



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)		Client sample ID						
		Client sampling date / time		Unit				
Compound	CAS Number	LOR	Result	GW1	GW2	GW3	SW1	
				17-Nov-2016 08:39	17-Nov-2016 09:20	17-Nov-2016 10:40	17-Nov-2016 09:26	
				EB1627332-001	EB1627332-002	EB1627332-003	EB1627332-004	
				Result	Result	Result	Result	
EA005P: pH by PC Titrator								
pH Value	---	0.01	pH Unit	6.81	6.27	6.87	7.48	---
EA006: Sodium Adsorption Ratio (SAR)								
Sodium Adsorption Ratio	---	0.01	-	5.74	6.80	7.15	2.31	---
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	---	1	µS/cm	3820	5180	4130	458	---
EA016: Calculated TDS (from Electrical Conductivity)								
Total Dissolved Solids (Calc.)	---	1	mg/L	2480	3370	2680	298	---
EA065: Total Hardness as CaCO3								
Total Hardness as CaCO3	---	1	mg/L	1260	1790	1220	99	---
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	---
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	---
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	441	227	521	85	---
Total Alkalinity as CaCO3	---	1	mg/L	441	227	521	85	---
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	1340	2340	1330	<1	---
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	357	494	428	86	---
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	253	342	235	20	---
Magnesium	7439-95-4	1	mg/L	152	227	155	12	---
Sodium	7440-23-5	1	mg/L	468	661	575	53	---
Potassium	7440-09-7	1	mg/L	4	9	24	5	---
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	0.4	0.1	0.4	0.1	---
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	0.11	0.19	0.23	0.01	---
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	---
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	---
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	---	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	---



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)		Client sample ID								
Compound	Client sampling date / time		GW1		GW2		GW3		SW1	
	CAS Number	LOR	Unit	Result	Result	Result	Result	Result	Result	Result
	EB1627332-001	17-Nov-2016 08:39	17-Nov-2016 09:20	17-Nov-2016 10:40	17-Nov-2016 09:26	EB1627332-002	EB1627332-003	EB1627332-004		
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser										
Total Kjeldahl Nitrogen as N	---	0.1	mg/L	2.7	3.3	1.7	1.2			
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser										
^ Total Nitrogen as N	---	0.1	mg/L	2.7	3.3	1.7	1.2			
EK067G: Total Phosphorus as P by Discrete Analyser										
Total Phosphorus as P	---	0.01	mg/L	2.17	3.65	2.24	0.20			
EK071G: Reactive Phosphorus as P by discrete analyser										
Reactive Phosphorus as P	14265-44-2	0.01	mg/L	0.03	0.17	0.16	0.06			
EN055: Ionic Balance										
Total Anions	---	0.01	meq/L	46.8	67.2	50.2	4.12			
Total Cations	---	0.01	meq/L	45.6	64.7	50.1	4.42			
Ionic Balance	---	0.01	%	1.28	1.86	0.06	3.45			



Environmental

CERTIFICATE OF ANALYSIS

Work Order	: EB1629361	Page	: 1 of 11
Client	: BRISBANE CITY COUNCIL	Laboratory	: Environmental Division Brisbane
Contact	: [REDACTED]	Contact	: Customer Services EB
Address	: CITY PROJECTS OFFICE 505 ST PAULS TERRACE FORTITUDE VALLEY QLD, AUSTRALIA 4006	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3027 4776	Telephone	: +61-7-3243 7222
Project	: 160725 - Sherwood Aboretum	Date Samples Received	: 13-Dec-2016 13:50
Order number	: M64232WD	Date Analysis Commenced	: 15-Dec-2016
C-O-C number	: [REDACTED]	Issue Date	: 21-Dec-2016 17:56
Sampler	: [REDACTED]		
Site	: [REDACTED]		
Quote number	: BNBQ/034/16		
No. of samples received	: 45		
No. of samples analysed	: 45		



Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Andrew Epps	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD



Page : 2 of 11
Work Order : EB1629361
Client : BRISBANE CITY COUNCIL
Project : 160725 - Sherwood Aboretum

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

Ø = ALS is not NATA accredited for these tests.

~ = Indicates an estimated value.



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)		Client sample ID												
Compound	Client sampling date / time				BH04/16 0.50m	BH04/16 1.00m	BH04/16 2.00m	BH04/16 2.50m	BH04/16 3.50m					
	CAS Number	LOR	Unit											
	Result	Result	Result	Result						Result				
EA002 : pH (Soils)														
pH Value	---	0.1	pH Unit	6.0	5.9	7.9	8.4	8.7						
EA010: Conductivity														
Electrical Conductivity @ 25°C	---	1	µS/cm	211	797	1320	1260	1070						
EA055: Moisture Content														
Moisture Content (dried @ 103°C)	---	1	%	20.4	23.5	----	----	----						
ED093S: Soluble Major Cations														
Calcium	7440-70-2	10	mg/kg	<10	20	----	----	----						
Magnesium	7439-95-4	10	mg/kg	<10	40	----	----	----						
Sodium	7440-23-5	10	mg/kg	230	1120	----	----	----						
Potassium	7440-09-7	10	mg/kg	<10	<10	----	----	----						
EK057G: Nitrite as N by Discrete Analyser														
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg	<0.1	<0.1	----	----	----						
EK058G: Nitrate as N by Discrete Analyser														
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg	<0.1	0.5	----	----	----						
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser														
Nitrite + Nitrate as N (Sol.)	---	0.1	mg/kg	<0.1	0.5	----	----	----						



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)		Client sample ID															
		Client sampling date / time				BH04/16 4.00m				BH04/16 5.00m		BH04/16 5.50m		BH04/16 7.00m		BH05/16 0.50m	
Compound	CAS Number	LOR	Unit														
EA002 : pH (Soils)																	
pH Value	---	0.1	pH Unit			9.0		8.8		8.7		8.4				5.8	
EA010: Conductivity																	
Electrical Conductivity @ 25°C	---	1	µS/cm			797		805		633		630				104	
EA055: Moisture Content																	
Moisture Content (dried @ 103°C)	---	1	%			---		---		---		26.6				9.5	
ED093S: Soluble Major Cations																	
Calcium	7440-70-2	10	mg/kg			---		---		---		<10				30	
Magnesium	7439-95-4	10	mg/kg			---		---		---		<10				20	
Sodium	7440-23-5	10	mg/kg			---		---		---		910				30	
Potassium	7440-09-7	10	mg/kg			---		---		---		<10				40	
EK057G: Nitrite as N by Discrete Analyser																	
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg			---		---		---		<0.1				0.4	
EK058G: Nitrate as N by Discrete Analyser																	
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg			---		---		---		0.2				30.9	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser																	
Nitrite + Nitrate as N (Sol.)	---	0.1	mg/kg			---		---		---		0.2				31.3	



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)		Client sample ID														
Compound	CAS Number		Client sampling date / time		LOR	Unit	BH05/16 1.00m		BH05/16 2.00m		BH05/16 2.50m		BH05/16 3.50m		BH05/16 4.00m	
	Result	Result	[05-Dec-2016]	EB1629361-011			[05-Dec-2016]	EB1629361-012	[05-Dec-2016]	EB1629361-013	[05-Dec-2016]	EB1629361-014	[05-Dec-2016]	EB1629361-015		
															Result	Result
EA002 : pH (Soils)																
pH Value	---	0.1	pH Unit	5.0	7.3	7.7	7.8	7.7								
EA010: Conductivity																
Electrical Conductivity @ 25°C	---	1	µS/cm	281	544	822	958	840								
EA055: Moisture Content																
Moisture Content (dried @ 103°C)	---	1	%	16.1	---	---	---	---								
ED093S: Soluble Major Cations																
Calcium	7440-70-2	10	mg/kg	<10	---	---	---	---								
Magnesium	7439-95-4	10	mg/kg	<10	---	---	---	---								
Sodium	7440-23-5	10	mg/kg	280	---	---	---	---								
Potassium	7440-09-7	10	mg/kg	<10	---	---	---	---								
EK057G: Nitrite as N by Discrete Analyser																
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg	<0.1	---	---	---	---								
EK058G: Nitrate as N by Discrete Analyser																
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg	0.2	---	---	---	---								
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser																
Nitrite + Nitrate as N (Sol.)	---	0.1	mg/kg	0.2	---	---	---	---								



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)		Client sample ID													
		Client sampling date / time													
Compound	CAS Number	LOR	Unit	BH05/16 5.00m		BH05/16 5.50m		BH05/16 7.00m		BH06/16 0.5m		BH06/16 1.00m			
				Result		Result		Result		Result		Result			
EA002 : pH (Soils)															
pH Value	---	0.1	pH Unit	6.0	6.6	5.1	6.9	7.1							
EA010: Conductivity															
Electrical Conductivity @ 25°C	---	1	µS/cm	1120	1180	2080	104	48							
EA055: Moisture Content															
Moisture Content (dried @ 103°C)	---	1	%	---	---	24.6	16.1	23.7							
ED093S: Soluble Major Cations															
Calcium	7440-70-2	10	mg/kg	---	---	590	20	<10							
Magnesium	7439-95-4	10	mg/kg	---	---	390	20	<10							
Sodium	7440-23-5	10	mg/kg	---	---	2720	60	50							
Potassium	7440-09-7	10	mg/kg	---	---	30	<10	<10							
EK057G: Nitrite as N by Discrete Analyser															
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg	---	---	<0.1	<0.1	<0.1							
EK058G: Nitrate as N by Discrete Analyser															
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg	---	---	0.5	0.4	1.4							
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser															
Nitrite + Nitrate as N (Sol.)	---	0.1	mg/kg	---	---	0.5	0.4	1.4							



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)		Client sample ID															
		Client sampling date / time				BH06/16 1.50m				BH06/16 2.00m		BH06/16 2.50m		BH07/16 0.50m		BH07/16 1.00m	
Compound	CAS Number	LOR	Unit			Result		Result		Result		Result		Result		Result	
EA002 : pH (Soils)																	
pH Value	---	0.1	pH Unit			7.5		8.0		8.0		6.8		7.1			
EA010: Conductivity																	
Electrical Conductivity @ 25°C	---	1	µS/cm			57		81		83		82		431			
EA055: Moisture Content																	
Moisture Content (dried @ 103°C)	---	1	%			---		25.2		22.6		17.9		18.1			
ED093S: Soluble Major Cations																	
Calcium	7440-70-2	10	mg/kg			---		<10		<10		<10		<10			
Magnesium	7439-95-4	10	mg/kg			---		<10		<10		<10		<10			
Sodium	7440-23-5	10	mg/kg			---		80		80		80		450			
Potassium	7440-09-7	10	mg/kg			---		<10		<10		<10		<10			
EK057G: Nitrite as N by Discrete Analyser																	
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg			---		<0.1		<0.1		0.4		<0.1			
EK058G: Nitrate as N by Discrete Analyser																	
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg			---		0.1		<0.1		2.3		<0.1			
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser																	
Nitrite + Nitrate as N (Sol.)	---	0.1	mg/kg			---		0.1		<0.1		2.7		<0.1			



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)		Client sample ID													
Compound	CAS Number	Client sampling date / time		LOR	Unit	BH07/16 1.50m		BH07/16 2.00m		BH07/16 2.50m		BH08/16 0.50m		BH08/16 1.00m	
		[05-Dec-2016]				[05-Dec-2016]		[05-Dec-2016]		[05-Dec-2016]		[05-Dec-2016]			
		Result				Result		Result		Result		Result			
EA002 : pH (Soils)															
pH Value	---	0.1	pH Unit			6.4		7.1		6.8		7.4		7.3	
EA010: Conductivity															
Electrical Conductivity @ 25°C	---	1	µS/cm			811		286		270		130		39	
EA055: Moisture Content															
Moisture Content (dried @ 103°C)	---	1	%			---		21.5		20.2		13.6		---	
ED093S: Soluble Major Cations															
Calcium	7440-70-2	10	mg/kg			---		<10		<10		100		---	
Magnesium	7439-95-4	10	mg/kg			---		<10		<10		20		---	
Sodium	7440-23-5	10	mg/kg			---		290		270		20		---	
Potassium	7440-09-7	10	mg/kg			---		<10		<10		10		---	
EK057G: Nitrite as N by Discrete Analyser															
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg			---		<0.1		<0.1		2.0		---	
EK058G: Nitrate as N by Discrete Analyser															
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg			---		0.1		<0.1		13.9		---	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser															
Nitrite + Nitrate as N (Sol.)	---	0.1	mg/kg			---		0.1		<0.1		15.9		---	



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)		Client sample ID																																																
Compound	CAS Number	Client sampling date / time		LOR	Unit	BH08/16 1.50m					BH08/16 2.00m					BH08/16 2.50m					BH09/16 0.50m					BH09/16 1.00m																								
		[05-Dec-2016]				EB1629361-031					[05-Dec-2016]					EB1629361-032					[05-Dec-2016]					EB1629361-033					[05-Dec-2016]					EB1629361-034					[05-Dec-2016]					EB1629361-035				
		Result				Result		Result		Result		Result		Result		Result		Result		Result		Result		Result		Result		Result		Result		Result		Result		Result		Result												
EA002 : pH (Soils)																																																		
pH Value		---	0.1	pH Unit		7.5					7.2					7.2					6.5					5.2																								
EA010: Conductivity																																																		
Electrical Conductivity @ 25°C		---	1	µS/cm		44					53					106					56					160																								
EA055: Moisture Content																																																		
Moisture Content (dried @ 103°C)		---	1	%		---					---					---					8.6					---																								
ED093S: Soluble Major Cations																																																		
Calcium		7440-70-2	10	mg/kg		---					---					---					10					---																								
Magnesium		7439-95-4	10	mg/kg		---					---					---					<10					---																								
Sodium		7440-23-5	10	mg/kg		---					---					---					30					---																								
Potassium		7440-09-7	10	mg/kg		---					---					---					10					---																								
EK057G: Nitrite as N by Discrete Analyser																																																		
Nitrite as N (Sol.)		14797-65-0	0.1	mg/kg		---					---					1.2					---																													
EK058G: Nitrate as N by Discrete Analyser																																																		
Nitrate as N (Sol.)		14797-55-8	0.1	mg/kg		---					---					8.6					---																													
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser																																																		
Nitrite + Nitrate as N (Sol.)		---	0.1	mg/kg		---					---					9.8					---																													



Page : 10 of 11
Work Order : EB1629361
Client : BRISBANE CITY COUNCIL
Project : 160725 - Sherwood Aboretum

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)		Client sample ID													
Compound	CAS Number	Client sampling date / time		LOR	Unit	BH09/16 2.00m		BH10/16 0.50m		BH10/16 1.00m		BH10/16 2.00m		BH11/16 0.50m	
		Result	Unit			Result	Unit	Result	Unit	Result	Unit	Result	Unit		
EA002 : pH (Soils)															
pH Value	---	0.1	pH Unit			6.1		7.2		7.0		7.2			6.8
EA010: Conductivity															
Electrical Conductivity @ 25°C	---	1	µS/cm			147		15		22		97			82
EA055: Moisture Content															
Moisture Content (dried @ 103°C)	---	1	%			---		9.3		---		---			14.3
ED093S: Soluble Major Cations															
Calcium	7440-70-2	10	mg/kg			---		<10		---		---			<10
Magnesium	7439-95-4	10	mg/kg			---		<10		---		---			<10
Sodium	7440-23-5	10	mg/kg			---		10		---		---			70
Potassium	7440-09-7	10	mg/kg			---		<10		---		---			<10
EK057G: Nitrite as N by Discrete Analyser															
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg			---		<0.1		---		---			0.1
EK058G: Nitrate as N by Discrete Analyser															
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg			---		0.2		---		---			1.3
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser															
Nitrite + Nitrate as N (Sol.)	---	0.1	mg/kg			---		0.2		---		---			1.4



Page : 11 of 11
Work Order : EB1629361
Client : BRISBANE CITY COUNCIL
Project : 160725 - Sherwood Aboretum

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)		Client sample ID													
Compound	CAS Number	Client sampling date / time		LOR	Unit	BH11/16 1.00m		BH11/16 1.50m		BH11/16 2.00m		BH11/16 2.50m		BH11/16 4.00m	
		[05-Dec-2016]				[05-Dec-2016]		[05-Dec-2016]		[05-Dec-2016]		[05-Dec-2016]			
		Result				Result		Result		Result		Result			
EA002 : pH (Soils)															
pH Value	---	0.1	pH Unit			6.5	7.0	7.4	7.1			7.5			
EA010: Conductivity															
Electrical Conductivity @ 25°C	---	1	µS/cm			590	1080	669	931			201			
EA055: Moisture Content															
Moisture Content (dried @ 103°C)	---	1	%			15.0	---	---	---			24.5			
ED093S: Soluble Major Cations															
Calcium	7440-70-2	10	mg/kg			60	---	---	---			10			
Magnesium	7439-95-4	10	mg/kg			30	---	---	---			<10			
Sodium	7440-23-5	10	mg/kg			570	---	---	---			210			
Potassium	7440-09-7	10	mg/kg			<10	---	---	---			20			
EK057G: Nitrite as N by Discrete Analyser															
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg			0.1	---	---	---			<0.1			
EK058G: Nitrate as N by Discrete Analyser															
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg			1.1	---	---	---			<0.1			
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser															
Nitrite + Nitrate as N (Sol.)	---	0.1	mg/kg			1.2	---	---	---			<0.1			



Environmental

CERTIFICATE OF ANALYSIS

Work Order	: EB1701527	Page	: 1 of 4
Client	: BRISBANE CITY COUNCIL	Laboratory	: Environmental Division Brisbane
Contact	: [REDACTED]	Contact	: Customer Services EB
Address	: CITY PROJECTS OFFICE 505 ST PAULS TERRACE FORTITUDE VALLEY QLD, AUSTRALIA 4006	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 [REDACTED]	Telephone	: +61-7-3243 7222
Project	: BH94 SHERWOOD ARBORETUM	Date Samples Received	: 25-Jan-2017 15:30
Order number	: M64232WD	Date Analysis Commenced	: 27-Jan-2017
C-O-C number	: ---	Issue Date	: 02-Feb-2017 11:13
Sampler	: [REDACTED]		
Site	: ---		
Quote number	: BNBQ/034/16		
No. of samples received	: 2		
No. of samples analysed	: 2		



Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD



Page : 2 of 4
Work Order : EB1701527
Client : BRISBANE CITY COUNCIL
Project : BH94 SHERWOOD ARBORETUM

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key :

CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

Ø = ALS is not NATA accredited for these tests.

~ = Indicates an estimated value.

- EK040P (Fluoride) - Sample required dilution due to matrix interference. LOR values have been adjusted accordingly.
- EA016: Calculated TDS is determined from Electrical conductivity using a conversion factor of 0.65.



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)		Client sample ID			
Compound	Client sampling date / time				
	CAS Number	LOR	Unit		
			Result	Result	
EA005P: pH by PC Titrator					
pH Value	---	0.01	pH Unit	8.28	
EA006: Sodium Adsorption Ratio (SAR)					
Sodium Adsorption Ratio	---	0.01	-	28.9	
EA010P: Conductivity by PC Titrator					
Electrical Conductivity @ 25°C	---	1	µS/cm	9540	
EA016: Calculated TDS (from Electrical Conductivity)					
Total Dissolved Solids (Calc.)	---	1	mg/L	6200	
EA065: Total Hardness as CaCO3					
Total Hardness as CaCO3	---	1	mg/L	940	
ED037P: Alkalinity by PC Titrator					
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	1300	
Total Alkalinity as CaCO3	---	1	mg/L	1300	
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA					
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	3050	
ED045G: Chloride by Discrete Analyser					
Chloride	16887-00-6	1	mg/L	905	
ED093F: Dissolved Major Cations					
Calcium	7440-70-2	1	mg/L	60	
Magnesium	7439-95-4	1	mg/L	192	
Sodium	7440-23-5	1	mg/L	2040	
Potassium	7440-09-7	1	mg/L	11	
EK040P: Fluoride by PC Titrator					
Fluoride	16984-48-8	0.1	mg/L	1.7	
EK055G: Ammonia as N by Discrete Analyser					
Ammonia as N	7664-41-7	0.01	mg/L	0.12	
EK057G: Nitrite as N by Discrete Analyser					
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	
EK058G: Nitrate as N by Discrete Analyser					
Nitrate as N	14797-55-8	0.01	mg/L	<0.01	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser					
Nitrite + Nitrate as N	---	0.01	mg/L	<0.01	



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)		Client sample ID							
		Client sampling date / time							
Compound	CAS Number	LOR	Unit	BH04/16	BH05/16				
				25-Jan-2017 00:00	25-Jan-2017 00:00				
				EB1701527-001	EB1701527-002				
				Result	Result				
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	1.6	1.1				
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
^ Total Nitrogen as N	----	0.1	mg/L	1.6	2.0				
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L	6.06	0.42				
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L	0.78	0.04				
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L	115	341				
Total Cations	----	0.01	meq/L	108	343				
Ionic Balance	----	0.01	%	3.23	0.26				



Environmental

CERTIFICATE OF ANALYSIS

Work Order	: EB1702288	Page	: 1 of 6
Client	: BRISBANE CITY COUNCIL	Laboratory	: Environmental Division Brisbane
Contact	: [REDACTED]	Contact	: Customer Services EB
Address	: GPO BOX 2567	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: BRISBANE QLD, AUSTRALIA 4001	Telephone	: +61-7-3243 7222
Project	: +61 07 [REDACTED]	Date Samples Received	: 07-Feb-2017 11:55
Order number	: BH94 Sherwood Arbitrium	Date Analysis Commenced	: 08-Feb-2017
C-O-C number	: M64232WD	Issue Date	: 13-Feb-2017 13:48
Sampler	: [REDACTED]		
Site	: [REDACTED]		
Quote number	: BNBQ/034/16		
No. of samples received	: 6		
No. of samples analysed	: 6		



Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD



Page : 2 of 6
Work Order : EB1702288
Client : BRISBANE CITY COUNCIL
Project : BH94 Sherwood Arbitrium

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key :

CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

Ø = ALS is not NATA accredited for these tests.

~ = Indicates an estimated value.

- EA016: Calculated TDS is determined from Electrical conductivity using a conversion factor of 0.65.



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)		Client sample ID				POND		BH01/16	BH02/16	BH03/16	BH04/16
Compound	CAS Number	LOR	Unit	Client sampling date / time	Result	EB1702288-001	EB1702288-002	EB1702288-003	EB1702288-004	EB1702288-005	Result
EA005P: pH by PC Titrator											
pH Value	---	0.01	pH Unit		7.83	7.24	6.43	7.11	7.95		
EA008: Sodium Adsorption Ratio (SAR)											
Sodium Adsorption Ratio	---	0.01	-		2.38	5.55	6.64	7.07	29.4		
EA010P: Conductivity by PC Titrator											
Electrical Conductivity @ 25°C	---	1	µS/cm		390	2980	4960	3960	9260		
EA016: Calculated TDS (from Electrical Conductivity)											
Total Dissolved Solids (Calc.)	---	1	mg/L		254	1940	3220	2570	6020		
EA065: Total Hardness as CaCO3											
Total Hardness as CaCO3	---	1	mg/L		77	887	1700	1140	1030		
ED037P: Alkalinity by PC Titrator											
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	<1	<1	<1		
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	<1	<1	<1	<1		
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		70	475	196	517	1320		
Total Alkalinity as CaCO3	---	1	mg/L		70	475	196	517	1320		
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA											
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		2	848	2200	1250	3020		
ED045G: Chloride by Discrete Analyser											
Chloride	16887-00-6	1	mg/L		75	273	487	413	866		
ED093F: Dissolved Major Cations											
Calcium	7440-70-2	1	mg/L		16	159	318	213	64		
Magnesium	7439-95-4	1	mg/L		9	119	220	149	212		
Sodium	7440-23-5	1	mg/L		48	380	629	550	2170		
Potassium	7440-09-7	1	mg/L		6	2	9	24	12		
EK040P: Fluoride by PC Titrator											
Fluoride	16984-48-8	0.1	mg/L		0.1	0.6	0.2	0.4	1.7		
EK055G: Ammonia as N by Discrete Analyser											
Ammonia as N	7664-41-7	0.01	mg/L		0.07	0.11	0.27	0.25	0.03		
EK057G: Nitrite as N by Discrete Analyser											
Nitrite as N	14797-65-0	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01		
EK058G: Nitrate as N by Discrete Analyser											
Nitrate as N	14797-55-8	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01		
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser											
Nitrite + Nitrate as N	---	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01		

Analytical Results

Sub-Matrix: WATER
(Matrix: WATER)

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID						
Compound	CAS Number	LOR	Client sampling date / time		POND	BH01/16	BH02/16	BH03/16	BH04/16
			Unit						
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	---	0.1	mg/L		9.2	0.3	0.6	0.4	0.3
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
^ Total Nitrogen as N	---	0.1	mg/L		9.2	0.3	0.6	0.4	0.3
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	---	0.01	mg/L		0.93	0.18	0.36	0.23	0.87
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		0.01	0.11	0.30	0.18	0.81
EN055: Ionic Balance									
Total Anions	---	0.01	meq/L		3.56	34.8	63.4	48.0	114
Total Cations	---	0.01	meq/L		3.78	34.3	61.6	47.4	115
Ionic Balance	---	0.01	%		3.06	0.78	1.51	0.60	0.72



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)		Client sample ID			BH05/16	
		Client sampling date / time			06-Feb-2017 15:00	
Compound	CAS Number	LOR	Unit			
				Result		
EA005P: pH by PC Titrator						
pH Value	---	0.01	pH Unit	7.12	----	-----
EA006: Sodium Adsorption Ratio (SAR)						
Sodium Adsorption Ratio	---	0.01	-	26.0	----	-----
EA010P: Conductivity by PC Titrator						
Electrical Conductivity @ 25°C	---	1	µS/cm	27700	----	-----
EA016: Calculated TDS (from Electrical Conductivity)						
Total Dissolved Solids (Calc.)	---	1	mg/L	18000	----	-----
EA065: Total Hardness as CaCO3						
Total Hardness as CaCO3	---	1	mg/L	6880	----	-----
ED037P: Alkalinity by PC Titrator						
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	-----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	----	-----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	186	----	-----
Total Alkalinity as CaCO3	---	1	mg/L	186	----	-----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA						
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	5760	----	-----
ED045G: Chloride by Discrete Analyser						
Chloride	16887-00-6	1	mg/L	8060	----	-----
ED093F: Dissolved Major Cations						
Calcium	7440-70-2	1	mg/L	795	----	-----
Magnesium	7439-95-4	1	mg/L	1190	----	-----
Sodium	7440-23-5	1	mg/L	4970	----	-----
Potassium	7440-09-7	1	mg/L	18	----	-----
EK040P: Fluoride by PC Titrator						
Fluoride	16984-48-8	0.1	mg/L	<0.1	----	-----
EK055G: Ammonia as N by Discrete Analyser						
Ammonia as N	7664-41-7	0.01	mg/L	0.52	----	-----
EK057G: Nitrite as N by Discrete Analyser						
Nitrite as N	14797-65-0	0.01	mg/L	0.02	----	-----
EK058G: Nitrate as N by Discrete Analyser						
Nitrate as N	14797-55-8	0.01	mg/L	0.40	----	-----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser						
Nitrite + Nitrate as N	---	0.01	mg/L	0.42	----	-----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID			
			Client sampling date / time			
			BH05/16			
			06-Feb-2017 15:00			
			EB1702288-006			
Compound	CAS Number	LOR	Unit	Result		
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser						
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	1.7		
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser						
^ Total Nitrogen as N	----	0.1	mg/L	2.1		
EK067G: Total Phosphorus as P by Discrete Analyser						
Total Phosphorus as P	----	0.01	mg/L	1.01		
EK071G: Reactive Phosphorus as P by discrete analyser						
Reactive Phosphorus as P	14265-44-2	0.01	mg/L	0.02		
EN055: Ionic Balance						
Total Anions	----	0.01	meq/L	351		
Total Cations	----	0.01	meq/L	354		
Ionic Balance	----	0.01	%	0.46		

Particle Size Distribution of a Soil - Standard method of fine analysis using a hydrometer



Laboratory Services
Planning and Design, City Projects Office
Brisbane Infrastructure
Brisbane City Council
25 Green Square Cl, Fortitude Valley
Ph (07) 340 30661 fax (07) 340 30833

Test Procedure: AS1289 2.1.1, 3.6.1, 3.6.3

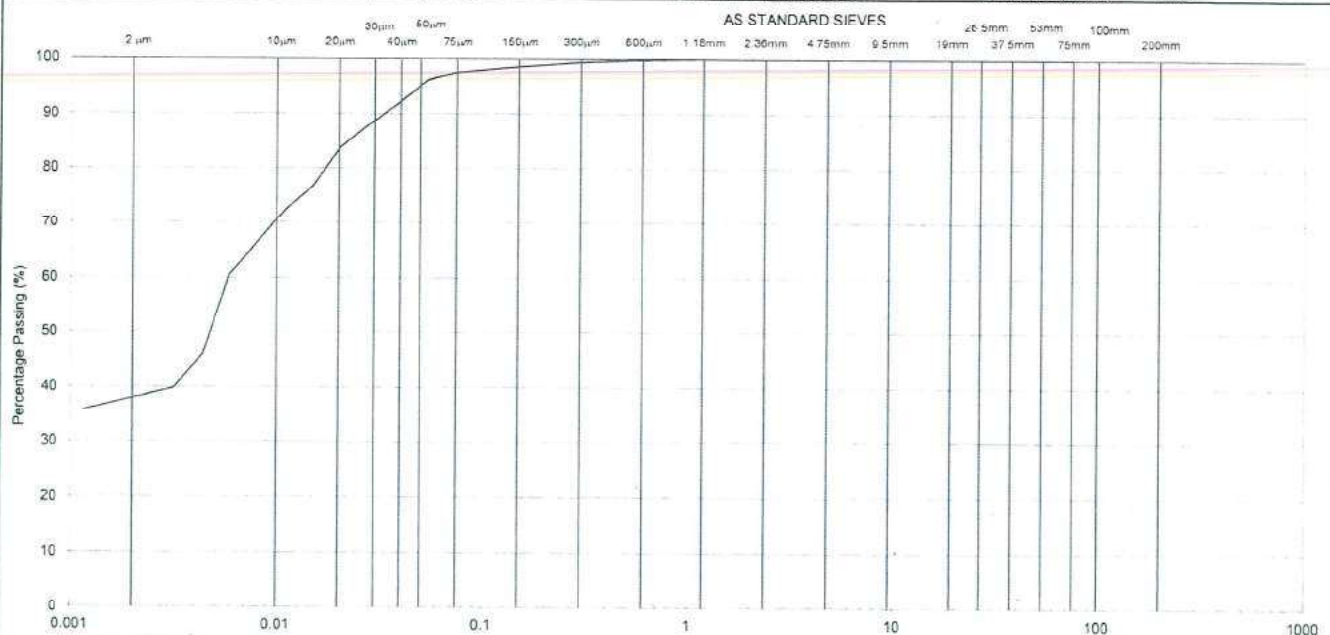
Report No BH94-1

Client Ground Engineering, Lvl 1 Green Square, Fortitude Valley
Project Sherwood Arboretum
Location Sherwood
Loss in pretreatment 0 % Sample not pretreated

Tested by BJ Date 10-Apr-17
Checked by GH Date 11-Apr-16

Type of hydrometer used: g/L

Method of dispersion: Mixer



SILT & CLAY	SAND		GRAVEL			COBBLES	BOULDERS
	fine	coarse	fine	medium	coarse		

Particle Size	Laboratory Registration No.	BH94-1
	Sample ID.	TP02/17 0.7 m
75 mm		
53 mm		
37.5 mm		
26.5 mm		
19 mm		
13.2 mm		
9.5 mm		
6.7 mm		
4.75 mm		
2.36 mm		
1.18 mm		
600 µm		
425 µm		100
300 µm		99
150 µm		99
75 µm		97
54 µm		96
39.1 µm		92
28.2 µm		88
20.4 µm		84
15 µm		77
11.2 µm		73
8.1 µm		67
5.9 µm		60
4.4 µm		46
3.2 µm		40
1.1 µm		36

Approved signatory: James Angus - Laboratory Manager

Date 19.4.17

This document is issued in accordance with NATA's accreditation requirements.



Accredited for compliance with ISO/IEC 17025

Particle Size Distribution of a Soil - Standard method of fine analysis using a hydrometer



Laboratory Services
Planning and Design, City Projects Office
Brisbane Infrastructure
Brisbane City Council
25 Green Square Cl, Fortitude Valley
Ph (07) 340 30661 fax (07) 340 30833

Test Procedure: AS1289 2.1.1, 3.6.1, 3.6.3

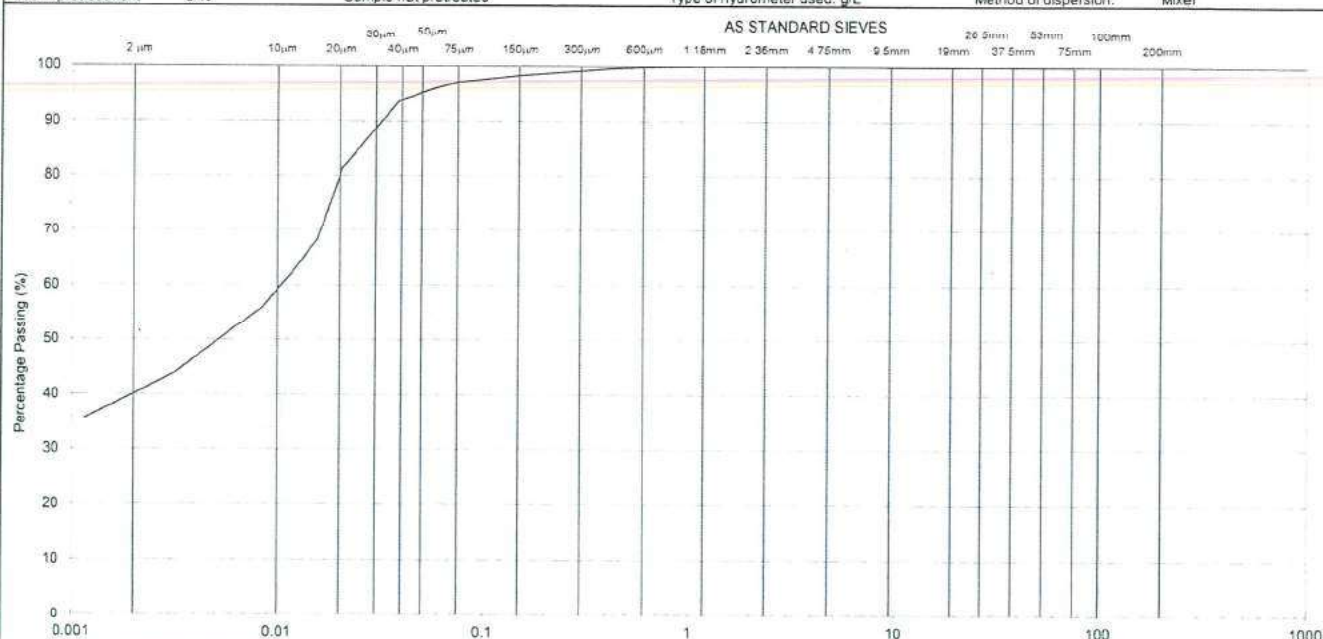
Report No BH94-2

Client Ground Engineering, Lvl 1 Green Square, Fortitude Valley
Project Sherwood Arboretum
Location Sherwood
Loss in pretreatment 0 % Sample not pretreated

Tested by BJ Date 10-Apr-17
Checked by GH Date 11-Apr-16

Type of hydrometer used: g/L

Method of dispersion: Mixer



SILT & CLAY	SAND		GRAVEL			COBBLES	BOULDERS
	fine	coarse	fine	medium	coarse		

Laboratory Registration No.	BH94-2
Sample ID.	TP02/17 1.00m
75 mm	
53 mm	
37.5 mm	
26.5 mm	
19 mm	
13.2 mm	
9.5 mm	
6.7 mm	
4.75 mm	
2.36 mm	
1.18 mm	
600 μm	
425 μm	100
300 μm	99
150 μm	98
75 μm	97
54 μm	96
38.6 μm	94
28.2 μm	87
20.6 μm	81
15.6 μm	68
11.7 μm	62
8.5 μm	56
6.1 μm	52
4.4 μm	48
3.1 μm	44
1.1 μm	36

Particle Size

Approved signatory: James Angus - Laboratory Manager

Date 19.4.17

This document is issued in accordance with NATA's accreditation requirements.



Accredited for compliance with ISO/IEC 17025

Particle Size Distribution of a Soil - Standard method of fine analysis using a hydrometer



Laboratory Services
Planning and Design, City Projects Office
Brisbane Infrastructure
Brisbane City Council
25 Green Square Cl, Fortitude Valley
Ph (07) 340 30661 fax (07) 340 30833

Test Procedure: AS1289 2.1.1, 3.6.1, 3.6.3

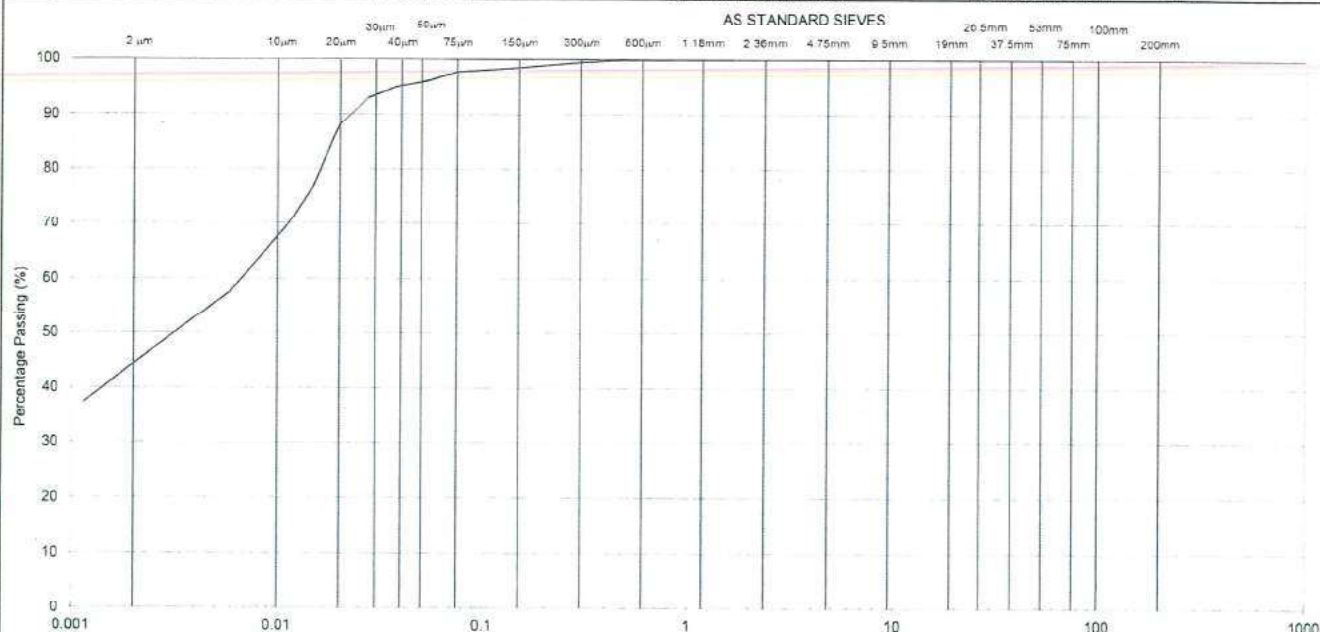
Report No BH94-3

Client Ground Engineering, Lvl 1 Green Square, Fortitude Valley
Project Sherwood Arboretum
Location Sherwood
Loss in pretreatment 0 % Sample not pretreated

Tested by BJ Date 10-Apr-17
Checked by GH Date 11-Apr-16

Type of hydrometer used: g/L

Method of dispersion: Mixer



SILT & CLAY	SAND		GRAVEL			COBBLES	BOULDERS
	fine	coarse	fine	medium	coarse		

Laboratory Registration No.	BH94-3
Sample ID.	TP03/17 0.40m

Particle Size	75 mm	
	53 mm	
	37.5 mm	
	26.5 mm	
	19 mm	
	13.2 mm	
	9.5 mm	
	6.7 mm	
	4.75 mm	
	2.36 mm	
	1.18 mm	
	600 μm	
	425 μm	100
	300 μm	99
	150 μm	98
	75 μm	98
	53.7 μm	96
	38.2 μm	95
	27.3 μm	93
	19.9 μm	88
	14.9 μm	77
	11.3 μm	70
	8.2 μm	64
	5.9 μm	58
	4.3 μm	54
	3.1 μm	50
	1.1 μm	37

Approved signatory: James Angus - Laboratory Manager

Date 19.4.17

This document is issued in accordance with NATA's accreditation requirements.



Accredited for compliance with ISO/IEC 17025

Particle Size Distribution of a Soil - Standard method of fine analysis using a hydrometer



Laboratory Services
Planning and Design, City Projects Office
Brisbane Infrastructure
Brisbane City Council
25 Green Square Cl, Fortitude Valley
Ph (07) 340 30661 fax (07) 340 30833

Test Procedure: AS1289 2.1.1, 3.6.1, 3.6.3

Report No BH94-4

Client Ground Engineering, Lvl 1 Green Square, Fortitude Valley

Tested by BJ Date 10-Apr-17

Project Sherwood Arboretum

Checked by GH Date 11-Apr-16

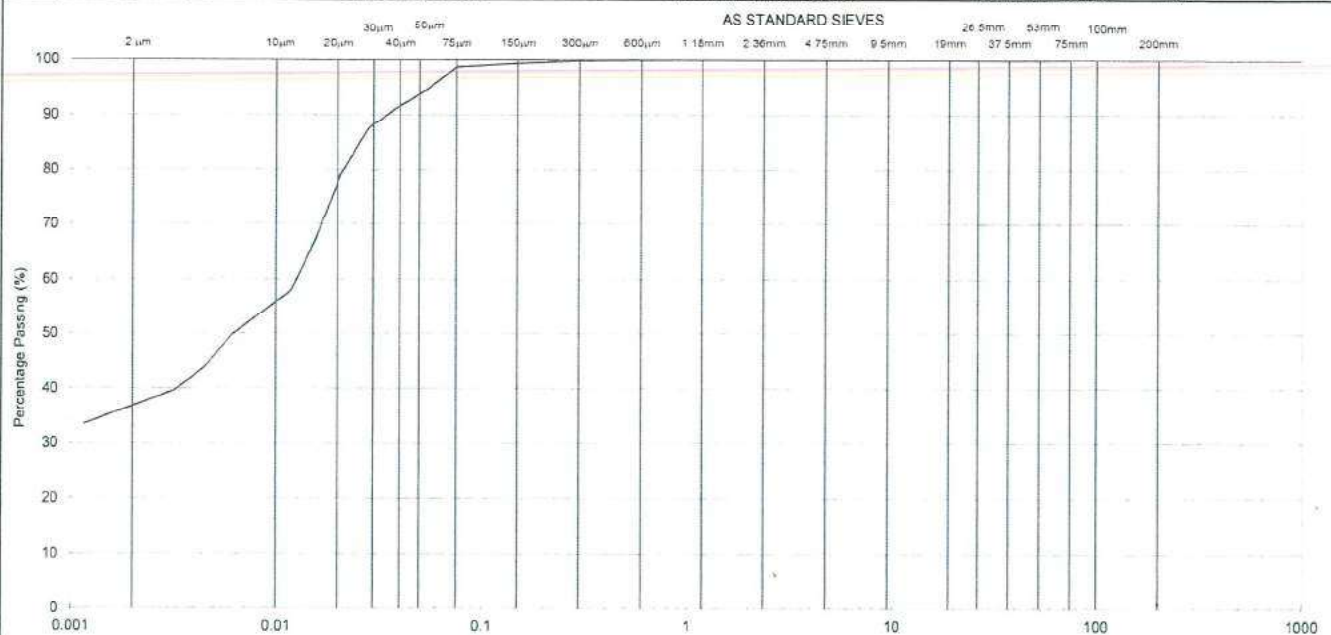
Location Sherwood

Loss in pretreatment 0 %

Sample not pretreated

Type of hydrometer used: g/L

Method of dispersion: Mixer



SILT & CLAY	SAND		GRAVEL			COBBLES	BOULDERS
	fine	coarse	fine	medium	coarse		

Laboratory Registration No.	BH94-4
Sample ID.	TP03/17 1.00m

Particle Size	75 mm
	53 mm
	37.5 mm
	26.5 mm
	19 mm
	13.2 mm
	9.5 mm
	6.7 mm
	4.75 mm
	2.36 mm
	1.18 mm
	600 µm
	425 µm
	300 µm
	150 µm
	75 µm
	54.3 µm
	39.1 µm
	28.2 µm
	20.8 µm
	15.6 µm
	11.9 µm
	8.5 µm
	6.1 µm
	4.4 µm
	3.2 µm
	1.2 µm

[Signature]

Approved signatory: James Angus - Laboratory Manager

Date 19.4.17

This document is issued in accordance with NATA's accreditation requirements.



Accredited for compliance with ISO/IEC 17025

Appendix D

Sherwood Arboretum Hydrological
Characterisation of Soils

– The Sustainable Minerals Institute –
University of Queensland

Sherwood Arboretum hydrological characterisation of soils

**The Sustainable Minerals Institute
The University of Queensland**

Prepared for


Brisbane City Council

Contact:


Sustainable Minerals Institute – Environment Centres



May 2017

Table of Contents

1. Objective	3
2. Sampling	3
3. Methodology	4
a. Field sampling	4
b. Test for soil physical and hydrological properties	5
Water content at the time of sampling.....	5
Soil saturated hydraulic conductivity k_{sat}	5
Water retention characteristic (WRC)	5
Soil dry bulk density	5
Fitting of van Genuchten parameters	5
4. Results	6
5. Summarising comments.....	12
6. References.....	12
7. Appendix.....	13

1. Objective

- a) Collection of undisturbed soil samples from 3 sites at the Sherwood Arboretum at four depths/site (0.1m, 0.4m, 0.7m and 1m) with three replicates per depth for the purposes of undertaking laboratory tests for assessment of hydrological properties.
- b) Laboratory testing on one soil core for each depth at each sampling site (12 tests in total) for derivation of the water retention curve; saturated hydraulic conductivity and bulk density. Untested samples will be retained for back-up purposes.
- c) For each sample, fitting of the water retention curve data to a standard unsaturated soil physics model and derivation of the unsaturated hydraulic conductivity function.

2. Sampling

The Sherwood Arboretum was visited on 29 March 2017 by Thomas Baumgartl and Vinod Nath (SMI, The University of Queensland) for soil core sampling.

Three sampling sites were selected in discussion with Bruce Cheeseman (Brisbane City Council; Figure 1). The criteria for the selection of the sampling sites were

- vicinity to trees, which were potentially exposed to high moisture conditions being situated close to the pond at a low lying location and identified as 'unhealthy' (site 1)
- a location close to the pond and in a similar low lying environment as site 1, but in the vicinity of 'healthy' trees (site 2)
- a control site in the vicinity of 'healthy' trees on a topographically higher position above the pond water level (site 3).

Gravimetric vs. volumetric water content

Volumetric water content rather than the standard geotechnical industry gravimetric water content is used in this report to compare water contents. This means of describing water content has been adopted as it allows for water contents to be normalised to the volume of soil and facilitates a direct comparison of values. Hence, volumetric water content takes indirectly into account the dry (bulk) density of the soil and allows direct quantification of water volumes available or stored within a soil volume.

Volumetric water content θ_v is calculated as: $\theta_v = \frac{Vol_{water}}{Vol_{dry\ soil}}$

Gravimetric water content θ_g is calculated as: $\theta_g = \frac{Weight_{water}}{Weight_{dry\ soil}}$

The volume of water and weight of water can be assumed as equal values.

Volumetric water content θ_v and gravimetric water content θ_g are linked via the calculated dry (bulk) density BD of the soil, i.e.

$$\theta_v = BD_{dry\ soil} * \theta_g$$



Figure 1. Sampling locations for site 1, site 2 and site 3

3. Methodology

a. Field sampling

Test pits were prepared with support of an excavator. Each test pit was dug to a depth of approximately 1.1m and had a width of approximately 0.6m.

Sampling depths for each pit were 0.1m, 0.4m, 0.7m and 1m. Four sampling rings (diameter: 56mm; height 39mm) were taken at each depth for the purpose of characterising the hydraulic properties of the soil (water retention curve and saturated hydraulic conductivity) plus providing three replicate samples.

The depths were labelled as '10-1' for depth 0.1m, replicate 1 up to '100-4' for depth 1m and 4th replicate sample for each site. In total 16 samples were collected per test pit. The site location was added as a prefix to each sample as a final identifier (e.g. 'Site1-70-3' explains the 3rd replicate sample taken at the depth of 0.7m of site 1).

For each depth a bulk soil sample was collected for the high pressure plate desiccation test and for other potential tests. The samples were trimmed in the field of excess soil, packed between lids on either side and immediately stored in a sealable plastic bag to avoid any uncontrolled water loss by evaporation.

b. Test for soil physical and hydrological properties

Water content at the time of sampling

One soil core from each site/depth was tested in the laboratory to determine the actual water content prior to any hydrological test. The samples were weighed and the volumetric water content calculated following drying at 105°C at the end of each of the tests.

Soil saturated hydraulic conductivity k_{sat}

Soil cores from each depth were slowly wet up to saturation by standing the core in a container of water to a depth of 10mm. The level of water was gradually increased until it was half way up the base of the core. Once saturated, the core was placed in Tempe type flow cell. Flow direction was from bottom to top to avoid any air inclusion. The hydraulic gradient was kept constant using the Mariotte-bottle principle for controlling the inflow water pressure. The outflow was collected in a 100ml PVC bottle. Evaporation from the bottle was prevented by pushing the outflow tube through a pre-drilled hole in the lid of the collection bottle. The hydraulic gradient, the volume of outflow and the time required were recorded for the calculation of k_{sat} .

Water retention characteristic (WRC)

One saturated core of each sampled depth was placed on a sand-based tension table and intervals of suction were applied to provide specified water suctions. The applied suctions were 10, 20, 30, 100, 300hPa. The soil water content after each suction application was back calculated from sample weight once equilibrium was reached. The volumetric water contents at the seven test suctions (the five test suctions plus the calculated volumetric water content at saturation and high pressure desiccation at a pressure equivalent to a suction of 5000hPa) were used to fit a continuous function using the van Genuchten model.

Soil dry bulk density

The dry bulk density was determined from the soil cores used for the determination of the WRC following the last step of desiccation of 300hPa. The soil cores were dried in an oven at 105°C. Drying time is standardized to 24 hours.

Dry bulk density was calculated as: $(W_s - W_c) \div V_c$, where V_c is the core volume, W_s is the combined weight of the oven-dried soil and soil core ring and W_c is the weight of the soil core ring.

Fitting of van Genuchten parameters

The water retention characteristic (WRC) was calculated from the seven measurements of water content at various water suctions and fitted to a continuous function using the model of van Genuchten (van Genuchten 1980). This model normalises the measured water content using:

$$\theta(\psi_M) = \frac{\theta - \theta_r}{\theta_s - \theta_r}$$

Equation 1: Normalised water content

where Θ is the water content, Ψ_M is the water suction [hPa] for a given water content and r and s subscripts denote residual water content and water saturated conditions. Based on the model:

$$\theta(\psi_M) = (1 + (\alpha\psi)^n)^{-m}$$

Equation 2. Van Genuchten equation for parameterisation of the WRC

Parameters α [1/hPa], n and the saturated water content ('WC-Sat' in Tables 1 to 3) are fitted. The parameter m is fixed to $m=1-(1/n)$. For fitting purposes and consistency reasons, the residual water content ('WC-Min' in Tables 1 to 3) has been set to zero.

If required for modelling purposes, the fitting parameters of van Genuchten can be used to calculate the unsaturated hydraulic conductivity based on the analytical expression for the permeability function (Mualem, 1986):

$$K_r(\psi) = \frac{\{1 - (\alpha\psi)^{n-1}[1 + (\alpha\psi)^n]^{-m}\}^2}{[1 + (\alpha\psi)^n]^{m/2}}$$

Equation 3. Mualem-van Genuchten equation for derivation of unsaturated hydraulic conductivity

where K_r : relative hydraulic conductivity ($k_{\text{actual}}/k_{\text{sat}}$), m : van Genuchten parameter fixed to $m=1-(1/n)$.

4. Results

The measured data for the water retention curve, saturated hydraulic conductivity, bulk density and calculated van Genuchten parameters for each site are summarised in Tables 1 to 3. The volumetric water content at saturated conditions (indicated as the volumetric water content at a desiccation water suction of 1hPa) was calculated from the measured bulk density (BD) and assuming a particle density (PD) of quartz of 2.65 [Mg/m³] using the relationship of total pore volume equals $1-(BD/PD)$.

Figures 2 to 4 plot the water retention curves for all depths and for each site. The white filled markers on each curve show the actual field volumetric water content and the corresponding field water suction (calculated from the van Genuchten formula; Equation 2) for each of the sampled soil cores. The dotted vertical grey line on each plot indicates the value of field capacity, i.e. the boundary between free drainage and water retained in pore system. Plots of the fitted the van Genuchten curve to the measured data for each sample are provided in the Appendix.

Calculated saturated volumetric water content (=total pore volume) is often overestimated compared to the fitted data. The reason for this discrepancy may be swelling of the soil or loss of material during the testing procedure. For this reason, the calculated saturated water content has been weighted less in the fitting procedure than the measured water suction/water content relationships for the fitting of the van Genuchten parameters.

Table 1: Site 1 measured and calculated hydraulic and physical properties

water suction for desiccation [hPa]	Depth [m]			
	0.1	0.4	0.7	1
1	0.468	0.506	0.467	0.439
10	0.462	0.454	0.469	0.468
20	0.455	0.451	0.465	0.465
30	0.452	0.450	0.464	0.466
100	0.431	0.441	0.452	0.454
300	0.406	0.429	0.437	0.443
5000	0.269	0.347	0.443	0.415
WC-Min	0	0	0	0
WC-Sat	0.459	0.451	0.489	0.478
α [1/hPa]	0.0045	0.0027	1.1654	0.0529
n	1.1664	1.095	1.0159	1.0288
bulk density [Mg/ton]	1.41	1.31	1.41	1.49
saturated hydraulic conductivity [m/s]	2.04E-08	<1e-9	2.42E-09	2.14E-09
field capacity [m ³ /m ³]	0.438	0.443	0.453	0.454
air capacity [m ³ /m ³]	0.02	0.01	0.03	0.02
volumetric water content at time of sampling [m ³ /m ³]	0.331	0.334	0.352	0.362
suction at time of sampling [hPa]	1453	8438	786626787	294156
gravimetric water content at time of sampling [kg/kg]	0.235	0.255	0.249	0.243
saturation at time of sampling	72%	74%	72%	76%

WC-min, WC-Sat, α , n: fitting parameter for van Genuchten equation

WC-Min: minimum relative (volumetric) water content

WC-Sat: saturated relative (volumetric) water content

Water contents for water retention characteristic and actual water content were calculated from two samples

Table 2: Site 2 measured and calculated hydraulic and physical properties

water suction for desiccation [hPa]	Depth [m]			
	0.1	0.4	0.7	1
1	0.515	0.483	0.448	0.436
10	0.484	0.481	0.467	0.445
20	0.479	0.477	0.465	0.447
30	0.477	0.477	0.465	0.448
100	0.467	0.460	0.453	0.436
300	0.452	0.441	0.442	0.424
5000	0.354	0.374	0.408	0.388
WC-Min	0	0	0	0
WC-Sat	0.482	0.4853	0.475	0.455
α [1/hPa]	0.0033	0.0121	0.0997	0.0227
n	1.1135	1.0661	1.0229	1.0347
bulk density [Mg/ton]	1.29	1.37	1.46	1.49
saturated hydraulic conductivity [m/s]	4.50E-05	2.45E-09	1.61E-09	1.78E-10
field capacity [m ³ /m ³]	0.470	0.462	0.450	0.437
air capacity [m ³ /m ³]	0.01	0.02	0.02	0.02
volumetric water content at time of sampling [m ³ /m ³]	0.35	0.348	0.361	0.336
suction at time of sampling [hPa]	4960	12661	1606754	274480
gravimetric water content at time of sampling [kg/kg]	0.272	0.254	0.247	0.225
saturation at time of sampling	73%	73%	76%	74%

WC-min, WC-Sat, α , n: fitting parameter for van Genuchten equation

WC-Min: minimum relative (volumetric) water content

WC-Sat: saturated relative (volumetric) water content

Water contents for water retention characteristic and actual water content were calculated from two samples

Table 3: Site 3 measured and calculated hydraulic and physical properties

water suction for desiccation [hPa]	Depth [m]			
	0.1	0.4	0.7	1
1	0.498	0.470	0.453	0.433
10	0.450	0.462	0.455	0.44
20	0.445	0.463	0.451	0.438
30	0.443	0.461	0.45	0.438
100	0.423	0.447	0.435	0.418
300	0.402	0.431	0.421	0.403
5000	0.301	0.365	0.408	0.358
WC-Min	0	0	0	0
WC-Sat	0.453	0.464	0.481	0.448
α [1/hPa]	0.0097	0.0077	0.7726	0.0323
n	1.1028	1.0622	1.0232	1.0454
bulk density [Mg/ton]	1.33	1.40	1.45	1.50
saturated hydraulic conductivity [m/s]	<1e-9	<1e-9	2.86E-09	<1e-9
field capacity [m ³ /m ³]	0.425	0.449	0.435	0.420
air capacity [m ³ /m ³]	0.03	0.01	0.04	0.03
volumetric water content at time of sampling [m ³ /m ³]	0.312	0.337	0.333	0.295
suction at time of sampling [hPa]	3784	21876	9901529	306945
gravimetric water content at time of sampling [kg/kg]	0.235	0.240	0.230	0.196
saturation at time of sampling	67%	73%	69%	66%

WC-min, WC-Sat, α , n: fitting parameter for van Genuchten equation

WC-Min: minimum relative (volumetric) water content

WC-Sat: saturated relative (volumetric) water content

Water contents for water retention characteristic and actual water content were calculated from two samples

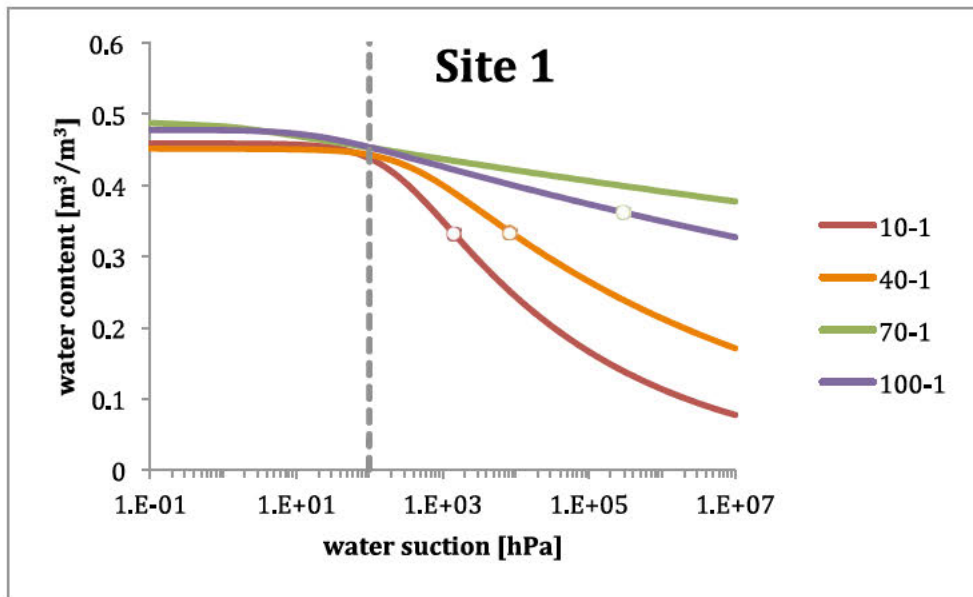


Figure 2: Site 1 water retention curves

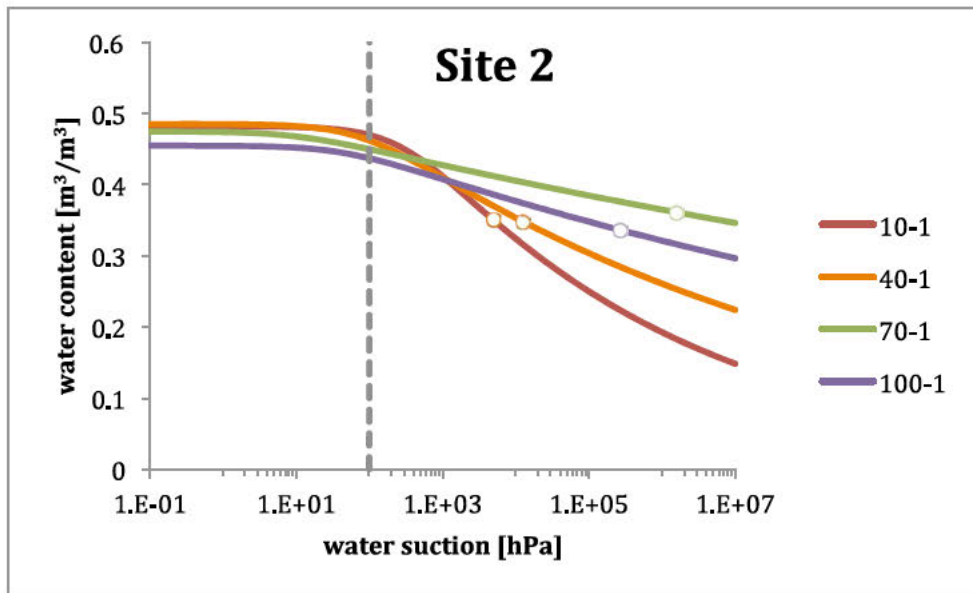


Figure 3: Site 2 water retention curves

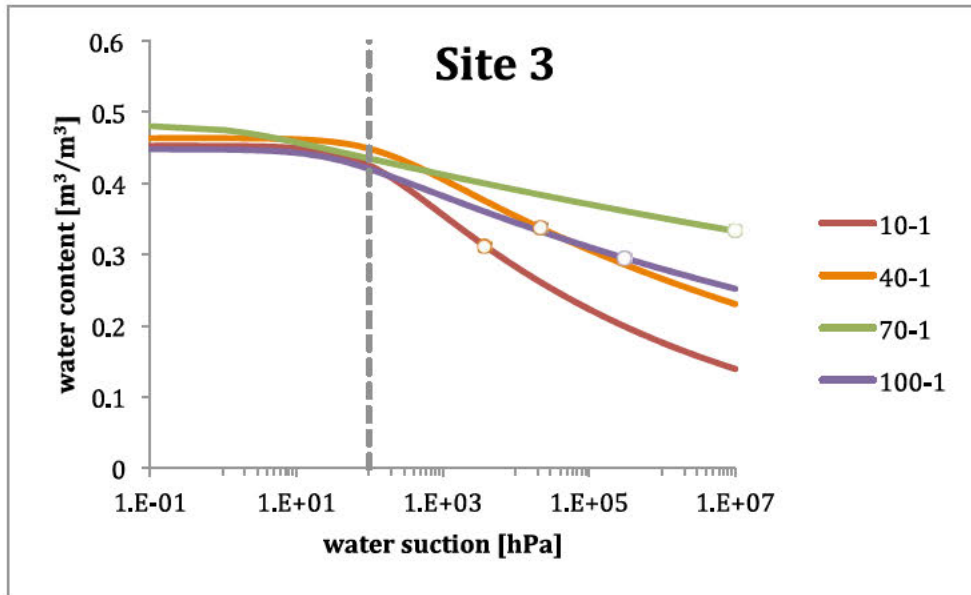


Figure 4: Site 3 water retention curves

The results show that the hydraulic characteristic of the soil between the three sites are very similar. Site 1 shows the highest calculated and measured total pore volume for most of the depths compared to site 2 and 3. Site 3 shows its largest pore volume at 0.7m depth, site 2 has the highest pore volume and lowest bulk density in the depths 0.1m and 0.4m. From the general trend it can be deduced that there are no significant differences in the pore size distribution across the sites and there is a trend of decreasing total pore volume with depth for all sites. All sites show that the proportion of finer sized pores increases with increasing depth, which will overall lead to less permeability with depth.

The water content at field capacity (water suction at 10^2 hPa; dotted line in Figures 2 to 4) is very similar across depths and sites and slightly lower in the two lower depths of site 3.

The volumetric water contents at the time of sampling were in general driest at site 3. Sites 1 and 2 are moist, with site 2 moister than site 1. Despite the increase in water content with depth, the water suction calculated using the water retention curve is increasing with depth, i.e. the ability for water uptake by plants becomes more difficult at depth. The large suction values presented in Table 1 indicate that the soil, despite its moist appearance, is "dry" from a plant physiological perspective.

Air capacity describes the proportion of pores available for free drainage and a measure of the potential for gas exchange from and into the soil. The air capacity, i.e. the pore volume between saturation and field capacity is less than 2.5%, for some depths even less than 1% (only for site 3, 0.7m an air capacity of 4% is calculated). These values are very low and well below optimal values. A lower limiting threshold for plant growth in literature has been set to around 5% air capacity.

The water suctions calculated from the van Genuchten parameters show that all measured water suction at the time of sampling were well above the suction at field capacity indicating there is no free water at any of the depths. This coincides with the observations during sampling, where the soil across all depths and sites was described as moist, but not wet.

The saturated hydraulic conductivity is very low for all depths. The values range between 4×10^{-5} m/s to less than 1×10^{-9} m/s. The high value of conductivity at depth 0.4m at site 2 appears not to be representative and may be a result of an active root canal.

In general, the tested soil depths appear very similar with very low values of hydraulic conductivity. A value of 1×10^{-9} m/s is considered as extremely low for natural substrates.

5. Summarising comments

The following conclusions can be drawn from observations and investigations of the hydrological properties of the soils at the Sherwood Arboretum:

- The soils are very rich in clay with little or no structure resulting in very low saturated hydraulic conductivity.
- At the time of sampling a relatively high (66% to 76%) water saturation was determined.
- The water suction at the time of sampling, calculated from the water retention curve, shows that the suction for plant roots to enable uptake of water was very high, and the soil can thus be considered “dry” from a plant perspective.
- The soils are relatively dense and root penetration to depth is not only mechanically impeded but is also affected by low values of air capacity, preventing aeration and gravitational water drainage.
- The groundwater level of a nearby groundwater monitoring point was measured at the time of sampling being just below the lowest sampling depth of site 1. The measured unsaturated conditions at this depth in the soil indicate that there seems to be no hydrological connection between the groundwater (pond water) and the alluvial soil.

6. References

van Genuchten, M. T. (1980). "A closed-form equation for predicting the hydraulic conductivity of unsaturated soils." *Soil Sci. Soc. Am. J.* 44: 892-898.

Mualem (1986): Hydraulic conductivity of unsaturated soils: prediction and formulas. In: Van Genuchten M.Th., Leij L.J., Lund L.J. (Eds): Proceedings of the International Workshop, Indirect Methods for Estimating the Hydraulic Properties of Unsaturated soils. Univ. of California, Riverside.

Acknowledgements

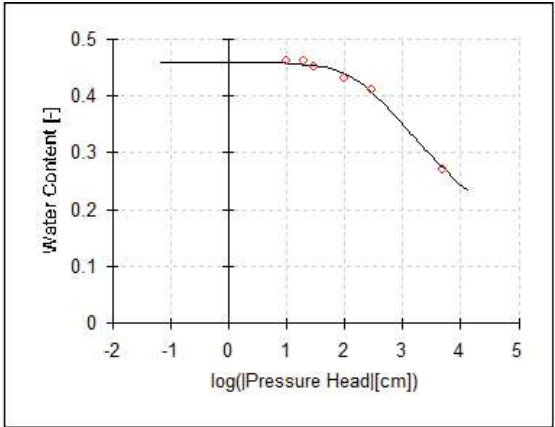
Vinod Nath, SMI with the preparation of the sampling campaign and the sampling work in the field, Cedric le Bars supported the analysis in the laboratory and data processing.

7. Appendix

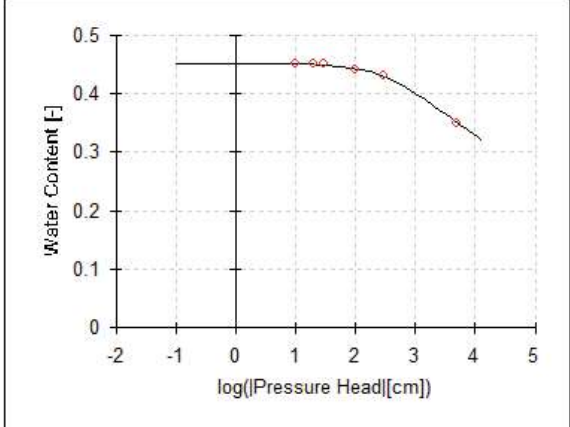
Results of fitting of measured water retention data with van Genuchten model. Each data point consists of the average of water content measurements of two samples

Site 1

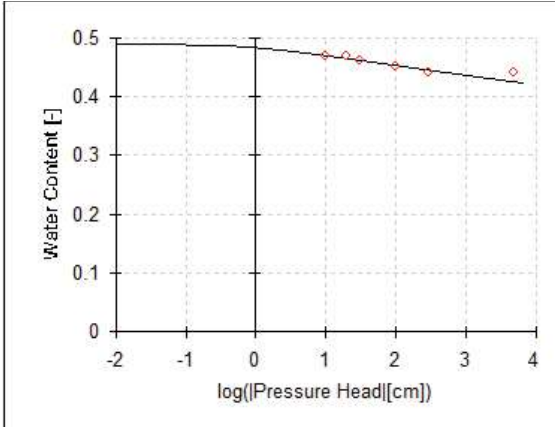
Site 1-10-1/3



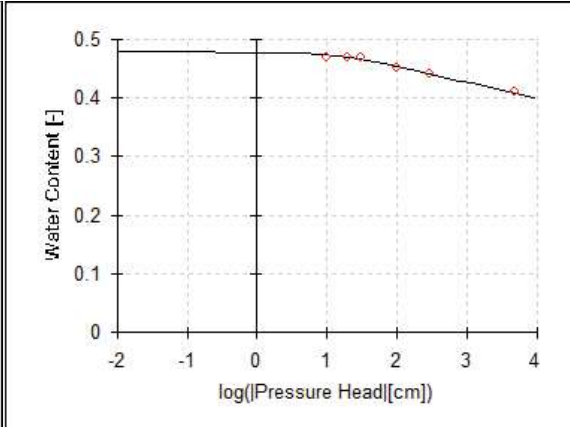
Site 1-40-1/3



Site 1-70-1/3

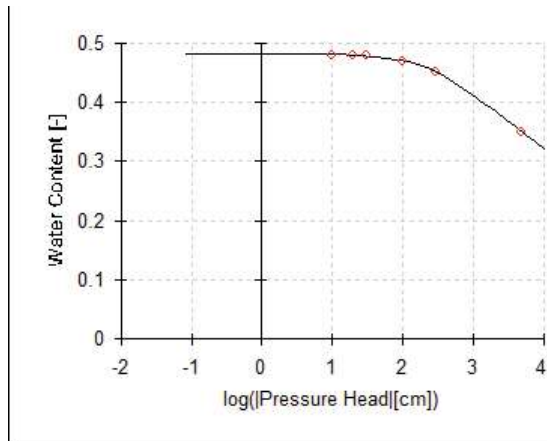


Site 1-100-1/3

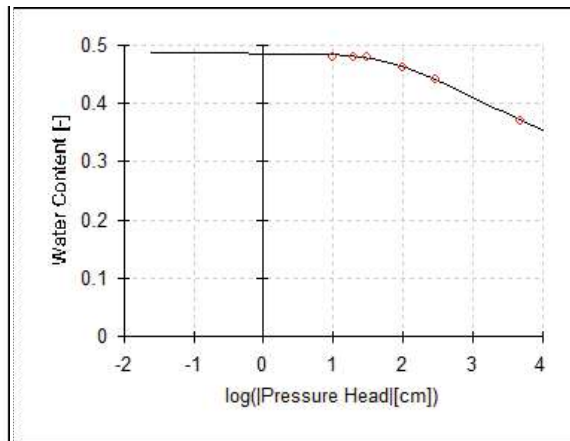


Site 2

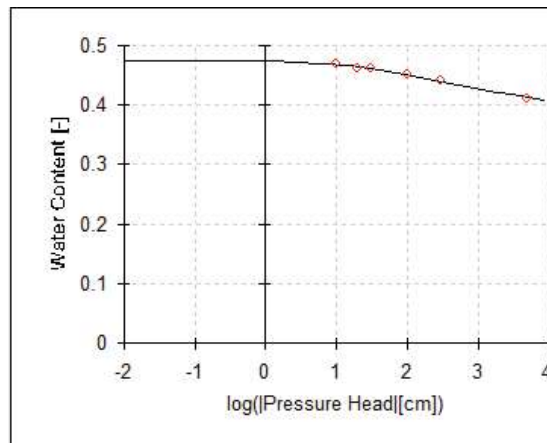
Site 2-10-1/3



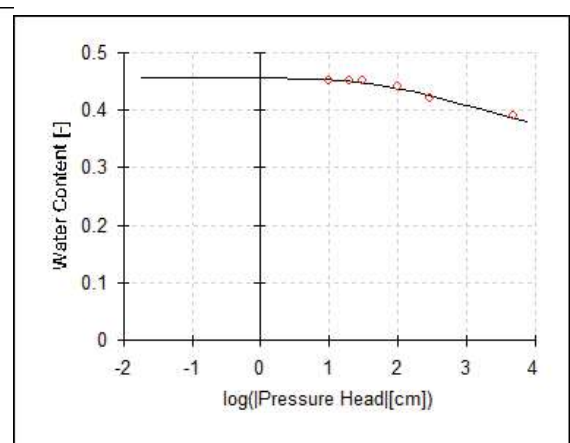
Site 2-40-1/3



Site 2-70-1/3

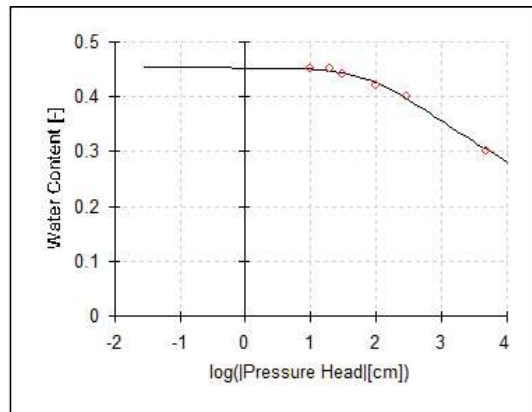


Site 2-100-1/3

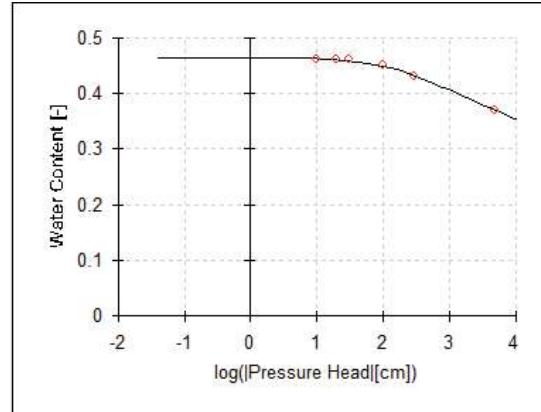


Site 3

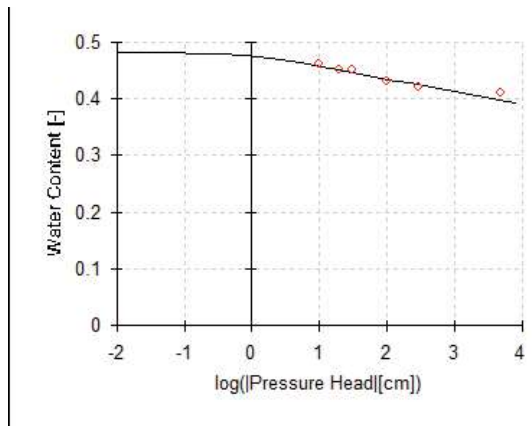
Site 3-10-1/3



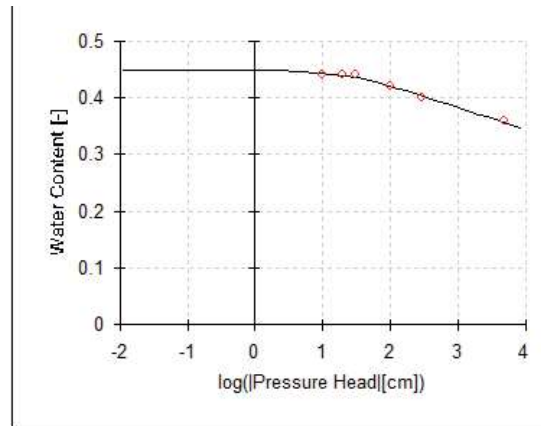
Site 3-40-1/3



Site 3-70-1/3



Site 3-100-1/3



Appendix C **Remediation Option Plans**

- C1 Concept Drainage Plan
- C2 Costing of Drainage Plan
- C3 Soil Remediation and Drainage Plan
- C4 Costing of Soil Remediation and Drainage Plan

B2 Factual Report - Sherwood Arboretum Soil and Groundwater
Characterisation - 2023



Dedicated to a better Brisbane

Brisbane City Council ABN 72 002 765 795

Brisbane Infrastructure
City Projects Office
505 St Pauls Terrace
Fortitude Valley Qld 4006
GPO Box 1434 Brisbane Qld 4001
[REDACTED] F 07 3334 0071
www.brisbane.qld.gov.au

30 June 2023

[REDACTED]
Project Manager. Water Management

City Projects Office

RE: Factual Report – Monitoring well installation, Sherwood Arboretum and Oxley Creek Common			
[REDACTED]	Version: rev 0	Date: 30/06/2023	CM:CA23/689349

1. Introduction

City Projects Office (CPO), Contaminated Land Services (CLS) were requested by CPO Water Management to undertake a targeted soil and groundwater investigation at two sites, Sherwood Arboretum, located at Jolimont Street, Sherwood and Secret Forest located at Oxley Creek Common, Sherwood Road, Rocklea (refer Figure 1, Attachment A). Historically, heritage listed Kauri pines (*Agatha Robusta*) in Sherwood Arboretum have been declining after flooding events, with replacements installed on “boxing” and subsequent mounding to elevate trees above surrounding soil levels. With several consecutive La Niña seasons between late 2020 to mid-2022, including flooding in 2022, Kauri pines have continued to decline.

This investigation was commissioned to provide factual soil descriptions, soil analysis and groundwater levels over time. This letter report summarises the initial investigation works undertaken, with follow up monitoring updates to be supplied in due course.

1.1 Objectives

The objectives of the investigation were to provide data of the soil and groundwater conditions at the targeted locations.

1.2 Scope

The scope of works is detailed in the Project Delivery Agreement (refer [CA23/533930](#)). The methodology adopted for the field work is contained within Attachment B. The scope of works is defined as:

Pre-field – project health and safety plan, Before You Dig Australia underground services search, engagement of contractors (underground services & driller).

Site inspection – undertake underground services location and clearance of investigation locations.