Appendix E4
Report No. 20-0399C

BusConnects Route 8 Tallaght/Clondalkin to City Centre - Ground Investigation

Bus Connects Route 8 Tallaght/Clondalkin to City Centre – Ground Investigation

Client:	National Transport Authority (NTA)
Client's Representative:	AECOM/Mott MacDonald
Report No.:	20-0399C
Date:	December 2020
Status:	Final for Issue

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APPENDICES

Document Control Sheet

Report No.:		20-0399C			
Project Title:		Bus Connects Route 8 Tallaght/Clondalkin to City Centre			
Client:		National Transport Authority (NTA)			
Client's Representative:		AECOM/Mott MacDonald			
Revision:	A01	**Status:**	Final for Issue	**Issue Date:**	14th December 2020
Prepared by:		**Reviewed by:**		**Approved by:**	
 Sean Ross BSc MSc MIEI		 Colm Hurley BSc FGS PGeo		 Darren O'Mahony BSc MSc MIEI EurGeol PGeo	

The works were conducted in accordance with:

British Standards Institute (2015) BS 5930:2015, Code of practice for site investigations.

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

Geotechnical Society of Ireland (2016), Specification & Related Documents for Ground Investigation in Ireland

Laboratory testing was conducted in accordance with:

British Standards Institute BS 1377:1990 parts 2, 4, 5, 7 and 9

METHODS OF DESCRIBING SOILS AND ROCKS

Soil and rock descriptions are based on the guidance in BS5930:2015, The Code of Practice for Site Investigation.

Abbreviations used on exploratory hole logs	
U	Nominal 100mm diameter undisturbed open tube sample (thick walled sampler).
UT	Nominal 100mm diameter undisturbed open tube sample (thin walled sampler).
P	Nominal 100mm diameter undisturbed piston sample.
B	Bulk disturbed sample.
LB	Large bulk disturbed sample.
D	Small disturbed sample.
C	Core sub-sample (displayed in the Field Records column on the logs).
L	Liner sample from dynamic sampled borehole.
W	Water sample.
ES / EW	Soil sample for environmental testing / Water sample for environmental testing.
SPT (s)	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.
(Y for Z/ Y for Z)	Incomplete standard penetration test where the full test length was not achieved. The blows 'X' represent the total blows for the given seating or test length 'Z' (mm).
N=X	SPT blow count 'N' given by the summation of the blows 'X' required to drive the full test length (300mm).
HVP / HVR	In situ hand vane test result (HVP) and vane test residual result (HVR). Results presented in kPa.
V VR	Shear vane test (borehole). Shear strength stated in kPa. V: undisturbed vane shear strength VR: remoulded vane shear strength
Soil consistency description	In cohesive soils, where samples are disturbed and there are no suitable laboratory tests, N values may be used to indicate consistency on borehole logs – a median relationship of Nx5=Cu is used (as set out in Stroud & Butler 1975).
dd-mm-yyyy	Date at the end and start of shifts, shown at the relevant borehole depth. Corresponding casing and water depths shown in the adjacent columns.
▽	Water strike: initial depth of strike.
▼	Water strike: depth water rose to.
Abbreviations relating to rock core – reference Clause 36.4.4 of BS 5930: 2015	
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.
(xxx/xxx/xxx)	Spacing between discontinuities (minimum/average/maximum) measured in millimetres.

Bus Connects Route 8 Tallaght/Clondalkin to City Centre

1 AUTHORITY

On the instructions of AECOM/Mott MacDonald, ("the Client's Representative"), acting on the behalf of National Transport Authority (NTA) ("the Client"), a ground investigation was undertaken at the above location to provide geotechnical and environmental information to inform the planning stage design and enable the design of Bus Connects Core Bus Corridors.

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. It should be noted that groundwater levels usually vary due to seasonal and/or other effects and may at times differ to those recorded during the investigation. No responsibility can be taken for conditions not encountered through the scope of work commissioned, for example between exploratory hole points, or beneath the termination depths achieved.

This report was prepared by Causeway Geotech Ltd for the use of the Client and the Client's Representative in response to a particular set of 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 boreholes, soil and rock core sampling, environmental sampling, groundwater monitoring, 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 from north west to north east across the junction of the Long Mile Road and the Naas Road in Drimnagh Dublin 12. The junctions also comprise the Luas Red Line from the Red Cow to Connolly station.

4 SITE OPERATIONS

4.1 Summary of site works

Site operations, which were conducted between 13th and 22nd October 2020, comprised:

- four light cable percussion boreholes
- four rotary follow-on boreholes
- a standpipe installation in two boreholes

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

4.2 Boreholes

Four boreholes (R8-CPGS01-R8-CPGS04) were put down by a combination of light cable percussion boring using a Dando 2000 rig and rotary follow-on drilling techniques with core recovery in bedrock using a truck mounted Berretta T44 rotary drilling rig.

Hand dug inspection pits were carried out between ground level and 1.20m depth to ensure boreholes were put down at locations clear of services or subsurface obstructions.

Disturbed (bulk and small bag) samples were taken within the encountered strata. Undisturbed (U100) samples were taken where appropriate and as directed within fine soils. Environmental samples were taken at standard intervals, as directed by the Client's Representative.

Any water strikes encountered during boring were recorded along with any changes in their levels as the borehole proceeded.

Where water was added to assist with boring, a note has been added to the log to account for same.

Where the cable percussion borehole had not been advanced onto bedrock, rotary percussive methods were employed to advance the borehole to bedrock after which rotary coring was employed to recover core samples of the bedrock. Symmetrix cased full-hole drilling was used, with SPTs carried out at standard intervals as required.

Standard penetration tests were carried out in accordance with BS EN 22476-3:2005+A1:2011 at standard depth intervals throughout the overburden using the split spoon sampler ($SPT_{(s)}$) or solid cone attachment ($SPT_{(c)}$). 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 SPT hammer energy measurement report is provided in Appendix E.

Where coring was carried out within bedrock strata, Geobor S Coring was used. The core was extracted in up to 1.5m lengths using a SK6L core barrel, which produced core of nominal 102mm diameter, and was placed in single channel wooden core boxes.

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: 2015: Code of practice for ground investigations*.

Appendix B presents the borehole logs, with core photographs presented in Appendix C.

4.3 Standpipe installations

A groundwater monitoring standpipe was installed in R8-CPGS02 and R8-CPGS04.

Details of the installations, including the depth range of the response zone, are provided in Appendix B on the individual borehole logs.

4.4 Surveying

The as-built exploratory hole positions were surveyed following completion of site operations by a Site Engineer from Causeway Geotech. Surveying was carried out using a Trimble R6 GPS system employing VRS and real time kinetic (RTK) techniques.

The plan coordinates (Irish Transverse Mercator) and ground elevation (mOD Malin (Irl)) at each location are recorded on the individual exploratory hole logs. The exploratory hole plan presented in Appendix A shows these as-built positions.

4.5 Groundwater monitoring

Following completion of site works, groundwater monitoring was conducted on one round. Ground water monitoring was carried out using a water interface probe.

The monitoring records are presented in Section 6.3.

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 and particle size distribution analysis.
- **soil chemistry:** pH and water soluble sulphate content

Laboratory testing of soils samples was carried out in accordance with British Standards Institute: *BS 1377, Methods of test for soils for civil engineering purposes; Part 1 (2016), and Parts 2-9 (1990).*

The test results are presented in Appendix D.

5.2 Geotechnical laboratory testing of rock

Laboratory testing of rock sub-samples comprised:

- point load index
- unconfined compressive strength (UCS) tests

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

The test results are presented in Appendix D.

6 GROUND CONDITIONS

6.1 General geology of the area

Published geological mapping indicate the superficial deposits underlying the site comprise Glacial Till. These deposits are underlain by limestones and shales of the Lucan Formation.

6.2 Ground types encountered during investigation of the site

A summary of the ground types encountered in the exploratory holes is listed below, in approximate stratigraphic order:

- **Paved surface:** all boreholes encountered paving brick at ground level. Beneath this were both bitmac and concrete of varying thickness likely representing old road surfaces. Concrete was encountered to a maximum depth of 1.00m in R8-CPGS01 and R8-CPGS02.

- **Made Ground (sub-base):** approximately 200-300mm of aggregate fill beneath the paved surface beneath the deepest paved surface to a maximum depth of 1.20m in R8-CPGS01 and R8-CPGS02.

- **Glacial Till:** sandy gravelly clay, frequently with low cobble content, typically firm or stiff in upper horizons, becoming very stiff with increasing depth.

- **Bedrock (Limestone):** Rockhead was encountered at depths ranging from 4.50m in R8-CPGS01-R8-CPGS03 to 6.00m in R8-CPGS04.

6.3 Groundwater

Details of the individual groundwater strikes, along with any relative changes in levels as works proceeded, are presented on the exploratory hole logs for each location.

Groundwater was encountered during percussion boring and rotary drilling through soil and rock as groundwater strikes as shown in Table 1 below.

Table 1: Groundwater strikes encountered during the ground investigation

GI Ref	Water Level (mbgl)	Comments
R8-CPGS01	4.30	
R8-CPGS02	3.40	
	3.60	Rose to 3.50m after 20 mins
R8-CPGS03	4.20	
R8-CPGS04	3.50	

It should be noted that the casing used in supporting the borehole walls during drilling may have sealed out any additional groundwater strikes and the possibility of encountering groundwater at other depths during excavation works should not be ruled out.

It should also be noted that any groundwater strikes within bedrock may have been masked by the fluid used as the drilling flush medium.

Subsequent groundwater monitoring of the standpipe installations recorded water levels as shown in Table 2.

Table 2: Groundwater monitoring

Date	Water level (mbgl)	
	R8-CPGS02	R8-CPGS04
19/11/20	3.29	2.53

Seasonal variation in groundwater levels should also be factored into design considerations and continued monitoring of the two installed standpipes will give an indication of the seasonal variation.

7 REFERENCES

Geotechnical Society of Ireland (2016), Specification & Related Documents for Ground Investigation in Ireland

IS EN 1997-2: 2007: Eurocode 7 - Geotechnical design - Part 2 Ground investigation and testing. National Standards Authority of Ireland.

BS 5930: 2015: Code of practice for ground investigations. British Standards Institution.

BS EN ISO 14688-1:2018: Geotechnical investigation and testing. Identification and classification of soil. Part 1 Identification and description.

BS EN ISO 14688-2:2018: Geotechnical investigation and testing. Identification and classification of soil. Part 2 Principles for a classification.

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

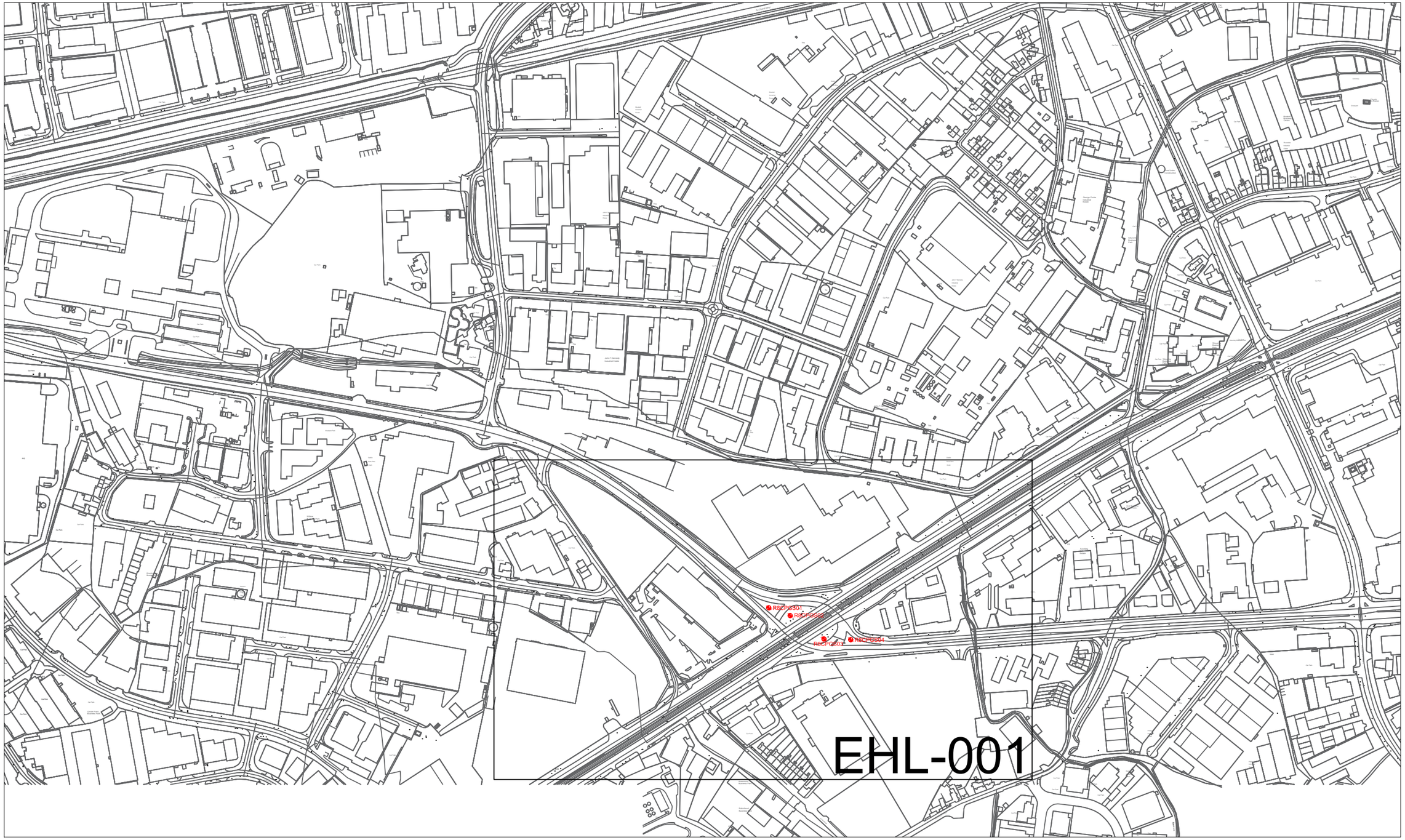
BS EN ISO 14689-1:2018: Geotechnical investigation and testing. Identification and classification of rock. Identification and description.

BS EN ISO 22476-3:2005+A1:2011: Geotechnical investigation and testing. Field testing. Standard penetration test.

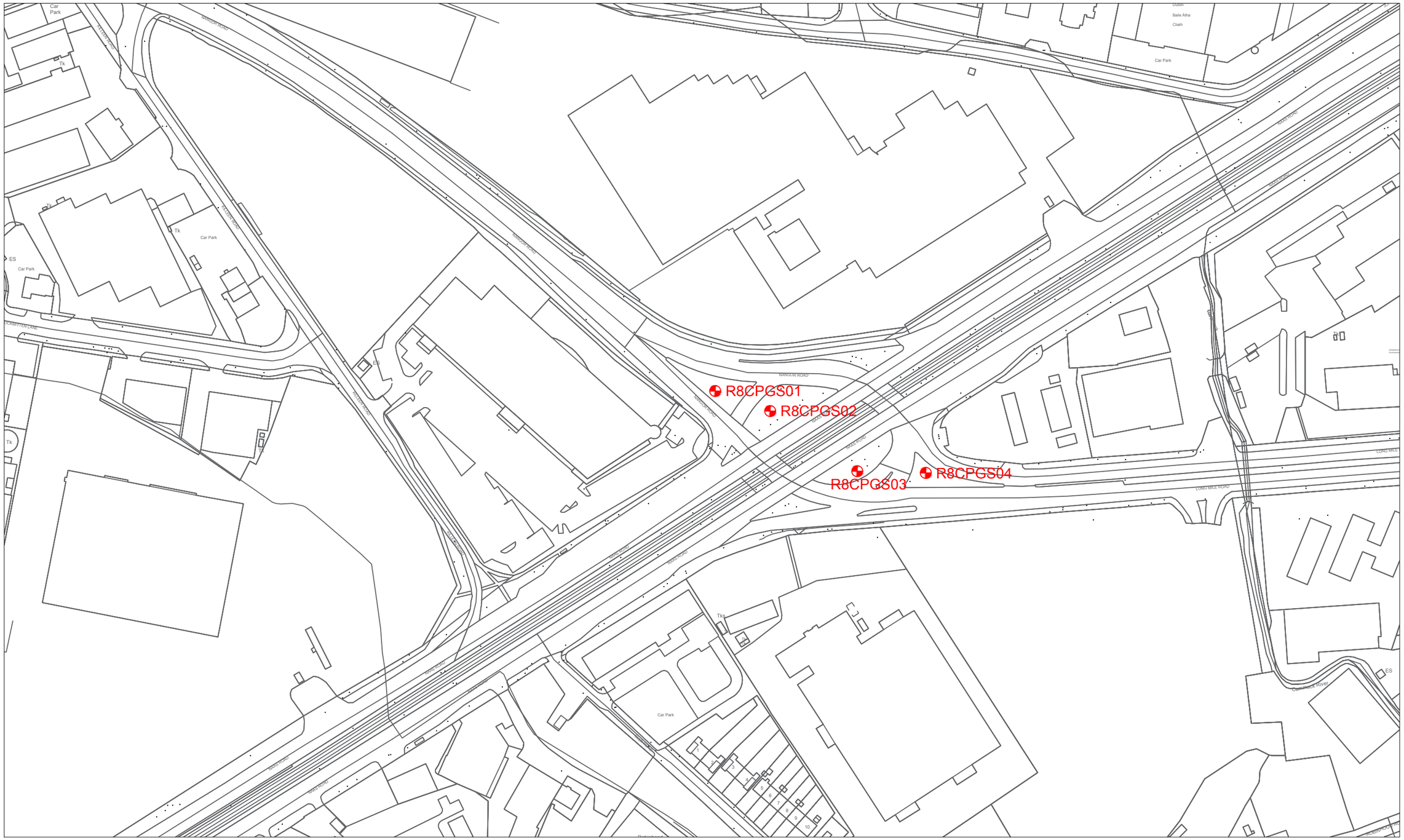
CAUSEWAY GEOTECH

APPENDIX A

SITE AND EXPLORATORY HOLE LOCATION PLAN



PROJECT: Bus Connects Route 8 Tallaght/Clondalkin to City Centre		TITLE: Exploratory hole location plan (Overview)			
CLIENT: National Transport Authority (NTA)	KEY: Borehole	CAUSEWAY GEOTECH	SCALE: NTS@A3	DATE: 23/11/2020	
ENGINEER: AECOM/Mott MacDonald			DRWN: BS CHCK: CH	SERIES: 1 of 1	DWG No: 20-0399C-EHL-OW-001



PROJECT: Bus Connects Route 8 Tallaght/Clondalkin to City Centre		TITLE: Exploratory hole location plan			
CLIENT: National Transport Authority (NTA)	KEY: Borehole	CAUSEWAY GEOTECH	SCALE: NTS@A3	DATE: 23/11/2020	
ENGINEER: AECOM/Mott MacDonald			DRWN: BS CHCK: CH	SERIES: 1 of 1	DWG No: 20-0399C-EHL-001

CAUSEWAY GEOTECH

APPENDIX B

BOREHOLE LOGS

CAUSEWAY GEOTECH

Project No.	Project Name:	Borehole ID
20-0399C	Bus Connects Route 8 Tallaght/Clondalkin to City Centre	R8-CPGS01
	Client: National Transport Authority (NTA)	
	Client's Rep: AECOM/Mott MacDonald	

Method	Plant Used	Top (m)	Base (m)	Coordinates
Cable Percussion	Dando 2000	0.00	4.00	
Rotary Drilling	Beretta T44	4.00	4.50	709700.59 E
Rotary Coring	Beretta T44	4.50	10.00	731671.04 N

Final Depth:	10.00 m	Start Date:	13/10/2020	Driller:	BM+GT	Sheet 1 of 2
Elevation:	48.19 mOD	End Date:	19/10/2020	Logger:	CH+NP	Scale: 1:50
						FINAL

Depth (m)	Sample / Tests	Field Records	Casing Depth (m)	Water Depth (m)	Level mOD	Depth (m)	Legend	Description	Water	Backfill
					48.09	0.10		MADE GROUND: Paving brick		
					47.89	0.30		CONCRETE		
								BITMAC		
0.50	B6				47.69	0.50		MADE GROUND: Grey angular fine to coarse GRAVEL of mixed lithologies.		
0.50	ES1				47.49	0.70		CONCRETE		
1.00	B7				47.19	1.00		MADE GROUND: Grey sandy silty subangular fine to coarse GRAVEL of mixed lithologies. Sand is fine to coarse.		
1.00	ES2				46.99	1.20		Very stiff black slightly sandy slightly gravelly CLAY with low cobble content. Sand is fine to coarse. Gravel is subangular to subrounded fine to coarse of mixed lithologies. Cobbles are subrounded of mixed lithologies.		
1.20	D12									
1.20 - 1.35	SPT (S)	N=50 (25 for 75mm/50 for 75mm) Hammer SN = 0643	0.00	Dry						
1.50	ES3									
2.00	B8				46.19	2.00		Very stiff brownish grey slightly sandy slightly gravelly CLAY with low cobble content. Sand is fine to coarse. Gravel is subangular to subrounded fine to coarse of mixed lithologies. Cobbles are subrounded of mixed lithologies.		
2.00	D13									
2.00	ES4									
2.00 - 2.28	SPT (S)	N=50 (11,15/50 for 135mm) Hammer SN = 0643	0.00	Dry						
3.00	B9									
3.00	D14									
3.00	ES5									
3.00 - 3.45	SPT (S)	N=42 (18,16/12,10,10,10) Hammer SN = 0643	0.00	Dry						
4.00	B10				44.19	4.00		Very stiff brownish grey sandy gravelly CLAY with low cobble content. (Driller's description)		
4.00 - 4.05	SPT (S)	N=50 (25 for 25mm/50 for 25mm) Hammer SN = 0643	0.00	Dry	43.89	4.30		Grey LIMESTONE. (Driller's description)	▼	
4.30	B11	Strike at 4.30m.			43.69	4.50		Medium strong (locally weak) thinly bedded dark grey LIMESTONE. Partially weathered: reduced strength, closer fracture spacing with brown clay deposits and brown staining on fracture surfaces. Discontinuities; 1. 0 to 15 degree bedding fractures, closely spaced (25/80/200), slightly undulating, smooth with brown clay deposits and brown staining on fracture surfaces. 2. At 4.50m to 4.70m and 4.70m to 5.05m: 75 to 90 degree joints, undulating, smooth with brown clay deposits and brown staining		
4.50	ES					(0.65)				
4.60	C									
5.00	C	100 97 53 >20			43.04	5.15				
5.75	C									
5.90	C									
6.00								Medium strong (locally strong) thinly bedded dark grey LIMESTONE. Partially weathered: slightly reduced strength, slightly closer fracture spacing with brown clay deposits. Discontinuities: 1. 0 to 15 degree bedding fractures, medium spaced (45/220/720), plana and slightly undulating, smooth with brown clay deposits on fracture surfaces. 2. 35 to 40 degree joints, widely spaced (240/615/>3400), slightly undulating, smooth with brown clay infill up to 5mm between fracture surfaces. 3.At 5.25m to 5.55m and 8.60m to 8.85m: 75 degree joints, undulating, smooth with brown clay infill up to 32mm between joint surfaces.		
6.35	C									
6.60	C	93 73 67 8				(4.85)				
6.90	C									
7.50										
7.50	C	100 100 92 3								
9.00										
		TCR SCR RQD FI								

Water Strikes				Chiselling Details			Remarks
Struck at (m)	Casing to (m)	Time (min)	Rose to (m)	From (m)	To (m)	Time (hh:mm)	Hand dug inspection pit excavated to 1.20m.
4.30	4.30			4.00	4.30	01:00	

Casing Details		Water Added	
To (m)	Diam (mm)	From (m)	To (m)

Core Barrel	Flush Type	Termination Reason	Last Updated
SK6L	Polymer	Terminated at scheduled depth.	14/12/2020

AGS

CAUSEWAY GEOTECH

Project No.	Project Name:	Borehole ID
20-0399C	Bus Connects Route 8 Tallaght/Clondalkin to City Centre	R8-CPGS01
	Client: National Transport Authority (NTA)	
	Client's Rep: AECOM/Mott MacDonald	

Method	Plant Used	Top (m)	Base (m)
Cable Percussion	Dando 2000	0.00	4.00
Rotary Drilling	Beretta T44	4.00	4.50
Rotary Coring	Beretta T44	4.50	10.00

Coordinates: 709700.59 E, 731671.04 N

Final Depth: 10.00 m | Start Date: 13/10/2020 | Driller: BM+GT

Elevation: 48.19 mOD | End Date: 19/10/2020 | Logger: CH+NP

Sheet 2 of 2 | Scale: 1:50 | FINAL

Depth (m)	Samples / Field Records	TCR	SCR	RQD	FI	Casing Depth (m)	Water Depth (m)	Level mOD	Depth (m)	Legend	Description	Water	Backfill
9.35	C	96	96	76	8						Medium strong (locally strong) thinly bedded dark grey LIMESTONE. Partially weathered: slightly reduced strength, slightly closer fracture spacing with brown clay deposits. Discontinuities: 1. 0 to 15 degree bedding fractures, medium spaced (45/220/720), plana and slightly undulating, smooth with brown clay deposits on fracture surfaces. 2. 35 to 40 degree joints, widely spaced (240/615/>3400), slightly undulating, smooth with brown clay infill up to 5mm between fracture surfaces. 3.At 5.25m to 5.55m and 8.60m to 8.85m: 75 degree joints, undulating, smooth with brown clay infill up to 32mm between joint surfaces.		
10.00								38.19	10.00		End of Borehole at 10.00m		
		TCR	SCR	RQD	FI								

9.5 10.0 10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.5 16.0 16.5 17.0 17.5 18.0 18.5

Water Strikes

Struck at (m)	Casing to (m)	Time (min)	Rose to (m)
4.30	4.30		

Chiselling Details

From (m)	To (m)	Time (hh:mm)
4.00	4.30	01:00

Remarks

Hand dug inspection pit excavated to 1.20m.

Casing Details

To (m)	Diam (mm)

Water Added

From (m)	To (m)

Core Barrel	Flush Type	Termination Reason	Last Updated
SK6L	Polymer	Terminated at scheduled depth.	14/12/2020

AGS

CAUSEWAY GEOTECH

Project No.	Project Name:	Borehole ID
20-0399C	Bus Connects Route 8 Tallaght/Clondalkin to City Centre	R8-CPGS02
	Client: National Transport Authority (NTA)	
	Client's Rep: AECOM/Mott MacDonald	

Method	Plant Used	Top (m)	Base (m)	Coordinates
Cable Percussion	Dando 2000	0.00	4.00	
Rotary Drilling	Beretta T44	4.00	4.50	709730.16 E
Rotary Coring	Beretta T44	4.50	10.00	731660.28 N

Final Depth:	10.00 m	Start Date:	14/10/2020	Driller:	BM+GT	Sheet 1 of 2
Elevation:	47.59 mOD	End Date:	20/10/2020	Logger:	CH+NP	Scale: 1:50
						FINAL

Depth (m)	Sample / Tests	Field Records	Casing Depth (m)	Water Depth (m)	Level mOD	Depth (m)	Legend	Description	Water	Backfill
					47.49	0.10		MADE GROUND: Paving brick		
								CONCRETE		
					47.19	0.40		BITMAC		
0.50	B5				46.99	0.60		CONCRETE		
0.50	ES1									
1.00	B6				46.59	1.00		MADE GROUND: Grey angular fine to coarse GRAVEL of mixed lithologies.		
1.00	ES2				46.39	1.20		Very stiff greyish black slightly sandy slightly gravelly CLAY with low cobble content. Sand is fine to coarse. Gravel is subangular to subrounded fine to coarse of mixed lithologies. Cobbles are subrounded of mixed lithologies.		
1.20	D10									
1.20 - 1.32	SPT (S)	N=50 (25 for 75mm/50 for 50mm) Hammer SN = 0643	0.00	Dry	46.09	1.50				
2.00	B7							Very stiff brown slightly sandy slightly gravelly CLAY with low cobble content. Sand is fine to coarse. Gravel is subangular to subrounded fine to coarse of mixed lithologies. Cobbles are subrounded of mixed lithologies.		
2.00	D11									
2.00	ES3									
2.00 - 2.28	SPT (S)	N=50 (14,26/50 for 125mm) Hammer SN = 0643	0.00	Dry						
3.00	B8									
3.00	ES4									
3.00 - 3.40	U13	Ublow=30 80% Strike at 3.40m. Slow seepage at 3.60m		Dry						
					43.99	3.60		Very stiff greyish black slightly sandy slightly gravelly CLAY with low cobble content. Sand is fine to coarse. Gravel issubangular to		
4.00	B9				43.59	4.00		subrounded fine to coarse of mixed lithologies. Cobbles are subrounded of mixed lithologies.		
4.00	D12				43.29	4.30		Very stiff greyish black sandy gravelly CLAY. (Driller's description)		
4.00 - 4.08	SPT(S) N=50 (25 for 25mm/50 for 50mm) Hammer SN = 0643	TCR: 10	SCR: 100	RQD: 100	FI: 85	43.09	4.50		Grey LIMESTONE. (Driller's description)		
4.50	C						(1.05)		Medium strong (locally weak) thinly bedded dark grey LIMESTONE. Partially weathered: slightly reduced strength, closer fractures spacing with localised brown clay deposits and brown staining on fracture surfaces. Discontinuities: 1. 10 to 15 degree bedding fractures, medium spaced (100/210/270), slightly undulating, smooth with brown clay infill up to 4mm between fracture surfaces and brown staining on fracture surfaces. 2. 60 to 70 degree joints, medium spaced (90/260/350), slightly undulating, smooth with brown clay deposits on joint surfaces and brown staining on joint surfaces.		
4.70	ES									
5.45	C									
5.55	C	TCR: 5	SCR: 100	RQD: 100	FI: 78	42.04	5.55			
6.00										
6.00	C	TCR: 19	SCR: 100	RQD: 100	FI: 78					
6.80	C									
7.10	C									
7.50		TCR: 7	SCR: 100	RQD: 100	FI: 61		(4.45)		Medium strong (locally weak) thinly bedded dark grey LIMESTONE. Partially weathered: slightly reduced strength, closer fracture spacing with localised brown clay deposits and brown staining on fracture surfaces. Discontinuities: 1. 10 to 20 degree bedding fractures, closely, spaced (20/150/310), slightly undulating, smooth with patchy brown clay deposits and brown staining on fracture surfaces. 2. 60 to 85 degree joints, probably widely spaced, slightly undulating to undulating, smooth with brown staining on joint surfaces and localised brown clay infill up to 12mm between joint surfaces.		
8.10	C									
		TCR: >20	SCR: 100	RQD: 100	FI: 61			*8.56m to 8.69m: Very weak thickly laminated carbonaceous MUDSTONE*		
9.00										

Water Strikes			
Struck at (m)	Casing to (m)	Time (min)	Rose to (m)
3.40			
3.60	3.60	20	3.50

Chiselling Details		
From (m)	To (m)	Time (hh:mm)
3.70	4.00	01:00

Casing Details	
To (m)	Diam (mm)
4.50	200

Water Added	
From (m)	To (m)

Remarks

Hand dug inspection pit excavated to 1.20m.

Core Barrel	Flush Type	Termination Reason	Last Updated
SK6L	Polymer	Terminated at scheduled depth.	14/12/2020

AGS

CAUSEWAY GEOTECH

Project No.	Project Name:	Borehole ID
20-0399C	Bus Connects Route 8 Tallaght/Clondalkin to City Centre	R8-CPGS02
	Client: National Transport Authority (NTA)	
	Client's Rep: AECOM/Mott MacDonald	

Method	Plant Used	Top (m)	Base (m)
Cable Percussion	Dando 2000	0.00	4.00
Rotary Drilling	Beretta T44	4.00	4.50
Rotary Coring	Beretta T44	4.50	10.00

Coordinates: 709730.16 E, 731660.28 N

Final Depth: 10.00 m | Start Date: 14/10/2020 | Driller: BM+GT | Sheet 2 of 2 | Scale: 1:50

Elevation: 47.59 mOD | End Date: 20/10/2020 | Logger: CH+NP | FINAL

Depth (m)	Samples / Field Records	TCR	SCR	RQD	FI	Casing Depth (m)	Water Depth (m)	Level mOD	Depth (m)	Legend	Description	Water	Backfill
9.35	C	96	96	81	8						Medium strong (locally weak) thinly bedded dark grey LIMESTONE. Partially weathered: slightly reduced strength, closer fracture spacing with localised brown clay deposits and brown staining on fracture surfaces. Discontinuities: 1. 10 to 20 degree bedding fractures, closely, spaced (20/150/310), slightly undulating, smooth with patchy brown clay deposits and brown staining on fracture surfaces. 2. 60 to 85 degree joints, probably widely spaced, slightly undulating to undulating, smooth with brown staining on joint surfaces and localised brown clay infill up to 12mm between joint surfaces.		
10.00								37.59	10.00		End of Borehole at 10.00m		

TCR	SCR	RQD	FI

Water Strikes

Struck at (m)	Casing to (m)	Time (min)	Rose to (m)
3.40			
3.60	3.60	20	3.50

Chiselling Details

From (m)	To (m)	Time (hh:mm)
3.70	4.00	01:00

Remarks

Hand dug inspection pit excavated to 1.20m.

Casing Details

To (m)	Diam (mm)
4.50	200

Water Added

From (m)	To (m)

Core Barrel	Flush Type	Termination Reason	Last Updated
SK6L	Polymer	Terminated at scheduled depth.	14/12/2020

AGS

CAUSEWAY GEOTECH

Project No.	Project Name:	Borehole ID
20-0399C	Bus Connects Route 8 Tallaght/Clondalkin to City Centre	R8-CPGS03
	Client: National Transport Authority (NTA)	
	Client's Rep: AECOM/Mott MacDonald	

Method	Plant Used	Top (m)	Base (m)	Coordinates
Cable Percussion	Dando 2000	0.00	3.00	
Rotary Drilling	Beretta T44	3.00	4.50	709776.99 E
Rotary Coring	Beretta T44	4.50	10.00	731627.95 N

Final Depth:	Start Date:	Driller:	Sheet 1 of 2
10.00 m	16/10/2020	BM+GT	Scale: 1:50
Elevation: 47.08 mOD	**End Date:** 21/10/2020	**Logger:** CH+NP	FINAL

Depth (m)	Sample / Tests	Field Records	Casing Depth (m)	Water Depth (m)	Level mOD	Depth (m)	Legend	Description	Water	Backfill
					46.98	0.10		MADE GROUND: Paving brick		
					46.78	0.30		CONCRETE		
0.50	B7							MADE GROUND: Grey slightly sandy angular fine to coarse GRAVEL of mixed lithologies. Sand is fine to coarse.		
0.50	ES1				46.48	0.60		Firm brown sandy gravelly CLAY. Sand is fine to coarse. Gravel is subangular to subrounded of mixed lithologies.		
1.00	B8									
1.00	ES2									
1.20 - 1.65	U20	Ublow=20 80%	0.00	Dry						
2.00	B9									
2.00	D16									
2.00	ES3									
2.00 - 2.40	SPT (S)	N=50 (2,5/50 for 245mm) Hammer SN = 0643	0.00	Dry	44.58	2.50		Very stiff dark grey slightly sandy very gravelly CLAY. Sand is fine to coarse. Gravel is subangular to subrounded of mixed lithologies.		
3.00	B10				44.08	3.00		Very stiff dark grey sandy gravelly CLAY. (Driller's description)		
3.00	D11									
3.00	ES4									
3.00 - 3.06	SPT (S)	N=50 (25 for 25mm/50 for 30mm) Hammer SN = 0643	0.00	Dry						
		Strike at 4.20m.			42.78	4.30		Grey LIMESTONE. Driller's description)		
4.55	C				42.58	4.50		Medium strong thickly bedded dark grey LIMESTONE. Partially weathered: slightly reduced strength, slightly closer fracture spacing with localised brown clay deposits. Discontinuities: 1. 0 to 15 degree bedding fractures, medium spaced (65/225/480), planar, and slightly undulating, smooth with brown clay infill up to 58mm between some fracture surfaces and orange staining on fracture surfaces. 2. 20 to 40 degree joints, widely spaced (210/1235/1370), undulating, smooth with brown clay infill up to 6mm between some joint surfaces and no staining on joint surfaces. 3. At 5.85m to 6.00m and 7.95m to 8.15m: 85 to 90 degree joints, undulating, smooth with brown clay deposits on joint surfaces.		
4.70	ES									
5.05	C									
5.30	C									
6.00										
6.00	C									
6.30	C									
6.80	C					(5.15)				
7.50										
7.50	C									
9.00										
9.05	C									

TCR	SCR	RQD	FI
100	97	72	
100	100	96	6
100	100	82	

Water Strikes

Struck at (m)	Casing to (m)	Time (min)	Rose to (m)
4.20			

Casing Details

To (m)	Diam (mm)
4.50	200

Water Added

From (m)	To (m)

Chiselling Details

From (m)	To (m)	Time (hh:mm)
2.50	3.00	01:00

Remarks

Hand dug inspection pit excavated to 1.20m.

Core Barrel	Flush Type	Termination Reason	Last Updated
SK6L	Polymer	Terminated at scheduled depth.	14/12/2020

AGS

CAUSEWAY GEOTECH

Project No.	Project Name:	Borehole ID
20-0399C	Bus Connects Route 8 Tallaght/Clondalkin to City Centre	R8-CPGS03
	Client: National Transport Authority (NTA)	
	Client's Rep: AECOM/Mott MacDonald	

Method	Plant Used	Top (m)	Base (m)
Cable Percussion	Dando 2000	0.00	3.00
Rotary Drilling	Beretta T44	3.00	4.50
Rotary Coring	Beretta T44	4.50	10.00

Coordinates: 709776.99 E, 731627.95 N

Final Depth: 10.00 m | Start Date: 16/10/2020 | Driller: BM+GT | Sheet 2 of 2 | Scale: 1:50

Elevation: 47.08 mOD | End Date: 21/10/2020 | Logger: CH+NP | FINAL

Depth (m)	Samples / Field Records	TCR	SCR	RQD	FI	Casing Depth (m)	Water Depth (m)	Level mOD	Depth (m)	Legend	Description	Water	Backfill
		100	57	55	NI			37.43	9.65 (0.35)		Medium strong thickly bedded dark grey LIMESTONE. Partially weathered: slightly reduced strength, slightly closer fracture spacing with localised brown clay deposits. Discontinuities: 1. 0 to 15 degree bedding fractures, medium spaced (65/225/480), planar, and slightly undulating, smooth with brown clay infill up to 58mm between some fracture surfaces and orange staining on fracture surfaces. 2. 20 to 40 degree joints, widely spaced (210/1235/1370), undulating, smooth with brown clay infill up to 6mm between some joint surfaces and no staining on joint surfaces. 3. At 5.85m to 6.00m and 7.95m to 8.15m: 85 to 90 degree joints, undulating, smooth with brown clay deposits on joint surfaces.		
10.00								37.08	10.00		*9.43m to 9.51m: Brown sandy gravelly clay infill.* Soft becoming firm brown sandy gravelly CLAY. Sand is fine to coarse. Gravel is subangular fine to coarse of limestone. End of Borehole at 10.00m		

TCR	SCR	RQD	FI

Water Strikes

Struck at (m)	Casing to (m)	Time (min)	Rose to (m)
4.20			

Chiselling Details

From (m)	To (m)	Time (hh:mm)
2.50	3.00	01:00

Casing Details

To (m)	Diam (mm)
4.50	200

Water Added

From (m)	To (m)

Remarks

Hand dug inspection pit excavated to 1.20m.

Core Barrel	Flush Type	Termination Reason	Last Updated
SK6L	Polymer	Terminated at scheduled depth.	14/12/2020

AGS

CAUSEWAY GEOTECH

Project No.	Project Name:	Borehole ID
20-0399C	Bus Connects Route 8 Tallaght/Clondalkin to City Centre	R8-CPGS04
	Client: National Transport Authority (NTA)	
	Client's Rep: AECOM/Mott MacDonald	

Method	Plant Used	Top (m)	Base (m)	Coordinates
Cable Percussion	Dando 2000	0.00	4.00	
Rotary Drilling	Beretta T44	4.00	6.00	709813.86 E
Rotary Coring	Beretta T44	6.00	12.00	731627.02 N

Final Depth:	12.00 m	Start Date:	15/10/2020	Driller:	BM+GT	Sheet 1 of 2
Elevation:	46.53 mOD	End Date:	22/10/2020	Logger:	CH+NP	Scale: 1:50
						FINAL

Depth (m)	Sample / Tests	Field Records	Casing Depth (m)	Water Depth (m)	Level mOD	Depth (m)	Legend	Description	Water	Backfill
					46.43	0.10		MADE GROUND: Paving brick		
					46.23	0.30		CONCRETE		
0.50	B5							MADE GROUND: Grey angular fine to coarse GRAVEL of mixed lithologies.		
0.50	ES1				45.83	0.70				
1.00	B6							Firm brown sandy gravelly CLAY. Sand is fine to coarse. Gravel is subangular to subrounded fine to coarse of mixed lithologies.		
1.00	ES2									
1.20	D12									
1.20 - 1.65	SPT (S)	N=13 (2,2/3,3,3,4) Hammer SN = 0643	0.00	Dry						
2.00	B7				44.53	2.00		Stiff greyish black slightly sandy slightly gravelly CLAY with low cobble content. Sand is fine to coarse. Gravel is subangular to subrounded fine to coarse of mixed lithologies. Cobbles are subrounded of mixed lithologies.		
2.00	ES3									
2.00 - 2.45	U13	Ublow=20 100%	0.00	Dry						
3.00	B8									
3.00	D11									
3.00	ES4									
3.00 - 3.45	SPT (S)	N=20 (2,3/4,5,5,6) Hammer SN = 0643 Strike at 3.50m.	0.00	Dry					▼	
					42.93	3.60		Very stiff greyish black slightly sandy slightly gravelly CLAY. Sand is fine to coarse. Gravel is subangular to subrounded fine to coarse of mixed lithologies.		
4.00	B12				42.53	4.00		Very stiff greyish black sandy gravelly CLAY. (Driller's description)		
4.00	D13									
4.00 - 4.07	SPT (S)	N=50 (25 for 15mm/50 for 50mm) Hammer SN = 0643	0.00	3.60						
5.00 - 5.25	SPT (S)	N=50 (8,15/50 for 100mm) Hammer SN = 0209	5.00	3.50						
					41.03	5.50		Grey LIMESTONE. (Driller's description)		
6.00	C				40.53	6.00		Medium strong thinly bedded dark grey LIMESTONE. Partially weathered: slightly reduced strength, slightly closer fracture spacing with brown slightly sandy slightly gravelly clay deposits. Discontinuities: 1. 0 to 10 degree bedding fractures, closely spaced (50/170/470), slightly undulating, smooth with brown slightly sandy slightly gravelly clay infill up to 40mm between some fracture surfaces and non staining on fracture surfaces. 2. At 7.20m to 7.60m: 85 to 90 degree joint, undulating, rough with brown slightly sandy slightly gravelly clay infill up to 7mm between joint surfaces. *6.75m to 7.20m: Firm grey becoming brown slightly sandy slightly gravelly CLAY. Sand is fine to coarse. Gravel is subangular fine to medium of limestone.*		
6.10	C									
6.20	C									
		100 70 51 4								
		NI				(2.25)				
7.40	ES									
		>20								
7.50										
7.60	C									
7.70	C									
		8								
		100 97 69			38.28	8.25		Medium strong becoming strong thickly bedded dark grey LIMESTONE. Partially weathered: closer fracture spacing with localised brown clay deposits. Discontinuities: 1. 0 to 10 degree bedding fractures, closely spaced (30/150/400), planar and slightly undulating, smooth with localised brown clay infill		
		11								
8.90	C									
9.00										
9.20	C									
		TCR SCR RQD FI								

Water Strikes

Struck at (m)	Casing to (m)	Time (min)	Rose to (m)
3.50			

Casing Details

To (m)	Diam (mm)
6.00	200

Water Added

From (m)	To (m)

Chiselling Details

From (m)	To (m)	Time (hh:mm)
3.60	4.00	01:00

Remarks

Hand dug inspection pit excavated to 1.20m.

Core Barrel	Flush Type	Termination Reason	Last Updated
SK6L	Polymer	Terminated at scheduled depth.	14/12/2020

AGS

CAUSEWAY GEOTECH

Project No.	Project Name:	Borehole ID
20-0399C	Bus Connects Route 8 Tallaght/Clondalkin to City Centre	R8-CPGS04
	Client: National Transport Authority (NTA)	
	Client's Rep: AECOM/Mott MacDonald	

Method	Plant Used	Top (m)	Base (m)
Cable Percussion	Dando 2000	0.00	4.00
Rotary Drilling	Beretta T44	4.00	6.00
Rotary Coring	Beretta T44	6.00	12.00

Coordinates: 709813.86 E, 731627.02 N

Final Depth: 12.00 m | Start Date: 15/10/2020 | Driller: BM+GT

Elevation: 46.53 mOD | End Date: 22/10/2020 | Logger: CH+NP

Sheet 2 of 2 | Scale: 1:50 | FINAL

Depth (m)	Samples / Field Records	TCR	SCR	RQD	FI	Casing Depth (m)	Water Depth (m)	Level mOD	Depth (m)	Legend	Description	Water	Backfill
		100	100	62	>20						Medium strong becoming strong thickly bedded dark grey LIMESTONE. Partially weathered: closer fracture spacing with localised brown clay deposits. Discontinuities: 1. 0 to 10 degree bedding fractures, closely spaced (30/150/400), planar and slightly undulating, smooth with localised brown clay infill up to 7mm between some fracture surfaces. 2. At 8.30m to 8.74m, 9.60m to 9.80m and 10.50m to 10.85m: 75 to 90 degree incipient joints, undulating, rough with localised brown clay infill up to 8mm and no staining on joint surfaces. 3. At 9.80m to 9.90m; 70 degree incipient joint, undulating, smooth with brown staining on joint surface.		
10.15	C												
10.50					9				(3.75)				
11.05	C	100	100	75									
12.00					3			34.53	12.00		End of Borehole at 12.00m		
		TCR	SCR	RQD	FI								

Water Strikes

Struck at (m)	Casing to (m)	Time (min)	Rose to (m)
3.50			

Chiselling Details

From (m)	To (m)	Time (hh:mm)
3.60	4.00	01:00

Casing Details

To (m)	Diam (mm)
6.00	200

Water Added

From (m)	To (m)

Remarks

Hand dug inspection pit excavated to 1.20m.

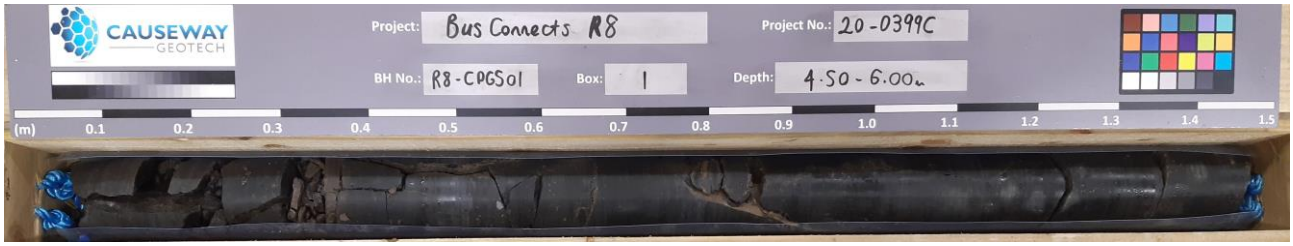
Core Barrel	Flush Type	Termination Reason	Last Updated
SK6L	Polymer	Terminated at scheduled depth.	14/12/2020

AGS

CAUSEWAY GEOTECH

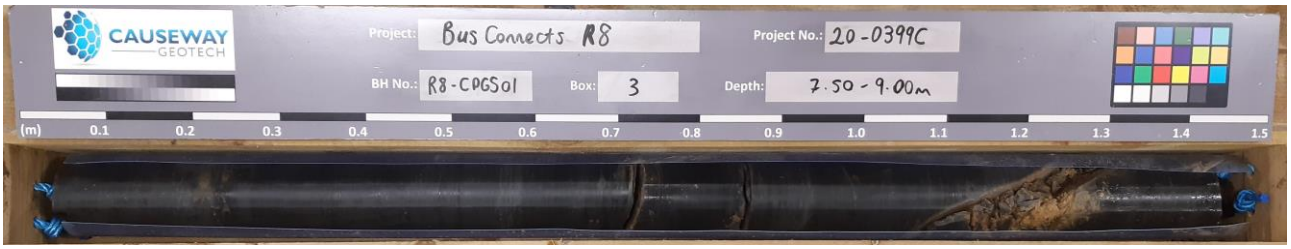
APPENDIX C

CORE PHOTOGRAPHS



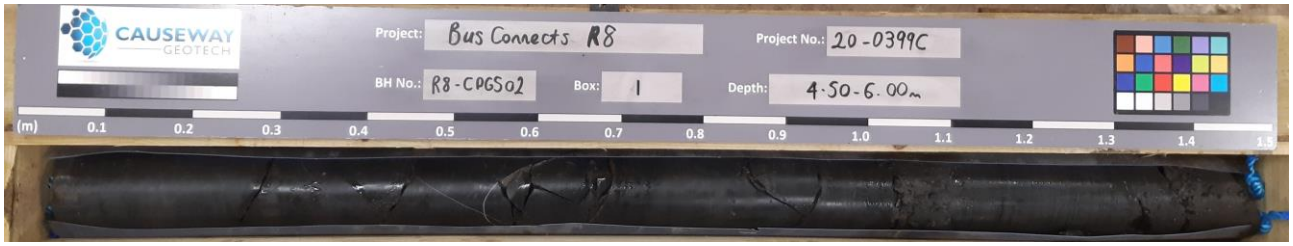
R8-CPGS01 Box 1 4.50-6.00m

R8-CPGS01 Box 2 6.00-7.50m



R8-CPGS01 Box 3 7.50-9.00m

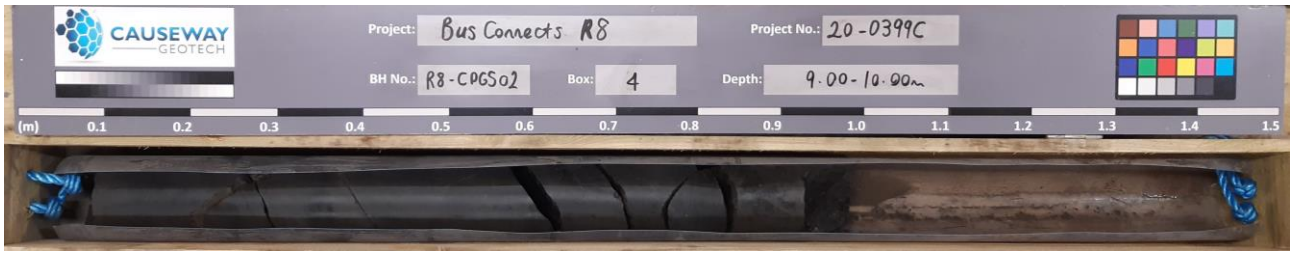
R8-CPGS01 Box 4 9.00-10.00m



R8-CPGS02 Box 1 4.50-6.00m

R8-CPGS02 Box 2 6.00-7.50m

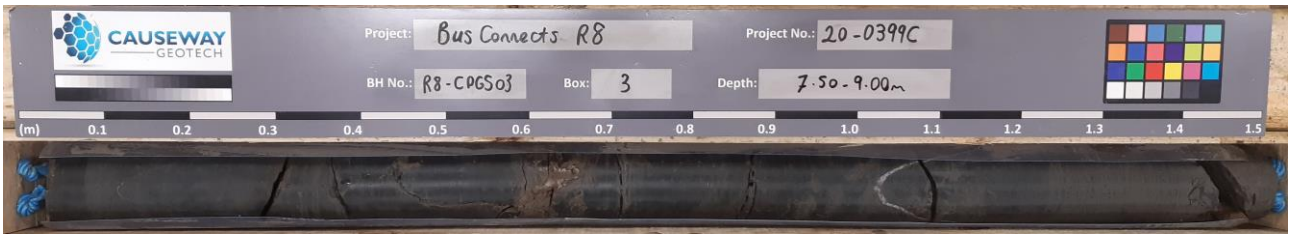
R8-CPGS02 Box 3 7.50-9.00m



R8-CPGS02 Box 4 9.00-10.00m

R8-CPGS03 Box 1 4.50-6.00m

R8-CPGS03 Box 2 6.00-7.50m



R8-CPGS03 Box 3 7.50-9.00m

R8-CPGS03 Box 4 9.00-10.00m

R8-CPGS04 Box 1 6.00-7.50m

R8-CPGS04 Box 2 7.50-9.00m

R8-CPGS04 Box 3 9.00-10.50m

R8-CPGS04 Box 4 10.50-12.00m

CAUSEWAY GEOTECH

APPENDIX D

GEOTECHNICAL LABORATORY TEST RESULTS

CAUSEWAY GEOTECH

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SOIL AND ROCK SAMPLE ANALYSIS
LABORATORY TEST REPORT

19 November 2020

Project Name:	Bus Connects Route 8 Tallaght/Clondalkin to City Centre
Project No.:	20-0399C
Client:	National Transport Authority (NTA)
Engineer:	AECOM

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 attached results complete the testing requested and we would therefore wish to confirm that samples will be retained without charge for a period of 28 days 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.

Stephen Watson

Laboratory Manager

Signed for and on behalf of Causeway Geotech Ltd

Project Name: Bus Connects - Route 8 - Tallaght/Clondalkin to City Centre

Report Reference: Schedule 1

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

Tests marked with* in this report are not United Kingdom Accreditation Service (UKAS) accredited and are not included in Causeway Geotech Limited's scope of UKAS Accreditation Schedule of Tests. Opinions and interpretations expressed herein are outside the scope of UKAS accreditation.

Material tested	Type of test/Properties measured/Range of measurement	Standard specifications	No. of results included in the report
SOIL	Moisture Content of Soil	BS 1377-2: 1990: Cl 3.2	14
SOIL	Liquid and Plastic Limits of soil-1 point cone penetrometer method	BS 1377-2: 1990: Cl 4.4, 5.3 & 5.4	3
SOIL	Particle size distribution - wet sieving	BS 1377-2: 1990: Cl 9.2	1
SOIL	Particle size distribution - sedimentation hydrometer method	BS 1377-2: 1990: Cl 9.5	1
SOIL	Undrained shear strength – triaxial compression without measurement of pore pressure (loads from 0.12 to 24 kN)	BS 1377-7: 1990: Cl 8	1
ROCK	Point load index	ISRM Commission on Testing Methods. Suggested Method for Determining Point Load Strength 1985	20
ROCK	Uniaxial Compressive Strength (UCS)*	ISRM Suggested Methods -Rock Characterization Testing and Monitoring, Ed. E T Brown - 1981	14

SUB-CONTRACTED TESTS

In agreement with Client, the following tests were conducted by an approved sub-contractor. All sub-contracting laboratories used are UKAS accredited.

Material tested	Type of test/Properties measured/Range of measurement	Standard specifications	No. of results included in the report
SOIL – Subcontracted to Eurofins Chemtest Ltd *(UKAS 2183)*	pH Value of Soil		4
SOIL – Subcontracted to Eurofins Chemtest Ltd *(UKAS 2183)*	Sulphate Content water extract		4

Summary of Classification Test Results

Project No.	Project Name
20-0399C	Bus Connects Route 8 - Tallaght/Clondalkin to City Centre

Hole No.	Sample				Soil Description	Density bulk	Density dry	w	Passing 425µm	LL	PL	PI	Particle density	Casagrande Classification
	Ref	Top	Base	Type		Mg/m3		%	%	%	%	%	Mg/m3	
R8-CPGS01	12	1.20		D	Grey sandy silty subangular fine to coarse GRAVEL.			7.9						
R8-CPGS01	13	2.00		D	Brown sandy gravelly silty CLAY.			10.0						
R8-CPGS01	14	3.00		D	Grey sandy silty subangular fine to coarse GRAVEL.			0.8						
R8-CPGS02	10	1.20		D	Greyish brown gravelly silty fine to coarse SAND.			6.9						
R8-CPGS02	11	2.00		D	Grey sandy slightly gravelly silty CLAY.			10.0						
R8-CPGS02	13	3.00		U	Grey sandy gravelly silty CLAY.			21.0	78	39 -1pt	19	20		CI
R8-CPGS02	12	4.00		D	Brown gravelly clayey fine to coarse SAND.			4.8						
R8-CPGS03	8	1.00		B	Grey sandy very gravelly silty CLAY.			15.0						
R8-CPGS03	20	1.20		U	Grey sandy slightly gravelly silty CLAY.			21.0	76	36 -1pt	19	17		CI
R8-CPGS03	16	2.00		D	Grey sandy gravelly silty CLAY.			7.7						
R8-CPGS03	11	3.00		D	Greyish brown sandy silty subangular fine to coarse GRAVEL.			1.6						
R8-CPGS04	13	2.00		U	Brown sandy slightly gravelly silty CLAY.			19.0	74	37 -1pt	19	18		CI

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

LAB 01R Version 4

Key

Density test	Liquid Limit	Particle density
Linear measurement unless :	4pt cone unless :	sp - small pyknometer
wd - water displacement	cas - Casagrande method	gj - gas jar
wi - immersion in water	1pt - single point test	

Date Printed

19/11/2020

Approved By

Stephen.Watson

UKAS TESTING

10122

Summary of Classification Test Results

Project No.	Project Name
20-0399C	Bus Connects Route 8 - Tallaght/Clondalkin to City Centre

Hole No.	Sample				Soil Description	Density bulk	Density dry	*w*	Passing 425µm	LL	PL	PI	Particle density	Casagrande Classification
	Ref	Top	Base	Type		Mg/m3		%	%	%	%	%	Mg/m3	
R8-CPGS04	11	3.00		D	Grey sandy gravelly silty CLAY.			9.8						
R8-CPGS04	13	4.00		D	Grey slightly sandy slightly silty subangular fine to coarse GRAVEL.			0.9						

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

LAB 01R Version 4

Key

Density test	Liquid Limit	Particle density
Linear measurement unless :	4pt cone unless :	sp - small pyknometer
wd - water displacement	cas - Casagrande method	gj - gas jar
wi - immersion in water	1pt - single point test	

Date Printed

19/11/2020

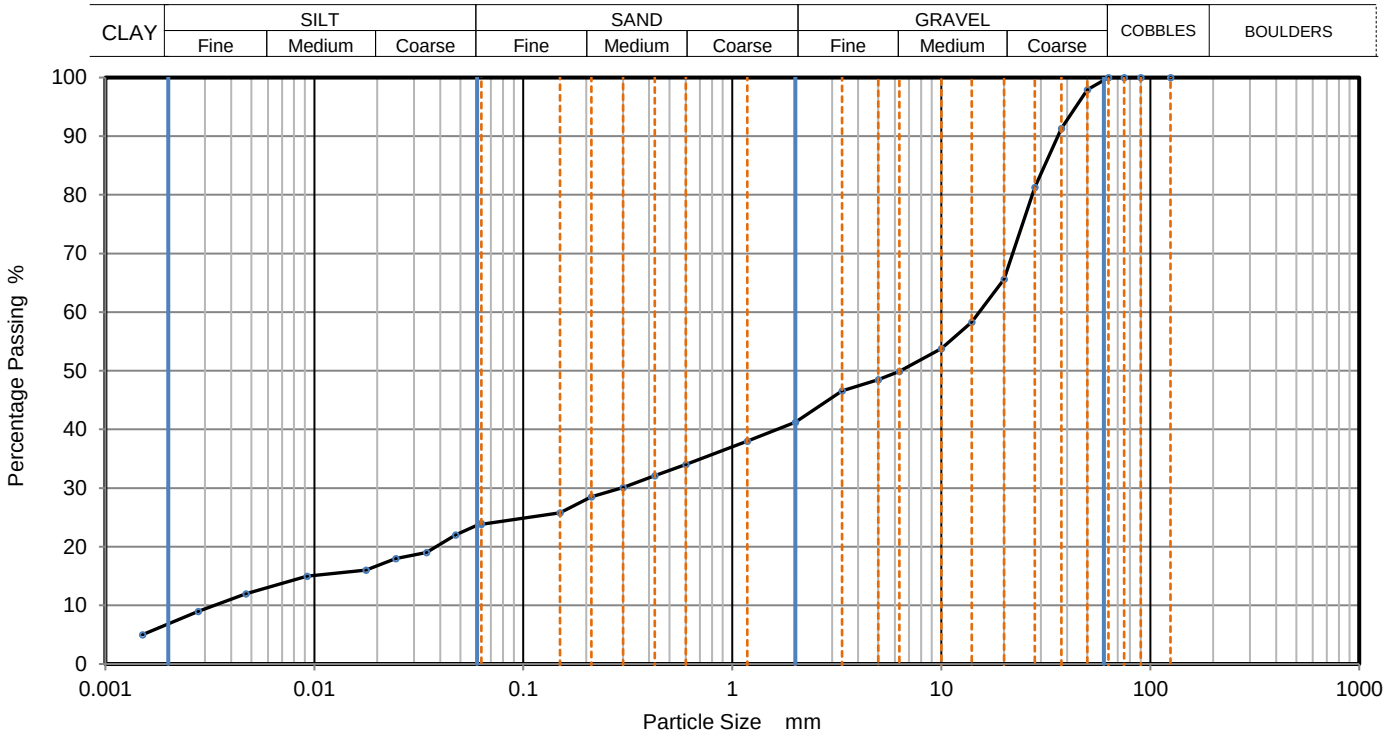
Approved By

Stephen.Watson

UKAS TESTING

10122

CAUSEWAY GEOTECH	**PARTICLE SIZE DISTRIBUTION**			Job Ref	**20-0399C**
				Borehole/Pit No.	R8-CPGS03
Site Name	Bus Connects Route 8 - Tallaght/Clondalkin to City Centre			Sample No.	8
Soil Description	Grey sandy very gravelly silty CLAY.			Depth, m	1.00
Specimen Reference	4	Specimen Depth	1 m	Sample Type	B
Test Method	BS1377:Part 2:1990, clauses 9.2 and 9.5			KeyLAB ID	Caus2020103052



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100	0.06290	24
90	100	0.04744	22
75	100	0.03447	19
63	100	0.02454	18
50	98	0.01769	16
37.5	91	0.00925	15
28	81	0.00471	12
20	66	0.00278	9
14	58	0.00150	5
10	54		
6.3	50		
5	49		
3.35	47		
2	41		
1.18	38		
0.6	34	Particle density	(assumed)
0.425	32	2.65	Mg/m3
0.3	30		
0.212	29		
0.15	26		
0.063	24		

Dry Mass of sample, g	6123

Sample Proportions	% dry mass
Cobbles	0.0
Gravel	58.8
Sand	17.4
Silt	16.6
Clay	7.2

Grading Analysis		
D100	mm	
D60	mm	15.2
D30	mm	0.294
D10	mm	0.00318
Uniformity Coefficient		4800
Curvature Coefficient		1.8

Remarks

Preparation and testing in accordance with BS1377-2 :1990 unless noted below

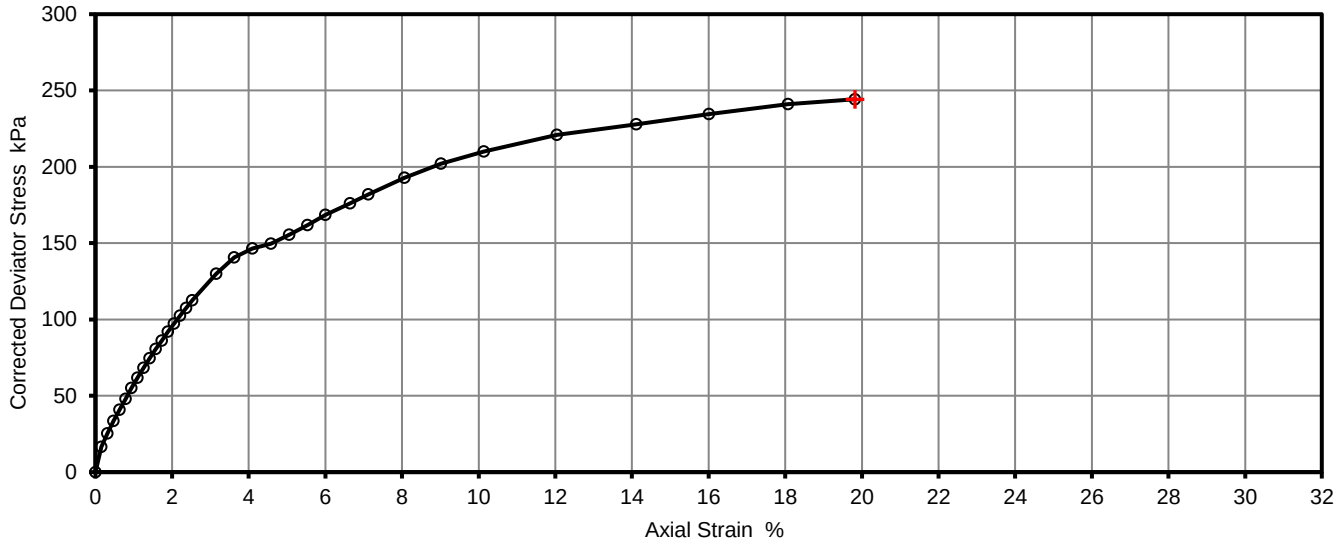
Approved
Stephen.Watson

UKAS TESTING 10122

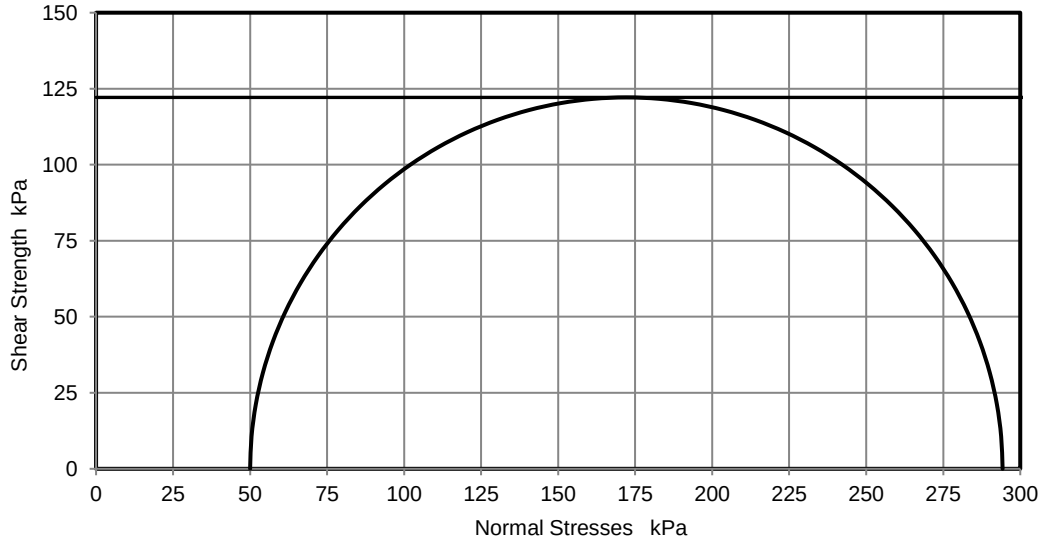
CAUSEWAY GEOTECH	**Unconsolidated Undrained Triaxial Compression Test without measurement of pore pressure - single specimen**			Job Ref	20-0399C
				Borehole/Pit No.	R8-CPGS04
Site Name	Bus Connects Route 8 - Tallaght/Clondalkin to City Centre			Sample No.	13
Soil Description	Brown sandy slightly gravelly silty CLAY.			Depth	2.00
Specimen Reference	6	Specimen Depth	2.05 m	Sample Type	U
Specimen Description	Stiff brown sandy slightly gravelly silty CLAY.			KeyLAB ID	Caus2020103056
Test Method	BS1377 : Part 7 : 1990, clause 8, single specimen			Date of test	09/11/2020

Test Number		1	
Length		209.4	mm
Diameter		104.5	mm
Bulk Density		2.39	Mg/m3
Moisture Content		10.6	%
Dry Density		2.16	Mg/m3
Rate of Strain		2.0	%/min
Cell Pressure		50	kPa
At failure	Axial Strain	19.8	%
	Deviator Stress, (σ1 - σ3)f	244	kPa
	Undrained Shear Strength, cu	122	kPa ½(σ1 - σ3)f
	Mode of Failure		

Deviator Stress v Axial Strain



Mohr Circles



Deviator stress corrected for area change and membrane effects based on Fig 11 BS1377-7:1990

Mohr circles and their interpretation is not covered by BS1377-7.
This is provided for information only.

Remarks

No failure defined. Testing terminated at 20% axial strian

Approved	Printed
Stephen.Watson	16/11/2020 14:12

UKAS TESTING

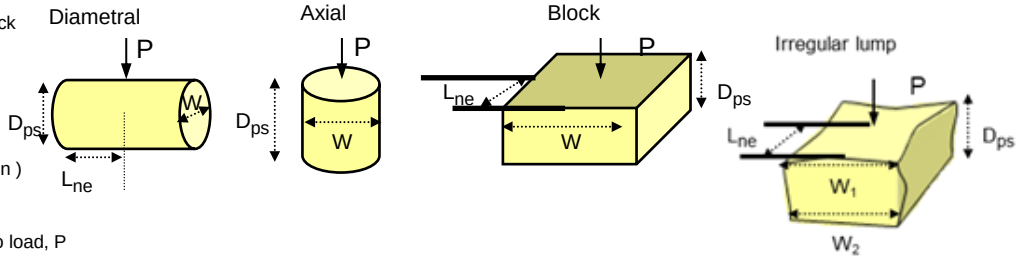
10122

Point Load Strength Index Tests
Summary of Results

Project No.	Project Name
20-0399C	Bus Connects Route 8 - Tallaght/Clondalkin to City Centre

Borehole No.	Sample			Specimen		Rock Type	Test Type see ISRM		Failure Valid (Y/N)	Dimensions				Force P	Equivalent diameter, De	Point Load Strength Index		Remarks (including water content if measured)
	Depth	Ref.	Type	Ref.	Depth		Type (D, A, I, B)	Direction (L, P or U)		Lne	W	Dps	Dps'			Is	Is(50)	
	m				m					mm	mm	mm	mm	kN	mm	MPa	MPa	
R8-CPGS01	4.60		C	1	4.60	LIMESTONE	A	U	NO		101.5	57.0	55.0	21.0	84.3	3.0	3.7	
R8-CPGS01	5.00		C	2	5.00	LIMESTONE	A	U	YES		101.6	61.0	57.0	18.4	85.9	2.5	3.2	
R8-CPGS01	5.75		C	3	5.75	LIMESTONE	D	U	NO	88.9	101.8	101.8	100.0	24.3	100.9	2.4	3.3	
R8-CPGS01	5.90		C	4	5.90	LIMESTONE	D	U	YES	81.2	101.6	101.6	99.0	19.6	100.3	1.9	2.7	
R8-CPGS01	6.35		C	5	6.35	LIMESTONE	A	U	YES		101.7	54.0	50.0	17.1	80.5	2.6	3.3	
R8-CPGS01	6.90		C	6	6.90	LIMESTONE	D	U	NO	78.3	101.4	101.4	97.0	14.9	99.2	1.5	2.1	
R8-CPGS02	4.50		C	7	4.50	LIMESTONE	D	U	NO	74.6	101.4	101.4	99.0	22.3	100.2	2.2	3.0	
R8-CPGS02	5.45		C	8	5.45	LIMESTONE	A	U	YES		101.3	59.0	56.0	17.6	85.0	2.4	3.1	
R8-CPGS02	6.00		C	9	6.00	LIMESTONE	D	U	YES	69.7	101.4	101.4	99.0	18.2	100.2	1.8	2.5	
R8-CPGS02	7.10		C	10	7.10	LIMESTONE	D	U	YES	73.9	101.5	101.5	97.0	19.8	99.2	2.0	2.7	
R8-CPGS03	4.55		C	11	4.55	LIMESTONE	D	U	YES	70.2	101.1	101.1	98.0	19.1	99.5	1.9	2.6	
R8-CPGS03	5.30		C	12	5.30	LIMESTONE	A	U	YES		101.3	48.0	44.0	18.0	75.3	3.2	3.8	
R8-CPGS03	6.30		C	13	6.30	LIMESTONE	D	U	NO	77.5	101.2	101.2	100.0	20.8	100.6	2.1	2.8	
R8-CPGS03	6.80		C	14	6.80	LIMESTONE	A	U	YES		101.3	55.0	51.0	17.6	81.1	2.7	3.3	
R8-CPGS04	6.00		C	15	6.00	LIMESTONE	D	U	NO	72.1	101.2	101.2	100.0	21.6	100.6	2.1	2.9	
R8-CPGS04	6.10		C	16	6.10	LIMESTONE	A	U	YES		101.3	59.0	54.0	24.5	83.5	3.5	4.4	
R8-CPGS04	7.60		C	17	7.60	LIMESTONE	D	U	NO	80.6	101.3	101.3	100.0	22.6	100.6	2.2	3.1	
R8-CPGS04	8.90		C	18	8.90	LIMESTONE	A	U	YES		101.2	51.0	47.0	16.5	77.8	2.7	3.3	

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.

LAB 17R Version 4

Date Printed: 19/11/2020

Approved By: Stephen.Watson

UKAS TESTING 10122

CAUSEWAY GEOTECH

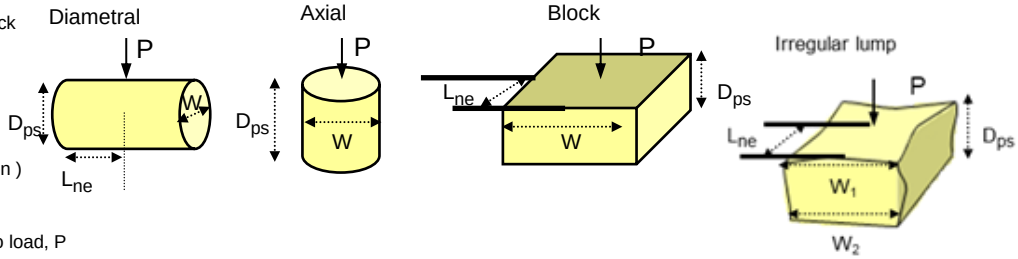
Point Load Strength Index Tests
Summary of Results

Project No.: 20-0399C

Project Name: Bus Connects Route 8 - Tallaght/Clondalkin to City Centre

Borehole No.	Sample			Specimen		Rock Type	Test Type see ISRM		Failure Valid (Y/N)	Dimensions				Force P	Equivalent diameter, De	Point Load Strength Index		Remarks (including water content if measured)
	Depth	Ref.	Type	Ref.	Depth		Type (D, A, I, B)	Direction (L, P or U)		Lne	W	Dps	Dps'			Is	Is(50)	
	m				m					mm	mm	mm	mm	kN	mm	MPa	MPa	
R8-CPGS04	9.20		C	19	9.20	LIMESTONE	D	U	YES	85.2	101.4	101.4	97.0	19.4	99.2	2.0	2.7	
R8-CPGS04	10.15		C	20	10.15	LIMESTONE	D	U	NO	81.0	101.3	101.3	99.0	22.7	100.1	2.3	3.1	

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.

LAB 17R Version 4

Date Printed: 19/11/2020

Approved By: Stephen.Watson

UKAS TESTING 10122

UNIAXIAL COMPRESSION TEST ON ROCK - SUMMARY OF RESULTS

Project No.	Project Name
20-0399C	Bus Connects Route 8 - Tallaght/Clondalkin to City Centre

Hole No.	Sample				Rock Type	Specimen Dimensions[2]			Bulk Density[2]	Water Content[1]	Uniaxial Compression[3]			Remarks
	Ref	Top	Base	Type		Dia. mm	Length mm	H/D	Mg/m^3	%	Condition	Mode of failure	UCS MPa	
R8-CPGS01		6.60		C	LIMESTONE	101.4	261.7	2.6	2.69	0.2	as received	F	99.9	
R8-CPGS01		7.50		C	LIMESTONE	101.4	251.9	2.5	2.69	0.1	as received	F	73.4	
R8-CPGS01		9.35		C	LIMESTONE	101.5	252.8	2.5	2.69	0.2	as received	F	93.6	
R8-CPGS02		5.55		C	LIMESTONE	101.4	253.7	2.5	0.27	0.1	as received	F	80.2	
R8-CPGS02		6.80		C	LIMESTONE	101.4	254.1	2.5	2.68	0.3	as received	F	88.2	
R8-CPGS02		8.10		C	LIMESTONE	101.5	252.7	2.5	2.68	0.1	as received	F	80.7	
R8-CPGS02		9.35		C	LIMESTONE	101.4	252.6	2.5	2.68	0.2	as received	F	104.0	
R8-CPGS03		5.05		C	LIMESTONE	101.5	254.1	2.5	2.69	0.2	as received	F	88.7	
R8-CPGS03		6.00		C	LIMESTONE	101.5	251.9	2.5	2.69	0.2	as received	F	92.4	
R8-CPGS03		7.50		C	LIMESTONE	101.4	253.6	2.5	2.72	0.2	as received	F	72.8	
R8-CPGS03		9.05		C	LIMESTONE	101.3	251.5	2.5	2.68	0.1	as received	F	76.7	
R8-CPGS04		6.20		C	LIMESTONE	101.4	255.6	2.5	2.68	0.2	as received	F	104.0	
R8-CPGS04		7.70		C	LIMESTONE	101.4	254.4	2.5	2.71	0.1	as received	F	99.3	
R8-CPGS04		11.05		C	LIMESTONE	101.5	251.0	2.5	2.67	0.1	as received	F	108.0	

Notes

1 ISRM p87 test 1, water content at 105 ± 3 °C, specimen as tested for UCS

2 ISRM p86 clause (vii), Caliper method used for determination of bulk volume and derivation of bulk density

3 ISRM p153 part 1, determination of Uniaxial Compressive Strength (UCS) of Rock Materials

above notes apply unless annotated otherwise in the remarks

Mode of failure :

S - Single shear MS - multiple shear

AC - Axial cleavage F - Fragmented

Test Specification	Date Printed	Approved By	Table
International Society for Rock Mechanics, The complete ISRM suggested methods for Rock Characterization Testing and Monitoring, 2007	19/11/2020	Stephen.Watson	1 sheet 1

eurofins | Chemtest
Eurofins Chemtest Ltd
Depot Road
Newmarket
CB8 0AL
Tel: 01638 606070
Email: info@chemtest.com

UKAS TESTING
2183

Final Report

Report No.:	20-30005-1
Initial Date of Issue:	10-Nov-2020
Client	Causeway Geotech Ltd
Client Address:	8 Drumahiskey Road Balnamore Ballymoney County Antrim BT53 7QL
Contact(s):	Carin Cornwall Colm Hurley Darren O'Mahony Gabriella Horan Joe Gervin John Cameron Lucy Newland Martin Gardiner Matthew Gilbert Neil Haggan Paul Dunlop Sean Ross Stephen Franey Stephen McCracken Stephen Watson Stuart Abraham Thomas McAllis
Project	20-0399C Bus Connects 8

Quotation No.:		**Date Received:**	05-Nov-2020
Order No.:		**Date Instructed:**	05-Nov-2020
No. of Samples:	4		
Turnaround (Wkdays):	5	**Results Due:**	11-Nov-2020
Date Approved:	10-Nov-2020		

Approved By:

Details: Glynn Harvey, Technical Manager

Eurofins Chemtest Ltd
Depot Road
Newmarket
CB8 0AL
Tel: 01638 606070
Email: info@chemtest.com

Results - Soil

Project: 20-0399C Bus Connects 8

Client: Causeway Geotech Ltd			**Chemtest Job No.:**		20-30005	20-30005	20-30005	20-30005
Quotation No.:			**Chemtest Sample ID.:**		1092179	1092180	1092181	1092182
Order No.:			Client Sample Ref.:		8	10	8	12
			Sample Location:		R8-CPGS01	R8-CPGS01	R8-CPGS03	R8-CPGS04
			Sample Type:		SOIL	SOIL	SOIL	SOIL
			Top Depth (m):		2.00	4.00	1.00	4.00
			Date Sampled:		04-Nov-2020	04-Nov-2020	04-Nov-2020	04-Nov-2020
Determinand	**Accred.**	**SOP**	**Units**	**LOD**				
Moisture	N	2030	%	0.020	13	8.5	14	0.47
pH	U	2010		4.0	8.4	8.7	8.6	9.6
Sulphate (2:1 Water Soluble) as SO4	U	2120	g/l	0.010	0.36	0.13	0.17	0.014

Test Methods

SOP	Title	Parameters included	Method summary
2010	pH Value of Soils	pH	pH Meter
2030	Moisture and Stone Content of Soils(Requirement of MCERTS)	Moisture content	Determination of moisture content of soil as a percentage of its as received mass obtained at <37°C.
2040	Soil Description(Requirement of MCERTS)	Soil description	As received soil is described based upon BS5930
2120	Water Soluble Boron, Sulphate, Magnesium & Chromium	Boron; Sulphate; Magnesium; Chromium	Aqueous extraction / ICP-OES

Report Information

Key

U	UKAS accredited
M	MCERTS and UKAS accredited
N	Unaccredited
S	This analysis has been subcontracted to a UKAS accredited laboratory that is accredited for this analysis
SN	This analysis has been subcontracted to a UKAS accredited laboratory that is not accredited for this analysis
T	This analysis has been subcontracted to an unaccredited laboratory
I/S	Insufficient Sample
U/S	Unsuitable Sample
N/E	not evaluated
<	"less than"
>	"greater than"

Comments or interpretations are beyond the scope of UKAS accreditation

The results relate only to the items tested

Uncertainty of measurement for the determinands tested are available upon request

None of the results in this report have been recovery corrected

All results are expressed on a dry weight basis

The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis TPH, BTEX, VOCs, SVOCs, PCBs, Phenols

For all other tests the samples were dried at < 37°C prior to analysis

All Asbestos testing is performed at the indicated laboratory

Issue numbers are sequential starting with 1 all subsequent reports are incremented by 1

Sample Deviation Codes

A - Date of sampling not supplied

B - Sample age exceeds stability time (sampling to extraction)

C - Sample not received in appropriate containers

D - Broken Container

E - Insufficient Sample (Applies to LOI in Trommel Fines Only)

Sample Retention and Disposal

All soil samples will be retained for a period of 45 days from the date of receipt

All water samples will be retained for 14 days from the date of receipt

Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:

customerservices@chemtest.com

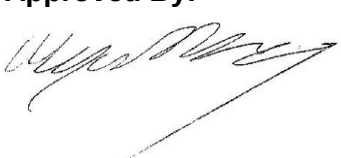
Eurofins Chemtest Ltd
Depot Road
Newmarket
CB8 0AL
Tel: 01638 606070
Email: info@chemtest.com

Final Report

Report No.:	20-31072-1
Initial Date of Issue:	19-Nov-2020
Client	Causeway Geotech Ltd
Client Address:	8 Drumahiskey Road Balnamore Ballymoney County Antrim BT53 7QL
Contact(s):	Carin Cornwall Colm Hurley Darren O'Mahony Gabriella Horan Joe Gervin John Cameron Lucy Newland Martin Gardiner Matthew Gilbert Neil Haggan Paul Dunlop Sean Ross Stephen Franey Stephen McCracken Stephen Watson Stuart Abraham Thomas McAllis
Project	20-0399C Route 8 Tallaght/ Clondalkin to City Centre

Quotation No.:		**Date Received:**	16-Nov-2020
Order No.:		**Date Instructed:**	16-Nov-2020
No. of Samples:	4		
Turnaround (Wkdays):	5	**Results Due:**	20-Nov-2020
Date Approved:	19-Nov-2020		

Approved By:



Details: Glynn Harvey, Technical Manager

Eurofins Chemtest Ltd
Depot Road
Newmarket
CB8 0AL
Tel: 01638 606070
Email: info@chemtest.com

Results - Soil

Project: 20-0399C Route 8 Tallaght/Clondalkin to City Centre

Client: Causeway Geotech Ltd			**Chemtest Job No.:**		20-31072	20-31072	20-31072	20-31072
Quotation No.:			**Chemtest Sample ID.:**		1097043	1097044	1097045	1097046
			Sample Location:		R8CPGS01	R8CPGS02	R8CPGS03	R8CPGS04
			Sample Type:		SOIL	SOIL	SOIL	SOIL
			Top Depth (m):		4.50	4.70	4.70	7.40
			Date Sampled:		13-Nov-2020	13-Nov-2020	13-Nov-2020	13-Nov-2020
Determinand	**Accred.**	**SOP**	**Units**	**LOD**				
Moisture	N	2030	%	0.020	0.38	0.58	1.3	5.1
pH	U	2010		4.0	8.9	9.2	8.8	8.9
Sulphate (2:1 Water Soluble) as SO4	U	2120	g/l	0.010	0.018	0.023	0.059	< 0.010

Test Methods

SOP	Title	Parameters included	Method summary
2010	pH Value of Soils	pH	pH Meter
2030	Moisture and Stone Content of Soils(Requirement of MCERTS)	Moisture content	Determination of moisture content of soil as a percentage of its as received mass obtained at <37°C.
2040	Soil Description(Requirement of MCERTS)	Soil description	As received soil is described based upon BS5930
2120	Water Soluble Boron, Sulphate, Magnesium & Chromium	Boron; Sulphate; Magnesium; Chromium	Aqueous extraction / ICP-OES

Report Information

Key

U	UKAS accredited
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N	Unaccredited
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N/E	not evaluated
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>	"greater than"

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Issue numbers are sequential starting with 1 all subsequent reports are incremented by 1

Sample Deviation Codes

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B - Sample age exceeds stability time (sampling to extraction)

C - Sample not received in appropriate containers

D - Broken Container

E - Insufficient Sample (Applies to LOI in Trommel Fines Only)

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All soil samples will be retained for a period of 45 days from the date of receipt

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Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:

customerservices@chemtest.com

LABORATORY RESTRICTION REPORT

Project Reference	20-0399C	To	Sean Ross
		Position	Project Manager
Project Name	Bus Connects Route 8 Tallaght/Clondalkin to City Centre	From	Joseph Nicholl
TR reference	20-0399C / G01	Position	Laboratory Quality Manager

The following sample(s) and test(s) are restricted as detailed below. Could you please complete the "Required Action" column and return the completed form to the laboratory.

Hole Number	Sample			Test Type	Reason for Restriction	Required Action
	Number	Depth (m)	Type			
R8 CPG S02	13	3.00	U	UU Triaxial	Unable to obtain specimen for test - coarse gravel content too high	CANCEL
R8 CPG S03	20	1.20	U	UU Triaxial	Unable to obtain specimen for test - coarse gravel content too high	CANCEL

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

Laboratory Signature	Project Manager Signature
Joseph Nicholl	Sean Ross
Date	Date
13 November 2020	

CAUSEWAY GEOTECH

APPENDIX E

SPT HAMMER ENERGY MEASUREMENT REPORT

Southern Testing
Environmental & Geotechnical

SPT Hammer Energy Test Report

in accordance with BSEN ISO 22476-3:2005

Southern Testing
Keeble House
Stuart Way
East Grinstead
West Sussex
RH19 4QA

SPT Hammer Ref: .0209
Test Date: 22/02/2020
Report Date: 03/03/2020
File Name: .0209.spt
Test Operator: NPB

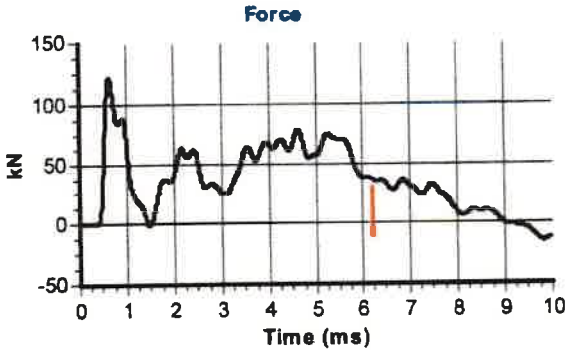
Instrumented Rod Data

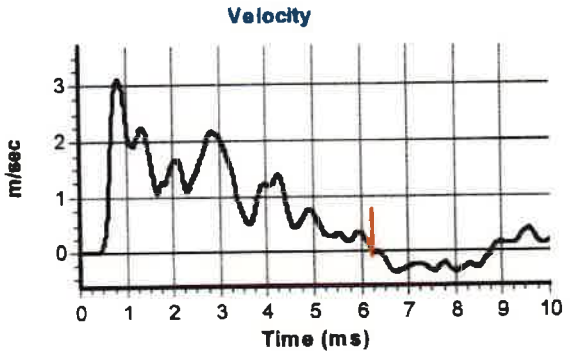
Diameter d_r (mm):	54
Wall Thickness t_r (mm):	6.0
Assumed Modulus E_a (GPa):	200
Accelerometer No.1:	6458
Accelerometer No.2:	9607

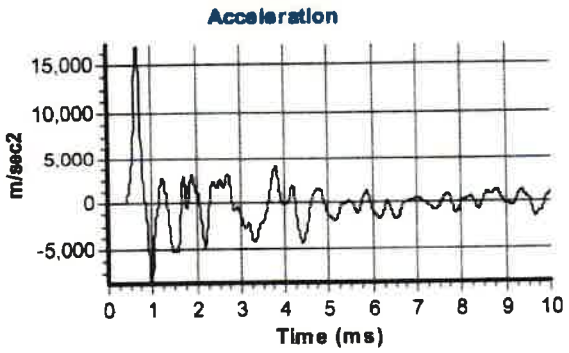
SPT Hammer Information

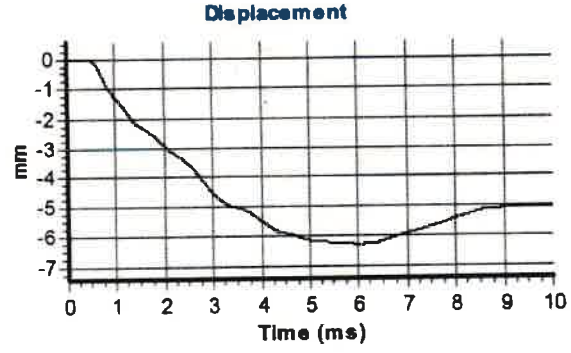
Hammer Mass m (kg):	63.5
Falling Height h (mm):	760
SPT String Length L (m):	10.0

Comments / Location
BALLEYMONEY









Calculations

Area of Rod A (mm2):	905
Theoretical Energy E_{theor} (J):	473
Measured Energy E_{meas} (J):	317

Energy Ratio E_r (%): **67**

Signed: Neil Burrows
Title: Field Operations Manager

The recommended calibration interval is 12 months

Southern Testing
Environmental & Geotechnical

SPT Hammer Energy Test Report

in accordance with BSEN ISO 22476-3:2005

Southern Testing
Keeble House
Stuart Way
East Grinstead
West Sussex
RH19 4QA

SPT Hammer Ref: .0643
Test Date: 22/02/2020
Report Date: 03/03/2020
File Name: .0643.spt
Test Operator: NPB

Instrumented Rod Data

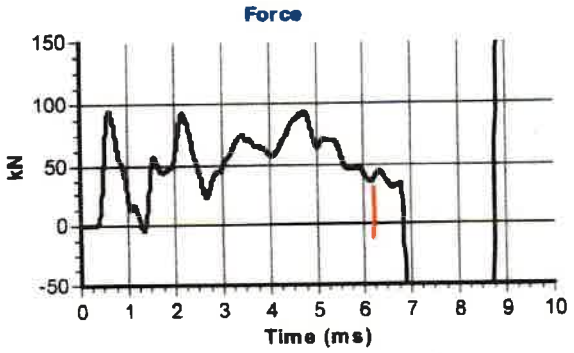
Diameter d_r (mm): 54
Wall Thickness t_r (mm): 6.0
Assumed Modulus E_a (GPa): 200
Accelerometer No.1: 6458
Accelerometer No.2: 9607

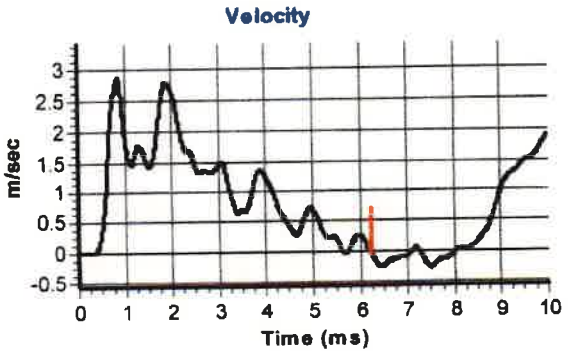
SPT Hammer Information

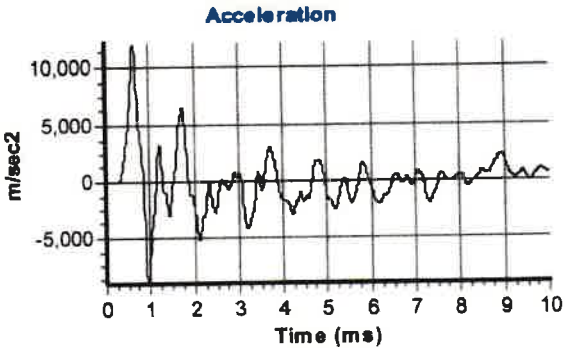
Hammer Mass m (kg): 63.5
Falling Height h (mm): 760
SPT String Length L (m): 10.0

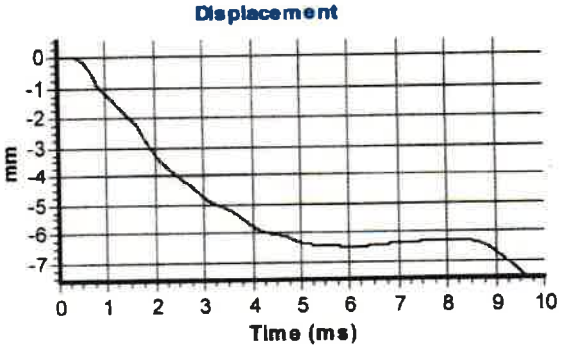
Comments / Location

BALLEYMONEY









Calculations

Area of Rod A (mm2): 905
Theoretical Energy E_{theor} (J): 473
Measured Energy E_{meas} (J): 400

Energy Ratio E_r (%): 85

Signed: Neil Burrows
Title: Field Operations Manager

The recommended calibration interval is 12 months