



Environmental Impact

Assessment Report (EIAR)

Volume 6 of 6: Appendices

(Appendix 10.2) RWI Ground Investigations 2018 - 2019

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December 2025

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IRISH DRILLING LIMITED

LOUGHREA, CO. GALWAY, IRELAND

**CONTRACT DRILLING
SITE INVESTIGATION**

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PROPOSED RAW WATER INTAKE AND PUMPING STATION AT PARTEEN BASIN

SITE INVESTIGATION DRAFT REPORT

Jacobs / Tobin Consulting Engineers,

May 2019

Ervia,
PO Box 1200,
Colville House,
Talbot St.,
Dublin 1.

FOREWORD

The borehole records have been compiled from an examination of the samples by a Geotechnical Engineer and from the Drillers' descriptions. The work was carried out in accordance with BS5930: 1999 +A2 2015, BS1377(1990) and IS EN 1997-2:2007.

The report presents an opinion on the configuration of the strata within the site based on the borehole results. The assumptions, though reasonable, are given for guidance only and no liability can be accepted for changes in conditions not revealed by the boreholes.

Contents:

1.0	Introduction
2.0	The Site & Geology
3.0	Fieldwork
4.0	Ground Conditions
4.1	Groundwater
	Site Plan
Appendix 1	Borehole Records
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Appendix 3	Laboratory Test Results
Appendix 4	Photographs

1.0 Introduction.

Irish Drilling Ltd. was instructed by Jacobs/Tobin consulting engineers, to drill two rotary core boreholes at a proposed Intake Works site at Parteen Basin, Co. Tipperary.

This investigation was carried out to determine the ground conditions and the depth and nature of the rock on the site.

The fieldwork was carried out between April 25th and May 3rd 2019.

2.0 Site & Geology

The site is located at the northern end of the Fort Henry embankment, adjacent to Parteen Basin, which is between Parteen Weir and Killaloe.

The area investigated is both in and adjacent to an SAC and was covered in trees and scrub at the time of this investigation, making access difficult for a drill rig.

Geological Survey maps of the area indicate that the site is underlain by the Carboniferous Limestone Formation.

3.0 Fieldwork.

The fieldwork was carried out in accordance with BS5930: 1999 +A2 2015, BS1377(1990) and IS EN 1997-2:2007.

The fieldwork consisted initially of carrying out a geophysical investigation which was done by Minerex Geophysics using 2D Resistivity and Seismic Refraction methods.

Two boreholes, by rotary coring, using wire-line drilling equipment, producing cores of 65mm diameter. Standard Penetration tests (SPT) were carried out in the overburden. The borehole records are included in Appendix 1.

Standpipes (50mm uPVC) were installed in the boreholes, to allow for monitoring of groundwater levels and taking of water samples. Permeability tests, by Rising Head method were carried out in the boreholes. The permeability test records and water levels are included in Appendix 2.

Laboratory testing was carried out on representative soil and rock samples. Tests include Particle Size Distribution (these are ongoing and will be presented in the Final Report) on soils, and Point Load tests on representative rock samples. The laboratory test results are presented in Appendix 3.

Photographs of the rock cores are included in Appendix 4.

All borehole locations were surveyed, to National co-ordinates, using a Trimble CU Bluetooth Total Station. All ground and strata levels are to Malin Ordnance Datum.

4.0 Ground Conditions.

The boreholes encountered silty sand and gravel, to between about 4.9m and 6.0m depth, overlying very stiff, slightly gravelly sandy clay with cobbles, to rockhead.

Rockhead was encountered at the following depths:

Borehole	Depth to rock	Comments
BH 1	11.90m (<i>21.03m O.D.</i>)	Weak to very strong limestone
BH 2	9.80m (<i>22.75m O.D.</i>)	Strong to very strong limestone

Rock generally consists of weak to very strong, thinly bedded, grey, fine to medium grained sparry bioclastic limestone, with medium spaced and locally closely spaced fractures. Reference should be made to the borehole logs and core photographs for detailed descriptions of the soils and rock at each borehole.

4.1 Groundwater.

A water flush system was used, that masks any inflows of groundwater, however the standpipes recorded a standing water level in Bh1 and Bh2 at 0.73m (*32.20m O.D.*) and 0.45m (*32.10m O.D.*) respectively.

Declan Joyce, B.E., M.Eng.Sc., C.Eng., M.I.E.I.
Chartered Geotechnical Engineer



LEGEND:

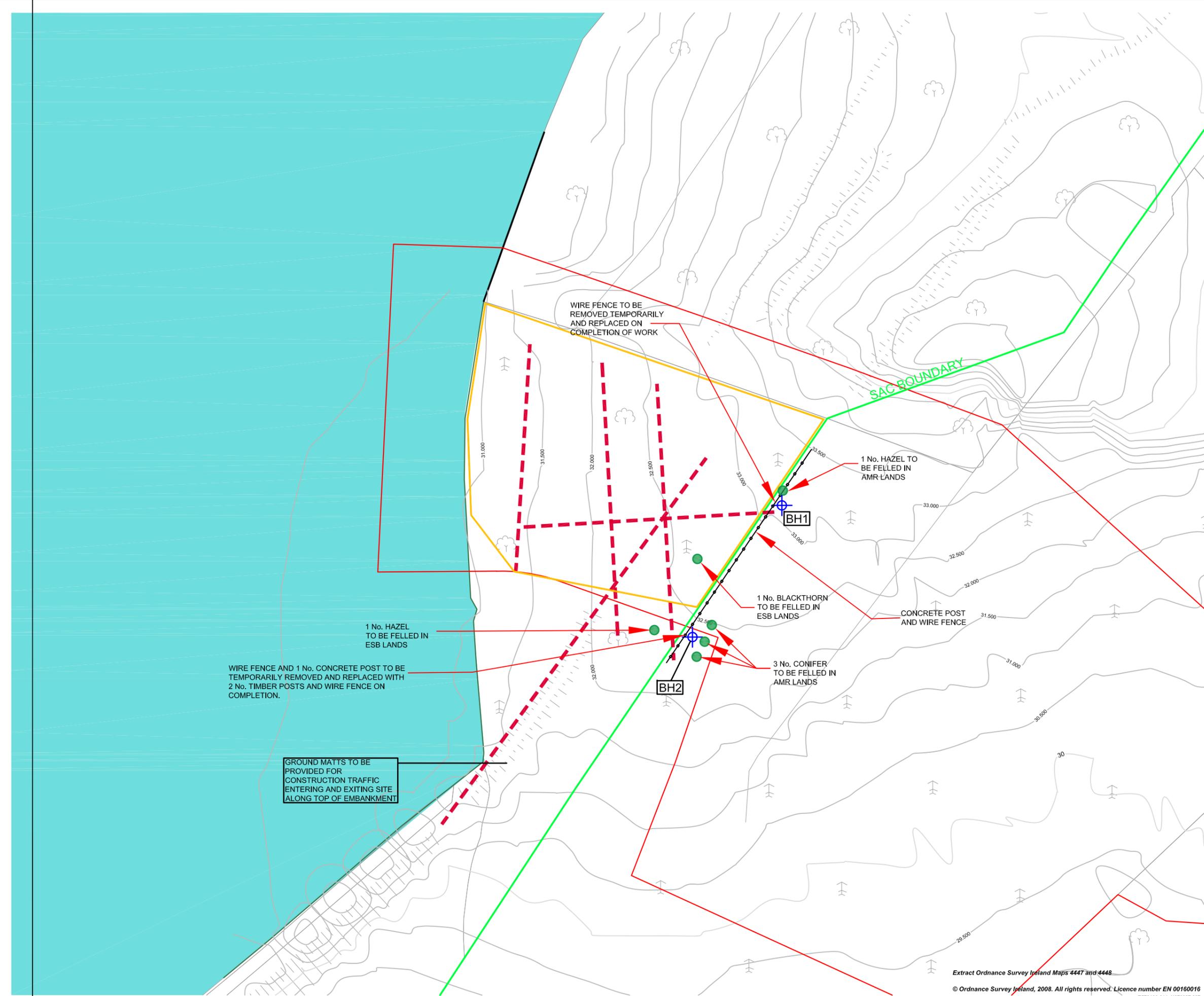
--- GEOPHYSICAL SURVEY LINE

NOTES:

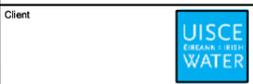
BRANCH CUTTING OF CONIFERS AT BOREHOLE LOCATIONS

BRANCH CUTTING ALONG GEOPHYSICAL SURVEY LINES

CUTTING OF FALLEN TREES FOR ACCESS AND CLEARANCE OF FALLEN BRANCHES WHERE REQUIRED



B	08-03-2019	NOTES ADDED AFTER SITE VISIT ON 07/03/2019	BM	MG		
0	25-01-2019	First Issue	JM	BD	BD	RFT
Rev	Rev. Date	Purpose of revision	Drawn	Checked	Rev'd	App'd



Client
**WATER SUPPLY PROJECT
EASTERN AND MIDLANDS REGION**

**RAW WATER INTAKE AND PUMP
STATION AT PARTEEN BASIN,
GEOPHYSICAL LOCATIONS**

Drawing status: DRAFT

Scale: 1:500@A1 DO NOT SCALE

Jacobs No.:

Client no.:

Drawing number: **6909-SK51** Rev **B**

APPENDIX 1

BOREHOLE RECORDS



Irish Drilling Ltd.
 Old Galway Rd., Loughrea,
 Co. Galway, Ireland.
 Telephone: 091841274

DRILLHOLE LOG

Project Proposed Intake Works at Parteen Basin				Location Parteen Basin		DRILLHOLE No BH 1	
Job No 19T102	Date 01-05-19 03-05-19	Ground Level (m OD) 32.93	Co-Ordinates () E 570,044.6 N 670,226.1				
Engineer Jacobs / Tobin						Sheet 2 of 3 Rev. 2	

RUN DETAILS					STRATA			Geology	Instrument/ Backfill	
Depth Date	TCR (SCR) RQD	(SPT) Fracture Spacing	Red'cd Level	Legend	Depth (Thick- ness)	DESCRIPTION				
						Discontinuities	Detail	Main		
9.00	90 (-)	9.00(55/25mm)			(7.00)			Very stiff, dark orangish brown, sandy, gravelly CLAY, with cobbles and small boulders. Gravel is sub-rounded to sub-angular, fine to medium, of assorted pink and brown sandstone and grey limestone. <i>(continued)</i>		
10.60	25 (-)									
12.00	21 (7) 0			21.03		11.90				
13.50	100 (98) 89	6				11.90 - 20.00 Medium and locally closely spaced, dipping 10 - 12 deg's, stepped and locally planar, smooth, with 0.5mm to 3mm orangish brown clay smear 12.75 - 12.82 Joint: dipping 55 deg's, stepped, smooth, 0.5mm to 2mm light orangish brown clay smear, open		Weak to very strong, thinly bedded, dark grey and grey, sparry, bioclastic, fine to medium grained LIMESTONE		
15.00	100 (90) 80	5								
15.00	100 (94) 88	5				14.60 - 14.80 Joint: vertical, undulose, tight 14.75 - 14.82 Joint: dipping 55 deg's, stepped, smooth, 0.5mm to 1mm grey silt smear, open				

IDL AGS UK DH (SPTS) PARTEEN INTAKE WORKS.GPJ IDL TP TEMPLATE.GDT 13/05/19

Drilling Progress and Water Observations								Rotary Flush				GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia	Core Dia mm	Water Strike	Water Standing	From (m)	To (m)	Type	Return (%)	
07-05-19	17.00	15.00	3.00	97	65							
08-05-19	08.00	15.00	3.00	97	65							

All dimensions in metres Scale 1:50	Client: Irish Water	Method/ Plant Used	Bit Design	HQ Driller	Logged By E.A.T.
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 Old Galway Rd., Loughrea,
 Co. Galway, Ireland.
 Telephone: 091841274

DRILLHOLE LOG

Project Proposed Intake Works at Parteen Basin				Location Parteen Basin		DRILLHOLE No BH 1	
Job No 19T102	Date 01-05-19 03-05-19	Ground Level (m OD) 32.93	Co-Ordinates () E 570,044.6 N 670,226.1				
Engineer Jacobs / Tobin						Sheet 3 of 3 Rev. 2	

RUN DETAILS						STRATA			Geology	Instrument/ Backfill
Depth Date	TCR (SCR) RQD	(SPT) Fracture Spacing	Red'cd Level	Legend	Depth (Thick- ness) (8.10)	DESCRIPTION				
						Discontinuities	Detail	Main		
16.50		4		[Brick pattern]						
18.00	100 (98) 96	3		[Brick pattern]		17.70 - 17.84 Joint: dipping 58 deg's, stepped, smooth, 0.5mm to 2mm orangish brown clay smear, open				
19.50	100 (95) 84	6		[Brick pattern]						
20.00	100 (100) 100	3	12.93	[Brick pattern]	20.00					

IDL AGS UK DH (SPTS) PARTEEN INTAKE WORKS.GPJ IDL TP TEMPLATE.GDT 13/05/19

Drilling Progress and Water Observations								Rotary Flush				GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia	Core Dia mm	Water Strike	Water Standing	From (m)	To (m)	Type	Return (%)	
08-05-19	14.00	20.00	3.00	97	65							

All dimensions in metres Scale 1:50	Client: Irish Water	Method/ Plant Used	Bit HQ Design	Driller	Logged By E.A.T.
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DRILLHOLE LOG

Project Proposed Intake Works at Parteen Basin				Location Parteen Basin		DRILLHOLE No BH 2	
Job No 19T102	Date 01-05-19 03-05-19	Ground Level (m OD) 32.55	Co-Ordinates () E 570,028.4 N 670,201.0				
Engineer Jacobs / Tobin						Sheet 1 of 3 Rev. 3	

RUN DETAILS						STRATA			Geology	Instrument/ Backfill
Depth Date	TCR (SCR) RQD	(SPT) Fracture Spacing	Red'cd Level	Legend	Depth (Thick- ness)	DESCRIPTION				
						Discontinuities	Detail	Main		
01.05 0.00	0 (-)				(1.50)			OPEN HOLE and insertion of casing (Overburden)		
1.50			31.05		1.50					
3.00	20 (-)	3.00 (32)			(2.70)			Recovered as: Dense, sub-angular to sub-rounded, medium to coarse, (assorted grey limestone and brown sandstone) GRAVEL		
4.50	33 (-)		28.35		4.20			Medium dense, light brown, slightly silty, fine to medium SAND.		
6.00	7 (-)	4.50 (23)			(1.80)					
7.20	17 (-)	6.00(65/75mm)	26.55		6.00			Very stiff, light orangish brown, slightly sandy, gravelly CLAY, with cobbles. Gravel is sub-rounded to sub-angular, fine to coarse, of assorted lithologies.		
7.50	67 (-)				(3.80)					

IDL AGS UK DH (SPTS) PARTEEN INTAKE WORKS.GPJ IDL TP TEMPLATE.GDT 13/05/19

Drilling Progress and Water Observations								Rotary Flush				GENERAL REMARKS
Date	Time	Depth	Depth	Casing Dia	Core Dia mm	Strike	Water Standing	From (m)	To (m)	Type	Return (%)	
01-05-19	11.00	0.00	0.00	97	65							

All dimensions in metres Scale 1:50	Client: Irish Water	Method/ Plant Used	Bit HQ Design	Driller	Logged By E.A.T.
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Project Proposed Intake Works at Parteen Basin				Location Parteen Basin		DRILLHOLE No BH 2	
Job No 19T102	Date 01-05-19 03-05-19	Ground Level (m OD) 32.55	Co-Ordinates () E 570,028.4 N 670,201.0				
Engineer Jacobs / Tobin						Sheet 2 of 3 Rev. 3	

RUN DETAILS					STRATA			Geology	Instrument/ Backfill
Depth Date	TCR (SCR) RQD	(SPT) Fracture Spacing	Red'cd Level	Legend	Depth (Thick- ness)	DESCRIPTION			
						Discontinuities	Detail	Main	
9.00	20 (-) -	9.00 (38/0mm)			9.80			Very stiff, light orangish brown, slightly sandy, gravelly CLAY, with cobbles. Gravel is sub-rounded to sub-angular, fine to coarse, of assorted lithologies. (continued)	
9.80	75 (-) -		22.75						
10.40	100 (93) 65	6			(10.20)	9.80 - 20.00 Medium and locally closely spaced, dipping 10 - 15 deg's, stepped, smooth, with 0.5mm to 1mm grey silt smear		Strong to very strong and occasionally weak, thinly bedded, grey, sparry, bioclastic, fine to medium grained LIMESTONE	
12.00	81 (75) 74	NI							
13.50	100 (97) 94	4							
		5							
15.00	100 (98) 89	3							
	100 (97) 84	4				14.25 - 14.50 Joint: sub-vertical, stepped, smooth, 0.5mm to 5mm light orangish brown clay smear, open to moderately wide			

IDL AGS UK DH (SPTS) PARTEEN INTAKE WORKS.GPJ IDL TP TEMPLATE.GDT 13/05/19

Drilling Progress and Water Observations								Rotary Flush				GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia	Core Dia mm	Water Strike	Water Standing	From (m)	To (m)	Type	Return (%)	

All dimensions in metres Scale 1:50	Client: Irish Water	Method/ Plant Used	Bit Design	HQ Driller	Logged By E.A.T.
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Job No 19T102	Date 01-05-19 03-05-19	Ground Level (m OD) 32.55	Co-Ordinates () E 570,028.4 N 670,201.0				
Engineer Jacobs / Tobin						Sheet 3 of 3 Rev. 3	

RUN DETAILS						STRATA			Geology	Instrument/ Backfill
Depth Date	TCR (SCR) RQD	(SPT) Fracture Spacing	Red'cd Level	Legend	Depth (Thick- ness)	DESCRIPTION				
						Discontinuities	Detail	Main		
16.50		4					Strong to very strong and occasionally weak, thinly bedded, grey, sparry, bioclastic, fine to medium grained LIMESTONE (<i>continued</i>)			
	100 (97) 93	3								
18.00		4								
	100 (96) 86	6								
19.50										
20.00	100 (96) 90		12.55		20.00					

IDL AGS UK DH (SPTS) PARTEEN INTAKE WORKS.GPJ IDL TP TEMPLATE.GDT 13/05/19

Drilling Progress and Water Observations								Rotary Flush				GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia	Core Dia mm	Water Strike	Water Standing	From (m)	To (m)	Type	Return (%)	
03-05-19	17.00	20.00	6.00	97	65							

All dimensions in metres Scale 1:50	Client: Irish Water	Method/ Plant Used	Bit HQ Design	Driller	Logged By E.A.T.
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APPENDIX 2

**WATER LEVELS
&
PERMEABILITY TEST RESULTS**

Groundwater Levels

Contract: Parteen Intake Works

Location: Parteen Basin

Client: Irish Water

Engineer:



Test carried out by: **Irish Drilling Ltd.**

Operators: D Franklin

Date installed: May 2019

Date: 10th May 2019

Standpipes	09/05/2019 m bgl			
Bh 1	0.73 (32.20m O.D.)			
Bh 2	0.45 (32.10m O.D.)			

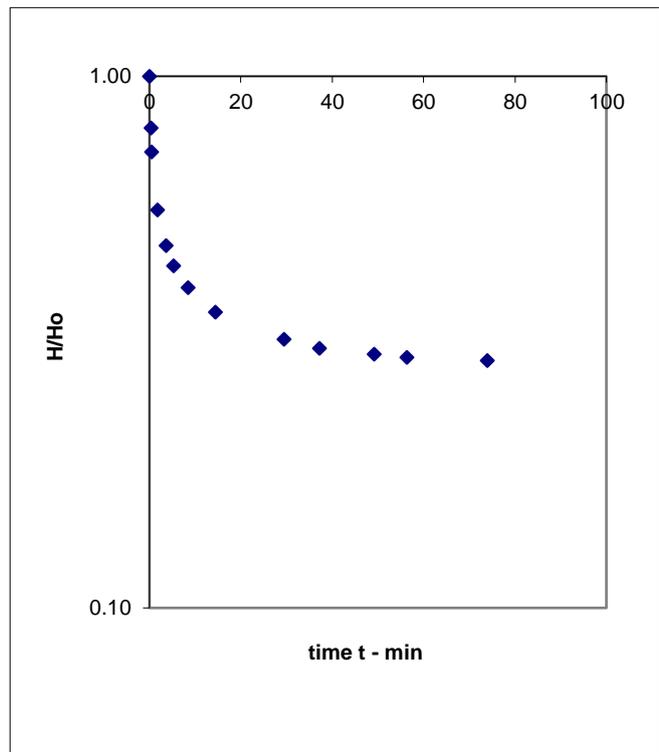
Note: O.D. levels are to Malin Ordnance Datum

IRISH DRILLING LTD. Loughrea Co. Galway Tel: (091) 841274 info@irishdrilling.ie 	Contract: Parteen Intake Works		BH 1 2.0m - 20m
	Date: 09/05/2019	Revision:	
	Eng.:	Operators: DF, SS	

Bottom of borehole (below G.L.)	20.00m	Weather	Fair
Bottom of solid casing (below g.L.)	2.00m	Type of test	Rising Head
Top of filter material	1.00m	Diameter of borehole	0.10m
Initial water level (m OD)	0.73m	Length of filter	18m
Initial water head difference	1.77m	Diameter of filter	0.1m
Ground level (m O.D.)	32.93m	Type of piezometer	50mm uPVC

RISING HEAD TEST

time min	water level m	H	H/Ho
0	2.50	2.50	1.00
0.33	2.00	2.00	0.80
0.5	1.80	1.80	0.72
1.73	1.40	1.40	0.56
3.62	1.20	1.20	0.48
5.32	1.10	1.10	0.44
8.5	1.00	1.00	0.40
14.43	0.90	0.90	0.36
29.48	0.80	0.80	0.32
37.17	0.77	0.77	0.31
49.17	0.75	0.75	0.30
56.37	0.74	0.74	0.30
74	0.73	0.73	0.29



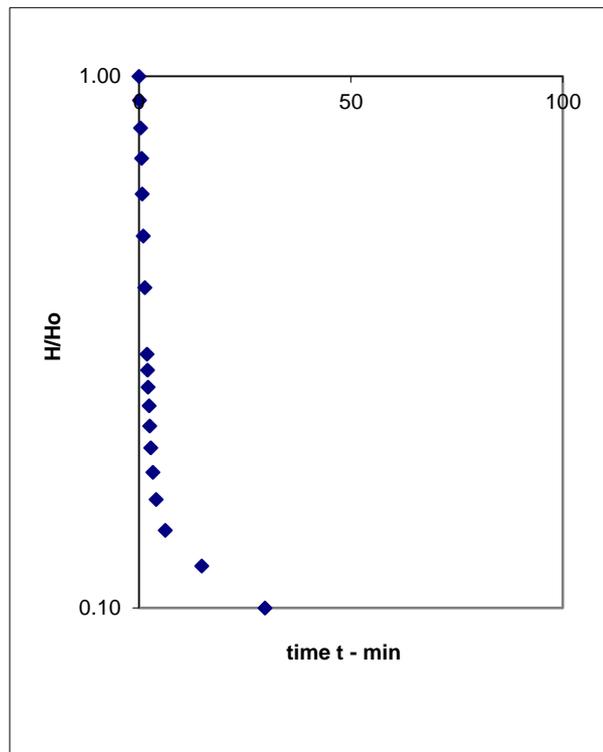
k (permeability) = 3.25E-05 m/sec

IRISH DRILLING LTD. Loughrea Co. Galway Tel: (091) 841274 info@irishdrilling.ie 	Contract: Parteen Intake Works		Borehole:
	Date: 09/05/2019		2
	Eng.:		17.0 - 20.0m
			Operators: DF

Bottom of borehole (below G.L.)	20.00m	Weather	Fair
Bottom of solid casing (below g.L.)	17.00m	Type of test	Rising Head
Top of filter material	1.00m	Diameter of borehole	0.10m
Initial water level (m OD)	0.45m	Length of filter	17m
Initial water head difference	4.50m	Diameter of filter	0.1m
Ground level (m O.D.)		Type of piezometer	50mm uPVC

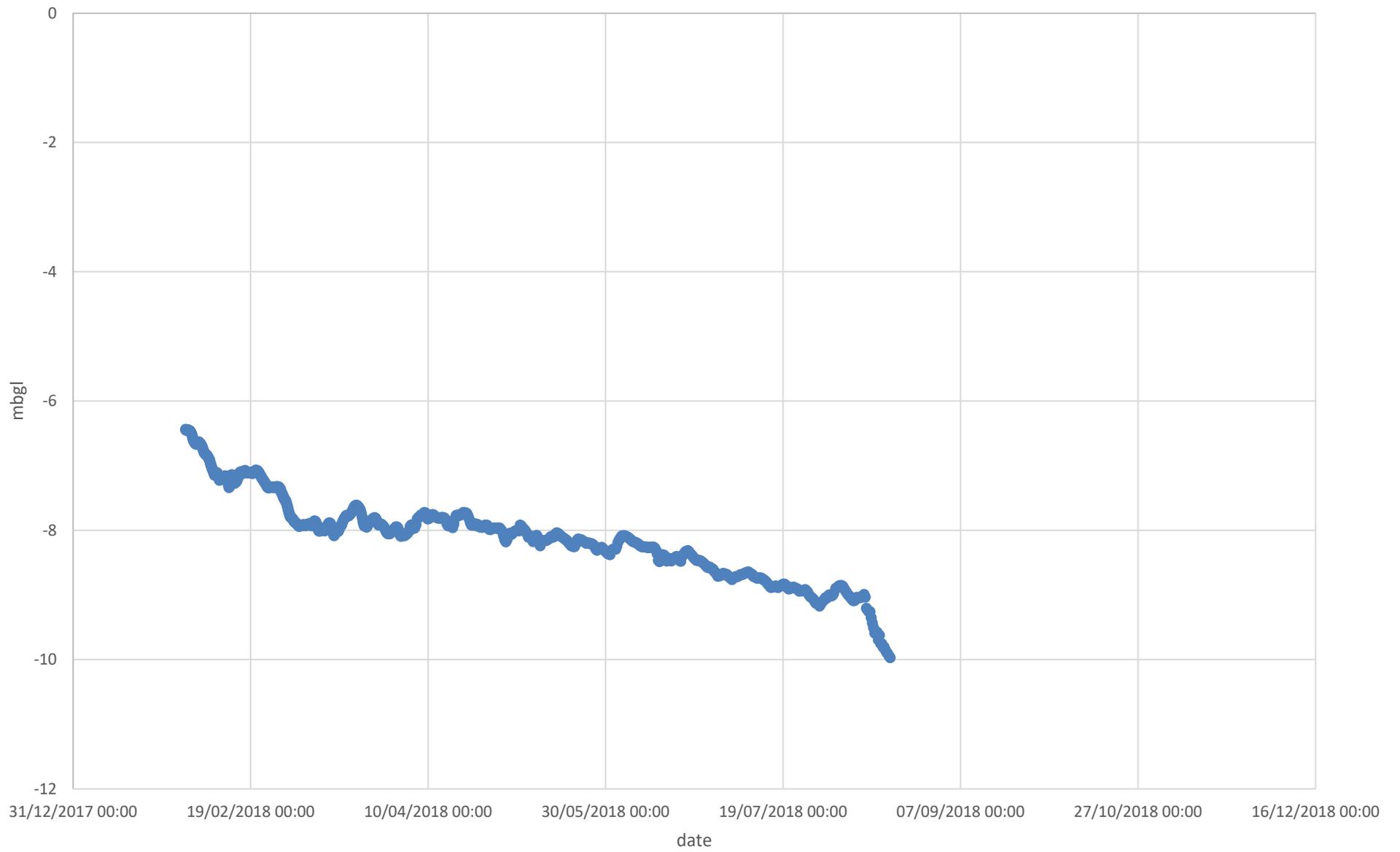
RISING HEAD TEST

time min	water level m	H	H/Ho
0	5.00	5.00	1.00
0.13	4.50	4.50	0.90
0.32	4.00	4.00	0.80
0.57	3.50	3.50	0.70
0.75	3.00	3.00	0.60
1	2.50	2.50	0.50
1.43	2.00	2.00	0.40
1.92	1.50	1.50	0.30
2.05	1.40	1.40	0.28
2.18	1.30	1.30	0.26
2.36	1.20	1.20	0.24
2.57	1.10	1.10	0.22
2.83	1.00	1.00	0.20
3.25	0.90	0.90	0.18
4	0.80	0.80	0.16
6.16	0.70	0.70	0.14
14.83	0.60	0.60	0.12
29.7	0.50	0.50	0.10

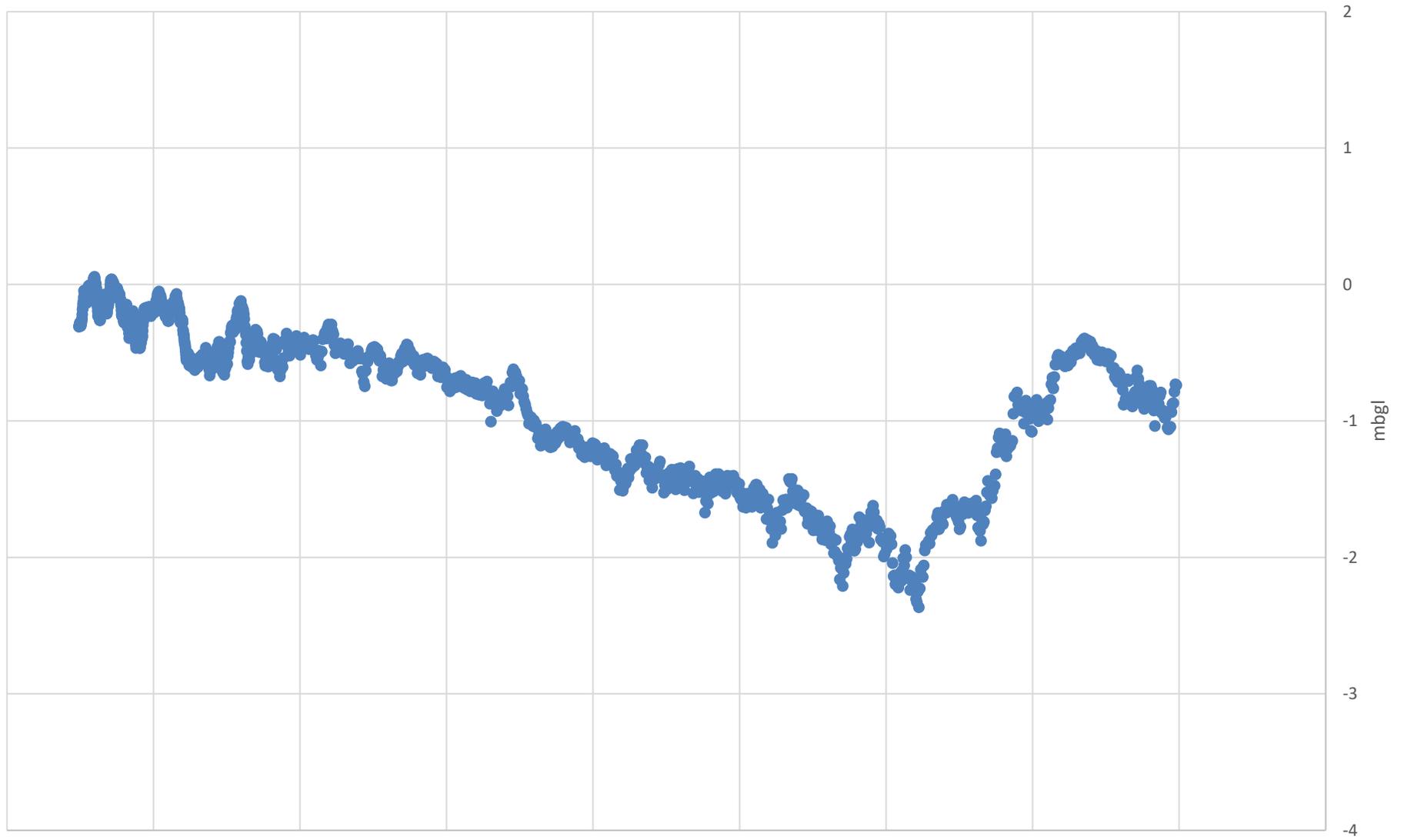


k (permeability) = 6.53E-05 m/sec

BH 5



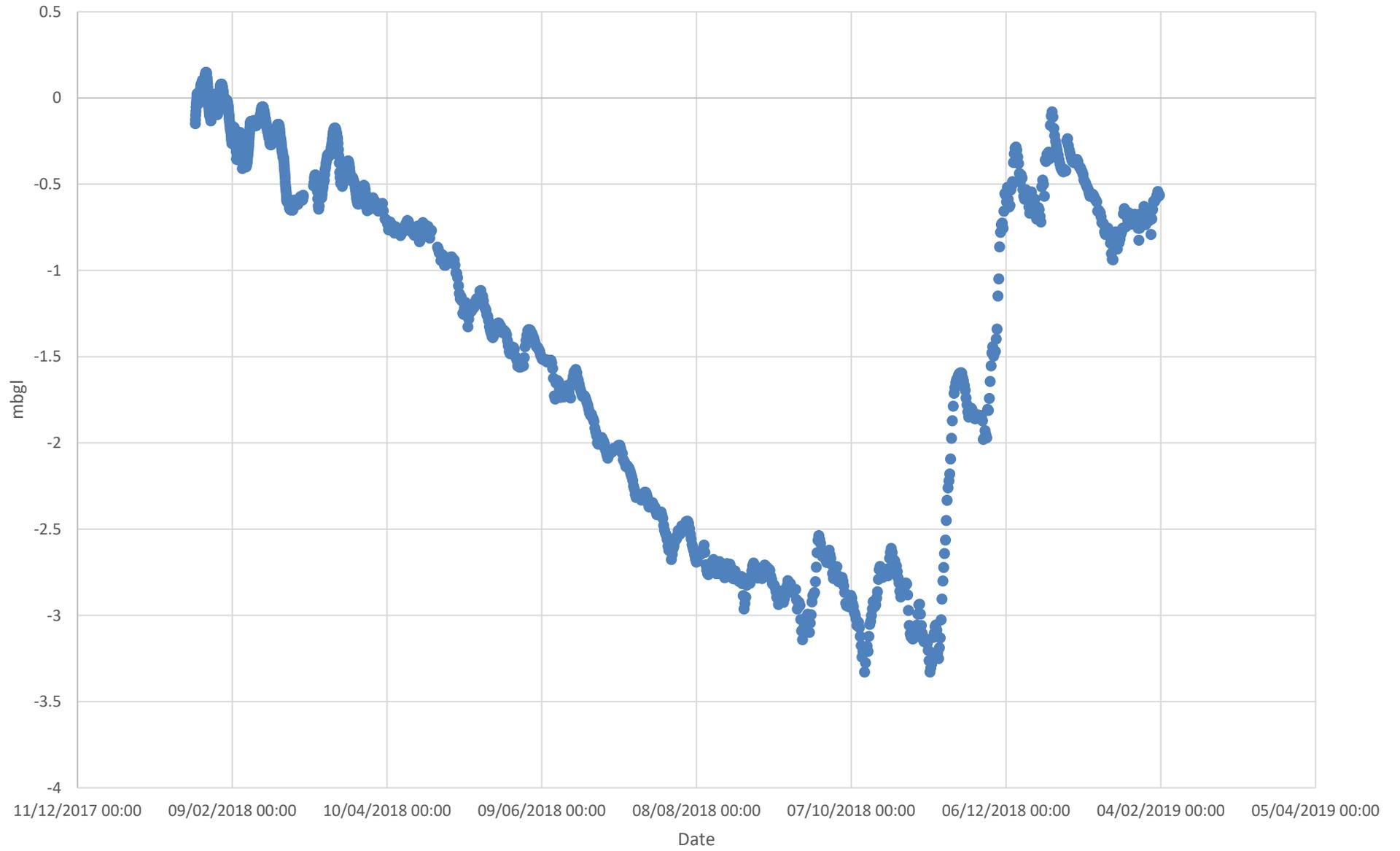
BH46



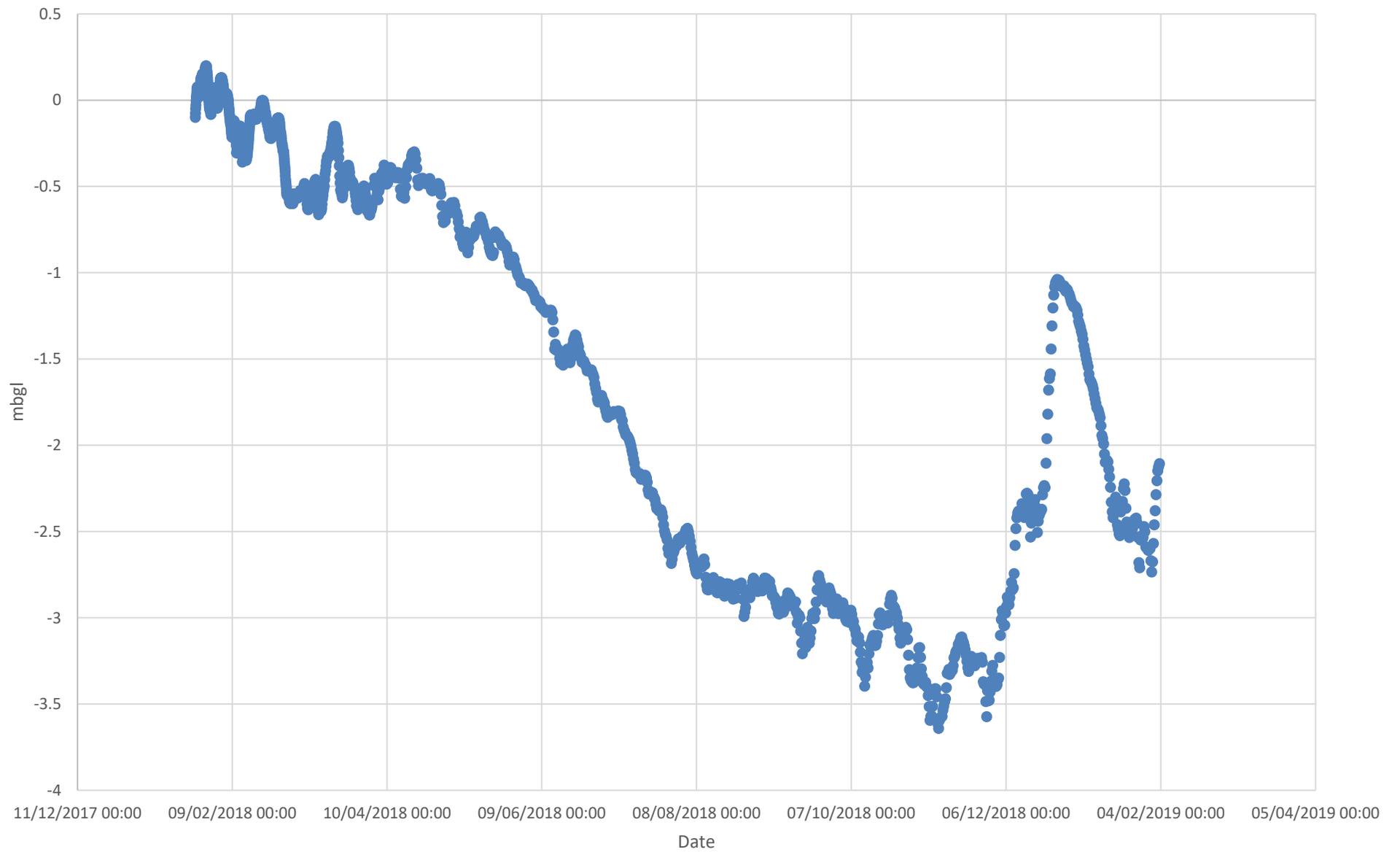
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Date

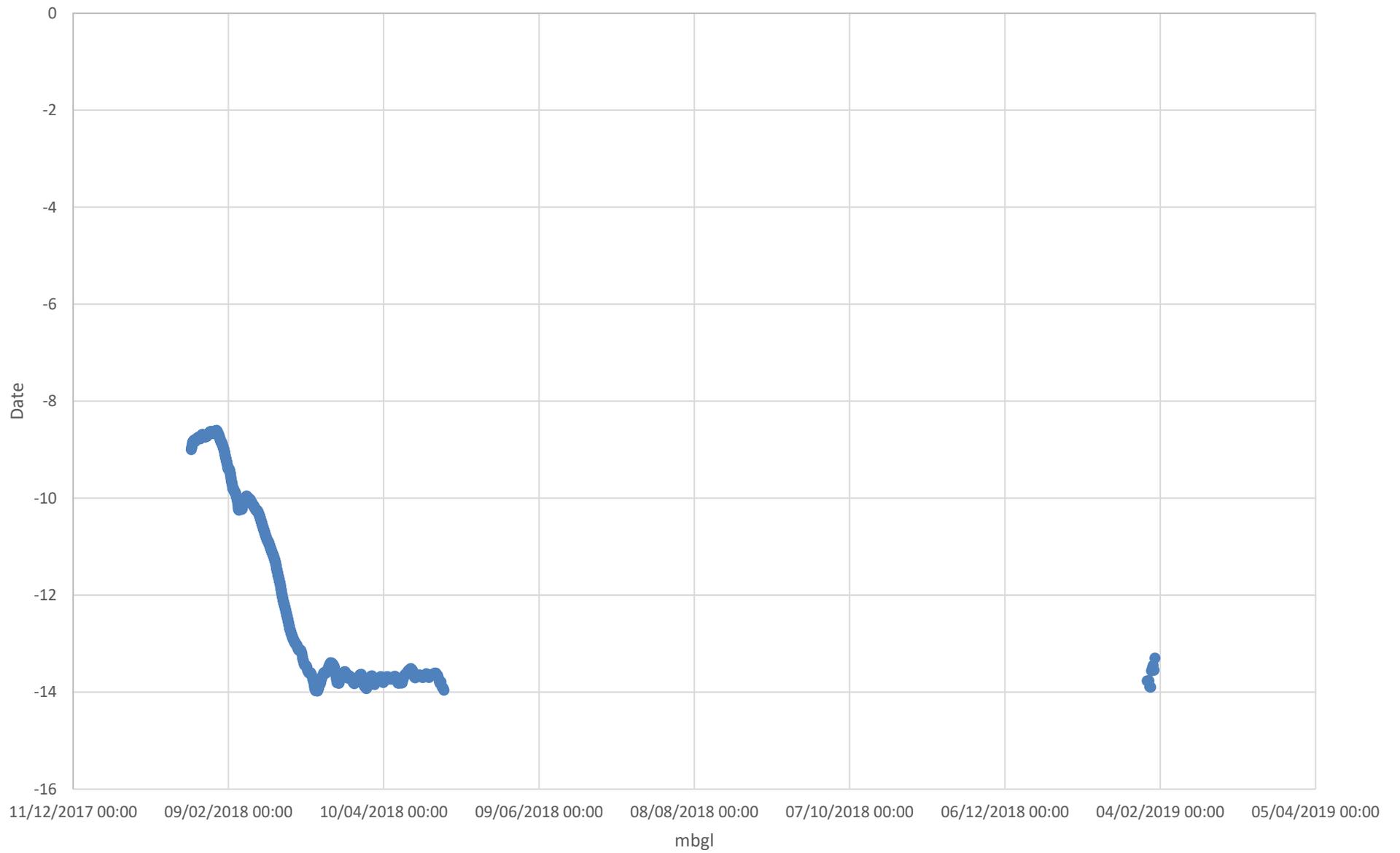
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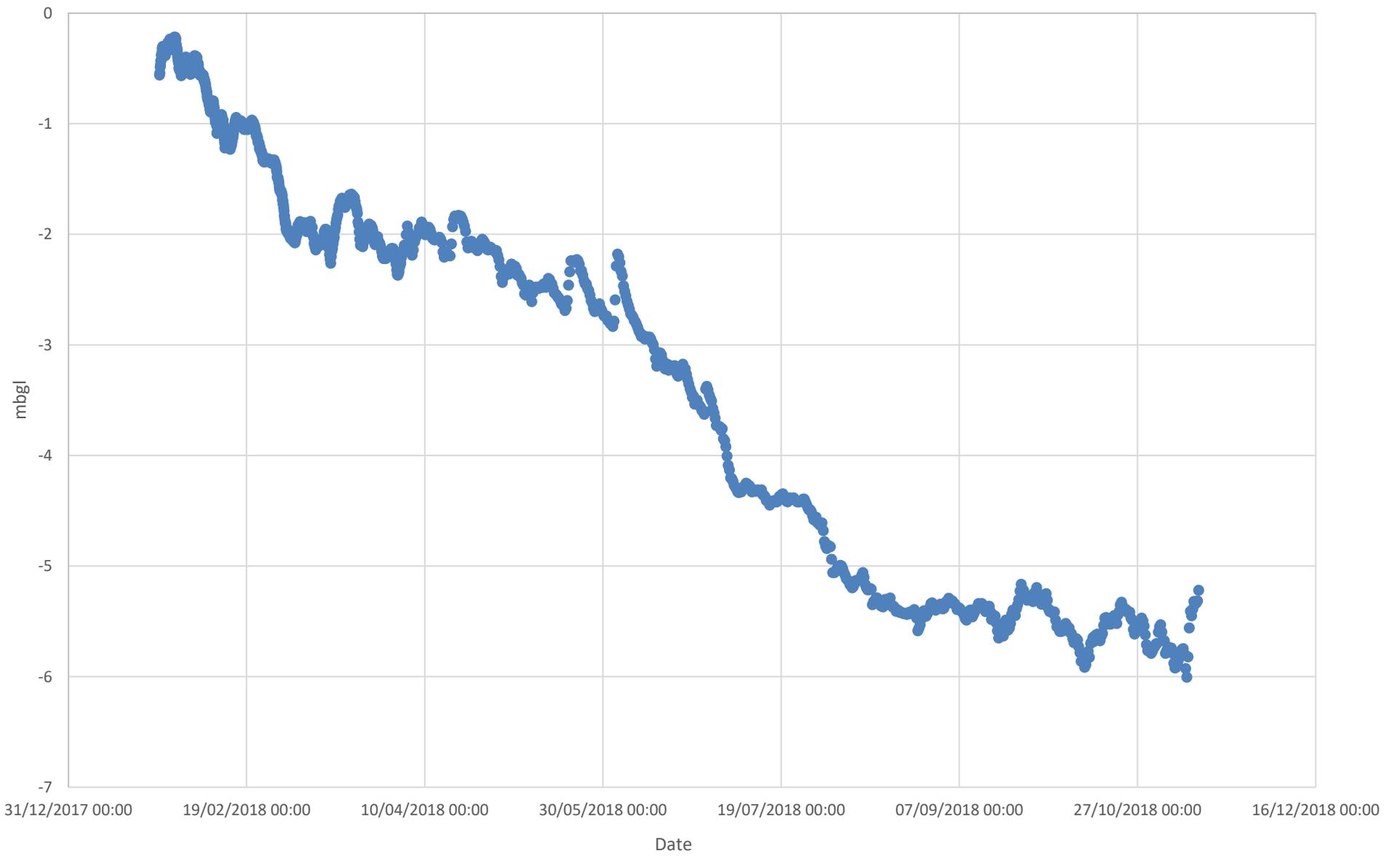
BH 63



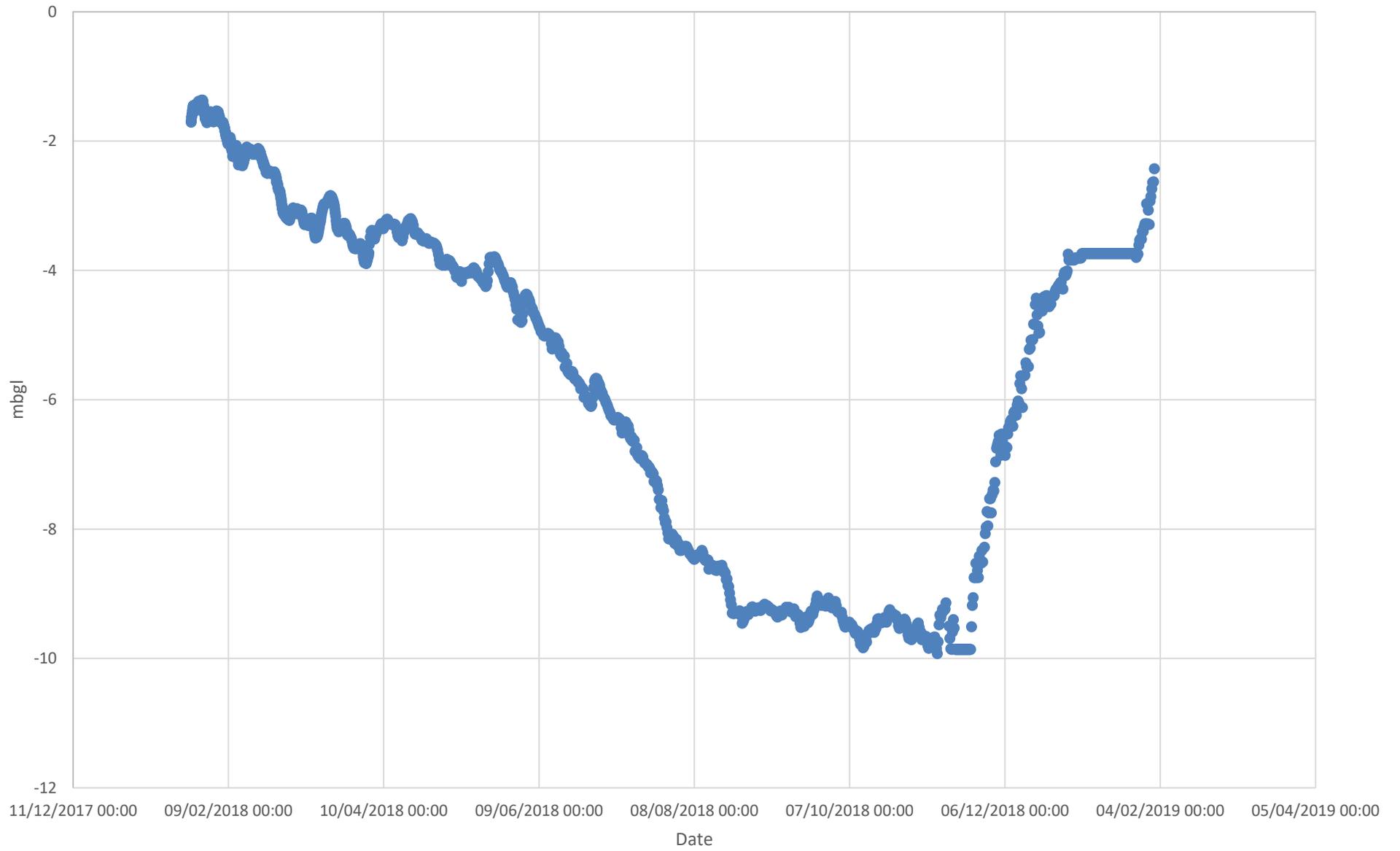
BH 189



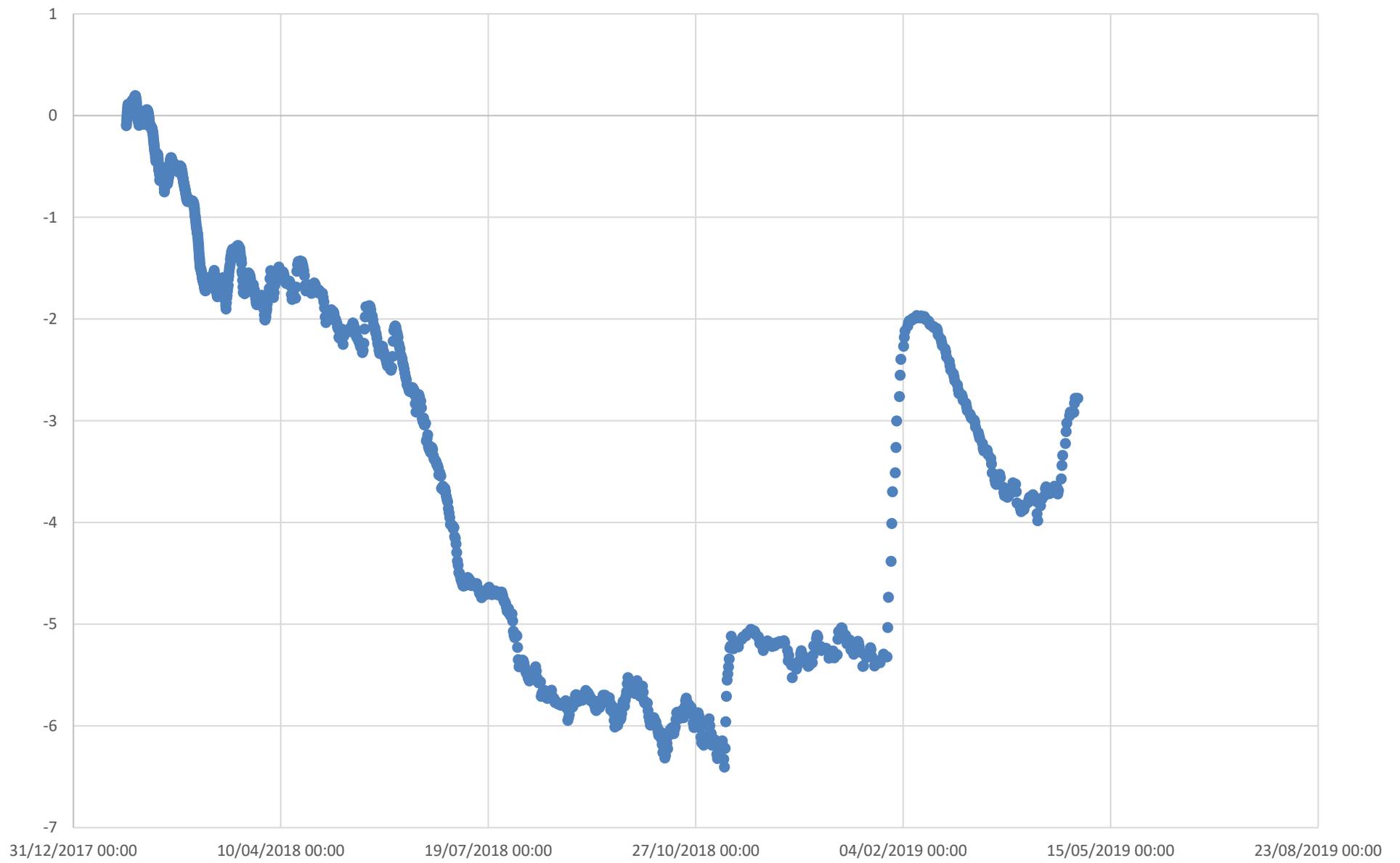
BH 192



BH 232



BH 233



APPENDIX 3

LABORATORY TEST RESULTS

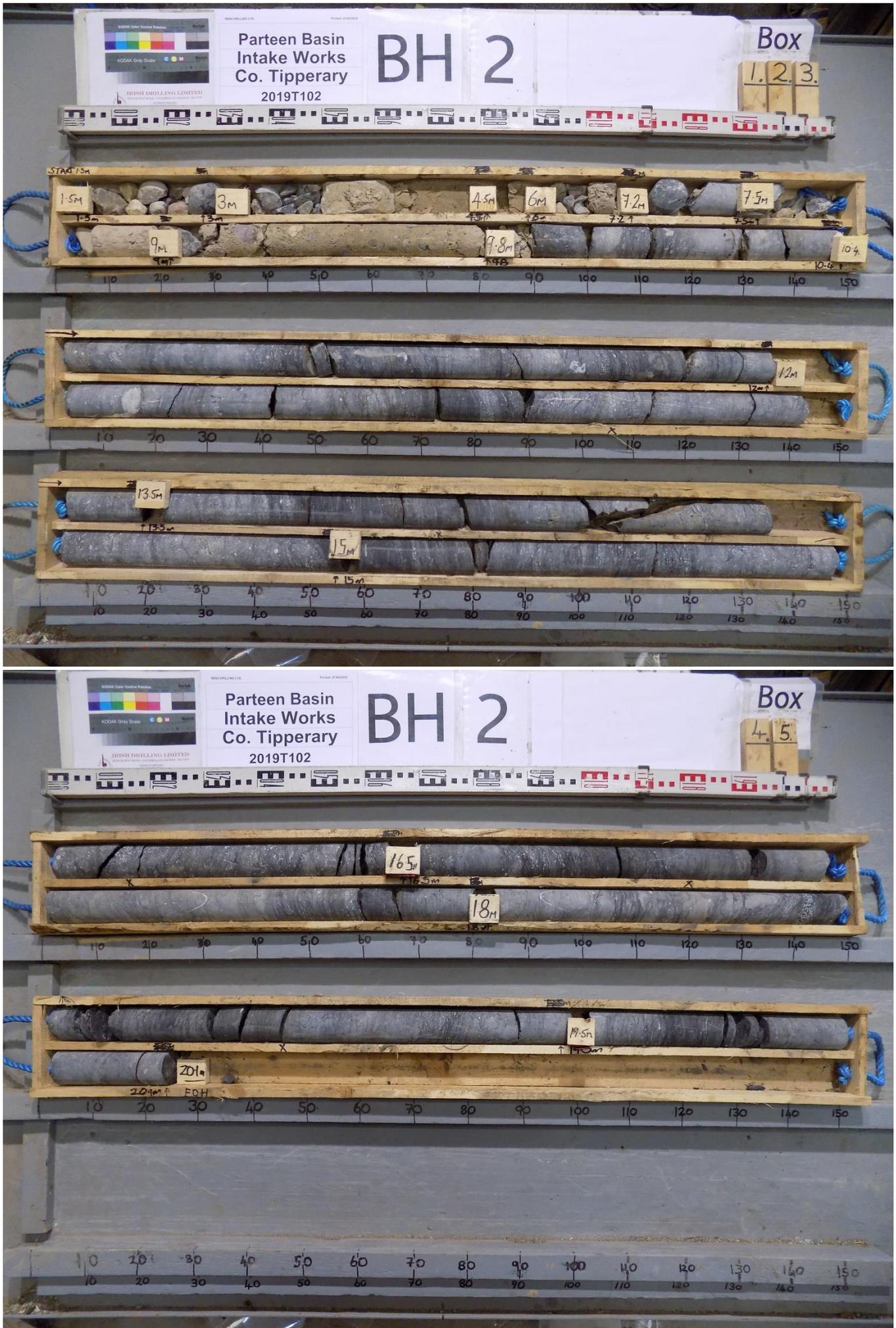
APPENDIX 4

PHOTOGRAPHS

Irish Drilling Ltd: Core Photos:



Irish Drilling Ltd: Core Photos:





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 Co. Galway, Ireland.
 Telephone: 091841274

DRILLHOLE LOG

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Job No 19T102	Date 01-05-19 03-05-19	Ground Level (m OD) 32.93	Co-Ordinates () E 570,044.6 N 670,226.1				
Engineer Jacobs / Tobin						Sheet 2 of 3 Rev. 3	

RUN DETAILS					STRATA			Geology	Instrument/ Backfill	
Depth Date	TCR (SCR) RQD	(SPT) Fracture Spacing	Red'cd Level	Legend	Depth (Thick- ness)	DESCRIPTION				
						Discontinuities	Detail	Main		
9.00	90 (-)	9.00(55/25mm)			(7.00)			Very stiff, dark orangish brown, slightly sandy, gravelly CLAY, with cobbles and small boulders. (Occasionally very gravelly, very silty (medium) sand)		
10.60	25 (-)							Gravel is sub-rounded to sub-angular, fine to medium, of assorted pink and brown sandstone and grey limestone. <i>(continued)</i>		
12.00	21 (7) 0			21.03		11.90				
13.50	100 (98) 89	6				11.90 - 20.00 Medium and locally closely spaced, dipping 10 - 12 deg's, stepped and locally planar, smooth, with 0.5mm to 3mm orangish brown clay smear 12.75 - 12.82 Joint: dipping 55 deg's, stepped, smooth, 0.5mm to 2mm light orangish brown clay smear, open		Weak to very strong, thinly bedded, dark grey and grey, sparry, bioclastic, fine to medium grained LIMESTONE		
15.00	100 (90) 80	5								
15.00	100 (94) 88	5				14.60 - 14.80 Joint: vertical, undulose, tight 14.75 - 14.82 Joint: dipping 55 deg's, stepped, smooth, 0.5mm to 1mm grey silt smear, open				

IDL AGS UK DH (SPTS) PARTEEN INTAKE WORKS.GPJ IDL TP TEMPLATE.GDT 16/05/19

Drilling Progress and Water Observations								Rotary Flush				GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia	Core Dia mm	Water Strike	Water Standing	From (m)	To (m)	Type	Return (%)	
07-05-19	17.00	15.00	3.00	97	65							
08-05-19	08.00	15.00	3.00	97	65							

All dimensions in metres Scale 1:50	Client: Irish Water	Method/ Plant Used	Bit Design	HQ Driller	Logged By E.A.T.
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Engineer Jacobs / Tobin						Sheet 3 of 3 Rev. 3	

RUN DETAILS						STRATA			Geology	Instrument/ Backfill
Depth Date	TCR (SCR) RQD	(SPT) Fracture Spacing	Red'cd Level	Legend	Depth (Thick- ness) (8.10)	DESCRIPTION				
						Discontinuities	Detail	Main		
16.50		4		[Brick pattern]				Weak to very strong, thinly bedded, dark grey and grey, sparry, bioclastic, fine to medium grained LIMESTONE <i>(continued)</i>	[Vertical line pattern]	
	100 (98) 96	3		[Brick pattern]			17.70 - 17.84 Joint: dipping 58 deg's, stepped, smooth, 0.5mm to 2mm orangish brown clay smear, open			
18.00				[Brick pattern]						
	100 (95) 84	6		[Brick pattern]						
19.50		3		[Brick pattern]						
20.00	100 (100) 100		12.93		20.00					

IDL AGS UK DH (SPTS) PARTEEN INTAKE WORKS.GPJ IDL TP TEMPLATE.GDT 16/05/19

Drilling Progress and Water Observations								Rotary Flush				GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia	Core Dia mm	Water Strike	Water Standing	From (m)	To (m)	Type	Return (%)	
08-05-19	14.00	20.00	3.00	97	65							

All dimensions in metres Scale 1:50	Client: Irish Water	Method/ Plant Used	Bit HQ Design	Driller	Logged By E.A.T.
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DRILLHOLE LOG

Project Proposed Intake Works at Parteen Basin				Location Parteen Basin		DRILLHOLE No BH 2	
Job No 19T102	Date 01-05-19 03-05-19	Ground Level (m OD) 32.55	Co-Ordinates () E 570,028.4 N 670,201.0				
Engineer Jacobs / Tobin						Sheet 1 of 3 Rev. 3	

RUN DETAILS						STRATA			Geology	Instrument/ Backfill
Depth Date	TCR (SCR) RQD	(SPT) Fracture Spacing	Red'cd Level	Legend	Depth (Thick- ness)	DESCRIPTION				
						Discontinuities	Detail	Main		
01.05 0.00	0 (-)				(1.50)			OPEN HOLE and insertion of casing (Overburden)		
1.50			31.05		1.50					
3.00	20 (-)	3.00 (32)			(2.70)			Recovered as: Dense, sub-angular to sub-rounded, medium to coarse, (assorted grey limestone and brown sandstone) GRAVEL		
4.50	33 (-)		28.35		4.20					
6.00	7 (-)	4.50 (23)			(1.80)			Medium dense, light brown, slightly silty, fine to medium SAND.		
7.20	17 (-)	6.00(65/75mm)	26.55		6.00					
7.50	67 (-)				(3.80)			Very stiff, light orangish brown, slightly sandy, gravelly CLAY, with cobbles. Gravel is sub-rounded to sub-angular, fine to coarse, of assorted lithologies.		

IDL AGS UK DH (SPTS) PARTEEN INTAKE WORKS.GPJ IDL TP TEMPLATE.GDT 16/05/19

Drilling Progress and Water Observations								Rotary Flush				GENERAL REMARKS
Date	Time	Depth	Depth	Casing Dia	Core Dia mm	Strike	Water Standing	From (m)	To (m)	Type	Return (%)	
01-05-19	11.00	0.00	0.00	97	65							

All dimensions in metres Scale 1:50	Client: Irish Water	Method/ Plant Used	Bit Design	HQ Driller	Logged By E.A.T.
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DRILLHOLE LOG

Project Proposed Intake Works at Parteen Basin				Location Parteen Basin		DRILLHOLE No BH 2	
Job No 19T102	Date 01-05-19 03-05-19	Ground Level (m OD) 32.55	Co-Ordinates () E 570,028.4 N 670,201.0				
Engineer Jacobs / Tobin						Sheet 2 of 3 Rev. 3	

RUN DETAILS					STRATA			Geology	Instrument/ Backfill	
Depth Date	TCR (SCR) RQD	(SPT) Fracture Spacing	Red'cd Level	Legend	Depth (Thick- ness)	DESCRIPTION				
						Discontinuities	Detail	Main		
9.00	20 (-) -	9.00 (38/0mm)	22.75		9.80			Very stiff, light orangish brown, slightly sandy, gravelly CLAY, with cobbles. Gravel is sub-rounded to sub-angular, fine to coarse, of assorted lithologies. (continued)		
9.80	75 (-) -									
10.40	100 (93) 65	6				9.80 - 20.00 Medium and locally closely spaced, dipping 10 - 15 deg's, stepped, smooth, with 0.5mm to 1mm grey silt smear		Strong to very strong and occasionally weak, thinly bedded, grey, sparry, bioclastic, fine to medium grained LIMESTONE		
12.00	81 (75) 74	NI								
13.50	100 (97) 94	4								
15.00	100 (98) 89	5								
	100 (97) 84	3								
		4								
					(10.20)	14.25 - 14.50 Joint: sub-vertical, stepped, smooth, 0.5mm to 5mm light orangish brown clay smear, open to moderately wide				

IDL AGS UK DH (SPTS) PARTEEN INTAKE WORKS.GPJ IDL TP TEMPLATE.GDT 16/05/19

Drilling Progress and Water Observations								Rotary Flush				GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia	Core Dia mm	Water Strike	Water Standing	From (m)	To (m)	Type	Return (%)	

All dimensions in metres Scale 1:50	Client: Irish Water	Method/ Plant Used	Bit Design	HQ Driller	Logged By E.A.T.
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DRILLHOLE LOG

Project Proposed Intake Works at Parteen Basin				Location Parteen Basin		DRILLHOLE No BH 2	
Job No 19T102	Date 01-05-19 03-05-19	Ground Level (m OD) 32.55	Co-Ordinates () E 570,028.4 N 670,201.0				
Engineer Jacobs / Tobin						Sheet 3 of 3 Rev. 3	

RUN DETAILS					STRATA			Geology	Instrument/ Backfill	
Depth Date	TCR (SCR) RQD	(SPT) Fracture Spacing	Red'cd Level	Legend	Depth (Thick- ness)	DESCRIPTION				
						Discontinuities	Detail	Main		
16.50		4						Strong to very strong and occasionally weak, thinly bedded, grey, sparry, bioclastic, fine to medium grained LIMESTONE <i>(continued)</i>		
	100 (97) 93	3								
18.00										
	100 (96) 86	4								
19.50		6								
20.00	100 (96) 90		12.55		20.00					

IDL AGS UK DH (SPTS) PARTEEN INTAKE WORKS.GPJ IDL TP TEMPLATE.GDT 16/05/19

Drilling Progress and Water Observations								Rotary Flush				GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia	Core Dia mm	Water Strike	Water Standing	From (m)	To (m)	Type	Return (%)	
03-05-19	17.00	20.00	6.00	97	65							

All dimensions in metres Scale 1:50	Client: Irish Water	Method/ Plant Used	Bit Design	HQ Driller	Logged By E.A.T.
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Supplementary information from Irish Drilling



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DRILLHOLE LOG

Project Proposed Intake Works at Parteen Basin				Location Parteen Basin		DRILLHOLE No BH 1	
Job No 19T102	Date 01-05-19 03-05-19	Ground Level (m OD) 32.93	Co-Ordinates () E 570,044.6 N 670,226.1				
Engineer Jacobs / Tobin						Sheet 2 of 3 Rev. 3	

RUN DETAILS					STRATA			Geology	Instrument/ Backfill		
Depth Date	TCR (SCR) RQD	(SPT) Fracture Spacing	Red'cd Level	Legend	Depth (Thick- ness)	DESCRIPTION					
						Discontinuities	Detail	Main			
9.00	90 (-)	9.00(55/25mm)			(7.00)			Very stiff, dark orangish brown, slightly sandy, gravelly CLAY, with cobbles and small boulders. (Occasionally very gravelly, very silty (medium) sand)			
10.60	25 (-)								Gravel is sub-rounded to sub-angular, fine to medium, of assorted pink and brown sandstone and grey limestone. <i>(continued)</i>		
12.00	21 (7) 0				21.03	11.90					
13.50	100 (98) 89	6				11.90 - 20.00 Medium and locally closely spaced, dipping 10 - 12 deg's, stepped and locally planar, smooth, with 0.5mm to 3mm orangish brown clay smear 12.75 - 12.82 Joint: dipping 55 deg's, stepped, smooth, 0.5mm to 2mm light orangish brown clay smear, open		Weak to very strong, thinly bedded, dark grey and grey, sparry, bioclastic, fine to medium grained LIMESTONE			
		5									
15.00	100 (90) 80	6									
15.00	100 (94) 88	5					14.60 - 14.80 Joint: vertical, undulose, tight 14.75 - 14.82 Joint: dipping 55 deg's, stepped, smooth, 0.5mm to 1mm grey silt smear, open				

IDL AGS UK DH (SPTS) PARTEEN INTAKE WORKS.GPJ IDL TP TEMPLATE.GDT 16/05/19

Drilling Progress and Water Observations								Rotary Flush				GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia	Core Dia mm	Water Strike	Water Standing	From (m)	To (m)	Type	Return (%)	
07-05-19	17.00	15.00	3.00	97	65							
08-05-19	08.00	15.00	3.00	97	65							

All dimensions in metres Scale 1:50	Client: Irish Water	Method/ Plant Used	Bit Design	HQ Driller	Logged By E.A.T.
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DRILLHOLE LOG

Project Proposed Intake Works at Parteen Basin				Location Parteen Basin		DRILLHOLE No BH 1	
Job No 19T102		Date 01-05-19 03-05-19		Ground Level (m OD) 32.93			
Engineer Jacobs / Tobin						Sheet 3 of 3 Rev. 3	

RUN DETAILS						STRATA			Geology	Instrument/ Backfill
Depth Date	TCR (SCR) RQD	(SPT) Fracture Spacing	Red'cd Level	Legend	Depth (Thick- ness) (8.10)	DESCRIPTION				
						Discontinuities	Detail	Main		
16.50		4		[Brick pattern]		17.70 - 17.84 Joint: dipping 58 deg's, stepped, smooth, 0.5mm to 2mm orangish brown clay smear, open	Weak to very strong, thinly bedded, dark grey and grey, sparry, bioclastic, fine to medium grained LIMESTONE (continued)		[Dotted pattern]	
	100 (98) 96	3		[Brick pattern]						
18.00		6		[Brick pattern]						
	100 (95) 84	3		[Brick pattern]						
19.50										
20.00	100 (100) 100		12.93		20.00					

IDL AGS UK DH (SPTS) PARTEEN INTAKE WORKS.GPJ IDL TP TEMPLATE.GDT 16/05/19

Drilling Progress and Water Observations								Rotary Flush				GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia	Core Dia mm	Water Strike	Water Standing	From (m)	To (m)	Type	Return (%)	
08-05-19	14.00	20.00	3.00	97	65							

All dimensions in metres Scale 1:50	Client: Irish Water	Method/ Plant Used	Bit HQ Design	Driller	Logged By E.A.T.
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DRILLHOLE LOG

Project Proposed Intake Works at Parteen Basin				Location Parteen Basin		DRILLHOLE No BH 2	
Job No 19T102	Date 01-05-19 03-05-19	Ground Level (m OD) 32.55	Co-Ordinates () E 570,028.4 N 670,201.0				
Engineer Jacobs / Tobin						Sheet 1 of 3 Rev. 3	

RUN DETAILS						STRATA			Geology	Instrument/ Backfill
Depth Date	TCR (SCR) RQD	(SPT) Fracture Spacing	Red'cd Level	Legend	Depth (Thick- ness)	DESCRIPTION				
						Discontinuities	Detail	Main		
01.05 0.00	0 (-)				(1.50)			OPEN HOLE and insertion of casing (Overburden)		
1.50			31.05		1.50					
3.00	20 (-)	3.00 (32)			(2.70)			Recovered as: Dense, sub-angular to sub-rounded, medium to coarse, (assorted grey limestone and brown sandstone) GRAVEL		
4.50	33 (-)		28.35		4.20					
6.00	7 (-)	4.50 (23)			(1.80)			Medium dense, light brown, slightly silty, fine to medium SAND.		
7.20	17 (-)	6.00(65/75mm)	26.55		6.00					
7.50	67 (-)				(3.80)			Very stiff, light orangish brown, slightly sandy, gravelly CLAY, with cobbles. Gravel is sub-rounded to sub-angular, fine to coarse, of assorted lithologies.		

IDL AGS UK DH (SPTS) PARTEEN INTAKE WORKS.GPJ IDL TP TEMPLATE.GDT 16/05/19

Drilling Progress and Water Observations								Rotary Flush				GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia	Core Dia mm	Water Strike	Water Standing	From (m)	To (m)	Type	Return (%)	
01-05-19	11.00	0.00	0.00	97	65							

All dimensions in metres Scale 1:50	Client: Irish Water	Method/ Plant Used	Bit Design	HQ Driller	Logged By E.A.T.
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DRILLHOLE LOG

Project Proposed Intake Works at Parteen Basin				Location Parteen Basin		DRILLHOLE No BH 2	
Job No 19T102	Date 01-05-19 03-05-19	Ground Level (m OD) 32.55	Co-Ordinates () E 570,028.4 N 670,201.0				
Engineer Jacobs / Tobin						Sheet 2 of 3 Rev. 3	

RUN DETAILS					STRATA			Geology	Instrument/ Backfill	
Depth Date	TCR (SCR) RQD	(SPT) Fracture Spacing	Red'cd Level	Legend	Depth (Thick- ness)	DESCRIPTION				
						Discontinuities	Detail	Main		
9.00	20 (-) -	9.00 (38/0mm)	22.75		9.80			Very stiff, light orangish brown, slightly sandy, gravelly CLAY, with cobbles. Gravel is sub-rounded to sub-angular, fine to coarse, of assorted lithologies. (continued)		
9.80	75 (-) -									
10.40	100 (93) 65	6			(10.20)	9.80 - 20.00 Medium and locally closely spaced, dipping 10 - 15 deg's, stepped, smooth, with 0.5mm to 1mm grey silt smear		Strong to very strong and occasionally weak, thinly bedded, grey, sparry, bioclastic, fine to medium grained LIMESTONE		
12.00	81 (75) 74	NI								
13.50	100 (97) 94	4								
15.00	100 (98) 89	5								
	100 (97) 84	3								
		4								

IDL AGS UK DH (SPTS) PARTEEN INTAKE WORKS.GPJ IDL TP TEMPLATE.GDT 16/05/19

Drilling Progress and Water Observations								Rotary Flush				GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia	Core Dia mm	Water Strike	Water Standing	From (m)	To (m)	Type	Return (%)	

All dimensions in metres Scale 1:50	Client: Irish Water	Method/ Plant Used	Bit Design	HQ Driller	Logged By E.A.T.
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DRILLHOLE LOG

Project Proposed Intake Works at Parteen Basin				Location Parteen Basin		DRILLHOLE No BH 2	
Job No 19T102	Date 01-05-19 03-05-19	Ground Level (m OD) 32.55	Co-Ordinates () E 570,028.4 N 670,201.0				
Engineer Jacobs / Tobin						Sheet 3 of 3 Rev. 3	

RUN DETAILS					STRATA			Geology	Instrument/ Backfill	
Depth Date	TCR (SCR) RQD	(SPT) Fracture Spacing	Red'cd Level	Legend	Depth (Thick- ness)	DESCRIPTION				
						Discontinuities	Detail	Main		
16.50		4				Strong to very strong and occasionally weak, thinly bedded, grey, sparry, bioclastic, fine to medium grained LIMESTONE (<i>continued</i>)				
	100 (97) 93	3								
18.00		4								
	100 (96) 86	6								
19.50										
20.00	100 (96) 90		12.55		20.00					

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Drilling Progress and Water Observations								Rotary Flush				GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia	Core Dia mm	Water Strike	Water Standing	From (m)	To (m)	Type	Return (%)	
03-05-19	17.00	20.00	6.00	97	65							

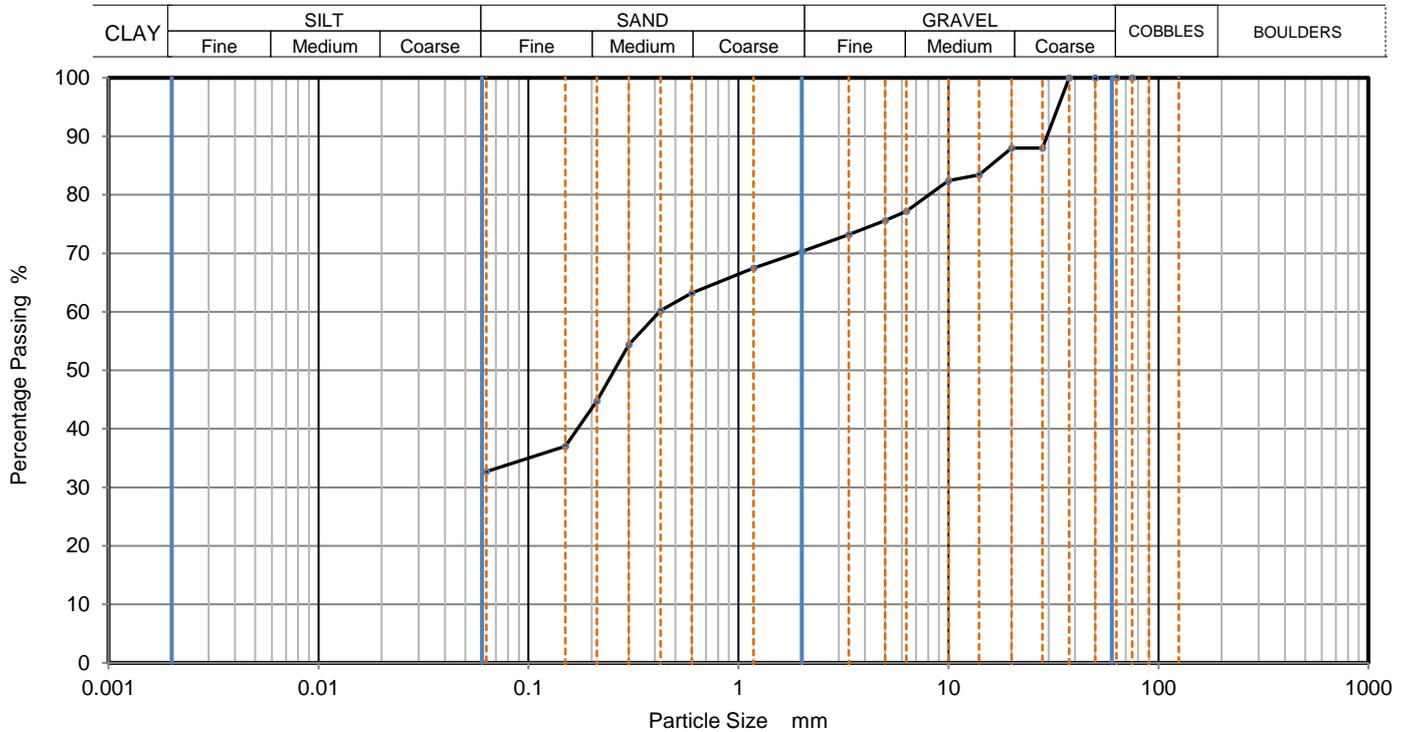
All dimensions in metres Scale 1:50	Client: Irish Water	Method/ Plant Used	Bit HQ Design	Driller	Logged By E.A.T.
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PARTICLE SIZE DISTRIBUTION

Job Ref	2019T101
Borehole/Pit No.	BH01
Sample No.	
Depth, m	4.50
Sample Type	C
KeyLAB ID	IDL1201905104

Site Name	Parteen Basin Intake Works		
Soil Description	Brown very gravelly very silty SAND.		
Specimen Reference	Specimen Depth	5.1-5.6	m
Test Method	BS1377:Part 2:1990, clause 9.2		



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
75	100		
63	100		
50	100		
37.5	100		
28	88		
20	88		
14	83		
10	82		
6.3	77		
5	76		
3.35	73		
2	70		
1.18	68		
0.6	63		
0.425	60		
0.3	54		
0.212	45		
0.15	37		
0.063	33		

Dry Mass of sample, g 1343

Sample Proportions	% dry mass
Very coarse	0
Gravel	30
Sand	38
Fines <0.063mm	33

Grading Analysis		
D100	mm	
D60	mm	0.42
D30	mm	
D10	mm	
Uniformity Coefficient		
Curvature Coefficient		

Remarks
Preparation and testing in accordance with BS1377 unless noted below

Operator	Checked	Approved	Sheet printed	1
		Dympna Darcy B.Sc.	14/05/2019 11:31	QC From No:R2



PARTICLE SIZE DISTRIBUTION

Job Ref **2019T101**

Borehole/Pit No. **BH01**

Site Name **Parteen Basin Intake Works**

Sample No.

Soil Description **Brown very gravelly very silty medium SAND.**

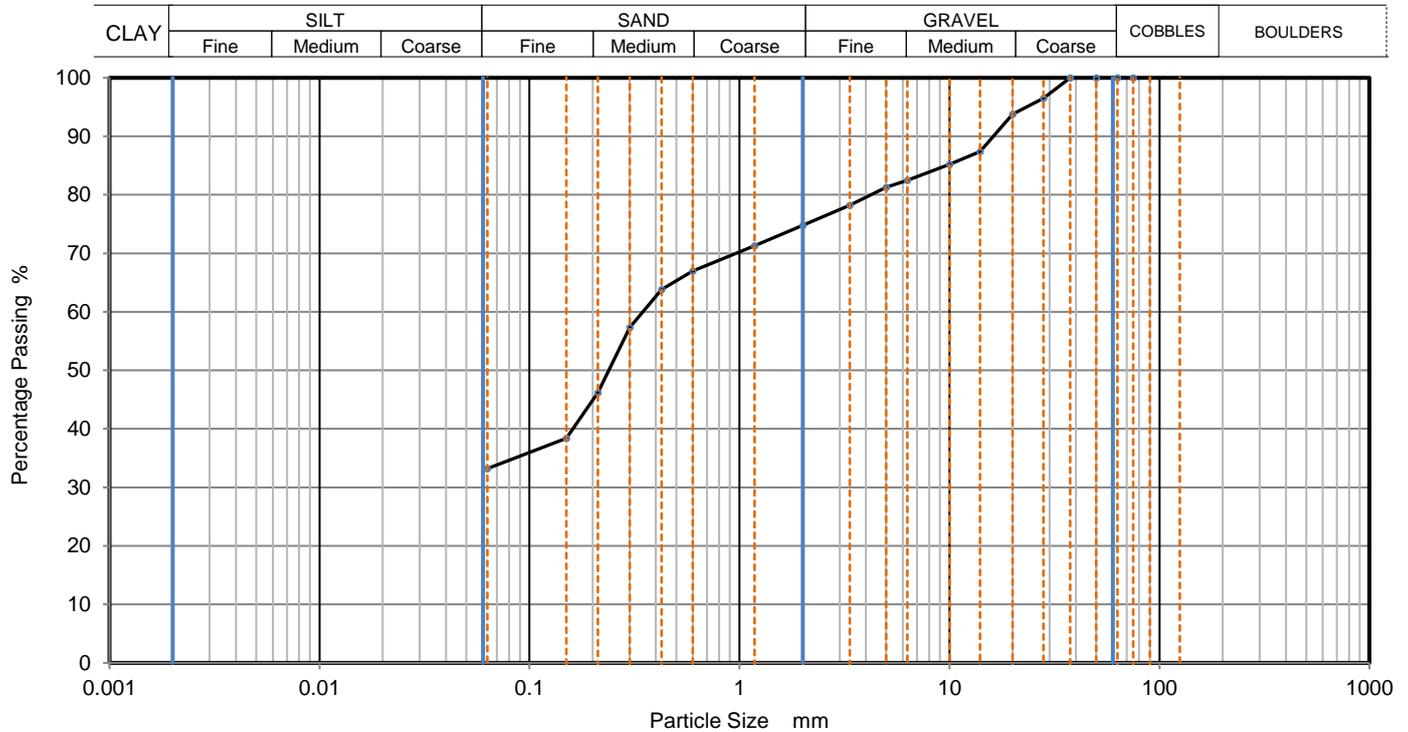
Depth, m **8.00**

Specimen Reference **8.7-9.0** m

Sample Type **C**

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

KeyLAB ID **IDL1201905108**



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
75	100		
63	100		
50	100		
37.5	100		
28	97		
20	94		
14	87		
10	85		
6.3	83		
5	81		
3.35	78		
2	75		
1.18	71		
0.6	67		
0.425	64		
0.3	57		
0.212	46		
0.15	38		
0.063	33		

Dry Mass of sample, g

1162

Sample Proportions	% dry mass
Very coarse	0
Gravel	25
Sand	42
Fines <0.063mm	33

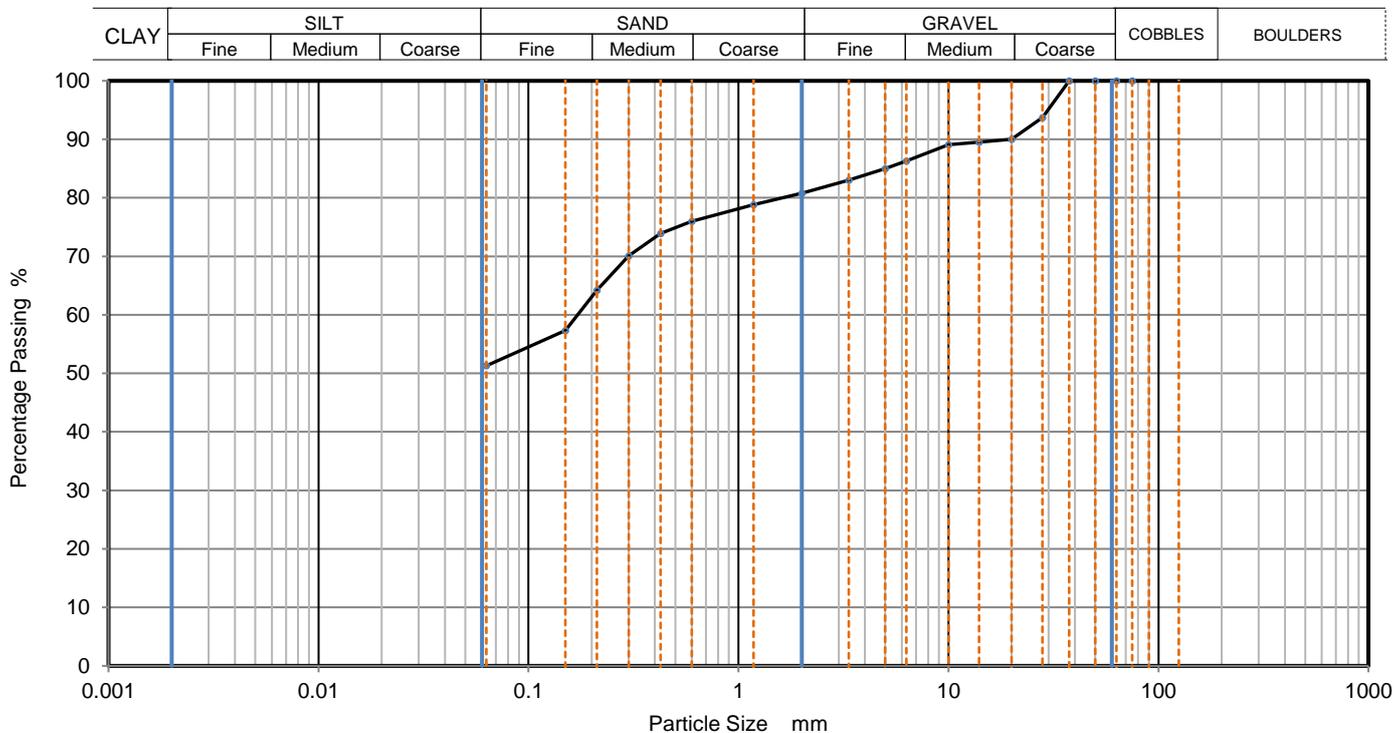
Grading Analysis		
D100	mm	
D60	mm	0.347
D30	mm	
D10	mm	
Uniformity Coefficient		
Curvature Coefficient		

Remarks

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Operator	Checked	Approved	Sheet printed	1
		Dympna Darcy B.Sc.	14/05/2019 11:31	
				QC From No:R2

	PARTICLE SIZE DISTRIBUTION		Job Ref	2019T101	
			Borehole/Pit No.	BH02	
Site Name	Parteen Basin Intake Works		Sample No.		
Soil Description	Light brown slightly gravelly slightly sandy SILT.		Depth, m	9.40	
Specimen Reference		Specimen Depth	9.5-9.8 m	Sample Type	C
Test Method	BS1377:Part 2:1990, clause 9.2		KeyLAB ID	IDL12019051022	



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
75	100		
63	100		
50	100		
37.5	100		
28	94		
20	90		
14	90		
10	89		
6.3	86		
5	85		
3.35	83		
2	81		
1.18	79		
0.6	76		
0.425	74		
0.3	70		
0.212	64		
0.15	57		
0.063	51		

Dry Mass of sample, g

1449

Sample Proportions	% dry mass
Very coarse	0
Gravel	19
Sand	30
Fines <0.063mm	51

Grading Analysis		
D100	mm	
D60	mm	0.172
D30	mm	
D10	mm	
Uniformity Coefficient		
Curvature Coefficient		

Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operator	Checked	Approved	Sheet printed	1
		Dympna Darcy B.Sc.	14/05/2019 11:31	
				QC From No:R2

Minerex Geophysical Report

Water Supply Project Eastern and Midlands Region
Ground Investigation Contract

Geophysical Survey Parteen Intake

Report Status: Draft

MGX Project Number: 6443

MGX File Ref: 6443d-005.doc

13th May 2019

Confidential Report To:

Irish Drilling Ltd.
Old Galway Road
Loughrea
Co. Galway

**Report submitted by :
Minerex Geophysics Limited**

Unit F4, Maynooth Business Campus
Maynooth, Co. Kildare
Ireland
Tel.: 01-6510030
Fax.: 01-6510033
Email: info@mgx.ie

Issued by:

Author: John Connaughton (Geophysicist)

Reviewer: Hartmut Krahn (Senior Geophysicist)



Subsurface Geophysical Investigations

EXECUTIVE SUMMARY

1. Minerex Geophysics Ltd. (MGX) carried out a geophysical survey consisting of 2D-Resistivity and seismic refraction (p-wave) surveying for the ground investigation for the Parteen Intake of the Water Supply Project Eastern and Midlands Region.
2. The main objectives of the survey were to determine the ground conditions under the site, determine the depth to rock and the overburden thickness, to estimate the strength/stiffness/compaction of overburden and the rock quality, to establish the presence of faults and fracture zones and to detect possible karstified rock.
3. The interpretation of the survey resulted in a ground model for the subsurface with four layers. These forest topsoil with a thickness between 0.5 and 1.0 m, Alluvium and weathered glacial till with a thickness of around 1.5 to 3.5 m, glacial till where the thickness varies between 3.5 and 12 m, and strong limestone rock occurring at elevations between 17 and 25 m OD.
4. High seismic velocities and high RQD values show that the rock quality is good to very good and that the rock layer will require breaking or blasting for removal. Map 3 shows the rock elevation as a contour map. The proposed works will require excavation to level of 19 and 24 mOD therefore removal of rock will be required.
5. The risk of karstification of the bedrock or the presence of karst features is interpreted as low. The zone of lowest rock elevation may indicate a fault or fracture zone where the top of the rock may contain some weathering.
6. The upper two layers are separated into more cohesive and less permeable material (clay and silt) and more granular and higher permeable material (sand and gravel). Map 2 indicates the outline of the near surface zone containing sand and gravel. Both boreholes encountered shallow sand and gravel though the geophysical survey indicates that most of the site is underlain by clay and silt.

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Figure 1e: Models and Interpretation of Geophysical Survey R8	1 x A3	6443d_MapsFigs.dwg

1. INTRODUCTION

1.1 Background

Minerex Geophysics Ltd. (MGX) carried out a geophysical survey for the Parteen Intake site of the Water Supply Project Eastern and Midland Region. The survey consisted of 2D-Resistivity and seismic refraction (p-wave) measurements. The survey was commissioned by Irish Drilling Ltd.

The survey employed various geophysical methods that complement each other and improve the interpretation. At the time of the survey two rotary core holes were drilled by Irish Drilling and the results of these are integrated with this survey and interpretation.

The proposed Parteen Intake will extract the water from the Shannon River and will pump it through water supply pipelines to Dublin. The proposed works will require deep excavations for the construction of the Raw Water Intake and Pump Station (base elevation around 19 mOD), for two Microfiltration Buildings (base elevation around 19 mOD) and an Invasive Species Debris Retention Tank (base elevation around 24.5 mOD).

1.2 Objectives

The main objectives of the geophysical survey were:

- To determine the ground conditions under the site
- To determine the depth to rock and the overburden thickness
- To estimate the strength/stiffness/compaction of overburden materials and the rock quality
- To determine the type of overburden and rock
- To detect lateral changes within the geological layers
- To determine the presence of possible faults and fracture zones
- To detect possible karstified zones within the rock

1.3 Site Description

The proposed Parteen Intake is located in the townland of Garrynatineel at the Parteen Basin on the northern end of the Fort Henry Embankment. The site is forested with elevations between 30 and 34 mOD (Malin Head). The water level in the reservoir was around 30.7 mOD at the time of the survey. From the south the embankment runs towards the survey area. The clay soil of the embankment ends and fades into the forest soil close to crossing of R1 and R4.

1.4 Geology

The overburden and bedrock geological conditions as taken from the Geological Survey of Ireland map (GSI, 2017).

The overburden is alluvium and glacial till.

The bedrock consists of the Ballysteen Formation described as dark muddy limestone and shale.

No shallow rock or faults are mapped under the site and or Karst features are mapped anywhere near the site.

1.5 Report

This report includes the results and interpretation of the geophysical survey. Maps, figures and tables are included to illustrate the results of the survey. More detailed descriptions of geophysical methods and measurements can be found in GSEG (2002), Milsom (1989) and Reynolds (1997).

The client provided maps of the site and the digital version was used as the background map in this report. Elevations were surveyed on site and are used in the vertical sections.

The interpretative nature and the non-invasive survey methods must be taken into account when considering the results of this survey and Minerex Geophysics Limited, while using appropriate practice to execute, interpret and present the data, give no guarantees in relation to the existing subsurface.

2. GEOPHYSICAL SURVEY

2.1 Methodology

The methodology was given by the client and consisted of 2D-Resistivity Profiling and Seismic Refraction Profiles at the locations indicated on Map 1.

Profile 1 consisted of a 189 m long 2D-Resistivity profile and a 141m long seismic refraction profile. All other profiles 2 - 8 consisted of 93m long 2D-Resistivity and 69 m long seismic refraction. Only R2 was shorter at 81m length.

All geophysical surveys are acquired, processed and reported in accordance with British Standards BS 5930:1999 +A2:2010 'Code of Practice for Site Investigations'.

2.2 2D-Resistivity

2D-Resistivity profiles were surveyed with an electrode spacing of 3 m, up to 642 electrodes per set-up and a maximum length of 189 m per profile. The readings were taken with a Tigre Resistivity Meter, Imager Cables, stainless steel electrodes, laptop and ImagerPro acquisition software.

During 2D-Resistivity surveying data is acquired in the form of linear profiles using a suite of metal electrodes. A current is injected into the ground via a pair of electrodes while a potential difference is measured across a second pair of electrodes. This allows for the recording of the apparent resistivity in a two-dimensional arrangement below the profile. The data is inverted after the survey to obtain a model of subsurface resistivities. The generated model resistivity values and their spatial distribution can then be related to typical values for different geological materials.

The penetration depth of a resistivity profile increases towards the centre where it reaches an approx. value of 1/6th of the layout length.

2D-Resistivity has previously proven zones of anomalous rock or karstified rock with lateral extents of 5 m and more.

2.3 Seismic Refraction

Seismic refraction profiles were surveyed with geophone spacing of 3 m and concatenated geophone layouts resulting in continuous coverage along each profile line. The recording equipment consisted of a 24 Channel GEOMETRICS ES-3000 engineering seismograph with 4.5 Hz vertical geophones on land or hydrophones in water. The seismic energy source consisted of a hammer and plate or a seismic gun where peat was present. A zero delay trigger was used to start the recording. Normally 7 shot points per p-wave profile were used.

Set-ups were acquired as 69m profile and for S1 as a combines 141m profile.

In the seismic refraction survey method a p-wave is generated by a source at the surface resulting in energy travelling through surface layers directly and along boundaries between layers of differing seismic wave velocities. Processing of the seismic data allows geological layer thicknesses and boundaries to be established.

Seismic Refraction generally determines the depth to horizontal or near horizontal layers where the compaction/strength/rock quality changes with an accuracy of 10 – 20% of depth to that layer. Where low velocity layers or shadow zones are present (e.g. below solid ground surface) or where layers dip with more than 20 degrees angle the accuracy becomes much less.

2.4 Site Work

The data acquisition was carried out between the 6th June and 13th July 2017. The weather conditions were variable throughout the acquisition period. Health and safety standards were adhered to at all times.

The locations and elevations were surveyed with a TRIMBLE RTK-GPS and with a level. The accuracy of the horizontal location is about 3m and the accuracy of the vertical elevation about 0.1 m.

3. RESULTS AND INTERPRETATION

The interpretation of geophysical data was carried out utilising the known response of geophysical measurements, typical physical parameters for subsurface features that may underlay the site, and the experience of the authors.

The results of the two boreholes BH1 and BH2 are displayed as abbreviated borehole logs on the figures.

3.1 2D-Resistivity

The 2D-Resistivity data was positioned and inverted with the RES2DINV inversion package. The programme uses a smoothness constrained least-squares inversion method to produce a 2D model of the subsurface resistivities from the recorded apparent resistivity values. Three variations of the least squares method are available and for this project the Jacobian Matrix was recalculated for the first three iterations, then a Quasi-Newton approximation was used for subsequent iterations. Each dataset was inverted using seven iterations resulting in a typical RMS error of < 3.0%. The resulting models were colour contoured with the same resistivity scale for all profiles and they are displayed as cross sections (Figures 1a to 1e). The sections have a vertical exaggeration of 2.

Resistivities are characteristic for certain overburden and rock types. If there is a high content of clay minerals (which are electrically conductive) then the overburden resistivity will be lower than if there is a high content of clastic grains like sand or gravel. The purer the clay and the lower the sand and gravel content the lower the resistivity. The water content in the overburden also influences the resistivities but generally the clay content has a larger effect.

The resistivities cover a range typical for materials from clay rich overburden (low resistivities) to fresh strong unweathered bedrock (high resistivities). The ranges have been taken into the consideration for the interpretation. Low resistivity values (< 240 Ohmm) typically indicate overburden with high clay and silt content. Higher resistivities (> 240 Ohmm) indicate mainly sand and gravel within the overburden. This occurs on some areas within the site at a shallow depth. The extent of this sand and gravel is shown on Map 2. The deeper overburden is more clay and silt rich as indicated by the lower resistivities and is interpreted as glacial till.

The top of the bedrock has been taken from the seismic refraction and the limestone has generally resistivities higher than 283 Ohmm. They reach to about 1100 Ohmm on the resistivity scale. The resistivity range indicates that the limestone is not significantly liable to karstification, from other sites in regions with karstifiable limestone it is known that the resistivities reach several thousand Ohmm.

3.2 Seismic Refraction

The seismic refraction data was positioned and processed with the SEISIMAGER software package to give a layered model of the subsurface. The numbers of layers has been determined by analysing the seismic traces and 4 layers in total were used in the model. All seismic profiles were subject to a standardised processing sequence which consisted of a topographic correction which was based on integrated elevation data, first break picking, tomographic inversion, travel-time computation via ray-tracing and velocity modelling. Residual deviations of typically 0.5 to 0.9 msec RMS have been obtained for each profile. Following each processing stage QC procedures were adhered to. The resulting layer boundaries are shown as thick lines overlaid on the 2D-Resistivity cross sections (Figures 1a to 1e). The average seismic velocities obtained within the layers are annotated on the sections as bold black numbers.

The p-wave seismic velocity is closely linked to the density of subsurface materials and to parameters like compaction, stiffness, strength and rock quality. The higher the density of the subsurface materials the higher the seismic velocity. Similarly for the other parameters it is generally valid that a more compacted, stiffer and stronger material will have a higher seismic velocity. For rock, the seismic velocity is higher when the rock is stronger, less weathered and has a higher quality. If the rock is more weathered, broken, fractured, fissured or karstified then the seismic velocity will be reduced compared to that of intact fresh rock.

Because of the above relationship, the seismic refraction method and seismic velocities are suitable to investigate ground where the layers get denser, more compacted and stronger with depth. A disadvantage is that some materials may have the same seismic velocity: Very stiff to hard glacial till and a weathered rock can have the same seismic velocity range.

3.3 Interpretation of Resistivity and Seismic Refraction

Table 1 summarises the interpretation. The stiffness or compaction and the rock strength or quality have been estimated from the seismic velocity. The estimation of the excavatability for the bedrock has been made according to the caterpillar chart published in Reynolds (1997). The geotechnical assessment for rippability will have to take factors like rock type and jointing into account and the estimation in this report is solely based on the seismic velocities.

Interpreted cross sections are shown in Figure 1a to 1e. The interpretation has been made from all available information. For overburden layers and the top of the rock, the seismic refraction data has been used as seismic refraction is the best method to delineate layer boundaries. The resistivity models have been used to delineate two generalised types of overburden. Resistivity data is better suited to show material while seismic refraction velocities are indicating the change of compaction, stiffness or rock quality with depth.

Table 1: Summary of Results and Interpretation

Layer	General Seismic Velocity Range (m/sec)	General Resistivity Range (Ohmm)	Stiffness/ Compaction or Rock Strength/ Quality	Interpretation	Estimated Excavation Method
1a	190	<240	Soft	Clayey silty Topsoil	Diggable
1b	190	>240	Loose	Sandy gravelly Topsoil	Diggable
2a	700	<240	Firm	Sandy gravelly Clay and Silt	Diggable
2b	700	>240	Dense	Clayey silty Sand and Gravel	Diggable
3	2300	<240	Very stiff or hard	Glacial Till	Diggable to rippable
4	5200	>283	Good to very good Rock	Strong Limestone	Breaking or Blasting

3.4 Top of Rock Contour Map

Map 3 shows the elevation of the top of the strong limestone rock, displayed as a contour map. The elevations values from the layers 4 of the seismic refraction have been used to create this map. At the seismic profiles the values are the same than in the vertical sections, between the profiles these are interpolated. Between S6 and S7 is the largest distance between two profiles, and the contour lines between these profiles are created by a gridding algorithm.

The elevation range between 17 and 25 mOD (Malin Head). The highest rock elevation and shallowest rock is on the southern half of profile R1. The lowest rock head elevation and deepest rock is along a trough stretching West to East over the northern part of the site. In the NW corner of the site the rock gets shallower again.

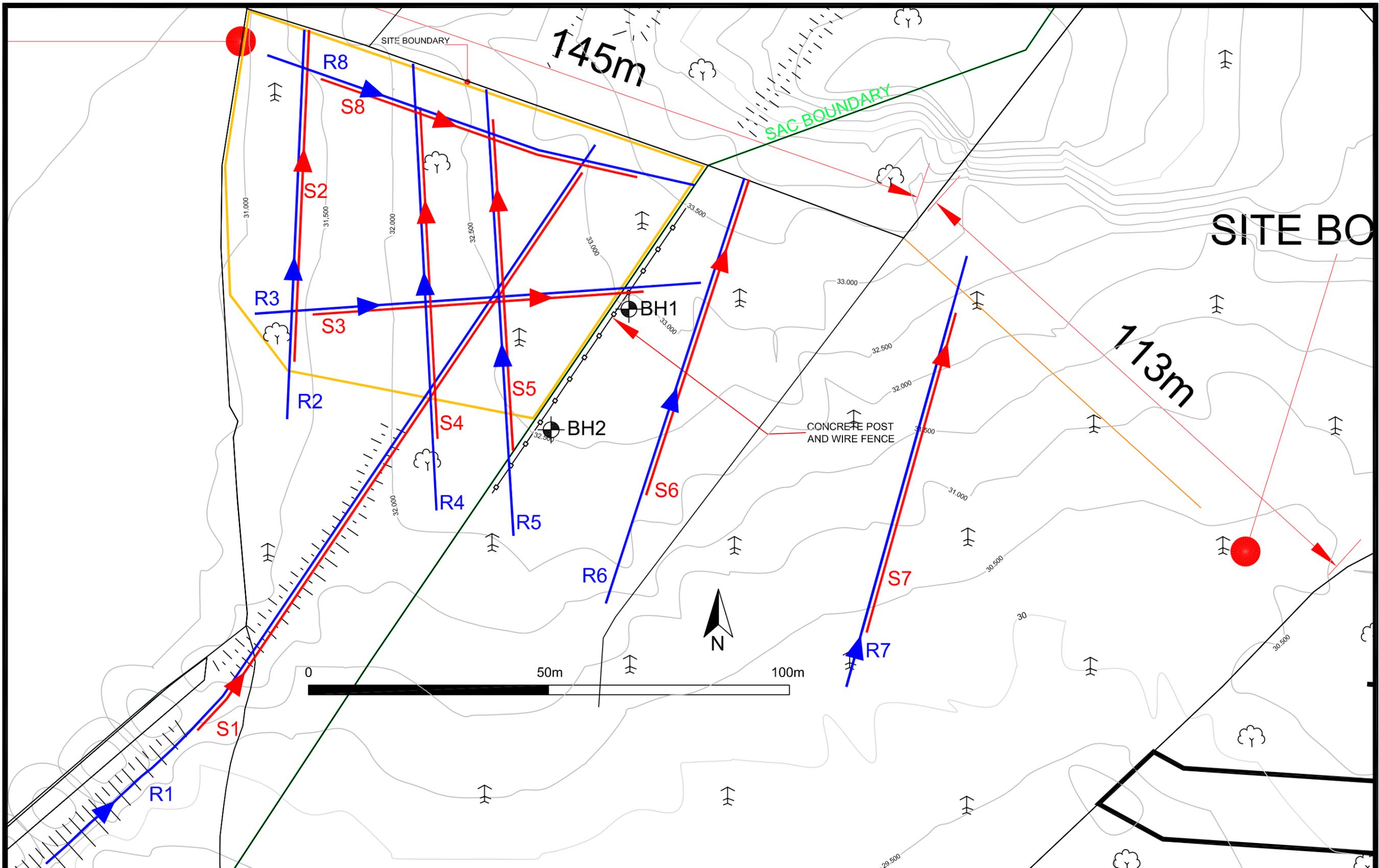
4. CONCLUSIONS

The following conclusions are made:

- A geophysical survey with 2D-Resistivity and Seismic Refraction was carried out at the proposed Parteen Intake site.
- The interpretation of the survey resulted in a ground model for the subsurface with four layers. The upper two layers are differentiated by two material types.
- The top layer is topsoil made up by forestry soil and differentiated into sandy gravelly topsoil and clayey silty topsoil. This topsoil layer has a thickness between 0.5 and 1.0 m.
- The second layer is mainly Alluvium and weathered glacial till which has been separated into sandy gravelly clay and silt and clayey silty sand and gravel. This layer has a thickness of around 1.5 to 3.5 m.
- The third layer is interpreted as glacial till. High seismic velocities indicate the high compaction and stiffness of this layer. The thickness varies between 3.5 and 12 m. This layer should be removable by digging and ripping, although larger boulders may have to be broken up.
- The fourth layer is strong limestone rock occurring at elevations between 17 and 25 m OD. The high seismic velocities indicate good to very good rock quality. This matches the high RQD values found in the boreholes.
- The rock layer will require breaking or blasting for removal. The rock elevation is shown on the contour map (Map 3). The proposed works will require excavation to level of 19 and 24 mOD therefore removal of rock will be required. On the northern part of the site the elevation of the lowest rock is 17mOD, therefore the base of the excavation I expected to consist of rock and glacial till.
- It is interpreted that the risk of karstification of the bedrock is low. The zone of lowest rock elevation may indicate a fault or fracture zone where the top of the rock may contain some weathering.
- Map 2 indicates the outline of the near surface zone containing sand and gravel. This material in this zone has a high water permeability than the clay and silt or the glacial till. The zone is approximate as there are some differences between the resistivities of the crossing profiles, due to the inversion. Both boreholes encountered shallow sand and gravel though the geophysical survey indicates that most of the site is underlain by clay and silt.

5. REFERENCES

1. **GSEG 2002.** Geophysics in Engineering Investigations. Geological Society Engineering Geology Special Publication 19, London, 2002.
2. **GSI, 2017.** Bedrock Geological Map of Ireland. Geological Survey of Ireland 2017.
3. **Milsom, 1989.** Field Geophysics. John Wiley and Sons.
4. **Reynolds, 1997.** An Introduction to Applied and Environmental Geophysics. John Wiley and Son.



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CLIENT Irish Drilling Ltd.
Irish Water

PROJECT WSP Parteen Intake
Geophysical Survey

TITLE Map 1: Geophysical Survey
Location Map

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PROJECT: 6443

DRAWN: HK

DATE: 02/05/2019

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STATUS: Draft

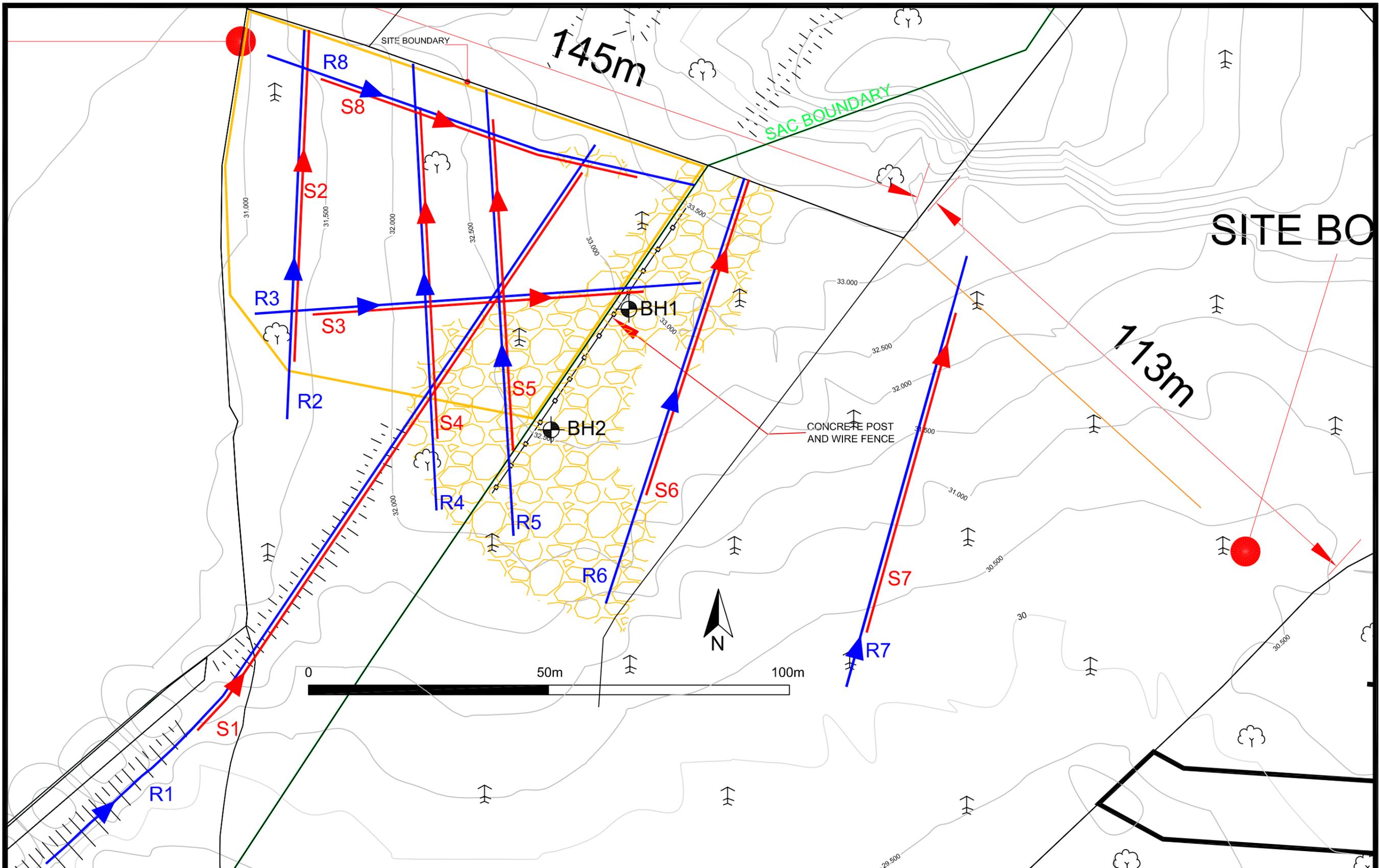
LEGEND: Geophysical Survey Locations:

— R2 2D-Resistivity Profile

— S1 Seismic Refraction Profile

Direct Ground Investigation Locations:

BH1 Borehole



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CLIENT	Irish Drilling Ltd. Irish Water
PROJECT	WSP Parteen Intake Geophysical Survey
TITLE	Map 2: Extent of shallow Sand and Gravel

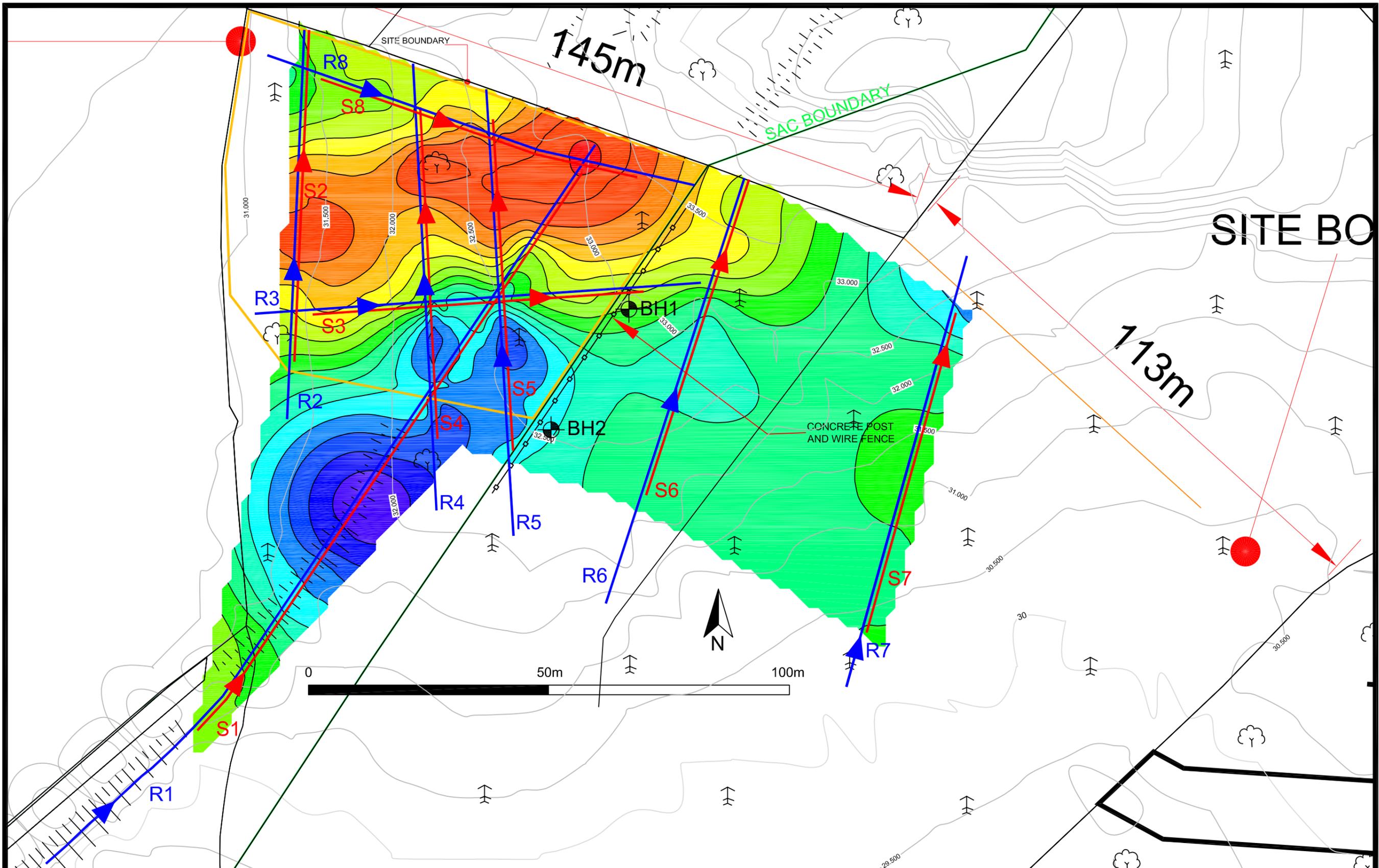
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LEGEND: Approximate Extent of shallow Sand and Gravel interpreted from Resistivities



— R2 2D-Resistivity Profile
— S1 Seismic Refraction Profile

 BH1 Borehole



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CLIENT Irish Drilling Ltd.
Irish Water
PROJECT WSP Parteen Intake
Geophysical Survey
TITLE Map 3: Contour Map of the Top of
Rock Elevation

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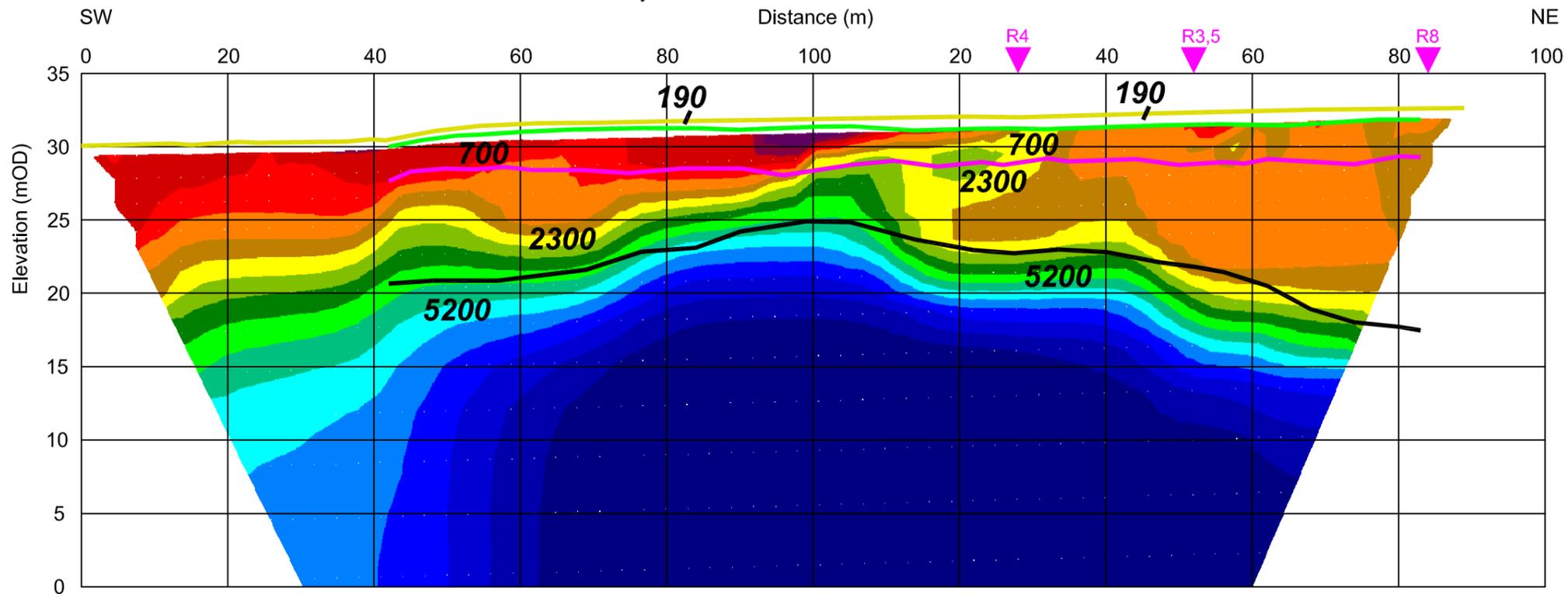
LEGEND: Elevation (mOD) of the Top of Rock from Interpretation of Seismic Refraction

17 18 19 20 21 22 23 24 25

— R2 2D-Resistivity Profile
— S1 Seismic Refraction Profile

⊙ BH1 Borehole

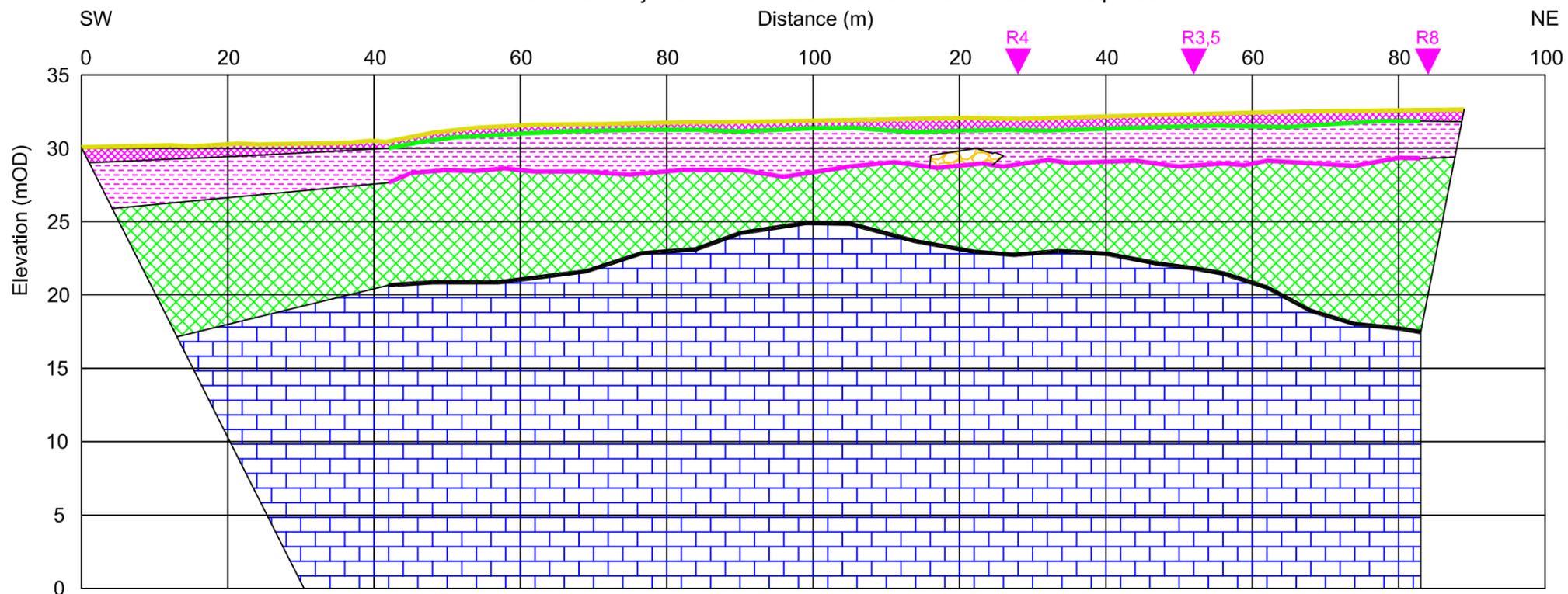
2D-Resistivity Profile R1 and Seismic Refraction Profile S1 Model



Abbreviated GI Logs:

- Cl Clay
- Sd Sand
- Grv Gravel
- Ls Limestone

2D-Resistivity Profile R1 and Seismic Refraction Profile S1 Interpretation



Interpretation

- 1a Soft clayey silty Topsoil
- 1b Loose sandy gravelly Topsoil
- 2a Firm sandy gravelly Clay and Silt
- 2b Dense clayey silty Sand and Gravel
- 3 Very stiff or hard glacial Till
- 4 Strong Limestone

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CLIENT Irish Drilling Ltd.
Irish Water
PROJECT WSP Parteen Intake
Geophysical Survey
TITLE Figure 1a: Models and Interpretation
of Geophysical Survey R1

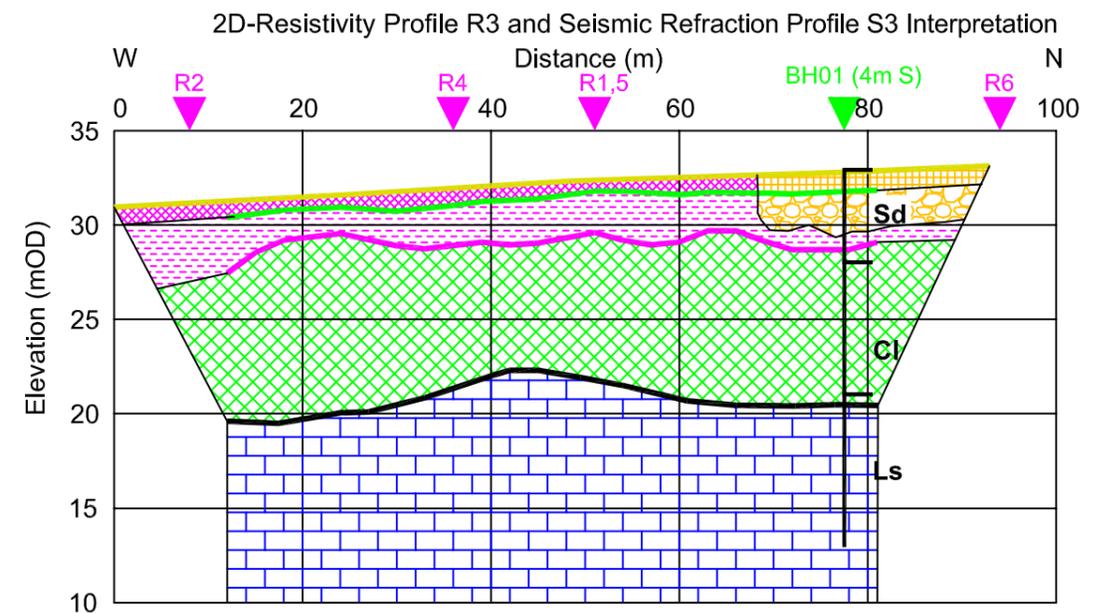
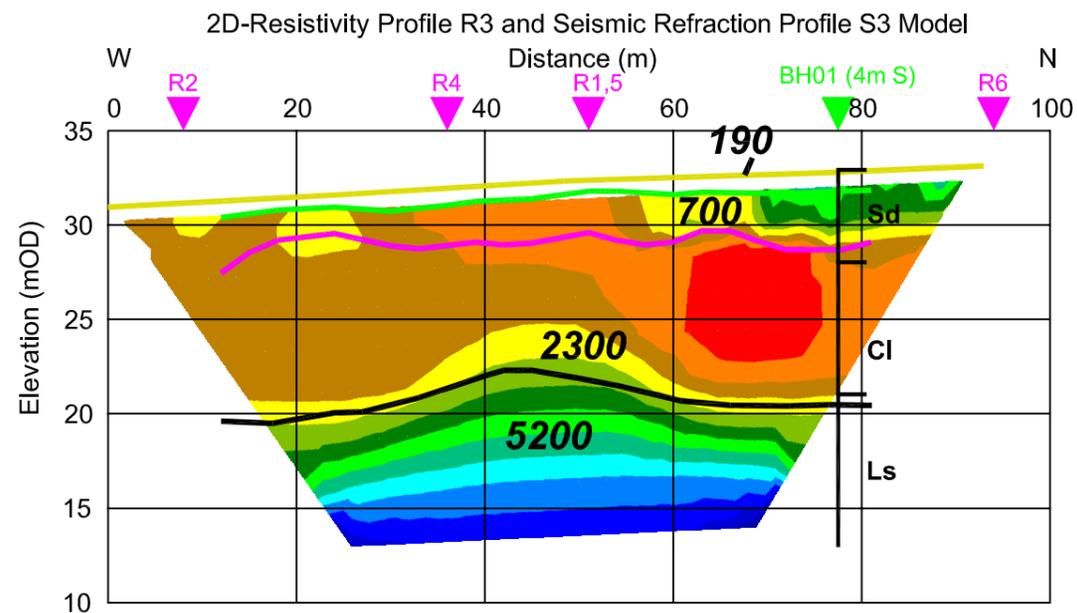
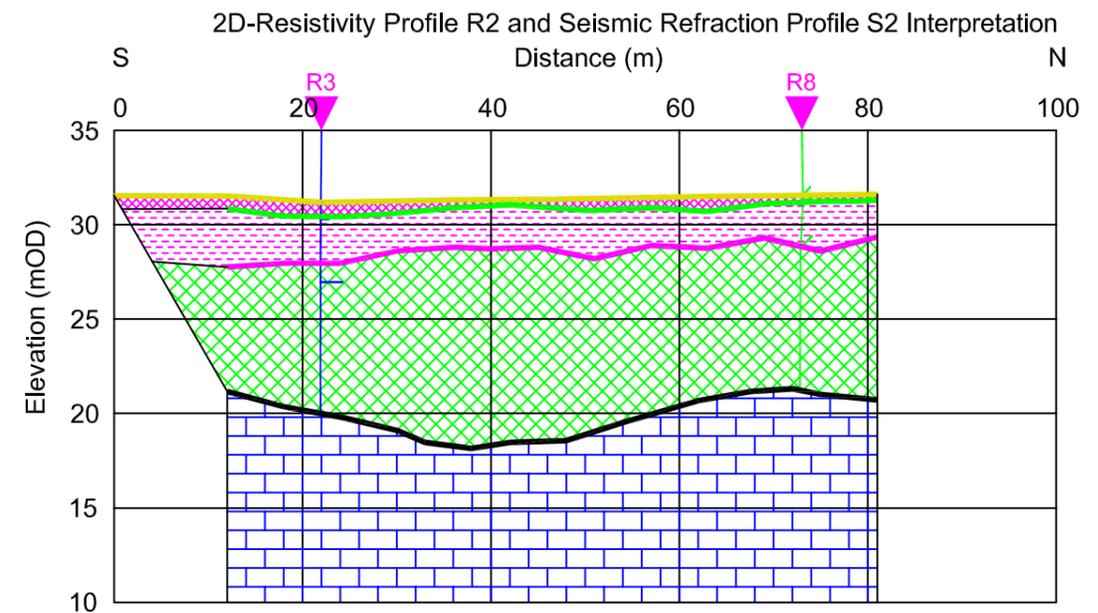
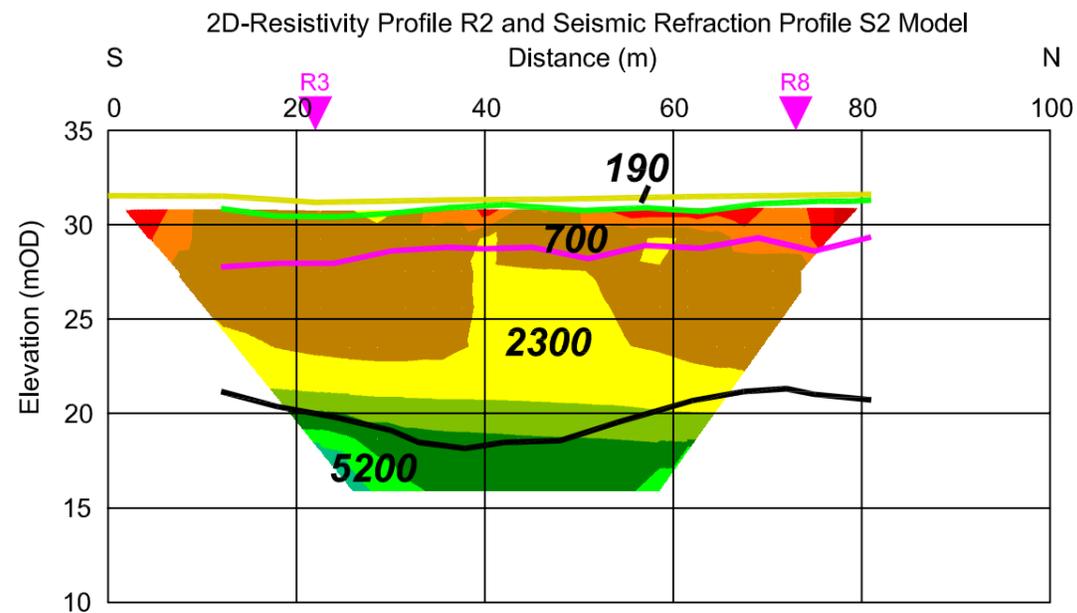
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DATE: 02/05/2019
MGX FILE: 6443d_MapsFigs.dwg
STATUS: Draft

LEGEND: Layers from Seismic Refraction Model:

- Ground Surface/Top of Layer 1 (190 m/s)
- Top of Layer 2 (700 m/s)
- Top of Layer 3 (2300 m/s)
- Top of Layer 4 (5200 m/s)
- Seismic Velocity in m/s

Resistivities (Ohmm) for 2D-Resistivity Model

100 141 200 283 400 566 800 1131



Layers from Seismic Refraction Model:

- Ground Surface/Top of Layer 1 (190 m/s)
- Top of Layer 2 (700 m/s)
- Top of Layer 3 (2300 m/s)
- Top of Layer 4 (5200 m/s)
- Seismic Velocity in m/s

Resistivities (Ohmm) for 2D-Resistivity Model



Interpretation

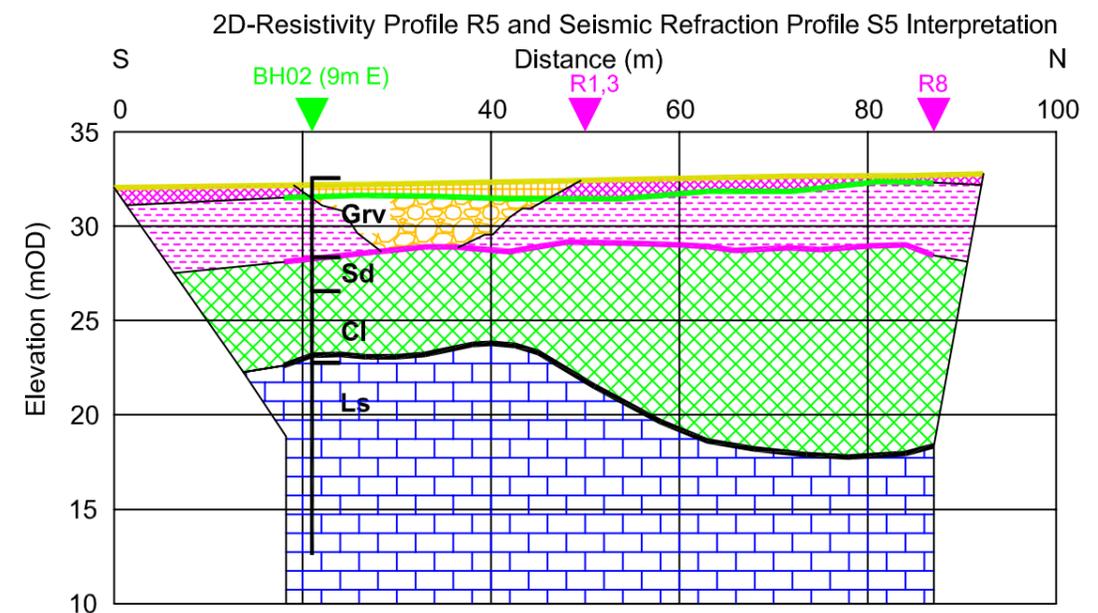
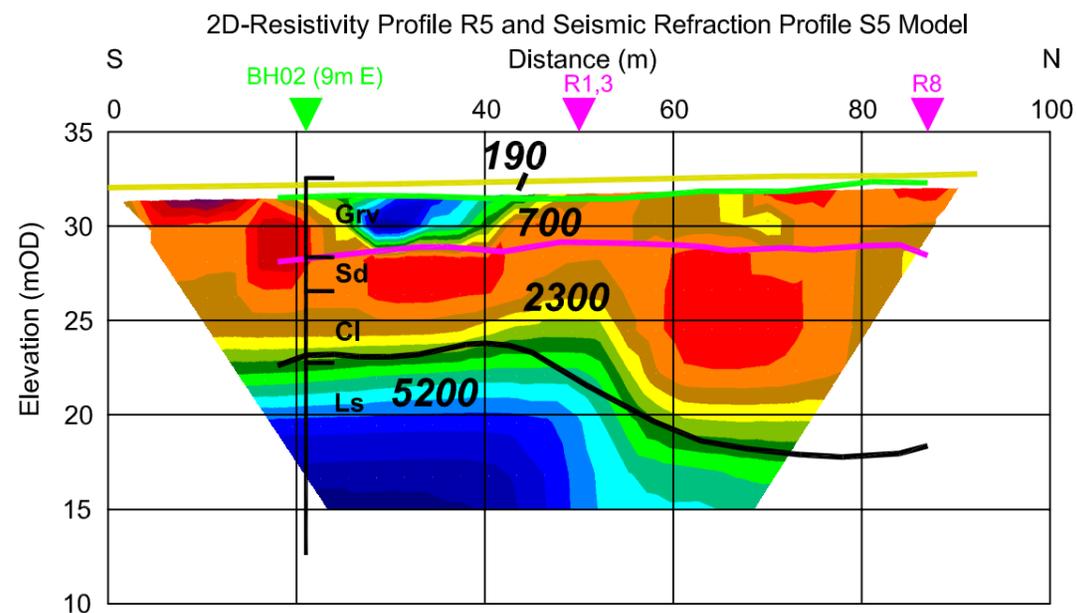
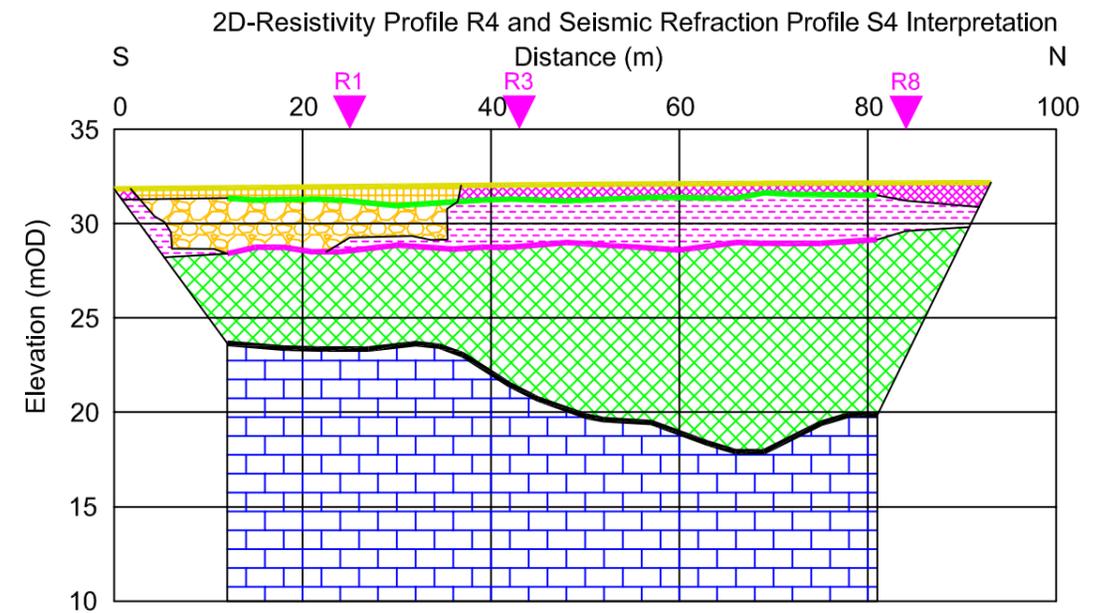
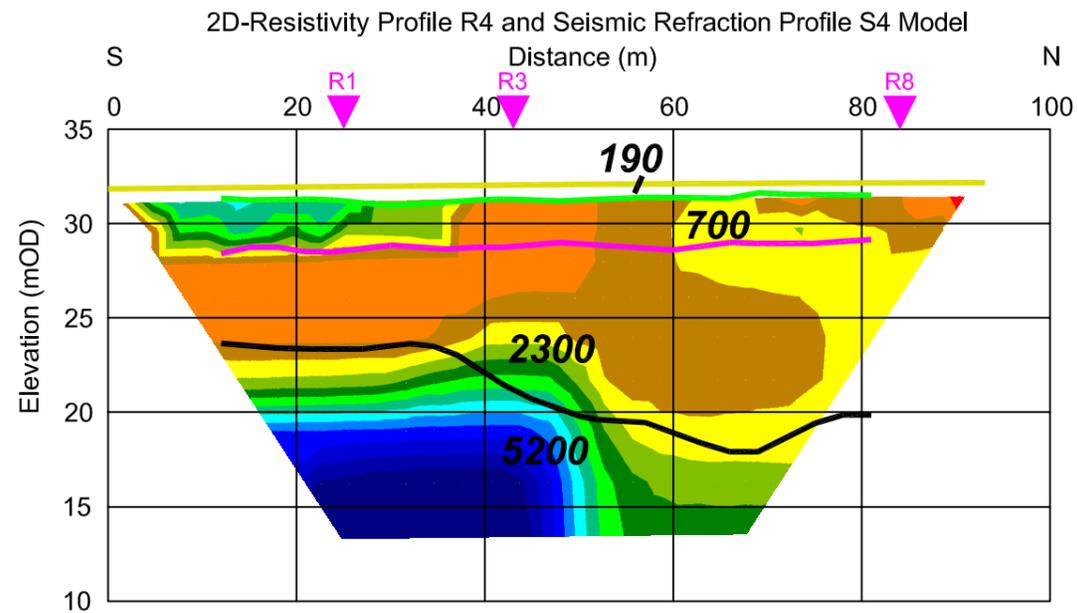
- 1a Soft clayey silty Topsoil
- 1b Loose sandy gravelly Topsoil
- 2a Firm sandy gravelly Clay and Silt
- 2b Dense clayey silty Sand and Gravel
- 3 Very stiff or hard glacial Till
- 4 Strong Limestone

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CLIENT Irish Drilling Ltd.
Irish Water
PROJECT WSP Parteen Intake
Geophysical Survey
TITLE Figure 1b: Models and Interpretation
of Geophysical Survey R2 and R3

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DATE: 02/05/2019
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LEGEND: Abbreviated GI Logs:
Cl Clay
Sd Sand
Grv Gravel
Ls Limestone



Layers from Seismic Refraction Model:

- Ground Surface/Top of Layer 1 (190 m/s)
- Top of Layer 2 (700 m/s)
- Top of Layer 3 (2300 m/s)
- Top of Layer 4 (5200 m/s)
- 1800 Seismic Velocity in m/s

Resistivities (Ohmm) for 2D-Resistivity Model



Interpretation

- 1a Soft clayey silty Topsoil
- 1b Loose sandy gravelly Topsoil
- 2a Firm sandy gravelly Clay and Silt
- 2b Dense clayey silty Sand and Gravel
- 3 Very stiff or hard glacial Till
- 4 Strong Limestone

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PROJECT WSP Parteen Intake
Geophysical Survey

TITLE Figure 1c: Models and Interpretation
of Geophysical Survey R4 and R5

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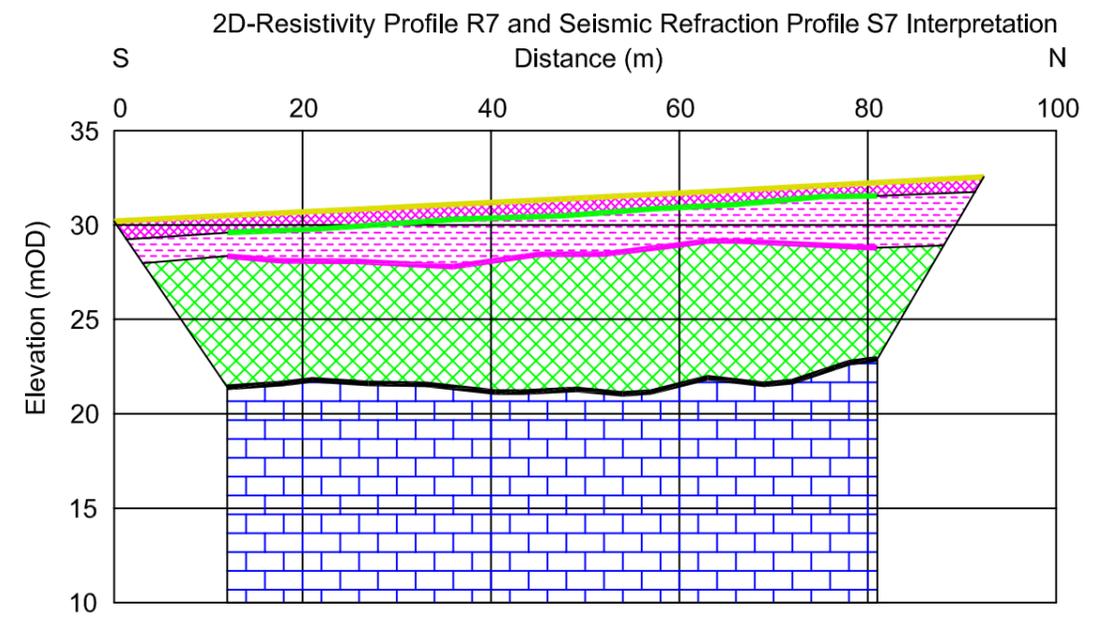
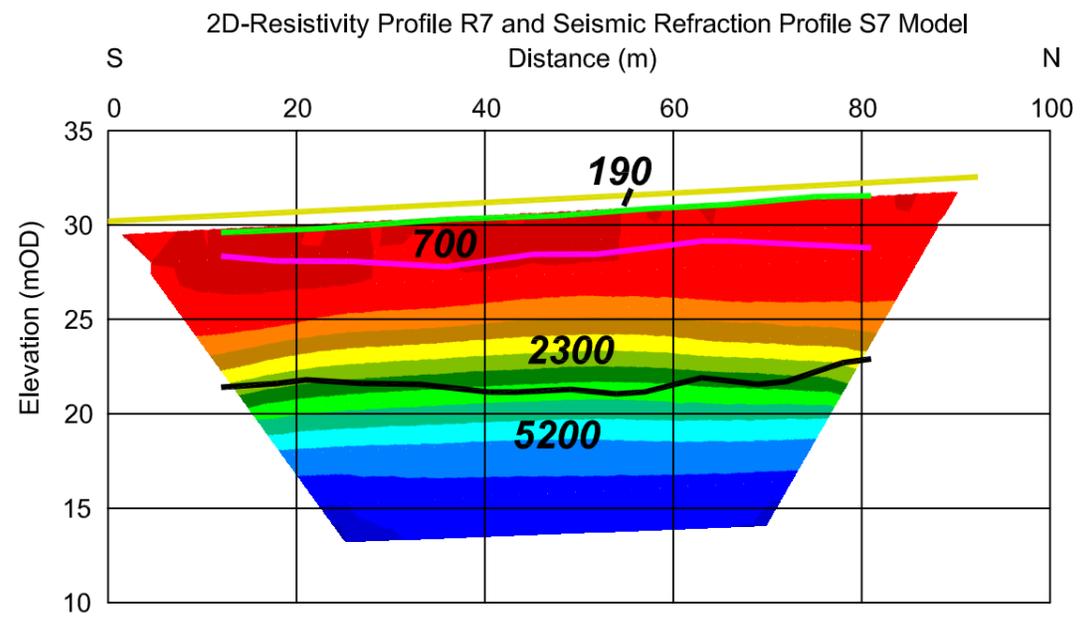
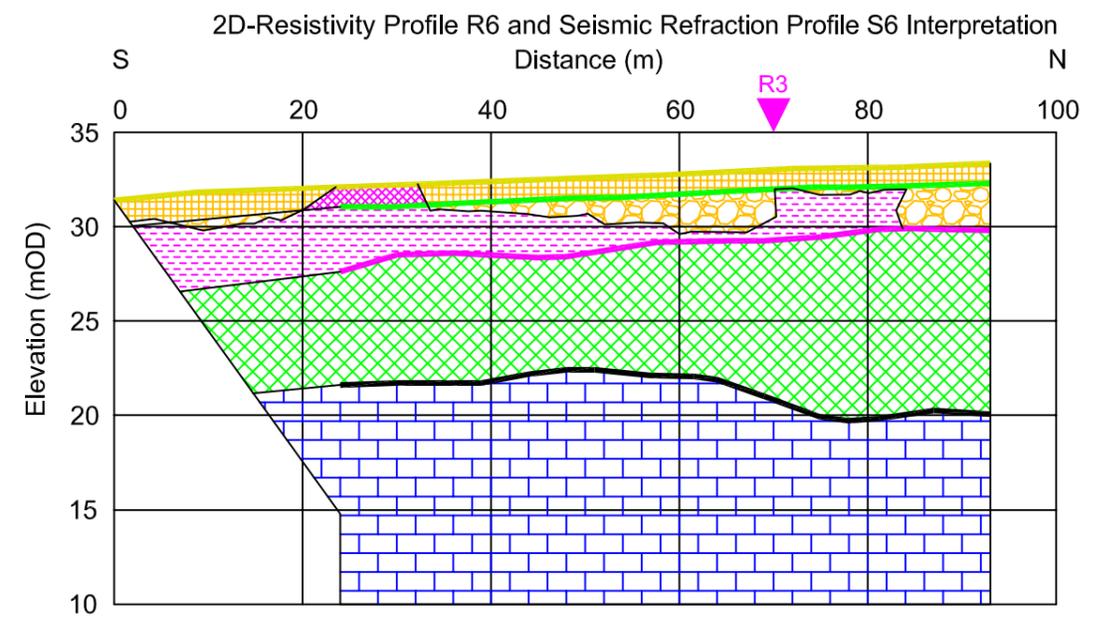
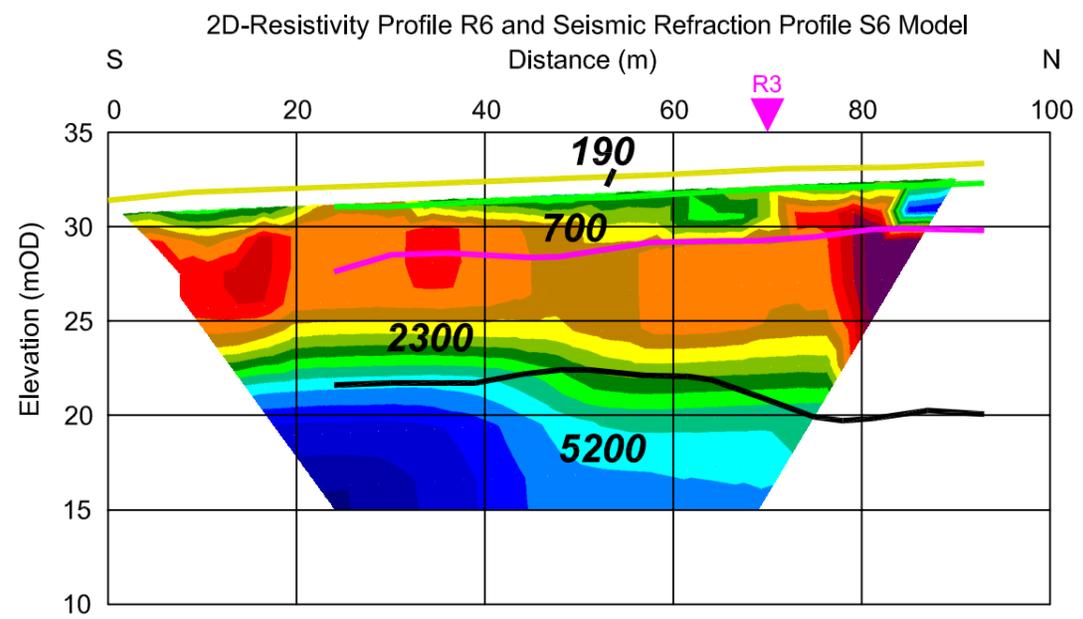
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STATUS: Draft

LEGEND: Abbreviated GI Logs:

Cl Clay
Sd Sand
Grv Gravel
Ls Limestone



Layers from Seismic Refraction Model:

- Ground Surface/Top of Layer 1 (190 m/s)
- Top of Layer 2 (700 m/s)
- Top of Layer 3 (2300 m/s)
- Top of Layer 4 (5200 m/s)
- Seismic Velocity in m/s

Resistivities (Ohmm) for 2D-Resistivity Model



Interpretation

- 1a Soft clayey silty Topsoil
- 1b Loose sandy gravelly Topsoil
- 2a Firm sandy gravelly Clay and Silt
- 2b Dense clayey silty Sand and Gravel
- 3 Very stiff or hard glacial Till
- 4 Strong Limestone

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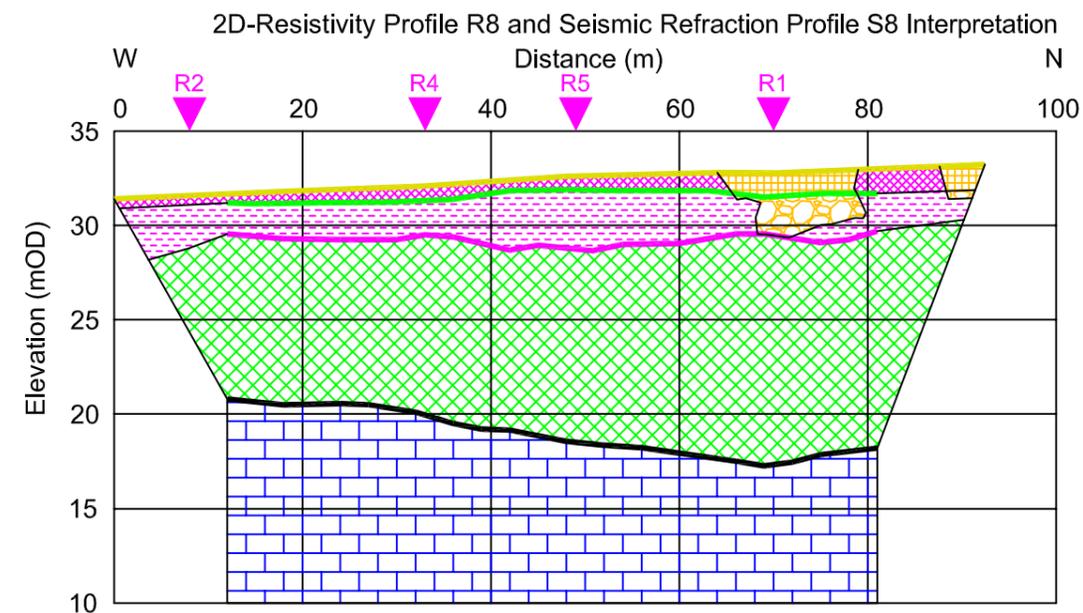
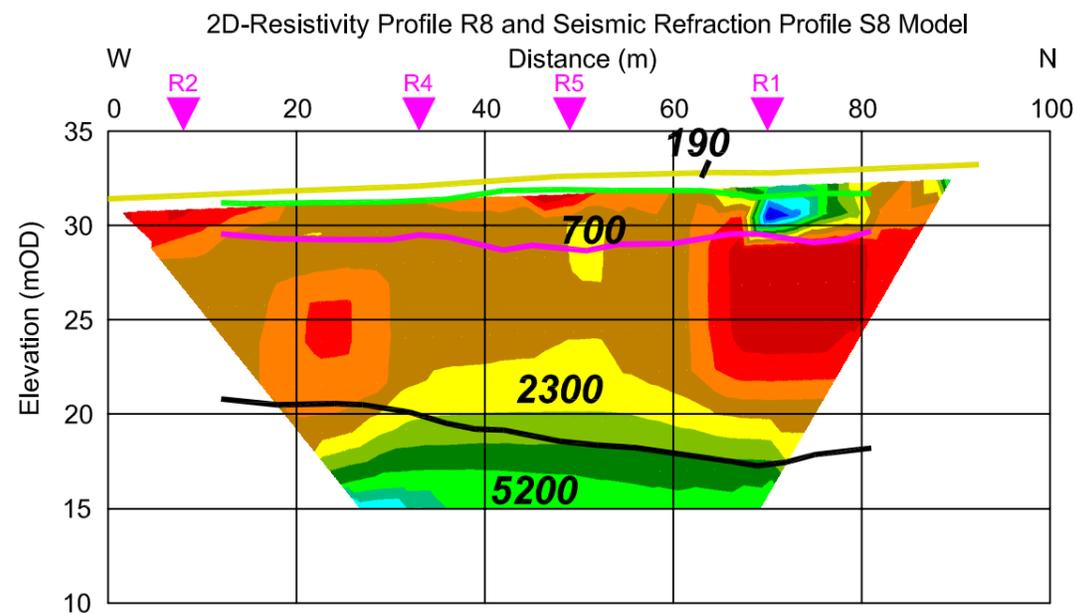
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CLIENT	Irish Drilling Ltd. Irish Water
PROJECT	WSP Parteen Intake Geophysical Survey
TITLE	Figure 1d: Models and Interpretation of Geophysical Survey R6 and R7

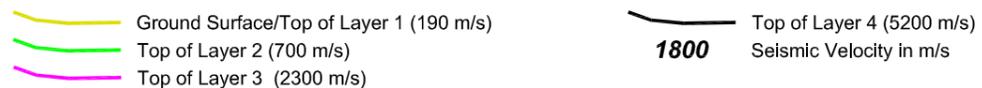
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LEGEND: Abbreviated GI Logs:

Cl Clay
Sd Sand
Grv Gravel
Ls Limestone



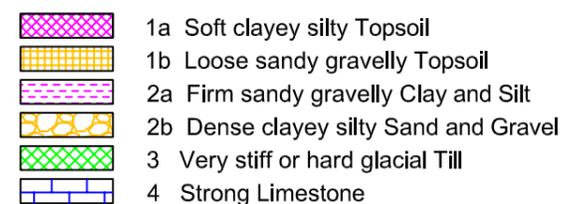
Layers from Seismic Refraction Model:



Resistivities (Ohmm) for 2D-Resistivity Model



Interpretation



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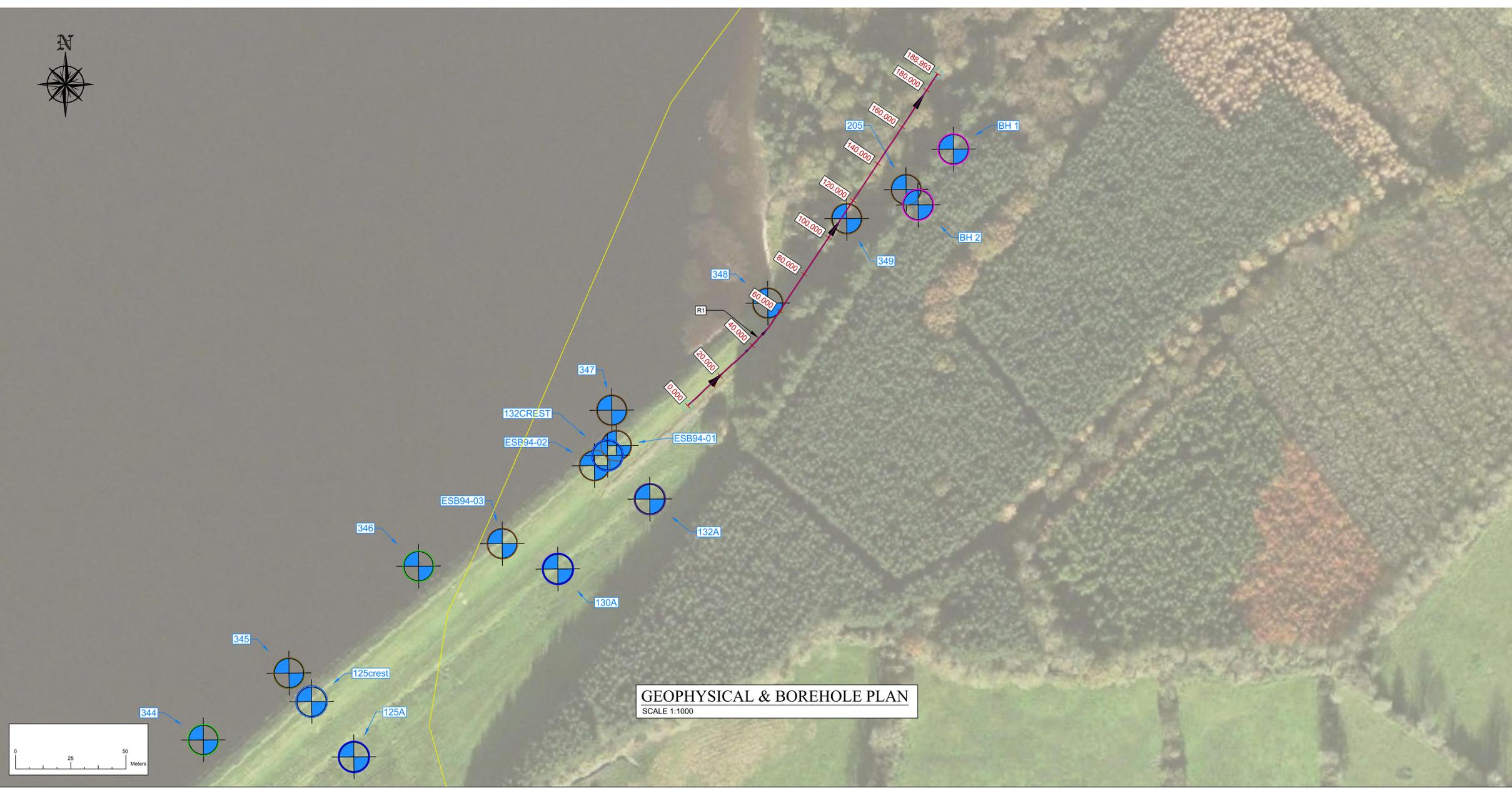
CLIENT Irish Drilling Ltd.
Irish Water
PROJECT WSP Parteen Intake
Geophysical Survey
TITLE Figure 1e: Models and Interpretation
of Geophysical Survey R8

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DRAWN: HK
DATE: 02/05/2019
MGX FILE: 6443d_MapsFigs.dwg
STATUS: Draft

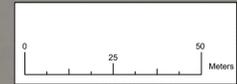
LEGEND: Abbreviated GI Logs:
Cl Clay
Sd Sand
Grv Gravel
Ls Limestone

Appendix E - Drawings

Note that the levels in the drawings using the IDL and Minerex reports are to Malin Datum

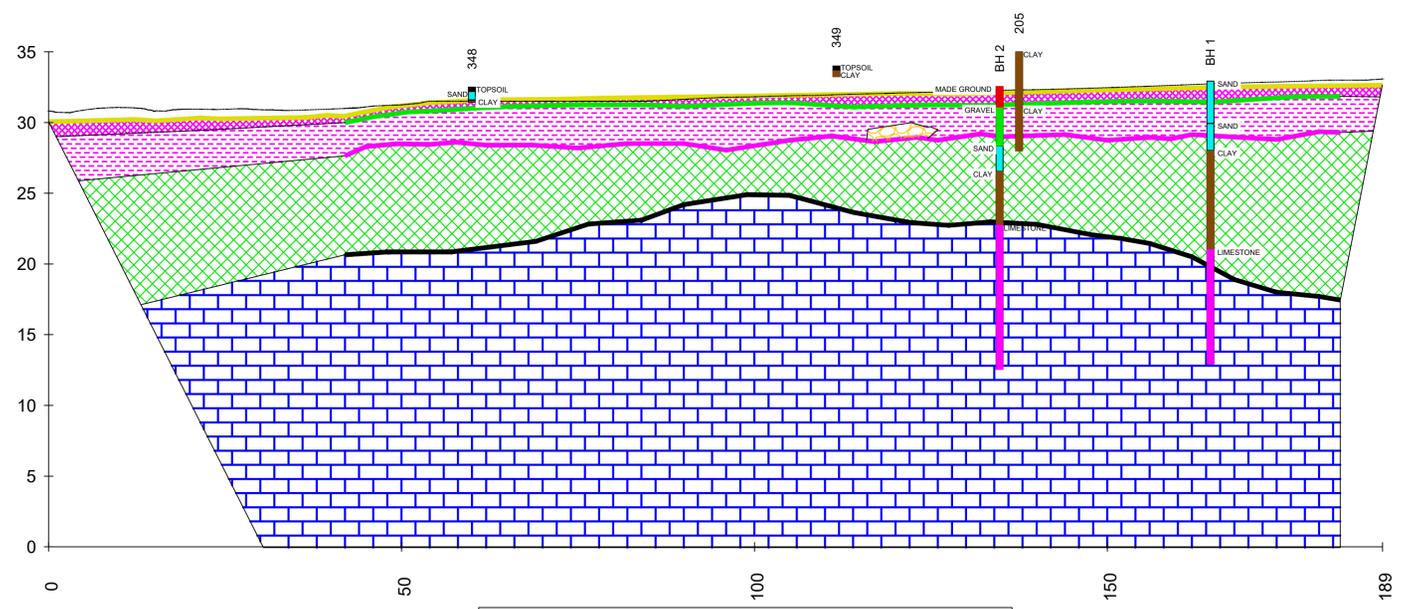


GEOPHYSICAL & BOREHOLE PLAN
SCALE 1:1000



- NOTES:**
1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE STATED
 2. USE DIMENSIONS ON DRAWINGS (DO NOT SCALE FROM DRAWINGS)
 3. ARRANGEMENT OF PUMPING STATION TAKEN FROM JACOBS TOBIN DRAWING 32105801-500-003-REVA (PROPOSED RAW WATER INTAKE AND PUMPING STATION AT PARTEEN LAGOON, SITE LAYOUT PLAN).

- LEGEND:**
- GEOPHYSICAL SURVEY LINE
 - SAC (SPECIAL AREA OF CONSERVATION)
 - BOREHOLE - LOCATION PROPOSED BY JACOBS TOBIN
 - CLAY
 - SAND
 - GRAVEL
 - MADE GROUND
 - TOPSOIL
 - LIMESTONE



GEOPHYSICAL & BOREHOLE PROFILE R1
SCALE 1:500

- CLAY
- SAND
- GRAVEL
- MADE GROUND
- TOPSOIL
- LIMESTONE

REV: F100	DATE: 13.05.19	DRAWN BY: E.J.B	CHECKED BY: P.Q
DESCRIPTION: ISSUED FOR INFORMATION			
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ISSUED AS: FOR INFORMATION			
CLIENT:			
<p>JACOBS </p>			
PROJECT TITLE: SHANNON PIPELINE INLET			
PROJECT No: 18197			
DRAWING No: 18197-D002-F100			
DRAWING TITLE: GEOPHYSICAL & BOREHOLE PLAN & PROFILES			
SCALE: 1:500	SHEET SIZE: A1	DATE: 13.05.19	
DRAWN BY: E.J.B	CHECKED BY: P.Q	APPROVED BY: P.Q	

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