Appendix E

GEOTECNICAL ASSESSMENT (RCA AUSTRALIA)

RCA ref 16035-201/0
Client ref WO13822

17 February 2022

Port of Newcastle
Level 4, 251 Wharf Road
NEWCASTLE NSW 2300

Attention: Peter Ostrowski

GEOTECHNICAL INVESTIGATION
CARRINGTON HYDRAULIC ENGINE HOUSE
106 BOURKE STREET, CARRINGTON

INTRODUCTION

This report describes geotechnical investigation studies carried out for Port of Newcastle for a proposed steel access ramp at Carrington Pump House.

Based on supplied information issue drawings prepared by Northrop dated 25 October 2021, it is understood that construction of a steel access ramp is proposed outside the building adjacent to the southern edge at the western end. It is understood that the steel access ramp will be lightly loaded with foundations to support the ramp being provisionally designed based on an allowable bearing pressure of 50kPa.

RCA have previously undertaken geotechnical investigations at the site for Port of Newcastle as described in the following:

- RCA ref 11968-201/1 dated 24 February 2016
- RCA ref 11968a-101-0 letter Report dated 6 July 2016

The previous investigations indicate the subsurface conditions at the site are characterised as uncontrolled fill comprising of a mixture of fines, sand, gravel and cobble sized particles overlying firm to stiff clays encountered between at about 4-5m depth overlying medium dense sands. Groundwater was previously encountered at approximately 1.5m depth.

FIELD INVESTIGATION AND SUBSURFACE CONDITIONS

Field investigation was carried out on 10 February 2022 and comprised:

- Hand auger boreholes at three locations shown on the attached **Drawing 1** to depths of up to 0.8m.
- Dynamic cone penetrometer (DCP) tests at the hand auger borehole locations to depths of up to 1.3m.

The hand auger boreholes generally encountered sandy and gravelly fill materials. All hand auger boreholes and DCP tests encountered refusal on obstructions, inferred to be large particles e.g. cobbles, within the fill profile. The dynamic penetrometer test results indicated poorly compacted/loose fill material was present in the upper 0.5m of the fill profile.

Details of the subsurface conditions at the borehole locations are shown on the attached engineering logs. Explanatory notes are also attached which define logging symbols, terms and abbreviations.

Groundwater was not encountered within the investigation depths at the time of field investigation. Groundwater conditions and levels may vary with climate and site conditions.

DISCUSSION AND COMMENTS ON FOUNDATIONS

The previous and current geotechnical investigations at the site indicate that deep foundations founded below the fill at the site are likely to be problematic due to the nature of the fill material, the depth to groundwater and the sensitivity of the building to vibrations from installation of driven piles.

The dynamic penetrometer tests carried out within the footprint of the proposed access ramp indicate that poorly compacted/loose fill material was present in the upper 0.5m of the fill profile.

Based on the site constraints and the subsurface conditions encountered, the most suitable founding strata for the proposed steel access ramp is expected to be the existing fill material below 0.5m depth and above the groundwater level previously encountered at about 1.5m depth.

Footings founded below 0.5m depth may be designed based on an allowable bearing pressure of 50kPa.

All loosened material or fall in should be removed from the base of footing excavations prior to placing concrete.

Footings proportioned for 50kPa bearing pressure are expected to settle less than 10mm.

All footings for the proposed access ramp should be founded on materials of similar stiffness. Due to potential variability within the existing fill material it is recommend that the footing excavations be inspected by a suitably qualified and experienced engineer during construction.

LIMITATIONS

This report has been prepared for Port of Newcastle in accordance with the agreement with RCA. The services performed by RCA have been conducted in a manner consistent with that generally exercised by members of its profession and consulting practice.

This report has been prepared for the sole use of Port of Newcastle for the specific purpose and the specific development described in the report. The report may not contain sufficient information for purposes or developments other than that described in the report or for parties other than Port of Newcastle. This report shall only be presented in full and may not be used to support objectives other than those stated in the report without permission.

The information in this report is considered accurate at the date of issue with regard to the current conditions of the site. The conclusions drawn in the report are based on interpolation between boreholes or test pits. Conditions can vary between test locations that cannot be explicitly defined or inferred by investigation.

Yours faithfully
RCA AUSTRALIA

Robert Cater
Senior Geotechnical Engineer

Dr Mark Allman
Principal Geotechnical Engineer

ATTACHMENTS

Drawing 1 - Test Location Plan

Engineering Logs

Explanatory Notes

LEGEND

Approximate site boundary

Approximate borehole location

Note: Aerial image taken from Nearmap, 6 November 2021
(used in accordance with commercial licence)

0 5 10 20 30 40
metres

N

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TEST LOCATION PLAN
106 BOURKE STREET
CARRINGTON

CLIENT	Port of Newcastle			RCA Ref	16035-201/0
DRAWN BY	RC	SCALE	1:24,000 (A3)	DRAWING No 1	REV 0
APPROVED BY	MA	DATE	17/02/2022	OFFICE	NEWCASTLE

GEOTECHNICAL BOREHOLE LOG
HA1

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PROJECT No: 16035
CLIENT: Port of Newcastle
PROJECT: Geotechnical Investigation
LOCATION: 106 Bourke Street, Carrington

DATE: 10/02/2022
SURFACE RL:
COORDS:
EXCAVATION METHOD: Hand Auger

WATER	DYNAMIC PENETROMETER	FIELD TEST	SAMPLE	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	STRUCTURE AND ADDITIONAL OBSERVATIONS
Not Encountered	1, 1			0.00–0.15		ML	FILL, Gravelly Sandy SILT, low plasticity, dark grey/brown, fine to medium sub-angular gravel	M		FILL Adjacent DCP test conducted with counts as follows: 1,0,5,5,3,12/90mm hammer bouncing
	2			0.15–0.30		SM	FILL, Silty SAND, fine to medium grained, dark grey			
	4, 5			0.30–0.50		SP	FILL, SAND, fine to medium grained, grey			
	4, 3, 4			0.50–0.80		GM	FILL, Silty Sandy GRAVEL, fine to coarse, grey, sub-rounded to sub-angular			
	6, 12, 14			0.80			BOREHOLE HA1 TERMINATED AT 0.80 m			Hand auger refusal on obstruction in fill. DCP hammer bouncing at 1.05m

Depth scale: 1.0, 1.5

LOGGED: RC | CHECKED: MA | DATE: 17/02/2022

GEOTECHNICAL BOREHOLE LOG
HA2

SHEET 1 OF 1

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PROJECT No: 16035
CLIENT: Port of Newcastle
PROJECT: Geotechnical Investigation
LOCATION: 106 Bourke Street, Carrington

DATE: 10/02/2022
SURFACE RL:
COORDS:
EXCAVATION METHOD: Hand Auger

Borehole Information					Field Material Information					
WATER	DYNAMIC PENETROMETER	FIELD TEST	SAMPLE	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	STRUCTURE AND ADDITIONAL OBSERVATIONS
Not Encountered	1, 1, 0, 2, 6, 10			0.0 – 0.60 (0.5)		SM	FILL, Gravelly Silty SAND, fine to medium grained, dark grey	M		FILL
	11			0.60 – 0.70		GM	FILL, Silty GRAVEL, fine to coarse, dark grey, sub-angular			
	11, 7, 4, 4, 25, 25			0.70 (1.0)			BOREHOLE HA2 TERMINATED AT 0.70 m			Hand auger refusal in fill. DCP hammer bouncing at 1.28m
				1.5						

LOGGED: RC | CHECKED: MA | DATE: 17/02/2022

GEOTECHNICAL BOREHOLE LOG
HA3

RCA AUSTRALIA
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PROJECT No: 16035
CLIENT: Port of Newcastle
PROJECT: Geotechnical Investigation
LOCATION: 106 Bourke Street, Carrington

DATE: 10/02/2022
SURFACE RL:
COORDS:
EXCAVATION METHOD: Hand Auger

Borehole Information					Field Material Information					
WATER	DYNAMIC PENETROMETER	FIELD TEST	SAMPLE	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	STRUCTURE AND ADDITIONAL OBSERVATIONS
Not Encountered							FILL, Silty Sandy GRAVEL, fine to coarse, dark grey, sub-angular, trace of glass	M		FILL
	4						BOREHOLE HA3 TERMINATED AT 0.20 m			Hand auger refusal on obstruction in fill, adjacent borehole attempted and met refusal at similar depth.
	2									
	2									
	3			0.5						
	11									
	5									
	4									
	11									DCP hammer bouncing at 1.28m
	4			1.0						
	23									
	30									
				1.5						

LOGGED: RC | CHECKED: MA | DATE: 17/02/2022

Explanatory Notes – Soil Description

In engineering terms, soil includes every type of uncemented or partially cemented material found in the ground. In practice, if the material can be remoulded by hand in its field condition or in water it is described as a soil. The dominant soil constituent is given in capital letters, with secondary textures in lower case. The dominant feature is assessed from *AS 1726:2017 – Geotechnical Site Investigations* and a soil symbol is used to define a soil layer.

METHOD

Method	Description
AD/T	Auger Drilling with tungsten carbide bit
AD/V	Auger Drilling with V Bit
AS	Auger Screwing
AT	Air Track
BH	Backhoe
CT	Cable Tool Rig
DB	Washbore Drag Bit
DT	Diatube
E	Excavator
EH	Excavator with Hammer
HA	Hand Auger
HQ	Diamond Core-63mm diameter
N	Natural Exposure
NMLC	Diamond Core-52mm diameter
NQ	Diamond Core-47mm diameter
Percussion	Percussion Drilling
PT	Push Tube
RR	Rock Roller
V	Vacuum Excavation
WS	Washbore
X	Existing Excavation

WATER

Water level at date shown

Seepage

NOT ENCOUNTERED: The borehole/test pit was dry soon after excavation. Inflow may have been observed had the borehole/test pit been left open for a longer period.

NOT OBSERVED: The observation of groundwater, whether present or not, was not possible due to drilling water, surface seepage or cave in of the borehole/test pit.

SAMPLING

Sample	Description
B	Bulk Disturbed Sample
D	Disturbed Sample
SPT	Standard Penetration Test
U50	Undisturbed Sample - 50mm diameter
U75	Undisturbed Sample - 75mm diameter
ES	Soil Sample, Environmental
EW	Water Sample, Environmental
G	Gas Sample

SOIL CLASSIFICATION

The appropriate symbols are selected based on the result of visual examination, field tests and available laboratory test results, such as particle size analysis, liquid limit and plasticity index.

Group Symbol	Description
GW	Well graded gravel
GP	Poorly graded gravel
GM	Silty gravel
GC	Clayey gravel
SW	Well graded sand
SP	Poorly graded sand
SM	Silty sand
SC	Clayey sand
ML	Silt of low plasticity
CL	Clay of low plasticity
OL	Organic soil of low plasticity
CI	Clay of medium plasticity
MH	Silt of high plasticity
CH	Clay of high plasticity
OH	Organic soil of high plasticity
Pt	Peat, highly organic soil

MOISTURE CONDITION

For coarse grained soils, the following terms are used

Dry - Non-cohesive and free-running

Moist - Soil feels cool, darkened in colour
- Soil tends to stick together

Wet - Soil feels cool, darkened in colour
- Soil tends to stick together, free water forms when handling

For fine grained soils, the following moisture content (w) terms are used:

w < PL - Moist, dry of plastic limit

w ≈ PL - Moist, near plastic limit.

w > PL - Moist, wet of plastic limit.

w ≈ LL - Wet, near liquid limit.

w > LL - Wet, wet of liquid limit

PLASTICITY

Soil plasticity is a measure of the range of water content over which a soil exhibits plastic properties. The classification of the degree of plasticity in terms of the Liquid Limit (LL) is as follows.

Description of Plasticity	Range of Liquid Limit for Silt	Range of Liquid Limit for Clay
Non-plastic	Not applicable	Not applicable
Low plasticity	≤50	≤35
Medium plasticity	Not applicable	>35 and ≤50
High plasticity	>50	>50

COHESIVE SOILS – CONSISTENCY

The consistency of a cohesive soil is defined by descriptive terminology such as very soft, soft, firm, stiff, very stiff and hard. These terms are assessed by the shear strength of the soil as observed visually, by hand penetrometer, dynamic cone penetrometer or vane shear values and by resistance to deformation to hand moulding.

A hand penetrometer may be used in the field or the laboratory to provide an approximate assessment of the unconfined compressive strength (UCS) of cohesive soils. Undrained shear strength c_u = 0.5×UCS. Undrained shear strength values are recorded in kPa as follows:

Strength	Symbol	Indicative Undrained Shear Strength, c_u (kPa)
Very Soft	VS	≤12
Soft	S	>12 and ≤25
Firm	F	>25 and ≤50
Stiff	St	>50 and ≤100
Very Stiff	VSt	>100 and ≤200
Hard	H	>200
Friable	Fr	—

COHESIONLESS SOILS – RELATIVE DENSITY

Relative density terms such as very loose, loose, medium dense, dense and very dense are used to describe silty and sandy material, and these are usually based on resistance to drilling penetration, Standard Penetration Test (SPT) N values or Perth Sand Penetrometer resistance.

Term	Symbol	Density Index
Very Loose	VL	0 to 15
Loose	L	15 to 35
Medium Dense	MD	35 to 65
Dense	D	65 to 85
Very Dense	VD	>85

SOIL PARTICLE SIZE DESCRIPTIVE TERMS

Fraction	Name	Subdivision	Size (mm)
Oversize	Boulders		>200
	Cobbles		63 to 200
Coarse grained soil	Gravel	Coarse	19 to 63
		Medium	6.7 to 19
		Fine	2.36 to 6.7
	Sand	Coarse	0.6 to 2.36
		Medium	0.21 to 0.6
		Fine	0.075 to 0.21
Fine grained soil	Silt		0.002 to 0.075
	Clay		<0.002

Explanatory Notes - Rock Description

METHOD

Refer to soil description sheet.

WATER

Refer to soil description sheet.

ROCK QUALITY

The defect spacing is shown where applicable and the Rock Quality Designation (RQD) and Total Core Recovery (TCR) for each core run is given where:

$$TCR = \frac{\text{Length of core recovered}}{\text{Length of core run}} \times 100\%$$

$$RQD = \frac{\text{Sum of axial length of sound core pieces >100mm long}}{\text{Length of core run}} \times 100\%$$

ROCK MATERIAL WEATHERING

Rock material weathering is described using the abbreviations and definitions used in *AS1726:2017– Geotechnical Site Investigations*.

<table>
<tr><th colspan="2">Term</th><th colspan="2">Abbreviation</th><th>Definition</th></tr>
<tr><td colspan="2">Residual Soil</td><td colspan="2">RS</td><td>Material is weathered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are no longer visible, but the soil has not been significantly transported.</td></tr>
<tr><td colspan="2">Extremely weathered</td><td colspan="2">XW</td><td>Material is weathered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are still visible.</td></tr>
<tr><td>Highly Weathered</td><td rowspan="2">Distinctly Weathered</td><td>HW</td><td rowspan="2">DW</td><td>The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable. Rock strength is significantly changed by weathering. Some primary minerals have weathered to clay minerals. Porosity may be increased by leaching or may be decreased due to deposition of weathering products in pores.</td></tr>
<tr><td>Moderately Weathered</td><td>MW</td><td>The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable, but shows little or no change of strength from fresh rock.</td></tr>
<tr><td colspan="2">Slightly Weathered</td><td colspan="2">SW</td><td>Rock is partially discoloured with staining or bleaching along joints but shows little or no change of strength from fresh rock.</td></tr>
<tr><td colspan="2">Fresh</td><td colspan="2">FR</td><td>Rock shows no sign of decomposition of individual minerals or colour changes.</td></tr>
</table>

Where it is not practicable to distinguish between ‘Highly Weathered’ and ‘Moderately Weathered’ rock the term ‘Distinctly Weathered’ may be used. ‘Distinctly Weathered’ is defined as follows: ‘Rock strength usually changed by weathering. The rock may be highly discoloured, usually by iron staining. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in the pores’. There is some change in rock strength.

ROCK MATERIAL STRENGTH

Rock strength is described using *AS1726:2017– Geotechnical Site Investigations* and *ISRM – Commission on Standardisation of Laboratory and Field Tests, ‘Suggested method of determining the Uniaxial Compressive Strength of Rock materials and the Point Load Index’* as follows:

Term	**Abbreviation**	**Uniaxial Compressive Strength (MPa)**	**Point Load Index Is_{50} (MPa)**
Very Low	VL	0.6 to 2	0.03 to 0.1
Low	L	2 to 6	0.1 to 0.3
Medium	M	6 to 20	0.3 to 1
High	H	20 to 60	1 to 3
Very High	VH	60 to 200	3 to 10
Extremely High	EH	>200	>10

◀ Diametral Point Load Index test.

▼ Axial Point Load Index test.

DEFECT SPACING/BEDDING THICKNESS

Depending on the project, may be either described as mean perpendicular spacing within a set of defects or bedding, or as the spacing between all defects within the rock mass.

Term	Defect Spacing	Bedding
Extremely closely spaced	<6 mm	Thinly laminated
	6 to 20 mm	Laminated
Very closely spaced	20 to 60 mm	Very thin
Closely spaced	0.06 to 0.2 m	Thin
Moderately widely spaced	0.2 to 0.6 m	Medium
Widely spaced	0.6 to 2.0 m	Thick
Very widely spaced	>2 m	Very thick

DEFECT DESCRIPTION

Type	Definition
JT	Joint
BP	Bedding Parting
CO	Contact
CS	Clay Seam
CZ	Crush Zone
DK	Dyke
DZ	Decomposed Zone
FC	Fracture
FZ	Fracture Zone
FL	Foliation
FLT	Fault
VN	Vein
SM	Seam
IS	Infilled Seam
SZ	Shear Zone

Planarity	Roughness
PR – Planar	VR – Very Rough
CU – Curved	RF – Rough
U – Undulating	S – Smooth
ST – Stepped	POL – Polished
IR – Irregular	SL – Slickensided

Symbol	Coating or Infill
CA	Calcite
Clay	Clay
CN	Clean
Fe	Iron oxide
KT	Chlorite
Qz	Quartz
X	Carbonaceous
SN	Stain
VNR	Veneer

The inclinations of defects are measured from perpendicular to the core axis.