



CAUSEWAY
— GEOTECH

FINAL
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Greater Dublin Drainage – Offshore Site Investigation of Outfall Pipeline

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Client: Irish Water
Client's Representative: Tobin Arup Joint Venture
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Document Control Sheet

Report No.: 15-664

Project title: Greater Dublin Drainage Scheme – Offshore Site Investigation of Outfall Pipeline

Client: Irish Water

Client's Representative: Tobins Arup Joint Venture

Revision	Status	Report prepared by:	Report reviewed by:	Report approved by:	Issue date
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The works were conducted in accordance with:

UK Specification for Ground Investigation 2nd Edition, published by ICE Publishing (2012)

British Standards Institute (2010) BS 5930:1999 + A2: 2010, Code of practice for site investigations. Incorporating Amendment Nos. 1 and 2, as partially replaced by:

- BS EN 1997-2:2007: Eurocode 7. Geotechnical design. Ground investigation and testing
- BS EN ISO 22475-1:2006: Geotechnical investigation and testing. Sampling methods and groundwater measurements. Technical principles for execution
- BS EN ISO 14688-1:2002/Amd 1:2013: Geotechnical investigation and testing. Identification and classification of soil. Identification and description
- BS EN ISO 14688-2:2004/Amd 1:2013: Geotechnical investigation and testing. Identification and classification of soil. Principles for a classification
- BS EN ISO 14689-1:2003: Geotechnical investigation and testing. Identification and classification of rock. Identification and description
- BS EN ISO 22476-2:2005/Amd 1:2011: Geotechnical investigation and testing. Field testing. Dynamic probing
- BS EN ISO 22476-3:2005/Amd 1:2011: Geotechnical investigation and testing. Field testing. Standard penetration test

METHODS OF DESCRIBING SOILS AND ROCKS

Soil and rock descriptions are based on the guidance in Section 6 of BS 5930: 1999 + A2: 2010, The Code of Practice for Site Investigation. The amendments revised the Standard to remove text superseded by BS EN ISO 14688-1:2002, BS EN ISO 14688-2:2004 and EN ISO 14689-1:2003 and refers to the relevant standard for each affected subclause. However, the following terms are used in the description of fine-grained soils, where applicable:

- soft to firm: fine-grained soil with consistency description close to the boundary between soft and firm soil (Table 13 of BS5930).
- firm to stiff: fine-grained soil with consistency description close to the boundary between firm and stiff soil (Table 13 of BS5930).

Abbreviations used on exploratory hole logs	
U	Nominal 100mm diameter undisturbed open tube sample
P	Nominal 100mm diameter undisturbed piston sample
B	Bulk disturbed sample
D	Small disturbed sample
W	Water sample
ES / EW	Soil sample for environmental testing / Water sample for environmental testing
SPT	Standard penetration test using a split spoon sampler (small disturbed sample obtained)
SPT (C)	Standard penetration test using 60 degree solid cone
x,x/x,x,x,x	Blows per increment during the standard penetration test. The initial two values relate to the seating drive (150mm) and the remaining four to the 75mm increments of the test length. The length achieved is stated (mm) for any test increment less than 75mm
N=X	SPT blow count 'N' given by the summation of the blows 'X' required to drive the full test length (300mm)
N=X/Z	Incomplete standard penetration test where the full test length was not achieved. The blows 'X' represent the total blows for the given test length 'Z' (mm)
V VR	Shear vane test (borehole) Hand vane test (trial pit) Shear strength stated in kPa V: undisturbed vane shear strength VR: remoulded vane shear strength
<u>dd/mm/yy: 1.0</u> dd/mm/yy: dry	Date & water level at the borehole depth at the end of shift and the start of the following shift
Abbreviations relating to rock core – reference Clause 44.4.4 of BS 5930: 1999	
TCR (%)	Total Core Recovery: Ratio of rock/soil core recovered (both solid and non-intact) to the total length of core run.
SCR (%)	Solid Core Recovery: Ratio of solid core to the total length of core run. Solid core has a full diameter, uninterrupted by natural discontinuities, but not necessarily a full circumference and is measured along the core axis between natural fractures.
RQD (%)	Rock Quality Designation: Ratio of total length of solid core pieces greater than 100mm to the total length of core run.
FI	Fracture Index: Number of natural discontinuities per metre over an indicated length of core of similar intensity of fracturing.
NI	Non Intact: Used where the rock material was recovered fragmented, for example as fine to coarse gravel size particles.
AZCL	Assessed zone of core loss: The estimated depth range where core was not recovered.
DIF	Drilling induced fracture: A fracture of non-geological origin brought about by the rock coring.

Greater Dublin Drainage Scheme – Offshore Site Investigation of Outfall Pipeline

1 AUTHORITY

On the instructions of Consulting Engineers, Tobin Arup Joint Venture (“the Client’s Representative”), acting on the behalf of Irish Water (“the Client”), a ground investigation was undertaken at the above location to provide an overview of the ground conditions across the site for input to the design of a proposed offshore outfall pipeline. Abco Marine (Ireland) Limited provided the marine plant for the project.

This report details the work carried out both on site and in the geotechnical and chemical testing laboratories; it contains a description of the site and the works undertaken, the exploratory hole logs and the laboratory test results.

All information given in this report is based upon the ground conditions encountered during the site investigation works, and on the results of the laboratory and field tests performed. However, there may be conditions at the site that have not been taken into account, such as unpredictable soil strata, contaminant concentrations, and water conditions between or below exploratory holes.

This report was prepared by Causeway Geotech Ltd for the use of the Client and the Client’s Representative in response to particular instructions. Any other parties using the information contained in this report do so at their own risk and any duty of care to those parties is excluded.

2 SCOPE

The extent of the investigation, as instructed by the Client’s Representative, included overwater and land based boreholes, soil and rock core sampling, in-situ and laboratory testing, and the preparation of a factual report on the findings.

3 DESCRIPTION OF SITE

As shown on the site location plan in Appendix A, the works were conducted around Portmarnock, north-east Dublin. The site is along the route of the proposed outfall running from Portmarnock strand in an easterly direction, extending some 6km offshore to the site of the proposed diffuser.

The existing site is presented on the site and exploratory hole location plans in Appendix A.

4 SITE OPERATIONS

4.1 Overview of site operations

Site operations were completed in two distinct phases: overwater operations, and then land-based works. Overwater works were carried out over the period 30 July to 22 August 2015. Land-based works were carried out over 30 September to 5 October 2015.

The scope of works comprised:

- 3 no. overwater boreholes, drilled off a jack-up barge (BH03, BH05 and BH08):
 - Cable percussion boring through overburden.
 - Rotary follow-on drilling by Geobor S wireline coring techniques to target completion depths within bedrock strata.
- 10 no. vibrocore seabed sediment sampling locations, completed off a jack-up barge.
- 1 no borehole drilled on the land at Portmarnock beach by cable percussion boring with rotary follow-on drilling (BH01).

4.2 Marine operations

Boreholes BH03, BH05 and BH08 were put down at overwater locations using a jack-up barge as a working platform.

The marine plant used was a C5 modular type jack-up barge (*Emotion*), supplied and operated by Abco Marine (Ireland) Limited.

All site works were supervised by a Geotechnical Engineer from Causeway Geotech.

The jack-up platform was some 12m x 15m in deck area and equipped with 27m long jack legs. The jack-up was manoeuvred to the locations using a workboat (Island Kestrel). A safety boat provided a watching brief and also provided access to the platform for the crew and Engineer's representatives.

The locations of the exploratory holes were set out from co-ordinates supplied by the Client's representative. Surveying operations were completed by a Site Engineer from Abco Marine, who was equipped with a GPS rover unit employing VRS techniques.

Seabed elevation at each position was recorded by subtracting the measured distance from (static) deck to seabed from the deck elevation as recorded using the GPS. The distance from deck to seabed level was measured using a weighted dip tape lowered down through the outer drill string, thus precluding the effects of the tide. By subtracting the deck to seabed length from the deck elevation, seabed elevation was hence calculated. The as-built survey information relative to each position is presented on the relevant borehole logs.

The exploratory holes were located as instructed by the Client's Representative, as shown on the exploratory hole location plan in Appendix A.

4.3 Boreholes

A total of four boreholes were put down as part of the works scope.

- Boreholes BH03, BH05, BH08 were overwater boreholes put down along the route of the outfall
- Borehole BH01 was drilled at the beach at Portmarnock near the launch point for the outfall pipe.

4.3.1 Boreholes by combined cable percussion boring and rotary follow-on drilling

The boreholes were put down by a combination of light cable percussion boring and rotary follow-on drilling techniques with core recovery. The overwater boreholes were drilled to depths of up to 58.3m below seabed level. Borehole BH01 on the beach was drilled to a completion depth of 59.9m below ground level.

Cable percussion boring techniques were employed to advance the boreholes to virtual refusal in the very stiff Glacial Till, after which rotary follow-on drilling by means of Geobor S triple-tube wireline coring was employed to recover core samples of the Glacial Till and bedrock strata.

Cable percussion boring was carried out using a Dando 3000 light cable percussion boring rig, with rotary follow-on drilling then carried out by a Comacchio 405 tracked rotary drilling rig.

Disturbed (bulk bag and small jar) samples were taken of the encountered strata at regular intervals or change of strata.

Standard penetration tests were carried out through overburden strata in accordance with EC7 at standard depth intervals using the split spoon sampler (SPT) or solid cone attachment (SPTc). The penetrations are stated for those tests for which the full 150mm seating drive or 300mm test drive was not possible. The *N*-values provided on the borehole logs are uncorrected and no allowance has been made for energy ratio corrections.

The core was extracted in up to 1.6m lengths using a metric SK6L (Geobor S) core barrel, which produced core of nominal 102mm diameter, and was placed in single channel wooden core boxes. The core was extracted in semi-rigid plastic liners.

The core was subsequently photographed and examined by a qualified and experienced Engineering Geologist, thus enabling the production of an engineering log in accordance with *BS 5930:1999 + A2: 2010, Code of practice for site investigations* (Incorporating Amendment Nos. 1 and 2).

Core logging was carried out both on and off site by the Causeway Geotech Engineering Geologist. Appendix B presents the borehole logs, with core photographs presented in Appendix C.

4.4 Vibrocores

A total of ten vibrocores (BHVC02 to BHVC11) were put down using a SonicSamp pneumatic vibrocore sampling rig, which was lowered onto the seabed at the sampling points using a crane mounted on the C5 jack-up barge, acting in spud-leg mode.

The vibrocores penetrated to a maximum depth of 1.7m below bed level, at which point they encountered refusal on stiff/dense soils. The cores were retrieved and logged on the barge deck, before being sub-sampled into appropriate containers for dispatch to the chemical testing laboratory.

The logs for the vibrocores are presented in Appendix D. Results of laboratory testing carried out on the samples are presented in Appendix F.

4.5 Surveying

The as-built exploratory hole positions were surveyed immediately following completion of site operations by a Site Engineer from Abco Marine. Surveying was carried out using a GPS rover employing VRS and real time kinetic (RTK) techniques.

The plan coordinates and ground elevation at each location are recorded on the individual exploratory hole logs. The exploratory hole plan presented in Appendix A takes these as-built positions into account.

5 LABORATORY WORK

Upon their receipt in the laboratory, all disturbed samples were carefully examined and accurately described and their descriptions incorporated into the borehole logs.

5.1 Geotechnical laboratory testing of soils

Laboratory testing of soils comprised:

- **soil classification:** moisture content measurement, Atterberg Limit tests, particle size distribution and particle density analysis.
- **shear strength** (total stress): lab vane, unconsolidated undrained triaxial and shear box tests
- **soil chemistry:** pH, organic matter and sulfate content

Laboratory testing of soils samples was carried out in accordance with British Standards Institute (1990) *BS 1377:1990, Methods of test for soils for civil engineering purposes. Parts 1 to 9.*

The geotechnical laboratory test results are presented in Appendix E.

5.2 Geotechnical laboratory testing of rock

Laboratory testing of rock sub-samples comprised:

- Uniaxial Compressive Strength Testing
- Point Load Testing

The above tests were carried out by Causeway Geotech Limited at their geotechnical testing laboratory in accordance with the following standards:

Test	Test carried out in accordance with
Point load index	ISRM Suggested Methods (1985) Suggested method for determining point-load strength. Int. J. Rock Mech. Min. Sci. Geomech. Abstr. 22, pp. 53–60
Uniaxial compression strength tests	ISRM Suggested Methods (1981) Suggested method for determining deformability of rock materials in uniaxial compression, Part 2 and ISRM (2007) Ulusay R, Hudson JA (eds) The complete ISRM suggested methods for rock characterization, testing and monitoring, 2007

More advanced rock testing was carried out in subcontracted testing laboratories.

GSTL in Llanelli, Wales, carried out the following tests:

- Indirect tensile strength testing
- Cerchar abrasivity
- Porosity
- Thin section petrographic analysis
- X-ray diffraction.

SINTEF, based in Trondheim, Norway, carried out the following specialised tunnelling/drillability testing:

- Norweigan Abrasion Cutter Steel Test, Swedish Brittleness Test and Sievers' J Value Test

The geotechnical laboratory test results for rock core sub-samples are presented to the rear of Appendix E.

5.3 Environmental laboratory testing of soils

In addition, environmental testing by way of the Marine Institute of Ireland suite relating to the testing of dredged materials for disposal at sea criteria, was carried out by RPS at their laboratories at Mountainheath. Testing was carried out on 13 samples selected from the vibrocore locations.

The test results are presented in Appendix F.

6 GROUND CONDITIONS

6.1 General geology of the area

Due to the offshore location of the exploratory holes, the superficial deposits consist of marine deposits overlying glacial till. The underlying bedrock consists of Carboniferous argillaceous limestone ('Calp'), with the possibility of faulting towards the east of the site and the presence of Cambrian greywacke and quartzite.

6.2 Ground types encountered during investigation of the site

The exploratory holes encountered the following ground types, listed in approximate stratigraphic order:

- **Marine Deposits:** granular deposits, extending from seabed level to up to 6.2m depth, comprising sands and gravels ranging from medium dense to very dense.
- **Glacial Till:** stiff to very stiff grey sandy gravelly clay, frequently with low cobble content and occasional bands of sand or gravel. Found beneath marine deposits, immediately overlying bedrock.
- **Bedrock:** bedrock generally comprised medium strong to strong grey Limestone of the Calp Formation. Borehole BH05 encountered a faulted zone, with a sequence of sandstone interbedded with layers of mudstone and limestone (locally dolomitised). The bedrock here was typically highly fractured and weaker than encountered at the other boreholes.

7 REFERENCES

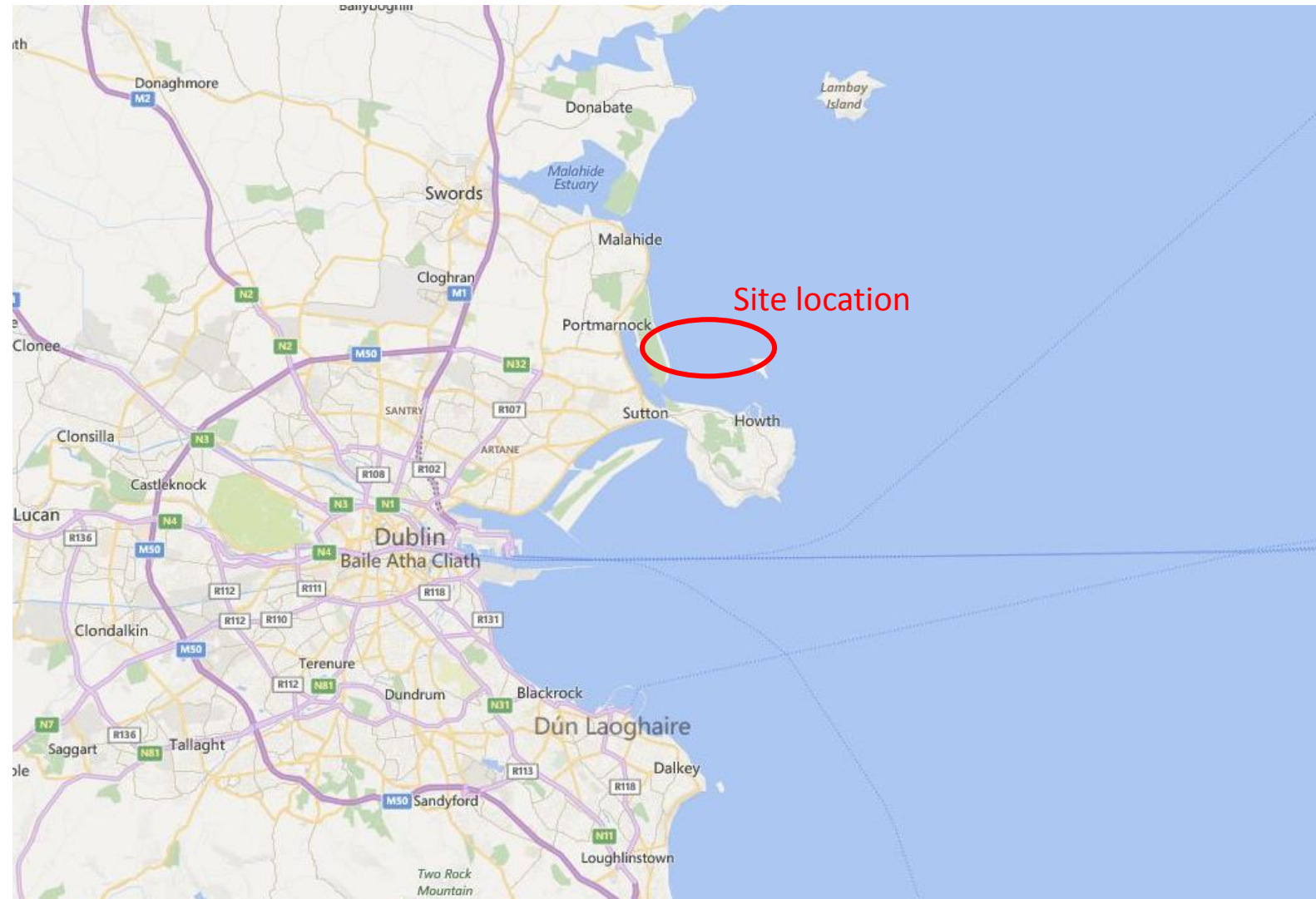
BS 1377: 1990: Methods of test for soils for civil engineering purposes. British Standards Institution.

BS 5930+A2: 2010: Code of practice for site investigations (Amendment 2). British Standards Institution.

BS EN 1997-2: 2007: Eurocode 7 - Geotechnical design - Part 2 Ground investigation and testing. British Standards Institution.

BS EN ISO 14688-1: 2002: Geotechnical investigation and testing - Identification and classification of soil - Part 1 Identification and description. British Standards Institution.

Appendix A
Site and exploratory hole location plans





APPENDIX B

Borehole logs



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Project No.: 15-664	Project Name: GDD Overwater SI	Borehole No.: BH01
Coordinates: 325073.98 E	Client: Irish Water	Sheet 1 of 6
Method: Cable Percussion+Symmetrix+Geobor S Coring	Client's Representative: Tobin Arup JV	Scale: 1:50
Plant: Dando 2000+Comacchio 405	Ground Level: 2.29 mOD	Dates: 30/09/2015 - 15/10/2015
		Driller: BM+SJ
		Logger: MFG

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Legend	Description	Water	Backfill
0.10	D1					(0.50)		Grey fine to coarse SAND.		
1.00	B14 D2				1.79	0.50		Medium dense grey slightly silty fine to coarse SAND with many gravel sized shells and shell fragments		
1.00 - 1.45	SPT (S) N=16	1.00		N=16 (2,2/3,4,4,5)						
2.00	B15 D3					(3.50)				
2.00 - 2.45	SPT (S) N=22	2.00		N=22 (3,4/4,5,6,7)						
3.00	B16 D4									
3.00 - 3.45	SPT (S) N=28	3.00		N=28 (3,4/5,7,7,9)						
4.00	B17 D5				-1.71	4.00		Dense grey slightly silty fine to coarse SAND with many gravel sized shells and shell fragments		
4.00 - 4.45	SPT (S) N=36	4.00		N=36 (4,6/7,8,9,12)						
5.00	B18 D6					(2.00)				
5.00 - 5.45	SPT (S) N=42	5.00		N=42 (4,4/6,11,12,13)						
6.00	B19 D7				-3.71	6.00		Medium dense grey slightly silty fine to coarse SAND with many gravel sized shells and shell fragments		
6.00 - 6.45	SPT (S) N=18	6.00		N=18 (2,2/3,4,5,6)		(1.60)				
7.00	B20 D8									
7.00 - 7.45	SPT (S) N=16	7.00		N=16 (2,2/3,4,4,5)						
8.00	B21 D9				-5.31	7.60		Medium dense grey very gravelly fine to coarse SAND. Gravel is fine to coarse, subrounded to rounded.		
8.00 - 8.45	SPT (S) N=18	8.00		N=18 (2,3/4,4,5,5)						
9.00	B22 D23					(3.60)				
9.00 - 9.45	SPT (S) N=23	9.00		N=23 (5,6/5,6,6,6)						
10.00	B24 D10									
10.00										

Continued on Next Page

Remarks

SPT's carried out using SPT hammer CC1
Water added from 0.20m

Water Added		Water Strike - General			
From (m)	To (m)	Struck at (m)	Casing to (m)	Time (min)	Rose to (m)
0.20	13.60				
Casing Details		Chiselling Details			
To (m)	Diam (mm)	From (m)	To (m)	Time (hh:mm)	
15.00	200				



CAUSEWAY
GEOTECH

Project No.: 15-664	Project Name: GDD Overwater SI	Borehole No.: BH01
Coordinates: 325073.98 E	Client: Irish Water	Sheet 2 of 6
Method: Cable Percussion+Symmetrix+Geobor S Coring	Client's Representative: Tobin Arup JV	Scale: 1:50
Plant: Dando 2000+Comacchio 405	Ground Level: 2.29 mOD	Dates: 30/09/2015 - 15/10/2015
		Driller: BM+SJ
		Logger: MFG

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Legend	Description	Water	Backfill
10.00 - 10.45	SPT (S) N=24	10.0 0		N=24 (6,6/6,5,6,7)						
11.00 11.00 11.00 - 11.45	B26 D27 SPT (S) N=39	11.0 0		N=39 (8,10/9,10,10,10)	-8.91	11.20 (0.80)		Dense grey sandy fine to coarse subrounded GRAVEL. Sand is fine to coarse.		
12.00 12.00 12.00 - 12.45	B27 D11 SPT (S) N=40	12.0 0	1.70 2.70	30-09-2015 05-10-2015	-9.71	12.00 (0.90)		Dense greyish brown gravelly fine to coarse SAND. Gravel is fine to coarse subangular to subrounded.		
12.90 - 13.60 13.00 13.00 - 13.35	B13 D12 SPT (S)	13.0 0	7.10	N=40 (10,10/9,11,10,10) 50 (9,12/50 for 200mm)	-10.61 -11.31	12.90 13.60 (0.70)		Stiff brownish grey slightly sandy gravelly CLAY with cobbles and boulders. Sand is fine to coarse. Gravel is subangular to subrounded fine to coarse.		
					-12.21	14.50 (0.90)		Grey sandy gravelly CLAY. Sand is fine to coarse. Gravel is subangular to subrounded fine to coarse. (Drillers description)		
						14.50		Medium strong, massive (indistinctly laminated in places), dark grey argillaceous LIMESTONE. Largely fresh to partially weathered: slightly closer fracture spacing.		
15.80	100 100 44							Discontinuity Set 1: 10-30 degree joints, medium to widely spaced, planar, becoming undulating below 17.30m, rough, occasionally with <1mm calcite mineralisation		
								Discontinuity Set 2: 50-70 degree joints, widely spaced, undulating, rough, stained black		
17.30	100 100 100					(5.50)		Discontinuity Set 3: 80-90 degree joints at 15.00m - 15.40m and 18.60m - 19.20m, undulating, rough, stained black		
18.80	100 98 90									
	96 96 54									
20.30					-17.71	20.00		Medium strong to strong, indistinctly thickly laminated dark grey argillaceous LIMESTONE. Unweathered		
	TCR SCR RQD FI									

Continued on Next Page

Remarks

SPT's carried out using SPT hammer CC1
Water added from 0.20m

Water Added		Water Strike - General			
From (m)	To (m)	Struck at (m)	Casing to (m)	Time (min)	Rose to (m)
0.20	13.60				
Casing Details		Chiselling Details			
To (m)	Diam (mm)	From (m)	To (m)	Time (hh:mm)	
15.00	200				



CAUSEWAY
GEOTECH

Project No.: 15-664	Project Name: GDD Overwater SI	Borehole No.: BH01
Coordinates: 325073.98 E	Client: Irish Water	Sheet 3 of 6
Method: Cable Percussion+Symmetrix+Geobor S Coring	Client's Representative: Tobin Arup JV	Scale: 1:50
Plant: Dando 2000+Comacchio 405	Ground Level: 2.29 mOD	Dates: 30/09/2015 - 15/10/2015
		Driller: BM+SJ
		Logger: MFG

Depth (m)	TCR	SCR	RQD	FI	Field Records	Level (mOD)	Depth (m) (Thickness)	Legend	Description	Water	Backfill
21.80	100	100	100					[Brick Pattern Legend]	Discontinuity Set 1: 10-40 degree joints (often parallel to bedding), widely spaced (occasionally medium spaced above 26.30m), planar, occasionally undulating, rough, typically stained black, occasionally with patches of brownish grey		
23.30	100	100	100								
24.80	100	100	95	2							
26.30	100	100	96								
27.80	100	100	100								
29.30	100	100	100	1							
30.80	100	100	100								
	TCR	SCR	RQD	FI							

Continued on Next Page

Remarks SPT's carried out using SPT hammer CC1 Water added from 0.20m	Water Added		Water Strike - General			
	From (m)	To (m)	Struck at (m)	Casing to (m)	Time (min)	Rose to (m)
	0.20	13.60				
	Casing Details		Chiselling Details			
To (m)	Diam (mm)	From (m)	To (m)	Time (hh:mm)		
15.00	200					



CAUSEWAY
GEOTECH

Project No.: 15-664	Project Name: GDD Overwater SI	Borehole No.: BH01
Coordinates: 325073.98 E	Client: Irish Water	Sheet 4 of 6
Method: Cable Percussion+Symmetrix+Geobor S Coring	Client's Representative: Tobin Arup JV	Scale: 1:50
Plant: Dando 2000+Comacchio 405	Ground Level: 2.29 mOD	Dates: 30/09/2015 - 15/10/2015
		Driller: BM+SJ
		Logger: MFG

Depth (m)	TCR	SCR	RQD	FI	Field Records	Level (mOD)	Depth (m) (Thickness)	Legend	Description	Water	Backfill
32.30	100	100	100						lanar, occasionally undulating, rough, typically stained black, occasionally with patches of brownish grey		31.0
33.80	90	85	70	4					<i>From 32.80m - 33.40m: 70-90 degree undulating vein/joint, mostly closed, partly incipient, up to 10mm of anastomosing calcite mineralisation, some drilling induced fracturing</i>		31.5
35.40	100	100	100								32.0
36.90	100	100	100	1			(39.90)				32.5
38.40	100	100	100								33.0
39.90	100	100	100								33.5
	TCR	SCR	RQD	FI							34.0
											34.5
											35.0
											35.5
											36.0
											36.5
											37.0
											37.5
											38.0
											38.5
											39.0
											39.5
											40.0
											40.5
											41.0

Continued on Next Page

Remarks SPT's carried out using SPT hammer CC1 Water added from 0.20m	Water Added		Water Strike - General			
	From (m)	To (m)	Struck at (m)	Casing to (m)	Time (min)	Rose to (m)
	0.20	13.60				
	Casing Details		Chiselling Details			
To (m)	Diam (mm)	From (m)	To (m)	Time (hh:mm)		
15.00	200					



CAUSEWAY
GEOTECH

Project No.: 15-664	Project Name: GDD Overwater SI	Borehole No.: BH01
Coordinates: 325073.98 E	Client: Irish Water	Sheet 5 of 6
Method: Cable Percussion+Symmetrix+Geobor S Coring	Client's Representative: Tobin Arup JV	Scale: 1:50
Plant: Dando 2000+Comacchio 405	Ground Level: 2.29 mOD	Dates: 30/09/2015 - 15/10/2015
		Driller: BM+SJ
		Logger: MFG

Depth (m)	TCR	SCR	RQD	FI	Field Records	Level (mOD)	Depth (m) (Thickness)	Legend	Description	Water	Backfill
41.50								[Brick pattern legend]	Discontinuity Set 1: 10-40 degree joints (often parallel to bedding), widely spaced (occasionally medium spaced above 26.30m), planar, occasionally undulating, rough, typically stained black, occasionally with patches of brownish grey <i>From 41.95m - 42.70m: 70-90 degree undulating joint, rough, stained black and dark brownish grey</i>		
	100	96	47								
43.00								[Brick pattern legend]			
	100	100	100								
44.50								[Brick pattern legend]			
	100	100	100								
46.00								[Brick pattern legend]			
	100	100	100								
47.60								[Brick pattern legend]			
	100	100	100	10							
49.10								[Brick pattern legend]			
	100	100	100	1							
50.60								[Brick pattern legend]			
	100	100	100	2							
								[Brick pattern legend]			
				8						<i>From 57.95m - 58.65m: Weak to medium strong black carbonaceous limestone with white calcite veining</i>	
	TCR	SCR	RQD	FI							

Continued on Next Page

Remarks SPT's carried out using SPT hammer CC1 Water added from 0.20m	Water Added		Water Strike - General			
	From (m)	To (m)	Struck at (m)	Casing to (m)	Time (min)	Rose to (m)
	0.20	13.60				
	Casing Details		Chiselling Details			
To (m)	Diam (mm)	From (m)	To (m)	Time (hh:mm)		
15.00	200					



CAUSEWAY
GEOTECH

Project No.: 15-664	Project Name: GDD Overwater SI	Borehole No.: BH01
Coordinates: 325073.98 E	Client: Irish Water	Sheet 6 of 6
Method: Cable Percussion+Symmetrix+Geobor S Coring	Client's Representative: Tobin Arup JV	Scale: 1:50
Plant: Dando 2000+Comacchio 405	Ground Level: 2.29 mOD	Dates: 30/09/2015 - 15/10/2015
		Driller: BM+SJ
		Logger: MFG

Depth (m)	TCR	SCR	RQD	FI	Field Records	Level (mOD)	Depth (m) (Thickness)	Legend	Description	Water	Backfill
52.10									lanar, occasionally undulating, rough, typically stained black, occasionally with patches of brownish grey		
	100	100	100								
53.60											
	100	100	100								
55.10				1							
	100	100	100								
56.70											
	100	100	80								
58.30									<i>From 57.95m - 58.65m: 80 degree white calcite vein, open, planar to slightly undulating, rough, up to 10mm mineralisation</i>		
	100	100	77								
				9					<i>From 59.20m - 59.40m: Two 65 degree joints/veins, undulating, rough, up to 1mm, white calcite mineralisation with patchy brown staining on surface</i>		
				1							
59.90						-57.61	59.90		End of borehole at 59.900m		

Remarks SPT's carried out using SPT hammer CC1 Water added from 0.20m	Water Added		Water Strike - General			
	From (m)	To (m)	Struck at (m)	Casing to (m)	Time (min)	Rose to (m)
	0.20	13.60				
Casing Details		Chiselling Details				
To (m)	Diam (mm)	From (m)	To (m)	Time (hh:mm)		
15.00	200					



CAUSEWAY
GEOTECH

Project No.: 15-664	Project Name: GDD Overwater SI	Borehole No.: BH03
Coordinates: 326052.50 E	Client: Irish Water	Sheet 1 of 6
Method: Cable Percussion+Geobor S Coring	Client's Representative: Tobin Arup JV	Scale: 1:50
Plant: Dando 3000+Comacchio 405	Ground Level: -5.00 mOD	Dates: 30/07/2015 - 07/08/2016
		Driller: CC+SS
		Logger: MFG

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Legend	Description	Water	Backfill
0.00 - 0.50	ES1							Medium dense grey slightly gravelly silty fine to coarse SAND with shells. Gravel is subrounded fine to coarse.		
0.00 - 1.00	B4					(1.00)				
1.00 - 1.50	ES2				-6.00	1.00		Medium dense silty fine to medium SAND with occasional fine subrounded gravel.		
1.00 - 2.00	B5									
1.20	D9			N=16 (1,3/3,4,4,5)						
1.20 - 1.65	SPT (S) N=16					(1.50)				
2.00	D10									
2.00 - 2.45	SPT (S) N=29			N=29 (3,4/6,6,7,10)						
2.00 - 2.50	ES3				-7.50	2.50		Dense grey silty fine to coarse SAND with occasional fine gravel.		
2.00 - 3.00	B6									
3.00	D11									
3.00 - 3.45	SPT (S) N=44			N=44 (6,6/8,11,12,13)		(1.50)				
3.00 - 4.00	B7									
4.00	D12				-9.00	4.00		Very stiff grey slightly gravelly slightly sandy silty CLAY with occasional shells. Sand is fine to coarse. Gravel is subangular to subrounded fine to coarse, of limestone.		
4.00 - 4.45	SPT (S) N=47			N=47 (5,7/9,10,13,15)						
4.00 - 5.00	B8									
5.00	D13									
5.00 - 5.45	SPT (S) N=50			N=50 (6,9/13,15,15,7)		(2.90)				
5.00 - 6.00	B14									
6.00	D15									
6.00 - 6.38	SPT (S)			N=50 (9,10/50 for 230mm)						
6.00 - 7.00	B16									
6.40 - 7.50	B18									
7.00	D17				-11.90	6.90		Very stiff brown slightly sandy slightly gravelly CLAY with occasional limestone and sandstone cobbles. Sand is fine to coarse. Gravel is subangular to subrounded fine to coarse, of limestone and sandstone.		
7.00 - 7.35	SPT (S)			50 (5,13/50 for 200mm)		(1.60)				
8.00 - 8.50	B19									
8.50	D20				-13.50	8.50		Very dense medium to coarse subrounded GRAVEL of dark grey limestone, with one cobble.		
8.50 - 8.75	SPT (S)			D20 50 (25 for 125mm/50 for 125mm/50 for 125mm/125mm)		(1.50)				
8.50 - 8.75		50	0	0						
10.00					-15.00	10.00 (0.30)		Dark grey very sandy fine to coarse subrounded GRAVEL of dark grey		
					-15.30	10.30				

Continued on Next Page

Remarks

SPT's carried out using SPT Hammer SPT CC1

Water Added		Water Strike - General			
From (m)	To (m)	Struck at (m)	Casing to (m)	Time (min)	Rose to (m)
Casing Details		Chiselling Details			
To (m)	Diam (mm)	From (m)	To (m)	Time (hh:mm)	
8.50	250				



CAUSEWAY
GEOTECH

Project No.: 15-664	Project Name: GDD Overwater SI	Borehole No.: BH03
Coordinates: 326052.50 E	Client: Irish Water	Sheet 2 of 6
Method: Cable Percussion+Geobor S Coring	Client's Representative: Tobin Arup JV	Scale: 1:50
Plant: Dando 3000+Comacchio 405	Ground Level: -5.00 mOD	Dates: 30/07/2015 - 07/08/2016
		Driller: CC+SS
		Logger: MFG

Depth (m)	TCR	SCR	RQD	FI	Field Records	Level (mOD)	Depth (m) (Thickness)	Legend	Description	Water	Backfill
10.80	100	44	0	20					Limestone. Sand is fine to coarse. Weak dark grey argillaceous LIMESTONE. Partially weathered: much closer fracture spacing.		10.5
	0	0	0	NR			(1.50)		Discontinuities: 10-60° joints, very closely to closely spaced, planar to irregular/undulating, rough, stained black.		11.0
11.80						-16.80	11.80		<u>No recovery at 10.80-11.80m.</u> Weak to medium strong medium bedded (locally indistinctly laminated) dark grey argillaceous LIMESTONE. Partially weathered: much closer fracture spacing.		11.5
12.50	90	80	0	20					Discontinuity sets:		12.0
13.30	100	25	0	NI			(3.00)		1. 0-20° joints, very closely to closely spaced, planar, smooth to rough. 2. 20-60° joints, medium spaced, planar to irregular, smooth to rough.		12.5
				20					<u>Weak carbonaceous limestone from 12.2-12.6m, destructured at 12.5-12.6m and recovered as soft dark grey sandy carbonaceous clay.</u>		13.0
14.80	90	73	7								13.5
15.30	100	70	30	10		-19.80	14.80		Medium strong medium bedded (thinly to thickly laminated in places) dark grey argillaceous LIMESTONE. Largely unweathered.		14.0
16.30	100	100	64	8					Discontinuity sets: 1. 0-20° joints, medium spaced, planar to irregular, rough. 2. 20-40° bedding fractures, medium spaced, planar, smooth to rough. <u>65° joint at 15.2m, planar with polished surface, stained black.</u> <u>70° vein at 15.65-15.95m, 1-2mm thick (white calcite), partially open/closed, rough.</u>		14.5
									<u>Very closely spaced fractures at 16.45-16.55m, planar, polished surfaces, stained black, 20mm calcite mineralisation at the bottom.</u>		15.0
17.80	100	95	90				(9.90)				15.5
				3					<u>75° joint at 17.8-18.3m, closed/incipient, planar to undulating, filled with 1-3mm hard dark grey clay.</u>		16.0
19.30	100	100	73								16.5
				6					<u>60° fracture, undulating, smooth, polished in parts with faint slickensides, stained black.</u>		17.0
	100	100	87	4							17.5
											18.0
											18.5
											19.0
											19.5
											20.0
											20.5
	TCR	SCR	RQD	FI							

Continued on Next Page

Remarks SPT's carried out using SPT Hammer SPT CC1	Water Added		Water Strike - General			
	From (m)	To (m)	Struck at (m)	Casing to (m)	Time (min)	Rose to (m)
	Casing Details		Chiselling Details			
To (m)	Diam (mm)	From (m)	To (m)	Time (hh:mm)		
8.50	250					



CAUSEWAY
GEOTECH

Project No.: 15-664	Project Name: GDD Overwater SI	Borehole No.: BH03
Coordinates: 326052.50 E	Client: Irish Water	Sheet 3 of 6
Method: Cable Percussion+Geobor S Coring	Client's Representative: Tobin Arup JV	Scale: 1:50
Plant: Dando 3000+Comacchio 405	Ground Level: -5.00 mOD	Dates: 30/07/2015 - 07/08/2016
		Driller: CC+SS
		Logger: MFG

Depth (m)	TCR	SCR	RQD	FI	Field Records	Level (mOD)	Depth (m) (Thickness)	Legend	Description	Water	Backfill
20.80									60-80° joint from 20.80-21.20m, irregular, smooth to rough.		21.0
	100	95	67	6					45° 5mm white calcite vein at 21.70m, open on downhole side, planar, smooth, stained black.		21.5
22.30									Weak black carbonaceous LIMESTONE at 22.60-23.10m, with very closely to closely spaced 0-15° fractures (planar, smooth to rough).		22.0
	100	95	57	20							22.5
23.80									55-75° joints at 24.00-24.20m ad 24.40-24.70m, undulating, rough, stained black.		23.0
	100	87	53	7							23.5
25.30									Medium strong to strong medium bedded (locally indistinctly laminated) dark grey argillaceous LIMESTONE. Unweathered.		24.0
	100	100	100	3					Discontinuity sets: 1. 10-40° joints, close to medium spaced (locally widely spaced in parts below 31.0m), planar, occasionally slightly irregular or slightly undulating, smooth to rough, typically stained black.		24.5
26.80											25.0
	100	100	100								25.5
28.30											26.0
	100	100	100	2							26.5
29.80											27.0
	100	100	92								27.5
											28.0
											28.5
											29.0
											29.5
											30.0
											30.5

Continued on Next Page

Remarks SPT's carried out using SPT Hammer SPT CC1	Water Added		Water Strike - General			
	From (m)	To (m)	Struck at (m)	Casing to (m)	Time (min)	Rose to (m)
	Casing Details		Chiselling Details			
To (m)	Diam (mm)	From (m)	To (m)	Time (hh:mm)		
8.50	250					



CAUSEWAY
GEOTECH

Project No.: 15-664	Project Name: GDD Overwater SI	Borehole No.: BH03
Coordinates: 326052.50 E	Client: Irish Water	Sheet 4 of 6
Method: Cable Percussion+Geobor S Coring	Client's Representative: Tobin Arup JV	Scale: 1:50
Plant: Dando 3000+Comacchio 405	Ground Level: -5.00 mOD	Dates: 30/07/2015 - 07/08/2016
		Driller: CC+SS
		Logger: MFG

Depth (m)	TCR	SCR	RQD	FI	Field Records	Level (mOD)	Depth (m) (Thickness)	Legend	Description	Water	Backfill
31.30				1							31.0
	100	100	93								31.5
				4							32.0
32.80											32.5
	100	100	87	1							33.0
											33.5
34.30									Two 75-80° calcite veins at 34.25-34.55m and 35.40-35.70m, 1-5mm thick, planar, rough. 60° joint at 35.70-35.80m, planar, smooth to polished, stained black.		34.0
	100	96	53	5							34.5
											35.0
35.80						-40.80	35.80		Medium strong to strong medium bedded (locally indistinctly laminated) dark grey argillaceous LIMESTONE. Unweathered. Discontinuity sets: 1. 0-30° joints, medium to widely spaced, planar to irregular, occasionally slightly undulating, rough, typically stained black.		35.5
	100	100	100								36.0
											36.5
37.30									60° joint at 37.55-37.75m, half open/closed, planar, rough, stained black.		37.0
	100	100	100	2							37.5
											38.0
38.80											38.5
	100	100	100								39.0
											39.5
40.30									Two 55-65° joints at 40.0m and 40.2m, planar to undulating, rough, stained black. 75° 1-3mm calcite vein at 40.30-40.85m, open, planar to undulating, rough, stained brown.		40.0
	100	100	100	3							40.5
											41.0
	TCR	SCR	RQD	FI					Continued on Next Page		

Remarks SPT's carried out using SPT Hammer SPT CC1	Water Added		Water Strike - General			
	From (m)	To (m)	Struck at (m)	Casing to (m)	Time (min)	Rose to (m)
Casing Details		Chiselling Details				
To (m)	Diam (mm)	From (m)	To (m)	Time (hh:mm)		
8.50	250					



CAUSEWAY
GEOTECH

Project No.: 15-664	Project Name: GDD Overwater SI	Borehole No.: BH03
Coordinates: 326052.50 E	Client: Irish Water	Sheet 5 of 6
Method: Cable Percussion+Geobor S Coring	Client's Representative: Tobin Arup JV	Scale: 1:50
Plant: Dando 3000+Comacchio 405	Ground Level: -5.00 mOD	Dates: 30/07/2015 - 07/08/2016
		Driller: CC+SS
		Logger: MFG

Depth (m)	TCR	SCR	RQD	FI	Field Records	Level (mOD)	Depth (m) (Thickness)	Legend	Description	Water	Backfill
41.80											
	100	100	100								
43.30											
	100	100	100								
44.80											
	100	100	100								
46.30							(22.50)				
	100	100	100								
47.80											
	100	100	100						30° fracture at 48.25m, planar, smooth, partly polished with faint slickensides, stained black.		
49.30											
	100	100	100								
50.80											
	TCR	SCR	RQD	FI							

Continued on Next Page

Remarks SPT's carried out using SPT Hammer SPT CC1	Water Added		Water Strike - General			
	From (m)	To (m)	Struck at (m)	Casing to (m)	Time (min)	Rose to (m)
	Casing Details		Chiselling Details			
To (m)	Diam (mm)	From (m)	To (m)	Time (hh:mm)		
8.50	250					



CAUSEWAY
GEOTECH

Project No.: 15-664	Project Name: GDD Overwater SI	Borehole No.: BH03
Coordinates: 326052.50 E	Client: Irish Water	Sheet 6 of 6
Method: Cable Percussion+Geobor S Coring	Client's Representative: Tobin Arup JV	Scale: 1:50
Plant: Dando 3000+Comacchio 405	Ground Level: -5.00 mOD	Dates: 30/07/2015 - 07/08/2016
		Driller: CC+SS
		Logger: MFG

Depth (m)	TCR	SCR	RQD	FI	Field Records	Level (mOD)	Depth (m) (Thickness)	Legend	Description	Water	Backfill
52.30	100	100	100								
53.80	100	100	90						10° vein at 53.45m, 10mm white calcite, open on downhole side, smooth, stained black.		
55.30	100	100	100	2							
56.80	100	100	100	1							
58.30	100	100	100	20					65° joint at 57.00-57.20m, undulating, smooth and polished in parts, stained black. At 57.20-57.60m, closely spaced 55-75° joints, planar, polished, possible faint slickensides. Also very closely spaced 10-20° joints at 57.30-57.50m, planar, smooth.		
58.30				3		-63.30	58.30		End of borehole at 58.300m		
	TCR	SCR	RQD	FI							

Remarks SPT's carried out using SPT Hammer SPT CC1	Water Added		Water Strike - General			
	From (m)	To (m)	Struck at (m)	Casing to (m)	Time (min)	Rose to (m)
Casing Details		Chiselling Details				
To (m)	Diam (mm)	From (m)	To (m)	Time (hh:mm)		
8.50	250					



CAUSEWAY
GEOTECH

Project No.: 15-664	Project Name: GDD Overwater SI	Borehole No.: BH05
Coordinates: 326981.50 E	Client: Irish Water	Sheet 1 of 6
Method: Cable Percussion+Geobor S Coring	Client's Representative: Tobin Arup JV	Scale: 1:50
Plant: Dando 3000+Comacchio 405	Ground Level: -7.76 mOD	Dates: 15/08/2015 - 18/08/2015
		Driller: CC
		Logger: MFG

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Legend	Description	Water	Backfill
0.00 - 1.00	B1							Medium dense grey silty fine to medium SAND with occasional shells.		
0.00 - 1.00	ES9									
1.00	D12			N=25 (3,3/4,5,7,9)		(3.10)				
1.00	ES10									
1.00 - 1.45	SPT (S)									
	N=25									
2.00	D13			N=26 (3,4/5,5,8,8)						
2.00 - 2.45	SPT (S)									
	N=26									
2.00 - 3.00	B2									
2.00 - 3.00	ES11									
3.00	D14			N=39 (4,6/8,9,11,11)	-10.86	3.10		Dense grey slightly silty very sandy subangular to subrounded fine to coarse GRAVEL with occasional cobbles and boulders with some shells. Sand is fine to coarse.		
3.00 - 3.45	SPT (S)									
	N=39									
3.10 - 3.50	B3									
4.00	D15			N=43 (6,8/10,10,11,12)		(1.50)				
4.00 - 4.45	SPT (S)									
	N=43									
4.60 - 5.00	B4				-12.36	4.60		Firm to stiff grey slightly sandy gravelly silty CLAY with occasional cobbles and boulders. Gravel is fine to coarse subangular to subrounded. Sand is fine to coarse.		
5.00	D16			N=12 (2,2/2,3,3,4)						
5.00 - 5.45	SPT (S)									
	N=12									
6.00 - 7.00	B5					(4.30)				
7.50 - 8.50	B6									
8.00 - 8.45	SPT (S)			N=15 (2,3/3,4,4,4)						
	N=15									
8.90 - 9.30	B7				-16.66	8.90		Stiff to very stiff greyish brown slightly sandy slightly gravelly CLAY with cobbles and boulders. Sand is fine to coarse. Gravel is subangular to subrounded fine to coarse.		
9.50	D17			50 (14,11/50 for 225mm)		(1.80)				
9.50 - 10.00	B8									
9.50 - 9.88	SPT (S)									

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Remarks

Deck to bed 13m
Chiseling:
6.60m to 7.80m = 01:00hr
10.30m to 10.70m = 01:00hr

Water Added		Water Strike - General			
From (m)	To (m)	Struck at (m)	Casing to (m)	Time (min)	Rose to (m)
Casing Details		Chiselling Details			
To (m)	Diam (mm)	From (m)	To (m)	Time (hh:mm)	
23.70	200				



CAUSEWAY
GEOTECH

Project No.: 15-664	Project Name: GDD Overwater SI	Borehole No.: BH05
Coordinates: 326981.50 E	Client: Irish Water	Sheet 2 of 6
Method: Cable Percussion+Geobor S Coring	Client's Representative: Tobin Arup JV	Scale: 1:50
Plant: Dando 3000+Comacchio 405	Ground Level: -7.76 mOD	Dates: 15/08/2015 - 18/08/2015
		Driller: CC
		Logger: MFG

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Legend	Description	Water	Backfill
10.70	D18 SPT (C)	56	0	D18 SPT (20.5/50 for 150mm 150mm)	-18.46	10.70		Firm to stiff dark brown slightly sandy gravelly CLAY with rare cobbles and one boulder. Sand is fine to coarse. Gravel is fine to coarse, subangular, predominantly of dark grey limestone.		
10.70 - 11:00						(3.90)				
12.30	81	0	0							
13.90	90	0	0		-22.36	14.60		Stiff dark brown slightly sandy slightly gravelly CLAY. Sand is fine to coarse. Gravel is fine to coarse, subrounded, predominantly of limestone.		
15.60	100	3	0			(2.20)				
17.20	85	13	0	NI	-24.56	16.80		Firm light orangey brown CLAY.		
					-24.76	(0.20) 17.00		Weak black fractured carbonaceous MUDSTONE. Discontinuities: 20-40°, very closely spaced, planar.		
18.70	0	0	0	NR	-25.36	17.60		Firm light brown slightly sandy slightly gravelly CLAY. (Highly weathered MUDSTONE.) Sand is fine to coarse. Gravel is fine to coarse, subangular, of mudstone lithorelics.		
					-26.46	18.70		No recovery. (Probably highly weathered sandstone, siltstone or mudstone.)		
20.10					-27.86	20.10		Stiff to very stiff light brown and yellowish brown slightly sandy to sandy gravelly CLAY. (Highly weathered SILTSTONE and SANDSTONE.) Sand is fine to coarse. Gravel is fine to coarse, subangular to angular of siltstone and		

Continued on Next Page

Remarks

Deck to bed 13m
Chiseling:
6.60m to 7.80m = 01:00hr
10.30m to 10.70m = 01:00hr

Water Added		Water Strike - General			
From (m)	To (m)	Struck at (m)	Casing to (m)	Time (min)	Rose to (m)
Casing Details		Chiselling Details			
To (m)	Diam (mm)	From (m)	To (m)	Time (hh:mm)	
23.70	200				



Project No.: 15-664	Project Name: GDD Overwater SI	Borehole No.: BH05
Coordinates: 326981.50 E	Client: Irish Water	Sheet 3 of 6
Method: Cable Percussion+Geobor S Coring	Client's Representative: Tobin Arup JV	Scale: 1:50
Plant: Dando 3000+Comacchio 405	Ground Level: -7.76 mOD	Dates: 15/08/2015 - 18/08/2015
		Driller: CC
		Logger: MFG

Depth (m)	TCR	SCR	RQD	FI	Field Records	Level (mOD)	Depth (m) (Thickness)	Legend	Description	Water	Backfill
21.70	82	25	0					xxxxxx	sandstone lithorelics.		
23.20	80	3	0	NI				xxxxxx			
24.70	100	10	0				(8.60)	xxxxxx			
26.20	100	38	23	15				xxxxxx	<u>Medium strong grey and light orange (possibly dolomitised) LIMESTONE at 24.90-25.05m and 25.25-25.60m.</u>		
27.70	93	0	0	NI				xxxxxx			
29.20	87	33	0				28.70	<u>Becomes slightly fissured at 27.70-28.70m, with cobble-sized lithorelics of grey dolomitised LIMESTONE.</u>		
30.70	93	27	0	NI			(1.20)	Dark brown slightly gravelly very clayey fine to coarse SAND with one sandstone cobble at 29.30-29.45m. (Highly weathered SANDSTONE.) Gravel is fine to coarse, subangular, of sandstone lithorelics.		
							29.90	Stiff to very stiff light brown and yellowish brown slightly sandy slightly gravelly to gravelly CLAY with occasional cobble-sized lithorelics. (Highly weathered SILTSTONE and SANDSTONE.) Sand is fine to coarse. Gravel is fine to coarse, angular to subangular of siltstone and sandstone lithorelics.		
							-36.46				
							-37.66				

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Remarks Deck to bed 13m Chiseling: 6.60m to 7.80m = 01:00hr 10.30m to 10.70m = 01:00hr	Water Added		Water Strike - General			
	From (m)	To (m)	Struck at (m)	Casing to (m)	Time (min)	Rose to (m)
	Casing Details		Chiselling Details			
To (m)	Diam (mm)	From (m)	To (m)	Time (hh:mm)		
23.70	200					



CAUSEWAY
GEOTECH

Project No.: 15-664	Project Name: GDD Overwater SI	Borehole No.: BH05
Coordinates: 326981.50 E	Client: Irish Water	Sheet 5 of 6
Method: Cable Percussion+Geobor S Coring	Client's Representative: Tobin Arup JV	Scale: 1:50
Plant: Dando 3000+Comacchio 405	Ground Level: -7.76 mOD	Dates: 15/08/2015 - 18/08/2015
		Driller: CC
		Logger: MFG

Depth (m)	TCR	SCR	RQD	FI	Field Records	Level (mOD)	Depth (m) (Thickness)	Legend	Description	Water	Backfill
41.20	80	20	0					XXXXXX			
42.70	80	13	0	NI			(4.55)	XXXXXX			
44.20	100	33	27	4 NI		-52.21 -52.46	44.45 44.70 (0.70)	XXXXXX	Medium strong grey and pinkish grey massive LIMESTONE.		
45.70	100	27	0	4 NI		-53.16 -53.36	45.40 45.60 (0.20)	XXXXXX	Firm orangey brown mottled dark brown slightly sandy slightly gravelly CLAY. (Highly weathered MUDSTONE.) Sand is fine to coarse. Gravel is fine to coarse, subangular of mudstone lithorelics.		
47.20	93	20	7	10 NI			(6.40)	XXXXXX	Medium strong light grey massive LIMESTONE.		
48.70	100	60	17	10				XXXXXX	Extremely weak to very weak (locally weak) yellowish brown, light brown and pinkish orange, fine to coarse grained SANDSTONE probably with minor siltstone. Regularly non-intact and recovered as sandy gravelly clay or clayey sandy gravel.		
50.20	80	7	0	5				XXXXXX	46.00-47.20m: Intact, but extremely weak.		
								XXXXXX	47.95-48.70m: Recovered as clayey sandy GRAVEL of very weak sandstone.		
								XXXXXX	48.70-49.60m: Very weak to weak.		
								XXXXXX	50.60-51.20m: Intact, but extremely weak.		

Continued on Next Page

Remarks Deck to bed 13m Chiseling: 6.60m to 7.80m = 01:00hr 10.30m to 10.70m = 01:00hr	Water Added		Water Strike - General			
	From (m)	To (m)	Struck at (m)	Casing to (m)	Time (min)	Rose to (m)
	Casing Details		Chiselling Details			
To (m)	Diam (mm)	From (m)	To (m)	Time (hh:mm)		
23.70	200					



CAUSEWAY
— GEOTECH

Project No.:

15-664

Project Name:

GDD Overwater SI

Borehole No.:

BH05

Coordinates:

326981.50 E

Client:

Irish Water

Sheet 6 of 6

Method:

Cable Percussion+Geobor S Coring

242310.94 N

Client's Representative:

Tobin Arup JV

Scale: 1:50

Plant:

Dando 3000+Comacchio 405

Ground Level:

-7.76 mOD

Dates:

15/08/2015 - 18/08/2015

Driller: CC

Logger: MFG

Depth (m)	TCR	SCR	RQD	FI	Field Records	Level (mOD)	Depth (m) (Thickness)	Legend	Description	Water	Backfill
51.70				NI 10		-59.76	52.00		Weak to medium strong light grey and dark grey LIMESTONE (probably dolomitised). Discontinuities: 10-30° fractures, occasionally subparallel to bedding, close to medium spaced, planar to stepped, rough.		
53.30				6			(3.00)		53.90-54.00m: Weak light brown SANDSTONE.		
									94		
55.00						-62.76	55.00		54.60-54.90m: Medium strong light greyish brown SANDSTONE.		

Remarks

Deck to bed 13m
Chiseling:
6.60m to 7.80m = 01:00hr
10.30m to 10.70m = 01:00hr

Water Added		Water Strike - General			
From (m)	To (m)	Struck at (m)	Casing to (m)	Time (min)	Rose to (m)
Casing Details		Chiselling Details			
To (m)	Diam (mm)	From (m)	To (m)	Time (hh:mm)	
23.70	200				



CAUSEWAY
— GEOTECH

Project No.: 15-664	Project Name: GDD Overwater SI	Borehole No.: BH08
Coordinates: 328288.30 E	Client: Irish Water	Sheet 1 of 5
Method: Cable Percussion+Geobor S Coring	Client's Representative: Tobin Arup JV	Scale: 1:50
Plant: Dando 3000+Comacchio 405	Ground Level: -14.00 mOD	Driller: CC+SS
	Dates: 08/08/2015 – 14/08/2016	Logger: MFG

Depth (m)	TCR	SCR	RQD	FI	Field Records	Level (mOD)	Depth (m) (Thickness)	Legend	Description	Water	Backfill
0.00 - 0.50 0.00 - 1.00					ES2 B1		(1.50)		Medium dense grey very sandy fine to coarse subrounded GRAVEL with many shells and occasional cobbles. Sand is fine to coarse.		
1.00 1.00 - 1.45 1.00 - 1.50					D3 N=12 (2,2/2,3,3,4) ES5						
1.50 - 2.50					B4	-15.50	1.50		Very dense grey very gravelly fine to coarse SAND with many shells and occasional cobbles. Gravel is subangular to subrounded fine to coarse.		
2.00 2.00 - 2.33 2.00 - 2.50					D6 50 (4,6/50 for 180mm) ES7		(1.50)				
3.00 - 3.45 3.00 - 3.50					N=15 (3,3/4,4,4,3) B8	-17.00	3.00		Medium dense grey sandy fine to coarse subangular to subrounded GRAVEL with medium cobble content. Sand is fine to coarse.		
4.00 - 4.45 4.00 - 4.50					N=10 (4,3/3,3,2,2) B9		(3.20)				
5.00 - 5.45 5.00 - 5.50					N=17 (3,3/2,3,5,7) B10						
6.00 6.00 - 6.45 6.20 - 7.20					D11 N=31 (5,6/7,8,7,9) B12	-20.20	6.20		Stiff to very stiff greyish brown slightly sandy silty CLAY. Sand is fine to coarse.		
7.00 7.00 - 7.45 7.30 - 7.80					D13 N=33 (5,5/8,7,8,10) B14	-21.20	7.20		Very stiff greyish brown slightly sandy slightly gravelly silty CLAY. Sand is fine to coarse. Gravel is subangular to subrounded fine to coarse.		
8.40 - 8.65					50 (25 for 115mm/50 for 135mm) B15	-22.40	8.40		Very dense dark grey fine to coarse subangular GRAVEL of limestone. (Possibly weathered bedrock.)		
8.40 - 8.70						-22.70	8.70		Weak to medium strong fractured dark grey argillaceous LIMESTONE. Partially weathered: closer fracture spacing, slightly weathered.		
	97	50	0	16			(2.00)		Discontinuity sets: 1. 0-30° joints, closely spaced, planar, rough, occasionally with <1mm calcite mineralisation.		
				NI							
				20							

Continued on Next Page

Remarks
SPT's carried out using SPT Hammer SPT CC1

Water Added		Water Strike - General			
From (m)	To (m)	Struck at (m)	Casing to (m)	Time (min)	Rose to (m)
Casing Details		Chiselling Details			
To (m)	Diam (mm)	From (m)	To (m)	Time (hh:mm)	
8.70	250				



CAUSEWAY
— GEOTECH

Project No.: 15-664	Project Name: GDD Overwater SI	Borehole No.: BH08
Coordinates: 328288.30 E	Client: Irish Water	Sheet 2 of 5
Method: Cable Percussion+Geobor S Coring	Client's Representative: Tobin Arup JV	Scale: 1:50
Plant: Dando 3000+Comacchio 405	Ground Level: -14.00 mOD	Driller: CC+SS
	Dates: 08/08/2015 – 14/08/2016	Logger: MFG

Depth (m)	TCR	SCR	RQD	FI	Field Records	Level (mOD)	Depth (m) (Thickness)	Legend	Description	Water	Backfill			
10.20				NI		-24.70	10.70		2. 40-60° joints, closely spaced (very closely spaced at 10.0-10.2m), planar, smooth to rough, with up to 3mm of dark brownish grey clay fill.					
	100	53	23								Medium strong (locally weak, and probably strong in places), indistinctly laminated dark grey argillaceous LIMESTONE. Largely unweathered.			
				10							<i>10.70-11.60m: 55-75° joints, very closely to closely spaced, planar to slightly undulating, smooth to rough, often with film of dark brownish grey clay.</i>			
11.70												<i>11.60-13.20m: 55-75° joints, closely to medium spaced, planar to slightly undulating, smooth to rough, often with film of dark brownish grey clay.</i>		
	100	98	80	5										
13.20												<i>80-90° joint at 13.2-14.3m, undulating, smooth to rough, patchy dark brown staining.</i>		
	100	63	17											
14.70												<i>14.30-14.50m: Very weak fractured limestone with calcite vein. Extremely closely spaced 50-55° fractures with 10mm calcite vein at 14.4m, and up to 5mm of soft brown clay fill.</i> <i>80° undulating joint at 14.70-15.25m, smooth to rough.</i>		
	100	100	73	3								<i>14.50-19.50m: 35-55° joints, medium spaced, planar (often parallel to bedding), smooth, occasionally rough.</i>		
16.20														
	100	100	93											
17.70														
	100	87	57	15										
19.20														
	100	73	13	20					<i>19.50-19.55m: Very weak fractured limestone with extremely closely spaced 45° fractures. 70° undulating joint at 19.70-20.05m (rough) with very closely spaced incipient fractures at 19.55-19.70m.</i>					
				10										

Continued on Next Page

Remarks
SPT's carried out using SPT Hammer SPT CC1

Water Added		Water Strike - General			
From (m)	To (m)	Struck at (m)	Casing to (m)	Time (min)	Rose to (m)
Casing Details		Chiselling Details			
To (m)	Diam (mm)	From (m)	To (m)	Time (hh:mm)	
8.70	250				



CAUSEWAY
— GEOTECH

Project No.: 15-664	Project Name: GDD Overwater SI	Borehole No.: BH08
Coordinates: 328288.30 E	Client: Irish Water	Sheet 3 of 5
Method: Cable Percussion+Geobor S Coring	Client's Representative: Tobin Arup JV	Scale: 1:50
Plant: Dando 3000+Comacchio 405	Ground Level: -14.00 mOD	Driller: CC+SS
	Dates: 08/08/2015 – 14/08/2016	Logger: MFG

Depth (m)	TCR	SCR	RQD	FI	Field Records	Level (mOD)	Depth (m) (Thickness)	Legend	Description	Water	Backfill
20.70				7							
	100	93	57	3					50° joint at 21.2m, planar, rough, stained brown.		
22.20				15					Very weak fractured limestone at 21.85-21.90m (extremely closely spaced 50° fractures with 0-1mm soft brown clay fill). 20mm calcite vein at 21.90m. 21.60-22.20m: Closely spaced 50° fractures (planar, smooth).		
	100	98	47	1					22.20-22.90m: 80-90° joint at 22.3-22.9m (slightly undulating, rough, stained dark brown) with 30-50° closely spaced fractures (planar, smooth).		
23.70				10					22.90-24.85m: 60-70° joints, medium spaced, planar, smooth, stained black with faint slickensides. 10-30° joints, medium spaced, planar, rough.		
	100	83	33	8							
25.20							(22.90)		24.85-28.00m: 5-25° joints, medium spaced, planar, smooth, rough. 30-50° joints, medium spaced (closely spaced at 26.90-28.0m), planar, smooth.		
	100	97	53	6							
26.70											
	100	93	30	8							
28.20									28.00-29.40m: 0-20° joints, close to medium spaced, planar, smooth to rough, stained brown and dark brown. 80° fracture at 28.30-28.50m, undulating, rough, patchy calcite mineralisation. Limestone highly fractured at 28.50-28.55m, 28.80-28.95m and 29.25-29.40m (extremely closely spaced fractures stained orangey brown and dark brown with up to 2mm dark brown clay film). 15° joint at 29.15m with 20mm of firm dark brown gravelly clay fill.		
	100	67	23	15							
29.70				1							
	TCR	SCR	RQD	FI							

Continued on Next Page

Remarks
SPT's carried out using SPT Hammer SPT CC1

Water Added		Water Strike - General			
From (m)	To (m)	Struck at (m)	Casing to (m)	Time (min)	Rose to (m)
Casing Details		Chiselling Details			
To (m)	Diam (mm)	From (m)	To (m)	Time (hh:mm)	
8.70	250				



CAUSEWAY
— GEOTECH

Project No.: 15-664	Project Name: GDD Overwater SI	Borehole No.: BH08
Coordinates: 328288.30 E	Client: Irish Water	Sheet 4 of 5
Method: Cable Percussion+Geobor S Coring	Client's Representative: Tobin Arup JV	Scale: 1:50
Plant: Dando 3000+Comacchio 405	Ground Level: -14.00 mOD	Driller: CC+SS
	Dates: 08/08/2015 - 14/08/2016	Logger: MFG

Depth (m)	TCR	SCR	RQD	FI	Field Records	Level (mOD)	Depth (m) (Thickness)	Legend	Description	Water	Backfill
31.20	100	93	67	NI					30.10-30.20m: Non-intact. Extremely closely spaced fractures with black clay coating.		
				5					30.20-31.20m: 50-70° joints, closely spaced, planar, smooth. Limestone becoming increasingly carbonaceous down to 31.2m.		
32.70	100	100	87	2					60° joint/vein at 31.85-32.10m, planar to slightly undulating, rough, 1-2mm calcite mineralisation with patchy brown staining.		
									40° joint at 32.6m, planar to irregular, rough, stained black and dark brown. 32.70-33.60m: ~60° joints at 32.7-32.8m, 32.8-32.9m and 33.45-33.55m, planar to irregular, rough, stained brown.		
34.20	100	97	77			-47.60	33.60		Medium strong to strong thinly to thickly laminated dark grey argillaceous LIMESTONE. Unweathered.		
									Discontinuity sets: 1. 40-50° bedding fractures, medium to widely spaced, planar, smooth.		
35.70	100	100	100	2							
37.20	100	100	100				(12.00)				
38.70	100	100	100						60-90° undulating joint at 38.30-38.60m, smooth, patchy grey staining.		
									45-55° joints/veins at 39.85m, 40.00m, 40.30m and 40.60m, planar to		

Continued on Next Page

Remarks
SPT's carried out using SPT Hammer SPT CC1

Water Added		Water Strike - General			
From (m)	To (m)	Struck at (m)	Casing to (m)	Time (min)	Rose to (m)
Casing Details		Chiselling Details			
To (m)	Diam (mm)	From (m)	To (m)	Time (hh:mm)	
8.70	250				



CAUSEWAY
— GEOTECH

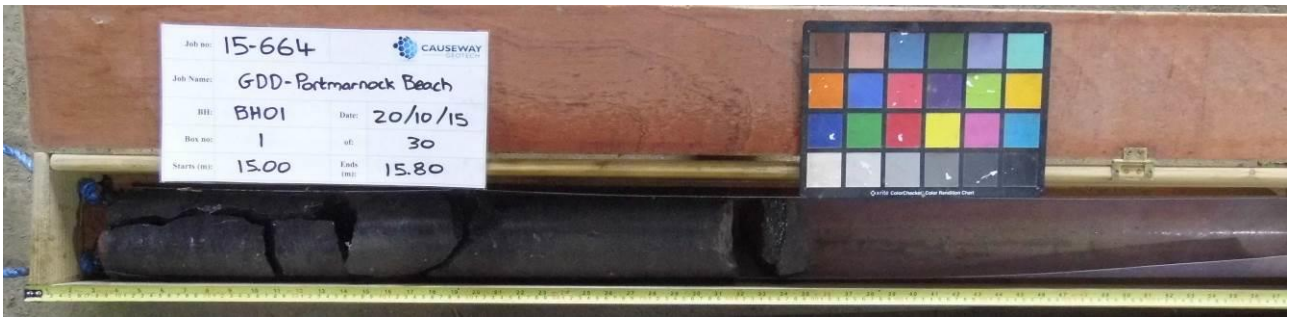
Project No.: 15-664	Project Name: GDD Overwater SI	Borehole No.: BH08
Coordinates: 328288.30 E	Client: Irish Water	Sheet 5 of 5
Method: Cable Percussion+Geobor S Coring	Client's Representative: Tobin Arup JV	Scale: 1:50
Plant: Dando 3000+Comacchio 405	Ground Level: -14.00 mOD	Dates: 08/08/2015 - 14/08/2016
		Driller: CC+SS
		Logger: MFG

Depth (m)	TCR	SCR	RQD	FI	Field Records	Level (mOD)	Depth (m) (Thickness)	Legend	Description	Water	Backfill
40.20									45-55° joints/veins at 39.85m, 40.00m, 40.30m and 40.60m, planar to undulating, smooth, up to 2mm calcite with patchy brown staining.		
	95	95	60								
41.70											
	100	100	100								
43.20											
	100	93	80								
44.70									60° joint at 44.25-44.40m, planar to irregular, rough, slight grey and black staining. 44.40-45.60m: bedding fractures become closely spaced (planar, smooth). 50° calcite vein at 45.35m (open, rough, partly stained orangey brown, and with up to 2mm of dark grey sandy clay fill) with single parallel joint at 45.40m.		
	100	90	25								
45.60						-59.60	45.60		End of borehole at 45.600m		

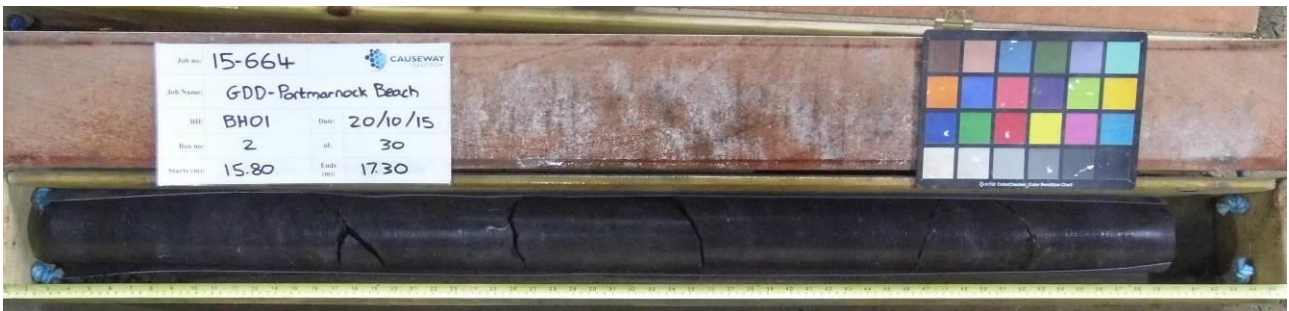
Remarks
SPT's carried out using SPT Hammer SPT CC1

Water Added		Water Strike - General			
From (m)	To (m)	Struck at (m)	Casing to (m)	Time (min)	Rose to (m)
Casing Details		Chiselling Details			
To (m)	Diam (mm)	From (m)	To (m)	Time (hh:mm)	
8.70	250				

Appendix C
Core photographs



Borehole BH01 15.00 – 15.80m



Borehole BH01 15.80 – 17.30m



Borehole BH01 17.30 – 18.80m



Borehole BH01 18.80 – 20.30m



Borehole BH01 20.30 – 21.80m



Borehole BH01 21.80 – 23.30m



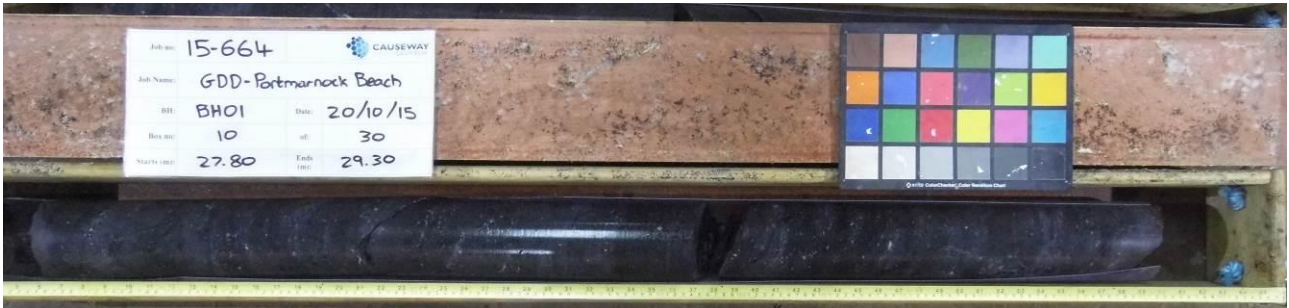
Borehole BH01 23.30 – 24.80m



Borehole BH01 24.80 – 26.30



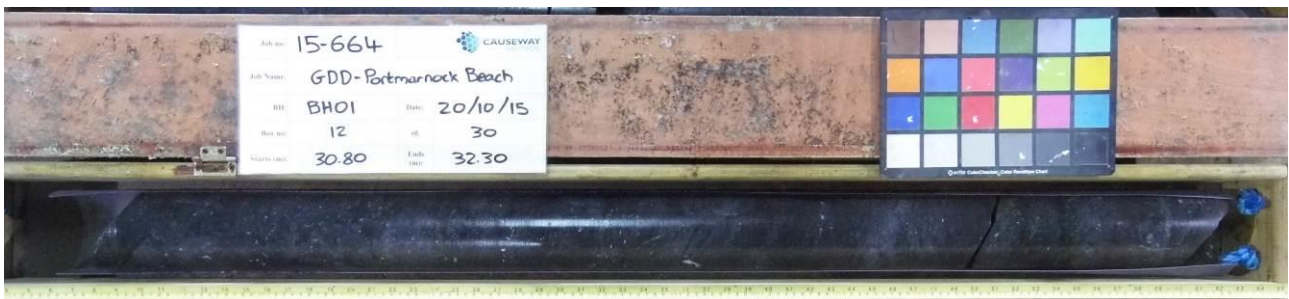
Borehole BH01 26.30 – 27.80m



Borehole BH01 27.80 – 29.30m



Borehole BH01 29.30 – 30.80m



Borehole BH01 30.80 – 32.30m



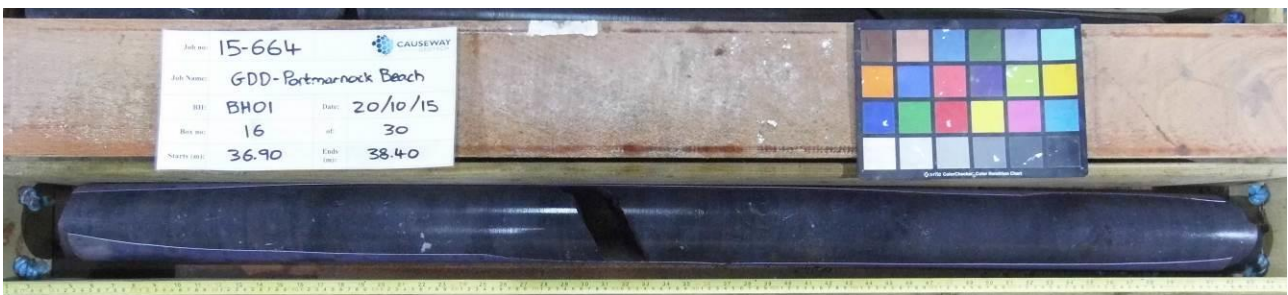
Borehole BH01 32.30 – 33.80m



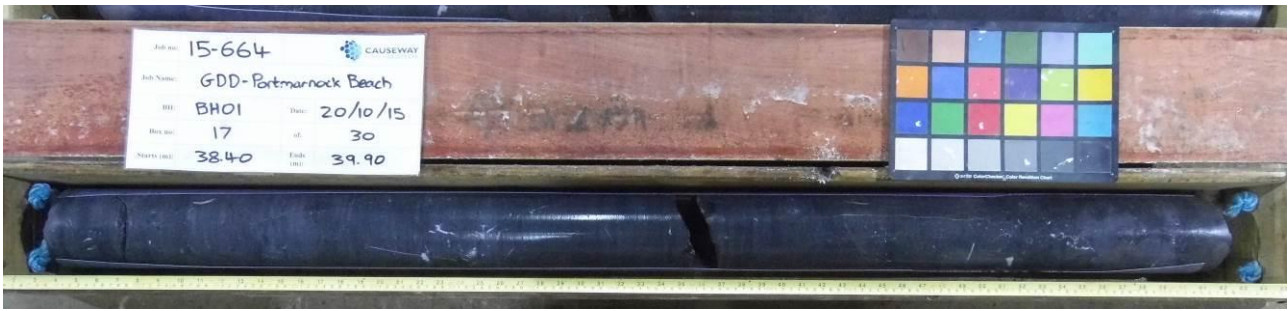
Borehole BH01 33.80 – 35.40m



Borehole BH01 35.40 – 36.90m



Borehole BH01 36.90 – 38.40m



Borehole BH01 38.40 – 39.90m



Borehole BH01 39.90 – 41.50m



Borehole BH01 41.50 – 43.00m



Borehole BH01 43.00m – 44.50m



Borehole BH01 44.50 – 46.00m



Borehole BH01 46.00 – 47.60m



Borehole BH01 47.60 – 49.10m



Borehole BH01 49.10 – 50.60m



Borehole BH01 50.60 – 52.10m



Borehole BH01 52.10 – 53.60m



Borehole BH01 53.60 – 55.10m



Borehole BH01 55.10 – 56.70m



Borehole BH01 56.70 – 58.30m



Borehole BH01 58.30 – 59.90m



Borehole BH03 8.50 – 10.00m



Borehole BH03 10.00 – 10.80m



Borehole BH03 10.80 – 12.50m



Borehole BH03 12.50 - 13.30m



Borehole BH03 13.30 - 14.80m



Borehole BH03 14.80 - 15.30m



Borehole BH03 15.30 – 16.30m



Borehole BH03 16.30 – 17.80m



Borehole BH03 17.80 – 19.30m



Borehole BH03 19.30 – 20.80m



Borehole BH03 20.80 – 22.30m



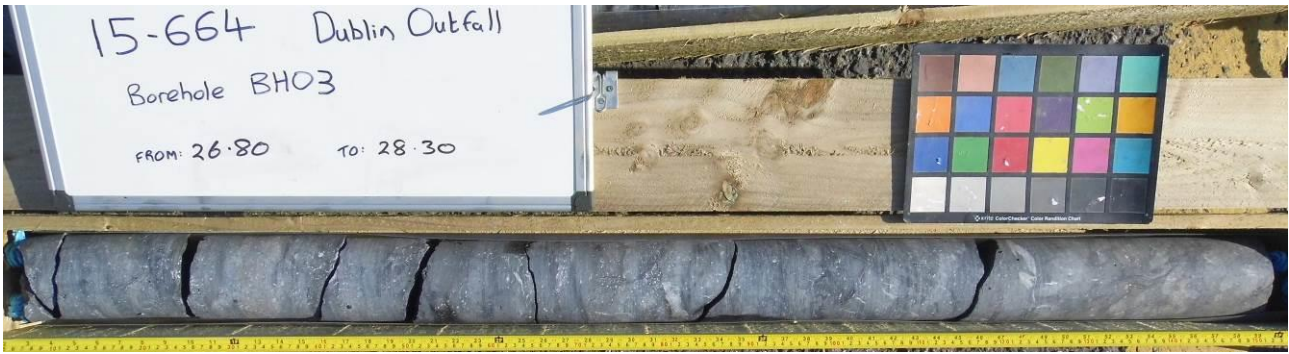
Borehole BH03 22.30 – 23.80m



Borehole BH03 23.80 – 25.30m



Borehole BH03 25.30 – 26.80m



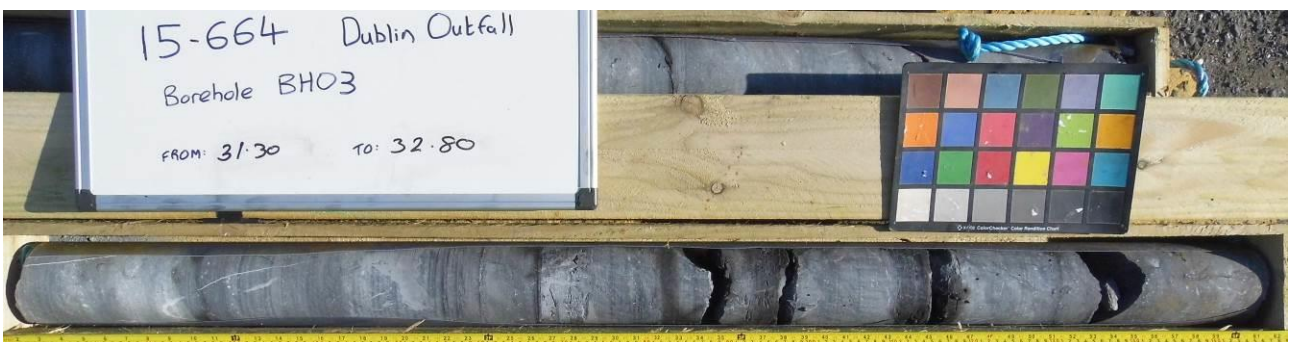
Borehole BH03 26.80 – 28.30m



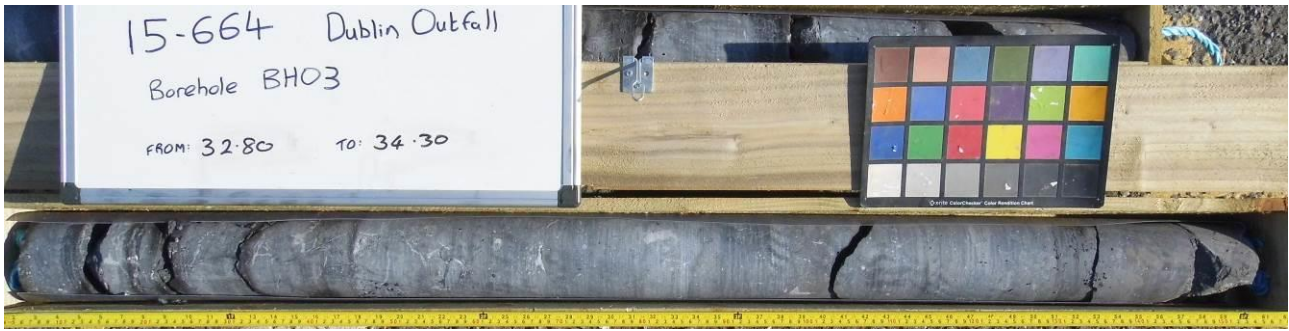
Borehole BH03 28.30 – 29.80m



Borehole BH03 29.80 – 31.30m



Borehole BH03 29.80 – 32.80m



Borehole BH03 32.80 – 34.30m



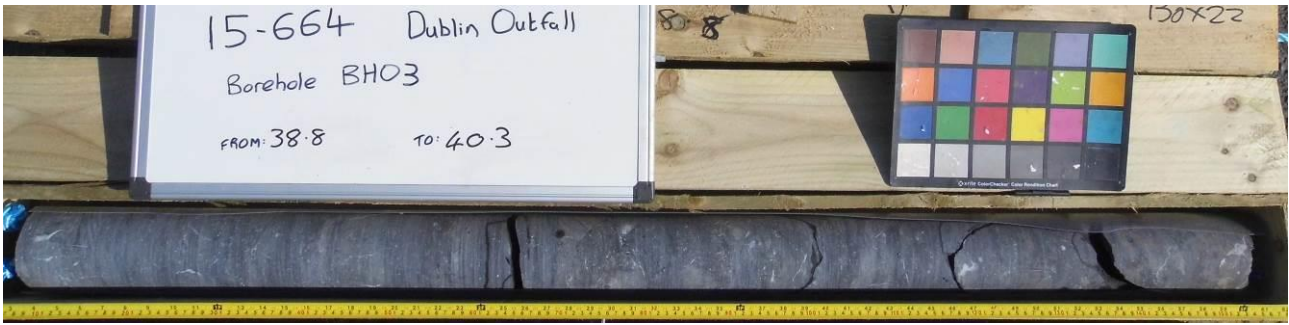
Borehole BH03 34.30 – 35.80m



Borehole BH03 35.80 – 37.30m



Borehole BH03 37.30 – 38.80m



Borehole BH03 38.80 – 40.30m



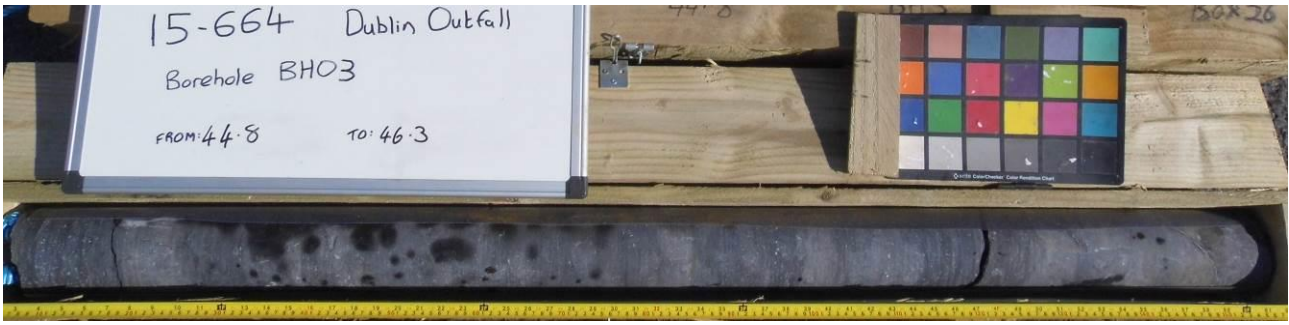
Borehole BH03 40.30 – 41.80m



Borehole BH03 41.80 – 43.30m



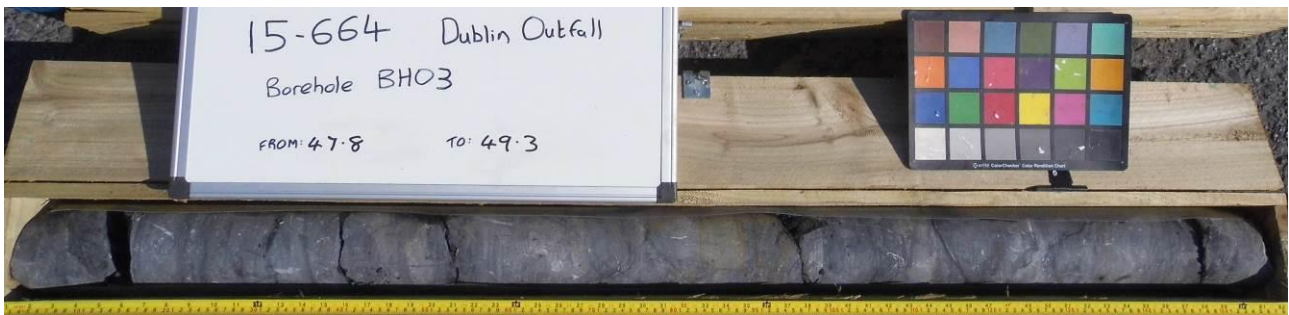
Borehole BH03 43.30 – 44.80m



Borehole BH03 44.80 – 46.30m



Borehole BH03 46.30 – 47.80m



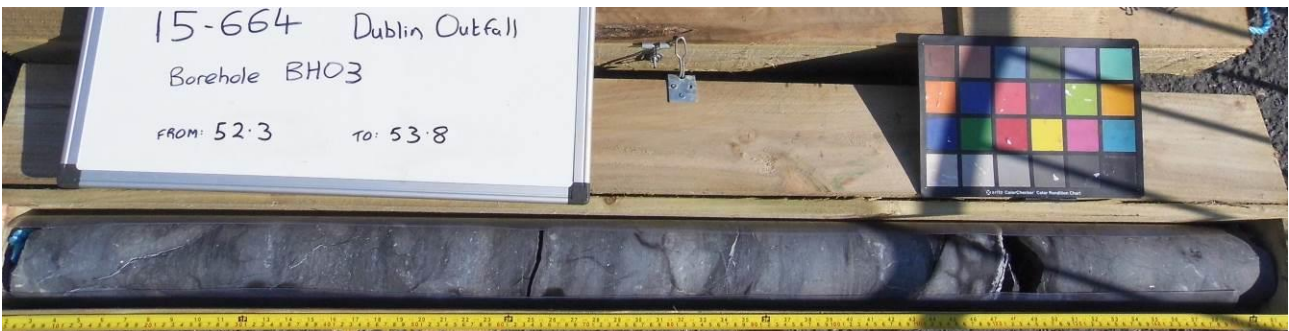
Borehole BH03 47.80 – 49.30m



Borehole BH03 49.30 – 50.80m



Borehole BH03 50.80 – 52.30m



Borehole BH03 52.30 – 53.80m



Borehole BH03 53.80 – 55.30m



Borehole BH03 55.30 – 56.80m



Borehole BH03 56.80 – 58.30m



Borehole BH05 10.70 – 12.30m



Borehole BH05 12.30 – 13.90m



Borehole BH05 13.90 – 15.60m



Borehole BH05 15.60 – 17.20m



Borehole BH05 17.20 – 18.70m

No Recovery between 18.70m – 20.10m



Borehole BH05 20.10 – 21.70m



Borehole BH05 21.70m – 23.20



Borehole BH05 23.20 – 24.70m



Borehole BH05 24.70 – 26.20m



Borehole BH05 26.20 – 27.70m



Borehole BH05 27.70 – 29.20m



Borehole BH05 29.20 – 30.70m



Borehole BH05 30.70 – 32.20m



Borehole BH05 32.20 – 33.70m



Borehole BH05 33.70 – 35.20m



Borehole BH05 35.20 – 36.70m



Borehole BH05 36.70 – 38.20m



Borehole BH05 38.20 – 39.70m



Borehole BH05 39.70 – 41.20m



Borehole BH05 41.20 – 42.70m



Borehole BH05 42.70 – 44.20m



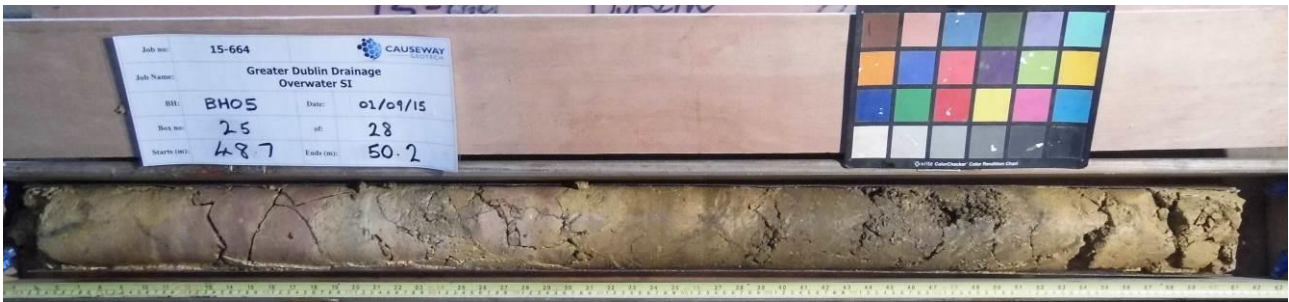
Borehole BH05 44.20 – 45.70m



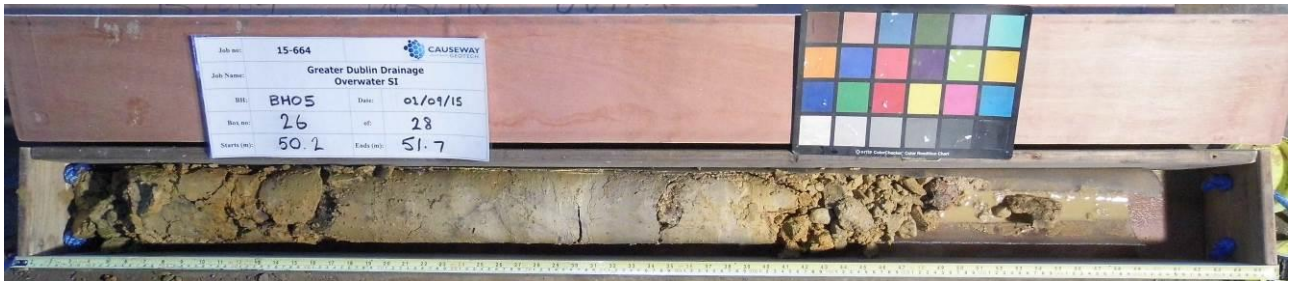
Borehole BH05 45.70 – 47.20m



Borehole BH05 47.20 – 48.70m



Borehole BH05 48.70 – 50.20m



Borehole BH05 50.20 – 51.70m



Borehole BH05 51.70 – 53.20m



Borehole BH05 53.20 – 55.00m



Borehole BH08 8.70 – 10.20m



Borehole BH08 10.20 – 11.70m



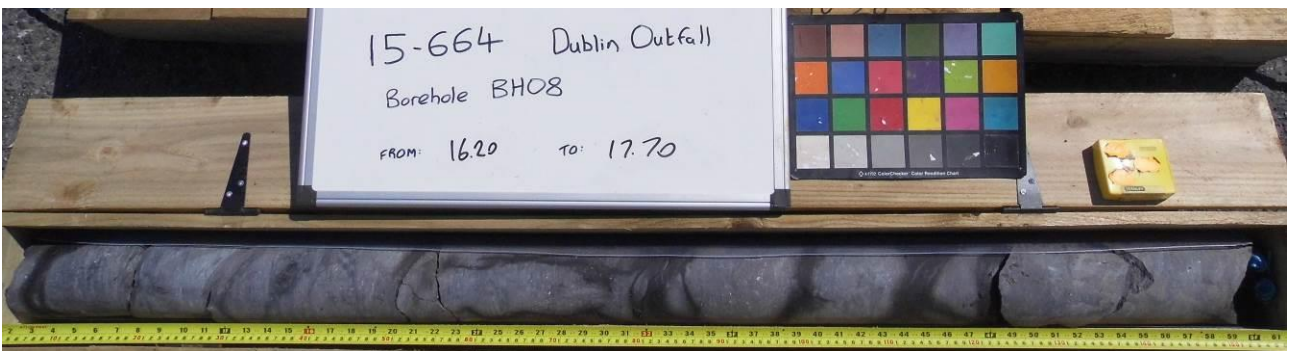
Borehole BH08 11.70 – 13.20m



Borehole BH08 13.20 – 14.70m



Borehole BH08 14.70 – 16.20m



Borehole BH08 16.20 – 17.70m



Borehole BH08 17.70 – 19.20m



Borehole BH08 19.20 – 20.70m



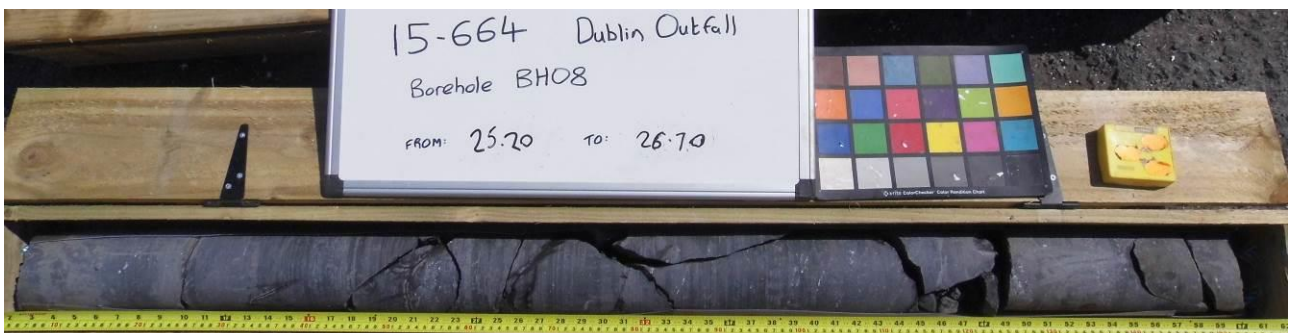
Borehole BH08 20.70 – 22.20m



Borehole BH08 22.20 – 23.70m



Borehole BH08 23.70 – 25.20m



Borehole BH08 25.20 – 26.70m



Borehole BH08 26.70 – 28.20m



Borehole BH08 28.20 – 29.70m



Borehole BH08 29.70 – 31.20m



Borehole BH08 31.20 – 32.70m



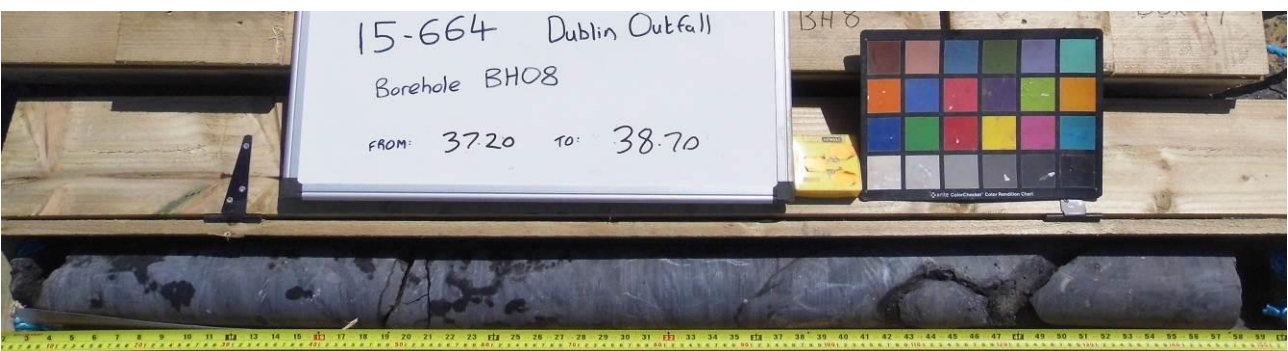
Borehole BH08 32.70 – 34.20m



Borehole BH08 34.20 – 35.70m (photo taken after sub-sampling)



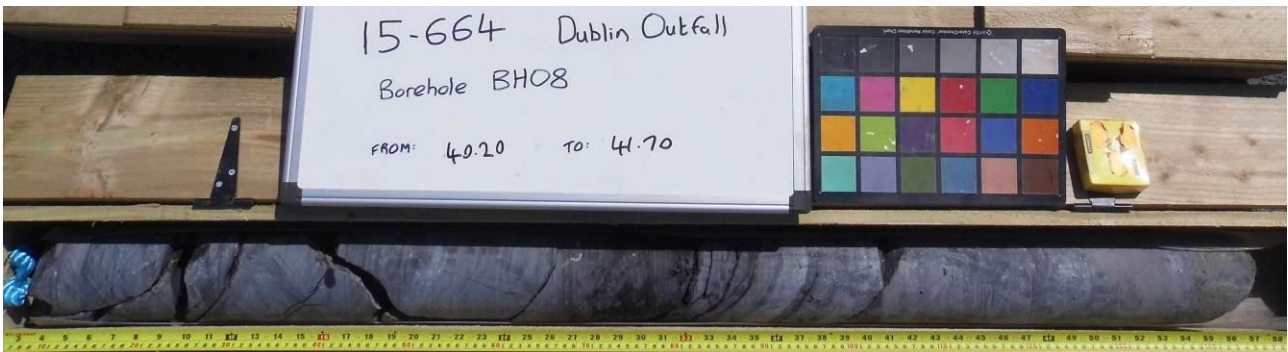
Borehole BH08 35.70 – 37.20m



Borehole BH08 37.20 – 38.70m



Borehole BH08 38.70 - 40.20m



Borehole BH08 40.20 - 41.70m



Borehole BH08 41.70 - 43.20m



Borehole BH08 43.20 - 44.70m



Borehole BH08 44.70 – 45.60m

APPENDIX D

Vibrocore logs

Causeway Geotech Ltd		Project no. 15-664	Project Name: GDD Overwater SI	Borehole No. BHVC02
Method: Pneumatic Vibrocore		Co-ords: 325628.60mE	Client: Irish Water	Sheet 1 of 1
Plant: Vibrocore		242320.00mN	Client's Representative: Tobin Arup JV	Scale: 1:50
		Ground Level: -2.79MOD	Dates: 22/08/2015 - 22/08/2015	Driller: TA
				Logged By: DC

Depth (m)	Sample / Test	Casing Depth (m)	Water Depth (m)	Field Records	Level & Depth	Stratum Description	Legend & Water Strikes	Backfill Installs
0.10 - 0.30 0.10 - 0.30 0.40 - 0.70 0.40 - 0.74	D ES ES D				(1.30)	Dense grey silty fine SAND with occasional shells 1.0m Recovery due to densifying of sample		
0.80 - 1.00 0.80 - 1.00	D ES				-4.09 1.30	----- End of borehole at 1.30 m		

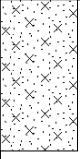
Remarks Deck to bed 3.53m Deck Level +0.743 mod	Chiselling:			Water Strikes:			Last Revised:
	From (m)	To (m)	Time (hh:mm)	Struck (m)	Rose to (m)	Time (min)	
	Water Added:		Casing:				
	From (m)	To (m)	To (m)	Diameter (mm)			
							www.causewaygeotech.com © Causeway Geotech Ltd


Causeway Geotech Ltd		Project no. 15-664	Project Name: GDD Overwater SI	Borehole No. BHVC03
Method: Pneumatic Vibrocore		Co-ords: 326077.10mE	Client: Irish Water	Sheet 1 of 1
Plant: Vibrocore		242322.90mN	Client's Representative: Tobin Arup JV	Scale: 1:50
		Ground Level: -5.57MOD	Dates: 22/08/2015 - 22/08/2015	Driller: TA
				Logged By: DC

Depth (m)	Sample / Test	Casing Depth (m)	Water Depth (m)	Field Records	Level & Depth	Stratum Description	Legend & Water Strikes	Backfill Installs
0.10 - 0.30	D					Dense grey silty fine SAND with occasional shells. 0.9m recovery from 1.3m due to densification		
0.10 - 0.30	ES				(1.30)			
0.40 - 0.70	D							
0.40 - 0.70	ES							
0.80 - 0.90	D							
0.80 - 0.90	ES				-6.87 1.30	----- End of borehole at 1.30 m		

Remarks Deck to bed 4.75m Deck Level -0.818 mod.	Chiselling:			Water Strikes:			Last Revised:
	From (m)	To (m)	Time (hh:mm)	Struck (m)	Rose to (m)	Time (min)	
	Water Added:		Casing:				
	From (m)	To (m)	To (m)	Diameter (mm)			
							www.causewaygeotech.com © Causeway Geotech Ltd

Causeway Geotech Ltd		Project no. 15-664	Project Name: GDD Overwater SI	Borehole No. BHVC04
Method: Pneumatic Vibrocore		Co-ords: 326528.70mE	Client: Irish Water	Sheet 1 of 1
Plant: Vibrocore		242311.70mN	Client's Representative: Tobin Arup JV	Scale: 1:50
		Ground Level: -6.70MOD	Dates: 22/08/2015 - 22/08/2015	Driller: TA
				Logged By: DC

Depth (m)	Sample / Test	Casing Depth (m)	Water Depth (m)	Field Records	Level & Depth	Stratum Description	Legend & Water Strikes	Backfill Installs
0.10	D					Dense grey silty fine SAND with occasional shells.		
0.10 - 0.30	ES					1.0m recovery from 1.0m penetration		
0.40 - 0.70	D				(1.00)	0.35 to 0.55m - Very shelly layer		
0.40 - 0.70	ES							
0.80 - 1.00	D							
0.80 - 1.00	ES				-7.70 1.00	----- End of borehole at 1.00m		

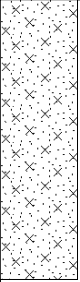
Remarks Deck to bed 5.9m Deck Level 0.798 mod	Chiselling: From (m) To (m) Time (hh:mm)			Water Strikes: Struck (m) Rose to (m) Time (min)			Last Revised: 
	Water Added: From (m) To (m)			Casing: To (m) Diameter (mm)			

Causeway Geotech Ltd		Project no. 15-664	Project Name: GDD Overwater SI	Borehole No. BHVC05
Method: Pneumatic Vibrocore		Co-ords: 326979.70mE	Client: Irish Water	Sheet 1 of 1
Plant: Vibrocore		242309.90mN	Client's Representative: Tobin Arup JV	Scale: 1:50
		Ground Level: -7.00MOD	Dates: 22/08/2015 - 22/08/2015	Driller: TA
				Logged By: DC

Depth (m)	Sample / Test	Casing Depth (m)	Water Depth (m)	Field Records	Level & Depth	Stratum Description	Legend & Water Strikes	Backfill Installs
0.10 - 0.30 0.10 - 0.30 0.40 - 0.70 0.40 - 0.70	D ES D ES				(1.20)	Dense grey silty fine SAND with occasional shell fragments. Densified to 1.0m recovery		
0.80 - 1.00 0.80 - 1.00	D ES				-8.20 1.20	----- End of borehole at 1.20 m		

Remarks Deck to bed 6.73m Deck Level -0.275	Chiselling:			Water Strikes:			Last Revised:
	From (m)	To (m)	Time (hh:mm)	Struck (m)	Rose to (m)	Time (min)	
	Water Added:		Casing:				
	From (m)	To (m)	To (m)	Diameter (mm)			
							www.causewaygeotech.com © Causeway Geotech Ltd

Causeway Geotech Ltd		Project no. 15-664	Project Name: GDD Overwater SI	Borehole No. BHVC06
Method: Vibrocore		Co-ords: 327429.20mE	Client: Irish Water	Sheet 1 of 1
Plant: Pneumatic Vibrocore		242308.40mN	Client's Representative: Tobin Arup JV	Scale: 1:50
		Ground Level: -8.35MOD	Dates: 22/08/2015 - 22/08/2015	Driller: TC
				Logged By:

Depth (m)	Sample / Test	Casing Depth (m)	Water Depth (m)	Field Records	Level & Depth	Stratum Description	Legend & Water Strikes	Backfill Installs
0.10 - 0.30	D					Dense grey silty fine SAND with occasional shells. 1.0m recovery due to densifying of sample.		
0.10 - 0.30	ES							
0.40 - 0.70	D							
0.40 - 0.70	ES							
0.80 - 1.00	D				(1.85)			
0.80 - 1.00	ES							
						-10.20 1.85	----- End of borehole at 1.85 m	



Remarks Deck to bed 10.1m Deck Level 1.77 mod Bottom dense/hard whilst dipping bed level. First attempt aborted on large piece of chipboard.	Chiselling:			Water Strikes:			Last Revised:
	From (m)	To (m)	Time (hh:mm)	Struck (m)	Rose to (m)	Time (min)	
Water Added:		Casing:					
From (m)	To (m)	To (m)	Diameter (mm)				



Causeway Geotech Ltd		Project no. 15-664	Project Name: GDD Overwater SI	Borehole No. BHVC07
Method: Pneumatic Vibrocore		Co-ords: 327728.90mE	Client: Irish Water	Sheet 1 of 1
Plant: Vibrocore		242303.30mN	Client's Representative: Tobin Arup JV	Scale: 1:50
		Ground Level: -9.58MOD	Dates: 22/08/2015 - 22/08/2015	Driller: TA
				Logged By: DC

Depth (m)	Sample / Test	Casing Depth (m)	Water Depth (m)	Field Records	Level & Depth	Stratum Description	Legend & Water Strikes	Backfill Installs
0.10 - 0.30 0.10 - 0.30	D ES					Dense grey silty fine SAND with occasional shells. 1.4m recovery due to densification		
0.70 - 0.90 0.70 - 0.90	D ES				(1.70)			
1.20 - 1.40 1.20 - 1.40	D ES				-11.28 1.70	----- End of borehole at 1.70 m		

Remarks Deck to bed 9.92m Deck Level 0.337 mod	Chiselling:			Water Strikes:			Last Revised:
	From (m)	To (m)	Time (hh:mm)	Struck (m)	Rose to (m)	Time (min)	
	Water Added:		Casing:				
	From (m)	To (m)	To (m)	Diameter (mm)			
							www.causewaygeotech.com © Causeway Geotech Ltd

Causeway Geotech Ltd				Project no. 15-664	Project Name: GDD Overwater SI	Borehole No. BHVC08														
Method: Pneumatic Vibrocore				Co-ords: 328414.40mE	Client: Irish Water	Sheet 1 of 1														
Plant: Vibrocore				242303.10mN	Client's Representative: Tobin Arup JV	Scale: 1:50														
				Ground Level: -15.53MOD	Dates: 22/08/2015 - 22/08/2015	Driller: TA														
						Logged By: DC														
Depth (m)	Sample / Test	Casing Depth (m)	Water Depth (m)	Field Records	Level & Depth	Stratum Description	Legend & Water Strikes	Backfill Installs												
0.10 - 0.40	D				0.10	Grey silty fine SAND														
0.10 - 0.40	ES				0.10	Dense grey silty gravelly fine to coarse SAND with high shell content.														
					0.40	Gravel is rounded fine to coarse. ----- End of borehole at 0.40 m														
Remarks Deck to bed 16.28m Deck Level 0.754 mod						Chiselling: <table border="1"> <tr> <th>From (m)</th> <th>To (m)</th> <th>Time (hh:mm)</th> </tr> <tr> <td></td> <td></td> <td></td> </tr> </table>	From (m)	To (m)	Time (hh:mm)				Water Strikes: <table border="1"> <tr> <th>Struck (m)</th> <th>Rose to (m)</th> <th>Time (min)</th> </tr> <tr> <td></td> <td></td> <td></td> </tr> </table>	Struck (m)	Rose to (m)	Time (min)				Last Revised:
From (m)	To (m)	Time (hh:mm)																		
Struck (m)	Rose to (m)	Time (min)																		
						Water Added: <table border="1"> <tr> <th>From (m)</th> <th>To (m)</th> </tr> <tr> <td></td> <td></td> </tr> </table>	From (m)	To (m)			Casing: <table border="1"> <tr> <th>To (m)</th> <th>Diameter (mm)</th> </tr> <tr> <td></td> <td></td> </tr> </table>	To (m)	Diameter (mm)							
From (m)	To (m)																			
To (m)	Diameter (mm)																			
						<small>www.causewaygeotech.com © Causeway Geotech Ltd</small>														


Causeway Geotech Ltd		Project no. 15-664	Project Name: GDD Overwater SI	Borehole No. BHVC09
Method: Pneumatic Vibrocore		Co-ords: 328722.00mE	Client: Irish Water	Sheet 1 of 1
Plant: Vibrocore		342297.90mN	Client's Representative: Tobin Arup JV	Scale: 1:50
		Ground Level: -17.42MOD	Dates: 22/08/2015 - 22/08/2015	Driller: TA
				Logged By: DC

Depth (m)	Sample / Test	Casing Depth (m)	Water Depth (m)	Field Records	Level & Depth	Stratum Description	Legend & Water Strikes	Backfill Installs
					(0.30) -17.72 0.30	Grey gravelly fine to coarse SAND with medium to high shell content. Gravel is fine to medium rounded. 0.15m Recovery ----- End of borehole at 0.30m		

Remarks Deck to bed 19.63m Deck Level 2.208 mod Insufficient sample for PSD	Chiselling:			Water Strikes:			Last Revised:
	From (m)	To (m)	Time (hh:mm)	Struck (m)	Rose to (m)	Time (min)	
	Water Added:		Casing:				
	From (m)	To (m)	To (m)	Diameter (mm)			
							www.causewaygeotech.com © Causeway Geotech Ltd


Causeway Geotech Ltd		Project no. 15-664	Project Name: GDD Overwater SI	Borehole No. BHVC10
Method: Pneumatic Vibrocore		Co-ords: 329170.90mE	Client: Irish Water	Sheet 1 of 1
Plant: Vibrocore		242293.30mN	Client's Representative: Tobin Arup JV	Scale: 1:50
		Ground Level: -20.40MOD	Dates: 22/08/2015 - 22/08/2015	Driller: TA
				Logged By: DC

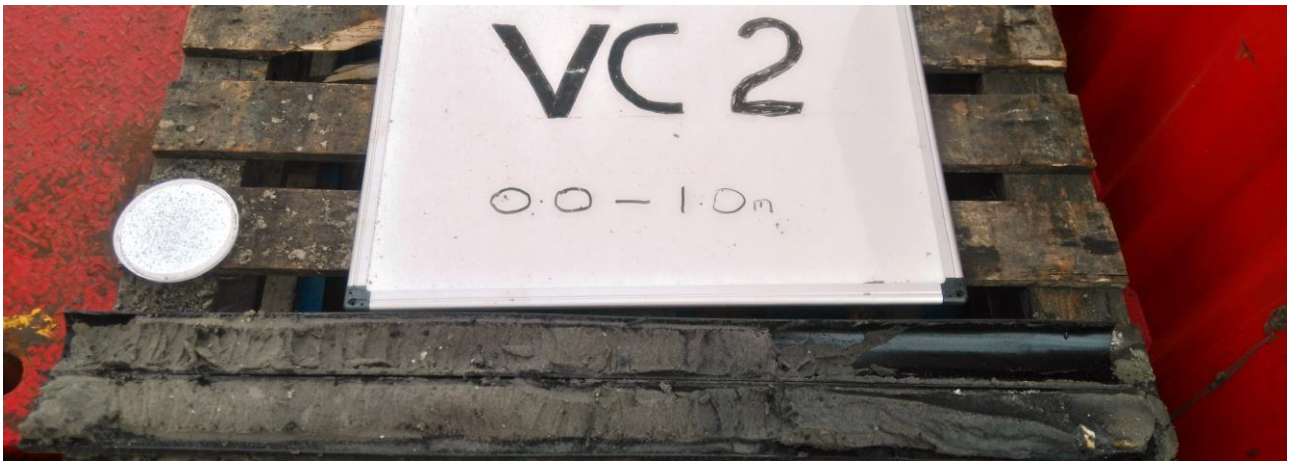
Depth (m)	Sample / Test	Casing Depth (m)	Water Depth (m)	Field Records	Level & Depth	Stratum Description	Legend & Water Strikes	Backfill Installs
					0.20 -20.60 0.20	No Recovery ----- End of borehole at 0.20 m		

Remarks Deck to bed 22.36m Deck Level 1.958 mod Two attempts at this location	Chiselling:			Water Strikes:			Last Revised:
	From (m)	To (m)	Time (hh:mm)	Struck (m)	Rose to (m)	Time (min)	
	Water Added:		Casing:				 <small>www.causewaygeotech.com © Causeway Geotech Ltd</small>
	From (m)	To (m)	To (m)	Diameter (mm)			

Causeway Geotech Ltd		Project no. 15-664	Project Name: GDD Overwater SI	Borehole No. BHVC11
Method: Pneumatic Vibrocore		Co-ords: 329621.00mE	Client: Irish Water	Sheet 1 of 1
Plant: Vibrocore		242326.30mN	Client's Representative: Tobin Arup JV	Scale: 1:50
		Ground Level: -26.34MOD	Dates: 22/08/2015 - 22/08/2015	Driller: TA
				Logged By: DC

Depth (m)	Sample / Test	Casing Depth (m)	Water Depth (m)	Field Records	Level & Depth	Stratum Description	Legend & Water Strikes	Backfill Installs
					0.10 -26.44 0.10	No Recovery ----- End of borehole at 0.10 m		

Remarks Deck to bed 27.25m Deck Level 0.91 Two attempts at this location	Chiselling: From (m) To (m) Time (hh:mm)			Water Strikes: Struck (m) Rose to (m) Time (min)			Last Revised: 
	Water Added: From (m) To (m)			Casing: To (m) Diameter (mm)			



Vibracore BHVC02



Vibracore BHVC03



Vibracore BHVC04



Vibracore BHVC05



Vibracore BHVC06



Vibracore BHVC07



Vibracore BHVC08



Vibracore BHVC09

Appendix E
Geotechnical laboratory test results



**SOIL AND ROCK SAMPLE ANALYSIS
LABORATORY TEST REPORT**

To:	ABCO
From:	Stephen Watson Laboratory Manager Causeway Geotech Ltd
Tel:	+44(0)2827666640
E-mail:	stephen.watson@causewaygeotech.com
Date:	14/09/15
Ref:	15-664/

Greater Dublin Drainage Scheme: Offshore SI

We are pleased to attach the results of laboratory testing carried out for the above project. This memo and its attachments constitute a report of the results of tests as detailed in the *Contents page(s)*.

The samples were delivered to our laboratory in Ballymoney, Co. Antrim on 24/08/15 and tested in accordance with the electronic schedule received on 28/08/15.

The attached results complete the testing requested and we would therefore wish to confirm that samples will be retained without charge for a period of one month from the above date after which they will be appropriately disposed of unless we receive written instructions to the contrary prior to that date.

We trust our report meets with your approval but if you have any queries or require additional information, please do not hesitate to contact the undersigned.

Approved Signatory

Stephen Watson
Laboratory Manager



Project Name **Greater Dublin Drainage Scheme: Offshore SI**

Report Reference. **15-664/1**

The table below details the tests carried out, the specifications used and the number of tests included in this report:

Material tested	Type of test/Properties measured/Range of measurement	Standard specifications	Number of test results included in the report
SOIL	Moisture content - oven drying method	BS 1377-2:1990	40
SOIL	Liquid limit - cone penetrometer	BS 1377-2:1990	17
SOIL	Liquid limit - cone penetrometer - one point	BS 1377-2:1990	17
SOIL	Plastic limit	BS 1377-2:1990	17
SOIL	Plasticity index and liquidity index	BS 1377-2:1990	17
SOIL	Particle size distribution - wet sieving	BS 1377-2:1990	19
SOIL	Particle size distribution - dry sieving	BS 1377-2:1990	19
SOIL	Particle size distribution -sedimentation hydrometer method	BS 1377-2:1990	7
SOIL	Particle density – gas jar	BS 1377-2:1990	18
SOIL	Laboratory vane	BS 1377- 7:1990	1
SOIL	Undrained shear strength – triaxial compression without measurement of pore pressure (loads from 0.12 to 24 kN)	BS 1377- 7:1990	4
SOIL	Shear strength by direct shear	BS1377 : Part 7 : Clause 4 : 1990	4



ROCK	Point load index	ISRM Commission on Testing Methods. Suggested Method for Determining Point Load Strength 1985	74
ROCK	UCS	ISRM Suggested Methods - Rock Characterization Testing and Monitoring, Ed. E T Brown - 1981	10
ROCK	Porosity/Density using saturation/buoyancy		9
ROCK	Indirect Tensile Strength (by the Brazilian Test)		10
ROCK	Norwegian Abrasion Cutter Steel Test Swedish Brittleness Test Sievers' J Value Test		4
ROCK	Cerchar Abrasivity		4
ROCK	Porosity		4
ROCK	Total Sulfur Content Acid Soluble Sulfate Content Water Soluble Sulfate		4
ROCK	Thin Section Petrography		4
ROCK	X-ray Diffraction		4



Summary of Classification Test Results

Project No. 15-664		Project Name GDD Overwater SI												
Hole No.	Sample				Soil Description	Density		w %	Passing 425µm %	LL %	PL %	PI %	Particle density Mg/m3	Casagrande classification
	Ref	Top	Base	Type		bulk Mg/m3	dry							
BH01	15	2.00		B	Grey slightly silty SAND			24.0	98	28 -1pt	NP		2.63-gj	
BH01	16	3.00		B	Grey slightly silty SAND			24.0	98	29 -1pt	NP			
BH01	18	5.00		B	Grey slightly silty SAND			24.0	90	30 -1pt	NP		2.64-gj	
BH01	21	8.00		B	Grey very gravelly SAND			9.3	56	25 -1pt	NP			
BH01	24	10.00		B	Grey very gravelly SAND			12.0						
BH01	27	12.00		B	Greyish brown gravelly SAND			6.0						
BH01	13	12.90	13.60	B	Brownish grey slightly sandy gravelly CLAY			14.0	70	26 -1pt	15	11	2.63-gj	CL
BH03	4	0.00	1.00	B	Grey brown silty SAND with shell and shell fragments.			22.0						
BH03	5	1.00	2.00	B	Grey silty SAND with shells and shell fragments.			24.0					2.59-gj	
BH03	9	1.20		D	Grey silty fine SAND with shells			24.0						
BH03	10	2.00		D	Grey silty fine SAND with shells			22.0						
BH03	6	2.00	3.00	B	Grey silty SAND with shells and shell fragments.			24.0					2.62-gj	
BH03	11	3.00		D	Grey silty SAND with shells and shell fragments			22.0						
BH03	7	3.00	4.00	B	Grey silty SAND with shells and shell fragments			27.0	97	29 -1pt	NP		2.65-gj	
BH03	12	4.00		D	Grey slightly gravelly sandy SILT with occasional shells.			26.0						
BH03	8	4.00	5.00	B	Grey slightly gravelly sandy SILT with occasional shells.			28.0	64	37 -1pt	NP			
BH03	13	5.00		D	Grey slightly gravelly sandy silty CLAY with occasional shells.			18.0						
BH03	14	5.00	6.00	B	Grey slightly gravelly sandy silty CLAY with occasional shells.			21.0	98	25 -1pt	16	9	2.61-gj	CL
BH03	15	6.00		D	Grey slightly gravelly sandy silty CLAY with occasional shells.			16.0						
BH03	16	6.00	7.00	B	Grey slightly gravelly sandy silty CLAY with occasional shells.			30.0	57	26 -1pt	16	10	2.64-gj	CL
BH03	18	6.40	7.50	B	Grey slightly gravelly sandy silty CLAY with occasional shells.			25.0	78	25 -1pt	16	9		CL
BH03	17	7.00		D	Brown slightly sandy gravelly silty CLAY with occasional limestone and sandstone cobbles.			20.0						
BH03	19	8.00	8.50	B	Brown slightly sandy gravelly silty CLAY with occasional limestone and sandstone cobbles.			7.3	36	21 -1pt	13	8	2.61-gj	CL
BH03	20	8.50		D	Dark grey sandy silty GRAVEL			7.8						
BH05	1	0.00	1.00	B	Grey silty SAND with shells and shell fragments.			24.0	90	29 -1pt	NP		2.62-gj	
BH05	2	2.00	3.00	B	Grey silty SAND with shells and shell fragments.			25.0	99	31 -1pt	NP		2.65-gj	

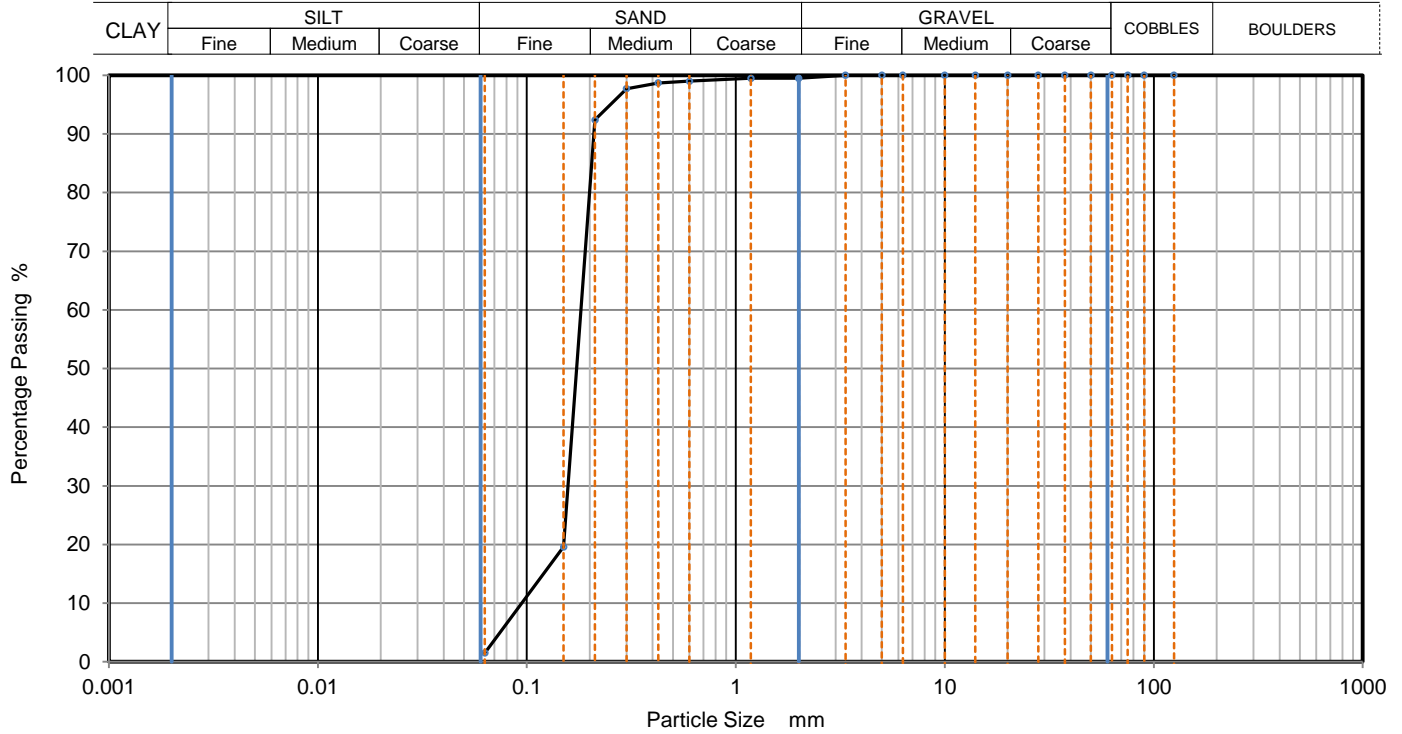
All tests performed in accordance with BS1377:1990 unless specified otherwise

Key Density test Linear measurement unless : wd - water displacement wi - immersion in water Liquid Limit 4pt cone unless : cas - Casagrande method 1pt - single point test Particle density sp - small pyknometer gj - gas jar	Date Printed 17/11/2015	Approved By Stephen.Watson	Table 1 sheet 1
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PARTICLE SIZE DISTRIBUTION

Job Ref	15-664
Borehole/Pit No.	BH01
Site Name	GDD Overwater SI
Sample No.	15
Soil Description	Grey slightly silty SAND
Depth, m	2.00
Specimen Reference	4
Specimen Depth	m
Sample Type	B
Test Method	BS1377:Part 2:1990, clause 9.2
KeyLAB ID	Caus20151104215



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	100		
28	100		
20	100		
14	100		
10	100		
6.3	100		
5	100		
3.35	100		
2	100		
1.18	100		
0.6	99		
0.425	99		
0.3	98		
0.212	92		
0.15	20		
0.063	2		

Dry Mass of sample, g 3256

Sample Proportions	% dry mass
Cobbles	0
Gravel	1
Sand	98
Fines <0.063mm	1

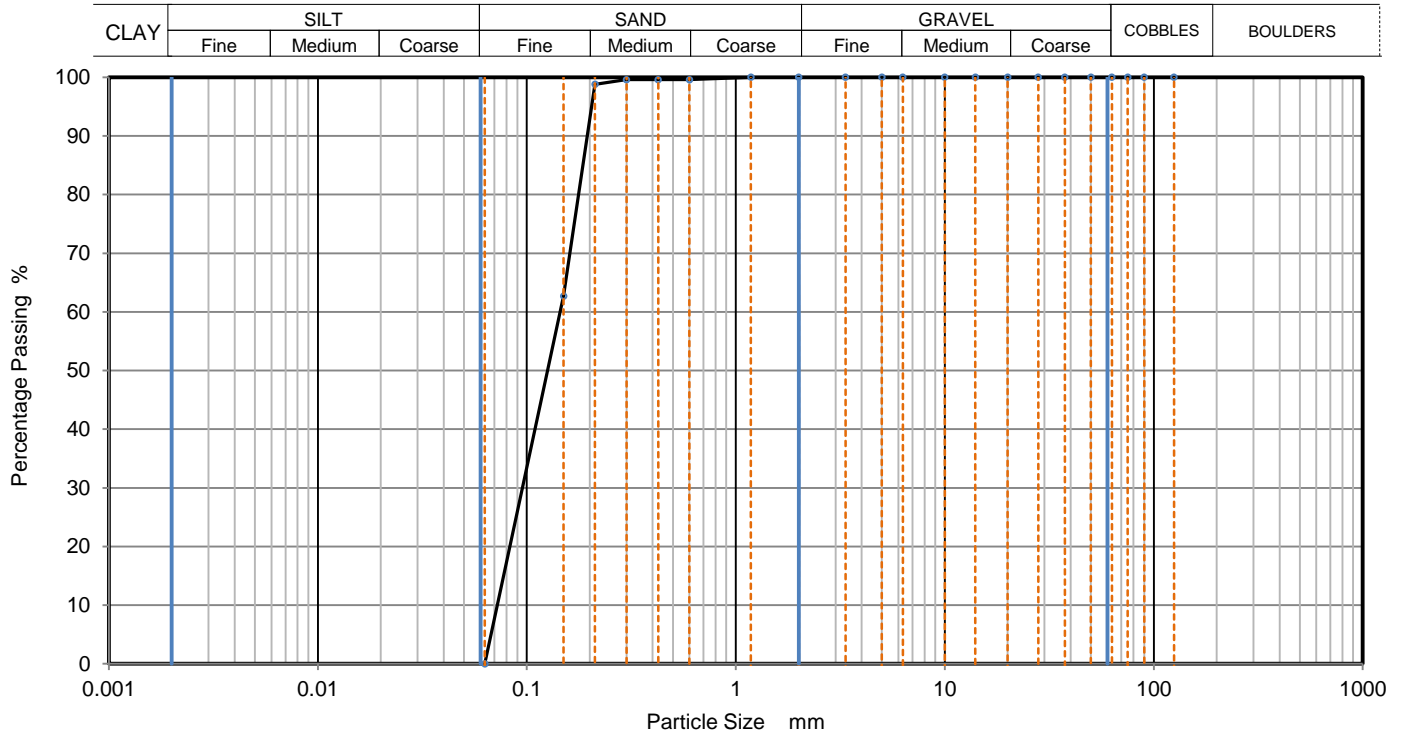
Grading Analysis	
D100	mm
D60	mm 0.182
D30	mm 0.158
D10	mm 0.0948
Uniformity Coefficient	1.9
Curvature Coefficient	1.4

Remarks
Preparation and testing in accordance with BS1377 unless noted below



PARTICLE SIZE DISTRIBUTION

Job Ref	15-664
Borehole/Pit No.	BH01
Site Name	GDD Overwater SI
Sample No.	18
Soil Description	Grey slightly silty SAND
Depth, m	5.00
Specimen Reference	4
Specimen Depth	m
Sample Type	B
Test Method	BS1377:Part 2:1990, clause 9.2
KeyLAB ID	Caus20151104218



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	100		
28	100		
20	100		
14	100		
10	100		
6.3	100		
5	100		
3.35	100		
2	100		
1.18	100		
0.6	100		
0.425	100		
0.3	100		
0.212	99		
0.15	63		
0.063	0		

Dry Mass of sample, g 2866

Sample Proportions	% dry mass
Cobbles	0
Gravel	0
Sand	100
Fines <0.063mm	0

Grading Analysis	
D100	mm
D60	mm 0.145
D30	mm 0.0954
D10	mm 0.0724
Uniformity Coefficient	2
Curvature Coefficient	0.87

Remarks
Preparation and testing in accordance with BS1377 unless noted below



PARTICLE SIZE DISTRIBUTION

Job Ref **15-664**

Borehole/Pit No. **BH01**

Site Name **GDD Overwater SI**

Sample No. **13**

Soil Description **Brownish grey slightly sandy gravelly CLAY**

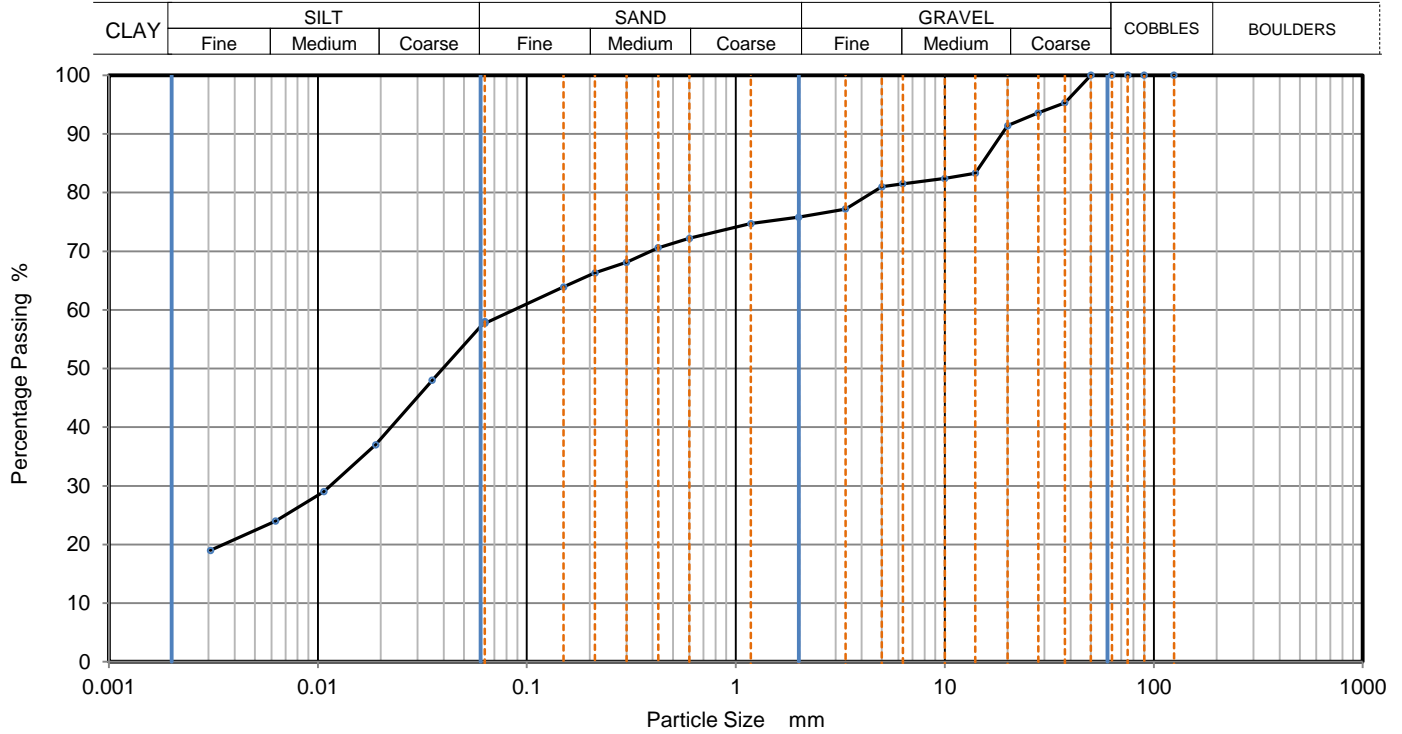
Depth, m **12.90**

Specimen Reference **4** Specimen Depth **m**

Sample Type **B**

Test Method **BS1377:Part 2:1990, clauses 9.2 and 9.5**

KeyLAB ID **Caus20151104213**



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100	0.0630	58
90	100	0.0353	48
75	100	0.0189	37
63	100	0.0107	29
50	100	0.0063	24
37.5	95	0.0031	19
28	94		
20	91		
14	83		
10	82		
6.3	82		
5	81		
3.35	77		
2	76		
1.18	75		
0.6	72		
0.425	71	Particle density (assumed)	
0.3	68	1.40	Mg/m ³
0.212	66		
0.15	64		
0.063	58		

Dry Mass of sample, g 5012

Sample Proportions	% dry mass
Cobbles	0
Gravel	24
Sand	18
Fines <0.063mm	58

Grading Analysis	
D100	mm
D60	mm
D30	mm
D10	mm
Uniformity Coefficient	
Curvature Coefficient	

Remarks
Preparation and testing in accordance with BS1377 unless noted below



PARTICLE SIZE DISTRIBUTION

Job Ref **15-664**

Borehole/Pit No. **BH03**

Site Name **GDD Overwater SI**

Sample No. **5**

Soil Description **Grey silty SAND with shells and shell fragments.**

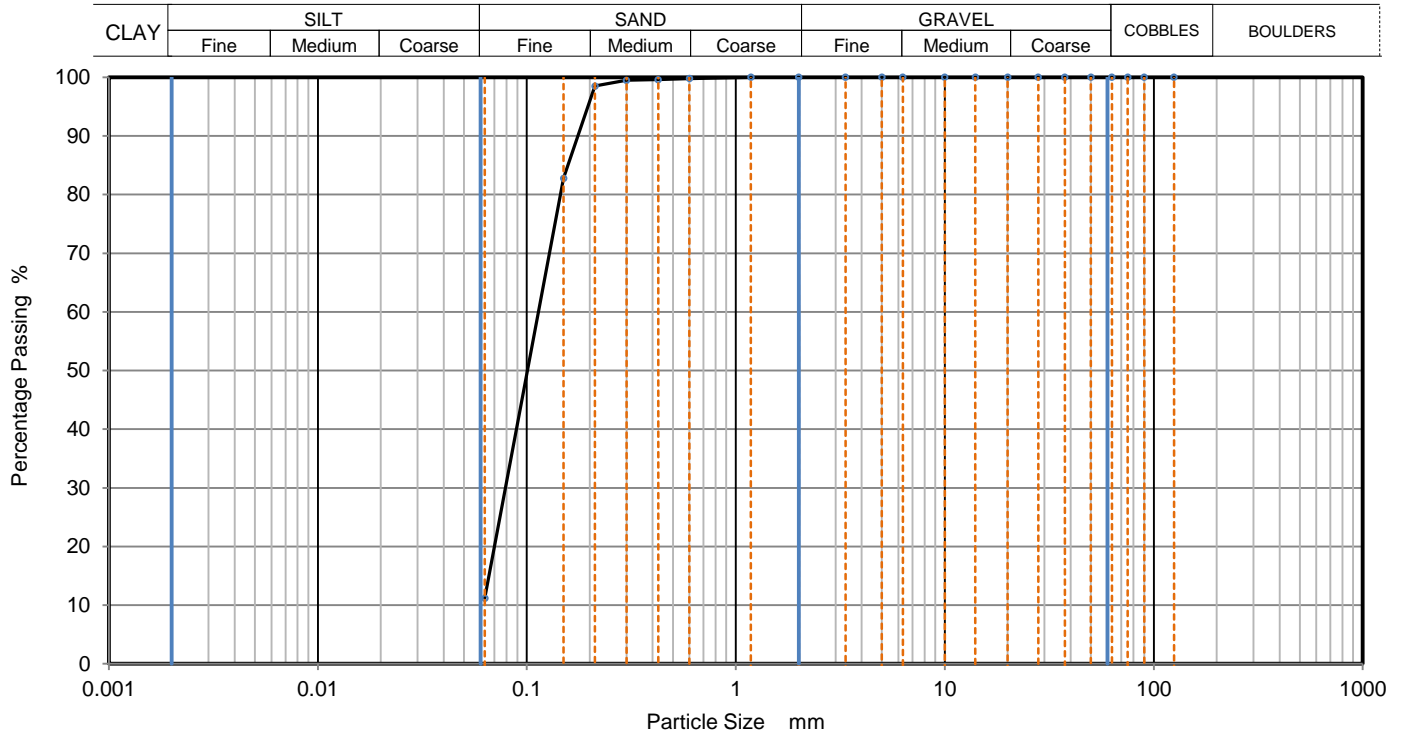
Depth, m **1.00**

Specimen Reference **3** Specimen Depth **m**

Sample Type **B**

Test Method **BS1377:Part 2:1990, clause 9.2**

KeyLAB ID **Caus201508294**



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	100		
28	100		
20	100		
14	100		
10	100		
6.3	100		
5	100		
3.35	100		
2	100		
1.18	100		
0.6	100		
0.425	100		
0.3	100		
0.212	99		
0.15	83		
0.063	11		

Dry Mass of sample, g **7405**

Sample Proportions	% dry mass
Cobbles	0
Gravel	0
Sand	89
Fines <0.063mm	11

Grading Analysis	
D100	mm
D60	mm 0.114
D30	mm 0.0791
D10	mm
Uniformity Coefficient	
Curvature Coefficient	

Remarks
Preparation and testing in accordance with BS1377 unless noted below



PARTICLE SIZE DISTRIBUTION

Job Ref **15-664**

Borehole/Pit No. **BH03**

Site Name **GDD Overwater SI**

Sample No. **6**

Soil Description **Grey silty SAND with shells and shell fragments.**

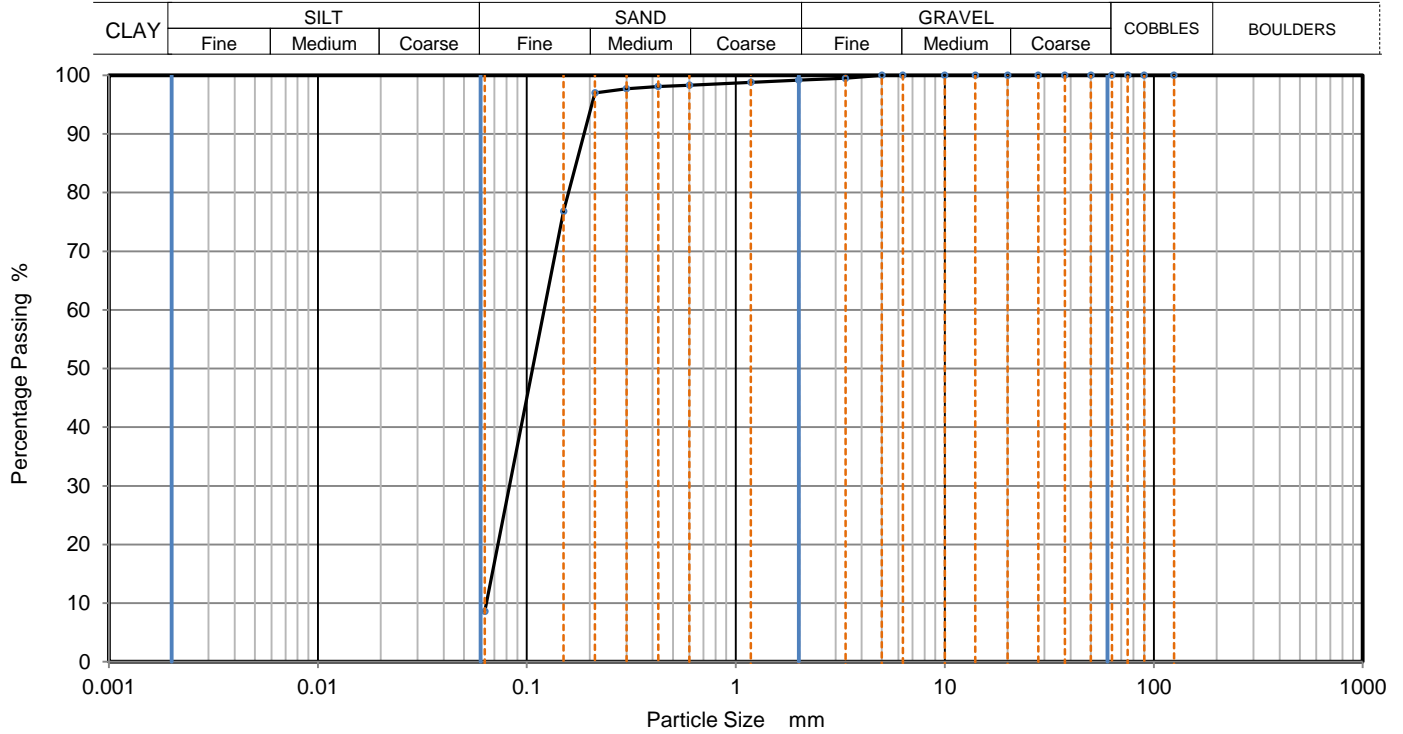
Depth, m **2.00**

Specimen Reference **3** Specimen Depth **m**

Sample Type **B**

Test Method **BS1377:Part 2:1990, clause 9.2**

KeyLAB ID **Caus201508295**



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	100		
28	100		
20	100		
14	100		
10	100		
6.3	100		
5	100		
3.35	100		
2	99		
1.18	99		
0.6	98		
0.425	98		
0.3	98		
0.212	97		
0.15	77		
0.063	9		

Dry Mass of sample, g **8652**

Sample Proportions	% dry mass
Cobbles	0
Gravel	1
Sand	91
Fines <0.063mm	9

Grading Analysis	
D100	mm
D60	mm 0.121
D30	mm 0.0827
D10	mm 0.0641
Uniformity Coefficient	1.9
Curvature Coefficient	0.88

Remarks
Preparation and testing in accordance with BS1377 unless noted below



PARTICLE SIZE DISTRIBUTION

Job Ref **15-664**

Borehole/Pit No. **BH03**

Site Name **GDD Overwater SI**

Sample No. **7**

Soil Description **Grey silty SAND with shells and shell fragments**

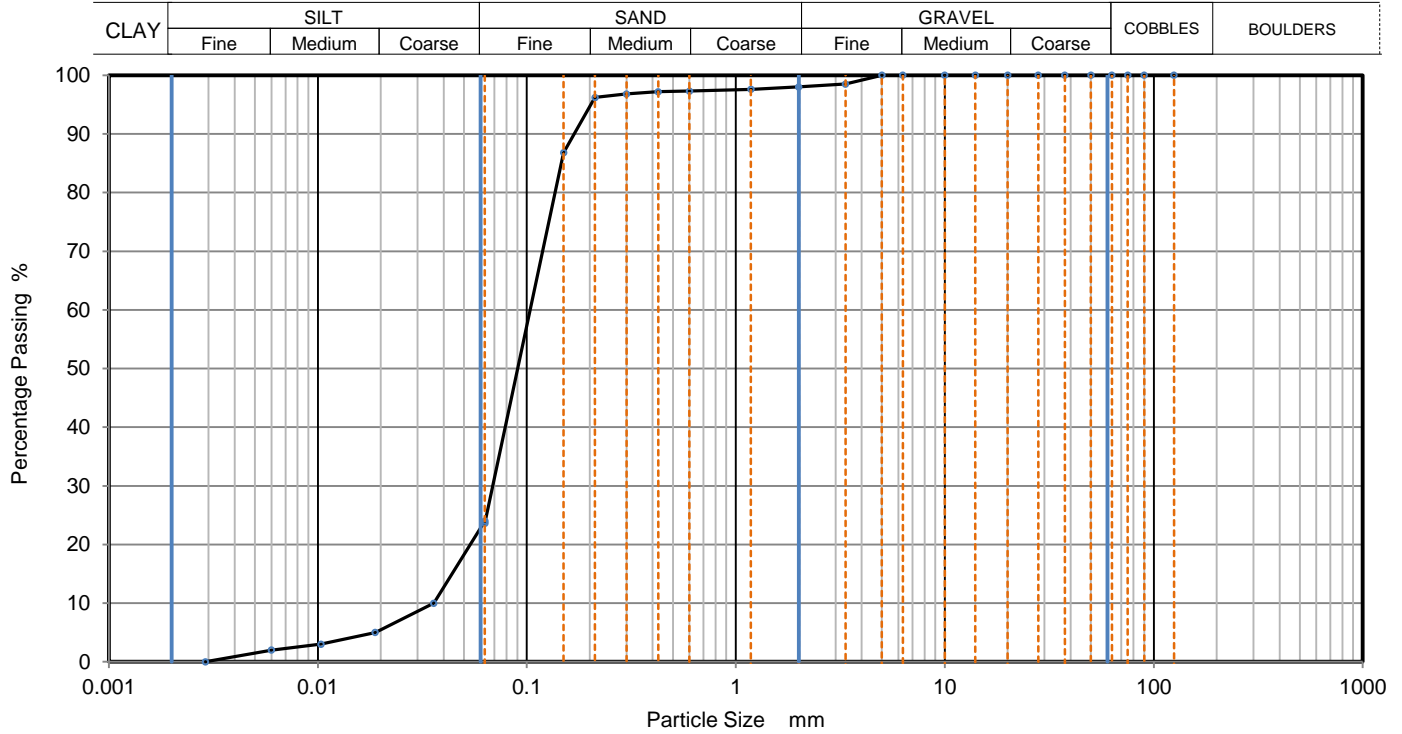
Depth, m **3.00**

Specimen Reference **4** Specimen Depth **m**

Sample Type **B**

Test Method **BS1377:Part 2:1990, clauses 9.2 and 9.5**

KeyLAB ID **Caus201508296**



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100	0.0630	24
90	100	0.0358	10
75	100	0.0188	5
63	100	0.0103	3
50	100	0.0060	2
37.5	100	0.0029	0
28	100		
20	100		
14	100		
10	100		
6.3	100		
5	100		
3.35	99		
2	98		
1.18	98		
0.6	97	Particle density (assumed)	
0.425	97	1.50 Mg/m ³	
0.3	97		
0.212	96		
0.15	87		
0.063	24		

Dry Mass of sample, g **6083**

Sample Proportions	% dry mass
Cobbles	0
Gravel	2
Sand	74
Fines <0.063mm	24

Grading Analysis	
D100	mm
D60	mm 0.104
D30	mm 0.0688
D10	mm 0.0353
Uniformity Coefficient	2.9
Curvature Coefficient	1.3

Remarks
Preparation and testing in accordance with BS1377 unless noted below



PARTICLE SIZE DISTRIBUTION

Job Ref **15-664**

Borehole/Pit No. **BH03**

Site Name **GDD Overwater SI**

Sample No. **14**

Soil Description **Grey slightly gravelly sandy silty CLAY with occasional shells.**

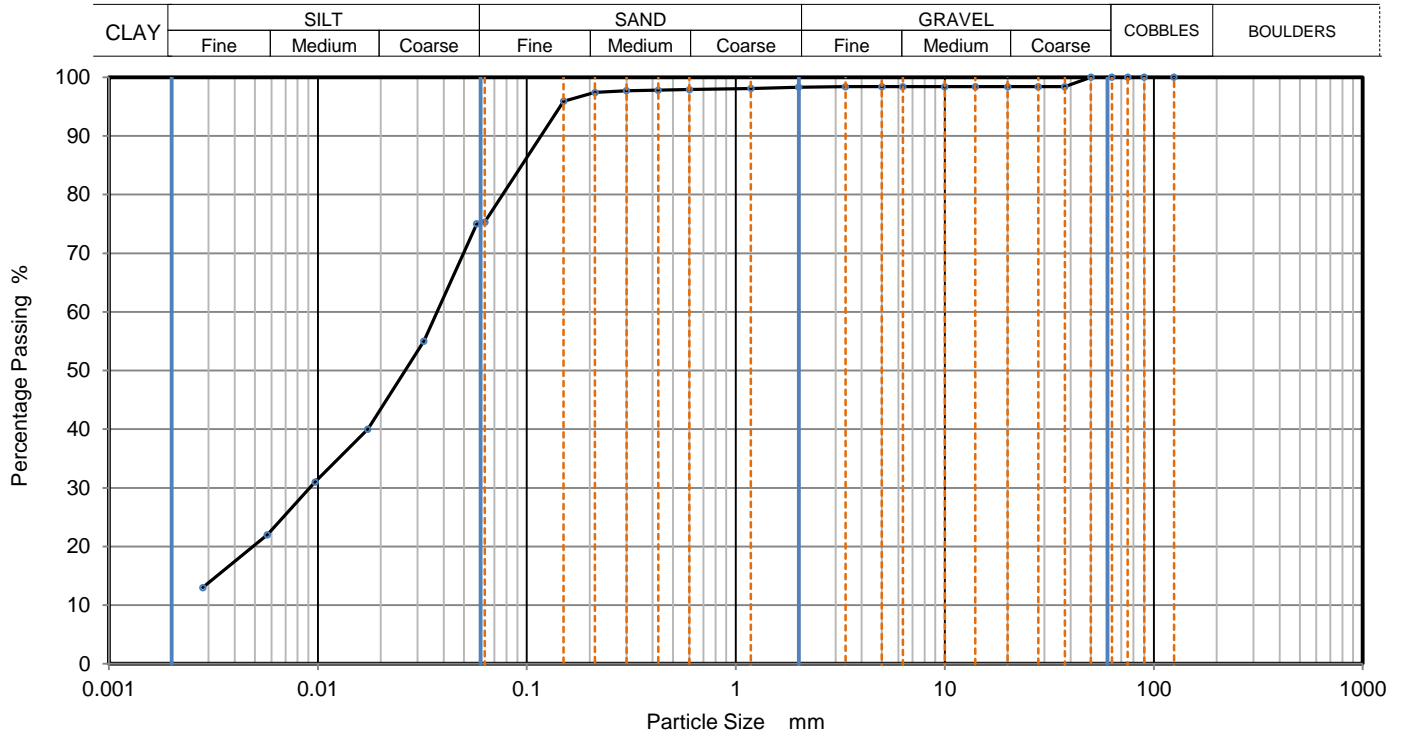
Depth, m **5.00**

Specimen Reference **4** Specimen Depth **m**

Sample Type **B**

Test Method **BS1377:Part 2:1990, clauses 9.2 and 9.5**

KeyLAB ID **Caus2015082913**



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100	0.075	75
90	100	0.0322	55
75	100	0.0173	40
63	100	0.0097	31
50	100	0.0057	22
37.5	98	0.0028	13
28	98		
20	98		
14	98		
10	98		
6.3	98		
5	98		
3.35	98		
2	98		
1.18	98		
0.6	98	Particle density (assumed)	
0.425	98	1.50 Mg/m ³	
0.3	98		
0.212	97		
0.15	96		
0.063	75		

Dry Mass of sample, g 6770

Sample Proportions	% dry mass
Cobbles	0
Gravel	2
Sand	23
Fines <0.063mm	75

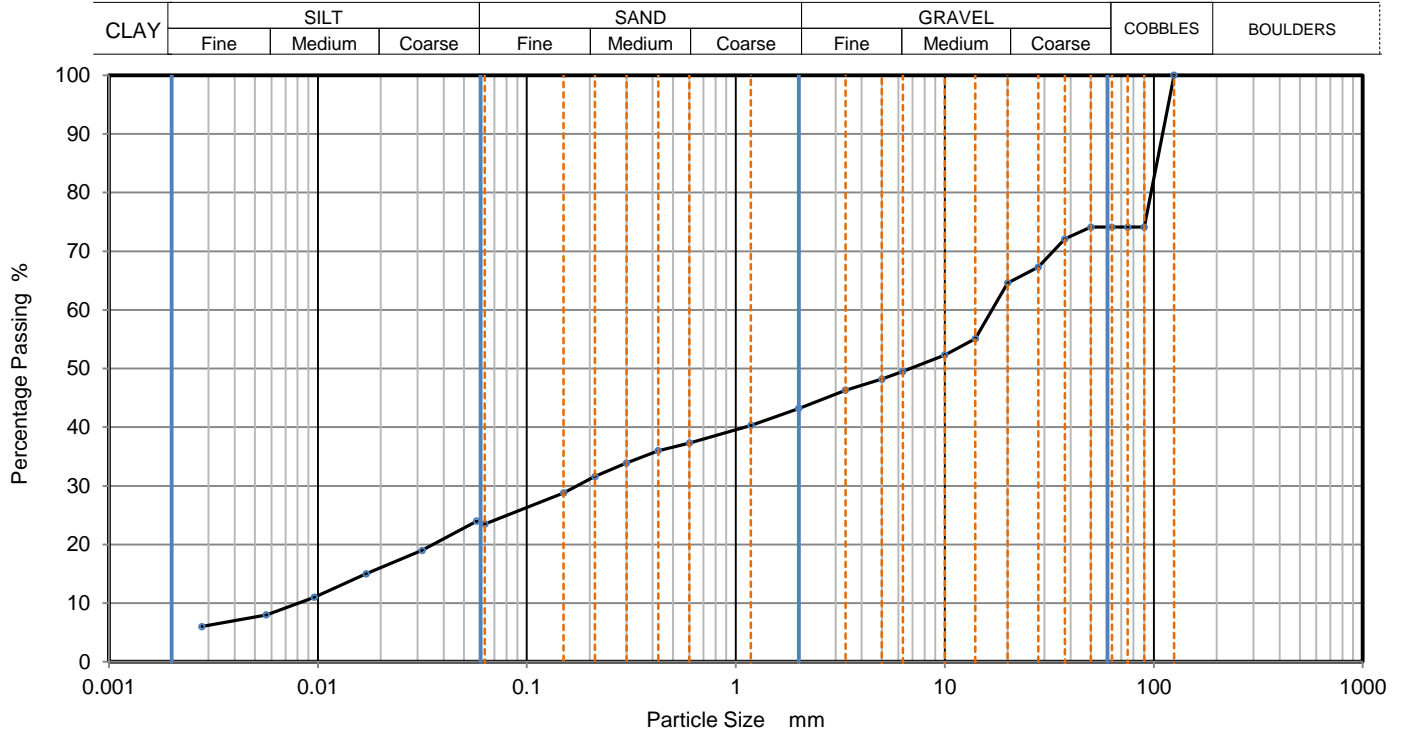
Grading Analysis	
D100	mm
D60	mm
D30	mm
D10	mm
Uniformity Coefficient	
Curvature Coefficient	

Remarks
Preparation and testing in accordance with BS1377 unless noted below



PARTICLE SIZE DISTRIBUTION

Job Ref	15-664
Borehole/Pit No.	BH03
Site Name	GDD Overwater SI
Sample No.	19
Soil Description	Brown slightly sandy gravelly silty CLAY with occasional limestone and sandstone cobbles.
Depth, m	8.00
Specimen Reference	4
Specimen Depth	m
Sample Type	B
Test Method	BS1377:Part 2:1990, clauses 9.2 and 9.5
KeyLAB ID	Caus2015082918



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100	0.0575	24
90	74	0.0315	19
75	74	0.0170	15
63	74	0.0096	11
50	74	0.0057	8
37.5	72	0.0028	6
28	67		
20	65		
14	55		
10	52		
6.3	50		
5	48		
3.35	46		
2	43		
1.18	40		
0.6	37	Particle density (assumed) 1.50 Mg/m ³	
0.425	36		
0.3	34		
0.212	32		
0.15	29		
0.063	24		

Dry Mass of sample, g 9149

Sample Proportions	% dry mass
Cobbles	26
Gravel	31
Sand	20
Fines <0.063mm	24

Grading Analysis		
D100	mm	125
D60	mm	16.8
D30	mm	0.174
D10	mm	0.00785
Uniformity Coefficient		2100
Curvature Coefficient		0.23

Remarks
Preparation and testing in accordance with BS1377 unless noted below



PARTICLE SIZE DISTRIBUTION

Job Ref **15-664**

Borehole/Pit No. **BH05**

Site Name **GDD Overwater SI**

Sample No. **1**

Soil Description **Grey silty SAND with shells and shell fragments.**

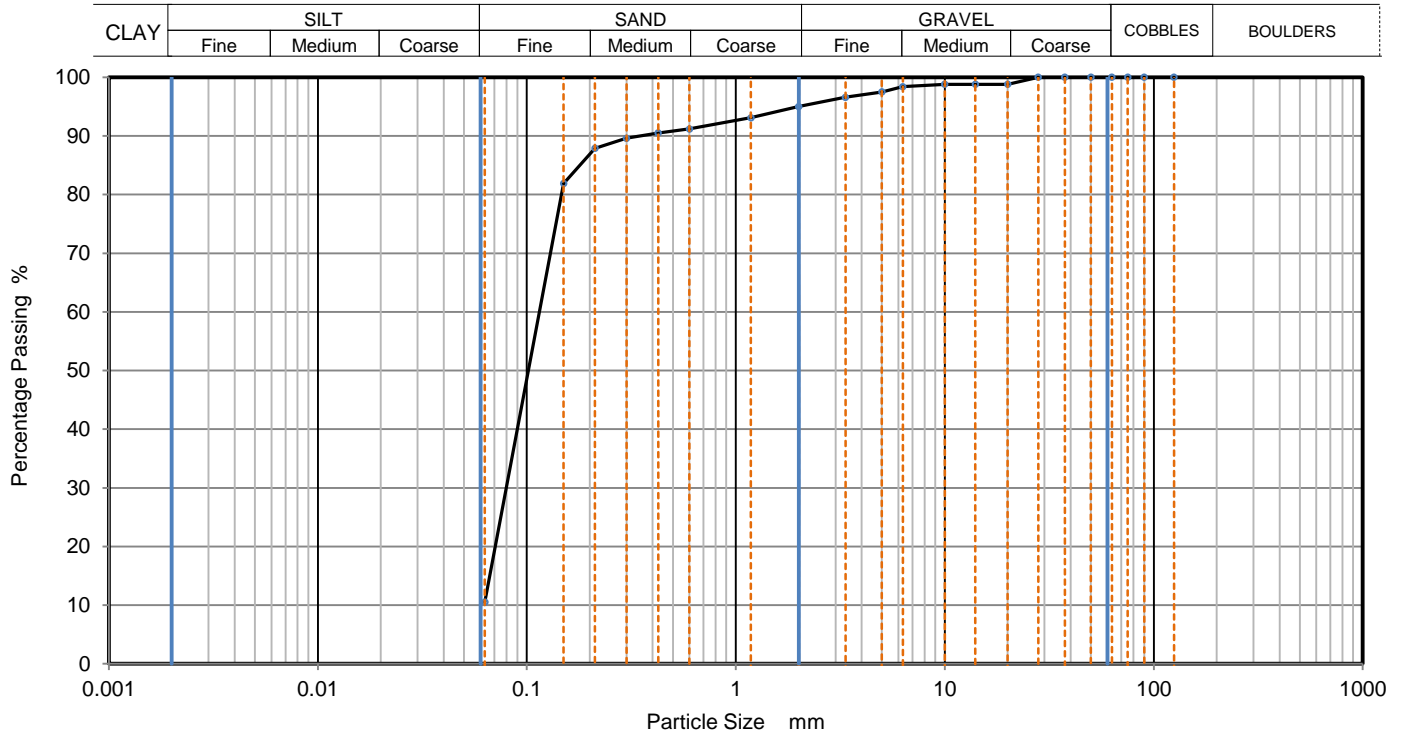
Depth, m **0.00**

Specimen Reference **4** Specimen Depth **m**

Sample Type **B**

Test Method **BS1377:Part 2:1990, clause 9.2**

KeyLAB ID **Caus201509013**



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	100		
28	100		
20	99		
14	99		
10	99		
6.3	98		
5	98		
3.35	97		
2	95		
1.18	93		
0.6	91		
0.425	91		
0.3	90		
0.212	88		
0.15	82		
0.063	11		

Dry Mass of sample, g 1723

Sample Proportions	% dry mass
Cobbles	0
Gravel	5
Sand	85
Fines <0.063mm	10

Grading Analysis	
D100	mm
D60	mm 0.115
D30	mm 0.0799
D10	mm
Uniformity Coefficient	
Curvature Coefficient	

Remarks
Preparation and testing in accordance with BS1377 unless noted below



PARTICLE SIZE DISTRIBUTION

Job Ref **15-664**

Borehole/Pit No. **BH05**

Site Name **GDD Overwater SI**

Sample No. **2**

Soil Description **Grey silty SAND with shells and shell fragments.**

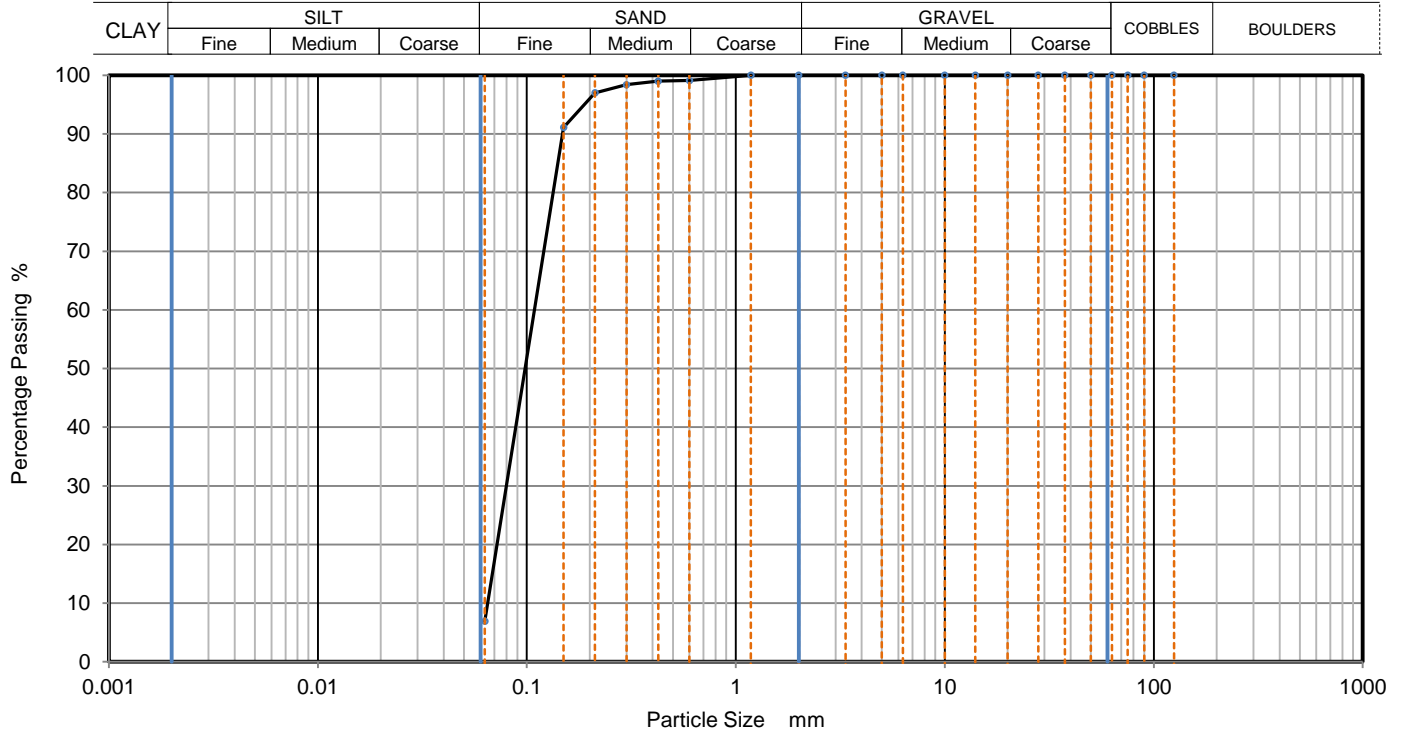
Depth, m **2.00**

Specimen Reference **4** Specimen Depth **m**

Sample Type **B**

Test Method **BS1377:Part 2:1990, clause 9.2**

KeyLAB ID **Caus201509014**



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	100		
28	100		
20	100		
14	100		
10	100		
6.3	100		
5	100		
3.35	100		
2	100		
1.18	100		
0.6	99		
0.425	99		
0.3	98		
0.212	97		
0.15	91		
0.063	7		

Dry Mass of sample, g 2799

Sample Proportions	% dry mass
Cobbles	0
Gravel	0
Sand	93
Fines <0.063mm	7

Grading Analysis	
D100	mm
D60	mm 0.109
D30	mm 0.0799
D10	mm 0.065
Uniformity Coefficient	1.7
Curvature Coefficient	0.9

Remarks
Preparation and testing in accordance with BS1377 unless noted below



PARTICLE SIZE DISTRIBUTION

Job Ref **15-664**

Borehole/Pit No. **BH05**

Site Name **GDD Overwater SI**

Sample No. **3**

Soil Description **Grey sandy silty GRAVEL with shells and shell fragments.**

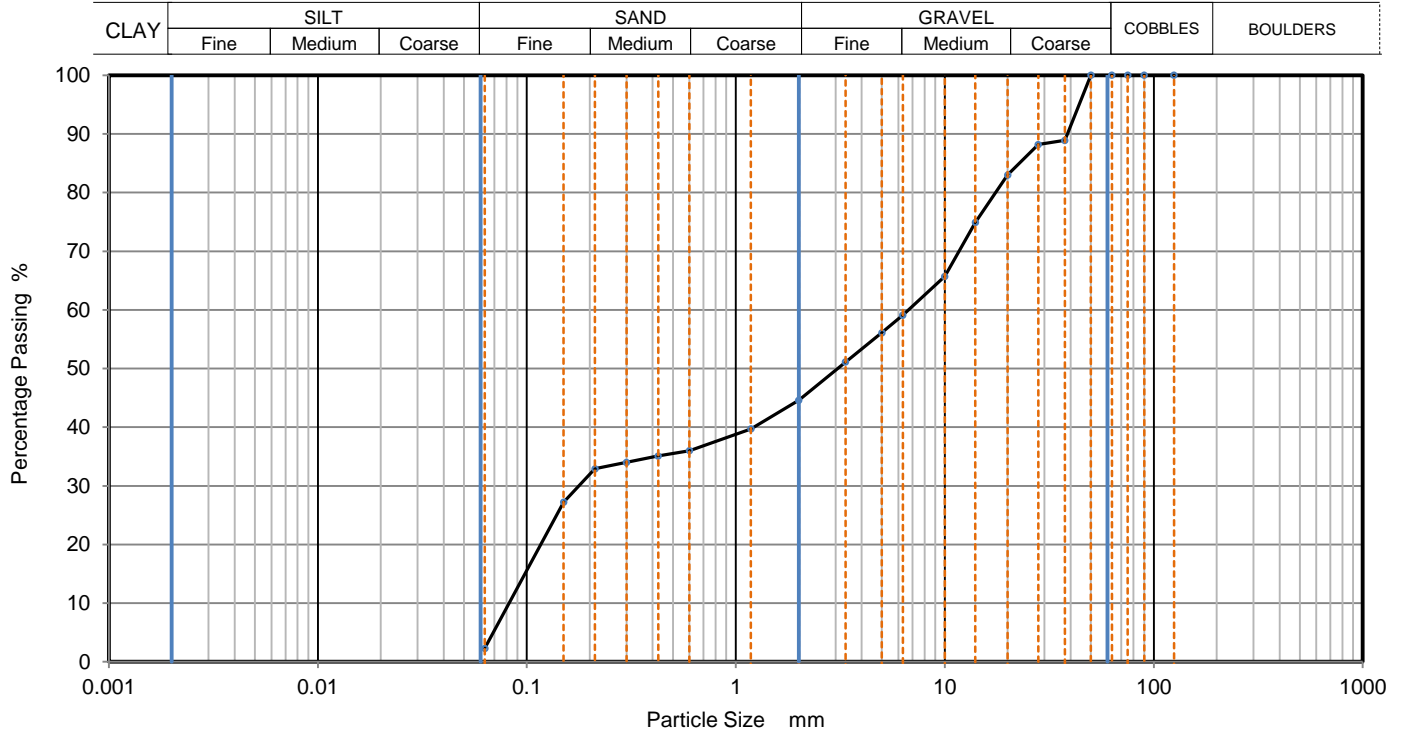
Depth, m **3.10**

Specimen Reference **4** Specimen Depth **m**

Sample Type **B**

Test Method **BS1377:Part 2:1990, clause 9.2**

KeyLAB ID **Caus201509015**



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	89		
28	88		
20	83		
14	75		
10	66		
6.3	59		
5	56		
3.35	51		
2	45		
1.18	40		
0.6	36		
0.425	35		
0.3	34		
0.212	33		
0.15	27		
0.063	2		

Dry Mass of sample, g **5432**

Sample Proportions	% dry mass
Cobbles	0
Gravel	55
Sand	42
Fines <0.063mm	2

Grading Analysis	
D100	mm
D60	mm 6.71
D30	mm 0.178
D10	mm 0.0824
Uniformity Coefficient	81
Curvature Coefficient	0.057

Remarks
Preparation and testing in accordance with BS1377 unless noted below



PARTICLE SIZE DISTRIBUTION

Job Ref **15-664**

Borehole/Pit No. **BH05**

Site Name **GDD Overwater SI**

Sample No. **5**

Soil Description **Grey sandy gravelly silty CLAY.**

Depth, m **6.00**

Specimen Reference

4

Specimen
Depth

m

Sample Type

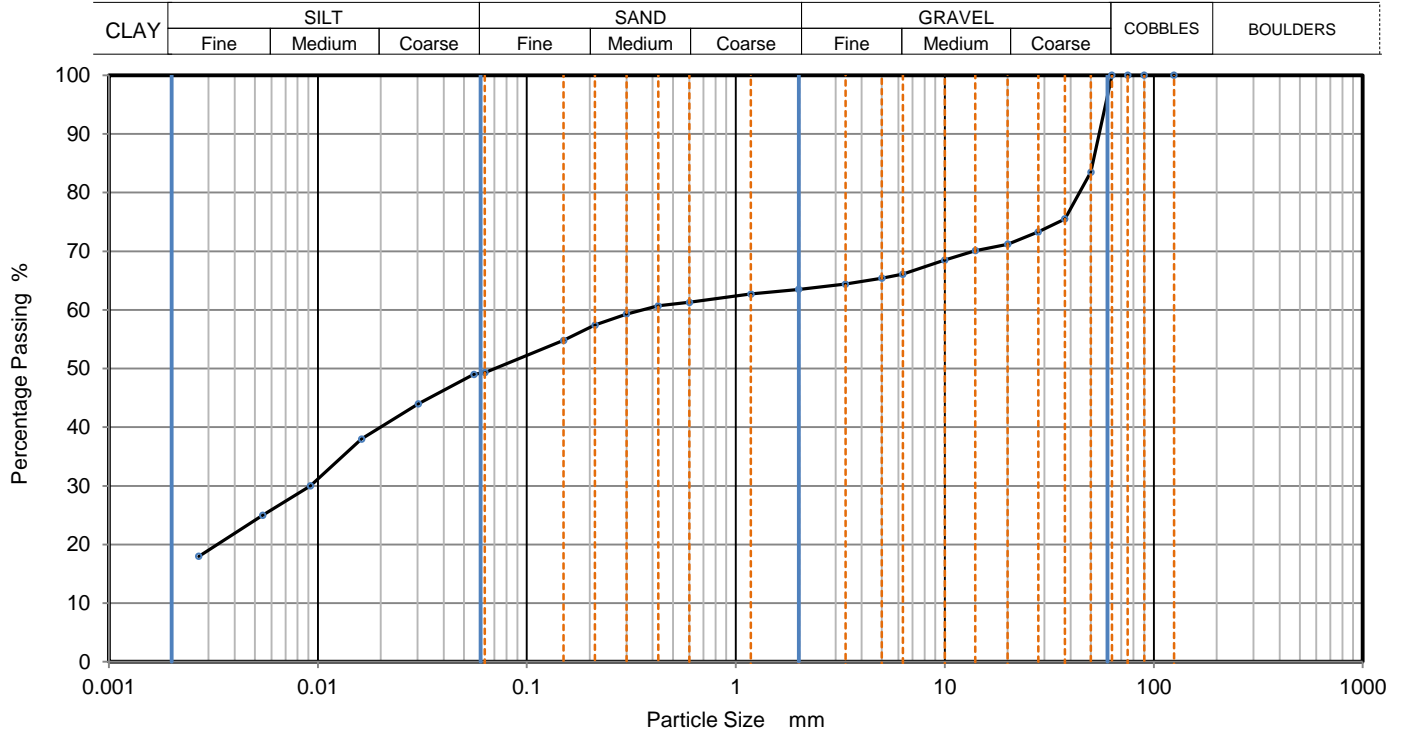
B

Test Method

BS1377:Part 2:1990, clauses 9.2 and 9.5

KeyLAB ID

Caus201509017



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100	0.0559	49
90	100	0.0303	44
75	100	0.0162	38
63	100	0.0092	30
50	84	0.0054	25
37.5	76	0.0027	18
28	73		
20	71		
14	70		
10	69		
6.3	66		
5	65		
3.35	64		
2	64		
1.18	63		
0.6	61	Particle density (assumed)	
0.425	61	1.50 Mg/m ³	
0.3	59		
0.212	57		
0.15	55		
0.063	49		

Dry Mass of sample, g

3144

Sample Proportions	% dry mass
Cobbles	0
Gravel	37
Sand	14
Fines <0.063mm	49

Grading Analysis	
D100	mm
D60	mm
D30	mm
D10	mm
Uniformity Coefficient	
Curvature Coefficient	

Remarks

Preparation and testing in accordance with BS1377 unless noted below

Approved

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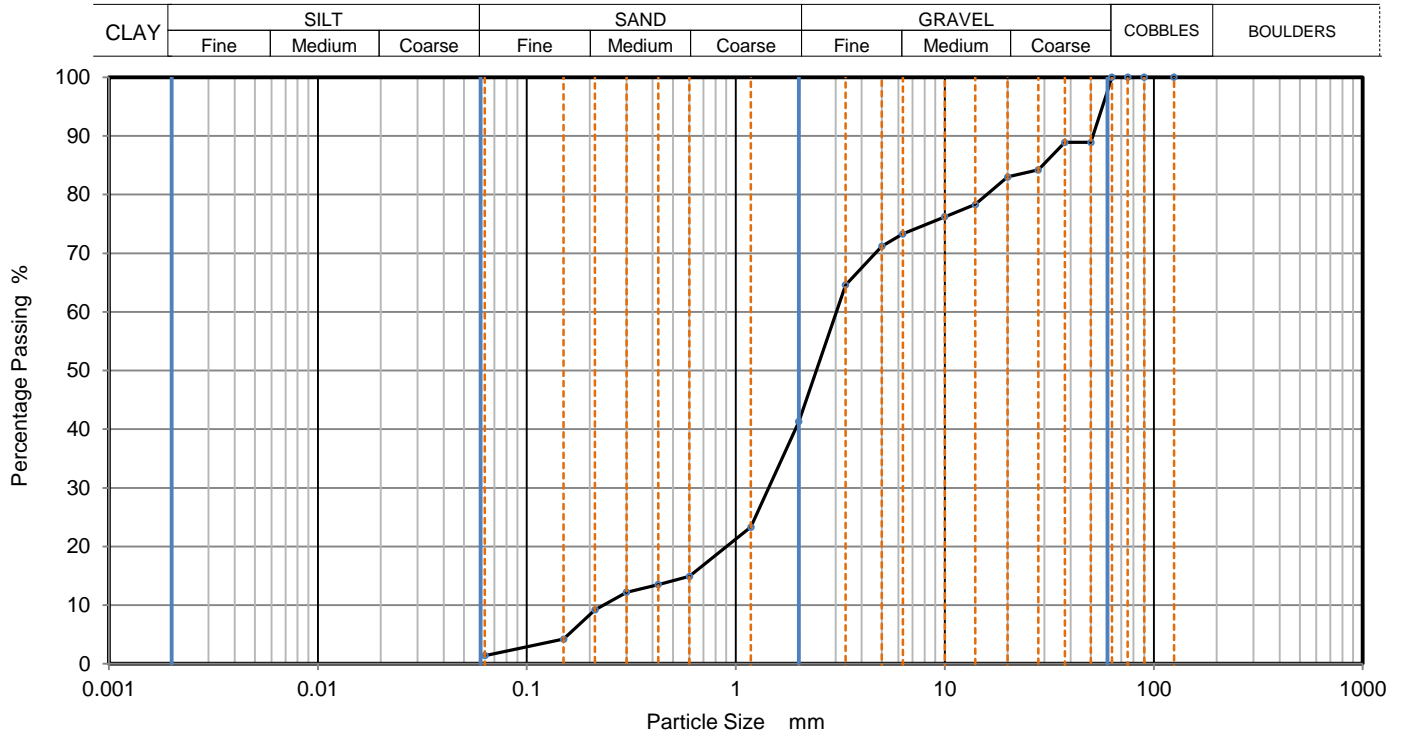
Fig **13**

Sheet



PARTICLE SIZE DISTRIBUTION

Job Ref	15-664
Borehole/Pit No.	BH08
Site Name	GDD Overwater SI
Sample No.	1
Soil Description	Grey fine to medium subrounded GRAVEL with shells and shell fragments.
Depth, m	0.00
Specimen Reference	3
Specimen Depth	m
Sample Type	B
Test Method	BS1377:Part 2:1990, clause 9.2
KeyLAB ID	Caus2015082939



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	89		
37.5	89		
28	84		
20	83		
14	78		
10	76		
6.3	73		
5	71		
3.35	65		
2	41		
1.18	23		
0.6	15		
0.425	14		
0.3	12		
0.212	9		
0.15	4		
0.063	1		

Dry Mass of sample, g 8535

Sample Proportions	% dry mass
Cobbles	0
Gravel	59
Sand	40
Fines <0.063mm	1

Grading Analysis	
D100	mm
D60	mm 3.02
D30	mm 1.44
D10	mm 0.233
Uniformity Coefficient	13
Curvature Coefficient	2.9

Remarks
Preparation and testing in accordance with BS1377 unless noted below



PARTICLE SIZE DISTRIBUTION

Job Ref **15-664**

Borehole/Pit No. **BH08**

Site Name **GDD Overwater SI**

Sample No. **4**

Soil Description **Grey sandy silty GRAVEL with shells and shell fragments.**

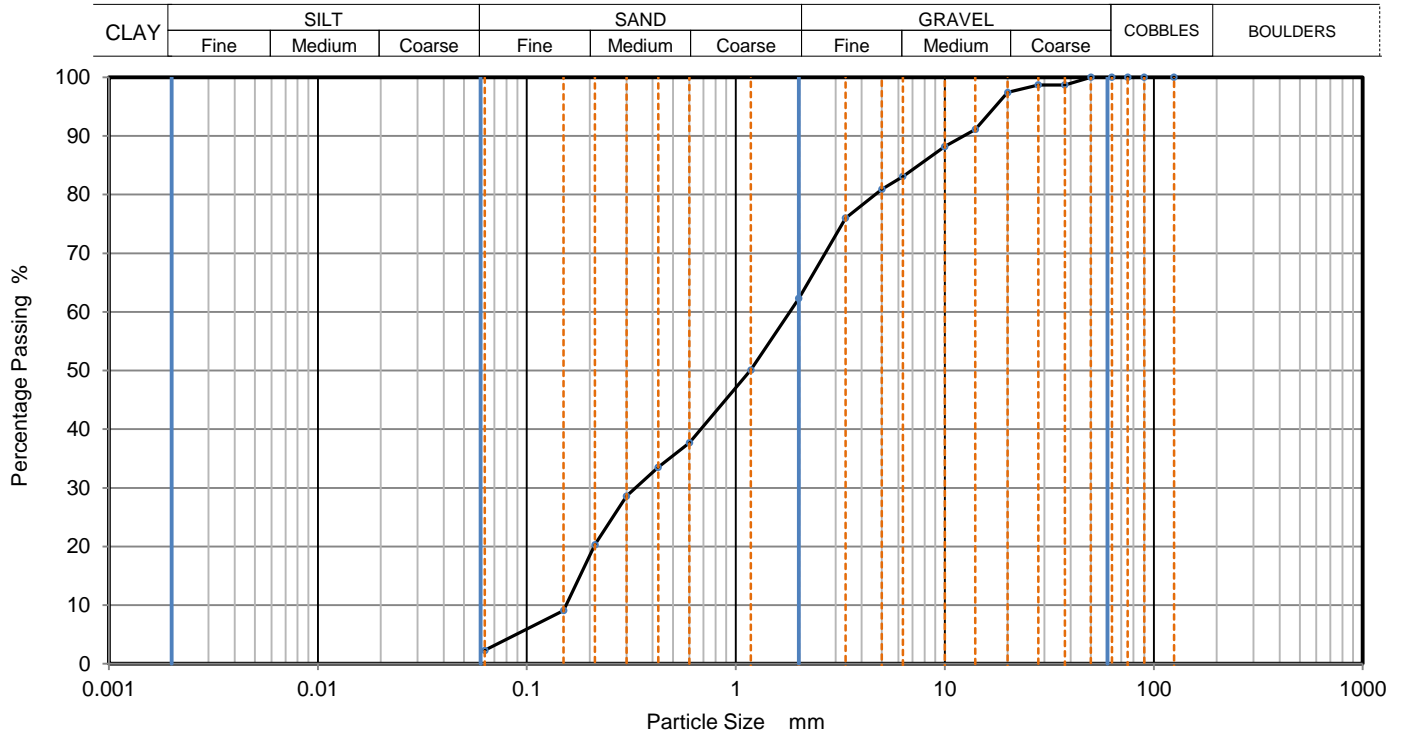
Depth, m **1.50**

Specimen Reference **4** Specimen Depth **m**

Sample Type **B**

Test Method **BS1377:Part 2:1990, clause 9.2**

KeyLAB ID **Caus2015082942**



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	99		
28	99		
20	97		
14	91		
10	88		
6.3	83		
5	81		
3.35	76		
2	62		
1.18	50		
0.6	38		
0.425	34		
0.3	29		
0.212	20		
0.15	9		
0.063	2		

Dry Mass of sample, g 8599

Sample Proportions	% dry mass
Cobbles	0
Gravel	38
Sand	60
Fines <0.063mm	2

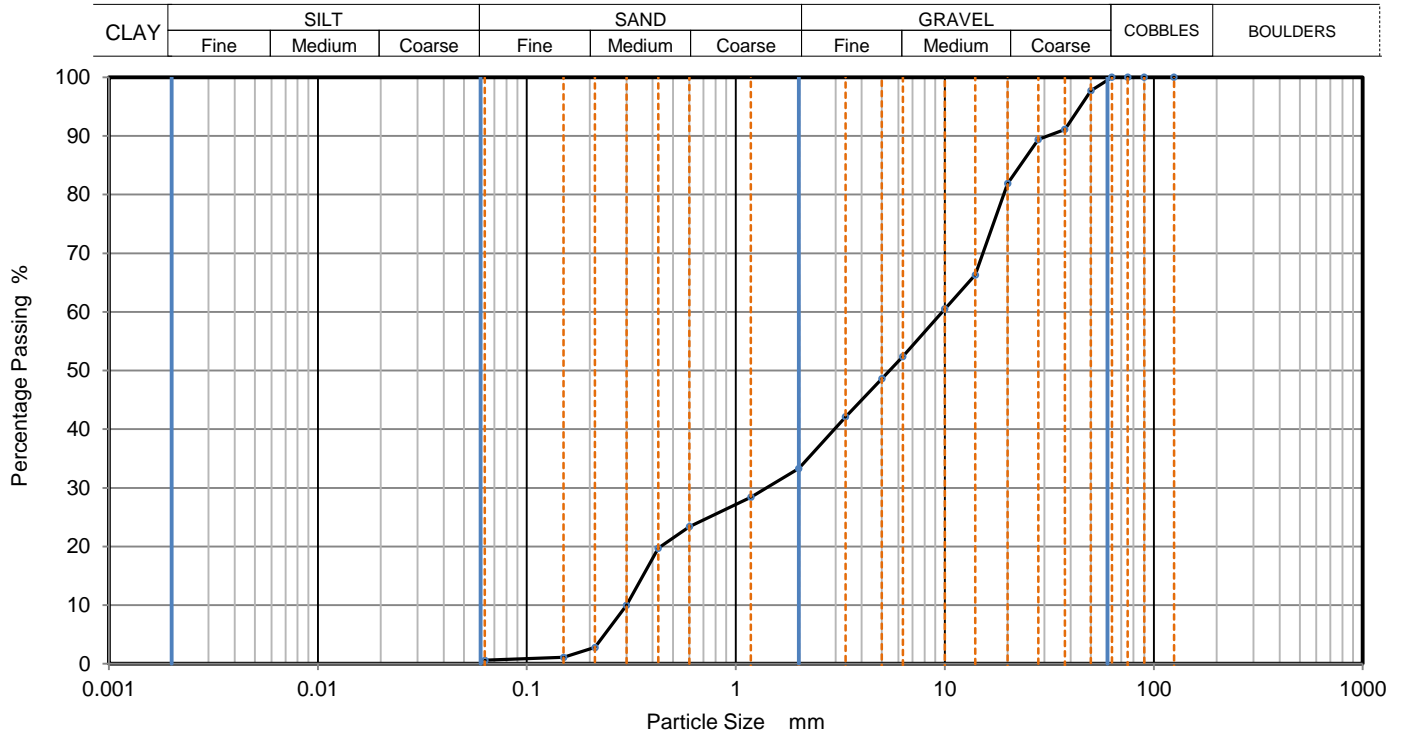
Grading Analysis	
D100	mm
D60	mm 1.81
D30	mm 0.332
D10	mm 0.154
Uniformity Coefficient	12
Curvature Coefficient	0.4

Remarks
Preparation and testing in accordance with BS1377 unless noted below



PARTICLE SIZE DISTRIBUTION

Job Ref	15-664
Borehole/Pit No.	BH08
Site Name	GDD Overwater SI
Sample No.	10
Soil Description	Grey sandy silty GRAVEL
Depth, m	5.00
Specimen Reference	4
Specimen Depth	m
Sample Type	B
Test Method	BS1377:Part 2:1990, clause 9.2
KeyLAB ID	Caus2015082948



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	98		
37.5	91		
28	89		
20	82		
14	66		
10	61		
6.3	52		
5	49		
3.35	42		
2	33		
1.18	28		
0.6	23		
0.425	20		
0.3	10		
0.212	3		
0.15	1		
0.063	1		

Dry Mass of sample, g 10221

Sample Proportions	% dry mass
Cobbles	0
Gravel	67
Sand	33
Fines <0.063mm	1

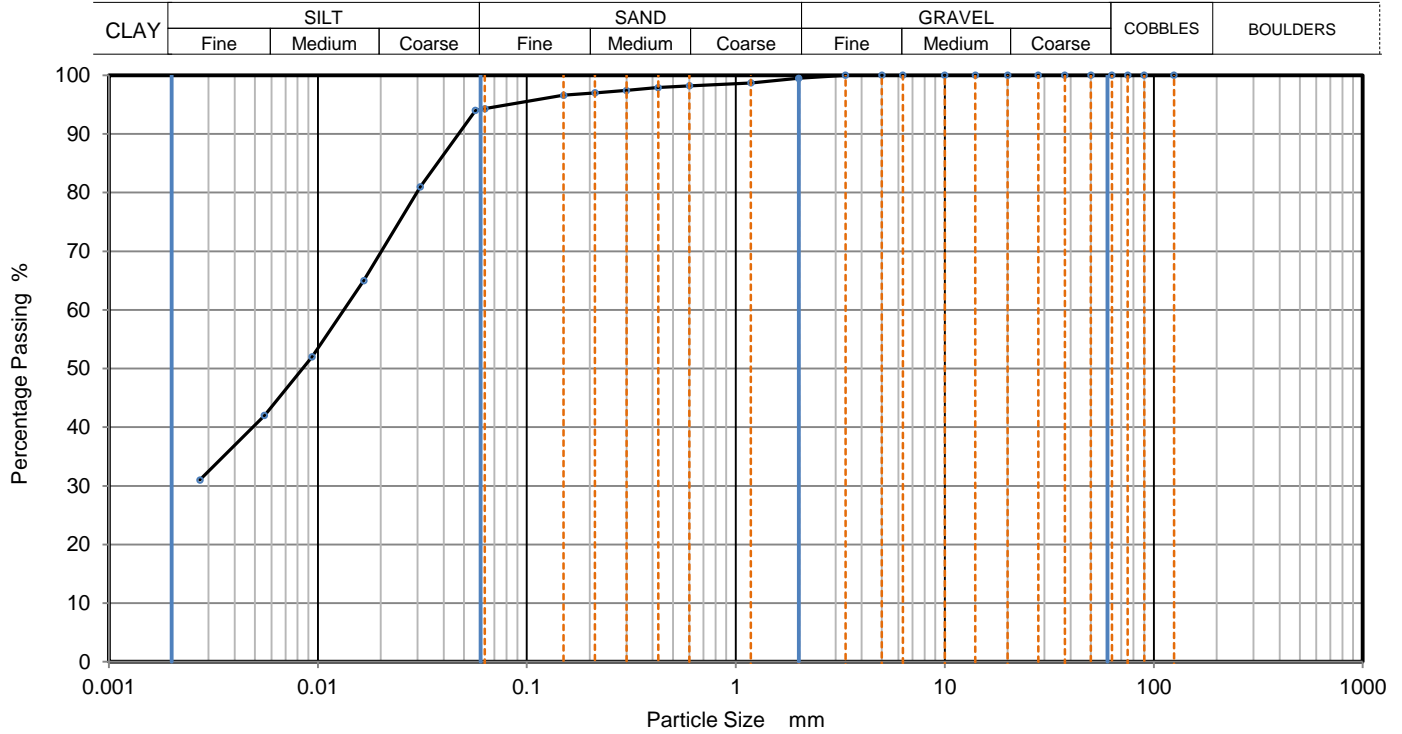
Grading Analysis	
D100	mm
D60	mm 9.71
D30	mm 1.4
D10	mm 0.3
Uniformity Coefficient	32
Curvature Coefficient	0.67

Remarks
Preparation and testing in accordance with BS1377 unless noted below



PARTICLE SIZE DISTRIBUTION

Job Ref	15-664
Borehole/Pit No.	BH08
Site Name	GDD Overwater SI
Sample No.	12
Soil Description	Grey brown sandy silty CLAY.
Depth, m	6.20
Specimen Reference	4
Specimen Depth	m
Sample Type	B
Test Method	BS1377:Part 2:1990, clauses 9.2 and 9.5
KeyLAB ID	Caus2015082950



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100	0.0567	94
90	100	0.0309	81
75	100	0.0166	65
63	100	0.0094	52
50	100	0.0055	42
37.5	100	0.0027	31
28	100		
20	100		
14	100		
10	100		
6.3	100		
5	100		
3.35	100		
2	100		
1.18	99		
0.6	98	Particle density (assumed) 1.50 Mg/m ³	
0.425	98		
0.3	97		
0.212	97		
0.15	97		
0.063	94		

Dry Mass of sample, g 4412

Sample Proportions	% dry mass
Cobbles	0
Gravel	1
Sand	5
Fines <0.063mm	94

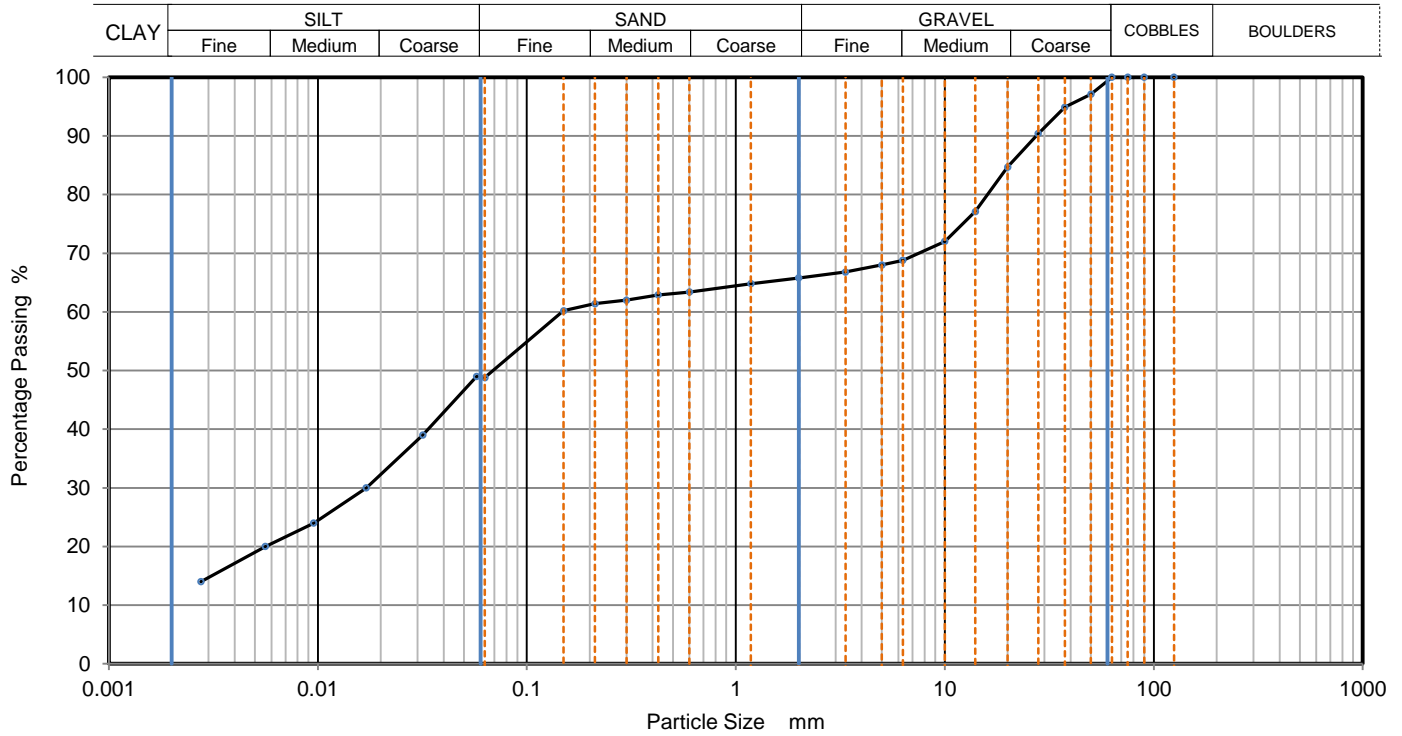
Grading Analysis	
D100	mm
D60	mm
D30	mm
D10	mm
Uniformity Coefficient	
Curvature Coefficient	

Remarks
Preparation and testing in accordance with BS1377 unless noted below



PARTICLE SIZE DISTRIBUTION

Job Ref	15-664
Borehole/Pit No.	BH08
Site Name	GDD Overwater SI
Sample No.	14
Soil Description	Grey brown sandy gravelly silty CLAY.
Depth, m	7.30
Specimen Reference	4
Specimen Depth	m
Sample Type	B
Test Method	BS1377:Part 2:1990, clauses 9.2 and 9.5
KeyLAB ID	Caus2015082952



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100	0.0575	49
90	100	0.0317	39
75	100	0.0170	30
63	100	0.0095	24
50	97	0.0056	20
37.5	95	0.0028	14
28	90		
20	85		
14	77		
10	72		
6.3	69		
5	68		
3.35	67		
2	66		
1.18	65		
0.6	63	Particle density (assumed) 1.50 Mg/m ³	
0.425	63		
0.3	62		
0.212	61		
0.15	60		
0.063	49		

Dry Mass of sample, g 9102

Sample Proportions	% dry mass
Cobbles	0
Gravel	34
Sand	17
Fines <0.063mm	49

Grading Analysis	
D100	mm
D60	mm 0.148
D30	mm 0.0168
D10	mm
Uniformity Coefficient	
Curvature Coefficient	

Remarks
Preparation and testing in accordance with BS1377 unless noted below



PARTICLE SIZE DISTRIBUTION

Job Ref **15-664**

Borehole/Pit No. **BH08**

Site Name **GDD Overwater SI**

Sample No. **15**

Soil Description **Dark grey silty GRAVEL (Possible weathered bedrock.)**

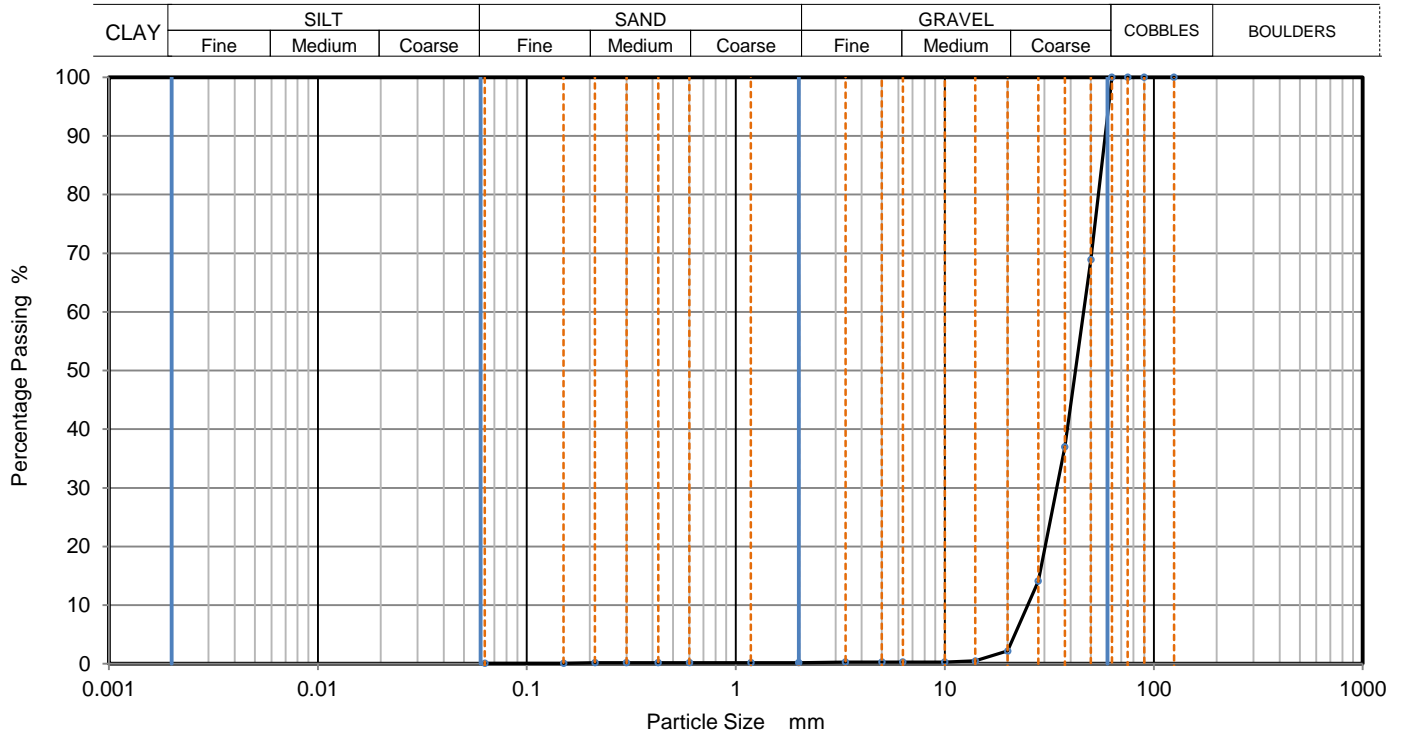
Depth, m **8.40**

Specimen Reference **4** Specimen Depth **m**

Sample Type **B**

Test Method **BS1377:Part 2:1990, clause 9.2**

KeyLAB ID **Caus2015082953**



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	69		
37.5	37		
28	14		
20	2		
14	1		
10	0		
6.3	0		
5	0		
3.35	0		
2	0		
1.18	0		
0.6	0		
0.425	0		
0.3	0		
0.212	0		
0.15	0		
0.063	0		

Dry Mass of sample, g 9343

Sample Proportions	% dry mass
Cobbles	0
Gravel	100
Sand	0
Fines <0.063mm	0

Grading Analysis	
D100	mm
D60	mm
D30	mm
D10	mm
Uniformity Coefficient	1.8
Curvature Coefficient	1

Remarks
Preparation and testing in accordance with BS1377 unless noted below

Shear Box Test GDD Overwater
--

Ref:	15-664	Size mm	100	Initial wet mass g	554
BH	BH03	Thickness mm	31.7	Bulk Density mg/m ³	1748

Depth m	0m		
Our Ref	4	σ'_v kPa	
Soil type	Grey Gravelly SAND cont shells		
Rate of shearing mm/min	0.5		
			30
			60
			120

Peak		Ultimate	
σ'_n kPa	τ kPa	σ'_n kPa	τ kPa
30		30	24
60		60	50
120		120	98

Peak angle of internal friction

Ultimate angle of internal friction

38

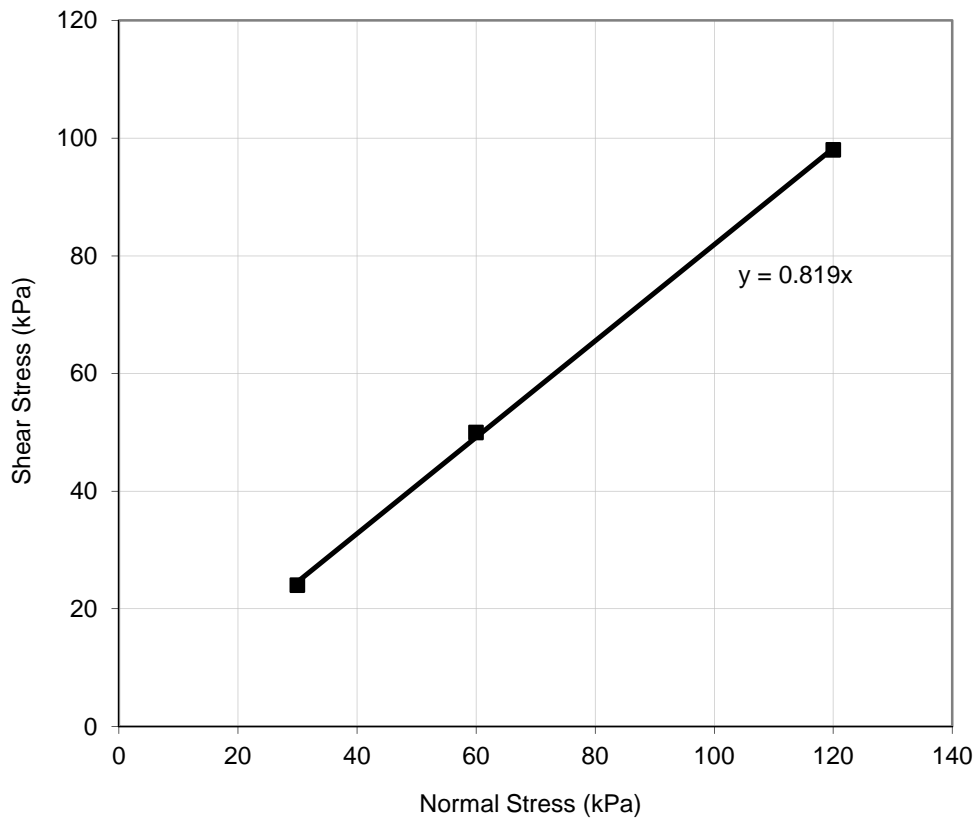


Figure 1 Failure Envelope

Shear Box Test

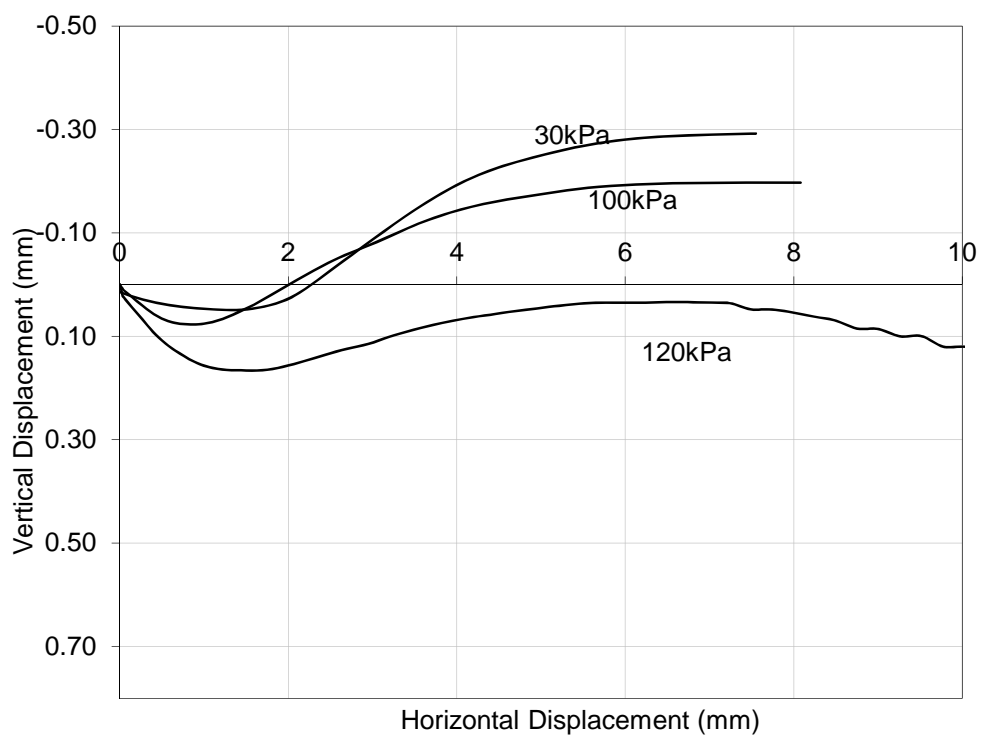
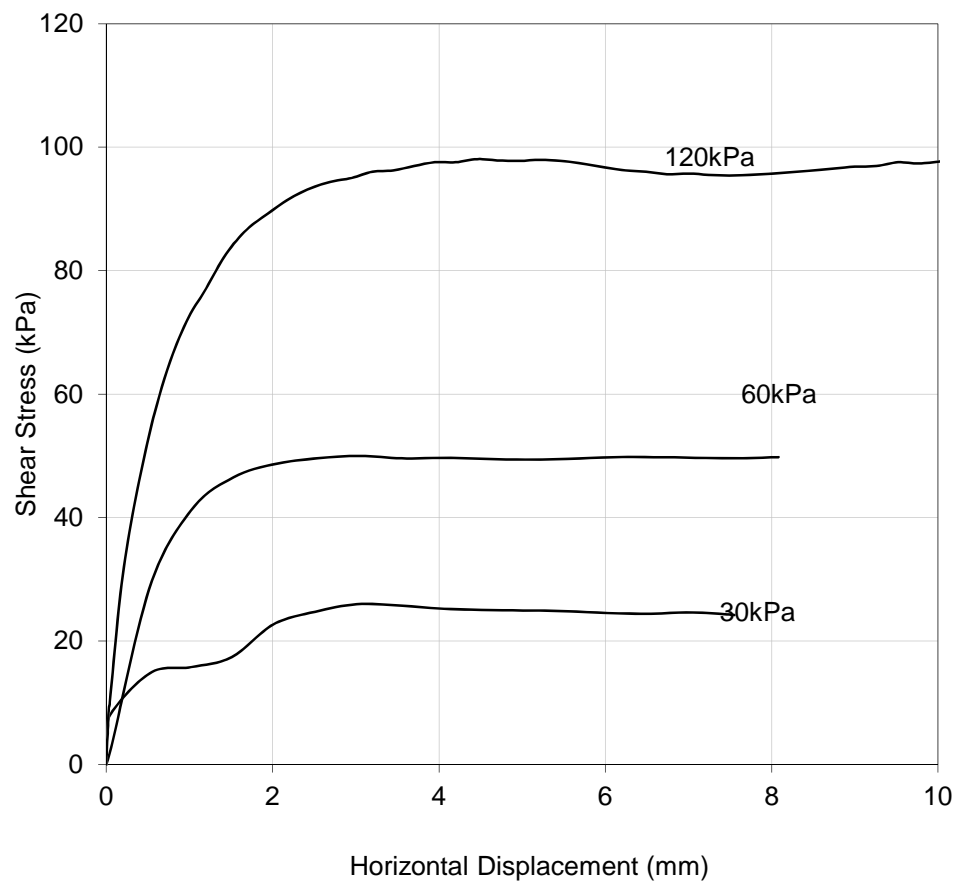


Figure 2 Stress-strain behaviour

Shear Box Test GDD Overwater
--

				Loading 50 kPa	
Ref:	15-664	Size mm	100	Initial wet mass g	610
BH	BH03	Thickness mm	31.7	Bulk Density mg/m ³	1924
Depth m	5m			Final wet mass g	612
Our Ref	14	σ'_v kPa		Dry mass g	500
Soil type	Grey Silty CLAY				
Rate of shearing mm/min		0.015	50	Initial water content %	22.0
			100	Final water content %	22.4
			200	Loading 100 kPa	
				Initial wet mass g	560
				Bulk Density mg/m ³	1924
				Final wet mass g	561
				Dry mass g	460
				Initial water content %	21.7
				Final water content %	22.0
				Loading 200 kPa	
				Initial wet mass g	606
				Bulk Density mg/m ³	1924
				Final wet mass g	599
				Dry mass g	495
				Initial water content %	22.4
				Final water content %	21.0

Peak		Ultimate	
σ'_n kPa	τ kPa	σ'_n kPa	τ kPa
50		50	38
100		100	60
200		200	111

Peak angle of internal friction

Ultimate angle of internal friction

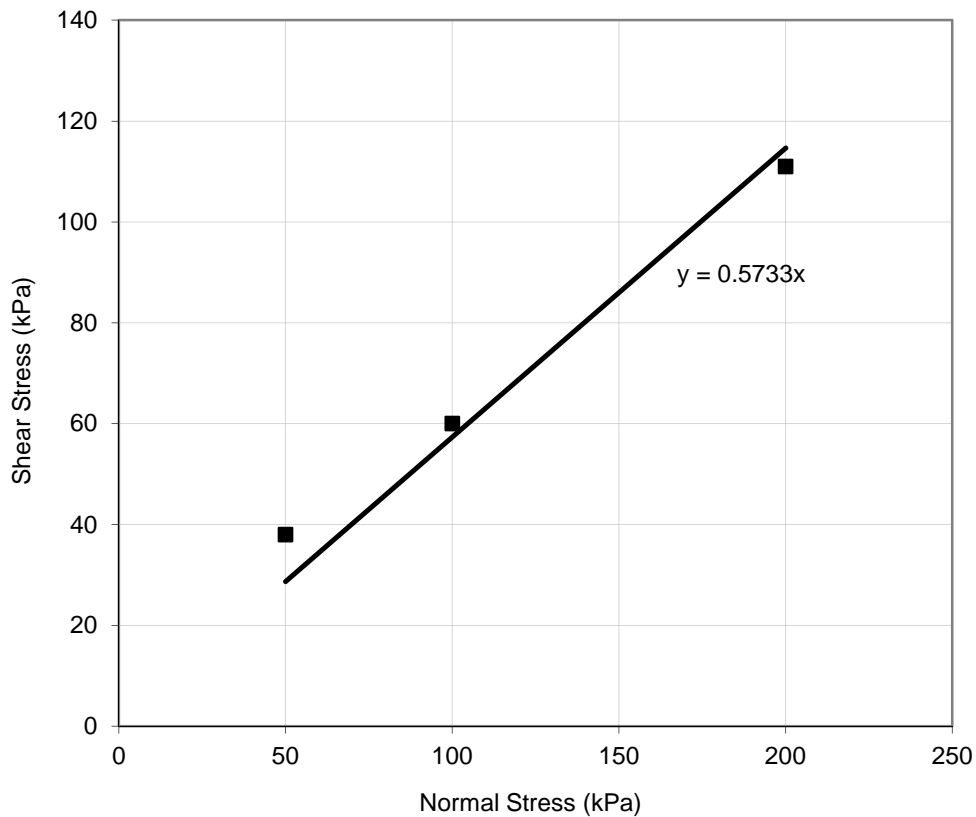


Figure 1 Failure Envelope

Shear Box Test

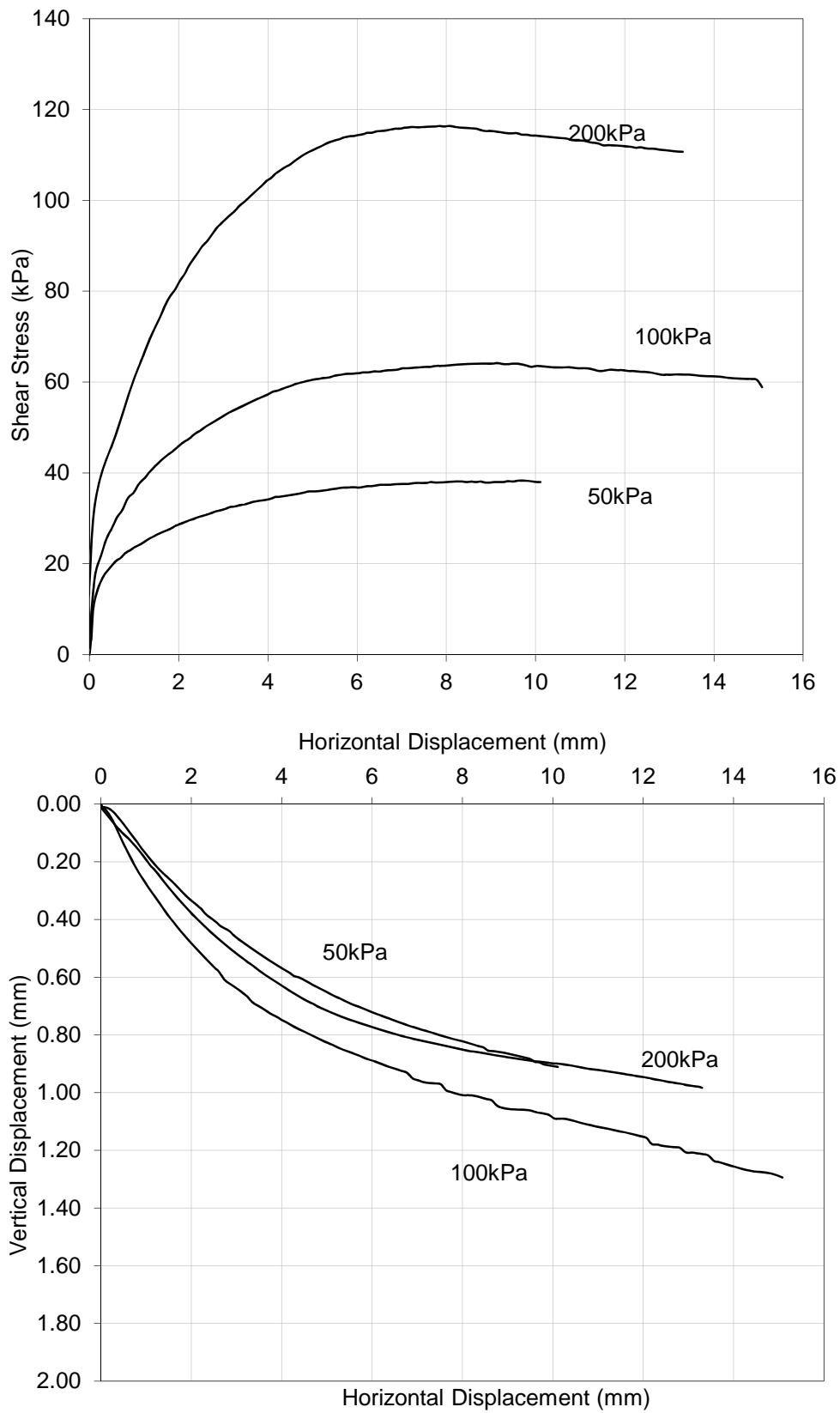


Figure 2 Stress-strain behaviour

Shear Box Test GDD Overwater
--

Ref:	15-664	Size mm	100	Initial wet mass g	645
BH	BH05	Thickness mm	33.7	Bulk Density mg/m ³	1914

Depth m	0m				
Our Ref	1			σ' _v kPa	
Soil type	Grey SAND				
Rate of shearing mm/min	0.5			40	
				80	
				160	

Peak		Ultimate	
σ' _n kPa	τ kPa	σ' _n kPa	τ kPa
40		40	34
80		80	57
160		160	103

Peak angle of internal friction

Ultimate angle of internal friction

33

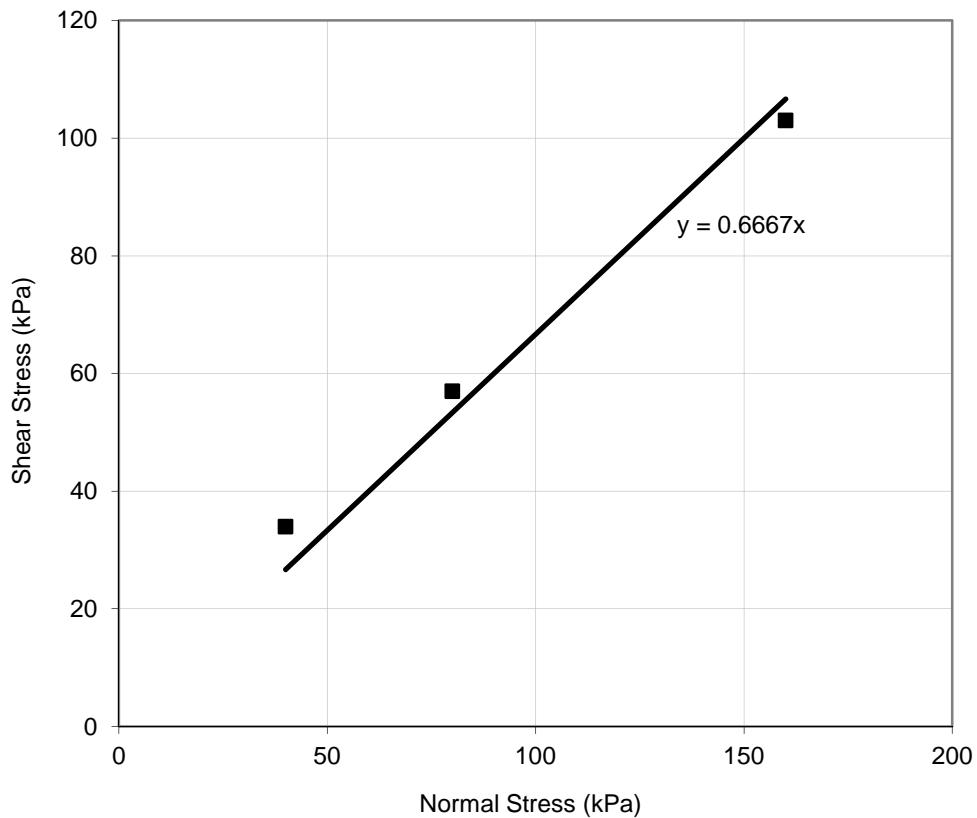


Figure 1 Failure Envelope

Shear Box Test

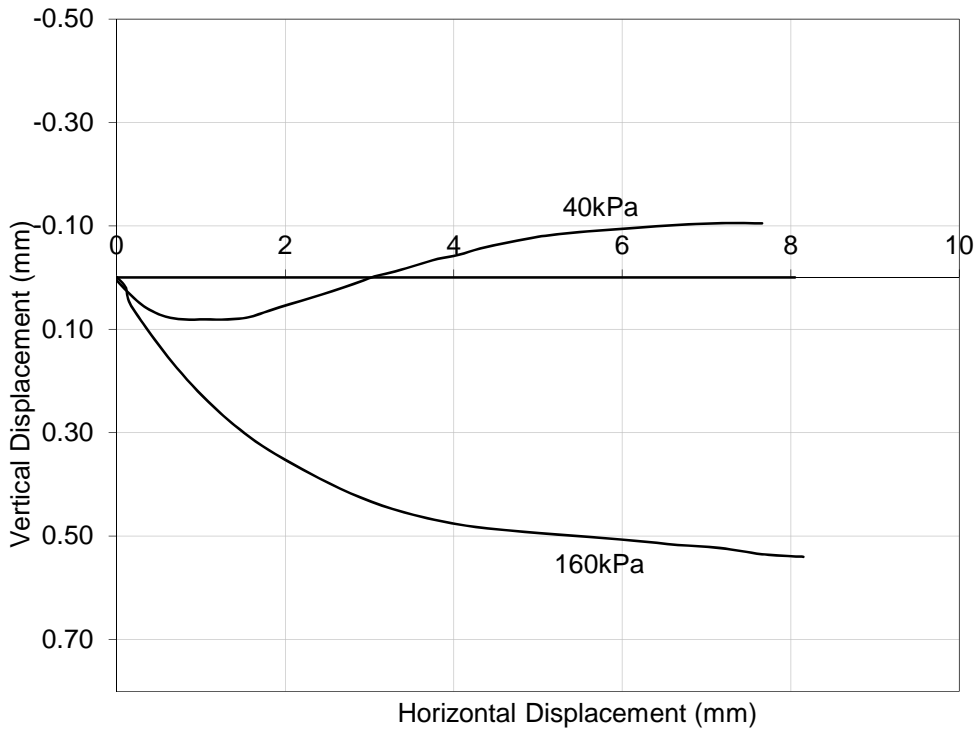
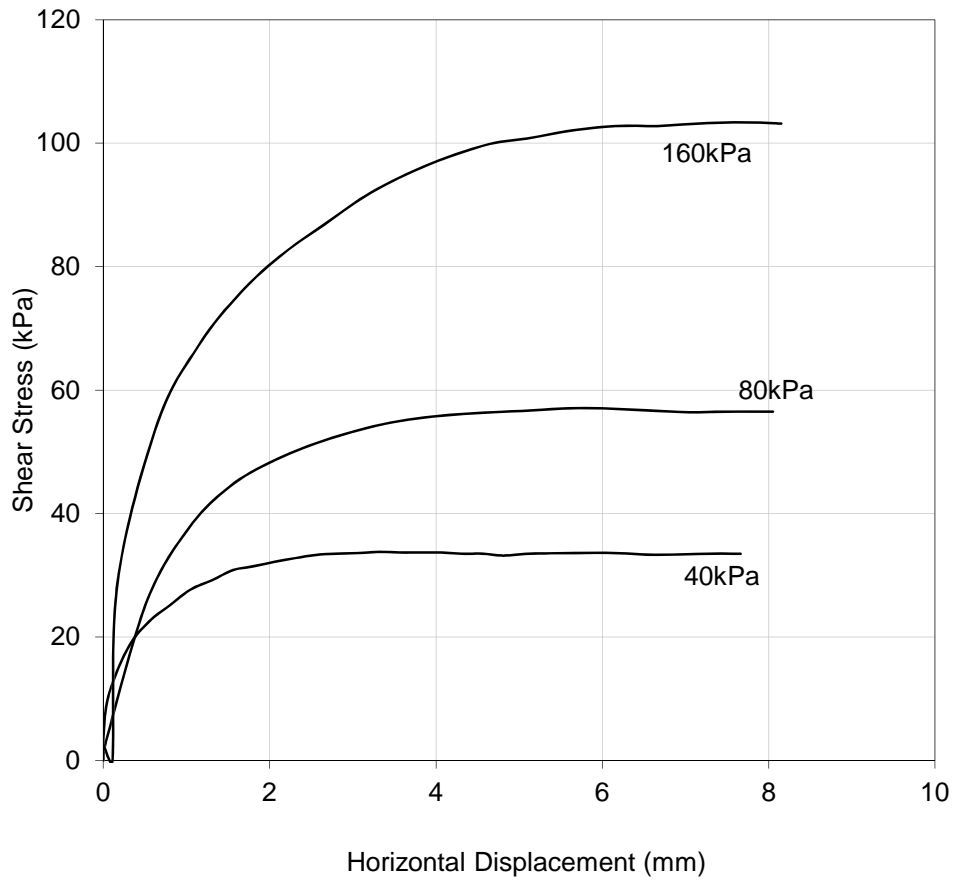


Figure 2 Stress-strain behaviour

Shear Box Test	GDD Overwater
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Ref:	15-664	Size mm	100	Initial wet mass g	749
BH	BH05	Thickness mm	34.2	Bulk Density mg/m ³	2190

Depth m	3.1m			
Our Ref	3			σ' _v kPa
Soil type	Grey Gravelly SAND cont shells			
Rate of shearing mm/min	0.5			40
				80
				160

Peak		Ultimate	
σ' _n kPa	τ kPa	σ' _n kPa	τ kPa
40	38	40	33
80	73	80	64
160	131	160	122

Peak angle of internal friction 39
 Ultimate angle of internal friction 37

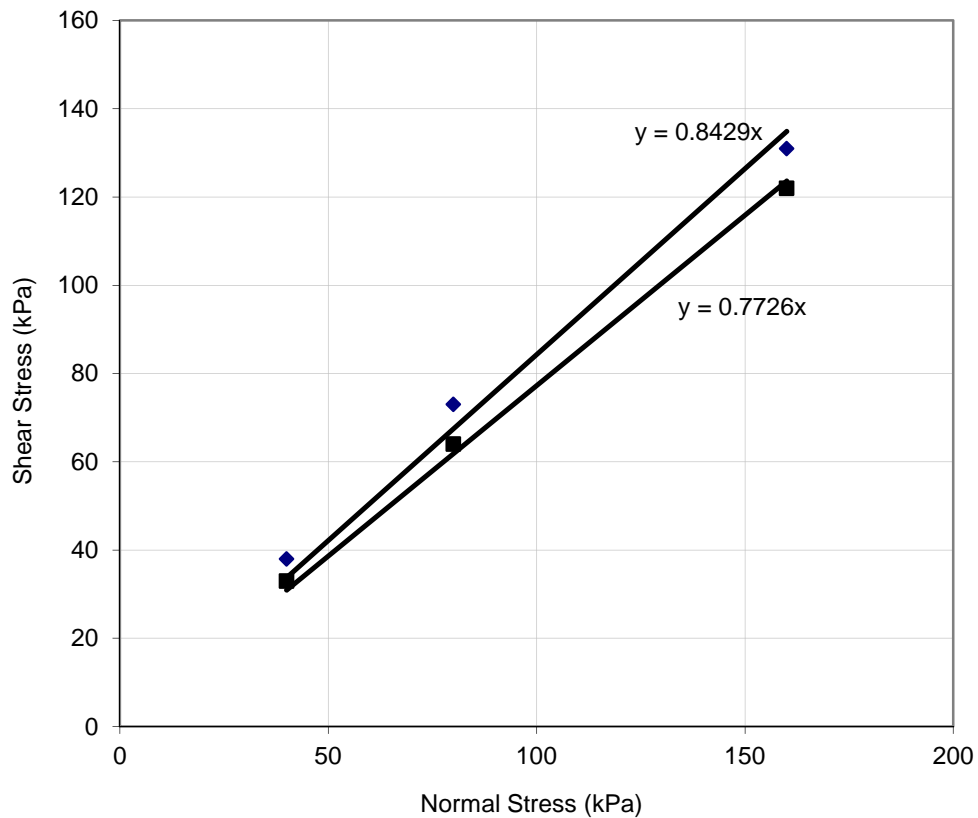


Figure 1 Failure Envelope

Shear Box Test

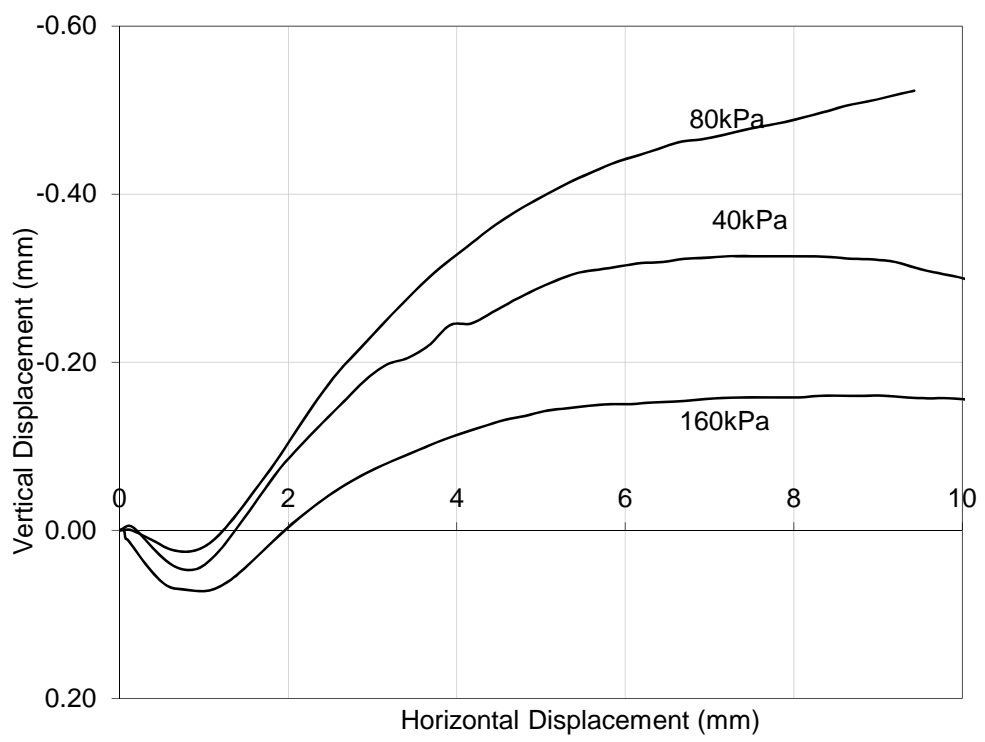
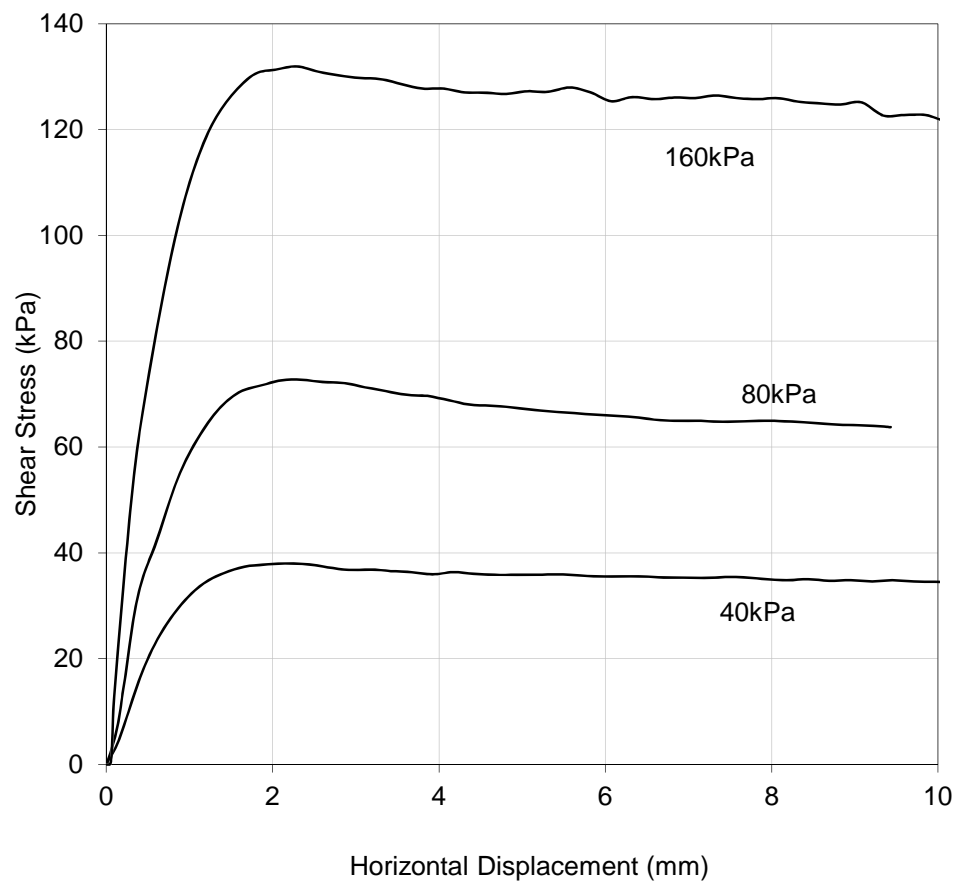


Figure 2 Stress-strain behaviour



Summary of Laboratory Vane Test Results

Project No. 15-664	Project Name GDD Overwater SI
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Hole No.	Sample				Soil Description at test horizon	Moisture Content %	Vane shear strength		Sensitivity	Remarks
	Ref	Top	Base	Type			Undisturbed kPa	Remoulded kPa		
BH05	5	6.00	7.00	B	Very soft grey sandy gravelly CLAY	20		17		

Notes Tests performed in accordance with BS 1377:Part 7:clause 3 using 19mm x 30mm vane Tests carried out in nominally 100mm diameter tube unless noted otherwise Shear strengths are average of at least 3 tests unless noted otherwise	Date Printed 14/09/2015	Approved By	Table sheet 1 1
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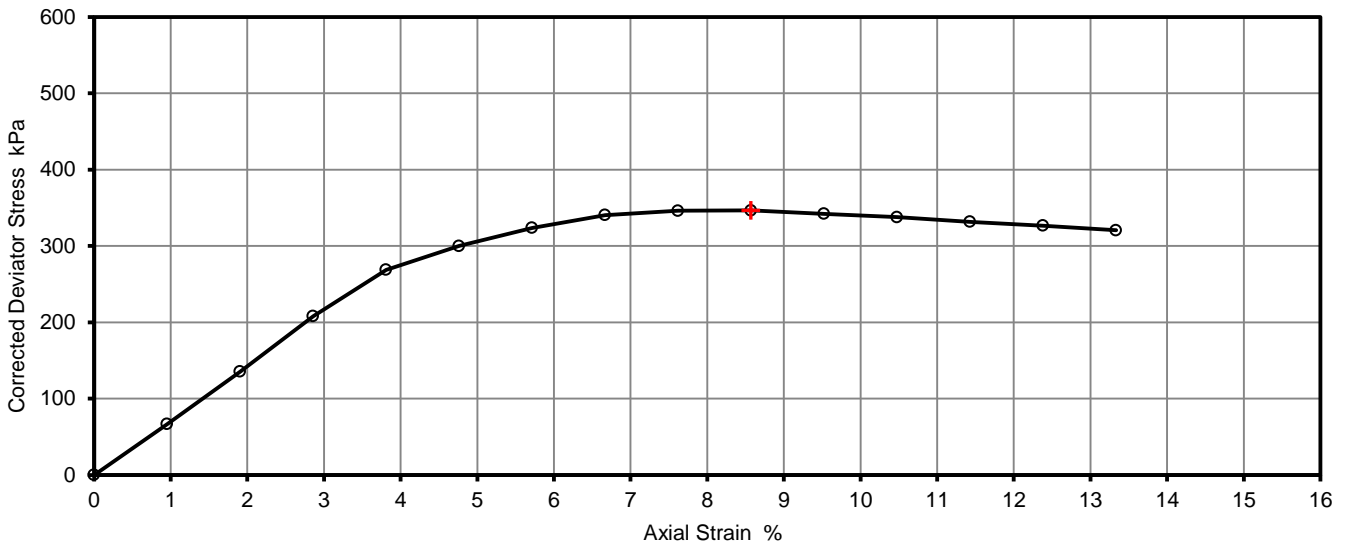
Unconsolidated Undrained Triaxial Compression Test without measurement of pore pressure - single specimen

Job Ref	15-664
Borehole/Pit No.	BH05
Sample No.	
Depth	16.40
Sample Type	C
KeyLAB ID	Caus20151117155
Date of test	

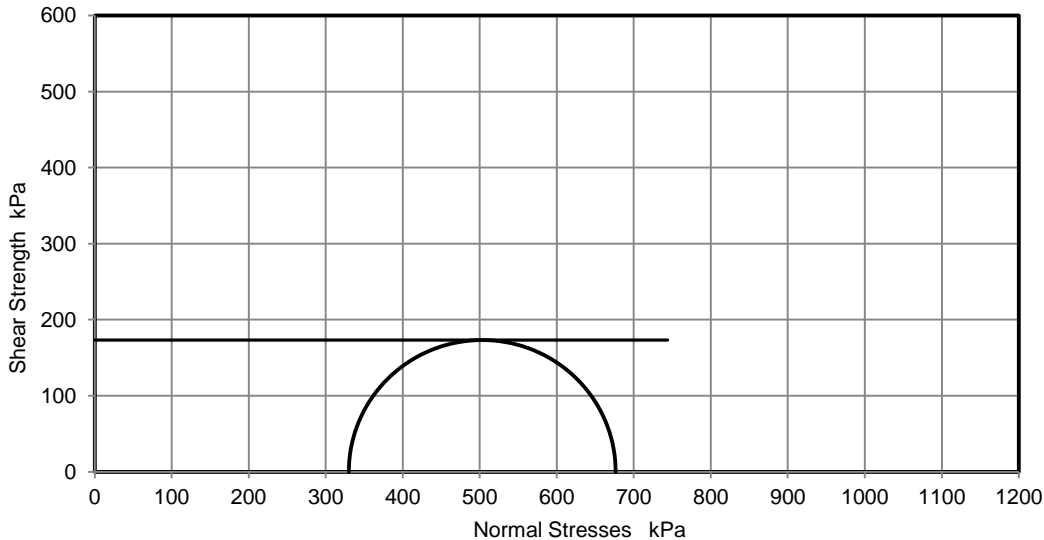
Site Name	GDD Overwater SI		
Soil Description	Grey brown sandy gravelly silty CLAY		
Specimen Reference	1	Specimen Depth	m
Specimen Description	Very stiff grey brown sandy gravelly silty CLAY		
Test Method	BS1377 : Part 7 : 1990, clause 8, single specimen		

Test Number	1	
Length	105.0	mm
Diameter	210.0	mm
Bulk Density	1.05	Mg/m ³
Moisture Content	8.0	%
Dry Density	0.97	Mg/m ³
Rate of Strain	2.0	%/min
Cell Pressure	330	kPa
At failure	8.6	%
Axial Strain	346	kPa
Deviator Stress, $(\sigma_1 - \sigma_3)_f$	173	kPa = $\frac{1}{2}(\sigma_1 - \sigma_3)_f$
Undrained Shear Strength, c_u		
Mode of Failure	Plastic	

Deviator Stress v Axial Strain



Mohr Circles



Deviator stress corrected for area change and membrane effects

Mohr circles and their interpretation is not covered by BS1377. This is provided for information only.

Remarks

Strengths corrected for area change, and membrane effects based on Fig 11 BS1377

Approved

Stephen.Watson

Printed

17/11/2015 11:51

Fig. No.

1

Sheet

1

Lab Sheet Reference :



**Unconsolidated Undrained Triaxial
Compression Test without measurement
of pore pressure - single specimen**

Job Ref	15-664
Borehole/Pit No.	BH05
Sample No.	
Depth	23.20
Sample Type	C
KeyLAB ID	Caus20151117157
Date of test	

Site Name	GDD Overwater SI		
Soil Description	Yellow brown sandy gravelly silty CLAY		
Specimen Reference	1	Specimen Depth	m
Specimen Description	Very stiff yellow brown sandy gravelly CLAY/SILT		
Test Method	BS1377 : Part 7 : 1990, clause 8, single specimen		

Test Number
Length
Diameter
Bulk Density
Moisture Content
Dry Density

1
210.0
105.0
2.25
10.1
2.05

mm
mm
Mg/m³
%
Mg/m³

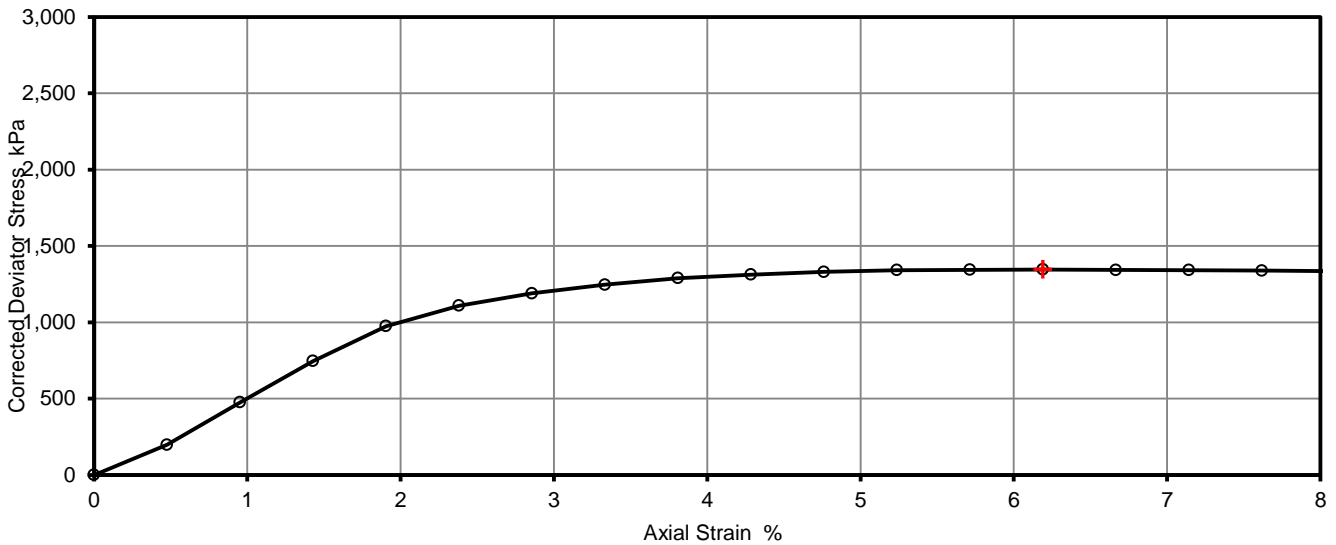
Rate of Strain
Cell Pressure
At failure

2.0
510
6.2
1346
673
Plastic

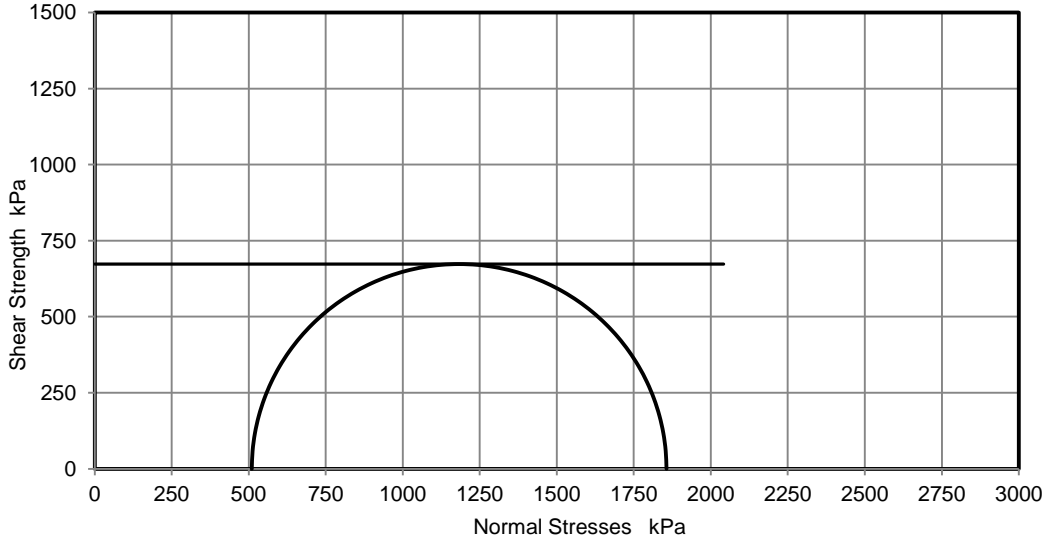
%/min
kPa
%
kPa
kPa = 1/2(σ₁ - σ₃)_f

Axial Strain
Deviator Stress, (σ₁ - σ₃)_f
Undrained Shear Strength, c_u
Mode of Failure

Deviator Stress v Axial Strain



Mohr Circles



Deviator stress corrected for area change and membrane effects

Mohr circles and their interpretation is not covered by BS1377. This is provided for information only.

Remarks

Strengths corrected for area change, and membrane effects based on Fig 11 BS1377

Approved

Stephen.Watson

Printed

04/01/2016 12:09

Fig. No.

1

Sheet

1

Lab Sheet Reference :



**Unconsolidated Undrained Triaxial
Compression Test without measurement
of pore pressure - single specimen**

Job Ref	15-664
Borehole/Pit No.	BH05
Sample No.	
Depth	41.20
Sample Type	C
KeyLAB ID	Caus20151117158
Date of test	

Site Name	GDD Overwater SI		
Soil Description	Yellow brown sandy gravelly silty CLAY		
Specimen Reference	1	Specimen Depth	m
Specimen Description	Very stiff yellow brown sandy gravelly silty CLAY		
Test Method	BS1377 : Part 7 : 1990, clause 8, single specimen		

Test Number
Length
Diameter
Bulk Density
Moisture Content
Dry Density

1
210.0
105.0
2.04
12.6
1.82

mm
mm
Mg/m³
%
Mg/m³

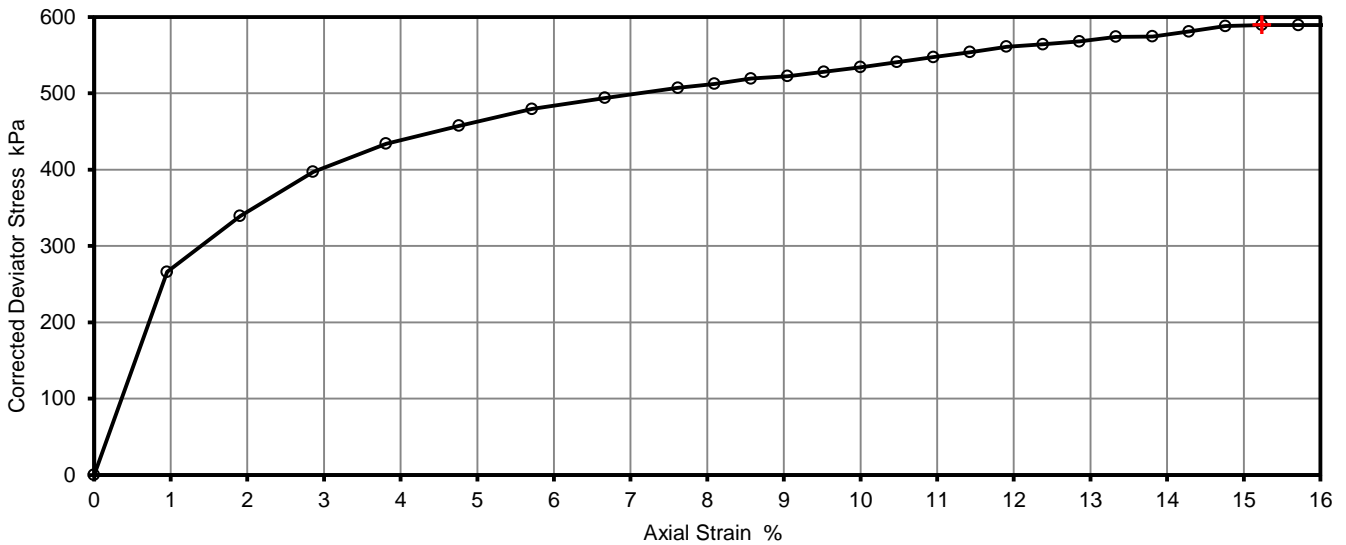
Rate of Strain
Cell Pressure
At failure

2.0
800
15.2
590
295
Plastic

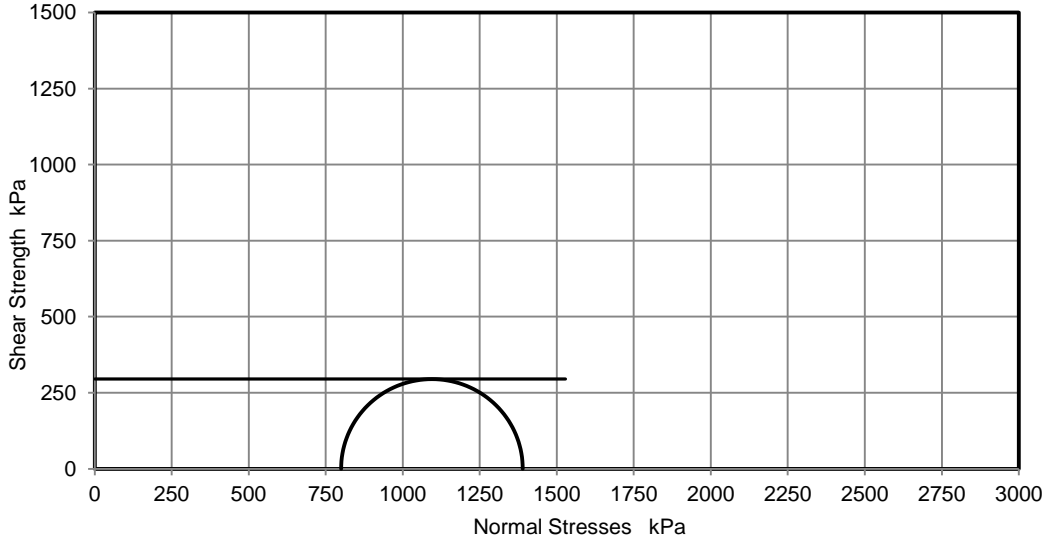
%/min
kPa
%
kPa
kPa = 1/2(σ₁ - σ₃)_f

Axial Strain
Deviator Stress, (σ₁ - σ₃)_f
Undrained Shear Strength, c_u
Mode of Failure

Deviator Stress v Axial Strain



Mohr Circles



Deviator stress corrected for area change and membrane effects

Mohr circles and their interpretation is not covered by BS1377. This is provided for information only.

Remarks

Strengths corrected for area change, and membrane effects based on Fig 11 BS1377

Approved

Stephen.Watson

Printed

17/11/2015 11:50

Fig. No.

1

Sheet

1

Lab Sheet Reference :



**Unconsolidated Undrained Triaxial
Compression Test without measurement
of pore pressure - single specimen**

Job Ref	15-664
Borehole/Pit No.	BH05
Sample No.	5
Depth	6.00
Sample Type	B
KeyLAB ID	Caus201509017
Date of test	

Site Name	GDD Overwater SI		
Soil Description	Grey sandy gravelly silty CLAY.		
Specimen Reference	5	Specimen Depth	m
Specimen Description	Very soft grey sandy gravelly silty CLAY		
Test Method	BS1377 : Part 7 : 1990, clause 8, single specimen		

Test Number
Length
Diameter
Bulk Density
Moisture Content
Dry Density

1
210.0
105.0
2.10
20.2
1.75

mm
mm
Mg/m³
%
Mg/m³

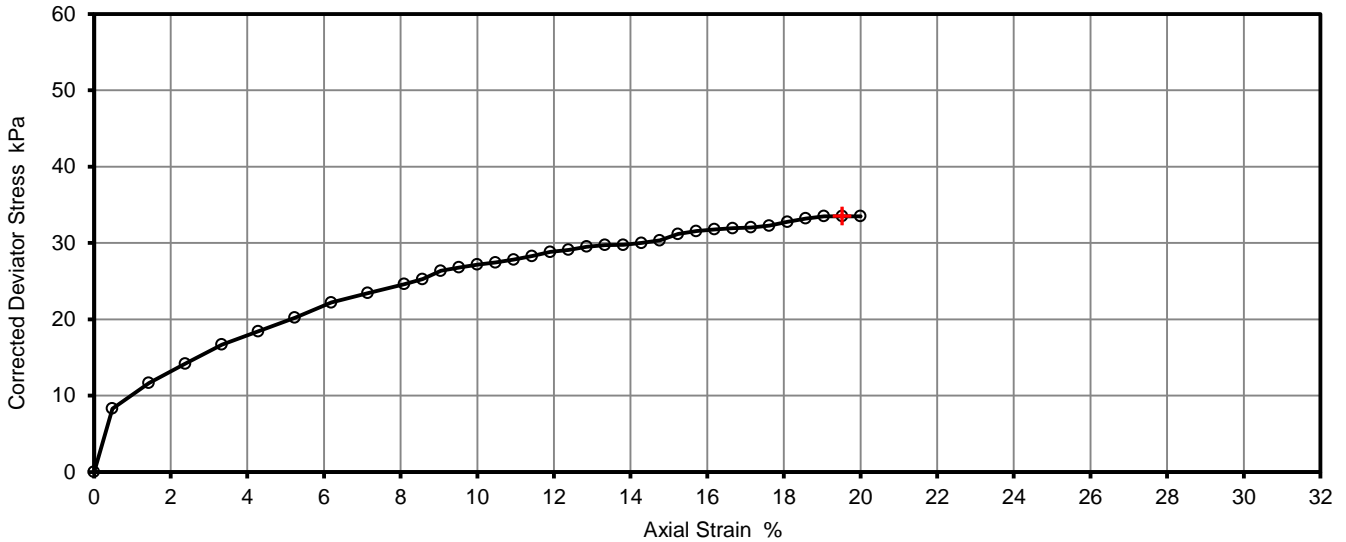
Rate of Strain
Cell Pressure
At failure

2.0
130
19.5
33
17
Plastic

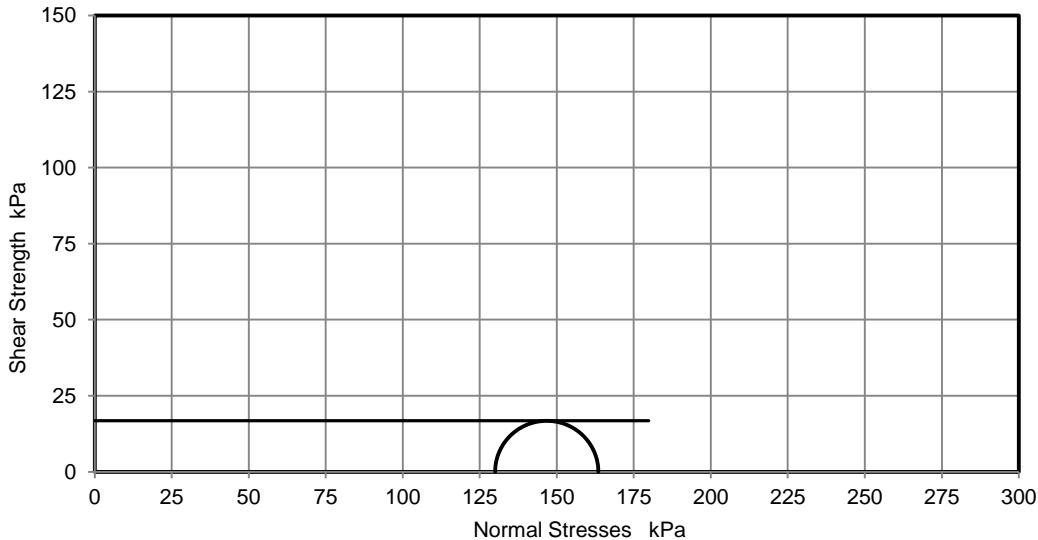
%/min
kPa
%
kPa
kPa = 1/2(σ₁ - σ₃)_f

Axial Strain
Deviator Stress, (σ₁ - σ₃)_f
Undrained Shear Strength, c_u
Mode of Failure

Deviator Stress v Axial Strain



Mohr Circles



Deviator stress corrected for area change and membrane effects

Mohr circles and their interpretation is not covered by BS1377. This is provided for information only.

Remarks

Remoulded specimen

Approved

Stephen.Watson

Printed

14/09/2015 15:16

Fig. No.

1

Sheet

1

Lab Sheet Reference :

LABORATORY RESTRICTION REPORT

Project Reference	15-664	To	Darren O'Mahony
Project Name	Greater Dublin Drainage Scheme: Offshore SI	Position	Project Manager
TR reference	15-664 / 1	From	Stephen Watson
		Position	Laboratory Manager

The following sample(s) and test(s) are restricted as detailed below.

Hole Number	Sample			Test Type	Reason for Restriction	Required Action
	Number	Depth (m)	Type			
BH03		0	B	Lab vane	SAND - Testing not suitable	Testing cancelled
BH03		5	B	Quick triaxial	Not suitable on a disturbed sample. Insufficient material to allow remoulded specimen. Shearbox testing took priority	Testing cancelled
BH08		0	B	Lab vane	GRAVEL - Testing not suitable	Testing cancelled
BH08		1.5	B	Atterberg Limit	GRAVELLY SAND - Testing not suitable	Testing cancelled
BH08		5	B	Atterberg Limit	SANDY GRAVEL - Testing not suitable	Testing cancelled
BH08		8.4	B	Atterberg Limit Particle density	GRAVEL - Testing not suitable	Testing cancelled

For electronic reporting a form of electronic signature or printed name is acceptable

Laboratory Signature Stephen Watson	Project Manager Signature Darren O'Mahony
Date 16 November 2015	Date 16 November 2015



TEST RESTRICTION FORM

Issue No. 1
Page 1 of 2
Date 16/11/2015

LABORATORY RESTRICTION REPORT

Project Reference	15-664	To	Darren O'Mahony
Project Name	Greater Dublin Drainage Scheme: Offshore SI	Position	Project Manager
TR reference	15-664 / 1	From	Stephen Watson
		Position	Laboratory Manager

The following sample(s) and test(s) are restricted as detailed below.

Hole Number	Sample			Test Type	Reason for Restriction	Required Action
	Number	Depth (m)	Type			
BH05		20.10-23.20		Quick triaxial	No suitable sample to allow QUT	Testing cancelled
BH05		32.30-33.70		Quick triaxial	No suitable sample to allow QUT	Testing cancelled
BH05		33.70-35.20		Quick triaxial	No suitable sample to allow QUT	Testing cancelled
BH05		39.70-41.20		Quick triaxial	No suitable sample to allow QUT	Testing cancelled
BH05		47.20-52.80		Quick triaxial	No suitable sample to allow QUT	Testing cancelled
BH01		1		Moisture content Atterberg	Lab did not receive sample	Testing cancelled
BH01		7		Moisture content PSD	Lab did not receive sample	Testing cancelled
BH01		9		Moisture content PSD	Lab did not receive sample	Testing cancelled
BH01		11		Moisture content PSD Particle density	Lab did not receive sample	Testing cancelled

For electronic reporting a form of electronic signature or printed name is acceptable

Laboratory Signature Stephen Watson	Project Manager Signature Darren O'Mahony
Date 16 November 2015	Date 16 November 2015



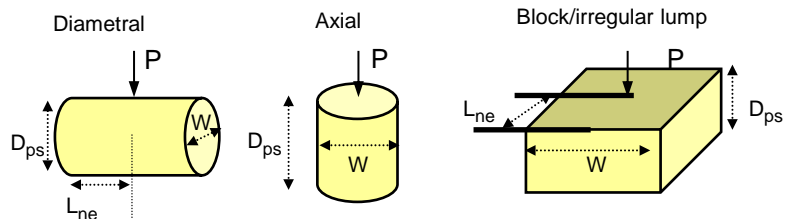
TEST RESTRICTION FORM

Issue No. 1
Page 2 of 2
Date 16/11/2015

Point Load Strength Index Tests Summary of Results

Project No. 15-664		Project Name GDD Overwater SI																
Borehole No.	Sample			Specimen		Rock Type	Test Type see ISRM		Failure Valid (Y/N)	Dimensions				Force P kN	Equivalent diameter, De mm	Point Load Strength Index		Remarks (including water content if measured)
	Depth m	Ref.	Type	Ref.	Depth m		Type (D, A, I, B)	Direction (L, P or U)		Lne mm	W mm	Dps mm	Dps' mm			Is MPa	Is(50) MPa	
BH01	18.90		C	2		LIMESTONE	I	U	YES	55.0	100.0	65.0	58.0	28.7	85.9	3.9	5.0	
BH01	20.20		C	2		LIMESTONE	D	U	YES	79.0	102.0	73.0	68.0	29.6	83.3	4.3	5.4	
BH01	22.50		C	2		LIMESTONE	A	U	YES		102.0	88.0	79.0	22.6	101.3	2.2	3.0	
BH01	23.20		C	2		LIMESTONE	D	U	NO	60.0	102.0	102.0	96.0	28.9	99.0	3.0	4.0	
BH01	29.00		C	2		LIMESTONE	D	U	NO	75.0	102.0	102.0	94.0	32.3	97.9	3.4	4.6	
BH01	29.10		C	2		LIMESTONE	A	U	YES		102.0	69.0	72.0	30.6	96.7	3.3	4.4	
BH01	32.50		C	2		LIMESTONE	D	U	YES	88.0	102.0	102.0	96.0	21.0	99.0	2.1	2.9	
BH01	33.50		C	2		LIMESTONE	A	U	YES		102.0	60.0	56.0	16.9	85.3	2.3	3.0	
BH01	41.70		C	2		LIMESTONE	A	U	NO		102.0	86.0	80.0	20.6	101.9	2.0	2.7	
BH01	42.80		C	2		LIMESTONE	D	U	YES	73.0	102.0	102.0	95.0	22.9	98.4	2.4	3.2	
BH01	44.60		C	2		LIMESTONE	D	U	YES	59.0	102.0	102.0	96.0	22.6	99.0	2.3	3.1	
BH01	44.70		C	2		LIMESTONE	A	U	YES		102.0	63.0	57.0	19.6	86.0	2.6	3.4	
BH01	48.00		C	2		LIMESTONE	A	U	YES	50.0	102.0	64.0	60.0	1.4	88.3	0.2	0.2	
BH01	48.80		C	2		LIMESTONE	D	U	YES	53.0	102.0	101.0	97.0	7.6	99.5	0.8	1.0	
BH01	52.80		C	2		LIMESTONE	D	U	YES	51.0	102.0	102.0	100.0	7.9	101.0	0.8	1.1	
BH01	53.40		C	2		LIMESTONE	A	U	NO		102.0	52.0	47.0	17.6	78.1	2.9	3.5	
BH01	55.30		C	2		LIMESTONE	D	U	YES	56.0	102.0	101.0	96.0	20.3	99.0	2.1	2.8	
BH01	55.50		C	2		LIMESTONE	A	U	NO		102.0	76.0	70.0	26.2	95.3	2.9	3.9	
BH01	56.90		C	2		LIMESTONE	D	U	YES	50.0	102.0	102.0	98.0	25.9	100.0	2.6	3.5	
BH01	57.40		C	2		LIMESTONE	A	U	YES	34.0	102.0	85.0	58.0	22.0	86.8	2.9	3.7	

Test Type
D - Diametral, A - Axial, I - Irregular Lump, B - Block
Direction
L - parallel to planes of weakness
P - perpendicular to planes of weakness
U - unknown or random
Dimensions
Dps - Distance between platens (platen separation)
Dps' - at failure (see ISRM note 6)
Lne - Length from platens to nearest free end
W - Width of shortest dimension perpendicular to load, P



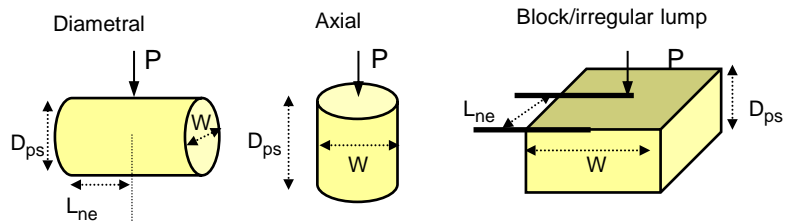
Test performed in accordance with ISRM Suggested Methods : 2007, unless noted otherwise Detailed legend for test and dimensions, based on ISRM, is shown above. Size factor, F = (De/50)0.45 for all tests.	Date Printed 16/11/2015	Approved By Stephen.Watson	Table sheet 1 1
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Point Load Strength Index Tests Summary of Results

Project No. 15-664	Project Name GDD Overwater SI
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Borehole No.	Sample			Specimen		Rock Type	Test Type see ISRM		Failure Valid (Y/N)	Dimensions				Force P kN	Equivalent diameter, De mm	Point Load Strength Index		Remarks (including water content if measured)
	Depth m	Ref.	Type	Ref.	Depth m		Type (D, A, I, B)	Direction (L, P or U)		Lne mm	W mm	Dps mm	Dps' mm			Is MPa	Is(50) MPa	
BH01	59.70		C	2		LIMESTONE	D	U	NO	59.0	102.0	102.0	95.0	27.5	98.4	2.8	3.8	
BH01	59.90		C	1		LIMESTONE	A	U	NO		65.0	65.0	59.0	20.5	69.9	4.2	4.9	
BH03	17.90		C	1		LIMESTONE	A	U	YES	55.0	103.0	79.0	73.0	21.6	97.8	2.3	3.1	
BH03	18.40		C	1		LIMESTONE	D	U	YES	56.0	103.0	103.0	94.0	27.6	98.4	2.9	3.9	
BH03	22.40		C	1		LIMESTONE	D	U	YES	55.0	103.0	103.0	93.0	30.6	97.9	3.2	4.3	
BH03	22.70		C	1		LIMESTONE	A	U	YES	55.3	103.0	37.0	32.0	11.6	64.8	2.8	3.1	
BH03	25.30		C	1		LIMESTONE	D	U	YES	56.0	103.0	103.0	90.0	23.6	96.3	2.5	3.4	
BH03	25.60		C	1		LIMESTONE	D	U	YES	55.2	103.0	103.0	91.0	32.1	96.8	3.4	4.6	
BH03	27.10		C	1		LIMESTONE	A	U	YES	55.9	103.0	88.0	80.0	20.9	102.4	2.0	2.8	
BH03	27.40		C	1		LIMESTONE	D	U	YES	55.1	103.0	103.0	93.0	30.4	97.9	3.2	4.3	
BH03	31.20		C	1		LIMESTONE	A	U	YES	55.5	103.0	68.0	60.0	24.7	88.7	3.1	4.1	
BH03	31.45		C	1		LIMESTONE	D	U	YES	55.4	103.0	103.0	92.0	31.8	97.3	3.4	4.5	
BH03	34.80		C	1		LIMESTONE	A	U	YES	55.0	103.0	64.0	59.0	11.6	88.0	1.5	1.9	
BH03	35.60		C	1		LIMESTONE	A	U	YES	45.0	103.0	55.0	47.0	18.6	78.5	3.0	3.7	
BH03	39.70		C	1		LIMESTONE	D	U	YES	53.2	103.0	102.0	94.0	19.4	98.4	2.0	2.7	
BH03	39.80		C	1		LIMESTONE	D	U	YES	55.4	103.0	103.0	95.0	23.2	98.9	2.4	3.2	
BH03	44.60		C	1		LIMESTONE	D	U	NO	55.2	103.0	102.0	95.0	29.6	98.9	3.0	4.1	
BH03	46.80		C	1		LIMESTONE	A	U	NO	33.0	103.0	68.0	61.0	26.0	89.4	3.3	4.2	
BH03	47.10		C	1		LIMESTONE	A	U	NO	29.0	103.0	58.0	50.0	23.0	81.0	3.5	4.4	
BH03	48.20		C	1		LIMESTONE	A	U	NO	56.0	103.0	102.0	94.0	23.6	111.0	1.9	2.7	

Test Type
D - Diametral, A - Axial, I - Irregular Lump, B - Block
Direction
L - parallel to planes of weakness
P - perpendicular to planes of weakness
U - unknown or random
Dimensions
Dps - Distance between platens (platen separation)
Dps' - at failure (see ISRM note 6)
Lne - Length from platens to nearest free end
W - Width of shortest dimension perpendicular to load, P



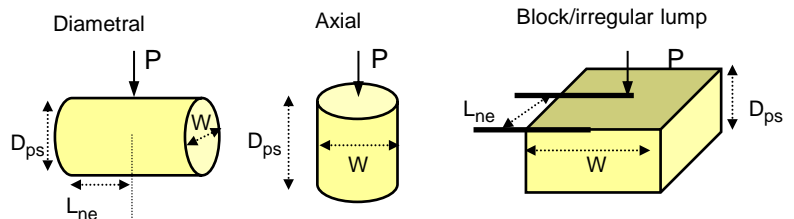
Test performed in accordance with ISRM Suggested Methods : 2007, unless noted otherwise Detailed legend for test and dimensions, based on ISRM, is shown above. Size factor, F = (De/50)0.45 for all tests.	Date Printed 16/11/2015	Approved By Stephen.Watson	Table sheet 2
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Point Load Strength Index Tests Summary of Results

Project No. 15-664	Project Name GDD Overwater SI
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Borehole No.	Sample			Specimen		Rock Type	Test Type see ISRM		Failure Valid (Y/N)	Dimensions				Force P kN	Equivalent diameter, De mm	Point Load Strength Index		Remarks (including water content if measured)
	Depth m	Ref.	Type	Ref.	Depth m		Type (D, A, I, B)	Direction (L, P or U)		Lne mm	W mm	Dps mm	Dps' mm			Is MPa	Is(50) MPa	
BH03	48.70		C	1		LIMESTONE	A	U	YES	57.0	103.0	102.0	95.0	20.5	111.6	1.6	2.4	
BH03	49.50		C	1		LIMESTONE	D	U	YES	56.0	103.0	102.0	97.0	22.9	100.0	2.3	3.1	
BH03	50.60		C	1		LIMESTONE	D	U	NO	58.0	103.0	101.0	95.0	10.6	98.9	1.1	1.5	
BH03	54.70		C	1		LIMESTONE	D	U	NO	55.0	103.0	102.0	99.0	16.4	101.0	1.6	2.2	
BH03	54.80		C	1		LIMESTONE	A	U	YES	55.0	103.0	90.0	82.0	19.2	103.7	1.8	2.5	
BH03	58.00		C	1		LIMESTONE	D	U	YES	60.0	103.0	103.0	93.0	20.6	97.9	2.2	2.9	
BH03	58.30		C	1		LIMESTONE	A	U	YES	45.0	103.0	57.0	46.0	19.3	77.7	3.2	3.9	
BH08	10.80		C	1		LIMESTONE	A	U	NO	55.0	103.0	70.0	62.0	16.9	90.2	2.1	2.7	
BH08	11.50		C	1		LIMESTONE	I	U	YES	39.0	65.0	49.0	41.0	19.8	58.3	5.8	6.3	
BH08	11.70		C	1		LIMESTONE	D	U	NO	59.0	103.0	103.0	98.0	18.4	100.5	1.8	2.5	
BH08	12.50		C	1		LIMESTONE	I	U	NO	55.0	103.0	73.0	66.0	14.9	93.0	1.7	2.3	
BH08	15.70		C	1		LIMESTONE	A	U	YES	17.0	103.0	39.0	33.0	29.6	65.8	6.8	7.7	
BH08	15.90		C	1		LIMESTONE	I	U	YES	51.0	97.0	65.0	60.0	22.3	86.1	3.0	3.8	
BH08	19.20		C	1		LIMESTONE	D	U	YES	52.0	103.0	103.0	98.0	16.0	100.5	1.6	2.2	
BH08	19.40		C	1		LIMESTONE	A	U	NO	16.0	103.0	31.0	27.0	3.6	59.5	1.0	1.1	
BH08	22.40		C	1		LIMESTONE	I	U	NO	30.2	76.0	67.0	57.0	22.6	74.3	4.1	4.9	
BH08	22.60		C	1		LIMESTONE	A	U	YES	31.0	103.0	65.0	58.0	23.5	87.2	3.1	4.0	
BH08	27.00		C	1		LIMESTONE	A	U	NO	32.5	103.0	66.0	61.0	8.9	89.4	1.1	1.4	
BH08	27.40		C	1		LIMESTONE	D	U	NO	55.0	103.0	103.0	95.0	23.3	98.9	2.4	3.2	
BH08	31.50		C	1		LIMESTONE	D	U	YES	55.2	103.0	103.0	96.0	26.3	99.4	2.7	3.6	

Test Type
D - Diametral, A - Axial, I - Irregular Lump, B - Block
Direction
L - parallel to planes of weakness
P - perpendicular to planes of weakness
U - unknown or random
Dimensions
Dps - Distance between platens (platen separation)
Dps' - at failure (see ISRM note 6)
Lne - Length from platens to nearest free end
W - Width of shortest dimension perpendicular to load, P



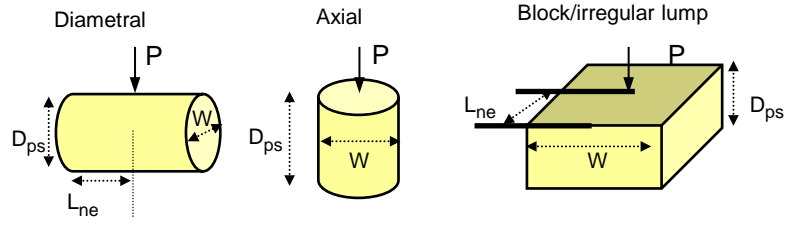
Test performed in accordance with ISRM Suggested Methods : 2007, unless noted otherwise Detailed legend for test and dimensions, based on ISRM, is shown above. Size factor, F = (De/50)0.45 for all tests.	Date Printed 16/11/2015	Approved By	Table 3 sheet 3
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Point Load Strength Index Tests Summary of Results

Project No. 15-664	Project Name GDD Overwater SI
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Borehole No.	Sample			Specimen		Rock Type	Test Type see ISRM		Failure Valid (Y/N)	Dimensions				Force P kN	Equivalent diameter, De mm	Point Load Strength Index		Remarks (including water content if measured)
	Depth m	Ref.	Type	Ref.	Depth m		Type (D, A, I, B)	Direction (L, P or U)		Lne mm	W mm	Dps mm	Dps' mm			Is MPa	Is(50) MPa	
BH08	32.45		C	1		LIMESTONE	A	U	YES	27.3	103.0	44.0	37.0	17.3	69.7	3.6	4.1	
BH08	32.65		C	1		LIMESTONE	D	U	YES	55.0	103.0	103.0	94.0	27.5	98.4	2.8	3.9	
BH08	32.90		C	1		LIMESTONE	A	U	YES	54.0	103.0	103.0	95.0	21.6	111.6	1.7	2.5	
BH08	33.30		C	1		LIMESTONE	A	U	NO	26.0	103.0	55.0	50.0	11.5	81.0	1.8	2.2	
BH08	35.35		C	1		LIMESTONE	A	U	YES	44.0	103.0	84.0	77.0	23.9	100.5	2.4	3.2	
BH08	35.60		C	1		LIMESTONE	D	U	YES	51.0	103.0	103.0	96.0	22.7	99.4	2.3	3.1	
BH08	37.00		C	1		LIMESTONE	D	U	NO	52.0	103.0	103.0	95.0	38.6	98.9	3.9	5.4	
BH08	37.10		C	1		LIMESTONE	A	U	YES	37.0	103.0	65.0	60.0	22.0	88.7	2.8	3.6	
BH08	40.00		C	1		LIMESTONE	D	U	YES	55.0	103.0	103.0	97.0	25.2	100.0	2.5	3.4	
BH08	40.15		C	1		LIMESTONE	D	U	NO	54.0	103.0	103.0	96.0	29.3	99.4	3.0	4.0	
BH08	42.50		C	1		LIMESTONE	A	U	YES	26.0	103.0	50.0	40.0	26.6	72.4	5.1	6.0	
BH08	43.00		C	1		LIMESTONE	D	U	YES	54.9	103.0	103.0	90.0	32.3	96.3	3.5	4.7	
BH08	44.90		C	1		LIMESTONE	A	U	NO	26.0	103.0	47.0	42.0	18.6	74.2	3.4	4.0	
BH08	50.00		C	1		LIMESTONE	D	U	YES	53.0	103.0	103.0	92.0	27.9	97.3	2.9	4.0	

Test Type
D - Diametral, A - Axial, I - Irregular Lump, B - Block
Direction
L - parallel to planes of weakness
P - perpendicular to planes of weakness
U - unknown or random
Dimensions
Dps - Distance between platens (platen separation)
Dps' - at failure (see ISRM note 6)
Lne - Length from platens to nearest free end
W - Width of shortest dimension perpendicular to load, P



Test performed in accordance with ISRM Suggested Methods : 2007, unless noted otherwise Detailed legend for test and dimensions, based on ISRM, is shown above. Size factor, F = (De/50)0.45 for all tests.	Date Printed 16/11/2015	Approved By 	Table 4 sheet 4
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UNIAXIAL COMPRESSION TEST ON ROCK - SUMMARY OF RESULTS

Project No. 15-664 Project Name GDD Overwater SI

Hole No.	Sample				Rock Type	Specimen Dimensions ²			Bulk Density ² Mg/m ³	Water Content ¹ %	Uniaxial Compression ³			Remarks
	Ref	Top	Base	Type		Dia. mm	Length mm	H/D			Condition	Mode of failure	UCS MPa	
BH01		50.10		C	LIMESTONE	103.0	252.0	2.4	2.67	0.2	as received	AC	69.4	
BH01		52.90		C	LIMESTONE	103.0	230.0	2.2	2.68	0.2	as received	S	38.3	
BH01		57.00		C	LIMESTONE	103.0	243.0	2.4	2.67	0.1	as received	AC	51.4	
BH03		25.40		C	LIMESTONE					0.2	as received			Sample broke during preparation
BH03		36.00		C	LIMESTONE	103.0	250.0	2.4	2.66	0.4	as received	MS	14.3	
BH03		46.30		C	LIMESTONE	103.0	205.0	2.0	2.64	0.1	as received	MS	16.7	
BH03		48.30		C	LIMESTONE	103.0	259.0	2.5	2.66	0.1	as received	AC	29.9	
BH08		16.00		C	LIMESTONE	103.0	205.0	2.0	2.63	0.1	as received	AC	43.6	
BH08		31.20		C	LIMESTONE	103.0	220.0	2.1	2.65	0.1	as received	AC	46.6	
BH08		33.00		C	LIMESTONE	103.0	213.0	2.1	2.64	0.2	as received	S	17.9	
BH08		35.40		C	LIMESTONE	103.0	182.0	1.8	2.65	0.1	as received	AC	36.5	

Notes

1 ISRM p87 test 1, water content at 105 ± 3 oC, specimen as tested for UCS Mode of failure :
2 ISRM p86 clause (vii), Caliper method used for determination of bulk volume and derivation of bulk density S - Single shear MS - multiple shear
3 ISRM p153 part 1, determination of Uniaxial Compressive Strength (UCS) of Rock Materials AC - Axial cleavage F - Fragmented
above notes apply unless annotated otherwise in the remarks

Test Specification International Society for Rock Mechanics, The complete ISRM suggested methods for Rock Characterization Testing and Monitoring, 2007	Date Printed 16/11/2015	Approved By Stephen.Watson	Table sheet 1 1
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Unit 4
Heol Aur
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SA14 8QN
Tel: 01554 784040
01554 750752
Fax: 01554 770529
01554 784041
Web: www.geo.uk.com

Certificate of Analysis

Date: 24/11/2015

Client: Causeway Geotech LTD

Our Reference: 29018-121115

Client Reference: 15.664

Contract Title: Greater Dublin Drainage

Description: (Total Samples) 1

Date Received: 12/11/2015

Date Started: 17/11/2015

Date Completed: 24/11/2015

Test Procedures: (B.S. 1377 : PART 3 : 1990)

Notes:


Solid samples will be disposed 1 month and liquids 2 weeks

Approved By:

Authorised Signatories:

Emma Williams
Laboratory Office Manager

Ben Sharp
Contracts Manager


Paul Evans
Quality Manager

Test Report:

Determination of Indirect Tensile Strength by the Brazil Test
ISRM : Document No. 8 : Part 2 : pp. 117-121 (1977).

Date: 19-Nov-15
Contract Number: 29018-121115
Location: Greater Dublin Drainage
Sample Type: Core
Sample Preparation: Capping and Grinding
Operator: Wayne Honey

Borehole Number	Sample Number	Depth (m)	Diameter mm (mm)	Length mm (mm)	Initial mass g (g)	Initial (cm3): Volume	Bulk Density Mg/m ³	Moisture Content %	Dry Density Mg/m ³	Load Failure kN	Maximum Tensile Strength (mpa)	Mode OF FAILURE	Date Tested
BH01		49.10-50.10	102.40	100.30	2218.4	826.13	2.69	0.10	2.68	90.3	5.592	Satisfactory	19-Nov-15
BH01		53.20-53.60	102.00	105.40	2357	861.36	2.74	0.12	2.73	128.2	7.584	Satisfactory	19-Nov-15
BH01		57.00-58.30	102.00	104.30	2335.6	852.38	2.74	0.14	2.74	117.4	7.018	Satisfactory	19-Nov-15

Remarks:

For and behalf of GEO Site & Testing Services Lir

Paul Evans - Technical/Quality Manager

Emma Sharp - Office Manager

Ben Sharp- Contracts Manager

Date Approved:

8.12.15



Test Report: Cerchar Test

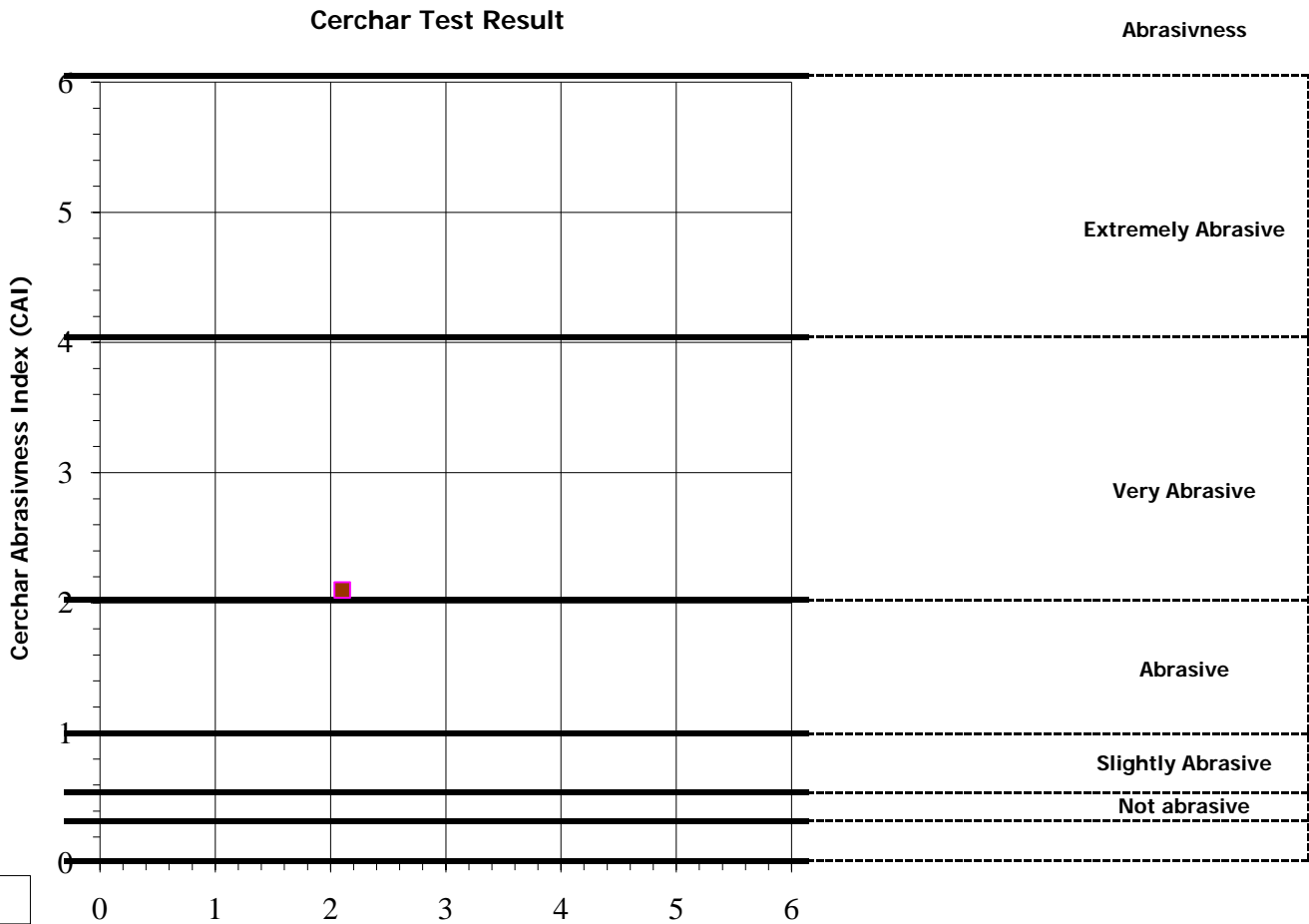
Cerchar Apparatus (1986)

GAI-JTr/JS No. 86-538 - ASTM D7625-10

Client ref: **15-664**
 Location: **Greater Dublin Drainage**
 Contract Number: **29018-121115**
 Date tested: **19/11/2015**
 BH Number: **BH01**
 Sample Number:
 Depth (m) : **52.10-53.20**

Tested By Wayne Honey

Mean Test Result (5 pi	2.1
CA Index	2.1



Sample Tested with a pin of hardened steel with a Rockwell hardness HRC of 54-56



For and behalf of GEO Site & Testing Services Ltd

Authorised By:
 Vaughan Edwards (Managing Director)

Date: **8.12.15**

Test Report: SUGGESTED METHOD FOR POROSITY/DENSITY DETERMINATION USING SATURATION AND CALIPER TECHNIQUES

(Rock Characterization Testing and Monitoring ISRM Suggested Methods Part 1 : 2 : Page 83)

Contract Number: 29018-121115
Location Greater Dublin Drainage
Client Ref 15-664

Borehole Number	BH01	BH01	BH01
Depth (m)	49.10-50.10	52.10-53.20	57.00-58.30
Bulk Density - p (Mg/m3):	2.69	2.73	2.76
Dry Density - pd (Mg/m3):	2.68	2.73	2.75
Bulk Volume - V (g):	98.27	44.59	44.18
Moisture Content - w (%)	0.04	0.16	0.16
Porosity - n (%):	0.3	1.6	1.4



For and behalf of GEO Site & Testing Services Limited

Paul Evans - Technical/Quality Manager

A handwritten signature in black ink, appearing to read 'P Evans', is written over a solid black circular dot.

Date Approved:

08/12/15

Test Report: Cerchar Test

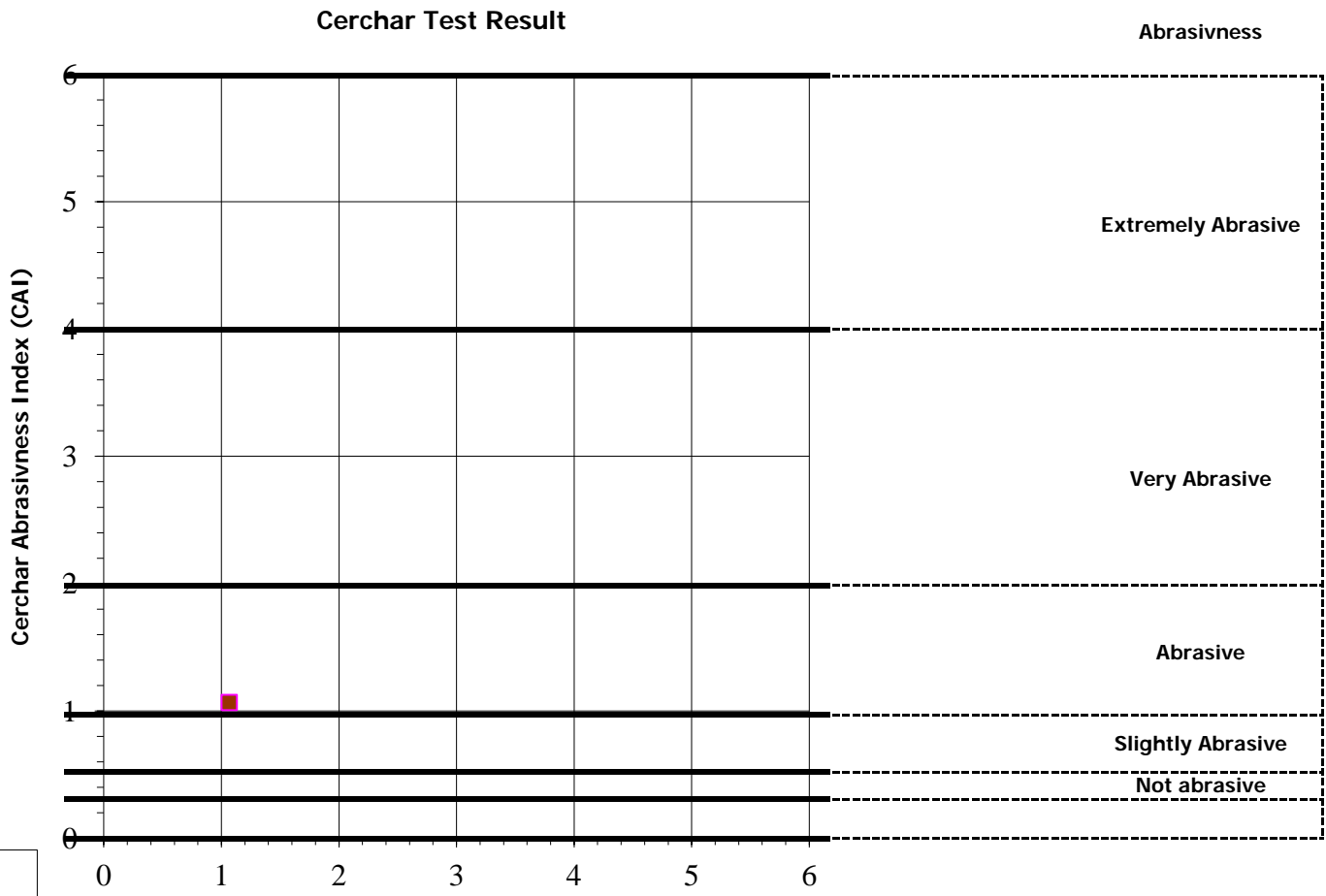
Cerchar Apparatus (1986)

GAI-JTr/JS No. 86-538 - ASTM D7625-10

Client ref: **15-664**
Location: **Greater Dublin Drainage**
Contract Number: **28551-061015**
Date tested: **18/10/2015**
BH Number: **BH03**
Sample Number:
Depth (m) : **46.30 - 47.80**

Tested By Wayne Honey

Mean Test Result (5 pins)	1.0667
CA Index	1.0667



Sample Tested with a pin of hardened steel with a Rockwell hardness HRC of 54-56



For and behalf of GEO Site & Testing Services Ltd

Authorised By:
Vaughan Edwards (Managing Director)

Date: 21.10.15

Test Report: Cerchar Test

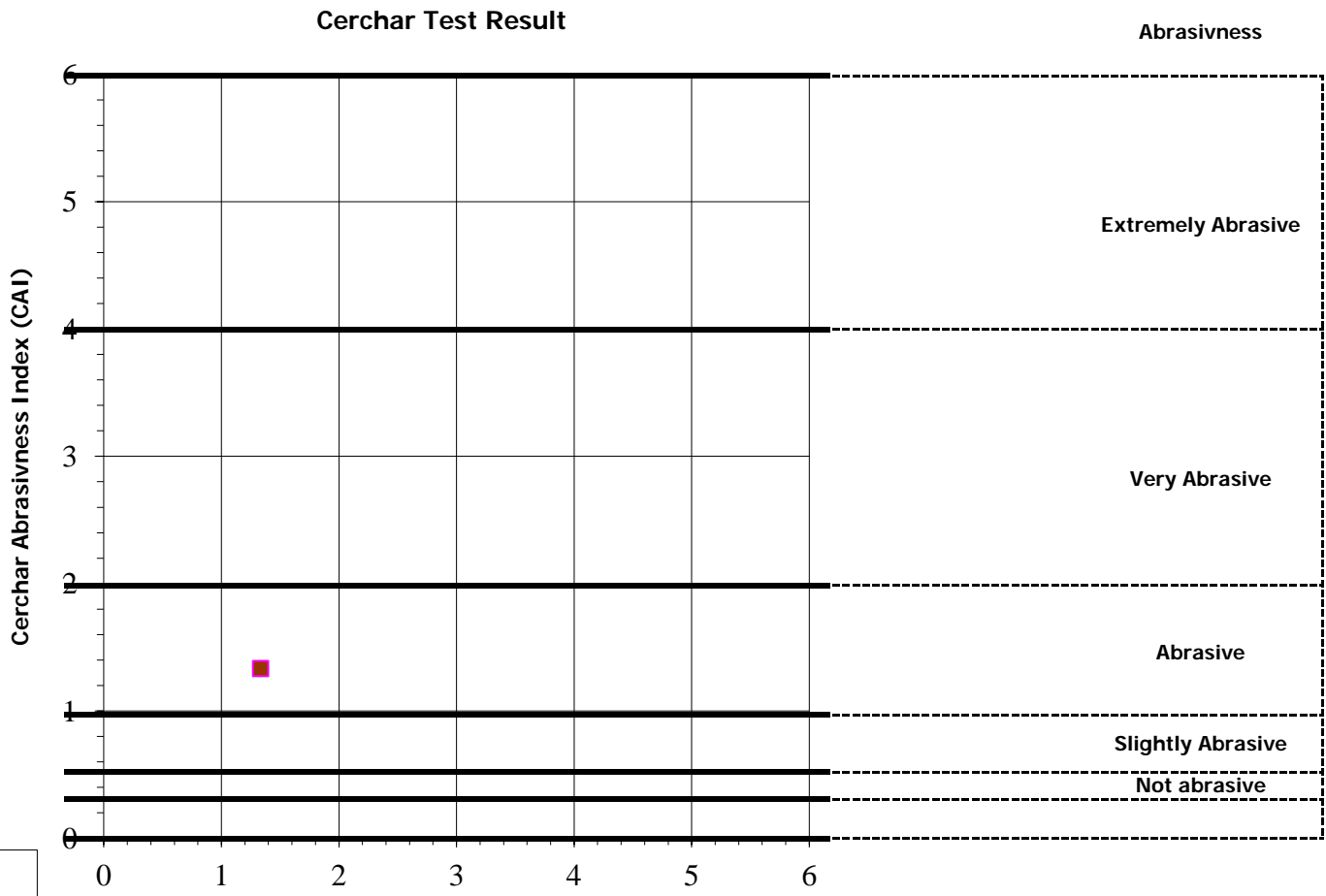
Cerchar Apparatus (1986)

GAI-JTr/JS No. 86-538 - ASTM D7625-10

Client ref: **15-664**
Location: **Greater Dublin Drainage**
Contract Number: **28551-061015**
Date tested: **18/10/2015**
BH Number: **BH05**
Sample Number:
Depth (m) : **48.70 - 50.20**

Tested By Wayne Honey

Mean Test Result (5 pins)	1.3333
CA Index	1.3333



Sample Tested with a pin of hardened steel with a Rockwell hardness HRC of 54-56

Test Report: Cerchar Test

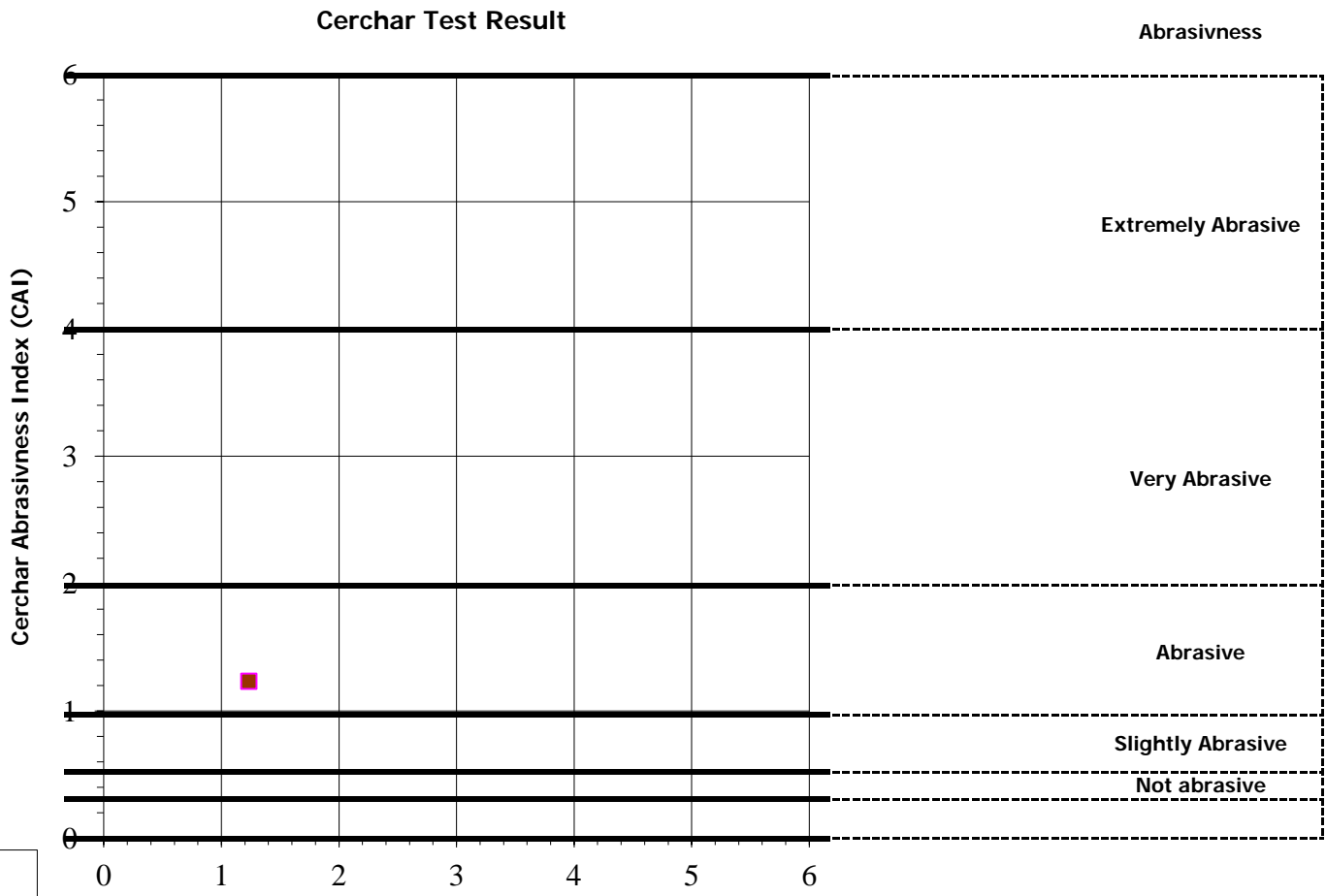
Cerchar Apparatus (1986)

GAI-JTr/JS No. 86-538 - ASTM D7625-10

Client ref: **15-664**
Location: **Greater Dublin Drainage**
Contract Number: **28551-061015**
Date tested: **18/10/2015**
BH Number: **BH08**
Sample Number:
Depth (m) : **35.70 - 36.20**

Tested By Wayne Honey

Mean Test Result (5 pins)	1.2333
CA Index	1.2333



Sample Tested with a pin of hardened steel with a Rockwell hardness HRC of 54-56

Test Report:

**Determination of Indirect Tensile Strength by the Brazil Test
ISRM : Document No. 8 : Part 2 : pp. 117-121 (1977).**

Date: 18-Oct-15
Contract Number: 28551-061015
Location: Greater Dublin Drainage
Sample Type: Core
Sample Preparation: Capping and Grinding
Operator: Wayne Honey

Borehole Number	Sample Number	Depth (m)	Diameter mm (mm)	Length mm (mm)	Initial mass g (g)	Initial (cm3): Volume	Bulk Density Mg/m ³	Moisture Content %	Dry Density Mg/m ³	Load Failure kN	Maximum Tensile Strength (mpa)	Mode OF FAILURE	Date Tested
BH03		25.60 - 26.80	101.70	110.60	2413.8	898.55	2.69	0.10	2.68	67.5	3.817	Satisfactory	18-Oct-15
BH03		35.80 - 37.30	102.00	110.00	2434.5	898.96	2.71	0.10	2.71	88.0	4.988	Satisfactory	18-Oct-15
BH03		46.30 - 47.80	102.10	104.90	2299.3	858.96	2.68	0.20	2.67	98.2	5.831	Satisfactory	18-Oct-15
BH08		35.70 - 36.20	102.00	106.90	2309.4	873.62	2.64	0.10	2.64	94.3	5.500	Satisfactory	18-Oct-15

Remarks:

For and behalf of GEO Site & Testing Services Lir

Paul Evans - Technical/Quality Manager

Emma Sharp - Office Manager

Ben Sharp- Contracts Manager



Date Approved:

21.10.15

Test report

Rock testing for 15-664 Greater Dublin

Determination of Drilling Rate Index™ and Cutter Life Index™ of 4 rock samples

Author

Niklas Haugen



Test report

Rock testing for 15-664 Greater Dublin

Determination of Drilling Rate Index™ and Cutter Life Index™ of 4 rock samples

VERSION 1	DATE 2015-11-13
AUTHOR Niklas Haugen	CLIENT'S REF. Ciaran Doherty
CLIENT Causeway Geotech Ltd	NUMBER OF PAGES/APPENDICES 23
PROJECT NO. 102009979-2	TEST OBJECT RECEIVED 2015-10-12
TEST OBJECT 4 rock samples	DATE OF TEST From 2015-10-13 To 2015-11-12
TEST PROGRAM DRI™, CLI™	TEST LOCATION Geological Engineering laboratory

ABSTRACT

The samples are analysed in order to determine Drilling Rate Index™ (DRI™) and Cutter Life Index™ (CLI™).

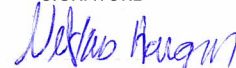
Drilling Rate Index™ (DRI™) and Cutter Life Index™ (CLI™) are determined in accordance with: <http://www.drillability.com>, SINTEF/NTNU (2003), *Suggested Methods for determining DRI™, BWI™ and CLI™*.

The trademarked acronyms and terms Drilling Rate Index™, Cutter Life Index™, DRI™ and CLI™ are unique for test results and calculated indices originating from the NTNU/SINTEF laboratory and can only be obtained by testing samples at our reference laboratory.

The test results relate only to the items tested

PREPARED BY
Niklas Haugen

SIGNATURE



APPROVED BY
Filip Dahl

SIGNATURE



REPORT NO.
15074IG

CLASSIFICATION
Restricted

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1 Executive summary

Test results, calculated indices and classifications are given in the following table.

Sample No. (given by SINTEF)	1	2	3	4
Sample ID (given by the Client)	BH03, 46.30 - 47.80	BH05, 48.70 - 50.20	BH08, 34.20 - 35.70	BH01, 52.10 - 53.00
Brittleness Value (S ₂₀)	50.8 <i>Medium</i>	75.0 <i>Extremely high</i>	46.8 <i>Medium</i>	48.0 <i>Medium</i>
Sievers' J-Value (SJ)	79.7 <i>Very low surface hardness</i>	101.7 <i>Extremely low surface hardness</i>	108.9 <i>Extremely low surface hardness</i>	79.0 <i>Very low surface hardness</i>
Abrasion Value Cutter Steel (AVS)	0.5 <i>Extremely low</i>	1.5 <i>Very low</i>	0.5 <i>Extremely low</i>	2.0 <i>Very low</i>
Drilling Rate Index™ (DRI™)	61 <i>High</i>	87 <i>Extremely high</i>	61 <i>High</i>	58 <i>High</i>
Cutter Life Index™ (CLI™)	97 <i>Extremely high</i>	70 <i>Very high</i>	110 <i>Extremely high</i>	57 <i>Very high</i>

Classification of S₂₀, SJ, and AVS according to Dahl, F., et al. 2012. Classifications of properties influencing the drillability of rocks, based on the NTNU/SINTEF test method. Tunnelling and Underground Space Technology 28 (2012). 150-158.

Classification of DRI™ and CLI™ according to Project Report "13A-98 Drillability Test Methods", published by the Department of Civil and Transport Engineering at the Norwegian University of Science and Technology.

1.1 Remark on sample No. 2, BH05, 48.70 – 50.20

The received *Sample No. 2, BH05, 48.70 - 50.20* consisted of highly weathered/altered rock core sections/fragments and soil particles (*see photo on page 22*). The sample was hence not well suited for rock drillability testing and it was in accordance with the Client decided to separate the intact rock core fragments and perform the testing on a reconstituted sample.

2 Table of rock samples received for testing

(given by the Client)

Sample No. ¹⁾	Exploratory hole number	Sample type: B, J/D, U, P, W, SPT	Sample depth at (m)	Sample depth to (m)
1	BH03	C	46.30	47.80
2	BH05	C	48.70	50.20
3	BH08	C	34.20	35.70
4	BH01	C	52.10	53.00

¹⁾ Given by SINTEF

3 Results DRI™ and CLI™

TEST RESULTS

Sample No. (given by SINTEF)	1	2	3	4
Sample ID (given by the Client)	BH03, 46.30 - 47.80	BH05, 48.70 - 50.20	BH08, 34.20 - 35.70	BH01, C, 52.10 - 53.00
Brittleness Value (S ₂₀ , 11.2 - 16.0 mm)	50.8	75.0	46.8	48.0
Flakiness	1.34	1.30	1.35	1.34
Compaction index	1	3	1	1
Density (g/cm ³)	2.70	2.52	2.69	2.73
Sievers' J-Value (SJ)	79.7	101.7	108.9	79.0
Abrasion Value Cutter Steel (AVS)	0.5	1.5	0.5	2.0

CALCULATED INDICES

Drilling Rate Index™ (DRI)	61	87	61	58
Cutter Life Index™ (CLI)	97	70	110	57

CLASSIFICATION

Category	DRI	CLI
Extremely Low	≤ 25	< 5
Very Low	26 - 32	5.0 - 5.9
Low	33 - 42	6.0 - 7.9
Medium	43 - 57	8.0 - 14.9
High	58 - 69	15 - 34
Very High	70 - 82	35 - 74
Extremely High	≥ 83	≥ 75

4 Comments and remarks on NTNU/SINTEF Drillability tests and test methods

4.1 Brittleness Value (S_{20})

Rock brittleness or the ability to be crushed by repeated impacts is determined by the Brittleness Value. The Brittleness Value test is normally performed on three extractions from one representative and homogenized sample of crushed and sieved rock material and should hence be regarded as representative for the tested rock sample.

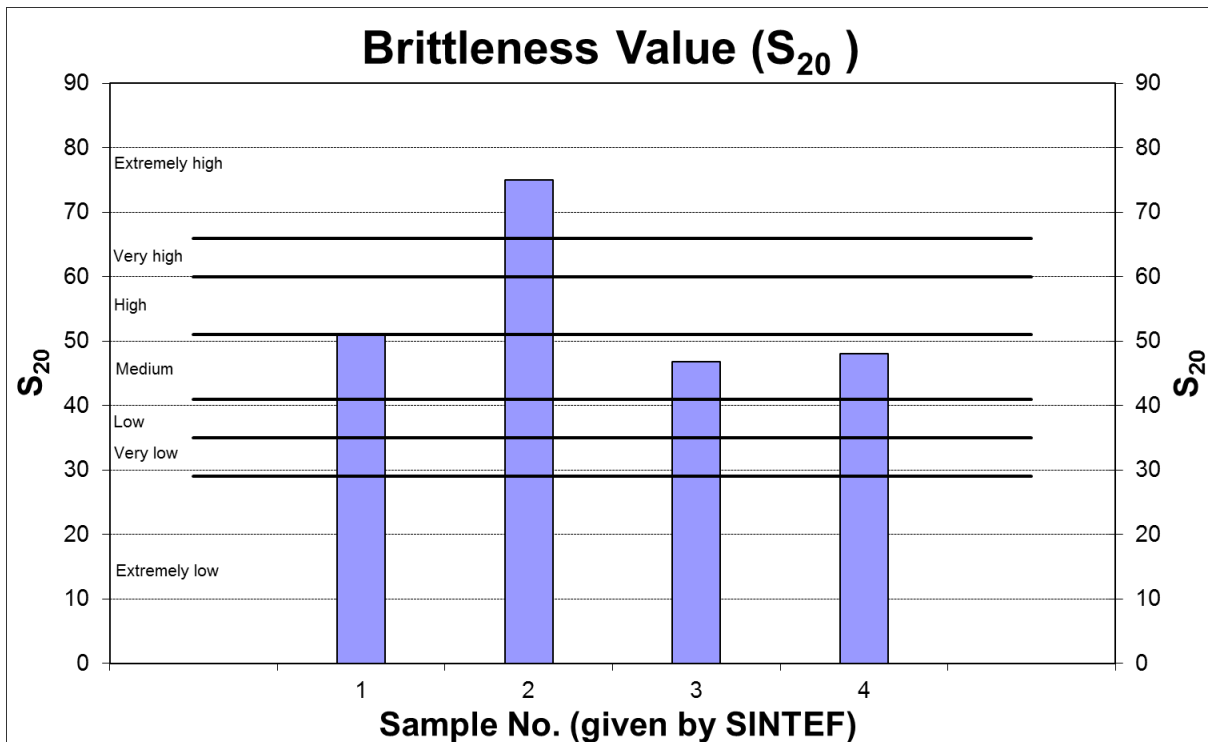


Table 1. Classification of rock brittleness or the ability to be crushed by repeated impacts according to Dahl. F., et al. TUST 28 (2012) 150 -158.

Category – brittleness	Brittleness Value [%]	Cumulative percentage
Extremely low	≤ 29.0	0 – 5 %
Very low	29.1 – 34.9	5 – 15 %
Low	35.0 – 40.9	15 – 35 %
Medium	41.0 – 50.9	35 – 65 %
High	51.0 – 59.9	65 – 85 %
Very high	60.0 – 65.9	85 – 95 %
Extremely high	≥ 66.0	95 – 100 %

4.2 Sievers' J-Value (SJ)

Rock surface hardness or the resistance to indentation is determined by the Sievers' J-Value. The standard number of Sievers' J drillings performed on each sample is 4 to 8, depending on the variation in the texture of the sample. We try to place the holes in soft and hard layers according to a visual interpretation of the composition of the rock. E.g. 60% light and 40% dark layers in a sample would result in 3 holes in the light layer(s) and 2 holes in the dark layer(s). We also try to avoid the soft/hard combination, but we do not always succeed in that matter due to e.g. thin layers of alternating mineral composition.

The Sievers' J charts on pages 14 - 17 show elapsed time in seconds. The Sievers' J-Value is defined as the penetration depth after 200 revolutions and the rotation of the drill bit is hence stopped when this is achieved. As may be seen in some of the graphs, 200 revolutions occur after approximately 67 seconds of drilling.

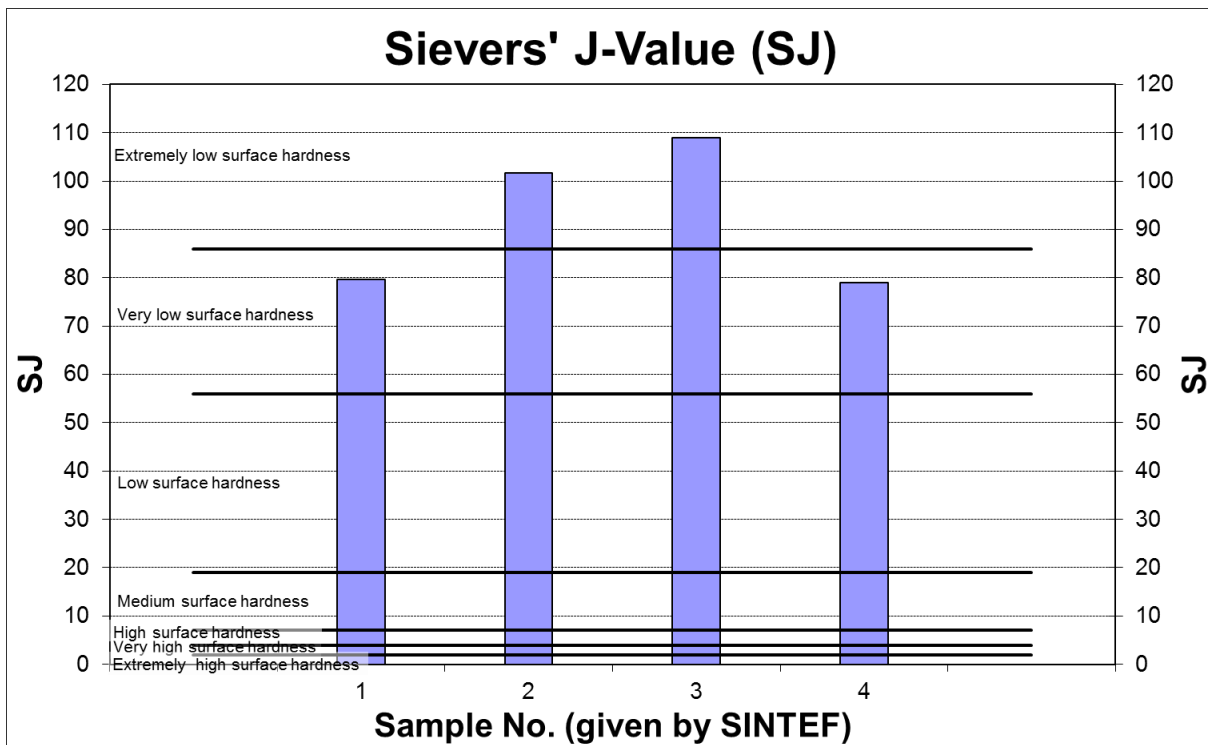


Table 2. Classification of rock surface hardness or the resistance to indentation according to Dahl, F., et al. TUST 28 (2012) 150 -158.

Category – surface hardness	SJ-Value [mm/10]	Cumulative percentage
Extremely high	≤ 2	0 – 5 %
Very high	2.0 – 3.9	5 – 15 %
High	4.0 – 6.9	15 – 35 %
Medium	7.0 – 18.9	35 – 65 %
Low	19.0 – 55.9	65 – 85 %
Very low	56.0 – 85.9	85 – 95 %
Extremely low	≥ 86.0	95 – 100 %

4.3 Abrasion Value Cutter Steel (AVS)

Rock abrasivity or the ability to induce wear on cutter ring steel is determined by the Abrasion Value Cutter Steel. Abrasion test material is taken from the extractions used for the Brittleness test. The AVS tests use test pieces of cutter ring steel. Quartz and other hard minerals will cause abrasion on the test pieces. Grain size, shape and binding are other factors that are believed to have substantial influence on the abrasiveness of the rock.

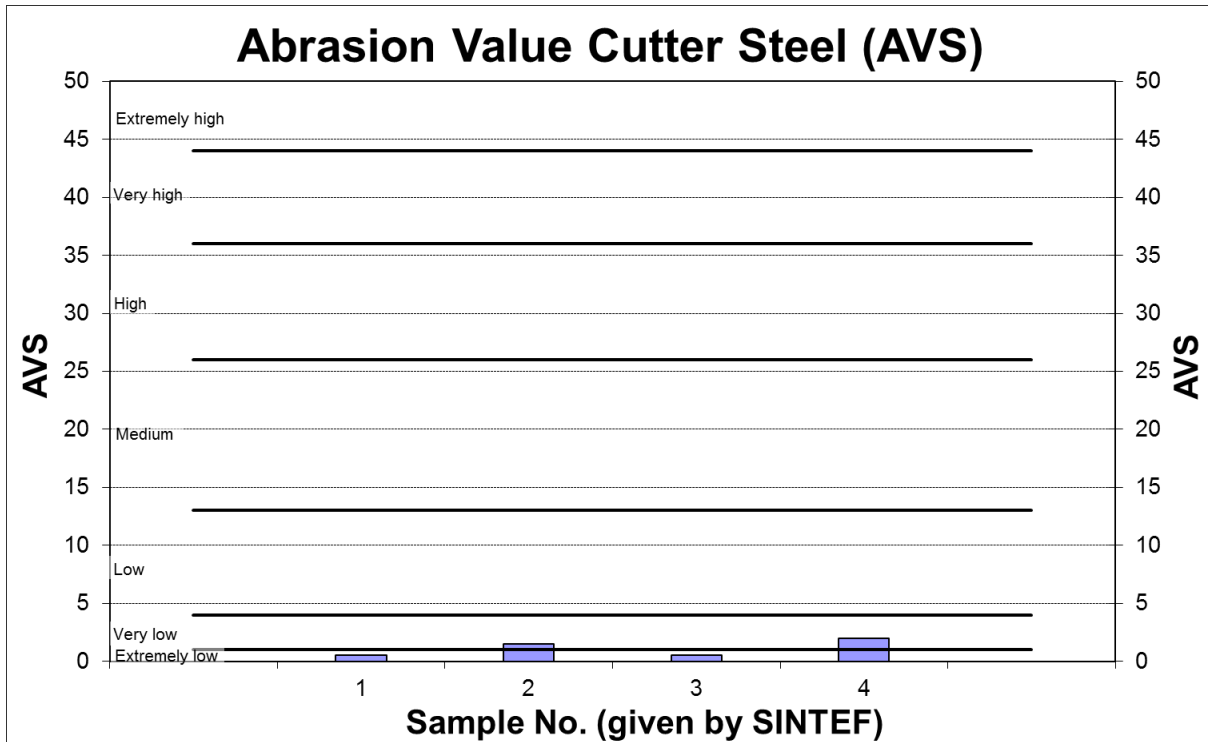


Table 3. Classification of rock abrasivity or the ability to induce wear on cutter ring steel according to Dahl.F., et al. TUST 28 (2012) 150 -158.

Category – cutter steel abrasion	AVS [weight loss mg]	Cumulative percentage
Extremely low	≤ 1.0	0 – 5 %
Very low	1.1 – 3.9	5 – 15 %
Low	4.0 – 12.9	15 – 35 %
Medium	13.0 – 25.9	35 – 65 %
High	26.0 – 35.9	65 – 85 %
Very high	36.0 – 43.9	85 – 95 %
Extremely high	≥ 44.0	95 – 100 %

4.4 Drilling Rate Index™

The Drilling Rate Index™ is assessed on the basis of the Brittleness Value (S_{20}) and the Sievers' J-Value (SJ). The DRI™ may be described as the Brittleness Value corrected for the rock surface hardness (SJ).

Sample No. 2, BH05, 48.70 - 50.20 showed an extremely high DRI™. The cause of the extreme value is the combination of extremely high brittleness (S_{20}) and extremely low surface hardness (SJ), as shown in Table 4.

Table 4. Sample showing extremely high DRI™ and the associated S_{20} and SJ values.

Sample	Drilling Rate Index™ (DRI™)	Brittleness Value (S_{20})	Sievers' J-Value (SJ)
No. 2, BH05, 48.70 - 50.20	87 Extremely high	75.0 Extremely high	101.7 Extremely low surface hardness

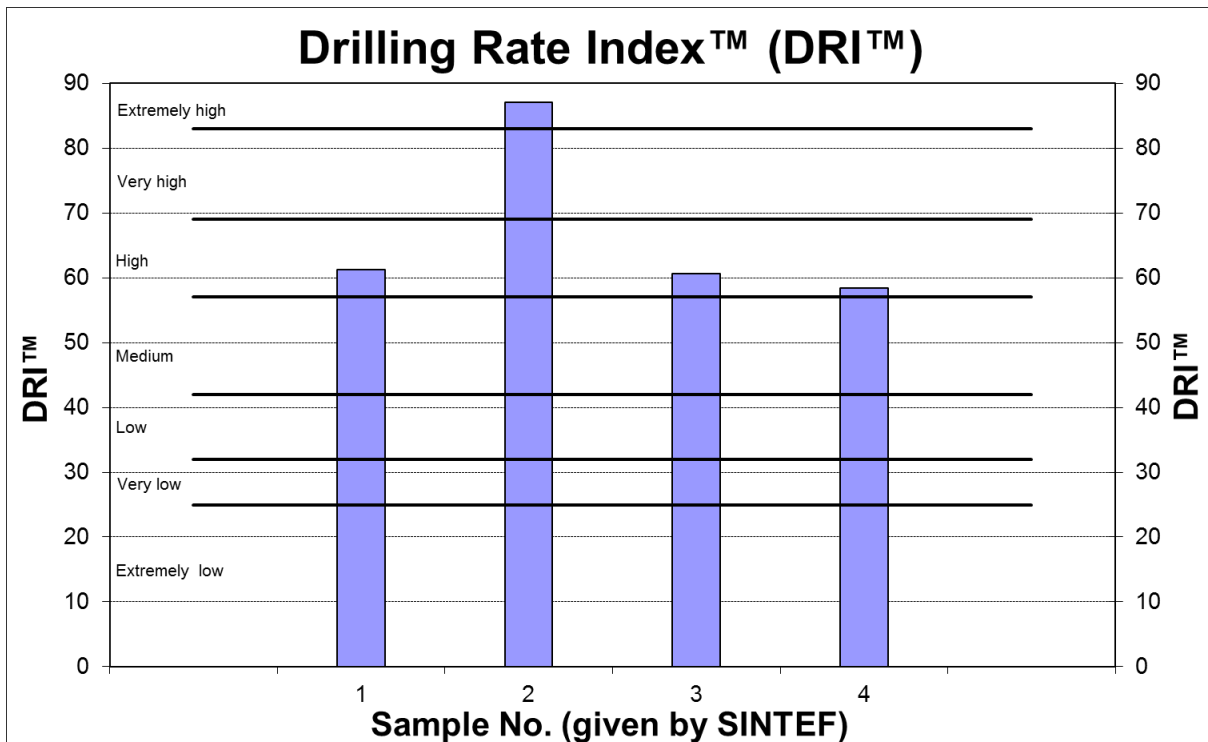


Table 5. Classification of Drilling Rate Index™ according to Project Report “13A-98 Drillability Test Methods”, published by the Department of Civil and Transport Engineering, NTNU.

Category – Drilling rate	Drilling Rate Index™	Cumulative percentage
Extremely low	≤ 25	0 – 5 %
Very low	26 – 32	5 – 15 %
Low	33 – 42	15 – 35 %
Medium	43 – 57	35 – 65 %
High	58 – 69	65 – 85 %
Very high	70 – 82	85 – 95 %
Extremely high	≥ 83	95 – 100 %

4.5 Cutter Life Index™

The Cutter Life Index™ is assessed on the basis of Sievers’ J-Value (SJ) and the Abrasion Value Cutter Steel (AVS). The CLI™ expresses lifetime of TBM disc cutter steel.

Sample No. 1, BH03, C, 46.30 - 47.80 and Sample No. 3, BH08, C, 34.20 - 35.70 showed an extremely high CLI™. The cause of the extreme values are combinations of very low/extremely low hardness and extremely low abrasion on cutter steel, as shown in Table 6.

Table 6. Sample showing extremely high CLI™ and the associated SJ and AVS values.

Sample	Cutter Life Index™ (CLI™)	Sievers' J-Value (SJ)	Abrasion Value Cutter Steel (AVS)
No. 1, BH03, 46.30 - 47.80	97 Extremely high	79.7 Very low surface hardness	0.5 Extremely low
No. 3, BH08, 34.20 - 35.70	110 Extremely high	108.9 Extremely low surface hardness	0.5 Extremely low

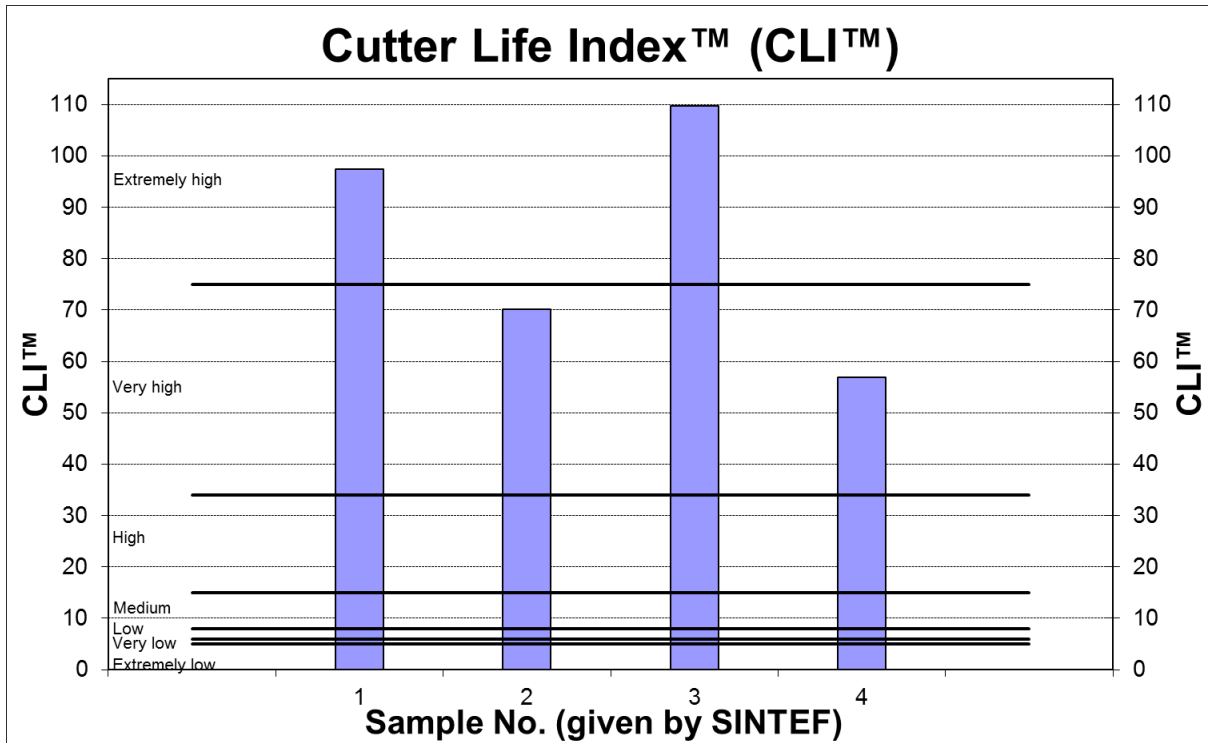


Table 7. Classification of Cutter Life Index™ according to Project Report “13A-98 Drillability Test Methods”, published by the Department of Civil and Transport Engineering, NTNU.

Category – Cutter life	Cutter Life Index™	Cumulative percentage
Extremely low	< 5	0 – 5 %
Very low	5.0 – 5.9	5 – 15 %
Low	6.0 – 7.9	15 – 35 %
Medium	8.0 – 14.9	35 – 65 %
High	15 – 34	65 – 85 %
Very high	35 – 74	85 – 95 %
Extremely high	≥ 75	95 – 100 %

5 Individual values from tests used to determine DRI™ and CLI™

Sample No.: 1 Sample ID: BH03, 46.30 - 47.80

Test No.	Brittleness Value S ₂₀ [%]	Sievers' J-Value SJ [1/10 mm]	Abrasion Value Cutter Steel AVS [mg]
1	48.2	69.5	1
2	53.5	70.4	0
3	50.9	90.7	
4		88.1	
Mean	50.8	79.7	0.5
Stdev	2.65	11.28	0.71

Sample No.: 2 Sample ID: BH05, 48.70 - 50.20

Test No.	Brittleness Value S ₂₀ [%]	Sievers' J-Value SJ [1/10 mm]	Abrasion Value Cutter Steel AVS [mg]
1	76.4	84.1	1
2	74.3	61.2	2
3	74.3	124.9	
4		106.3	
5		65.3	
6		75.2	
7		178.8	
8		118.0	
Mean	75.0	101.7	1.5
Stdev	1.22	39.19	0.71

Sample No.: 3 Sample ID: BH08, 34.20 - 35.70

Test No.	Brittleness Value S ₂₀ [%]	Sievers' J-Value SJ [1/10 mm]	Abrasion Value Cutter Steel AVS [mg]
1	46.0	136.0	0
2	47.8	87.9	1
3	46.6	97.6	
4		85.4	
		97.4	
		149.2	
Mean	46.8	108.9	0.5
Stdev	0.90	26.85	0.71

Sample No.: 4 Sample ID: BH01, 52.10 - 53.00

Test No.	Brittleness Value S_{20} [%]	Sievers' J-Value SJ [1/10 mm]	Abrasion Value Cutter Steel AVS [mg]
1	48.7	68.9	2
2	43.9	69.7	2
3	51.4	84.5	
4		92.8	
Mean	48.0	79.0	2.0
Stdev	3.84	11.66	0.00

6 Sievers' J-Value drillings presented as charts

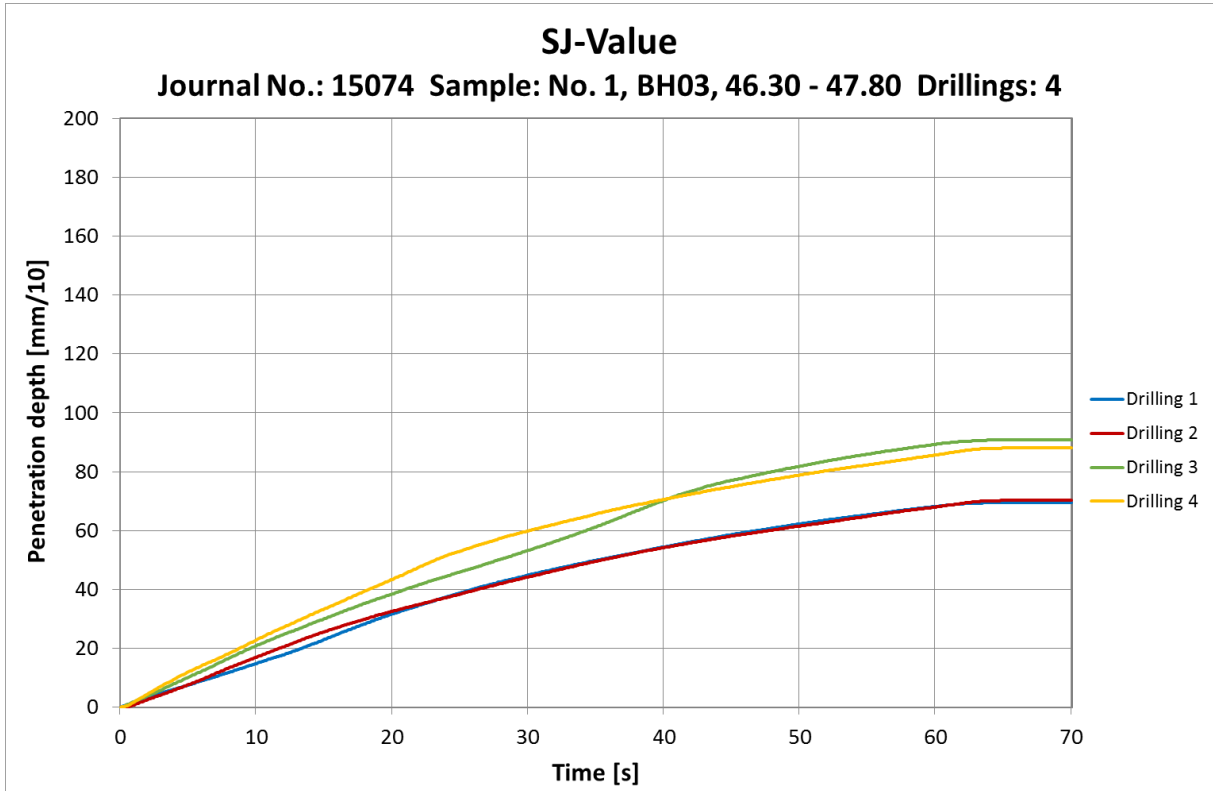


Photo of the Sievers' J (SJ) specimen subsequent to completed testing. The numbered white arrows indicate the position of the drillings.

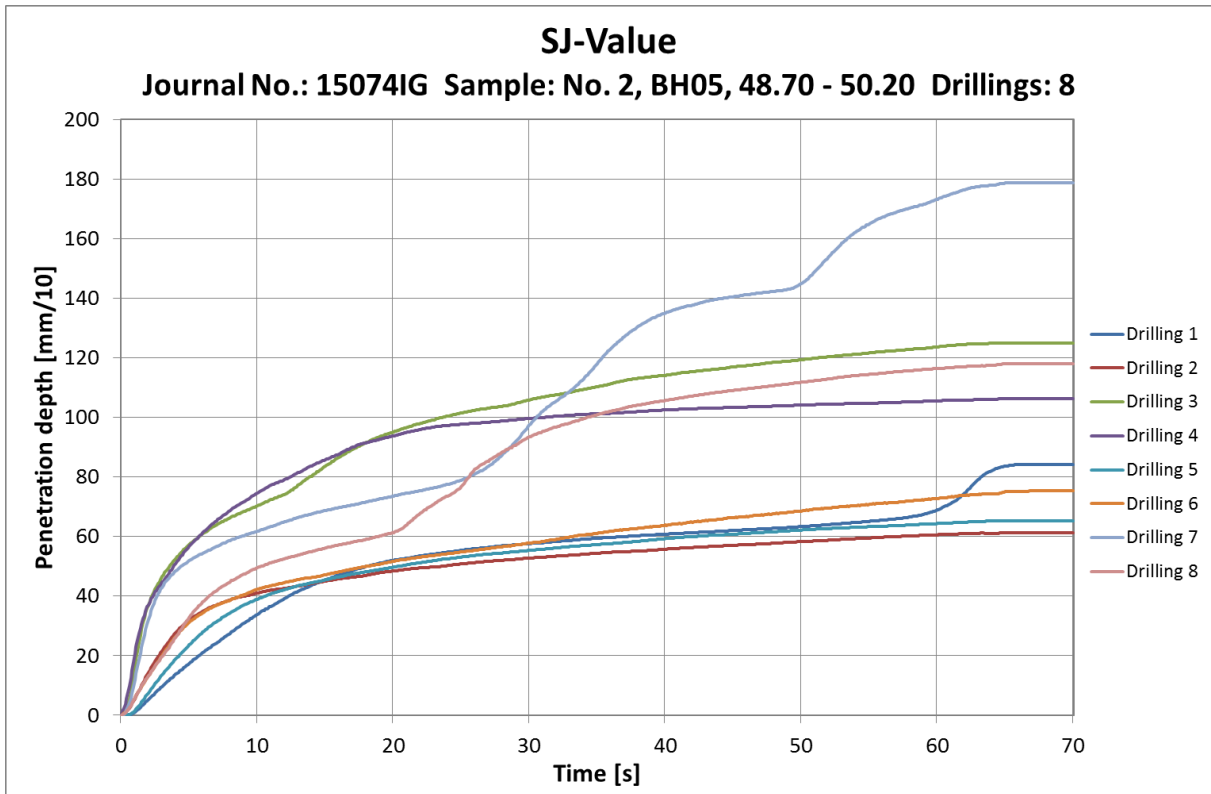


Photo of the Sievers' J (SJ) specimens subsequent to completed testing. The received sample consisted of weathered/alterd rock core sections/fragments and soil particles (see photo on page 22). It was in accordance with the Client hence decided to separate the intact rock core fragments and perform the testing on a reconstituted sample. The selected two core fragments for determination of SJ were, due to the visually observed weak texture, moulded in epoxy prior to testing in order to avoid breakage. The numbered white arrows indicate the position of the drillings.

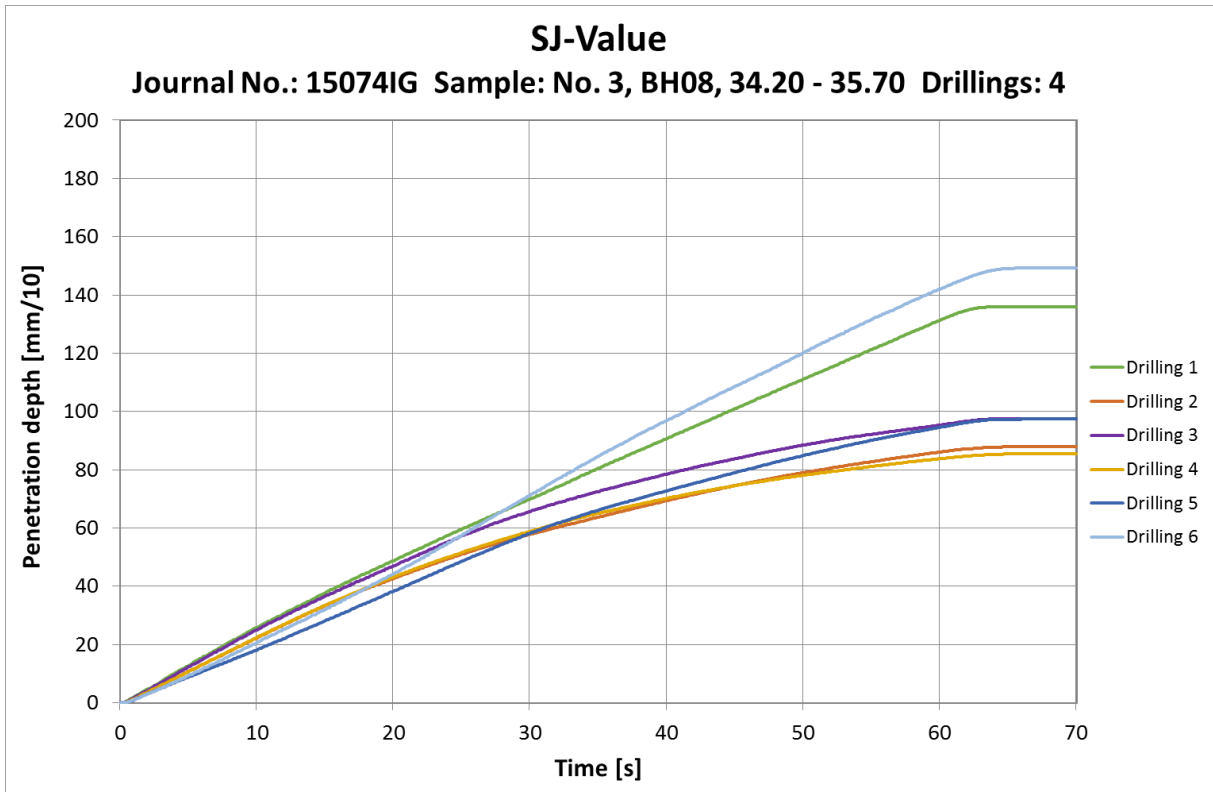


Photo of the Sievers' J (SJ) specimen subsequent to completed testing. The numbered white arrows indicate the position of the drillings. Red X indicates an unsuccessful drilling which not has been used for calculation of the SJ-Value.

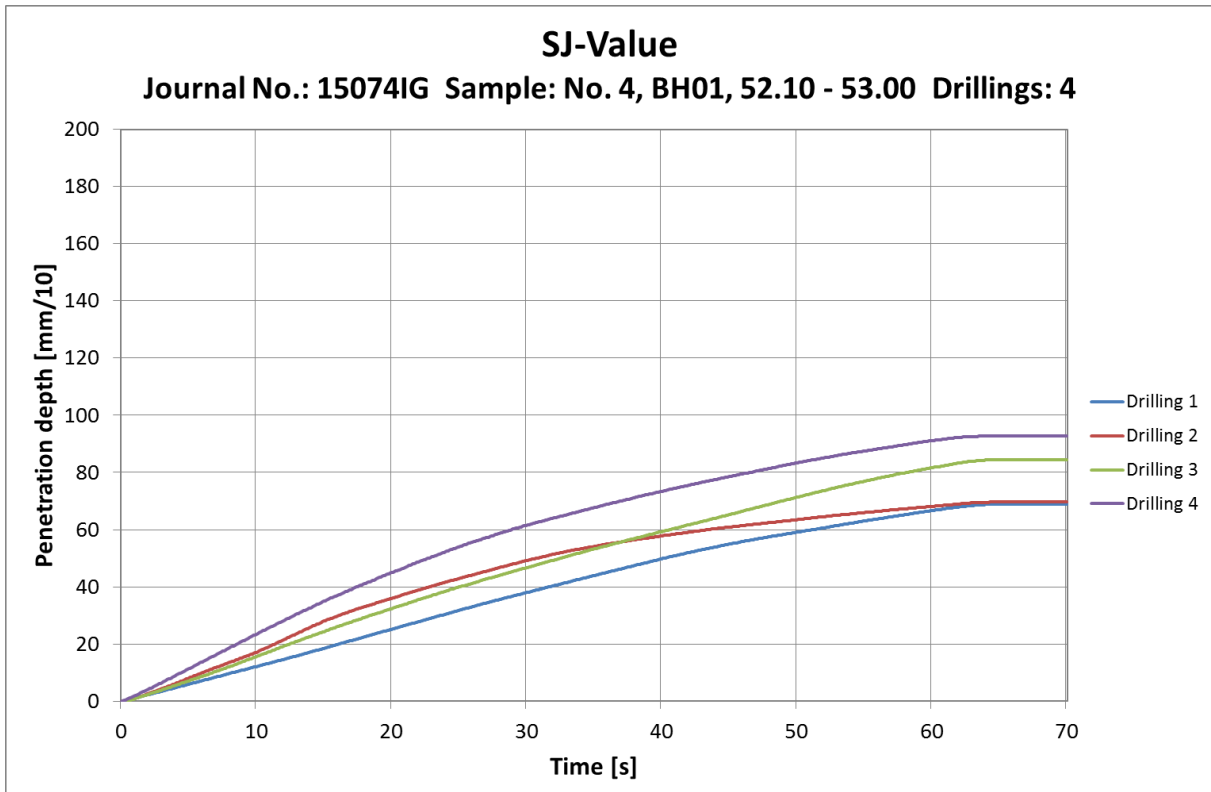


Photo of the Sievers' J (SJ) specimen subsequent to completed testing. The numbered white arrows indicate the position of the drillings.

7 Photographs of the test methods, equipment and methodology



Pre-cutting of a piece from a rock core for determination of Sievers' J-Value.



A section of a rock core sample showing the orientation of the pre-cut Sievers' J piece in relation to the core axis and foliation.



Jaw crusher.



Sieving machine.



Brittleness test equipment.



Brittleness test. Mortar with sample.



A sample prior to impacts.



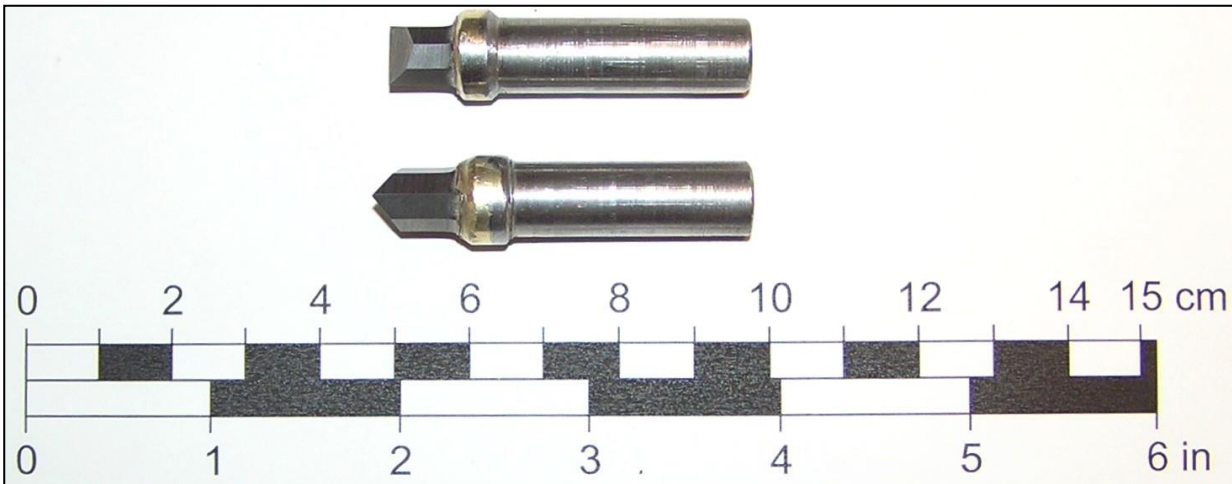
A sample subsequent to 20 impacts.



Sievers' J-Value test equipment.



Close up of drill and Sievers' J piece.



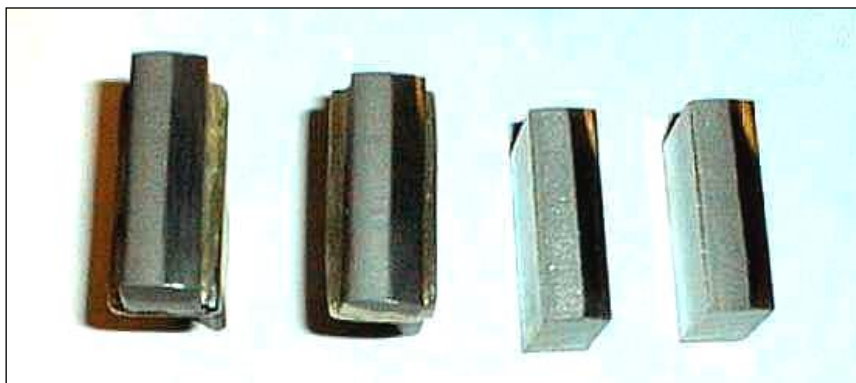
Miniature drills used to determine Sievers' J-Value.



Test equipment used to determine Abrasion Value (AV) and Abrasion Value Cutter Steel (AVS).



Part of a cutter ring, a 10 mm slice taken from the same ring, and two prepared AVS test pieces which are cut out of the centre of the slice.



AV (left) and AVS (right) test pieces subsequent to testing. For scale, the right-hand test piece is 30 mm long.

8 Photographs of the received rock samples



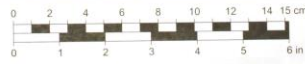
Sample No. 1, "BH03, 46.30 - 47.80".



Sample No. 2, "BH05, 48.70 - 50.20".



Sample No. 3, "BH08, 34.20 - 35.70".



Sample No. 4, "BH01, 52.10 - 53.00".



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Appendix F
Environmental laboratory test results

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Certificate of Analysis

Report No.: 15-46959

Issue No.: 1

Date of Issue 06/10/2015

Customer Details: Darren O'Mahony
Causeway Geotech Ltd
8 Drumahiskey Road
Ballymoney
Co. Antrim
BT53 7QL

Order No.: Not given

Customer Reference: 15-664

Quotation Reference: 150827/10

Description: 13 sediment samples in plastic containers

Date Received: 8/9/2015

Test Methods: Details available on request (refer to SOP code against relevant result/s)

Notes: None



Approved By: **Marco Lattughi, Operational Director**

This certificate is issued in accordance with the accreditation requirements of the United Kingdom Accreditation Service.
Observations and interpretations are outside of the scope of UKAS accreditation.
Results reported herein relate only to the items supplied to the laboratory for testing.



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Results Summary - Dry Weights, Moisture, Total Organic Carbon, TPH, Organotins & Density

Report No.: 15-46959
Customer Reference: 15-664
Order No.: Not given

Customer Sample No	Certified Reference Material	AQC spike	BHVC02 0.1	BHVC02 0.8	BHVC03 0.1	BHVC03 0.8	BHVC04 0.1	BHVC04 0.8	BHVC05 0.1	BHVC05 0.8	BHVC06 0.1	BHVC06 0.8	BHVC07 0.1	BHVC07 1.2	BHVC08 0.1						
			276955	276956	276957	276958	276959	276960	276961	276962	276963	276964	276965	276966	276967						
RPS Sample ID	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT						
Sample Location	CRM-646	Spike on clean sediment (20µg/kg)	0.1	0.8	0.1	0.8	0.1	0.8	0.5	0.8	0.1	0.8	0.1	1.2	0.1						
Sample Depth (m)			/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /					
Sampling Date																					
Sampling Time																					
Determinand	CAS No	Codes	SOP	Units	Result	Recovery %															
dry solids (at 105°C)			In house	%	n/a	n/a	n/a	n/a	81.2	81.7	82.5	79.5	81.8	78.8	81	80.7	80.8	82.2	79.4	81.8	81.3
dry solids (assisted air-drying at <30°C)			208	% w/w	n/a	n/a	n/a	n/a	Completed	Completed	Completed	Completed	Completed	Completed	Completed	Completed	Completed	Completed	Completed	Completed	Completed
carbonate % dry matter			In house	%	n/a	n/a	n/a	n/a	14.7	34	10.1	9.37	10.1	9.38	10.8	18.7	9.8	10.3	10.5	10.6	39.1
total organic carbon*		S		%	n/a	n/a	n/a	n/a	0.09	0.14	0.17	0.16	0.16	0.27	0.11	0.13	0.17	0.16	0.35	0.21	0.29
total petroleum hydrocarbons by GCFID (C10 - C40)			In house	mg/kg	n/a	n/a	n/a	n/a	< 10.00	< 10.00	< 10.00	< 10.00	< 10.00	< 10.00	< 10.00	< 10.00	< 10.00	< 10.00	14.1	< 10.00	15.8
dibutyltin (DBT)	1002-53-5		In house	ug/kg DW	626	81.3	20.02	100.1	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00
tributyltin (TBT)	56573-85-4		In house	ug/kg DW	472	98.3	20.16	100.8	< 2.00	< 2.00	< 2.00	< 2.00	< 2.00	< 2.00	< 2.00	< 2.00	< 2.00	< 2.00	< 2.00	< 2.00	< 2.00
density (on dry solid)			In house	g/cm3	n/a	n/a	n/a	n/a	1.6	1.7	1.5	1.6	1.5	1.5	1.6	1.4	1.5	1.6	1.5	1.7	1.6

Dibutyltin and tributyltin results have been dry weight corrected



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Results Summary - Metals

Report No.: 15-46959
Customer Reference: 15-664
Order No: Not given

Customer Sample No	Standard Reference Material	BHVC02 0.1	BHVC02 0.8	BHVC03 0.1	BHVC03 0.8	BHVC04 0.1	BHVC04 0.8	BHVC05 0.1	BHVC05 0.8	BHVC06 0.1	BHVC06 0.8	BHVC07 0.1	BHVC07 1.2	BHVC08 0.1						
		276955	276956	276957	276958	276959	276960	276961	276962	276963	276964	276965	276966	276967						
Customer Sample ID	Sample Type	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT						
RPS Sample No	Sample Location	SRM-2702																		
Sample Depth (m)	Sampling Date	0.1	0.8	0.1	0.8	0.1	0.8	0.5	0.8	0.1	0.8	0.1	1.2	0.1						
Sampling Time		//	//	//	//	//	//	//	//	//	//	//	//	//						
Determinand	CAS No	Codes	SOP	Mass	Units	Result	Recovery %													
aluminium*	7429-90-5	SI	ICP-MS	27	mg/kg DW	8570	101.9	15000	14000	16100	14200	18200	18300	17200	16600	17200	15400	17600	15900	17700
arsenic*	7440-38-2	SI	ICP-MS	75	mg/kg DW	46.6	102.9	3.67	5.12	6.87	4.73	5.33	6.57	5.63	5.95	11.4	6.66	5.08	6.32	7.82
cadmium*	7440-43-9	SI	ICP-MS	111	mg/kg DW	0.97	118.7	0.21	0.16	0.13	0.14	0.2	0.17	0.13	0.14	0.14	0.12	0.15	0.11	0.12
chromium*	7440-47-3	SI	ICP-MS	52	mg/kg DW	338.3	96.1	35.1	35.1	33.1	27.8	35.5	44.2	27.5	33.6	53.8	31.8	30.3	27.2	27.9
copper*	7440-50-8	SI	ICP-MS	65	mg/kg DW	Not certified	n/a	3.22	3.76	3.87	3.8	4.65	5.79	4.68	4.42	6.7	4.17	5.66	3.8	4.39
lead*	7439-92-1	SI	ICP-MS	208	mg/kg DW	138.8	104.5	7.8	8.69	8.11	10.7	8.83	14.2	8.38	9.19	8.71	8.33	14.5	7.95	7.82
lithium*	7439-93-2	SI	ICP-MS	7	mg/kg DW	Not certified	n/a	14.5	9.67	9.06	4.24	7.97	18.3	8.71	9.11	9.89	7.13	10.1	5.32	8.04
mercury*	7439-97-6	SI	AFS	202	mg/kg DW	0.4	89.4	< 0.01	< 0.01	< 0.01	0.02	0.02	0.02	< 0.01	0.01	0.02	< 0.01	0.02	< 0.01	0.01
nickel*	7440-02-0	SI	ICP-MS	60	mg/kg DW	66.3	87.9	8.23	8.62	9.21	7.4	11	11.1	9.67	10.2	16.1	9.58	9.85	9.44	10.9
zinc*	7440-66-6	SI	ICP-MS	65	mg/kg DW	592.4	122.1	24.9	33.9	32.6	36.2	34.1	51.6	32.1	35.4	54.8	34.4	50.9	33.1	37.2



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Results Summary - Polycyclic Aromatic Hydrocarbons (EPA 16 PAHs)

Report No.: 15-46959
 Customer Reference: 15-664
 Order No: Not given

Customer Sample No	Customer Sample ID	RPS Sample No	Sample Type	Sample Location	Sample Depth (m)	Sampling Date	Sampling Time	Certified Reference Material	AQc spike	BHVC02 0.1	BHVC02 0.8	BHVC03 0.1	BHVC03 0.8	BHVC04 0.1	BHVC04 0.8	BHVC05 0.1	BHVC05 0.8	BHVC06 0.1	BHVC06 0.8	BHVC07 0.1	BHVC07 1.2	BHVC08 0.1
										276955	276956	276957	276958	276959	276960	276961	276962	276963	276964	276965	276966	276967
										SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT
										NIST-1944		Spike on clean sediment (1000mg/kg)		0.1	0.8	0.1	0.8	0.1	0.8	0.5	0.8	0.1
										//	//	//	//	//	//	//	//	//	//	//	//	//
Determinand	CAS No	Codes	SOP	Mass	Units	Result	Recovery %	Result	Recovery %													
naphthalene	91-20-3		304	128	ug/kg DW	Not certified	n/a	1017.7	101.77	7.02	5.26	6.91	7.05	5.99	7.61	7.04	7.56	6.44	7.06	10.60	6.48	9.85
acenaphthylene	208-96-8		304	152	ug/kg DW	Not certified	n/a	1020.9	102.09	7.14	7.10	7.03	7.43	7.09	7.61	7.41	7.56	7.18	7.06	9.94	5.50	9.11
acenaphthene	83-32-9		304	154	ug/kg DW	Not certified	n/a	1044.9	104.49	5.67	5.51	5.58	5.79	5.63	6.09	5.80	5.95	5.70	5.60	23.30	5.50	6.03
fluorene	86-73-7		304	166	ug/kg DW	Not certified	n/a	1059	105.9	6.40	5.99	6.31	6.80	6.36	7.87	6.55	6.69	6.44	6.33	21.00	6.24	7.88
phenanthrene	85-01-8		304	178	ug/kg DW	5086.3	96.5142315	985.8	98.58	5.17	4.40	5.21	7.05	5.38	9.64	5.43	5.33	5.20	5.23	110.00	5.14	11.90
anthracene	120-12-7		304	178	ug/kg DW	Not certified	n/a	996.5	99.65	6.90	6.73	6.67	8.06	6.73	7.49	8.03	6.94	6.81	6.69	30.20	6.73	10.60
fluoranthene	206-44-0		304	202	ug/kg DW	8152.98	91.40112108	1089.4	108.94	6.77	6.12	6.31	14.30	6.36	10.30	6.30	6.45	6.31	6.33	188.00	6.36	6.40
pyrene	129-00-0		304	202	ug/kg DW	8227.51	84.81969072	1097.5	109.75	6.16	5.63	5.70	12.50	5.87	9.64	5.80	5.83	5.82	5.84	169.00	5.87	21.80
benzo(a)anthracene	56-55-3		304	228	ug/kg DW	3772.66	79.92923729	1104.2	110.42	7.39	6.97	7.64	13.10	7.09	9.51	7.04	7.06	7.06	7.06	115.00	7.09	17.40
chrysene	218-01-9		304	228	ug/kg DW	4844.79	99.68703704	1000.8	100.08	4.68	< 0.100	4.49	8.43	4.65	6.34	4.57	4.21	4.58	4.50	82.90	4.65	11.80
benzo(b)fluoranthene	205-99-2		304	252	ug/kg DW	5467.14	91.42374582	966.1	96.61	7.51	6.36	6.67	14.30	6.85	12.30	6.67	6.69	6.56	6.81	130.00	6.73	27.70
benzo(k)fluoranthene	207-08-9		304	252	ug/kg DW	1905.15	82.8326087	861	86.1	6.65	6.24	6.18	9.57	6.24	8.50	6.30	6.32	6.31	6.21	48.50	6.24	13.20
benzo(a)pyrene	50-32-8		304	252	ug/kg DW	3515.21	81.74906977	953.1	95.31	8.13	7.71	7.03	13.20	7.71	10.50	7.78	7.81	7.68	7.67	112.00	7.71	22.50
indeno(1,2,3-c,d)pyrene	192-39-5		304	276	ug/kg DW	772.1	101.7259552	841.3	84.13	7.39	6.85	6.79	9.94	6.85	9.90	6.92	6.94	6.92	6.81	53.40	6.85	15.90
dibenz(a,h)anthracene	53-70-3		304	278	ug/kg DW	2255.18	81.12158273	886.2	88.62	7.14	6.97	6.91	8.18	6.97	7.99	7.04	7.06	7.06	6.94	24.30	6.97	9.85
benzo(g,h)perylene	191-24-2		304	276	ug/kg DW	2650.99	93.34471831	895.9	89.59	7.27	6.48	6.67	9.94	6.73	9.77	6.67	6.69	6.56	6.69	65.80	6.73	17.10

PAH results have been dry weight corrected



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Results Summary - Organochlorine Pesticides & Polychlorinated Biphenyls (ICES 7)

Report No.: 15-46959
 Customer Reference: 15-664
 Order No: Not given

Customer Sample No	Certified Reference Material	AQc spike	BHVC02 0.1	BHVC02 0.8	BHVC03 0.1	BHVC03 0.8	BHVC04 0.1	BHVC04 0.8	BHVC05 0.1	BHVC05 0.8	BHVC06 0.1	BHVC06 0.8	BHVC07 0.1	BHVC07 1.2	BHVC08 0.1	
			276955	276956	276957	276958	276959	276960	276961	276962	276963	276964	276965	276966	276967	
			SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT
			NIST-1944	Spike on clean sediment (25µg/kg)		0.1	0.8	0.1	0.8	0.1	0.8	0.5	0.8	0.1	0.8	0.1
			/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /
Determinand	CAS No	Codes	SOP	Units	Result	Recovery %	Result	Recovery %								
aldrin	309-00-2		In house	ug/kg DW	n/a	n/a	n/a	n/a	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00
alpha-hexachlorocyclohexane (alpha-HCH)	319-84-6		In house	ug/kg DW	n/a	n/a	n/a	n/a	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00
beta-hexachlorocyclohexane (beta-HCH, beta-BHC)	319-85-7		In house	ug/kg DW	n/a	n/a	n/a	n/a	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00
delta-hexachlorocyclohexane (delta-HCH)	319-86-8		In house	ug/kg DW	n/a	n/a	n/a	n/a	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00
gamma-hexachlorocyclohexane (lindane)	58-89-9		In house	ug/kg DW	n/a	n/a	n/a	n/a	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00
hexachlorobenzene (HCB)	118-74-1		In house	ug/kg DW	n/a	n/a	n/a	n/a	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00
cis-chlordane	5103-71-9		In house	ug/kg DW	n/a	n/a	n/a	n/a	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00
trans-chlordane	5103-74-2		In house	ug/kg DW	n/a	n/a	n/a	n/a	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00
dieldrin	60-57-1		In house	ug/kg DW	n/a	n/a	n/a	n/a	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00
endrin	72-20-8		In house	ug/kg DW	n/a	n/a	n/a	n/a	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00
endosulfan A	959-98-8		In house	ug/kg DW	n/a	n/a	n/a	n/a	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00
endosulfan B	33213-65-9		In house	ug/kg DW	n/a	n/a	n/a	n/a	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00
heptachlor	76-44-8		In house	ug/kg DW	n/a	n/a	n/a	n/a	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00
heptachlor epoxide	1024-57-3		In house	ug/kg DW	n/a	n/a	n/a	n/a	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00
methoxychlor	72-43-5		In house	ug/kg DW	n/a	n/a	n/a	n/a	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00
p,p'-DDD	53-19-0		In house	ug/kg DW	n/a	n/a	n/a	n/a	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00
p,p'-DDD	3424-82-6		In house	ug/kg DW	n/a	n/a	n/a	n/a	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00
p,p'-DDT	789-02-6		In house	ug/kg DW	n/a	n/a	n/a	n/a	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00
p,p'-DDT	72-54-8		In house	ug/kg DW	n/a	n/a	n/a	n/a	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00
p,p'-DDE	72-55-9		In house	ug/kg DW	n/a	n/a	n/a	n/a	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00
p,p'-DDE	50-29-3		In house	ug/kg DW	n/a	n/a	n/a	n/a	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00
trilurain	1582-09-8		In house	ug/kg DW	n/a	n/a	n/a	n/a	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00
2,4,4'-trichlorobiphenyl (PCB congener 28)	7012-37-5		319	ug/kg DW	72.3	89.5	27.6	110.2	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20
2,2',5,5'-tetrachlorobiphenyl (PCB congener 52)	35693-99-3		319	ug/kg DW	84.4	106.3	27.7	110.8	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20
2,2',4,5,5'-pentachlorobiphenyl (PCB congener 101)	37680-73-2		319	ug/kg DW	71.7	97.6	28.1	112.5	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20
2,3',4,4',5'-pentachlorobiphenyl (PCB congener 118)	31508-00-6		319	ug/kg DW	60.1	103.6	30.1	120.4	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20
2,2',3,4,4',5'-hexachlorobiphenyl (PCB 138)	35065-28-2		319	ug/kg DW	65.0	104.7	30.1	120.3	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20
2,2',4,4',5',5'-hexachlorobiphenyl (PCB 153)	35065-27-1		319	ug/kg DW	75.4	101.9	29.2	116.8	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20
2,2',3,4,4',5,5'-heptachlorobiphenyl (PCB 180)	35065-29-3		319	ug/kg DW	46.5	104.9	30.6	122.4	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20

OCL and PCB results have been dry weight corrected



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Results Summary - PSA Results

Report No.: 15-46959
Customer Reference: 15-664
Order No.: Not given

Customer Sample No	BHVC02 0.1	BHVC02 0.8	BHVC03 0.1	BHVC03 0.8	BHVC04 0.1	BHVC04 0.8	BHVC05 0.1	BHVC05 0.8	BHVC06 0.1	BHVC06 0.8	BHVC07 0.1	BHVC07 1.2	BHVC08 0.1				
Customer Sample ID																	
RPS Sample No	276955	276956	276957	276958	276959	276960	276961	276962	276963	276964	276965	276966	276967				
Sample Type	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT				
Sample Location																	
Sample Depth (m)	0.1	0.8	0.1	0.8	0.1	0.8	0.5	0.8	0.1	0.8	0.1	1.2	0.1				
Sampling Date	/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /				
Sampling Time																	
Determinand	CAS No	Codes	SOP	Units													
sample type*		S			Unimodal, Well Sorted	Unimodal, Well Sorted	Unimodal, Moderately Sorted	Unimodal, Moderately Well Sorted	Unimodal, Poorly Sorted	Unimodal, Moderately Sorted	Unimodal, Moderately Well Sorted	Unimodal, Moderately Sorted	Unimodal, Poorly Sorted	Unimodal, Moderately Well Sorted	Bimodal, Poorly Sorted		
textural group (GRADISTAT)*		S			Sand	Sand	Sand	Sand	Sand	Sand	Sand	Muddy Sand	Sand	Muddy Sand	Sand	Gravelly Sand	
sediment name*		S			Well Sorted Fine Sand	Well Sorted Fine Sand	Moderately Sorted Fine Sand	Moderately Well Sorted Fine Sand	Poorly Sorted Fine Sand	Moderately Sorted Fine Sand	Moderately Well Sorted Fine Sand	Moderately Sorted Fine Sand	Coarse Silty Fine Sand	Moderately Sorted Fine Sand	Medium Silty Fine Sand	Moderately Well Sorted Fine Sand	Very Fine Gravelly Coarse Sand
arithmetic mean (method of moments)*		S		um	229	221	211	237	176	177	193	199	156	214	195	250	1700
arithmetic sorting (method of moments)*		S		um	66.4	65.3	88.7	81.3	80.7	75.7	78.9	84.1	81.5	94.9	104	100	2270
arithmetic skewness (method of moments)*		S		um	0.759	0.77	0.231	0.903	0.003	0.131	0.245	0.248	0.316	0.015	0.013	0.213	2.86
arithmetic kurtosis (method of moments)*		S		um	3.62	3.67	3.62	3.95	3.34	3.55	3.67	3.66	3.05	3.33	2.87	3.46	14.4
geometric mean (method of moments)*		S		um	216	209	175	221	135	144	163	165	118	168	136	211	742
geometric sorting (method of moments)*		S		um	1.33	1.34	2.24	1.4	2.74	2.39	2.16	2.24	2.67	2.63	3.16	2.18	4.54
geometric skewness (method of moments)*		S		um	-0.014	-0.015	-3.46	0.026	-2.86	-3.35	-3.68	-3.44	-2.47	-3.09	-2.12	-3.97	-1.12
geometric kurtosis (method of moments)*		S		um	2.74	2.73	17.6	2.66	11.4	15.9	19.9	17.4	9.94	13.3	6.96	22.4	5.64
logarithmic mean (method of moments)*		S		phi	2.21	2.26	2.52	2.18	2.89	2.8	2.62	2.6	3.09	2.58	2.88	2.24	0.43
logarithmic sorting (method of moments)*		S		phi	0.414	0.421	1.17	0.484	1.45	1.26	1.11	1.17	1.41	1.39	1.66	1.12	2.18
logarithmic skewness (method of moments)*		S		phi	0.014	0.015	3.46	-0.026	2.86	3.35	3.68	3.44	2.47	3.09	2.12	3.97	1.12
logarithmic kurtosis (method of moments)*		S		phi	2.74	2.73	17.6	2.66	11.4	15.9	19.9	17.4	9.94	13.3	6.96	22.4	5.64
mean (Folk and Ward method - um)*		S		um	216	209	199	220	164	165	183	189	139	203	178	233	838
sorting (Folk and Ward method - um)*		S		um	1.36	1.37	1.73	1.43	2.1	1.82	1.51	1.71	2.14	1.99	2.35	1.52	3.93
skewness (Folk and Ward method - um)*		S		um	-0.009	-0.012	-0.275	0.023	-0.398	-0.318	-0.128	-0.262	-0.339	-0.351	-0.457	-0.085	-0.022
kurtosis (Folk and Ward method - um)*		S		um	1.03	1.01	1.72	0.985	2.53	1.95	1.1	1.7	1.83	2.27	2.46	1.12	1.07
mean (Folk and Ward method - phi)*		S		phi	2.21	2.26	2.33	2.18	2.61	2.6	2.45	2.41	2.84	2.3	2.49	2.11	0.255
sorting (Folk and Ward method - phi)*		S		phi	0.446	0.453	0.789	0.516	1.07	0.863	0.595	0.776	1.1	0.99	1.24	0.599	1.97
skewness (Folk and Ward method - phi)*		S		phi	0.009	0.012	0.275	-0.023	0.398	0.318	0.128	0.262	0.339	0.351	0.457	0.085	0.022
kurtosis (Folk and Ward method - phi)*		S		phi	1.03	1.01	1.72	0.985	2.53	1.95	1.1	1.7	1.83	2.27	2.46	1.12	1.07
mean description (Folk and Ward method)*		S			Fine Sand	Fine Sand	Fine Sand	Fine Sand	Fine Sand	Fine Sand	Fine Sand	Fine Sand	Fine Sand	Fine Sand	Fine Sand	Fine Sand	Coarse Sand
sorting description (Folk and Ward method)*		S			Well Sorted	Well Sorted	Moderately Sorted	Moderately Well Sorted	Poorly Sorted	Moderately Sorted	Moderately Well Sorted	Moderately Sorted	Poorly Sorted	Moderately Sorted	Poorly Sorted	Moderately Well Sorted	Poorly Sorted

skewness description (Folk and Ward method)*		S			Symmetrical	Symmetrical	Fine Skewed	Symmetrical	Very Fine	Very Fine	Fine Skewed	Fine Skewed	Very Fine	Very Fine	Very Fine	Symmetrical	Symmetrical
kurtosis description (Folk and Ward method)*		S			Mesokurtic	Mesokurtic	Very Leptokurtic	Mesokurtic	Very Leptokurtic	Very Leptokurtic	Mesokurtic	Very Leptokurtic	Very Leptokurtic	Very Leptokurtic	Very Leptokurtic	Leptokurtic	Mesokurtic
MODE 1 - um*		S	um		215	215	215	215	215	215	215	215	153	215	215	215	428
MODE 2 - um*		S	um														1700
MODE 3 - um*		S	um														
MODE 1 - phi*		S	phi		2.24	2.24	2.24	2.24	2.24	2.24	2.24	2.24	2.74	2.24	2.24	2.24	1.25
MODE 2 - phi*		S	phi														-0.743
MODE 3 - phi*		S	phi														
D10 - um*		S	um		142	138	112	138	87.4	94.4	103	104	48.6	105	19.1	136	181
D50 - um*		S	um		216	210	202	220	171	170	186	191	147	207	194	236	782
D90 - um*		S	um		324	317	327	344	281	276	302	313	262	334	327	387	4350
(D90/D10) - um*		S	um		2.28	2.31	2.93	2.49	3.21	2.93	2.93	3	5.38	3.18	17.2	2.85	24
(D90 - D10) - um*		S	um		182	180	216	206	193	182	199	209	213	229	308	251	4170
(D75/D25) - um*		S	um		1.47	1.49	1.72	1.61	1.76	1.73	1.71	1.72	2.06	1.76	1.9	1.69	6.24
(D75 - D25) - um*		S	um		85.2	83.3	108	108	96.5	93.5	98.2	101	106	116	120	126	1770
D10 - phi*		S	phi		1.62	1.66	1.61	1.54	1.83	1.86	1.73	1.68	1.93	1.58	1.61	1.37	-2.12
D50 - phi*		S	phi		2.21	2.25	2.31	2.18	2.55	2.56	2.43	2.39	2.77	2.27	2.37	2.09	0.355
D90 - phi*		S	phi		2.82	2.86	3.16	2.86	3.52	3.41	3.28	3.27	4.36	3.25	5.71	2.88	2.47
(D90/D10) - phi*		S	phi		1.73	1.73	1.96	1.85	1.92	1.83	1.9	1.95	2.26	2.06	3.54	2.1	-1.16
(D90 - D10) - phi*		S	phi		1.19	1.21	1.55	1.32	1.68	1.55	1.55	1.59	2.43	1.67	4.1	1.51	4.59
(D75/D25) - phi*		S	phi		1.29	1.29	1.4	1.38	1.38	1.36	1.37	1.38	1.46	1.43	1.47	1.45	-1.46
(D75 - D25) - phi*		S	phi		0.558	0.575	0.781	0.687	0.814	0.79	0.773	0.779	1.05	0.816	0.924	0.753	2.64
% gravel*		S	%		0	0	0	0	0	0	0	0	0	0	0	0	26.2
% sand*		S	%		100	100	94.8	100	91.5	94.2	95.7	94.9	88.9	92.6	86.3	96.3	68.6
% mud*		S	%		0	0	5.22	0	8.5	5.85	4.35	5.15	11.1	7.42	13.7	3.68	5.16
% very coarse gravel (>32<64mm or <-5>-6phi)*		S	%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% coarse gravel (>16<32mm or <-4>-5phi)*		S	%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20
% medium gravel (>8<16mm or <-3>-4phi)*		S	%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.77
% fine gravel (>4<8mm or <-2>-3phi)*		S	%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.31
% very fine gravel (>2<4mm or <-1>-2phi)*		S	%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.90
% very coarse sand (>1<2mm or <0>-1phi)*		S	%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.70
% coarse sand (>0.5<1mm or <1>0phi)*		S	%		0.00	0.00	0.04	0.28	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.47	20.40
% medium sand (>0.25<0.5mm or <2>1phi)*		S	%		29.60	25.90	26.80	34.70	14.50	13.60	19.20	22.00	11.40	30.00	25.90	43.60	19.90
% fine sand (>0.125<0.25mm or <3>2phi)*		S	%		68.30	70.90	60.70	61.20	62.10	63.70	64.10	62.70	50.50	57.20	53.20	49.60	10.50
% very fine sand (>0.0625<0.125mm or <4>3phi)*		S	%		2.07	3.21	7.21	3.84	15.00	16.90	12.30	10.20	27.00	5.37	7.16	2.63	1.26
% very coarse silt (>0.03125<0.0625mm or <5>4phi)*		S	%		0.00	0.00	0.42	0.00	0.25	0.13	0.17	0.28	2.46	0.74	1.10	0.48	0.81
% coarse silt (>0.015625<0.03125mm or <6>5phi)*		S	%		0.00	0.00	1.69	0.00	2.21	1.70	1.45	1.63	2.96	1.74	3.67	0.55	0.96
% medium silt (>0.007813<0.015625mm or <7>6phi)*		S	%		0.00	0.00	0.92	0.00	1.54	0.89	0.57	0.90	1.75	1.37	3.85	0.58	1.19
% fine silt (>0.003906<0.007813mm or <8>7phi)*		S	%		0.00	0.00	0.98	0.00	1.83	1.18	0.83	1.04	1.64	1.57	2.93	0.85	1.09
% very fine silt (>0.001953<0.003906mm or <9>8phi)*		S	%		0.00	0.00	0.62	0.00	1.49	1.04	0.70	0.69	1.30	1.08	1.33	0.63	0.70
% clay (<0.001953mm or >9phi)*		S	%		0.00	0.00	0.60	0.00	1.18	0.92	0.64	0.60	1.01	0.91	0.83	0.58	0.42



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Results Summary - PSA Size Class & Statistics

Report No.: 15-46959

Customer Reference: 15-664

Order No: Not given

Customer Sample No	BHVC02 0.1	BHVC02 0.8	BHVC03 0.1	BHVC03 0.8	BHVC04 0.1	BHVC04 0.8	BHVC05 0.1	BHVC05 0.8	BHVC06 0.1	BHVC06 0.8	BHVC07 0.1	BHVC07 1.2	BHVC08 0.1
Customer Sample ID													
RPS Sample No	276955	276956	276957	276958	276959	276960	276961	276962	276963	276964	276965	276966	276967
Sample Type	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT
Sample Location													
Sample Depth (m)	0.1	0.8	0.1	0.8	0.1	0.8	0.5	0.8	0.1	0.8	0.1	1.2	0.1
Sampling Date	//	//	//	//	//	//	//	//	//	//	//	//	//
Sampling Time													
Sediment	mm	phi φ	Units										
Very coarse gravel	>32<64	<-5>-6	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coarse gravel	>16<32	<-4>-5	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20
Medium gravel	>8<16	<-3>-4	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.77
Fine gravel	>4<8	<-2>-3	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.31
Very fine gravel	>2<4	<-1>-2	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.90
Very coarse sand	>1<2	<0>-1	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.70
Coarse sand	>0.5<1	<1>0	%	0.00	0.00	0.04	0.28	0.00	0.00	0.01	0.00	0.00	20.40
Medium sand	>0.25<0.5	<2>1	%	29.60	25.90	26.80	34.70	14.50	13.60	19.20	22.00	11.40	19.90
Fine sand	>0.125<0.25	<3>2	%	68.30	70.90	60.70	61.20	62.10	63.70	64.10	62.70	50.50	10.50
Very fine sand	>0.0625<0.125	<4>3	%	2.07	3.21	7.21	3.84	15.00	16.90	12.30	10.20	27.00	1.26
Very coarse silt	>0.03125<0.0625	<5>4	%	0.00	0.00	0.42	0.00	0.25	0.13	0.17	0.28	2.46	0.81
Coarse silt	>0.015625<0.03125	<6>5	%	0.00	0.00	1.69	0.00	2.21	1.70	1.45	1.63	2.96	0.96
Medium silt	>0.007813<0.015625	<7>6	%	0.00	0.00	0.92	0.00	1.54	0.89	0.57	0.90	1.75	1.19
Fine silt	>0.003906<0.007813	<8>7	%	0.00	0.00	0.98	0.00	1.83	1.18	0.83	1.04	1.64	1.09
Very fine silt	>0.001953<0.003906	<9>8	%	0.00	0.00	0.62	0.00	1.49	1.04	0.70	0.69	1.30	0.70
Clay	<0.001953	>9	%	0.00	0.00	0.60	0.00	1.18	0.92	0.64	0.60	1.01	0.42
Statistics*	Mean (phi)			2.21	2.26	2.33	2.18	2.61	2.6	2.45	2.41	2.84	2.3
	Sorting			0.446	0.453	0.789	0.516	1.07	0.863	0.595	0.776	1.1	0.99
	Skewness			0.009	0.012	0.275	-0.023	0.398	0.318	0.128	0.262	0.339	0.351
	Kurtosis			1.03	1.01	1.72	0.985	2.53	1.95	1.1	1.7	1.83	2.27
	% Silt/Clay	%		0.00	0.00	5.23	0.00	8.50	5.86	4.36	5.14	11.12	7.41
Textural Group**				Sand	Sand	Sand	Sand	Sand	Sand	Sand	Muddy Sand	Sand	
												Muddy Sand	Sand
													Sand
													Gravelly Sand

* Folk & Ward

** GRADISTAT classification system (Blott, S. J. & Pye, K., 2001)



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Results Summary - PSA Wentworth Scale

Report No.: 15-46959

Customer Reference: 15-664

Order No: Not given

Customer Sample No	BHVC02 0.1	BHVC02 0.8	BHVC03 0.1	BHVC03 0.8	BHVC04 0.1	BHVC04 0.8	BHVC05 0.1	BHVC05 0.8	BHVC06 0.1	BHVC06 0.8	BHVC07 0.1	BHVC07 1.2	BHVC08 0.1
Customer Sample ID													
RPS Sample No	276955	276956	276957	276958	276959	276960	276961	276962	276963	276964	276965	276966	276967
Sample Type	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT
Sample Location													
Sample Depth (m)	0.1	0.8	0.1	0.8	0.1	0.8	0.5	0.8	0.1	0.8	0.1	1.2	0.1
Sampling Date	//	//	//	//	//	//	//	//	//	//	//	//	//
Sampling Time													
Parameter	Units												
Pebble	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.28
Granule	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.90
Very coarse sand	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.70
Coarse sand	%	0.00	0.00	0.04	0.28	0.00	0.00	0.00	0.01	0.00	0.01	0.00	20.40
Medium sand	%	29.60	25.90	26.80	34.70	14.50	13.60	19.20	22.00	11.40	30.00	25.90	19.90
Fine sand	%	68.30	70.90	60.70	61.20	62.10	63.70	64.10	62.70	50.50	57.20	53.20	10.50
Very fine sand	%	2.07	3.21	7.21	3.84	15.00	16.90	12.30	10.20	27.00	5.37	7.16	1.26
Silt Clay	%	0.00	0.00	5.23	0.00	8.50	5.86	4.36	5.14	11.12	7.41	13.71	5.17
Total	%	100.0	100.0	100.0	100.0	100.1	100.1	100.0	100.1	100.0	100.0	100.0	100.1



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Report No.: 15-46959
Customer Reference: 15-664
Order No: Not given

Comments

Job	Description	Job Comments
15-46959	13 sediment samples in plastic containers	n/a



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Report Information

Key to Report Codes

U	UKAS Accredited
M	MCERTS Accredited
S	Subcontracted to approved laboratory
US	Subcontracted to approved laboratory UKAS Accredited for the test
MS	Subcontracted to approved laboratory MCERTS/UKAS Accredited for the test
SI	Subcontracted to internal RPS Group Laboratory
USI	Subcontracted to internal RPS Group Laboratory UKAS Accredited for the test
MSI	Subcontracted to internal RPS Group Laboratory MCERTS/UKAS Accredited for the test
I/S (in results)	Insufficient Sample
U/S (in results)	Unsuitable sample
S/C (in results)	See Comments
ND (in results)	Not Detected
DW (in units)	Results are expressed on a dry weight basis

Sample Retention and Disposal

Samples will generally* be retained for the following times prior to disposal:

Perishables, e.g. foodstuffs	1 month (if frozen) from the issue date of this report
Waters	2 weeks from the issue date of this report
Other Liquids	1 months from the issue date of this report
Solids (including Soils)	1 months from the issue date of this report

*Sample retention may be subject to agreement with the customer for particular projects

Analytical Methods

PAH's and PCB's	GCMS analysis following extraction of the wet sediment with hexane:acetone by ultrasonic and equilibrium extraction. Extract cleaned-up with alumina and activated copper.
Metals	ICP-MS analysis following microwave assisted digestion in hydrofluoric acid of the dried (<30°C) and ground sediment.
TOC	Combustion and infrared analysis following carbonate removal with hydrochloric acid.
PSA	Wet and dry sieving followed by laser diffraction analysis.
Density	Determination of density from the dry sediment by gravimetric analysis of a known volume of sediment.
Dry solids at 105°C	A portion of the wet sediment is dried at 105°C to constant weight.
TBT and DBT	GCMS analysis following the extraction of the wet sediment and subsequent derivatisation.

Please note:

All testing carried out using the <2mm fraction

Laboratories

RPS Letchworth	UKAS Test House 1663
RPS Manchester (Metals only)	UKAS Test House 0605
ESG Scientifics (TOC only)	UKAS Test House 0001
Thompson PSA only	

Proficiency Testing (PT)

RPS Letchworth and Manchester Laboratories participate in the QUASIMEME Proficiency Testing Scheme

Appendix G
SPT hammer energy measurement report



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SPT Calibration Report

Hammer Energy Measurement Report

Type of Hammer: SPTL
 Client: CAUSEWAY DRILLING
 Test No: EQU1175
 Test Depth (m): 6.50
 Date of Test: **10 January 2015**
 Valid until: **10 January 2016**
 Hammer ID: **CC1**

Mass of the hammer $m = 63.5\text{kg}$
 Falling height $h = 0.76\text{m}$
 $E_{\text{theor}} = m \times g \times h = 473\text{J}$

Characteristics of the instrumented rod

Diameter $d_r = 0.052\text{ m}$
 Length of the instrumented rod 0.558 m
 Area $A = 11.61\text{ cm}^2$
 Modulus $E_a = 206843\text{ MPa}$

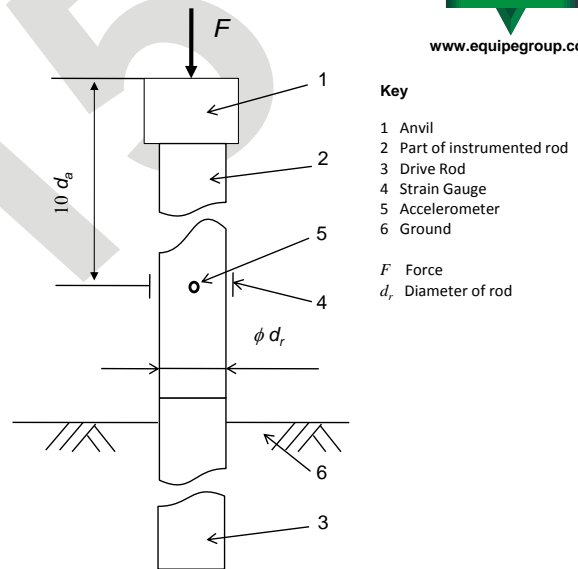
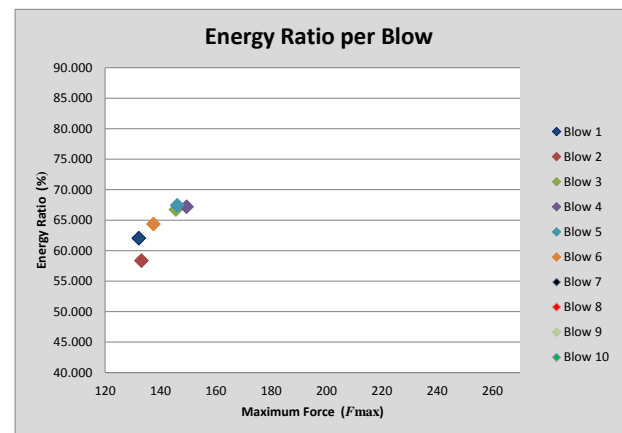
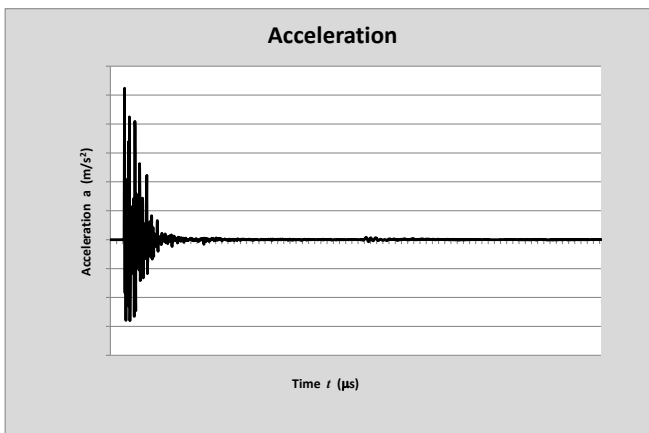
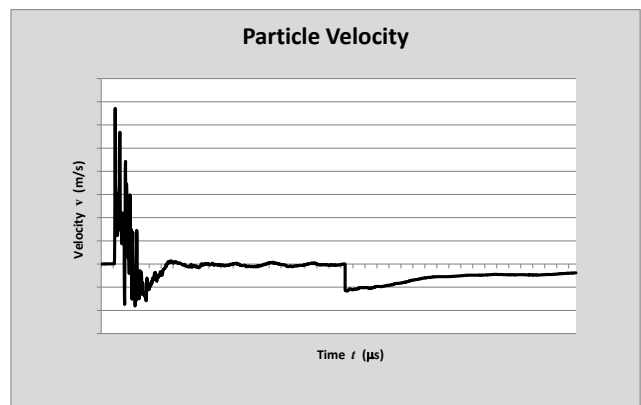
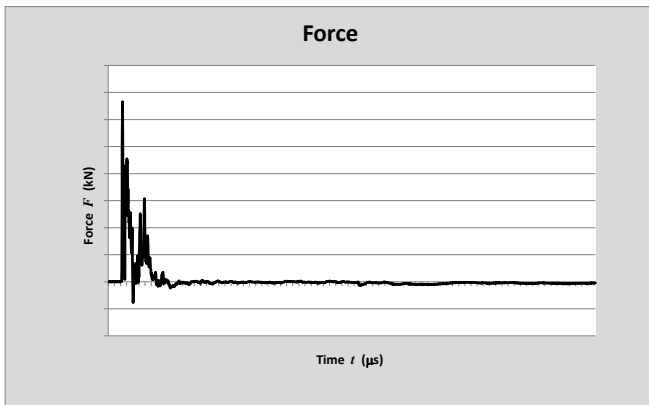


Fig. B.1 and B.2 BS EN ISO 22476-3 : 2005 + A1 : 2011



Observations:
1.

$E_{\text{meas}} = 0.290\text{ kN-m}$
 $E_{\text{theor}} = 0.473\text{ kN-m}$

$$\text{Energy Ratio} = \frac{E_{\text{meas}}}{E_{\text{theor}}} = 61.28\%$$

Equipe SPT Analyzer Operators: MH

Prepared by: *[Signature]* Checked by: _____ Date: 10/06/2015