to follow regional topography and flow towards the nearest surface water, Berrys Creek, 175 m to the south.

Encountered

During drilling, groundwater was encountered in sandstone bedrock at 4.8 mbg in boring MW1 and at 5.2 mbg in boring MW2, respectively equivalent to 61.9 and 57.9 metres Australian Height Datum (mAHD). After well installation and equilibration, stabilised groundwater was measured at 3.905 metres below top of casing (mBTOC) in well MW1 and 3.730 mBTOC in well MW2, respectively equivalent to 62.695 and 59.340 mAHD.

Based on Aqtesolv® calculations, aquifer hydraulic conductivity is estimated at 7.8×10^{-8} to 6.9×10^{-7} m/s, within the typical range of conductivities for sandstone (Freeze and Cherry, 1979).

Groundwater is considered to exist as a semi-confined aquifer within sandstone bedrock. Actual groundwater inflow during construction will be highly dependent on intersected rock fractures.

RECOMMENDATIONS

Based on the results of this preliminary groundwater level investigation, onsite groundwater is not expected to affect constructability of the proposed development within the proposed building envelope.

The results of this investigation are necessarily limited as access was only permitted to two site areas. Groundwater depth is expected to vary across the site due to differences in topography and infiltration. In particular, a groundwater discontinuity is expected between the portion of the site between Berry Road and Holdsworth Avenue and the lower elevation site area along River Road. Once further access to the site is available, additional groundwater investigation including installation of a more extensive groundwater monitoring network is recommended. Potential areas for investigation include:

- Installation of two additional wells to 7–8 mbg in properties on Berry Rd/Holdsworth Avenue and surveying of top of well elevations to determine the phreatic surface and hydraulic gradient of groundwater;
- Installation of three wells in the properties at lower elevation along river road to determine the phreatic surface and hydraulic gradient of onsite groundwater in this area which is expected to be discontinuous from the northern portion of site;
- Groundwater sampling and laboratory analysis may be conducted for dewatering assessment in accordance with the *Sydney Coastal Councils Groundwater Management Handbook*; and
- Long term monitoring to evaluate seasonal groundwater elevation fluctuations.

Please do not hesitate to contact Geo-Logix directly (02) 9979 1722 should you require further information.

Yours sincerely

EdiFLy

Edward Lilly BSc Civil Engineering, MIEAust Senior Geotechnical Engineer

FIGURES

Figure 1: Site Location Map Figure 2: Site Map

ATTACHMENTS

Attachment A: Monitoring Well Logs Attachment B: Slug Test Data Attachment C: Aqtesolv® Reports

Ben Pearce BSc (Hons), CEnvP#321 Principal

LIMITATIONS

This report should be read in full, and no executive summary, conclusion or other section of the report may be used or relied on in isolation, or taken as representative of the report as a whole. No responsibility is accepted by Geo-Logix, and any duty of care that may arise but for this statement is excluded, in relation to any use of any part of this report other than on this basis.

This report has been prepared for the sole benefit of and use by the Client. No other person may rely on the report for any purpose whatsoever except with Geo-Logix' express written consent. Any duty of care to third parties that would or may arise in respect of persons other than the Client, but for this statement, is excluded.

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This report is based on the available project information and the subsurface information obtained by Geo-Logix. If there are any revisions to the plans for this project or if deviations from the subsurface conditions noted in this report are encountered during construction, Geo-Logix should be notified immediately to determine if there are consequences to the recommendations provided in this report. If Geo-Logix is not retained to perform these functions, Geo-Logix cannot be responsible for the impact of those conditions on the performance of the project.

Unless otherwise expressly stated, Geo-Logix has assumed that the information and data contained in previous reports carried out by others and reviewed in preparation of this report are completely accurate and has not sought independently to verify the accuracy of the information or data.

Where data from previous reports carried out by others has been incorporated into this report the data are reproduced in this report on the assumption that the data are accurate. Geo-Logix has not sought independently to verify the accuracy of this data and assumes no responsibility in respect of them.

Where laboratory tests have been carried out by others on Geo-Logix' behalf, the tests are reproduced in this report on the assumption that the tests are accurate. Geo-Logix has not sought independently to verify the accuracy of those tests and assumes no responsibility in respect of them.

The geotechnical engineer warrants that the findings, recommendations, specifications, or professional advice contained herein have been made in accordance with generally accepted professional geotechnical engineering practices in the local area at the time of this report. No other warranties are implied or expressed.

This report has been prepared for the specific application to the proposed high density residential development located at 24-34 Berry Rd and 42-46 River Road, St Leonards NSW 2065. After the plans and specifications for the project are more complete the geotechnical engineer should be provided with the opportunity to review the final design plans and specifications to assess whether our engineering recommendations have been properly incorporated into the design documents. At that time, it may be necessary to submit supplementary recommendations.

FIGURES





ATTACHMENT A

Monitoring Well Log

	Geo-Logix environment · geotech	Geo-Logix Pty Ltd Building Q2, Level 3 Unit 2309 / 4 Daydream Street Warriewood NSW 2102 www.geo-logix.com.au	Hole ID. Project Number: Hole Depth: Sheet:	MW1 1901011 7.00 m 1 of 1
Project Name:	Preliminary Groundwater Level	Date Started:	25/02/2019	
Location / Site:	24 Berry Road, St Leonards NS	W	Date Completed:	25/02/2019
Client:	Greaton Development Pty Ltd		Depth to Groundwater: (mBT	OC) 3.905
Contractor:	BG DRILLING PTY LTD	Ground Level: (mAHD)	66.66	
Method:	Solid Flight Auger, Rotary Air H	lammer	Top of Casing: (mAHD)	66.60

Method	Water Level	Depth (mBGL)	HC Odour	Material Type	USCS Symbol	Graphic Log	Material Description	Moisture	Observations / Comments	Well Details	Well Construction
		- - 0.40 0.5 0.60	z z	Fill		×	FILL - moderate brown (5YR 3/4), 20% clay, 60% sand, 20% gravel, moderately compacted. FILL - moderate brown (5YR 4/4), 5% clay, 90% sand, 5% gravel, poorly	damp			
	þ	0.60	2				Compacted.	damp damp			
	_ Г	<u>1.0</u>	Z		SC		Clayey SAND - dark yellowish orange (10YR 6/6), 30% clay, 70% sand, medium dense.				1
A	F	1.20 - 1.50	Z		SC		Clayey SAND - pale yellowish orange (10YR 8/6), 20% clay, 80% sand, medium dense.	damp			
SFA		2.0	z		SC		Clayey SAND - pale yellowish orange (10YR 8/6), 15% clay, 85% sand, medium dense.	damp	2.00		
	F	2.20	z		SP		SAND with Clay - pale yellowish orange (10YR 8/6) and very pale orange	damp			
	F	- 2.80	z				(10YR 8/2), 10% clay, 90% sand, medium dense. Highly Weathered SANDSTONE - greyish orange pink (10R 8/2), soft rock.	damp			-
		<u>3</u> .0	z				Highly Weathered SANDSTONE - moderate reddish orange (10R 6/6), soft rock.	damp	3.00		
	V	3.50 	z	Natural			Moderately Weathered SANDSTONE - moderate red (5R 4/6), hard rock.	damp	4.00		
		4.10 	Z				Moderately Weathered SANDSTONE - very pale orange (10YR 8/2), hard rock.	damp			
	_	4.50					Moderately Weathered SANDSTONE - moderate red (5R 4/6), hard rock.	damp			
RAH		- 5.0 - 5.5 - 6.0 - 6.5	Ζ					wet			<u> </u>
	-	7.0 7.5					Hole Terminated at 7.000 m Target depth.				<u>·</u>
	bre droca Hi M	8.0 eviati arbon ligh lediun ow ero	Odo	ur		Sampl D U B R C J ASB	e Type Strength Testing Additional Comments Disturbed SPT Standard Penetration Test Encountered Groundwater at Undisturbed DCP Dynamic Cone Penetrometer Stabilised Groundwater at 3.5 Bulk PP Pocket Penetrometer Stabilised Groundwater at Continuous Image: Contered Groundwater Encountered Groundwater Jar Stabilised Groundwater			L	
R	6	U	M	A	Þ	Lo	g Drawn By: Laurie White Logged By: Kiran Baby Contact: laurie.white@reumad.com.au Checked By: Ted Lilly		Date: 25/02/2019 Date: 06/03/2019		

Monitoring Well Log

	Geo-Logix environment · geotech	Geo-Logix Pty Ltd Building Q2, Level 3 Unit 2309 / 4 Daydream Street Warriewood NSW 2102 www.geo-logix.com.au	Hole ID. Project Number: Hole Depth: Sheet:	MW2 1901011 7.40 m 1 of 1
Project Name:	Preliminary Groundwater Level	Date Started:	27/02/2019	
Location / Site:	27 Holdsworth Avenue, St Leor	nards NSW	Date Completed:	27/02/2019
Client:	Greaton Development Pty Ltd		Depth to Groundwater: (mBT	OC) 3.730
Contractor:	BG DRILLING PTY LTD	Ground Level: (mAHD)	63.14	
Method:	Solid Flight Auger, Rotary Air H	lammer	Top of Casing: (mAHD)	63.07

Method Water Level	Depth (mBGL)	HC Odour	Material Type	USCS Symbol	Graphic Log	Material Description	Moisture	Observations / Comments	Well Details	Well Construction
	0.03 0.10 0.50 0.50 0.70 - 1.00 - - - - - - - - - - - - - - - - - -	z	Fill	sc sc sc		TILE. FILL - moderate brown (5YR 3/4), 20% clay, 10% silt, 60% sand, 10% gravel, medium compaction. Clayey SAND - moderate brown (5YR 4/4), 20% clay, 80% sand, loose. Clayey SAND - dark yellowish orange (10YR 6/6), 40% clay, 60% sand, medium dense. Clayey SAND - dark yellowish orange (10YR 6/6), 30% clay, 70% sand, medium dense. Clayey SAND - dark yellowish orange (10YR 6/6), 30% clay, 70% sand, medium dense. Clayey SAND - moderate reddish brown (10R 4/6), 20% clay, 80% sand, medium dense. Clayey SAND - moderate reddish brown (10R 4/6), 20% clay, 80% sand, medium dense. Clayey SAND - light red (5R 6/6), 30% clay, 70% sand, medium dense. Highly Weathered SANDSTONE - moderate reddish orange (10R 6/6), dense, weathered sandstone. Highly Weathered SANDSTONE - greyish orange pink (10R 8/2), dense, weathered sandstone. Moderately Weathered SANDSTONE - moderate orange pink (5YR 8/4),	damp damp damp damp damp damp damp damp	damp damp damp damp damp damp damp damp 2.50		
SFA, HFA	3.5 4.0 4.5 5.0 7 5.5 5.5	z	Natural			dense, weathered sandstone.	wet	3.50 4.40		
	6.00 6.5 7.0 7.5	z				Moderately Weathered SANDSTONE - very pale orange (10YR 8/2), very dense, weathered sandstone. Moderately Weathered SANDSTONE - moderate orange pink (5YR 8/4), very dense, weathered sandstone. Hole Terminated at 7.400 m Target depth.	damp damp			
Hydro H M L	reviati ocarbor High Mediur Low Zero	1 Odo	ur		D U B R C J	e Type Strength Testing Disturbed SPT Undisturbed DCP Dynamic Cone Penetrometer Bulk PP Pocket Penetrometer Continuous Jar Asbestos				<u> </u>
R	-0	M	A	Þ	Log	g Drawn By: Laurie White Logged By: Kiran Baby Contact: laurie.white@reumad.com.au Checked By: Ted Lilly		Date: 27/02/2019 Date: 06/03/2019		

ATTACHMENT B

Aquifer Rising Head Test Data



MW1									
Standing Water Level: 3.905 m									
Total Well Depth: 7.014 m									
Set 1 Set 2 Set 3									
Time	Depth	Time	Depth	Time	Depth	Time	Depth		
(s)	(m)	(s)	(m)	(s)	(m)	(s)	(m)		
0	4.791	720	4.172	0	5.015	0	5.086		
30	4.698	780	4.151	30	4.887	30	4.994		
60	4.661	840	4.129	60	4.824	60	4.925		
90	4.621	900	4.112	90	4.764	90	4.861		
120	4.591	960	4.094	120	4.716	120	4.805		
150	4.556	1020	4.080	150	4.672	150	4.762		
180	4.529	1080	4.065	180	4.639	180	4.714		
210	4.498	1140	4.051	210	4.606	210	4.672		
240	4.471	1200	4.037	240	4.574	240	4.643		
270	4.441	1260	4.028	270	4.547	270	4.610		
300	4.416	1320	4.019	300	4.516	300	4.585		
360	4.371	1380	4.012	360	4.462	360	4.529		
420	4.330	1440	4.005	420	4.416	420	4.475		
480	4.293	1500	3.998	480	4.375	480	4.428		
540	4.255	1560	3.991	540	4.334	540	4.386		
600	4.226	1620	3.985	600	4.302	600	4.345		
660	4.200								

	MW2								
	Standing Water Level: 3.730 m								
Total Well	Total Well Depth: 7.545 m								
	et 1		et 2	Set 3					
Time	Depth	Time	Depth	Time	Depth				
(s)	(m)	(s)	(m)	(s)	(m)				
0	5.515	0	6.461	0	6.669				
30	5.489	30	6.434	30	6.654				
60	5.470	60	6.415	60	6.641				
90	5.454	90	6.394	90	6.630				
120	5.441	120	6.378	120	6.619				
150	5.429	150	6.365	150	6.607				
180	5.417	180	6.351	180	6.598				
210	5.407	210	6.339	210	6.586				
240	5.400	240	6.326	240	6.574				
270	5.392	270	6.313	270	6.563				
300	5.384	300	6.301	300	6.554				
360	5.369	360	6.276	360	6.539				
420	5.355	420	6.255	420	6.515				
480	5.341	480	6.231	480	6.495				
540	5.328	540	6.210	540	6.478				
600	5.314	600	6.191	600	6.459				
660	5.302								

ATTACHMENT C



