

Report

# Prince of Wales/Omāroro Reservoir - Geotechnical Factual Report

Prepared for Wellington Water Ltd

Prepared by Beca Limited

20 October 2017



## Revision History

Revision N°	Prepared By	Description	Date

## Document Acceptance

Action	Name	Signed	Date
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Reviewed by	<b>Philip Robins</b>		20/10/2017
Approved by	<b>Richard Hickman</b>		20/10/2017
on behalf of	Beca Limited		

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# 1 Introduction

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Wellington Water Ltd. is proposing to build a reservoir at the Prince of Wales Park in the Wellington suburb of Mt. Cook. The Prince of Wales/Omārore Reservoir (hereafter 'the Reservoir') has been proposed to be built into a ridge off Mt. Cook. The material recovered during the excavations is proposed to be used to raise the surface of the upper and lower playing fields.

## 1.1 Object and Scope of the Investigation

The purpose of these ground investigations was to inform the resource consent, and design of a retaining wall on the lower playing field of the Prince of Wales Park. This wall will retain the fill which will be used to raise the surface of the field.

The scope included three boreholes, all terminated at approximately 10m depth or when rock had been proven. A site investigation location plan, showing the locations of the three boreholes, is provided in Appendix A.

## 1.2 Site Location and Description

The site is located on the lower playing field of the Prince of Wales Park in Wellington. The field is situated along the eastern slopes of Mt. Cook, adjacent to Salisbury Terrace. The field is relatively flat, sloping gently toward the east. It lies between 59m and 60m above sea level.

The land on which the field is situated appears to have been modified using cut/fill to construct level ground. Retaining walls on the eastern side of the field, bordering Salisbury Terrace, are evidence of this. At the cut slope on the southern end of the field, highly to moderately weathered greywacke is exposed.

A stream, originating from a gully in Mt. Cook, enters the site in the southwest corner of the lower playing field. The stream has been re-directed using a bund to flow along the western edge of the field, exiting the site to the west of the clubhouse at the northern end of the field.

## 1.3 Site Geology

The published geology (Begg & Johnston, 2000; Begg & Mazengarb, 1996) shows the site to be underlain by alternating sandstones (greywacke) and mudstones of the Rakaia Terrane.

Higher detailed maps (Semmens et al., 2010) show that on the lower playing field the Rakaia Terrane greywacke is overlain by reclamation fill of unknown thickness.

A currently inactive splinter fault connecting the Lambton and Terrace Faults is known to pass through the lower playing field, exiting near the clubhouse at the northern end (Semmens et al., 2010; Begg & Mazengarb, 1996).

# 2 Site Investigations

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Site investigations were undertaken between 5 October and 11 October 2017. The investigations comprised three machine boreholes, drilled by Griffiths Drilling using a Fraste PL.G rotary rig. The boreholes were initially vacuum extracted to 1.5m depth, and drilling was undertaken using the triple-tube method.

A summary of all machine boreholes undertaken is given Table 1, and the locations of the boreholes are shown on the site plan in Appendix A.

Table 1 - Summary of Boreholes Drilled

BH No.	Location	Easting	Northing	RL ground (m)	Total Depth (m)
BH01	Northeastern corner of lower field; opposite 12 Salisbury Tce.	1748389	5425760	59	10.79
BH02	Eastern edge of lower field; opposite 11 Salisbury Tce.	1748398	5425738	59	10.37
BH03	Eastern edge of lower field; opposite 8 Salisbury Ave.	1748394	5425680	59	7.75

Field testing, undertaken during drilling of the machine boreholes comprised:

- Standard Penetration Tests (SPTs) were typically carried out at 1.5m centres, and the uncorrected N-values are recorded on the borehole logs.
- Hand held shear vane tests were carried out within the end of the core barrel in cohesive soils. The corrected and uncorrected shear vane values are reported on the machine borehole logs.

All core samples were logged on site by a Beca Engineering Geologist. A Beca Senior Engineering Geologist has reviewed these logs. Machine borehole logs, core and SPT photographs are presented in Appendices B to D. After the core samples had been logged, they were wrapped in plastic to reduce moisture loss and placed in labelled core boxes before being transferred to Beca's Wellington office for storage. Some natural desiccation and degradation of the core samples will occur through time following storage. Upon completion, all boreholes were backfilled with cement bentonite grout.

## 2.1 Standards and Calibrations

A list of standards used during the site investigation is shown in Table 2, below.

Table 2 - Summary of Standards used in this Investigation

Field Procedure	Standard Used
Soil and Rock logging	In general accordance with New Zealand Geotechnical Society Guidelines (NZGS, 2005).
Hand held shear vane testing	In general accordance with New Zealand Geotechnical Society Guidelines (NZGS, 2001).
Standard Penetration Testing	ASTM D1586-11

Up to date calibrations for the following testing equipment used in the investigations are attached in Appendices E and F:

- Hand held shear vane
- SPT Hammer

## 2.2 Groundwater

The boreholes were dipped following completion of drilling. At the time of the measurements of water levels in BH01 and BH02, the boreholes were cased to a depth of 3m. No casing was installed when the water level in BH03 was measured. None of the boreholes had been developed to remove drilling muds or other fluids added during the drilling process, and hence the water levels are indicative only and do not allow for the interpretation of water levels or vertical gradients between individual units. Table 3 summarises the water level measurements.

Table 3 - Groundwater Measurements

Borehole/ Piezometer ID	Date of measurement	Water level (m, bgl)	Water level (m, RL)
BH01	10/10/2017	7.10	51.90
BH02	10/10/2017	4.80	54.20
BH03	09/10/2017	1.75	57.25

### 3 References

ASTM, 2011: ASTM D1586-11, Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils. ASTM International, West Conshohocken, PA.

Begg, J.G., and Johnston, M.R., 2000: Geology of the Wellington area. Institute of Geological & Nuclear Sciences 1:250 000 geological map 10. 1 sheet + 64p. Lower Hutt, New Zealand: Institute of Geological & Nuclear Sciences Limited.

Begg, J.G., and Mazengarb, C., 1996: Geology of the Wellington area, scale 1:50 000. Institute of Geological & Nuclear Sciences geological map 22. 1 sheet + 128p. Lower Hutt, New Zealand: Institute of Geological & Nuclear Sciences Limited.

NZGS, 2005: Field Description for Soil and Rock. Guideline for the Field Classification and Description of Soil and Rock for Engineering Purposes. New Zealand Geotechnical Society.

NZGS, 2001: Guidelines for the Hand Held Shear Vane Test. New Zealand Geotechnical Society.

Semmens, S., Perrin, N.D., and Dellow, G.D, 2010: It's Our Fault – Geological and Geotechnical Characterisation of the Wellington Central Business District. GNS Consultancy Report 2010/176. 52p.

### 4 Applicability

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*This is a factual report of field investigations. The field investigations have been undertaken at discrete locations and no inferences about the nature and continuity of ground conditions away from the investigation locations are made. Furthermore logs are provided presenting description of the soils and geology based on our observation of the samples recovered in the fieldwork and may not be truly representative of the actual underlying conditions.*

*No interpretation of the investigation results has been made in this report. Should you be in any doubt as to the applicability of this report for the proposed development described herein, it is essential that you carry out independent investigations to satisfy your needs.*



## Appendix A

# Site Investigation Location Plan







## Appendix B

# Machine Borehole Logs



## WATER



Water level on date shown

## METHOD (shows drilling method)

OB	open barrel
Wash	wash boring
TT	triple tube
UT	thin walled undisturbed tube
SPT	standard penetration test – open nose sampler
Nc	standard penetration test – solid nose sampler
MA	machine auger
PS	piston sample
PCT	percussion – top drive
PCB	percussion – bottom drive
Conc	concentrics
Sonic	sonic
HA	hand auger
VE	vacuum excavation

## SAMPLES

Dx	Disturbed sample, number x
Bx	Bulk sample, number x
Ux(d)	Undisturbed sample, number x, tube diameter d in mm
Wx	Water sample, number x

## MOISTURE

Dry, looks and feels dry  
 Moist, no free water on hand when remoulding  
 Wet, free water on hand when remoulding  
 Saturated, soil below water table

## SOIL AND ROCK DESCRIPTIONS

### CONSISTENCY

Cohesive Soils	Undrained Shear Strength (kPa)
Very soft	<12
Soft	12 to 25
Firm	25 to 50
Stiff	50 to 100
Very stiff	100 to 200
Hard	>200

Soil and Rock Descriptions are generally as described in the NZ Geotechnical Society "Field Description of Soil and Rock – Guideline for the Field Classification and Description of Soil and Rock for Engineering Purposes", dated December 2005.

Vane Shear Strength measurements in accordance with the NZ Geotechnical Society "Guideline for hand held shear vane test" dated August 2001.

### IN SITU TESTS

SV	= 40/10	In situ shear strength and remoulded shear strength respectively, as measured by Geotechnics/ Pilcon Shear Vane
$\tau$	= 50/12	Vane shear strength and remoulded vane shear strength respectively, corrected to BS1377
UTP	=	Unable To Penetrate with Shear Vane
N	= 15	SPT uncorrected blow count for 300mm penetration
N <sub>c</sub>	= 50+	SPT uncorrected blow count for 300 mm penetration using solid nose sampler



















### ★

AL	Atterberg limits
UU	Unconsolidated undrained triaxial
PSD	Particle size
CU	Consolidated undrained triaxial
CONS	Consolidation
COMP	Compaction
UCS	Unconfined compression

### WEATHERING

CW	Completely weathered
HW	Highly weathered
MW	Moderately weathered
SW	Slightly weathered
UW	Unweathered

### GRAPHIC LOG (1 or a combination of the following)

	Fill		Silt		Cobbles		Sandstone		Fine igneous
	Core loss		Sand		Boulders		Limestone		Coarse igneous
	Organics		Shells		Mudstone		Schist		
	Clay		Gravel		Siltstone		Basalt		

### ORGANIC SOILS

#### Von Post Degree of Humification

H1	Completely unconverted and mud-free peat, when pressed gives clear water and plant structure is visible.
H2	Practically unconverted and mud-free peat, when pressed gives almost clear water and plant structure is visible.
H3	Very slightly decomposed or very slightly muddy peat, when pressed gives marked muddy water, no peat substance passes through the fingers and plant structure is less visible.
H4	Slightly decomposed or slightly muddy peat, when pressed gives marked muddy water and plant structure is less visible.
H5	Moderately decomposed or very muddy peat with growth structure evident but slightly obliterated.
H6	Moderately decomposed or very muddy peat with indistinct growth structure.
H7	Fairly well decomposed or very muddy peat but the growth structure can just be seen.
H8	Well decomposed or very muddy peat with very indistinct growth structure.
H9	Practically decomposed or mud-like peat in which almost no growth structure is evident.
H10	Completely decomposed or mud peat where no growth structure can be seen, entire substance passes through the fingers when pressed.

**MACHINE BOREHOLE LOG**

SHEET 1 of 2

PROJECT: Prince of Wales/Omaroro Reservoir										JOB NUMBER: 6513361									
SITE LOCATION: Prince of Wales Park, Wellington										CLIENT: Wellington Water									
CIRCUIT: NZTM										BOREHOLE LOCATION: Northeastern corner of lower field; opposite 12 Salisbury Tce.									
COORDINATES: N 5,425,760 m										R L: 59 m									
E 1,748,388 m										COORDINATE ORIGIN: hhGPS									
										DATUM: MSL									
										ACCURACY: ±5m									

DRILLING						IN-SITU TESTS			SAMPLES	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK DESCRIPTION	GEOLOGICAL UNIT	R L (m)
FLUID LOSS	DAILY WATER LEVEL	CORE RECOVERY	METHOD	CASING	RQD	SV	γ (kPa)	SPT 'N'						
		0 %	VE									FIII		
		62 %	SPT					1 1 0 1 0 1 N = 2	1		'Firm', SILT, some rootlets, minor clay, trace fine to medium gravel; brown; saturated (drilling induced), high plasticity. Gravel: angular, HW, greywacke. [TOPSOIL]. (Logged downhole).  'Dense', silty medium to coarse sandy fine to coarse GRAVEL, minor cobbles, trace boulders (<220mm diameter) clay; light brown, mottled orange; saturated (drilling induced), non plastic. Gravel / cobbles: angular, SW-HW, greywacke. (Logged downhole).			
		21 %	TT						2		'Firm', fine to medium sandy fine to coarse gravelly SILT, trace clay; light brown; moist, low plasticity. Gravel: angular to subangular, SW-CW, greywacke.  Firm, SILT, minor fine to medium gravel, trace fine to medium sand, trace clay; light brown; dry, low plasticity (when wetted). No recovery (2.17-3.00m). Driller's note: soft, no water used.			
		60 %	SPT					1 1 1 1 1 1 N = 4	3		Loose, fine to medium sandy fine to coarse GRAVEL, some silt, trace clay; light brown; dry, non plastic. Gravel: angular to subrounded, SW-HW, greywacke.  No recovery (3.27-3.45m).			
		19 %	TT						4		'Firm', fine to coarse gravelly SILT, minor fine to medium sand, minor clay; light brown; moist, high plasticity. Gravel: angular to subangular, SW-CW, greywacke.  No recovery (3.65-4.50m).			
		80 %	SPT					2 1 0 1 1 1 N = 3	5		Loose, silty fine to coarse GRAVEL, minor fine to medium sand, trace clay; light brown; moist, low plasticity (matrix). Gravel: angular to subrounded, SW-HW, greywacke. Matrix supported.  4.95m: some fine to coarse sand, trace cobbles, Gravel: angular, SW-CW, greywacke. Cobbles: SW, greywacke.  No recovery (5.40-6.00m). Driller's note: soft, blocked core barrel preventing core recovery.			
		43 %	TT						6		Loose, silty fine to medium GRAVEL, trace fine to coarse sand, trace clay; reddish brown; moist, low plasticity (matrix). Gravel: subangular, SW-MW, greywacke.  'Firm', SILT, some fine to medium sand, minor clay, trace fine to medium gravel; grey; moist; high plasticity. Gravel: angular to subangular, MW-CW, greywacke.			
		78 %	SPT					2 2 1 1 2 1 N = 5	7		'Stiff', fine to medium sandy SILT, minor clay, trace fine gravel; light brown; moist, high plasticity. Gravel: angular, SW-CW, greywacke. 6.68m: grey, mottled reddish brown.  'Dense', COBBLES, minor fine to medium gravel, minor fine to coarse sand, minor silt; grey; moist, non plastic. Gravel / cobbles: SW, greywacke.  'Dense', silty fine to coarse sandy fine to coarse GRAVEL, trace clay; reddish brown; moist, non plastic. Gravel: angular to subangular, MW-HW, greywacke. 7.12m: thin (50mm) bed of fine to medium sandy SILT, minor fine gravel. 7.25-7.35m: cobble (SW, greywacke).			
		91 %	TT					6						

DATE STARTED: 6/10/17	DRILLED BY: Griffiths Drilling	COMMENTS: - Terminated at target depth.
DATE FINISHED: 10/10/17	EQUIPMENT: Fraste PL.G	
LOGGED BY: CK	DRILL METHOD: SPT/TT/VE	
SHEAR VANE No: DR2777	DRILL FLUID: Polymer	
	DIAMETER/INCLINATION: 100 mm/ 90°	

FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS SEE KEY SHEET

**MACHINE BOREHOLE LOG**

SHEET 2 of 2

PROJECT: Prince of Wales/Omaroro Reservoir						JOB NUMBER: 6513361					
SITE LOCATION: Prince of Wales Park, Wellington						CLIENT: Wellington Water					
CIRCUIT: NZTM						BOREHOLE LOCATION: Northeastern corner of lower field; opposite 12 Salisbury Tce.					
COORDINATES: N 5,425,760 m E 1,748,388 m						R L: 59 m		COORDINATE ORIGIN: hhGPS			
						DATUM: MSL		ACCURACY: ±5m			

DRILLING						IN-SITU TESTS			SAMPLES	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK DESCRIPTION	GEOLOGICAL UNIT	R L (m)
FLUID LOSS	DAILY WATER LEVEL	CORE RECOVERY	METHOD	CASING	RQD	SV	γ (kPa)	SPT 'N'						
		78 %	SPT					50 for 25mm N = 50+				'Dense', silty fine to coarse sandy fine to coarse GRAVEL, trace clay; reddish brown; moist, non plastic. Gravel: angular to subangular, SW-CW, greywacke. 7.50m: grey mottled reddish brown.  Very dense, COBBLES, some medium to coarse gravel; grey; moist, non plastic. Gravel / cobbles: subangular, UW-SW, greywacke.  8.20-8.60m: moderately strong, SW, brown GREYWACKE (retrieved as fine to coarse gravel, broken before photo was taken).  No recovery (8.60-9.00m).  No recovery (9.00-9.45, solid cone SPT - SPT overdrill logged). 9.00-9.12m: medium dense, fine to coarse GRAVEL; brownish grey; moist, non plastic. 9.12-9.32: 'very stiff', fine to medium gravelly fine to medium sandy SILT, minor clay; light brown; moist, high plasticity. Gravel: angular to subrounded, MW-HW, greywacke. 9.32-9.45m: 'hard', clayey SILT, some fine gravel, trace medium to coarse sand; dark brown; moist, high plasticity. Gravel: subangular to subrounded, MW-CW, greywacke. [BURIED TOPSOIL]. 'Hard', clayey SILT, some fine to medium gravel, trace medium to coarse sand; dark brown; moist, high plasticity. Gravel: subangular to subrounded, MW-CW, greywacke. [BURIED TOPSOIL]. Very weak to weak, MW-HW, greyish brown stained orange GREYWACKE. Defects: very closely spaced (recovered as 6-20mm blocks). Drilling disturbed. 9.60m: defects: very closely spaced (recovered as 15-50mm blocks). FeO stained, minor coarse sand, minor silt. Drilling disturbed. 9.80m: ARGILLITE. 9.95m: greyish brown GREYWACKE. Defects: very closely spaced (recovered as 6-30mm blocks). FeO stained, some silt. 10.10m: extremely weak, MW-CW, orange-brown GREYWACKE. Defects: very closely spaced (recovered as 6-60mm blocks). FeO stained, some silt, minor fine to medium sand, trace clay. No recovery (10.50-10.79m, solid cone SPT). END OF LOG @ 10.79 m	Fill	51
		60 %	TT					7 9 7 7 8 N = 29			50			
		0 %	SPT											
		100 %	TT											
		82 %	TT											
		0 %	SPT					1 10 20 30 for 60mm N = 50+				Rakala Terrane	49	
													48	
													47	
													46	
													45	

DATE STARTED: 6/10/17	DRILLED BY: Griffiths Drilling	COMMENTS: - Terminated at target depth.
DATE FINISHED: 10/10/17	EQUIPMENT: Fraste PL.G	
LOGGED BY: CK	DRILL METHOD: SPT/TT/VE	
SHEAR VANE No: DR2777	DRILL FLUID: Polymer	
DIAMETER/INCLINATION: 100 mm/ 90°		

FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS SEE KEY SHEET



**MACHINE BOREHOLE LOG**

SHEET 1 of 2

PROJECT: Prince of Wales/Omaroro Reservoir				JOB NUMBER: 6513361			
SITE LOCATION: Prince of Wales Park, Wellington				CLIENT: Wellington Water			
CIRCUIT: NZTM		BOREHOLE LOCATION: Eastern edge of lower field; opposite 11 Salisbury Tce.		COORDINATE ORIGIN: hhGPS		ACCURACY: ±5m	
COORDINATES: N 5,425,738 m E 1,748,397 m		R L: 59 m		DATUM: MSL			

DRILLING						IN-SITU TESTS			SAMPLES	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK DESCRIPTION	GEOLOGICAL UNIT	R L (m)
FLUID LOSS	DAILY WATER LEVEL	CORE RECOVERY	METHOD	CASING	RQD	SV	γ (kPa)	SPT 'N'						
		0 %	VE									'Firm', SILT, some rootlets, minor fine to medium gravel, minor clay, trace refuse; brown; saturated (drilling induced), high plasticity. Gravel: angular, HW, greywacke. Refuse: glass, crockery. [TOPSOIL]. (Logged downhole).  'Dense', silty fine to coarse sandy fine to coarse GRAVEL, trace cobbles; light brown; saturated (drilling induced), non plastic. Gravel / cobbles: angular, SW-HW, greywacke. (Logged downhole).	Fill	58
		53 %	SPT					1 1 1 0 1 0 N = 2		1				
		6 %	TT									'Soft', fine to coarse gravelly fine to medium sandy SILT, trace clay; light brown; moist, low plasticity. Gravel: angular, SW-HW, greywacke.  2.05m: light brown, mottled orange. No recovery (2.11-3.00m). Driller's note: soft run, little water used.	Fill	57
		78 %	SPT					1 0 1 2 2 3 N = 8		2				
		30 %	TT									Stiff, clayey SILT, trace coarse sand; light brown, mottled orange; moist, high plasticity. (Residual Soil). 3.10m: fine gravel. Gravel: subangular to subrounded, MW-HW, greywacke. 3.30m: gravel: angular to subangular, MW-HW, greywacke. 3.45m: no gravel, no sand; light brown. 3.82m: trace fine gravel. Gravel: subrounded, MW-HW, greywacke. No recovery (3.77-4.50m).	Rakaia Terrane	56
		100 %	SPT					2 2 2 3 4 N = 12		3				
		84 %	TT									Stiff, clayey SILT, trace fine gravel; light greyish brown, mottled orange; moist, high plasticity. Gravel: subrounded, HW-MW, greywacke. (Residual Soil).  4.95m: 'very stiff', trace medium to coarse sand. Gravel: subrounded, HW-CW, greywacke.  'Firm', SILT, some fine to coarse sand, minor clay, trace fine to medium gravel; grey, mottled reddish brown; moist, high plasticity. Gravel: subrounded to subangular, HW-CW, greywacke sandstone; subangular, MW, argillite. (Extremely weak, CW, GREYWACKE). Dense, silty fine to coarse sandy fine to coarse GRAVEL, minor cobbles, trace clay; reddish brown; moist, non plastic. Gravel / cobbles: angular to subangular, MW-CW, greywacke. (Extremely weak, HW-CW, GREYWACKE). 6.23m: moderately thick (220mm) fine to medium sandy SILT bed. 6.45m: silty fine sandy fine to coarse GRAVEL; grey, mottled orange and reddish brown.	Rakaia Terrane	54
		100 %	SPT					5 7 7 8 10 12 N = 37		4				
		67 %	TT									Very stiff, fine to coarse gravelly fine to medium sandy SILT, trace cobbles, trace clay; light brownish grey, mottled orange and reddish brown; moist, low plasticity. Gravel / cobbles: angular, MW-CW, greywacke. (Extremely weak, HW-CW, GREYWACKE). 7.00m: some clay; reddish brown; high plasticity. No recovery (7.15-7.50m).	Rakaia Terrane	53
								3		5				
DATE STARTED: 6/10/17		DRILLED BY: Griffiths Drilling		COMMENTS:										
DATE FINISHED: 10/10/17		EQUIPMENT: Fraste PL.G		- Terminated at target depth.										
LOGGED BY: CK		DRILL METHOD: SPT/TT/VE												
SHEAR VANE No: DR2777		DRILL FLUID: Polymer												
		DIAMETER/INCLINATION: 100 mm/ 90°												

DATE STARTED: 6/10/17		DRILLED BY: Griffiths Drilling		COMMENTS:	
DATE FINISHED: 10/10/17		EQUIPMENT: Fraste PL.G		- Terminated at target depth.	
LOGGED BY: CK		DRILL METHOD: SPT/TT/VE			
SHEAR VANE No: DR2777		DRILL FLUID: Polymer			
		DIAMETER/INCLINATION: 100 mm/ 90°			

FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS SEE KEY SHEET

**MACHINE BOREHOLE LOG**

SHEET 2 of 2

PROJECT: Prince of Wales/Omaroro Reservoir						JOB NUMBER: 6513361					
SITE LOCATION: Prince of Wales Park, Wellington						CLIENT: Wellington Water					
CIRCUIT: NZTM						BOREHOLE LOCATION: Eastern edge of lower field; opposite 11 Salisbury Tce.					
COORDINATES: N 5,425,738 m						R L: 59 m		COORDINATE ORIGIN: hhGPS			
E 1,748,397 m						DATUM: MSL		ACCURACY: ±5m			

DRILLING					IN-SITU TESTS			SAMPLES	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK DESCRIPTION	GEOLOGICAL UNIT	R L (m)
FLUID LOSS	DAILY WATER LEVEL	CORE RECOVERY	METHOD	CASING	RQD	SV	γ (kPa)						
		89 %	SPT					4 5 8 12 13 N = 38		8	<p>Very stiff, fine to medium sandy SILT, some fine to medium gravel, trace clay; reddish brown; moist, low plasticity. Gravel: angular, HW, greywacke. (Extremely weak, HW-CW, GREYWACKE).</p> <p>Dense, silty fine sandy fine to medium GRAVEL; reddish brown; moist, non plastic. Gravel: MW-HW, greywacke. (Extremely weak, HW, GREYWACKE).</p> <p>7.95m: trace clay; greyish brown.</p> <p>No recovery (8.03-9.00m).</p>	Rakaia Terrane	51
		8 %	TT					6 11 20 30 for 65mm N = 50+		9	<p>Very dense, silty fine sandy fine to medium GRAVEL, trace clay; reddish brown; moist, non plastic. Gravel: angular, MW-HW, greywacke sandstone; interlocking. (Extremely weak, HW, GREYWACKE).</p> <p>Hard, fine sandy SILT, trace clay; reddish brown; moist, low plasticity. (Extremely weak, HW, GREYWACKE).</p> <p>Weak, MW, reddish brown GREYWACKE.</p> <p>9.29-9.39m: recovered as small blocks (20-60mm).</p> <p>9.49-9.63m: broken zone, recovered as interlocking small blocks (20-60mm).</p> <p>9.48-9.55m: very steeply inclined to subvertical (70-90°) defects, extremely closely spaced, planar, rough, some silt infilled, FeO stained.</p> <p>9.54-9.75m: three steeply inclined (50-60°) defects, very closely to closely spaced, planar, rough, FeO stained.</p> <p>9.55m: subhorizontal defect, planar, rough, FeO stained.</p> <p>9.65m: gently inclined (10-20°), planar, rough.</p> <p>9.77-9.81m: very steeply inclined (60-70°, opposite direction) defect, undulating, rough, FeO stained.</p> <p>9.79-9.91m: three very steeply inclined (60-70°) defects, very closely spaced, planar, rough, FeO stained.</p> <p>9.91-10.20m: MW, broken zone. Recovered as interlocking small blocks (20-60mm).</p> <p>No recovery (10.20-10.37m, solid cone SPT).</p> <p>END OF LOG @ 10.37 m</p>		50
		70 %	SPT					11 28 50 for 15mm N = 50+		10			49
		95 %	TT							11			48
		0 %	SPT							12			47
										13			46
										14			45

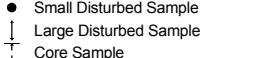
DATE STARTED: 6/10/17	DRILLED BY: Griffiths Drilling	COMMENTS: - Terminated at target depth.
DATE FINISHED: 10/10/17	EQUIPMENT: Fraste PL.G	
LOGGED BY: CK	DRILL METHOD: SPT/TT/VE	
SHEAR VANE No: DR2777	DRILL FLUID: Polymer	
DIAMETER/INCLINATION: 100 mm/ 90°		

FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS SEE KEY SHEET

BECA LIB 1.074.GLB Log BECA MACHINE BOREHOLE PRINCE OF WALES OMARORO RESERVOIR.GPJ &lt;DrawingFile&gt; 24/10/2017 11:58 8.30.004 Dinged Lib and In Situ Tool - DGD Lib Beca 1.074 2016-01-15 Proj Beca 1.07 2014-12-16

Beca										ROCK LOG																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
Project: Prince of Wales/Omaroro Reservoir					Site Location Prince of Wales Park, Wellington					Exposure Location: Opposite 8 Salisbury Ave.					No.:  BH03																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
Job No.: 6513361			Start Date: 05/10/2017 Finish Date: 09/10/2017			Ground Level (m MSL): 59.00			Co-Ordinates (NZTM): E 1,748,394.0 N 5,425,680.0																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
Client: Wellington Water					Hole Depth: 7.75 m			Angle from Horiz.: -90°			Direction:			Sheet: 1 of 2																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
Depth (m)	Method	Run / Core Recovery	Fluid & Water	Geological Description										Material Legend	Geological Unit	Weathering	Field Strength	Elevation (m MSL)	Defect Symbolic Log	Defect Spacing (mm)	Defect Description										(SCR) RQD (%)	Samples	Tests e.g. SPT, Packer, Permeability																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
1	VE	0.00 0%		'Firm', SILT, some rootlets, minor clay; brown; wet (drilling induced), high plasticity. [TOPSOIL]. (Logged downhole). 0.30m: minor fine to medium gravel. Gravel: subangular, HW-CW, greywacke.  'Dense', fine to coarse sandy fine to coarse GRAVEL, minor silt, trace rootlets; brownish grey, mottled orange; wet (drilling induced), non plastic. Gravel: angular to subangular, SW-MW, greywacke.  'Firm', SILT, some fine to coarse sand, trace fine to medium gravel, trace clay; light brown; wet (drilling induced), low plasticity. Gravel: angular to subangular, HW, greywacke. (Residual Soil). 1.50m: no gravel; moist. 1.65m: moderately thin (80mm) steeply inclined bed of clayey SILT; light grey. 1.73: minor clay; grey, mottled orange; high plasticity. 1.95m: moderately thin (150mm) steeply inclined bed of clayey SILT, trace fine gravel; grey. Gravel: subrounded, SW, greywacke.  Hard, fine to medium gravelly SILT, minor fine to medium sand, trace clay; light greyish brown, mottled orange; moist, low plasticity. Gravel: angular, HW, greywacke; some interlocking. (Extremely weak, HW, GREYWACKE). 2.27m: some fine to medium sand. No recovery (2.35-2.94m).  Hard, fine sandy SILT, some fine to medium gravel, trace clay; light greyish brown, mottled orange; moist, low plasticity. Gravel: angular, HW, greywacke; interlocking. (Extremely weak, HW, GREYWACKE). Moderately strong, MW, greyish brown mottled reddish brown GREYWACKE. FeO stained defects.  6.00m: moderately strong, SW.											Fill			+58.60		10	3.41-4.75: subvertical defects, extremely closely to moderately widely spaced, undulating, rough, some silica infilled. 3.46-3.68: steeply inclined (40-50°) defects, very closely spaced, planar, rough. 3.47-5.00: very steeply inclined (60-70°) defects, closely to widely spaced, planar, rough. 3.71-3.86: gently to moderately inclined (10-20°) defects, extremely to very closely spaced. 3.96-4.05: two steeply inclined (40-50°) defects, very closely spaced, undulating, rough. 4.54-4.65: subhorizontal defects, very closely spaced, planar, rough. 4.65: steeply inclined (50-60°) defect, planar, rough. 4.90-5.40: steeply inclined (30-40°) defects, very closely to closely spaced, planar, rough, some silt infilled. 5.00-7.50: very steeply inclined (60-70°) defects, very closely to moderately widely spaced, planar, rough. 5.07-5.17: subvertical defect, undulating, rough (drilling induced?). 5.43-5.87: steeply inclined (50-60°, opposite direction) defects, very closely to closely spaced, planar, rough. 5.47-5.57: subvertical defect, stepped, rough (drilling induced?). 6.03-6.19: subvertical defects, very closely spaced.										50	100	500	0	SPT 1.50 m 1 2 3 3 N = 10 P = UTP kPa	SPT 3.00 m 7 7 13 17 20 N = 50+																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
	SPT	1.50 100%																+58.15																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																

[illegible]

<b>Explanations:</b> Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered Relative Rock Strength - extremely weak, very weak, weak, moderately strong, strong, very strong SCR - Solid Core Recovery RQD - Rock Quality Designation Attitude of discontinuities displayed as Dip/Dip Direction							<b>Remarks</b> - Terminated at target depth.	
All dimensions in metres Scale 1:47		Contractor: Griffiths Drilling		Core Boxes:	Rig/Plant Used: Fraste PL.G	Driller: MT	Logged by: CK	Checked by: JUB



## Appendix C

### Core Photographs



## Prince of Wales/Omāroro Reservoir



**BOX: 1**

**DEPTH: 0.00 to 8.00m**



**BOX: 2**

**DEPTH: 8.00 to 10.785m**



# Prince of Wales/Omāroro Reservoir



**BOX: 1**

**DEPTH: 0.00 to 7.50m**



**BOX: 2**

**DEPTH: 7.50 to 10.365m**



# Prince of Wales/Omāroro Reservoir



**BOX: 1**

**DEPTH: 0.00 to 5.27m**



**BOX: 2**

**DEPTH: 5.27 to 7.75m**



## Appendix D

# SPT Photographs



## Prince of Wales/Omāroro Reservoir



SPT 1

DEPTH: 1.50 to 1.95m



SPT 2

DEPTH: 3.00 to 3.45m



## Prince of Wales/Omāroro Reservoir



SPT 3

DEPTH: 4.50 to 4.95m



SPT 4

DEPTH: 6.00 to 6.45m

## Prince of Wales/Omāroro Reservoir



**SPT 5**

**DEPTH: 7.50 to 7.675m**

**No recovery, solid cone SPT**

**SPT 6**

**DEPTH: 9.00 to 9.45m**



## Prince of Wales/Omāroro Reservoir

**No recovery, solid cone SPT**

**SPT 7**

**DEPTH: 10.50 to 10.785m**

## Prince of Wales/Omāroro Reservoir



SPT 1

DEPTH: 1.60 to 2.05m



SPT 2

DEPTH: 3.00 to 3.45m



## Prince of Wales/Omāroro Reservoir



**SPT 3**

**DEPTH: 4.50 to 4.95m**



**SPT 4**

**DEPTH: 6.00 to 6.45m**



## Prince of Wales/Omāroro Reservoir



SPT 5

DEPTH: 7.50 to 7.95m



SPT 6

DEPTH: 9.00 to 9.29m



## Prince of Wales/Omāroro Reservoir

**No recovery, solid cone SPT**

**SPT 7**

**DEPTH: 10.20 to 10.365m**

# Prince of Wales/Omāroro Reservoir



SPT 1

DEPTH: 1.50 to 1.95m



SPT 2

DEPTH: 2.94 to 3.315m

## Prince of Wales/Omāroro Reservoir

**No recovery, solid cone SPT**

**SPT 3**

**DEPTH: 7.50 to 7.75m**



## Appendix E

# Current Shear Vane Calibration



## PILCON SHEAR VANE CALIBRATION REPORT SHEET

Vane Number: DR2777

Vane Dimensions							
Measured by: S.Shah				Date Measured: 8 August 2017 (Internal Calibration)			
Diameter (mm)	Height (mm)	Thickness (mm)	Rod Diameter (mm)	Area Ratio	Vane Size (mm)	Friction	K
18.91	28.98	1.53	6.33	24.87	19 (New)	-	0.01982
33.19	49.50	1.52	6.33	13.05	33	-	0.10482

**Calibration Authority:** Strainer Systems  
**Calibration Standard:** ISO 6789/2003  
**Calibration Date:** 16 March 2016  
**Calibration Authority Rep #:** 692  
**Calibration Interval:** 2 Yearly

**Calculated by:** S.Shah  
**Checked by:** N.Agarkova  
**Date Entered:** 8 August 2017  
**Date Checked:** 8 August 2017  
**Report Number:** 163164

The uncertainty of the shear vane (spring) calibration has been determined by Strainer Systems Limited to be:

Gauge Reading Kpa	30	90	140
Expanded uncertainty N.m	0.24	0.26	0.29
Coverage factor	2.01	1.99	1.99

Dial Gauge Reading	Applied Torque (Nm)	Vane Shear Strength 19mm (kPa)	Vane Shear Strength 33mm (kPa)	Dial Gauge Reading	Applied Torque (Nm)	Vane Shear Strength 19mm (kPa)	Vane Shear Strength 33mm (kPa)
0	0	0	0	50	1.57	79	15
2	0.07	3	1	52	1.63	82	16
4	0.14	7	1	54	1.68	85	16
6	0.20	10	2	56	1.74	88	17
8	0.27	14	3	58	1.80	91	17
10	0.34	17	3	60	1.85	94	18
12	0.41	20	4	62	1.92	97	18
14	0.47	24	5	64	1.98	100	19
16	0.54	27	5	66	2.05	103	20
18	0.60	30	6	68	2.11	107	20
20	0.67	34	6	70	2.18	110	21
22	0.73	37	7	72	2.24	113	21
24	0.78	40	7	74	2.30	116	22
26	0.84	42	8	76	2.36	119	22
28	0.90	45	9	78	2.41	122	23
30	0.96	48	9	80	2.47	125	24
32	1.01	51	10	82	2.53	128	24
34	1.07	54	10	84	2.59	130	25
36	1.13	57	11	86	2.64	133	25
38	1.19	60	11	88	2.70	136	26
40	1.25	63	12	90	2.76	139	26
42	1.31	66	13	92	2.80	141	27
44	1.38	69	13	94	2.85	144	27
46	1.44	73	14	96	2.90	146	28
48	1.51	76	14	98	2.94	149	28

### Notes:

Vane Shear Strength = Torque Applied / K

Authorised Signatory.....  
 D.Anstiss - Quality Manager

## PILCON SHEAR VANE CALIBRATION REPORT SHEET

Vane Number: DR2777

Vane Dimensions							
Measured by: S.Shah				Date Measured: 8 August 2017 (Internal Calibration)			
Diameter (mm)	Height (mm)	Thickness (mm)	Rod Diameter (mm)	Area Ratio	Vane Size (mm)	Friction	K
18.91	28.98	1.53	6.33	24.87	19 (New)	-	0.01982
33.19	49.50	1.52	6.33	13.05	33	-	0.10482

**Calibration Authority:** Strainer Systems  
**Calibration Standard:** ISO 6789/2003  
**Calibration Date:** 16 March 2016  
**Calibration Authority Rep #:** 692  
**Calibration Interval:** 2 Yearly

**Calculated by:** S.Shah  
**Checked by:** N.Agarkova  
**Date Entered:** 8 August 2017  
**Date Checked:** 8 August 2017  
**Report Number:** 163164

The uncertainty of the shear vane (spring) calibration has been determined by Strainer Systems Limited to be:

Gauge Reading Kpa	30	90	140
Expanded uncertainty N.m	0.24	0.26	0.29
Coverage factor	2.01	1.99	1.99

Dial Gauge Reading	Applied Torque (Nm)	Vane Shear Strength 19mm (kPa)	Vane Shear Strength 33mm (kPa)	Dial Gauge Reading	Applied Torque (Nm)	Vane Shear Strength 19mm (kPa)	Vane Shear Strength 33mm (kPa)
100	2.99	151	29	132	4.05	204	39
102	3.05	154	29	134	4.10	207	39
104	3.12	157	30	136	4.14	209	40
106	3.18	160	30	138	4.19	212	40
108	3.24	164	31	140	4.24	214	40
110	3.31	167	32	142	4.29	216	41
112	3.39	171	32	144	4.34	219	41
114	3.47	175	33	146	4.49	226	43
116	3.55	179	34				
118	3.63	183	35				
120	3.71	187	35				
122	3.77	190	36				
124	3.83	193	37				
126	3.88	196	37				
128	3.94	199	38				
130	4.00	202	38				

### Notes:

Vane Shear Strength = Torque Applied / K

Authorised Signatory.....

D.Anstiss - Quality Manager



## Appendix F

# Current SPT Hammer Calibration



**Summary of SPT Hammer Energy Transfer Measurements, SPT Field N Value & N<sub>60</sub>**

Hammer No.	Test Sample No.	SPT rod length <sup>(1)</sup>	Sample Starting Depth	Reported SPT Values per 150mm increment	SPT Field N Value	Average Energy Transferred to Rod <sup>(2)</sup>	Average Energy Transfer Ratio <sup>(3)</sup>	SPT N Value Corrected for 60% Energy <sup>(4)</sup> N <sub>60</sub>	Average Blow Rate (blows/min)
PLG SPT Auto hammer	1	Invalid test as SPT Field N value > 50 during testing.							
	2	11.7m	10.0m	5-19-19	38	0.413kNm	87.1%	55	30
	3	12.8m	11.0m	16-26-18	44	0.436kNm	91.8%	67	30
	4	13.1m	11.5m	8-8-8	16	0.421kNm	88.6%	24	30

(1) Below gauge station. Add 300mm for total rod length

(2) Average energy transfer over second and third increment from FV method

(3) Based upon average energy transferred to the calibrated NWJ SPT rod divided by 0.475kNm (theoretical energy)

(4) SPT N Value corrected for 60% energy using Schmertman Correction Method