GEOTECHNIQUE® PTY LTD

ABN 64 002 841 063

Member of
Australian Contaminated
Land Consultants Association Inc

Certified System
Quality
ISO 9001
SAI GLOBAL

Job No: 13262/1
Our Ref: 13262/1-AB
18 September 2014

ARH Warriewood Pty Ltd
Level 1, 76 Queen Street
WOOLLAHRA NSW 2025
Email: john@ashtonrowe.com.au

Attention: Mr J Tyree

Dear Sir

re: **Proposed Subdivision for Residential Development**
53C Warriewood Road, Warriewood
Permeability Tests

This report provides the results of permeability tests carried out at 53C Warriewood Road, Warriewood.

We understand that the proposed development at the above site comprises subdivision to facilitate construction of medium density residential flat buildings with two to three storeys above the ground, one level of basement and two storey townhouses. The basement excavation is anticipated to be up to about 2.0m deep.

Geotechnique Pty Ltd completed a geotechnical investigation at the above site and provided Report No 13262/1-AA dated 5 September 2014. This report indicates that the subsurface profile across the site comprises a sequence of topsoil/fill and alluvial soils underlain by bedrock. The depth to alluvial soils and bedrock in boreholes vary from 0.8m to 0.9m and 13.7m to 16.6m respectively. The report also provides recommendations on design of excavations, retaining walls, floor slabs and footings.

It is now understood that the proposed development at the site also includes construction of an On-site Stormwater Detention (OSD) system. Therefore, permeability tests were required to assess water absorption capacity of soils across the site.

A Field Engineer from this company carried out permeability tests in three boreholes, designated as P-1, P-2 and P-3 and indicated by Stephen Bowers Architects in a site plan provided for preparation of this report. Approximate test locations are indicated on attached Drawing No 13262/1-AB1. The architect also indicated that the permeability tests are to be carried out in about 1.5m deep boreholes.

Additionally we have also carried out infiltration tests, using double ring infiltrometer, adjacent to permeability tests.

Permeability indicates the relative ease of movement of water within the soil and determines how fast water move through the soil. But infiltration represents rate of downward entry of liquid into the ground. Therefore, even if permeability and infiltration have the same unit they do not represent exactly the same thing.

Permeability Tests

Permeability tests were carried out boreholes using the Falling Head test method and involved the following steps:

- Drilling boreholes using an auger mounted on a bobcat. Boreholes were terminated in fine to medium grained silty sand at depths of about 1.5m from the existing ground surface.
- Inserting PVC casing to the bottom of boreholes.
- Back filling the annular space between the casing and borehole walls using clayey soils obtained from excavation within the site. Saturating the soil surrounding the boreholes by filling and refilling the boreholes several times.
- Saturating the soil surrounding the boreholes by filling and refilling the boreholes several times.
- After saturation of soil is achieved, the borehole is filled with water and rate of water level drop in the borehole is measured with time. The measurements were repeated several times until similar falling rates were obtained in two consecutive tests.

The measurements of rate of water level drop in the casing were used to estimate permeability of soil at the base of the boreholes. Estimates of permeability at three test locations are as follows:

Test Location	Nature of Soil	Estimate of Vertical Permeability (m/s)	Estimate of Horizontal Permeability (m/s)
P-1	Silty Sand, fine to medium grained	$6.6x10^{-9}$	$3.3x10^{-7}$
P-2	Silty Sand, fine to medium grained	$3.2x10^{-8}$	$4.8x10^{-6}$
P-3	Silty Sand, fine to medium grained	$3.2x10^{-8}$	$4.8x10^{-6}$

The alluvial deposit comprises mixture and layers of sandy and silty soils. The horizontal permeability is higher than the vertical permeability because of ease of flow of water along the horizontal layers of sandy soils. The layers of silty soil reduced the permeability in vertical direction.

Infiltration Tests

The double ring infiltrometer test involved the following:

- Strip about 50mm to 100mm of surface soil and levelling the exposed surface of soil by very gently tamping. Gravel where encountered was removed.
- Drive both inner and outer rings into to the ground by about 50mm to 100mm.
- Fill the inner ring and annular space between inner and outer ring with water to depth of about 100mm.
- Start the test by measuring rate of water level drop in the inner ring and annular space with time and volume of water required to maintain the water levels constant. The measurements were repeated several times until similar water level falling rate or water volume to maintain the same water level were obtained in two consecutive tests.

The measurements of water volume added to maintain the water levels in inner ring and annular space between inner and outer rings were used to estimate the infiltration rate of near surface soils. Estimates of infiltration at three test locations are as follows:

Test Location	Nature of Soil	Estimate of Vertical Infiltration (m/s)
P-1	Silty Sand, fine to medium grained, with some gravel	$1.9x10^{-5}$
P-2	Silty Sand, fine to medium grained, with some gravel	$1.7x10^{-5}$
P-3	Silty Sand, fine to medium grained, with some gravel	$1.7x10^{-5}$

Discussion and Conclusion

Results of permeability and infiltration tests summarised above indicate the following:

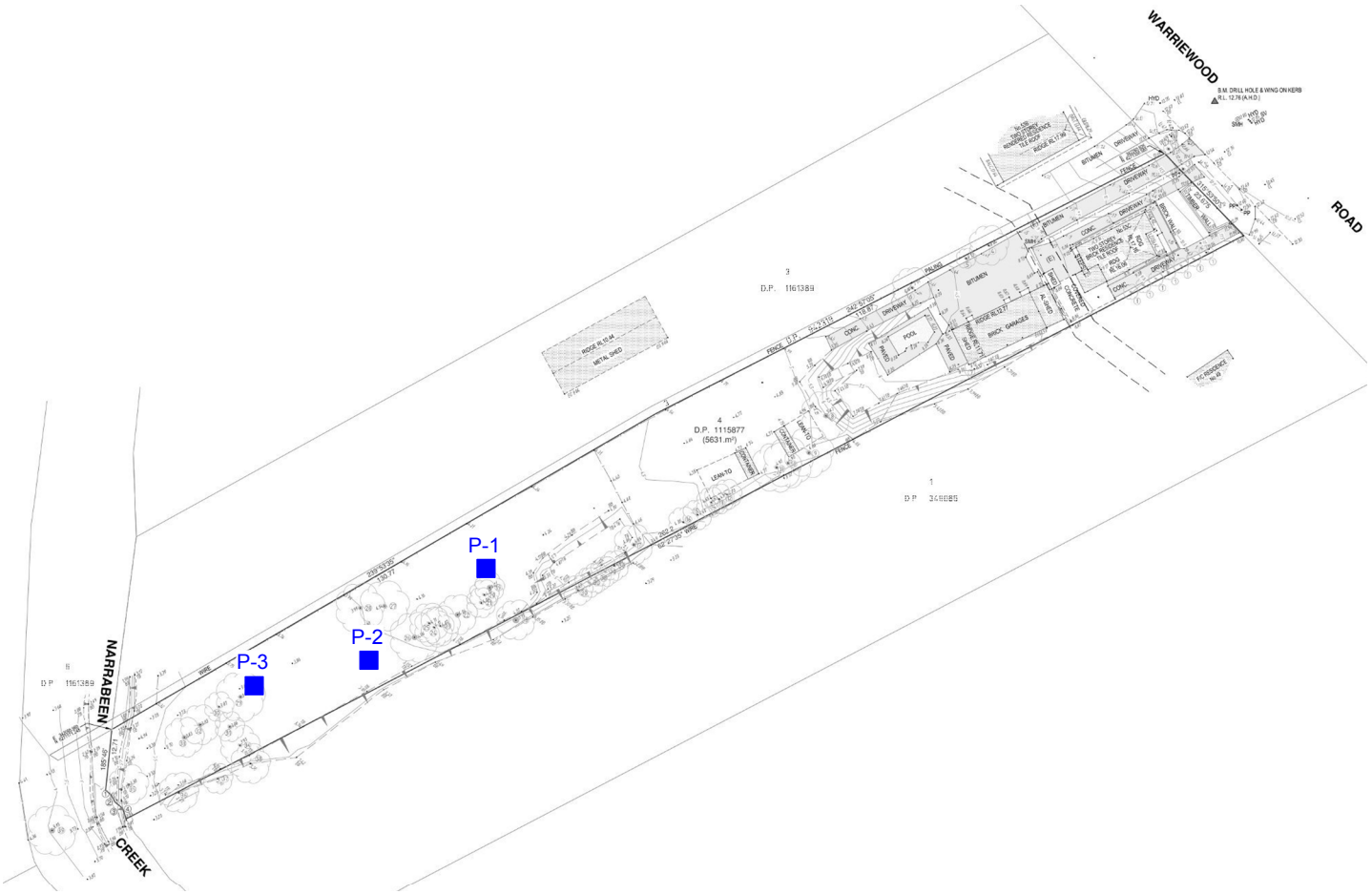
- The sub-surface profile to depth of about 1.5m comprises a layer of about 1.0m thick fill comprising silty sand with some gravel and alluvial soils comprising fine to medium grained silty sand. It is also our assessment that the silty sand extends to depth of about 6.0m.
- Depth to groundwater level across the site is about 1.0m to 1.5m from existing ground surface.
- Based on permeability tests the subsurface soils to depth of about 1.5m is assessed to have good drainage characteristics in horizontal direction but poor drainage characteristics in vertical direction.
- Based on infiltration tests the absorption capacity of silty sand to depth of about 1.5m is estimated to be about $0.02L/m^2/s$.
- As sub-surface soils are sandy and stormwater is expected to contain insignificant amount of clayey materials (resulting in blocking of voids in sand), the change in absorption rate in the long term is anticipated to be insignificant. Therefore, the long term infiltration rate will be similar to that indicated above.
- As the sub-surface material is predominantly sandy and the depth to groundwater table is assessed to be about 1.0m to 1.5m from existing ground surface, water in the absorption pit is anticipated to infiltrate both horizontally and vertically.

Should you have any questions relating to this report, please do not hesitate to contact the undersigned.

Yours faithfully
GEOTECHNIQUE PTY LTD

INDRA JWORCHAN
Principal Geotechnical Engineer

Attached Location Plan – Drawing No 13262/1-AB1



N

LEGEND

Permeability Test

0 15 30 45 60 75m

Scale 1:1500

GEOTECHNIQUE ® PTY LTD

PO Box 880
Penrith NSW 2750
Tel: 02 4722 2700
Fax: 02 4722 2777
e-mail:info@geotech.com.au
www.geotech.com.au

NOTES

1. Site features are indicative and are not to scale.
2. This drawing has been produced using a base plan provided by others to which additional information e.g test pits, borehole locations or notes have been added. Some or all of the plan may not be relevant at the time of producing this drawing

ARH Warriewood
Proposed Residential Subdivision
53C Warriewood Road
Warriewood

Permeability Test Locations

Drawing No: 13262/1-AB1
Job No: 13262/1
Drawn By: MH
Date: 18 September 2014
Checked By: IJ

File No: 13262-1
Layers: 0, AB1