Detailed analysis of a raft would be required to estimate the settlements and the contact pressures below the raft. The preliminary design of the raft may be completed using the elastic parameter model provided below with both upper and lower bound parameters being checked so as to estimate differential settlements due to horizontal variations in soil properties beneath the raft. We must emphasise that the properties of the deep soil layers have not been clearly established to date and further work in this regard is necessary.

RECOMMENDED ELASTIC PARAMETERS FOR DESIGN			
Unit	**Parameters**	**Lower Bound**	**Upper Bound**
Medium Dense to Dense Sand	Depth (m)/ Elastic Modulus (MPa)/ Poisson's Ratio	7m – 14.9m/20/0.3	6m – 16m/50/0.3
Very Loose to Loose Clayey Sand	Depth (m)/ Elastic Modulus (MPa)/ Poisson's Ratio	Various bands/4/0.3	Various bands/12/0.3
Clay or sandy clay, firm to stiff or stiff	Depth (m)/ Elastic Modulus (MPa)/ Poisson's Ratio	16m – 21.8m/8/0.3	15.2m – 16.8m/15/0,3
Dense to Very Dense Sand	Depth (m)/ Elastic Modulus (MPa)/ Poisson's Ratio	0	19.8m – 22.9m/100/0.3
Bedrock	Depth (m)	>24m	21.8m

The design of heavily loaded raft footings is complex and requires complex analysis procedures for soil/structure interaction. Therefore, we expect that the design of the raft will be an iterative procedure with both the geotechnical and structural engineers having input to the process. The first pass of the analysis will demonstrate the potential of the concept and identify the parameters critical to the design. The parameters will then need refinement and may require further investigation and testing to justify the key assumptions and enable the design to be refined. Further geotechnical investigations involving a close grid of Electrical Friction Cone Penetrometer (EFCP) testing together with Marchetti Dilatometer testing may be needed to obtain a continuous subsurface profile and assess the extent of any weaker subsurface conditions. The latter tool, the dilatometer, is particularly useful as it provides a direct measurement of the soil stiffness characteristics (elastic modulus). A potential drawback of any indirect testing such as the EFCP is that the mixed soils (not clearly clay or sand) are difficult to interpret and some direct sampling may be necessary.

We can assist with the detailed geotechnical analysis of the raft using our finite element analysis software, once the initial raft details are supplied by the structural engineer.

4.7 Basement Slab

For a tanked basement, the basement floor slab or raft slab must be designed for uplift forces due to hydrostatic pressure, with normal groundwater levels assumed at depths of about 1m below existing ground levels but with peak levels at ground surface level. Peak levels can be limited by use of pressure relief drains if necessary, but in this case as the groundwater is so shallow it may not really be worthwhile. Waterproof construction systems are required for external walls. An assessment of groundwater seepage rates during construction can be assessed by computer modelling. Data could be improved by completing pump out tests within the monitoring wells installed in BH1 and BH4.

As a minimum, following dewatering and bulk excavation, the exposed subgrade should be proof-rolled with a 5 tonne deadweight, smooth drum vibratory roller. The proof-rolling should be carried out under the direction of an experienced earthworks superintendent to assist in the detection of unstable areas which were not disclosed by this investigation and to be sure that vibrations do not affect adjoining properties. Any unstable areas identified during proof-rolling should be locally excavated down to a competent base and replaced with engineered fill. If a raft slab footing is adopted a more stringent specification will be needed which will include a testing regime to demonstrate that the subgrade matches the design assumptions for the raft.

The materials recommended for use as engineered fill are well-graded granular materials, such as ripped and/or crushed sandstone, free of deleterious substances, contaminants and having a maximum particle size of 75mm. The sandy soils excavated from the site would also be suitable for reuse as engineered fill. Engineered fill should generally be placed in loose layers not exceeding 150mm and compacted to at least 98% of Standard Maximum Dry Density (SMDD). In-situ density tests will be required at close frequency to confirm the target density has been achieved.

A gravel working platform would be necessary to support the large piling rigs likely to be needed within the excavation if piled footings are used; such a layer would also be useful as a construction platform. This working platform can be a significant cost factor which must be considered early in the design. Large rigs even on medium dense sand may need platforms 600mm or more in thickness and the cost of exporting the over-excavated material for the platform is also likely to be high.

4.8 Further Work

Although the investigation to date has provided a good basic understanding of the geotechnical conditions at the site, design and construction of the proposed development will require significant further geotechnical work once the design concepts are better known. We envisage some or all of the following being necessary:

- Additional EFCP and/or dilatometer testing to assess soil parameters for raft slab design.
- Additional cored boreholes to assess rock properties for pile design.
- Groundwater quality testing.
- Wallap/Plaxis analysis of shoring walls.
- Seepage analysis to assess likely volumes of groundwater inflows during construction and drawdown effect on water table outside the excavation.
- Calculation of working platform thickness for construction plant.

5 GENERAL COMMENTS

The recommendations presented in this report include specific issues to be addressed during the construction phase of the project. In the event that any of the construction phase recommendations presented in this report are not implemented, the general recommendations may become inapplicable and JK Geotechnics accept no responsibility whatsoever for the performance of the structure where recommendations are not implemented in full and properly tested, inspected and documented.

The long term successful performance of raft slabs may be dependent on the satisfactory completion of the earthworks. In order to achieve this, the quality assurance program should not be limited to routine compaction density testing only. Other critical factors associated with the earthworks may include subgrade preparation, selection of fill materials, control of moisture content and drainage, etc. The satisfactory control and assessment of these items may require judgment from an experienced engineer. Such judgment often cannot be made by a technician who may not have formal engineering qualifications and experience. In order to identify potential problems, we recommend that a pre-construction meeting be held so that all parties involved understand the earthworks requirements and potential difficulties. This meeting should clearly define the lines of communication and responsibility.

Occasionally, the subsurface conditions between the completed test locations may be found to be different (or may be interpreted to be different) from those expected. Variation can also occur with groundwater conditions, especially after climatic changes. If such differences appear to exist, we recommend that you immediately contact this office.

This report provides advice on geotechnical aspects for the proposed civil and structural design. As part of the documentation stage of this project, Contract Documents and Specifications may be prepared based on our report. However, there may be design features we are not aware of or have not commented on for a variety of reasons. The designers should satisfy themselves that all the necessary advice has been obtained. If required, we could be commissioned to review the geotechnical aspects of contract documents to confirm the intent of our recommendations has been correctly implemented.

A waste classification will need to be assigned to any soil excavated from the site prior to offsite disposal. Subject to the appropriate testing, material can be classified as Virgin Excavated Natural Material (VENM), General Solid, Restricted Solid or Hazardous Waste. Analysis takes seven to 10 working days to complete, therefore, an adequate allowance should be included in the construction program unless testing is completed prior to construction. If contamination is encountered, then substantial further testing (and associated delays) should be expected. We strongly recommend that this issue is addressed prior to the commencement of excavation on site.

This report has been prepared for the particular project described and no responsibility is accepted for the use of any part of this report in any other context or for any other purpose. If there is any change in the proposed development described in this report then all recommendations should be reviewed. Copyright in this report is the property of JK Geotechnics. We have used a degree of care, skill and diligence normally exercised by consulting engineers in similar circumstances and locality. No other warranty expressed or implied is made or intended. Subject to payment of all fees due for the investigation, the client alone shall have a licence to use this report. The report shall not be reproduced except in full.

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SOIL TEST SERVICES
ABN 43 002 145 173

TABLE A
POINT LOAD STRENGTH INDEX TEST REPORT

Client:	JK Geotechnics	**Ref No:**	29353S
Project:	Proposed Residential Development	**Report:**	A
Location:	177 Russell Avenue, Dolls Point, NSW	**Report Date:**	11/05/2016
		Page 1 of 1	

BOREHOLE NUMBER	DEPTH m	$I_{S\,(50)}$ MPa	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH (MPa)
1	22.33-22.37	0.2	4
	22.90-22.94	0.09	2
	23.18-23.21	0.2	4
	23.72-23.76	0.6	12
	24.15-24.19	1.2	24
	24.65-24.70	1.4	28
	25.22-25.26	1.7	34
2	24.40-24.44	0.04	1
	24.84-24.87	1.1	22
	25.31-25.35	1.3	26
	25.71-25.76	1.7	34
	26.11-26.15	2.4	48
	26.67-26.70	1.3	26
3	23.31-23.35	0.2	4
	23.85-23.89	0.5	10
	24.25-24.29	0.5	10
	24.71-24.75	1.4	28
	25.09-25.14	1.2	24
	25.62-25.66	1.6	32
	26.04-26.07	1.8	36
4	22.53-22.56	0.4	8
	23.00-23.04	0.6	12
	23.50-23.54	1.1	22
	24.16-24.20	1.7	34
	24.72-24.76	1.2	24
	25.26-25.31	1.8	36

NOTES:

1. In the above table testing was completed in the Axial direction.
2. The above strength tests were completed at the 'as received' moisture content.
3. Test Method: RMS T223.
4. For reporting purposes, the $I_{S(50)}$ has been rounded to the nearest 0.1MPa, or to one significant figure if less than 0.1MPa
5. The Estimated Unconfined Compressive Strength was calculated from the point load Strength Index by the following approximate relationship and rounded off to the nearest whole number :
   U.C.S. = 20 $I_{S\,(50)}$

12 Ashley Street, Chatswood, NSW 2067
tel: +61 2 9910 6200

email: sydney@envirolab.com.au
envirolab.com.au

Envirolab Services Pty Ltd - Sydney | ABN 37 112 535 645

CERTIFICATE OF ANALYSIS 146253

Client:
JK Geotechnics
PO Box 976
North Ryde BC
NSW 1670

Attention: Arthur Billingham

Sample log in details:

Your Reference:	**29353S, Dolls Point**
No. of samples:	3 Soils
Date samples received / completed instructions received	09/05/2016 / 09/05/2016

Analysis Details:
Please refer to the following pages for results, methodology summary and quality control data.
Samples were analysed as received from the client. Results relate specifically to the samples as received.
Results are reported on a dry weight basis for solids and on an as received basis for other matrices.
Please refer to the last page of this report for any comments relating to the results.

Report Details:

Date results requested by: / Issue Date:	16/05/16 / 13/05/16
Date of Preliminary Report:	Not Issued

NATA accreditation number 2901. This document shall not be reproduced except in full.
Accredited for compliance with ISO/IEC 17025. **Tests not covered by NATA are denoted with *.**

Results Approved By:

Jacinta Hurst
Laboratory Manager

Misc Inorg - Soil Our Reference: Your Reference Depth Date Sampled Type of sample	UNITS ---------- - ---------- 	146253-1 BH1 20.7-21.15 4/05/2016 Soil	146253-2 BH2 5.7-6.15 3/05/2016 Soil	146253-3 BH3 15.4-15.85 5/05/2016 Soil
Date prepared	-	11/05/2016	11/05/2016	11/05/2016
Date analysed	-	11/05/2016	11/05/2016	11/05/2016
pH 1:5 soil:water	pH Units	6.6	7.5	7.6
Chloride, Cl 1:5 soil:water	mg/kg	1,100	2,100	1,800
Sulphate, SO4 1:5 soil:water	mg/kg	220	360	470
Resistivity in soil*	ohmm	13	7.0	7.5

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA latest edition, 4500-H+. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B. Alternatively determined by colourimetry/turbidity using Discrete Analyer.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25oC in accordance with APHA 22nd ED 2510 and Rayment & Lyons. Resistivity is calculated from Conductivity.

Client Reference: 29353S, Dolls Point

QUALITY CONTROL Misc Inorg - Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			11/05/2016	146253-1	11/05/2016 || 11/05/2016	LCS-1	11/05/2016
Date analysed	-			11/05/2016	146253-1	11/05/2016 || 11/05/2016	LCS-1	11/05/2016
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	146253-1	6.6 || 6.5 || RPD: 2	LCS-1	101%
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	<10	146253-1	1100 || 1100 || RPD: 0	LCS-1	99%
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	146253-1	220 || 190 || RPD: 15	LCS-1	114%
Resistivity in soil*	ohmm	1	Inorg-002	<1.0	146253-1	13 || 14 || RPD: 7	[NR]	[NR]

Report Comments:

Asbestos ID was analysed by Approved Identifier:	Not applicable for this job
Asbestos ID was authorised by Approved Signatory:	Not applicable for this job

INS: Insufficient sample for this test	PQL: Practical Quantitation Limit	NT: Not tested
NR: Test not required	RPD: Relative Percent Difference	NA: Test not required
<: Less than	>: Greater than	LCS: Laboratory Control Sample